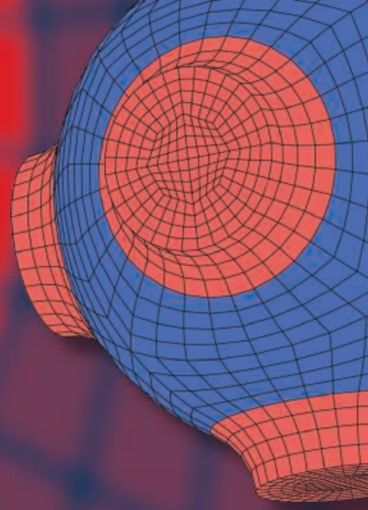
Advanced Structured Materials



Azman Ismail
Wardiah Mohd Dahalan
Andreas Öchsner *Editors*

Advanced Engineering for Processes and Technologies II

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Advanced Structured Materials

Volume 147

Common engineering materials reach in many applications their limits and new developments are required to fulfil increasing demands on engineering materials. The performance of materials can be increased by combining different materials to achieve better properties than a single constituent or by shaping the material or constituents in a specific structure. The interaction between material and structure may arise on different length scales, such as micro-, meso- or macroscale, and offers possible applications in quite diverse fields.

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Azman Ismail · Wardiah Mohd Dahalan ·
Andreas Öchsner
Editors

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Editors
Azman Ismail
Malaysian Institute of Marine Engineering Technology
Universiti Kuala Lumpur
Lumut, Perak, Malaysia

Wardiah Mohd Dahalan
Malaysian Institute of Marine Engineering Technology
Universiti Kuala Lumpur
Lumut, Perak, Malaysia

Andreas Öchsner
Faculty of Mechanical Engineering
Esslingen University Applied Sciences
Esslingen am Neckar, Germany

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Preface

This book *Advanced Engineering for Processes and Technologies II* provides a good platform for participating researchers and academicians to share their latest innovation, technology and research findings in the areas of marine engineering technology and applications, sea management as well as engineering education. It offers an opportunity for academicians of the Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology (UniKL MIMET) to exchange ideas and establish a professional network. There are more than 30 papers covering a wide range of topics related to technologies and education including simulation, intellectual discussion, environmental awareness, enhancement of knowledge and skills. The aim of this book focuses more on the numerous technological methods used for the establishment of engineering innovation and productivity through their competitive research findings and the exposure of their relative merits and limitations. The papers shared in this issue will enable other researchers to generate interest and novel ideas that can lead to the discovery of new engineering knowledge.

Lumut, Malaysia	Azman Ismail
Lumut, Malaysia	Wardiah Mohd Dahalan
Esslingen am Neckar, Germany	Andreas Öchsner

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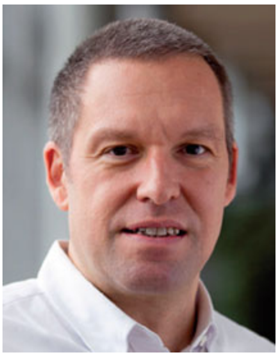
About the Editors

Azman Ismail is a Senior Lecturer at the Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Malaysia. He is also a registered Professional Technologist with the Malaysia Board of Technologist, Malaysia. He obtained his doctorate degree in mechanical engineering specializing in friction stir welding for pipeline joining at the Universiti Teknologi PETRONAS, Malaysia. He continuously seeks and managed to secure several reputable international funding opportunities in relation to his research interest. He also owns a series of patents in friction stir welding and actively published his research findings in high reputable publications. He won several reputable awards in regard of his research excellence. He is an active researcher in his field of expertise. Apart of his academic and research excellent, he has actively served many conservation works and as part of committee members with the World Wide Fund for Nature of Malaysia (WWF-Malaysia).

Wardiah Mohd Dahalan had received her B.Eng. (Hons.) in Electrical & Electronics Engineering from University of Dundee, Scotland, UK and Master in Decision Science from Universiti Utara Malaysia. She had obtained her Ph.D. in Power System from the University of Malaya, Kuala Lumpur, Malaysia in 2014. She is currently appointed as a Senior Lecturer at the Department of Marine Electrical and Electronics Engineering of University of Kuala Lumpur (UniKL-MIMET). As the Head of Research & Innovation Department, she actively administers all research activities in UniKL-MIMET. Supervision of internal and external research grants and organization of all activities related to innovation such as exhibitions, competition and conferences are her core activities at UniKL-MIMET. She participates in research as a principle or co-principle in many research grants. At the same time, she also shares her expertise by becoming either the author or co-author of the publications of local as well as international journals, books and proceedings especially in the area of power system and energy. Besides, she has also successfully supervised postgraduate and undergraduate students of several universities. Such track record has led her to be appointed as a reviewer for various international journal such as *IEEE Transaction on Power Systems*, *IET Generation*, *Transmission & Distribution*, *International Journal of Electrical Power & Energy Systems*. Her deep research interest includes network reconfiguration, optimization techniques and renewable energy. She is also a member of IEEE, Rina-IMARest, Malaysian Society for Engineering & Technology (MySET) and Malaysia Board of Technologist (MBOT).



Andreas Öchsner is a Full Professor of Lightweight Design and Structural Simulation at Esslingen University of Applied Sciences, Germany. Having obtained a Dipl.-Ing. degree in Aeronautical Engineering at the University of Stuttgart (1997), Germany, he served as a research and teaching assistant at the University of Erlangen-Nuremberg from 1997 to 2003, while working to complete his Doctor of Engineering Sciences (Dr.-Ing.) degree. From 2003 to 2006, he was an Assistant Professor at the Department of Mechanical Engineering and Head of the Cellular Metals Group affiliated with the University of Aveiro, Portugal. He spent seven years (2007–2013) as a Full Professor at the Department of Applied Mechanics, Technical University of Malaysia, where he was also Head of the Advanced Materials and Structure Lab. From 2014 to 2017, he was a Full Professor at the School of Engineering, Griffith University, Australia, and Leader of the Mechanical Engineering Program (Head of Discipline and Program Director).

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Chapter 1
The Potential of Using Unmanned Aerial Vehicles for Sea Patrol: Case Study at Royal Malaysian Navy, Lumut Base

Aizat Khairi and Ali 'Izzat Sa'ari

Abstract This paper analyzes the potential of using unmanned aerial vehicles (UAVs) for sea patrol purposes at the Royal Malaysian Navy, Lumut base. Nowadays, there is a growing need for flying drones or unmanned aerial vehicles with diverse capabilities for both civilian and military applications. UAVs are utilized in carrying out a variety of operations including military tasks, search-and-rescue missions, reconnaissance, and load transportation. This study is using a qualitative approach by conducting an in-depth interview. Purposive sampling was applied by meeting with navy officers who are involved in UAV activities. The data is analyzed by the content analysis method based on the semi-structured question of the interview. As a result, there is a significant interest in the development of novel drones which can autonomously fly in different environments and locations and can perform various missions. In the past decade, the broad spectrum of applications of these drones has received the most attention which led to the invention of various types of drones with different sizes and weights. This study concluded that the potential of using unmanned aerial vehicles for sea patrol purposes, benefits in terms of the maritime sector, and challenges of the existing UAVs with various navigation and control approaches.

Keywords Unmanned aerial vehicles (UAVs) · Royal malaysian navy (RMN) · Benefits and challenges

1.1 Introduction

Malaysia has a very wide economy exclusive zone (EEZ) and a long cost line. Geographically, to make permanent patrolling or surveillance, always it requires

A. Khairi (✉) · A. 'Izzat Sa'ari
Malaysian Institute of Marine Engineering Technology Lumut,
Universiti Kuala Lumpur, Lumut, Perak, Malaysia
e-mail: aizat@unikl.edu.my

A. 'Izzat Sa'ari
e-mail: aliizzatsaari@gmail.com

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many assets (vessel) [1]—meaning that it is very costly due to the use of assets all the time for the enforcement. To do patrolling and surveillance the enforcement agency needs something that can operate at minimum costs, requiring less manpower, and less work. So, by operating unmanned aerial vehicles, it seems to have the potential to reduce in terms of operating cost, manpower, and time. Thus, this study is to explore the function of UAVs, to identify the benefits of UAVs, and to analyze the challenges of UAVs for sea patrol activities by the navy.

This study has the potential to give benefits for a government based on an in-depth analysis of current research. UAVs and drones have same characteristic that is that they are unmanned [2]. But an UAV is more advanced in terms of its function to use for military purposes. By using the UAV, it can help to save costs in the defense sector. Other than that, it also helps to reduce the risk of life. The most important things are that it helps to save more time and it provides faster information. Therefore, UAVs can contribute to the defense sectors. The use of an UAV is a smart investment as it can save money, energy, and time.

This study focuses on the Malaysian water area. It involves the officers of the Royal Malaysian Navy (RMN) at the Lumut area on the purpose of studying the potential of using unmanned aerial vehicles for sea patrol activities at the Malaysian water border. The scope of the study is about the functions, benefits, and challenges of the potential toward the usage of the UAV for sea patrol purposes [3].

1.2 Literature Review

1.2.1 Drones Versus UAVs

In a general sense, these two things are the same, but the terms are used in different ways. Generally, a drone is any aircraft that does not have a pilot in it, whether it is operated by software or by a remote pilot [4]. The term UAV generally refers to any military aircraft operated without a pilot that can be reused.

These are the rules to follow to use the correct term [5]:

1. French-speaking: drones;
2. US and UK: UAS;
3. International and other national aviation agencies: RPAS;
4. on the Internet: UAVs and drones;

1.2.2 Functions of UAVs

There are various functions of UAVs used by people, core implementation fields as shown below [6]:

Table 1.1 Weight of UAVs

Classification by weight		
Designation	Weight range	Example
Super Heavy	>2000 kg	Global Hawk
Heavy	200 – 2000 kg	A – 160
Medium	50 – 200 kg	Raven
Light	5 – 50 kg	RPO Midget
Micro	<5 kg	Dragon Eye

- Search and rescue—Drones are extremely useful for search and rescue operations. Using the special measuring equipment, for instance, they are used in firefighting to determine the amount of certain gasses in water.
- Security—During different incidents, most governments use drones to protect people. They can, for instance, assist during organizing a few security operations and can also preserve evidence.
- Inspections—Various systems can be tracked by drones, such as power lines, wind turbines, and pipelines.
- Surveillance—A drone enables recording and surveillance of public events, demonstrations, or any unusual activity without being heard or seen. It is therefore ideal for recording public events.
- Science and research—They help scientists to identify various phenomena in nature or a specific earthly climate, particularly in science. Drones are used for instance to record historical excavations, to track volcanic eruptions (measurement of contamination), ice observation, and others [7].

The weight, range and endurance, and also the maximum altitude of UAVs are shown in Tables 1.1, 1.2, and 1.3 [8].

Table 1.2 Range and endurance of UAVs

Range and endurance			
Category	Endurance	Range	Example
High	>24 h	>1500 km	Predator B
Medium	5 – 24 h	100 – 400 km	Silver Fox
Low	<5 h	<100 km	Pointer

Table 1.3 Maximum altitude of UAVs

Classification by maximum altitude		
Category	Max Altitude	Example
Low	<1000 m	Pointer
Medium	1000 – 10000 m	Finder
High	>10000 m	Darkstar

- Aerial photography and video recording—They will take interesting pictures and capture high-quality images from the air with a drone fitted with an HD screen.
- Surveying and geographical information system (mapping)—Drones can create high-quality 3D maps utilizing multi-spectral cameras and laser scanners. Ultimately, implementations are identified in several fields including distance sensing, surveying, and mapping, photogrammetry, farming in precision, and other sectors.
- Unmanned cargo system—Drones sometimes carry lightweight boxes and bunches of all sizes, thus they are able to transport goods easily, eco-friendly, and rapidly by sea.

The key specifications performances are (1) weight, (2) range and endurance, and (3) high altitude

1.2.3 Benefits of UAVs

Drones are able to explore wherever people cannot safely go. They can provide improvement of protection, cost reduction, speed of procedures, quicker data access when there are unknown things occurring, and in the case of access problems [9]. UAVs may usually be managed without a large security network by one person, which significantly reduces the associated costs. UAVs are easy to deploy and reduce downtime compared to conventional approaches. Instead of booting ships, the use of UAVs can minimize vessel activities and ship management costs by up to 90 percent. It can cut costs for many issues like energy expenses, operating costs, and salaries.

Drones can be deployed to locations that are large and hazardous to track terrorism, trafficking, and other illegal activities in emergencies. Before this, a high-risk role belonged to a crew member, a drone can now travel to the inspection center and this does not only minimize the risk, but it is also easier with high-definition imagery and camera input to the control center [10]. There are several ships that have been re-supplied onshore, since after drones have been developed, various jobs become easier as much easier as the definition of this role. By using UAVs, operating costs are more effective than using patrol ships in terms of manpower and maintenance costs. Besides, it saves time and speeds up operational surveys. Besides that, it makes also access during critical situations easier, which are difficult to be accessed by humans.

1.2.4 Challenges/Risks of UAVs

There are many and varied issues that need to be tackled concerning the harmonization of drone use requirements [11]. The use of surveillance drones raises many questions not only from the general perspective of international and human rights laws but also from a moral point of view, such as the psychological effects on local populations, or the risk of collateral damage, which may be caused by a constant presence of military drones in supervision or attack operations. The next question in terms of using the drones while carry weapon should be critically addressed by the law and enforcement mechanism to avoid bad consequences in the future. Such legal and ethical dilemmas constantly threaten their wide use, including trust in the advantages of such technologies.

Every drone form could raise issues about its safety and security that are likely to increase with the exponential use of drones. It has been stated, for instance, that UAVs intervene with civil aviation, purposely and accidentally travel over sensitive areas such as nuclear plants or even injure people if their remote pilot loses control [12]. Nonetheless, it is possible to confuse the difference between a military drone and commercial drones since not each military drone carries weapons; most military drones can be used in many respects, for war, trade, and arts purposes including. Drone debates would also benefit from more comprehensive drone type research and guidance. A simpler, more detailed definition will render certain developments in drone technology more recognizable and therefore allow for greater openness, oversight, and inspection than is the case today, which are critical to drone adoption and legitimacy.

Although unmonitored patrols are of major importance, many obstacles still lie ahead. Originally, consideration should be given to capabilities shortcomings of base stations. For every specified station to be properly utilized, the UAV number cannot be below a lower limit, while the upper limit of restrictions on military ranks is unfair. It is also unrealistic to surpass a cap [13]. Provided that several base stations should be set up to ensure compatible operations, both the number and the location of the base stations must be optimized. In the meantime, UAV flight paths should also be designed jointly. These are all variables that reduce the overall cost, which makes the problem more complicate. It is likely to be making wrong decisions sooner or later.

1.3 Methodology

1.3.1 Research Design

In the qualitative method, the design usually uses interviews as a method to collect primary data. There is various preparation required by a researcher in preparing the questions as they need to be a tailor with the research field to ensure it fulfills the scope and objective of the research. Other than that, searching from Internet websites and making reading from journals, articles, and others are also part of the qualitative method [14]. For this research, the interviews involved the navy officer at the Lumut base, specifically officers from the KD Mahawangsa that cover sea area operation. Thus, they are officers from the fleet operations command west (FOC) department.

The structure of the interview questions is divided into four sections which are A, B, C, and D the type of questions is semi-structured interviews. The details of the sections are given in the following:

1. Section A—This section covers the demographics and other general information which includes name, gender, unit, and respondent work experience.
2. Section B—This section is focused on the general function of the UAVs and their implementation in Malaysia.
3. Section C—benefits of using UAVs for sea patrol related to achieving the objectives of the research.
4. Section D—focused on the challenges of using UAVs for sea patrol related to achieving the objectives of the research.

1.3.2 The Interview Method

The interview method is one of the main methods of collecting data for survey research. For the semi-structured interview, the interviewer not only asks several formal questions which have been prepared before the interview, but the researcher is also given the freedom to question and explore the answers given by respondents in a more in-depth manner. Besides formal questions, entry open-ended questions are very helpful to the interviewer as to get more explanation regarding the objectives especially in this research. It is providing an opportunity to identify new ways to see and understand the topic at hand.

Although the interviewer can ask any question in a semi-structured question, the question must relate to the research objectives in the case study. In other words, the interviewer can ask the questions, but they have to have same aim. Moreover, questions can be added depending on the respondents' situation.

1.3.3 Sampling

Sampling is the process of selecting several subjects from a population as research respondents. Purposive sampling is the process whereby a group of subjects is chosen as respondents because they have certain characteristics. About 10 respondents from Navy officers and non-officers have been interviewed. This is based on the intention or the purpose of the study. Only those elements will be selected from the population which suits the best for our study likewise for this UAVs research.

The main aim of purposive sampling is to focus on certain characteristics of a population that are respondent during interviews which will best enable to answer the research questions. The sample being studied is not representative of the population but for the researcher pursuing qualitative or mixed methods research design. Therefore, this is not considered to be a weakness.

1.3.4 Content Analysis

Content analysis is a research tool used to determine the presence within texts or sets of texts of certain words or concepts. Researchers evaluate and analyze the presence, meanings, and relationships of such words and terms, then make inferences about the messages in the texts, the writer(s), the audience, and even the culture and time of which they are part.

1.4 Result and Discussion

1.4.1 Data Analysis

To help to get the data for this study, the method of reading and interviews were used. This method is a great combination to obtain data from the authority which is the Royal Malaysian Navy. For the structure of the interview, we used 18 semi-structured questions, to produce detailed data. The question consists of 2 parts, A and B. Section A is the basic questions related to personal details and demography of the navy staff. While Section B is more related to the functions of UAVs, benefits and challenges of using them, and to know their opinion in regard to the use of UAVs in the Navy.

1.4.2 Data Analysis on Research Team

The target of the respondent is based on the selected person or the method is known as purposive sampling which means that they are suitable and know this research title. The respondents are only selected from the FOC department that is related to the sea patrol activities. The total amount of respondents is equal to 10 persons. The number of respondents is shown in Table 1.4.

Table 1.4 The amount of respondents

Respondents by category	Number of respondents
Officer	6
Non-officer	4
Amount	10

Table 1.5 ScanEagle specification

General characteristics	Performance
Crew: None Payload: 3.4 kg Length: 1.55 m–1.7 m Empty weight: 14 kg Loaded weight: 18 kg Max. takeoff weight: 22 kg Power plant: 1 × 2-stroke 3 W piston engine—1.5 hp	Maximum speed: 80 knots or 148 km/h Cruise speed: 60 knots or 111 km/h Endurance: 24-plus hours Service ceiling: 5,950 m
Avionics	
High resolution, day/night camera, and thermal imagery	

1.4.3 Function of UAVs

In terms of UAVs, it is all about the intelligence, surveillance, and reconnaissance (ISR). Malaysia should keep abreast of current trends as technology becomes sophisticated every day. Formerly, Malaysia used to be second ranking in Southeast Asia in terms of defence system, but now it is backward. For example, the Philippines is ranked last in Southeast Asia but has now risen to third place after Singapore and Indonesia. This has allowed Malaysia to improve its defense systems by using this application. Based on the interview, the navy has stated that the type of UAV to be used is the ScanEagle UAV with a medium range. This UAV will be imported from the United States of America (USA) as the navy team who took the course was also sent to the USA (Table 1.5).

1.4.4 Benefits of UAVs

Time is important for Navy operations especially in border surveillance. So, the UAV is good in terms of low usage of man and in terms of time and also fast with unpredictable weather conditions in Malaysia. The UAVs are fast and save time by minimizing the time required to erect ladders, access towers, swing stages, aerial lifts, and other heavy equipment. The UAV also is the best solution for navy operation. It is due to several factors such as maintenance cost, usage of workforce, oil consumption, and the difference in purchase price. The first factor is about maintenance cost: every time before going out to sea to conduct sea patrol activities, the navy will run a thorough inspection and maintenance to ensure that no damage will occur during the operation.

The second factor is the number of workforces. A vessel will cost a lot than an UAV does not have to produce such as a vessel that needs to provide food for the crew, water logistics management and other requirements, bulk maintenance, and so on while the UAV does not require all of that. The last factor is about the purchase price. The most noticeable difference is that the price of a vessel reaches hundreds of millions Dollars while a UAV of only four to five million Dollars for the medium range. This UAV is as good as a rescue mission. The search and rescue speed are an important part of a rescue mission then the UAV is the perfect fit for this mission. Likewise, for surveys and border surveillance operations, UAV is ideal for use instead of the ship because it may be a long way to get to a place that is long and time-consuming, but the UAV can monitor crime movements or foreigners quickly.

Remote pilots can launch a UAV inspection within a very short time upon request. It only takes minutes to launch an UAV and it is suitable for both regular and emergency scenarios. Besides, the UAV is fast and there is no need for long preparation for deployment or launch because it takes about 5–15 minutes. As such, intelligence, surveillance, and reconnaissance (ISR), sea patrol, or search and rescue (SAR) missions can be easily requested, and results can be available in less than one hour.

The UAV can give flexibility and easing the access to hard-to-reach places and it can be efficiently, economically, and safely captured by a UAV. It minimizes the obvious dangers and enables easy and safe inspections. They eliminate the need for workers to physically access hostile environments, where factors such as height, wind, waves, weather, radiation, and enemies can lead to loss of a life. Moreover, UAVs are making it possible for professionals to easily collect aerial data in places where it would be logically impossible. It is less risky and safer to use UAVs in hostile environments for applications, such as radiation monitoring, inspecting high-voltage lines, and other activities that can cause injuries or death. Especially during reconnaissance, the navy does not need to send a suicide squad, thus, the UAV can contribute or substitution regular soldiers. UAVs can easily access difficult-to-reach areas while eliminating the need for a human to go there using risky mechanical tools.

1.4.5 Challenges of UAVs

Security is a very sensitive issue for every country. Is it transparent when hiring outsiders for maintenance due to this new technology and lack of local skills and experience. The Navy only operates the UAVs while for the maintenance external experts are used. This threatens the navy in terms of security due to its dependence on external experts for maintenance. The same goes for vulnerabilities in the command and control of UAV operations. It is a good idea to apply a UAV within the RMN; it is just that one needs to think about the operation and maintenance culture. This is because sometimes when adopting a technology, it will be obsolete or forgotten how to fix it and use it. In other words, the successor for the next generation to share knowledge about UAV is less emphasized and when this happens, the expertise to use the UAV is lost and the UAV is no longer available. Therefore, the operation and maintenance culture must be sharpened and polished.

The UAV has its weaknesses such as the inability to recognize and avoid other aircrafts and airborne objects in a manner like manned aircrafts. Other than that, UAVs only give information instead of taking action. If we look at the concept of operation itself, the UAV will provide the data feedback to the monitoring vessel on duty. This is because the UAV is only capable of monitoring, in the event of any suspicion at sea the UAV should report to the patrol vessel immediately for further action.

1.5 Conclusion

The roles of UAVs are to maintain the sovereignty and security of the country's sea borders. The UAV brings more benefits than patrol vessels, such as wider surveillance scope, lower error, and faster task completion time. The key challenges for using UAV for sea patrol purposes are such as security breaches, obsolete of operation and maintenance culture and one of the biggest safety issues is to enter the unmanned aircraft into non-segregated airspace. This may cause UAV accidents due to the limitation of the UAV operation. In conclusion, it is hoped that the key benefits and challenges described in this research will help to pave the way for the RMN to improve UAV applications in the future. Since the UAV seems to be able to penetrate the world market because of its potential of opening a new era of modern technology, it has given puzzle in minds of the Royal Malaysian Navy of whether this magnificent device and machine can be used for weaponry in the future instead of patrolling the EEZ and the Malaysian border. The UAV as we know seems to run through evolution over the times thus, it is essential to modify UAV in the latest technology according to the surroundings and environment of the situation. When this modification and innovation is being made, the Royal Malaysian Navy should give and provide training from time to time on controlling and handing the updated UAV.

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Chapter 2
The Determinants for Successful Ferry Operation: A Delphi Study at Penang Port, Malaysia

Amayrol Zakaria, Aminuddin Md Arof, and Ain Nur Najwa Nor Sabinja

Abstract Ferry passenger vessels have been used as a sea transportation that were designed to carry passengers from one place to another place. The focus of this research is on the Penang port. This transportation system is an alternative conveyance to transport people to both sides, i.e., mainland and the island. The dissatisfaction of passengers with the service had been immense, and no sign of improvements by the ferry organization at Penang port has been discovered. Thus, this research aims to investigate the key for a successful operation of the ferry passenger vessel at Penang port and to determine the relationship between key factors toward a successful ferry operation at Penang port. The purposive sampling method is used, and seven competent expertise and experienced respondents in the maritime sector at the Penang port have been contributed to this research. A Delphi survey has been conducted for this research to identify any key factors and access their opinion on the relationship of all key factors involved. Two rounds of the Delphi questionnaire survey have been used as a research instrument with the Likert scale. In conclusion, the finding revealed that the key factors that have been analyzed play an important role in realizing the successful ferry operation at the Penang port.

Keywords Sea transportation · Ferry passenger vessel · Research instrument · Likert scale · Delphi

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A. Zakaria (✉) · A. M. Arof · A. N. N. N. Sabinja
Malaysian Institute of Marine Engineering Technology,
Universiti Kuala Lumpur, Lumut, Perak, Malaysia
e-mail: amayrol@unikl.edu.my

A. M. Arof
e-mail: aminuddin@unikl.edu.my

A. N. N. N. Sabinja
e-mail: ainnajwa5a@gmail.com

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2.1 Introduction

Pulau Pinang or Penang is one of the acknowledgeable islands which is located in northwest Malaysia encompassing two separated areas, namely Seberang Perai on the mainland and the Penang Island. It is as well one of the world's must-visit destinations because Penang is a tropical paradise that not only offers beautiful beaches and lush rainforests, it is also known for its centuries of heritage, gorgeous colonial and pre-war architecture, an active arts and festivals scene, world famous gastronomic culture—all juxtaposed against the backdrop of an international city.

Since Penang has many interesting places to attract the tourists, there are various types of transportation modes that provide easy mobility. The tourist and even local people may experience the use of the ferry services as it is one of the modes of transportation that is available at Penang aside from using the bridges.

Previously, the Penang ferry was the only way to get on and off the island before the Penang Bridge was built in 1984 [7]. Various types of infrastructure have been developed in order to provide the best mobility and accessibility between Penang Islands and mainland due to the state's significance in urban, industrial and economic growth. Thereby, the ferry services at the Penang Ferry Terminal have become the famous transportation mode to travel from the mainland to Penang Islands.

Apart from that, the users may also be able to travel by cars, buses or even lorries through the bridges: Penang Bridge and Sultan Abdul Halim Muadzam Shah Bridge. The use of ferry services between Pengkalan Raja Tun Uda in George Town, on Penang Island, and Pengkalan Sultan Abdul Halim in Butterworth, on the Penang mainland, as public transport is for making journeys to work, school, shops and other daily activities [2]. Since that, the ferry operation at Penang port becomes popular for a daily use.

2.1.1 Problem Statement

Obviously, regular ferry customers had been complaining that the service had been tremendously poor with no sign of improvements and the users keep on wondering if anyone would do anything regarding this issue [4]. Meanwhile, the ferry operation has been delayed due to the malfunction as the ferry suddenly stopped in the middle of the sea and was towed by a tugboat which took about 30 min [3]. Thus, problems arise and the defect contributes to a negative impact on achieving high-quality service. Therefore, it is the intention of the researcher to investigate the determinants of successful ferry operation at Penang port, Malaysia.

2.1.2 Objectives of the Study

The aim of this research is to study the determinants for a successful ferry operation at Penang port, Malaysia. Below are the research objectives that are carried out along the process: firstly, to investigate the key factors that contribute to a successful ferry operation that is provided at Penang port, Malaysia; secondly, to determine the influence of the key success factors toward ferry operation at Penang port, Malaysia.

2.1.3 Significance of Study

Relatively, the finding of this study will provide favorable and valuable information to the management of the Penang port authority in order to identify the key determinants for a successful ferry operation while evaluating the problems and challenges concerning service delivered.

The finding of research study also can influence passengers to travel from one place to another place by using the service provided at the ferry terminal. Besides that, the outcome from this study might be able to influence the country's economic growth since it contributes in terms of knowledge in the ferry operation literature, specifically in the sustainable transportation industry.

2.1.4 Limitations and Scope of Study

The scope of this study only focuses on ferry services that are delivered at the Penang port. The main target sample for this research study is the respondents who have sufficient experience to provide an appropriate information needed along the research, especially regarding the ferry operation at the Penang Port.

2.2 Literature Review

2.2.1 Definition of Delphi Study

Reference [5] revealed that a Delphi study is an instrument that is defined as a systematic forecasting tool that is used to assemble opinions and information of the experts' panel. Usually, it is conducted through the questionnaire or interview [5].

The Delphi technique typically includes at least two rounds of experts answering questions and giving justification for their answers by providing the opportunity between rounds for changes and revisions. It is argued by [1] where Delphi was employed with concession of experts' opinion when there is a necessity to provide a judgment to address an explicit problem. Thus, Delphi is employed to reach superior decision making [1].

2.2.2 Ferry Operation

Reference [8] revealed that the ultimate purpose of a ferry operation is to allow the passengers to reach the destination as fast as possible while providing the smoothest and affordable way to embark or disembark. Then, the port also must have sufficient intermodal links. Basically, the main reason for the utilization of ferry passenger vessel is to avoid congestion. The ferry operation in Penang port enables the passengers or travelers to reach their main activities or daily activities such as work, welfare, education and shopping easily and in a safe manner.

2.3 Research Methodology

2.3.1 Population and Sampling

This research was to be conducted at the Penang port. This research was focused on gathering information data in selected samples from the population at Penang port. The researcher utilized the purposive sampling method. For this research, only seven expert respondents with adequate experience were selected from the total population. This purposive sampling method technique is used to ensure that only respondents with adequate knowledge on the ferry operation are interviewed and surveyed to obtain their feedback.

2.3.2 Primary Data

A set of seven Likert scale questionnaire is used as a primary research method to enable data collection during the survey. Questionnaire survey will be done to acquire the information directly from the respondents. These questionnaires are divided into two categories which are open-ended and close-ended questions.

Table 2.1 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha based on standardized items	No of items
.914	.912	30

2.3.3 Secondary Data

The supplementary info from earlier scholars will help to support the linked data information that will support to complete this research. Some of the secondary data are from the literature review, journal, books and websites.

2.4 Finding and Discussion

2.4.1 Reliability Statistics

Table 2.1 shows that the result of the pilot test has utilized Cronbach's alpha. Cronbach's alpha value is 0.914 which means the set of questionnaires is reliable to utilize the gathering process. The reliability statistic is shown in Table 2.1.

2.4.2 Result of First-Round Survey

Based on Table 2.2, the highest mean value is the corporate image and intermodal link which is 4.57 compared to the other independent variables that are used in this research for Round 1. The lowest mean value is the service quality which is 4.00. Based on these results, it shows that the Penang port is able to attain the successful operations since it has a good intermodal link such as a great accessibility by an integrated rail, bus and ferry hub.

Obviously, in order to maintain the Penang ferry terminal performance, the Penang port authority also strictly follows the rule and specification of IMO classification

Table 2.2 First-Round Survey

Determinant	N	Mean	S.D
Infrastructure	7	4.14	.378
Service Quality	7	4.00	.816
Payload	7	4.29	.488
Corporate Image	7	4.57	.535
Intermodal Link	7	4.57	.535
Valid N (listwise)	7		

Table 2.3 Second-Round Survey

Determinant	N	Mean	S.D
Number of Crew	7	3.43	.787
Departure Schedule	7	3.57	.787
Standard Operating Procedure	7	4.00	.577
Briefing/Roll-Call	7	3.71	.951
Safety Measure	7	4.86	.378
Crew's Discipline	7	4.71	.488
Customer's Feedback	7	4.29	.488
Valid N (listwise)	7		

society. As for the standard deviation, the close value to the mean value is the corporate image and intermodal link which is 0.535. This indicated that the data are close to the mean value or average of the data set.

2.4.3 Result of Second-Round Survey

Table 2.3 shows that the highest mean value is the safety measure which is 4.86 compared to all independent variables that are used in this research. The lowest mean value is the number of crew which is 3.43. For the standard deviation, the highest value is the briefing/roll-call which is 0.951, and the lowest value is the safety measure which is 0.378. If the value of standard deviation is small, the data are close to the mean value or average of data set; besides that, the data were distant from the mean value if the standard deviation is large. This result shows that the respondents are emphasizing the safety measure as an important factor that will determine the success of ferry operations at Penang port compared to all independent variables.

Table 2.4 shows the degree of correlation between two variables which are the dependent variable and independent variable. The number of crew is the highest value compared to any other variable which is 0.500, and the data are close to 1. The consequences of this result demonstrate that there is a significant relationship between two variables.

Obviously, this is a positive correlation. Since the value is positive, it can be concluded that the sufficient numbers of the crew play an important role in influencing the successful ferry operations and also contribute to the efficiency trip as scheduled.

Besides that, there is a negative correlation when the result of Pearson's generated a negative Pearson's r value; for example, as one variable increases a value, the second variable decreases the value. For instance, the discipline and attitude value is −0.427, and it can be concluded that the negligence of crew does not directly affect the whole ferry operations as compared to another variable.

Table 2.4 Pearson Correlation Analysis

	1	2	3	4	5	6	7	8
1	1.00	.500	.118	.280	.462	−.275	−.427	−.237
2	.500	1.00	.615	.000	−.255	.240	−.496	−.372
3	.118	.615	1.00	.000	−.191	.881	−.372	−.062
4	.280	.000	.000	1.00	.303	.000	−.592	.000
5	.462	−.255	−.191	.303	1.00	−.132	−.205	.564
6	−.275	.240	.881	.000	−.132	1.00	−.258	.258
7	−.427	−.496	−.372	−.592	−.205	−.258	1.00	−.300
8	−.237	−.172	−.062	.000	.564	.258	−.300	1.00

Legend:
1: Successful Ferry Operation
2: Number of Crew
3: Departure Schedule
4: Standard Operating Procedure
5: Briefing/Roll-Call
6: Safety Measure
7: Crews Discipline
8: Customers Feedback

2.5 Discussion

Obviously, there is a differentiation between first-round survey and second-round survey. It can be observed that additional variables are added to the existing variables based on the present judgment by similar expert respondents. The Delphi technique plays the momentous role to achieve the best decision making.

Based on objective 1, it could be observed that there are several key factors that contribute to the successful ferry operation that is provided at the Penang port, Malaysia. The seven experts that have been contributed for both rounds of survey at Penang port mostly agreed and accepted that the number of crew, departure schedule, standard operating procedure (SOP), briefing/roll-call, safety measure, crew's discipline and attitude, and customer's feedback and complaint are the key factors that play an important role in achieving the successful ferry operations at Penang port.

On top of that, the findings also revealed that most of the passengers prefer to use a ferry as a transportation mode because of the safe and comfortable trip. Furthermore, the ferry at Penang is built to carry and transit the passengers from Pengkalan Sultan Abdul Halim to Pengkalan Raja Tun Uda. This cross-transit makes it the oldest ferry operation in Malaysia as it has been operational since 1894.

Based on objective 2, it could be observed that the expert respondents that contributed to this research agreed that the sufficient numbers of crew play an important role in achieving the success toward ferry operations and it will influence the efficiency trip as scheduled. This is to preserve the smooth operation of the ferry at the Penang ferry terminal.

Moreover, the successful ferry operations also can be achieved since the infrastructure that is provided by Penang ferry terminal authority is comfy and easy for passengers and crew usage. It is because the Penang ferry terminal authority takes a safety precaution toward infrastructure and facilities at ferry terminal by ensuring all the SOPs are strictly followed by all crew. More importantly, the SOP of Penang ferry terminal is competent in fulfilling the passengers' need and requirement, while being able to ensure the safety and security of passengers and crew onboard [9].

Additionally, the finding also revealed that Penang ferry terminal is emphasizing the safety measure as one of the important factors to guarantee the customers' satisfaction concerning achieving successful ferry operations. Last but not least, due to increasing the performance of ferry operations, all the customers' feedback and complaint can become an initiative tool in order to achieve successful ferry operations at Penang port. On the other hand, all crews either directly or indirectly involved in ferry operations must take part in ensuring the key factors in determining the successful ferry operations at the Penang port.

2.6 Conclusion

In conclusion, in order to maintain the successful ferry operations at the Penang port, there are several factors that need to be taken into account such as providing an adequate training or conducting a briefing and roll-call before the operations. Based on the findings, most of the expert respondents agreed the statements of "a short briefing to the passenger before departure is necessary to ensure the smooth and safe ferry operations." Even though the single journey from mainland to island only takes roughly less than an hour, it is important to give a briefing to the passengers to ensure the safety of the passengers as well as the crew onboard the ferry.

Last but not least, further research is a necessity to explore from the other perspective rather than experts' judgment. For instance, the customer point of view also plays an important role to measure the prolong of the successful ferry operations. This is because customers and passengers are the reasons why smoothness and efficiency of the ferry operations are a necessity [10].

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Chapter 3
The Commercial Success Factor Towards Ro-Ro Operation at Port Klang, Malaysia

Amayrol Zakaria, Aminuddin Md Arof, and Bisiakri Mohamed Khalifa

Abstract Ro-Ro ships are a specialized form of sea freight transportation. The combination between different types of cargo that are transported together with Ro-Ro ship leads its service to be one of the highest competitors in the industry. Despite providing a door-to-door service, there are a number of advantages that Ro-Ro provides such as the most known one of these advantages is the speed of charging and discharging cargoes. Mainly, the intention of this research is to investigate the influence of commercial success factor towards Ro-Ro operation at the Port Klang, Malaysia. Basically, this study employed the Delphi technique to obtain the concrete and solid data from the respondents. An interview supported by well-designed seven Likert scale questionnaires was disseminated to the seven expert respondents involved by the top management level of Port Klang and local Ro-Ro companies. The finding revealed that the commercial success factor has a significant relationship toward Ro-Ro operation at Port Klang, Malaysia.

Keywords Ro-Ro operation · Safety · Cargoes · Delphi technique · Door-to-door service

3.1 Introduction

Port Klang is a Malaysian port that is located in the western coastal area of Malaysia, established in 1945, and it is considered as the number one port in Malaysia and

A. Zakaria (✉) · A. M. Arof · B. M. Khalifa
Malaysian Institute of Marine Engineering Technology,
Universiti Kuala Lumpur, Lumut, Perak, Malaysia
e-mail: amayrol@unikl.edu.my

A. M. Arof
e-mail: aminuddin@unikl.edu.my

B. M. Khalifa
e-mail: khalifa.fsh@gmail.com

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number twelve in the world in containers' sector. Port Klang is authorized by the Port Klang Authority (PKA) since July 1963 [3].

Port Klang provides vehicle terminal as one of its facilities provided by the port. The terminal is a joint venture comprising Konsortium Perkapalan Bhd, Klang Multi Terminal, NYK Line and Mitsui OSK Line. The center provides services such as pre-shipment and pre-delivery inspections, a computerized vehicle tracking system, minor repairs and insurance coverage [3].

3.1.1 Problem Statement

Obviously, Ro-Ro ships are a specialized form of sea freight transportation. The advantages that it holds are that it can take advantage of smaller ports because the cost and complexity of the loading and unloading process are easier [1]. On the other hand, the expensive loading equipment and staff are not needed when using this type of loading. The Ro/Ro process has made the entire loading and unloading process much safer and efficient [2].

Nevertheless, the Ro-Ro operation that is operated in Port Klang has a high market comparator that might affect the service provided in Ro-Ro operation in Port Klang [9]. Despite encountering with the issues of different ports functions and operations, Ro-Ro operations service in port Klang is remain competitively even in local market or internationally [3]. Adding to the note, the commercial factor, for instance payload factor, types of vessel and the speed of vessel are among the important factors that influence the successful Ro-Ro operation at Port Klang. Thus, this is the intention of this study to determine the commercial success factors that influence the successful Ro-Ro operation in Port Klang.

3.1.2 Objectives of the Study

The aim of this research is to examine the commercial success factors for a successful ferry operation at Port Klang, Malaysia. Below are the research objectives that are carried out along the process: firstly, to investigate the commercial success factors of the Ro-Ro operation at Port Klang, Malaysia; secondly, to determine the influence of commercial successes toward the Ro-Ro operation at Port Klang, Malaysia.

3.1.3 Significance of Study

Relatively, the finding of this study will provide favorable and valuable information to the management of Port Klang Authority in order to identify the key determinants for successful Ro-Ro operation.

The finding of this research study also can influence the shipowner to mobile their vehicles from one place to another place by using the service provided at the terminal.

On the other hand, the research is able to contribute to the deeper insight into the concept of understating the Ro-Ro ship operation. The study will help the other scholars and academia in their future research and their exploration purpose. The result of this research will be able to contribute to the country's economic growth and a better understanding of the Ro-Ro operation literature, especially in the viable transportation industry.

3.1.4 Limitations and Scope of Study

The scope of this study only focuses on ferry services at Port Klang, Malaysia. The main target sample for this research study is the expert respondents who have an adequate capability and experience to provide an appropriate information needed along the research, especially regarding the Ro-Ro operation at Port Klang.

3.2 Literature Review

3.2.1 Definition of Delphi Study

Reference [5] revealed that a Delphi study is an instrument that is defined as a systematic forecasting tool that is used to assemble opinions and information of the experts' panel. Usually, it is conducted through the questionnaire or interview [5]. The Delphi technique typically includes at least two rounds of experts answering questions and giving justification for their answers by providing the opportunity between rounds for changes and revisions. It is argued by [3] where Delphi was employed with concession of experts' opinion when there is a necessity to provide a judgment to address an explicit problem. Thus, Delphi is employed to reach superior decision making [3]. Adding to the notes, [10] also supported that the Delphi technique is among the best techniques that can be employed in the shipping study.

3.2.2 Definition of Ro/Ro Vessel

Reference [6] revealed that Ro-Ro is a short form for Roll on Roll off. A Ro-Ro ship is a vessel where wheeled cargoes are carried from point A to point B [6]. A Ro-Ro ship is a different type of ship that does not use any cranes as Lo-Lo or any other type of ship. Ro-Ro is designed with a built-in ramp which is normally located at the stern (backside) of the ship to load and unload the cargoes [6].

3.2.3 Ro-Ro Service

Reference [7] determined that the Ro-Ro service has advantages due to the various types of cargoes that can handle the Ro-Ro. The combination between the different types of cargoes that are transported together with the Ro-Ro ship leads its service to be one of the highest competitors in the industry. Reference [6] argued that since the cargoes of Ro-Ro vessel are wheeled cargoes that means the speed of loading and unloading would be faster than any other because the cargoes will be driven straightly out and into the vessel. The method of charging and discharging the cargoes leads the Ro-Ro service to be one of the fastest services in the maritime industry if not the fastest [6].

3.3 Research Methodology

3.3.1 Population and Sampling

This research was conducted at the Klang port. This research was focused on gathering information data in selected samples from the population at the Klang port. This study utilized the purposive sampling method. For this research, only seven expert respondents with adequate experience and knowledge were selected from the total population. This research also employed a purposive sampling method technique to ensure that only respondents with adequate knowledge on the Ro-Ro operation were interviewed and surveyed to obtain their feedback.

3.3.2 Primary Data

A set of seven Likert scale questionnaire is used as a primary research method to enable data collection during the survey. The questionnaire survey will be done to acquire the information directly from the respondents. These questionnaires are divided into two categories which are open-ended and close-ended questions.

3.3.3 Secondary Data

The supplementary info from earlier scholars will help to support the linked data information that will support to complete this research. Some of the secondary data are from the literature review, journal, books and websites.

Table 3.1 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.702	.689	40

3.4 Finding and Discussion

3.4.1 Reliability Statistics

Table 3.1 shows that the result of the pilot test has utilized Cronbach's alpha. Cronbach's alpha value is 0.702 which indicates that the set of questionnaires is reliable to be utilized for the collecting process.

3.4.2 Result of First-Round Survey

Based on Table 3.2, the highest mean values are the payload factor and port efficiency which is 4.59 compared to the other independent variables that used in this research for Round 1. The lowest mean value is the speed of vessel which is 4.00. Based on these results, it indicates that the Klang port is able to manage the port efficiency and the payload factor will influence the volume of the cargo.

As for the standard deviation, the close value to the mean value is the payload factor and port efficiency cost which is 0.537. This indicated that the data are close to the mean value or the average of the data set.

Table 3.3 shows that the highest mean value is the cargo handling cost which is 4.89 compared to all independent variables that are developed in this research. The lowest mean value is the speed of the vessel which is 3.43. The highest value of the standard deviation is the payload factor which is 0.951, and the lowest value is the safety measure, which is 0.381. If the value of the standard deviation is small, the data are close to the mean value or average of data set; besides that, the data were distant from the mean value if the standard deviation is large. This result shows that the respondents are emphasizing the cargo handling cost as an important factor that

Table 3.2 First-Round Survey

Determinant	N	Mean	S.D
Speed of vessel	7	4.00	. 817
Ro-Ro service promotion	7	4.12	. 377
Types of ship	7	4.27	.486
Payload factor	7	4.59	.537
Port efficiency	7	4.59	.537
Valid N (listwise)	7		

Table 3.3 Second-Round Survey

Determinant	N	Mean	S.D
Speed of vessel	7	3.43	.787
Port efficiency	7	3.56	.787
Types of ship	7	4.00	.577
Payload factor	7	3.70	.951
Cargo handling cost	7	4.89	.381
Ro-Ro service Promotion	7	4.70	.488
Service quality	7	4.29	.488
Valid N (listwise)	7		

will determine the success of the Ro-Ro operations at Klang Port compared to all independent variables.

3.4.3 *Pearson Correlation Analysis*

Table 3.4 indicates the degree of correlation between two variables which are the dependent variable and independent variable. The cargo handling cost is the highest value compared to any other variable which is 0.500, and the data are close to 1. The consequences of this result demonstrate that there is a significant relationship between two variables.

Table 3.4 Pearson Correlation Analysis

	1	2	3	4	5	6	7	8
1	1.00	.500	.118	.281	.462	−.275	−.427	−.235
2	.500	1.00	.615	.000	−.255	.240	−.496	−.373
3	.118	.615	1.00	.000	−.191	.881	−.372	−.063
4	.280	.000	.000	1.00	.302	.000	−.592	.000
5	.462	−.255	−.191	.303	1.00	−.132	−.205	.565
6	−.276	.240	.881	.000	−.133	1.00	−.258	.257
7	−.425	−.496	−.372	−.591	−.204	−.258	1.00	−300
8	−.238	−.172	−.062	.000	.565	.258	−.300	1.00

Legend:
1: Successful Ro-Ro Operation
2: Cargo handling cost
3: Port efficiency
4: Types of ship
5: Payload factor
6: Ro-Ro service Promotion
7: Speed of vessel
8: Service Quality

Obviously, this is a positive correlation. Since the value is positive, it can be concluded that an appropriate cargo handling cost management plays an important role in influencing the successful Ro-Ro operations and also contributes to the efficiency of the vessel as scheduled.

Besides that, based on Table 3.4, there is a negative correlation when the result of Pearson's generated a negative Pearson's r value; for example, as one variable increases a value, the second variable decreases the value. For instance, the speed of the vessel value is -0.425, and it can be concluded that the speed of the vessel is not directly affecting the whole Ro-Ro operations as compared to another variable.

3.5 Discussion

Obviously, there is a distinction concerning the earliest round survey and the following round survey. It can be observed that additional variables are added to the existing variables based on the present judgment by similar expert respondents. This Delphi technique plays the momentous role to achieve the best decision making and the strategies for the future industry player.

Based on objective 1, it could be observed that there are several key factors that contribute to the successful Ro-Ro operation that is delivered at the Klang port, Malaysia. The seven experts that furnished the great contribution for both rounds of survey at Klang port typically agreed and believed that the cargo handling cost, port efficiency, types of ship, payload factor, Ro-Ro service promotion, speed of vessel and service quality are under the commercial factors that play an important role in achieving the successful Ro-Ro operations at Klang port.

Moreover, the findings also revealed that most of the expert respondents prefer to utilize Ro-Ro as a transportation mode for vehicles because of the advantages of the Ro-Ro operations.

Based on objective 2, it could be observed that the seven experts that delivered the great contribution for both rounds of survey at the Klang port typically agreed and believed that there is a significant relationship between cargo handling cost and payload factor toward the successful Ro-Ro operations at Klang port, Malaysia.

Additionally, the successful Ro-Ro operations also can be achieved since the infrastructure that is provided by the Port Klang Authority is safe for the cargo handling purpose. It is because the Port Klang Authority takes a safety precaution toward infrastructure and facilities at the Ro-Ro terminal by ensuring all the standard operating procedures (SOP) are strictly followed by all crew. More importantly, the SOP of the Port Klang Authority is competent in achieving the customer needs and requirements, while being able to ensure the safety and security of cargo and crew onboard.

3.6 Conclusion

In conclusion, in order to maintain the successful Ro-Ro operations at Port Klang, there are several factors that need to be taken into account such as delivering an adequate cargo handling financial management and delivering the best service quality to improve the port efficiency. Ultimately, most of the expert respondents agreed the statements of "a good cargo handling practices" are necessary to ensure the sustainability of Ro-Ro operations".

Last but not least, further research is a necessity to explore from the other perspective rather than experts' judgment. For instance, customer perspectives and opinions also play the important role to measure the quality of Ro-Ro operations services towards the successful for Ro-Ro operations [8]. This is because customers and passengers are the reasons why efficiency and smoothness of the Ro-Ro operations are essential [8].

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Chapter 4
Hybrid Composite Fiberglass Structure with Embedded Aluminum Phosphate New Fire Retardants Additive: Effect of Fiberglass Types

Asmalina Mohamed Saat, Syarmela Alaauldin, Asmawi Malik, Md Salim Kamil, and Abdul Latiff Mohd Zaini

Abstract Composite fiberglass is a common material used in marine industry to fabricate marine sport equipment, boats, yachts and others. The material is expected to have a performance such as high strength, economic and safety especially related to fire incidents. However, in composite fiberglass, the resin in the system has high flammability properties and becomes the acceleration factor of fire propagation after ignition. The current system is a combination of ATH and APP and produces optimum fire-retardant performance. The mixture with a fire-retardant additive leads to an extra procedure and risk to the mechanical properties of the structure. Thus, this study is conducted to evaluate the mechanical and fire retardants performance of various hybrid multilayer fiberglass composites embedded with aluminum phosphate (0 wt%, 5 wt%, 10 wt%), a new fire-retardant additive. The highest mechanical strength was observed in samples with in all samples with 5wt% of aluminum phosphate additive. A combination layer of CSM, WR and CSM shows the optimum result for mechanical strength and fire-retardant properties.

Keywords Composite fiberglass · ATH · APP · $AlPO_4$ · Fire-retardant coating

A. M. Saat · S. Alaauldin (✉) · A. Malik · M. S. Kamil · A. L. M. Zaini
Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: syarmela@unikl.edu.my

A. M. Saat
e-mail: asmalina@unikl.edu.my

A. Malik
e-mail: asmawiam@unikl.edu.my

M. S. Kamil
e-mail: mdsalim@unikl.edu.my

A. L. M. Zaini
e-mail: latif.zaini92@gmail.com

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4.1 Introduction

Composite fiberglass is widely used in fabrication of boats, aircrafts, civil construction and other industries. Composite fiberglass materials are in high demand due to their lightweight performance, ease of manufacturing, corrosion resistance, less maintenance and low costs. However, the usage of composites in marine industries is still lack behind due to limited knowledge about reliable analysis on explosion, collision, impact and fire behavior [1]. A resin in a mixture of composite fiberglass gives high flammability properties in the system which lead researcher to evaluate various resin performances in marine structures [2]. Resin filled with alumina trihydrate (ATH) additive were introduced to composite fiberglass in order to replace halogenate type fire-retardant additives. ATH reduce production of toxic gas and it generates less smoke due to burning, however it needs a high percentage in resin in order to be an efficient fire-retardant additive. Thus, a combination of ATH and APP (ammonium polyphosphate) was introduced to reduce the ATH ratio and to increase the fire-retardant performance without risking mechanical performance of the structure and to meet the toxicity requirement. Both aluminum and phosphate elements in ATH and APP are important in the fire-retardant process. Layered aluminum phosphate has been reported to have flame retardant properties in polymer composites [3]. Aluminum phosphate was also reported to have a good interaction in unsaturated polyester and composite fiberglass by structural analysis with the bond of Al and phosphate in both polyester and composite fiberglass [4]. The thermal analysis of unsaturated composite fiberglass in seven design layers also reported an increase in char layer with an increase in the aluminum phosphate ratio, thus increasing the flame retardancy [5]. The mechanical properties in a seven-layer composite fiberglass were reported to have an increase in tensile and flexural strength at a ratio of 5wt% of aluminum phosphate [6].

The mechanical properties, such as tensile and flexural strength, of composite fiberglass with polyester matrix, vary with the type of reinforcement material, design layer and fabrication method. Hand lay-up is a simple and easy method to fabricate composite fiberglass and focused in this research. A number of researchers reported on the tensile and flexural strength of various layers of composite fiberglass such as three layers [7, 8], four layers [9], five layers [10], and seven layers [6] and ten layers [11]. The Brinell method is one of popular methods conducted to measure hardness of composite fiberglass. Elahi et al. 20 used 305.92 kg(f) with a 5 mm steel ball indenter on 4 layers of composite fiberglass and recorded 37 BHN [12]. Meanwhile Chavan et al. [7] recorded 76 BHN by using a 1.6 mm steel ball indenter with 100 kg(f) load. Additionally, Hasan et al. [10] recorded 39.9 HVN in 5 layers of E glass. A summary of mechanical properties for composite fiberglass is presented in Table 4.1. Meanwhile the fire-retardant performance of composite fiberglass still lacks behind [1]. Recently, the fire-retardant performance of seven layers composite fiberglass reported a reduced fire propagation at early stage [6]. However, analysis of mechanical properties and fire performance related to types of fiberglass such as chopped strand mat (CSM), woven roving (WR) and combination are still unknown.

Table 4.1 Summary of various layer composite fiberglass fabricated by hand lay-up method

Layer	Method	Finding
10 layers	• Flexural (ASTM D790) • Tensile (ASTM D638) • Impact (ASTM D256) • Hand lay-up • Epoxy matrix, MEKP 2%	• E glass specimen flexural (359.14 N/mm^2) [11] • Flexural modulus (254.28 N/mm$^{2)}$ [11] • Tensile (280.25 N/mm^2) [11] • Tensile modulus (5136.27 N/mm^2) [11] • Impact (11.4 J) [11]
7 layers	• Tensile (ASTM D3039) crosshead speed (10 mm/min.) • Flexural (ASTM D790). crosshead speed (1.2 mm/min) • Impact (ASTM D256) • Hand lay-up • Polyester matrix, aluminum phosphate additive	• The tensile strength (239.706 MPa) [6] • Tensile strain (0.0530) [6] • Flexural strength (316.33 N/mm^2) [6] • Flexural strain (7.89%) [6] • Impact (0.3126 J/mm^2) [6] • Additive 5wt% produced optimum mechanical strength [6]
5 layers	• Flexural (ASTM D790) • Tensile (ASTM D638) • Vickers hardness test (245.2mN, HV0.025) • Polyester matrix, E Fiberglas	• Flexural strength (176.8 MPa) [10] • Tensile (106.8 MPa) [10] • Hardness (39.9 HV) [10]
4 layers	• Tensile (ASTM D 638). Crosshead speed (10 mm/min.) • Brinell (305.92 kg(f), steel ball, 5 mm) • Hand lay-up, cold compression • Polyester matrix, E fiberglass, heat treatment	• Tensile strength (135 -200 MPa) [9] • Tensile modulus (1400-2400 MPa) [9] • Impact (140–155 kJ/m^2) [12] • Hardness (37–54 BHN) [12]
3 layers	• Hand lay-up process • Impact (ASTM E23) • Brinell (100 kg, steel ball 1.6 mm) • Hematite additive	• Impact 90° orientation (2.10 J/mm$^{2)}$ [7] • Hardness 90° orientation (76 BHN) [7] • 6 wt% additive produced optimum mechanical strength [7]
3 layer	• Hand lay-up process • MEKP 10% • Flexural (ASTM D790) • Polyester matrix, fiberglass (chopped, 0/90° fiber mat)	• Flexural 3 layers random orientation (158 MPa), Young Modulus (85.103 MPa) [8] • Flexural 3 layers 90° orientation (165 MPa), Young Modulus (61.085 MPa) [8] • Flexural (random/90°/random) orientation (195 MPa), Young Modulus (107.59 MPa) [8]

Thus, this research is focused to explore on the effect different types of fiberglass and ratios of aluminum phosphate on the performance of mechanical and fire retardants properties of a new hybrid composite fiberglass embedded with aluminum phosphate.

Table 4.2 Design layer of hybrid fiberglass composite embedded with aluminum phosphate

Samples		Panel								
		1	2	3	4	5	6	7	8	9
Layer	1	CSM 450	WR 600	CSM 450	CSM 450	WR 600	CSM 450	CSM 450	WR 600	CSM 450
	2	CSM 450	WR 600	WR 600	CSM 450	WR 600	WR 600	CSM 450	WR 600	WR 600
	3	CSM 450	WR 600	CSM 450	CSM 450	WR 600	CSM 450	CSM 450	WR 600	CSM 450
Resin + $AlPO_4$		675 g + 0%	900 g + 0%	750 g + 0%	675 g + 5%	900 g + 5%	750 g + 5%	675 g + 10%	900 g + 10%	750 g + 10%

4.2 Methodology

The project prepared 9 composite panels consisting of a combination of a chopped strand mat 450 (CSM) and a woven roving 600 (WR) type fiberglass. Mixtures of aluminum phosphate with ratios of 0 wt%, 5 wt% and 10 wt% were added in the composite systems as reported earlier [6]. A summary of the design layers is presented in Table 4.2. The panels were then characterized in regard to their mechanical properties such as tensile (ASTM D3039) and flexural (ASTM D790) by using an Instron 1195 universal testing machine at a strain rate of 10 mm/min, and 1.2 mm/min, respectively. Charpy impact testing with a V notched shape was conducted using a Charpy Izod Tester 300 J (LS-220060300 J). The hardness was tested using an Affri universal hardness tester MRS 250 by applying the Brinell method with a 2.5 mm diameter steel ball indenter. A load of 1839 N was applied at five various indentations places for 30 s. Average indentations are used to calculated the hardness using the Brinell formula as reported in Chavan et al. [7]. A vertical burning test was conducted by applying a blue flame at the bottom of the specimen at 20 m distance for 10, 20 and 30 seconds. Cotton pieces were placed at the bottom of the samples to record any burning drop that may ignite fire on it. The length of the fire burning propagation was recorded.

4.3 Results and Discussion

Figure 4.1a and b shows an image of a tensile and a flexural specimen after testing of the hybrid composite fiberglass samples A (3 layers CSM), B (3 layers WR) and C (CSM, WR, CSM) with various percentage of aluminum phosphate (0, 5, 10% wt%). All specimens break at the middle of the specimen due to good interaction between the fiberglass layer and the modified resin. The specimen with the CSM fiberglass layer shows a slight shift near to the grip as observed in specimen A (3

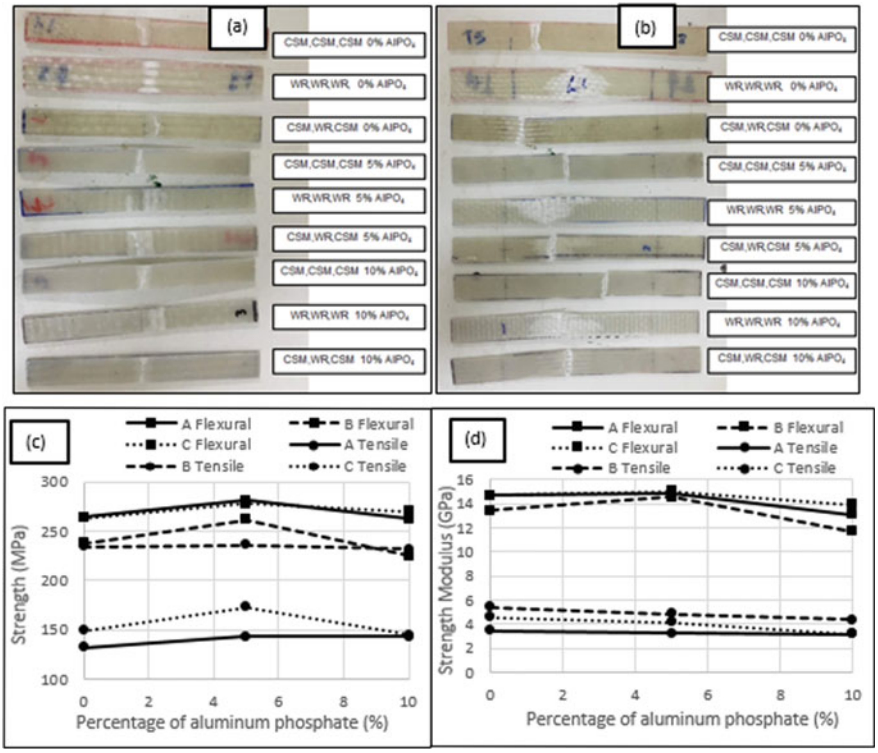

Fig. 4.1 Hybrid composite fiberglass samples A (3-layer CSM), B (3-layer WR) and C (CSM, WR, CSM) with various percentage of aluminum phosphate (0, 5, 10wt%) (**a**) Image of Tensile specimen after testing; (**b**) Image of Flexural specimen after testing; (**c**) Tensile and Flexural strength; (**d**) Tensile and Flexural Modulus

layers CSM) with 0 wt% aluminum phosphate and specimen C (CSM, WR, CSM) with 0 wt% of aluminum phosphate. WR shows a good interaction with the modified polyester in all samples. Figure 4.1c shows the tensile and flexural strength, meanwhile Fig. 4.1d shows the tensile and flexural modulus for all samples. Samples with 5 wt% of aluminum phosphate produce the highest strength value in both tensile and flexural testing. Both flexural strength and modulus observed higher values compared to tensile strength and modulus in all design layers. Flexural strength recorded its highest values in samples A and C with 281.15 MPa and 278.15 MPa, respectively. Samples B recorded the lowest flexural strength with 261.52 MPa. The highest value of the flexural modulus was in C with 15.02 GPa, followed by samples A and B with 14.83 and 14.56 GPa, respectively. The observed flexural modulus gives higher values than the tensile modulus in all samples. The flexural modulus reveals a similar trend as the flexural strength with the highest values recorded in samples with 5 wt% of aluminum phosphate. The observed tensile modulus for samples with 0 wt% of aluminum phosphate produces the highest values in all samples. The tensile modulus of samples B recorded the highest values of tensile strength followed by samples C and A with values of 5.38 MPa, 4.56 MPa and 3.48 MPa, respectively. The tensile strength shows the highest values in sample B followed by samples C and A with values of 236.62 MPa, 173.27 MPa and 143.11 MPa, respectively. The tensile modulus also decreased as the aluminum phosphate ratio increased. Tensile testing with a combination of three layers WR produced the highest strength and modulus due to its continues reinforcement phases. In flexural testing, samples C with three layers of CSM and WR produced higher values compared to other design layer. The recorded flexural data is higher compared to the tensile data, thus the design layers are more suitable to applications related to flexural strength. The tensile and flexural strain observed an increase in strain as the aluminum phosphate ratio increased. Addition of aluminum phosphate in the hybrid composite system produced high strain and a softer composite. However, at 5 wt% aluminum phosphate the mechanical properties are in accepting improved values. Table 4.3 summarizes the mechanical properties data for hybrid composite fiberglass embedded with aluminum phosphate.

Figure 4.2a and b shows images of impacted specimens after testing and values of impact and hardness testing, respectively. The specimen with 5 wt% of aluminum phosphate has the highest values in impact and hardness testing. Sample C with a combination of CSM, WR and CSM shows the highest impact strength for all percentages while sample A with three layers of CSM shows the lowest impact strength. The highest impact strength value is recorded for sample C (CSM, WR and CSM) with 5 wt% of $AlPO_4$ (711.36 kJ/m^2) and the lowest value in sample A (3 layers CSM) with 0 wt% of $AlPO_4$ (139.5454 kJ/m^2). Brinell hardness testing shows the highest hardness number in sample with 5 wt% of aluminum phosphate in all design configurations. However, sample A (187.35 BHN) observed the highest Brinell hardness value compared to samples B (170.51 BHN) and C (170.51 BHN). This finding supports the observation in impact testing that the design layer with 5 wt% produced the highest value of Brinell hardness. Samples with 0 wt% recorded to have the highest hardness followed by samples 10 wt% and 5 wt%. The sample with 5 wt% can be concluded to be softer due to the addition of aluminum phosphate which also support the increase in both tensile and flexural strain.

Samples with 5 wt% of aluminum phosphate produced the highest values of tensile strength, flexural strength, flexural modulus, Brinell hardness and impact strength, except for the tensile modulus. The highest values in samples with 5 wt% were due to good interaction between the fiberglass, resin and aluminum phosphate additive. Thus, this finding is almost similar to Chavan et al. [7], who observed an additive with hematite filler of 6 wt% produced the highest mechanical properties values compared to 0, 8 and 10 wt%. Samples C with three layers CSM and WR produced the optimum mechanical values for flexural strength, flexural modulus, hardness and impact. However, Samples B produced the highest values in both tensile strength and modulus. Meanwhile hardness data observed for samples A produced the highest BHN values. Samples C with a combination of CSM and WR produced better mechanical properties due to good interaction between the fiberglass, resin and aluminum phosphate additive compared to three layers CSM and three layers WR.

Table 4.3 Mechanical properties of hybrid fiberglass composite embedded with aluminum phosphate

Samples	Design layer	$AlPO_4$ percentage (%)	Tensile			Flexural			Impact	Hardness
			Stress (MPa)	Strain (mm/mm)	Modulus (GPa)	Stress (MPa)	Strain (mm/mm)	Modulus (GPa)	Strength (kJ/m^2)	BHN
A	3 layers CSM	0	132.49	0.0414	3.49	264.58	0.0180	14.67	139.55	155.71
		5	143.11	0.0436	3.28	281.44	0.0190	14.83	423.18	187.36
		10	142.85	0.0452	3.16	262.92	0.0201	13.09	280.45	170.51
B	3 layers WR	0	234.31	0.0435	5.38	238.13	0.0177	13.42	423.18	155.71
		5	236.62	0.0488	4.85	261.52	0.0180	14.57	566.82	170.51
		10	231.84	0.0530	4.38	225.29	0.0193	11.66	423.18	155.71
C	CSM,WR, CSM	0	148.89	0.0327	4.56	263.87	0.0180	14.66	566.82	155.71
		5	173.27	0.0419	4.14	278.15	0.0185	15.02	711.36	170.51
		10	144.97	0.0457	3.17	270.30	0.0194	13.91	566.82	155.71

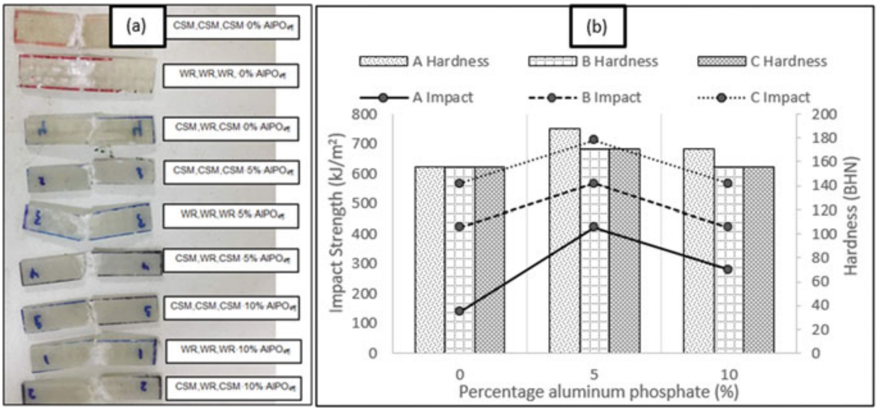

Fig. 4.2 Hybrid composite fiberglass samples A (3 layers CSM), B (3 layers WR) and C (CSM, WR, CSM) with various percentage of aluminum phosphate (0, 5, 10%) (**a**) Image of impact specimen after testing; (**b**) Impact and Brinell hardness testing

Figure 4.3a shows the image of the vertical burning after testing. Meanwhile Fig. 4.3b–d shows the vertical burning length at 10 s, 20 s and 30 s, respectively. All samples observed no self-ignition during the vertical burning process. The vertical testing at 10 s recorded for samples A have the shortest burning length followed by samples C and B in all aluminum phosphate ratios. However, at vertical burning of 20 s, samples C recorded the shortest burn length followed by samples B and A. Meanwhile at 30 s burning time, sample C remains as the shortest length and followed by B and A. Thus, it can be concluded for the first 10 s, the design layer with three layers of CSM can slow down the fire initiation progress. However, after 20 s, samples C with a combination of layers CSM and WR exhibit a better fire propagation compared to the other design layers. The highest burn length (56 mm) was recorded at 30 s in samples A with 0 wt% of aluminum phosphate. Meanwhile the shortest burn length (32 mm) was recorded in sample C with 10 wt% of aluminum phosphate. This finding proves that the burn length decreased as the amount of aluminum phosphate increased. Table 4.4 summarizes of the vertical burn lengths.

4.4 Conclusion

Samples of hybrid composite fiberglass embedded with aluminum phosphate were successfully fabricated and characterized. Analysis of mechanical and fire-retardant properties in relation to aluminum phosphate ratios and types of fiberglass reinforcement has led to the following conclusions:

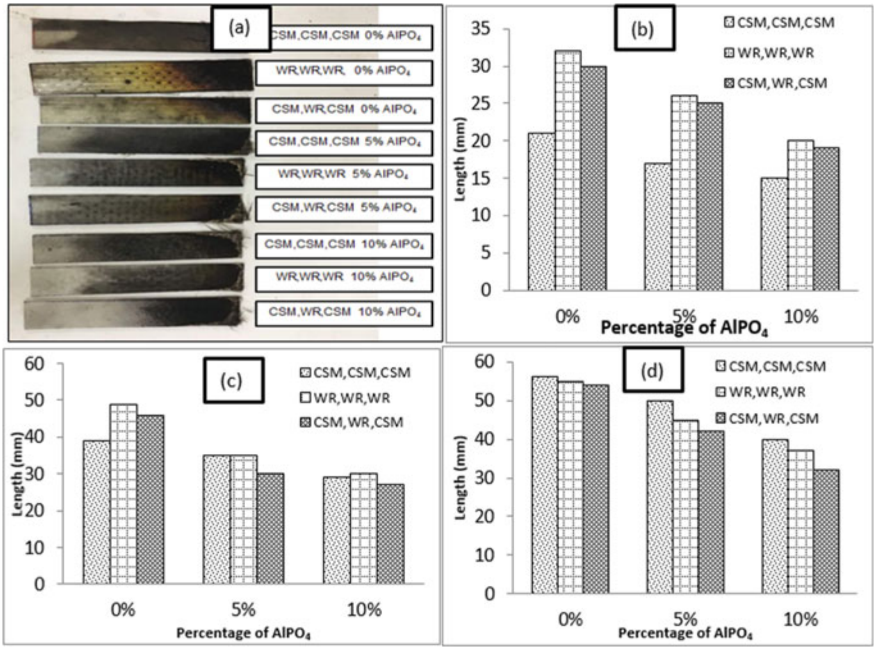

Fig. 4.3 Hybrid composite fiberglass with various percentage of aluminum phosphate (0, 5, 10%) in samples A (3-layer CSM), B (3-layer WR) and C (CSM, WR, CSM) (**a**) Image of vertical burning sample; Vertical burning at (**b**) 10 s, (b) 20 s and (**c**) 30 s vertical burning test

Table 4.4 Vertical burning

Sample type		3 layers CSM			3 layers WR			CSM, WR, CSM		
Aluminum phosphate ratio		0	5	10	0	5	10	0	5	10
t1 (10 s)	Self-extinguishing	No	No	No	No	No	No	No	No	No
	Burn length	21	17	15	32	26	20	30	25	19
t2 (20 s)	Burn length	29	35	29	49	35	30	46	30	27
t3 (30 s)	Burn length	56	50	40	55	45	37	54	42	32

1. Samples with 5 wt% of aluminum phosphate produced the highest values of tensile strength, flexural strength, flexural modulus, Brinell hardness and impact strength, except in tensile modulus.
2. Samples C with combinations of three layers CSM and WR produced the highest values mechanical data in flexural strength, flexural modulus and impact.
3. Samples C with a combination of CSM and WR produced the highest mechanical properties and fire retardant due to good interaction between the fiberglass, resin and aluminum phosphate additive compared to three layers CSM and three layers WR.

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Chapter 5
The Effective Elements in Responding on the Oil Spill Occurrences by Selected Marine Companies in Lumut, Perak

Ismila Che Ishak, Muhammad Khalil Aminudin Sulaiman, and Muhammad Kasffi Ramli

Abstract This study aims to study the effective elements in oil spill responses from the selected marine companies in Lumut, Perak. The scope of the companies covers oil and gas, import, export and logistics companies, and other sectors. This study has analysed the effective elements of the oil spill response. The effective elements that were identified *equipment, regular training and management practices*. A method of question survey has been conducted in this study by 32 sets of questionnaires received from respondents. The closed-ended questions comprised the respondent demographical background, the effective elements and response towards the oil spill incidents. The descriptive and frequency analysis, normality test, and multiple correlations were utilized for the data analysis. The outcome has indicated that the effective elements for the oil spill response are substantially correlated on the response in oil spill.

Keywords Oil spill response · Marine companies · Effective elements

5.1 Introduction

Oil pollution or oil spills are harmful as they affect many parties such as environment, human, marine life. Oil spills are an international or worldwide problem as they involve many countries as they are also influencing the human's health. The oil spills are detrimental to public health, imperial consumption water, destroyed environmental reserves and disconcerting the social and economy [16, 17]. Many causes

I. C. Ishak (✉) · M. K. A. Sulaiman · M. K. Ramli
Malaysian Institute Marine Engineering and Technology,
Universiti Kuala Lumpur, Lumut, Perak, Malaysia
e-mail: ismila@unikl.edu.my

M. K. A. Sulaiman
e-mail: khalilaminuddin1@gmail.com

M. K. Ramli
e-mail: mkasffi@unikl.edu.my

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Table 5.1 Definition of oil spill

[9]	Oil spills are the significant sources of hydrocarbons entering into the receiving aquatic environment
[21]	Some pollution of a natural habitat, which has devastating effects on species and inhibits the growth rate and development of plants or animals or interacts with human comfort, security, property values, and facilities
[26]	The release is caused by human activity that oppresses and explores liquid petroleum for daily use resulting in an oil spill disaster
[19]	Oil spill involves the release into the atmosphere of a liquid oil hydrocarbon, primarily from human activities, into the marine or coastal waters. Oil can consist of a variety of materials, including crude oil, petroleum products, and by-products, oil waste, or waste-mixed oil

contribute to marine pollution and affect the marine life as well as other parties involved. The oil spill affects the marine life, cause severe damage to ecosystems and loss to human society [7]. This study is focused on the oil spill response by the marine-related companies in Lumut, Perak. The objectives of this study were to identify the key effective elements towards accomplishment of the oil spill response by the selected marine companies.

5.2 Literature Review

5.2.1 Overview of Oil Spill

The oil spillage happens when there is any negligence due to human error or technical error [3]. Table 5.1 shows several definitions of oil spills from different authors. In common, the oil spill is known as any substance entering the seawater that could cause a pollution of the marine environment. These releases may cause harm and affect marine life, human life, society, economy and nation [4]. Human life is the priority in marine oil spill response [2].

5.2.2 Effects of the Oil Spill

Oil spills are caused by the release of liquid petroleum hydrocarbon in the ocean or natural environment because of the human fault from activities and they caused serious contamination which gives worrisome to a lot of groups who are influenced by these harms [25]. Besides that, the oil spills can have disastrous consequences for society; economically, environmentally, and socially. As a consequence, accidents involving oil spills have generated intense media coverage and political controversy, putting together a political struggle to tackle oil spills by the state and the best way to prevent it [4].

5.2.3 Effect to the Fisheries

It is crucial to managing seafood safety after the oil spill incidents [33]. Major oil spills can result in loss of fishing opportunities with boats unable or unwilling to fish due to the risk of fouling. Even though the oil spill influences the fishery reserves obviously at the population stage, here is a significant indication and causes at the organismic and sub-individual stages [13]. It is concerned with effects that might impact the fishery reserves in the extensive run [13]. Reactions of fish and shellfish populations examined relative to propagative tactics, allocation of nursery fields and crucial habitations, exploitation condition, oil spill dissemination and whole pollution concentrations [13]. Fish and shellfish inhabitants demonstrate a great volume to survive/recuperate from biological and anthropogenetic effects by getting benefits of constructive ecological circumstances and growing life antiquity approaches towards regular and interannual inconsistency [13]. Besides, the oil spill incidents also threaten the marine sanctuary [24, 29].

5.2.4 Effect on the Social and Economy

Authors of [27] provided taxonomies of procedures, effects, and weaknesses correlated with human aspects of oil spills. The oil spills moreover influence aboriginal communities and ethnic or rural enclaves that require the biological aligning for subsistence and social-cultural uses [25]. Many maritime industries such as harbour, sea-based, and businesses use seawater as inputs for production, although with financial implications, are also exposed to oil spills [19, 28]. The economic movement which correlate with the industrial and recreational fisheries could be diminished due to substantial influences on the biophysical atmosphere and human populations due to normal or man-made catastrophe occurrences [15]. Even though the quantity of oil spills around the world has a declining trend, risks caused by oil spills nevertheless persist as foremost worries for societies around the world. These anxieties evolve from the potential harms to ecology and economy, as well as by contemplating the unfavourable influences related to sociocultural and psycho-social aspects [5].

5.2.5 Preparation and Response Towards Oil Spill Incident

The preparation planning to prevent oil spill should create activities and execute opportunities for upgrading the procedures, especially in the coastal area. Several impressive research and development (R&D) activities could be done to counteract the oil spills incident, and tactical preparing has remained independently headed through industry and government. The response team ought to adhere to the directive or obligation along with the standard operation procedure (SOP). The particular obligations towards the state and community governments alongside private business appropriately response proposals and organizations remain consistent as well as synchronized with the national oil spill contingency system (NOSCS). The outline of the substantive rights and duties should be determined by the contracts, the operational procedures and decision-making practices [14].

5.3 Methodology

5.3.1 Questionnaire Survey Method

A closed-ended questionnaire survey technique was performed towards the scale of the study. There were 28 items covered in the questionnaire which covered 7 questions from each section. The questionnaire covered four sections as follows: Section A: Background of respondent, Section B: Background of company, Section C: Independent variables for equipment, training and management practices, and Section D: Dependent variable on the reaction on the oil spill incidents. The Section C magnitude was addressed through a Likert scale of 1–5. The Likert scale stipulates 1—strongly disagree, 2—disagree, 3—neutral, 4—agree, and 5—strongly agree. [20] remained established to evaluate opinions. The representative Likert scale is a 5- or 7-point ordinal scale applied via respondents towards to assess the level to reach an agreement or disagreement with a statement [30].

5.3.2 Population, Sample and Respondents

A total of 32 respondents provided their feedback by the questionnaire distribution. The total of 32 respondents were taken from the whole population as a sample in this study (Table 5.2).

Table 5.2 List of population, sample, and respondents

Parties	Population	Sample	Respondents
Marine Companies	32	32	32
Total	32	32	32

5.3.3 Analysis of Data

The data remained established from 32 respondents by utilizing the reliability analysis, normality test and the multiple correlation analysis from the Statistical Package for Social Science (SPSS), version 25.

5.3.4 The Background of Respondents

Table 5.3 shows the respondent's backgrounds from 32 respondents. Gender: Most of the gender was dominant male by 22 respondents which represents 68.8%, while for female were 10 respondents which contributes to 31.3%. The majority of employees are male since it is related to the maritime industry where men are dominant as compared to the female gender. Marital status: There were 3 respondents widowed which makes 9.4%, 24 respondents are married which contributes to 75%, and 5 respondents were single which makes 15.6%. There was a slight difference in the marital status of the respondent. Age: The age was divided into four categories. The highest number of respondents was in the category of 26–35 years old by 11 respondents at 34.4%. The second age category was at 18–25 years old by 9 respondents or

Table 5.3 The respondents' background

Background Respondents	Descriptions	Frequency	Percentage
Gender	**Male**	**22**	**68.8**
	Female	10	31.2
Marital Status	**Married**	**24**	**75.0**
	Widow	3	9.4
	Single	5	15.6
Age	18–25 years	9	28.1
	26–35 years	**11**	**34.4**
	36–45 years	8	25.0
	46 years above	4	12.5
Working experiences	Less than 1 year	7	21.9
	2–5 years	9	28.1
	6–10 years	**11**	**34.4**
	11 years and above	5	15.6
Types of company	**Oil and gas**	**20**	**62.5**
	Import, Export, and Logistics	2	6.3
	Others	10	31.3

Table 5.4 Summary of Cronbach's Alpha

Item	Scale means if an item deleted			Scale variance if item deleted	Corrected Item-Total Correlation	Cronbach's alpha if item deleted
28 items	117.65–118.19		83.96–89.71		0.175–0.633	
						0.864–0.939

Table 5.5 Cronbach's alpha interpretation

Cronbach's Alpha Value	Description
More than 0.9	Excellent
0.8	Good
0.7	Acceptable
0.6	Quotable
0.5	Poor
Less than 0.5	Unacceptable

at 28.1%. Age category of 36–45 years old was represented by 8 respondents or at 25% and followed by the last age category at 46 years old and above at 12.5% or by 4 respondents. Working experiences: The highest percentage was at 6–10 years by 34.4%. The second highest was at 2–5 years by 28.1%. Working less than 1 year was by 21.9% and for 11 years and above was by 5 respondents or 15.6%. Types of the sector: The most dominant sector was oil and gas which was 20 respondents or by 62.5%. This is due to the fact that the marine industry in Lumut is monopolized by the oil and gas industry. The second sector was others which contributes by 31.3%, and 6.3% represented by import, export, and logistics companies.

5.3.5 The Cronbach's Alpha

Table 5.4 shows that the Cronbach's alpha assortment is from 0.864 to 0.939. Once the amount is lower than 0.806 questions ought to be excluded from the questionnaire. The rate is larger than Cronbach's alpha, the questionnaire's reliability plus validity will rise as referred to Table 5.5.

5.3.6 Pilot Test

A pilot test has been conducted to check the validity of the questionnaire, the time to answer the questions, mutual comprehension, as well as interpretation of the questions. The meet-to-face questionnaire survey remained applied amongst 10 respondents because it offered a chance to evaluate the questionnaire. The total respondent

Table 5.6 Descriptive statistics

Gender	Pilot Test
Male	6
Female	4
Total	10

Table 5.7 Summary of Reliability Statistic

Cronbach's Alpha	N of Items
.806	28

Table 5.8 Summary of the normality test

Kolmogorov-Smirnov[a]		
Statistic	Df.	Sig.
.251–.419	32	.000

for the pilot test of 10 subjects which comprised 4 females and 6 males is shown in Table 5.6. Most respondents remained male and it is a mutual ailment on maritime industry professionals who have been conquered by the male group. The participants were easy to deal with as amongst the maritime industry located in Lumut, Perak.

5.3.7 The Reliability Test and the Cronbach's Alpha

28 elements of the questionnaires have been examined and it indicated a Cronbach's alpha in the range from 0.864 to 0.939. The Cronbach's alpha value was 0.806. This Cronbach's coefficient alpha displayed an internal uniform reliability of the study questions that reliability coefficient is closer to 1.0. as shown in Tables 5.7 and 5.8.

5.3.8 Normality Test

A normality test was applied to determine whether the sample data has been drawn from a normally distributed population by conducted the normality test using the Kolmogorov-Smirnov test (KS test). This method is applied for the testing of the distribution with the specified mean and variance at 0.000 as shown in Table 5.6. It has indicated that the data qualifies for data normalization and it can be established that the sample normality does not differ from the population.

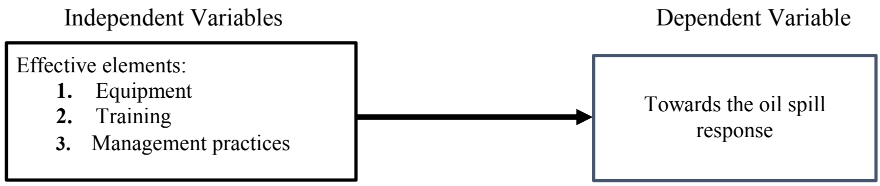

Fig. 5.1 Correlation theoretical framework

5.3.9 The Correlation Theoretical Framework

Recommended correlation theoretical framework encompasses components of independent and dependent variables as displayed in Fig. 5.1. The independent variables consist of three success factors such as equipment, training, and management practices towards the oil spill response as the dependent variable. Correlation analysis is a method specifically utilized for analysing the connection amongst two quantitative and also continuous variables. The correlation analysis delivers an evaluation pertaining to the relationship amongst two measurement variables. Pearson's correlation coefficient (r) is a solid component of correlation amongst two variables.

5.3.10 The Rule of Thumb Guideline for Interpretation of Correlation Coefficient

Figure 5.2 represents the assortment of value for the correlation coefficient intensity towards establishing the connection concentration of the variables. Pearson's correlation coefficient entails together variables towards remaining the control at an intermission or ratio range and the computation is established on the significant value [23]. The correlation value which is closer to the value of 1.0 has a solid substantial connection amongst the variables. Moreover, the connection value that is near to 0 or −1 has a correlation amongst the variables, although a destructive correlation coefficient substantially fragile on the correlation amongst variables [23].

Fig. 5.2 Correlation Coefficient Guideline: (Montgomery & Runger, 2014)

- $0.0 = |r|$: no correlation
- $0.0 < |r| < 0.2$: very weak correlation
- $0.2 \leq |r| < 0.4$: weak correlation
- $0.4 \leq |r| < 0.6$: moderately strong correlation
- $0.6 \leq |r| \leq 0.8$: strong correlation
- $0.8 \leq |r| < 1.0$: very strong correlation
- $1.0 = |r|$: perfect correlation

Table 5.9 The correlation between equipment and response

Correlation			
		Equipment	Response
Equipment	Pearson Correlation	1	**.893****
	Sig. (2-tailed)		.000
	N	32	32
Response	Pearson Correlation	**.893****	1
	Sig. (2-tailed)	.000	
	N	32	32

**. Correlation is significant at the 0.01 level (2-tailed).

5.3.11 The Analysis of the Correlation

The correlation evaluation was applied to obtain the level and direction of action and allows to investigate anticipated correlation amongst the two variables [27]. The correlation evaluation is also utilized to illustrate the intensity of the connection between two or more variables. The Pearson correlation coefficient (r) is a gauge for determining the intensity of the relationship amongst these two variables [8]. The assortment of the correlation coefficient (r) as shown in Table 5.5 has revealed that the value of $r = 0.80$ is acceptable of the internal consistency to reveal the constructive and resilient correlation amongst the variables. It was indicated that the closer the connection is to 1.0, the better the correlation amongst the two variables [6].

The Pearson correlation value between equipment and response is $r = 0.893$ as shown in Table 5.9 which specifies that the value of connection is a very strong constructive correlation and constructive. The trigger and appropriate reaction is the vital duration of the oil spill situation in which the utilization of equipment is essential [18]. The contribution of equipment is significant particularly in the view of the oil spill response that requires an entire reaction [18].

Table 5.10 shows that the training amongst the response team members and all employees including the practical exercises in the direction of the oil spill response is clearly correlated with 0.734. The association value is ranked as the second success factor during the oil spill response.

The value of the Pearson correlation coefficient between the management practices and response is $r = 0.647$ as shown in Table 5.9 which reveals that the value of correlation is strongly correlated [34] and [1]. The association value is ranked as the third successful factor in the oil spill response. The influence of management practices in relation to the oil spill response is substantial in fact the management practices are essential in the issue of the oil spill response [10–12].

Table 5.10 The correlation between training and response

Correlation			
		Regular training	Response
Regular training	Pearson Correlation	1	**.734****
	Sig. (2-tailed)		.000
	N	32	32
Response	Pearson Correlation	**.734****	1
	Sig. (2-tailed)	.000	
	N	32	32
**. Correlation is significant at the 0.01 level (2-tailed).			

5.4 Conclusion

The conclusions are established on the aims of the study which have remained effectively accomplished in this study. The results were established on 32 randomly designated maritime industry employees located in Lumut, Perak. The success factors of equipment, regular training, and management practices towards the reaction in the oil spill have been examined. The equipment towards oil spill response is extremely crucial according to the rank of the evaluation, followed by the regular training and the management practices. The relationship between each success factor is significant towards each other. Prevention is constantly healthier than treatment from the perspective of the oil spill. The release of the oil is constant and creates pollution in marine natural environment. The efficiency of the response is the vital component to the command of the future oil spill catastrophes which might generate more pollution to human life, marine life, society, and economy (Table 5.11).

Table 5.11 The correlation between management practices and response

Correlation			
		Management practices	Response
Management practices	Pearson Correlation	1	**.647****
	Sig. (2-tailed)		.000
	N	32	32
Response	Pearson Correlation	**.647****	1
	Sig. (2-tailed)	.000	
	N	32	32
**. Correlation is significant at the 0.01 level (2-tailed).			

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Chapter 6
A Study on Tool Directions of an Underwater Friction Stir Welded AA5083 Plate Butt Joint

Iliani Mohd Ikram, Azman Ismail, Ahmad Zakaria, Muhammad Fadhli Makhtar, Fauziah Ab Rahman, and Bakhtiar Ariff Baharudin

Abstract Underwater friction stir welding (UFSW) is a joining technique with an important role. This present study investigated the effects on the AA5083 plate butt joint configuration from various tool directions that were carried either as forward or as backward during the UFSW process. Experiments were conducted using different travel directions and welding parameters. Based on the results, the travel tool at forward with a tilt angle of 2° in a water temperature of 100° C gives an improved joining capability. This result showed that the tool direction will determine the quality of UFSW specimen.

Keywords Underwater friction stir welding · AA5083 plate · Butt joint · Tool directions

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I. M. Ikram
Bid Planning, Estimation and Proposal, Sapura Energy Berhad, Lumut, Malaysia
e-mail: Iliani.ikram@sapuraenergy.com

A. Ismail (✉) · F. A. Rahman · B. A. Baharudin
Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: azman@unikl.edu.my

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

A. Zakaria
Universiti Kuala Lumpur, Malaysia Italy Design Institute, Cheras, Malaysia
e-mail: dzakaria@unikl.edu.my

M. F. Makhtar
Marine and Offshore Department, TLT Power Sdn Bhd, Lumut, Malaysia
e-mail: fadhlimakhtar@tltpower.com

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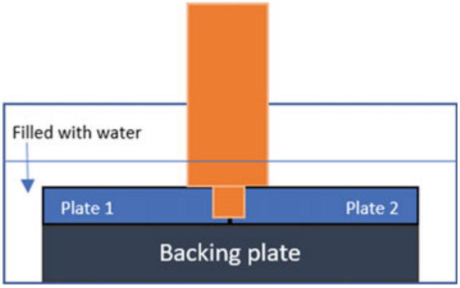

Fig. 6.1 UFSW setup

6.1 Introduction

Underwater friction stir welding (UFSW) is a state-of-the-art method for joining two plates without melting them underwater [1]. UFSW presents wide applications in various industries as it provides a good joining method that produces less defects and pollutions [2]. UFSW is a green and environmentally friendly process, creating less defects compared to traditional welding methods [3]. The frictional heat formed between the tool and plate will soften the adjacent edges and join the plates below the melting point [4].

For this research, a standard milling machine at which the tool rotates on the specimen was used to join two plates together [5]. The plates were fixed onto the customized fixture and properly clamped to hold the specimen tightly during the UFSW process [1]. UFSW's tool has two key roles during the UFSW process [6]; that is, it produces considerable frictional heat and stirs the specimen to form the joint of two metal parts together [7].

The UFSW is a joining technique performed underwater and below the melting point of the metals with less defects [8, 9]. This research paper aims to determine the effects of different travel directions of the tool on the weld quality of UFSW joining. The joint setup is shown in Fig. 6.1.

6.2 Experimental Procedure

Figure 6.2 displays the specimen setup for the UFSW process and the fixture employed on the Milko 37. A special tank was produced to submerge the specimen underwater for joining purposes. Milko 37, a standard milling unit, was used to perform the joining process on the AA5083 specimen in the underwater butt joint configuration [10]. A 4-mm-long cone-shape tool pin was used [11]. The specimen size was 356 mm (length) × 204 mm (width) x 5 mm (thick) based on the standard stated by the American National Standard Institute [12]. In this experiment setting, the tool made by H13 high carbon steel was utilized due to its ability to withstand

Fig. 6.2 UFSW plate setup on Milko 37

high force during the joining process [13]. Figure 6.3 shows the use of conventional milling machine as FSW machine.

The rotational speeds were set at 1600 RPM and 910 RPM, and the travel speed was set constant at 16 mm/min. The travel directions for the tool were set forward and reverse. The tool tilt angle was kept constant at 2°, and the plunge depth and dwelling time were set at 4 mm and 30s, respectively. The tilt angle of the tool was

Fig. 6.3 Milling machine and tool

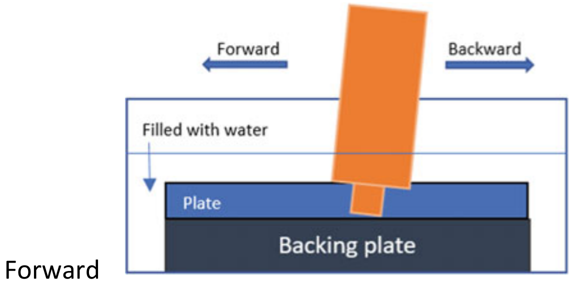

Fig. 6.4 Tilt angle and weld direction

Table 6.1 Welding parameters

Welding parameters			
Specimen	Rotational speed (RPM)	Travel speed (mm/min)	Travel direction
1	1600	16	Backward
2	1600	16	Forward
3	910	16	Backward
4	910	16	Forward

maintained at 2° as it produced a better strength compared to a lower tilt angle [14]. The welding direction and parameters used in this experiment setting are shown in Fig. 6.4 and Table 6.1, respectively.

6.3 Result and Discussion

Based on Figs. 6.5, 6.6, 6.7, and 6.8, the presentation of UFSW specimen No. 1 produced some lateral flashes and improperly joining. As the travel direction was pushed backward, the tilt angle failed to yield the desired plowing effect as it caused material removal. This tilt angle is vital to ensure that the tool provides the maximum impact and forges power on the joining plates [14, 15].

Fig. 6.5 Specimen No. 1—1600 RPM and 16 mm/min (backward)

Fig. 6.6 Specimen No. 2—1600 RPM and 16 mm/min (forward)

Fig. 6.7 Specimen No. 3—910 RPM and 16 mm/min (backward)

Fig. 6.8 Specimen No. 4—910 RPM and 16 mm/min (forward)

Although the experiment's specimen No. 2 uses the same parameter as the previous experiment environment, the direction of travel of the tools was modified in contrast. The tool has been moved forward [16]. Specimen No. 2 visibly shows a good surface and less lateral flash. In the meantime, the underwater plate joining has also shown a better joining capability.

A similar result as for specimen No. 1 was shown for specimen No. 3. Although the parameter used in specimen No. 3 was different, the surface appearance showed the same effect as the travel direction was pushed backward. The poor appearance of the joining and surface was observed in this condition. The travel direction affects the underwater friction stir welding joining capability and surface finishing. Specimen No. 4 showed a good surface appearance and better quality of plate joining by the UFSW process. The tool's direction was identical to specimen No. 2, which indicates improved joining and adequate welded joint capability.

6.4 Conclusion

From the observation, it can be concluded that the tool travel direction should be pushed forward of the specimen and this will provide sufficient plowing effect instead of pushing the tool backward.

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Chapter 7
The Challenges of the Oil Spill Preparedness and Responses

Ismila Che Ishak, Aminuddin Md Arof, Md Redzuan Zoolfakar, Ahmad Shahrul Nizam, and Nurain Jainal

Abstract Once an oil spill incident happens, it produces serious long-term effects on environmental, social, economics, marine ecosystems, coastal communities, and human life. Thus, this paper reviews the challenges on the oil spill incidents in Malaysia faced by main government agencies such as the Marine Department, Department of Environment, and a key player private organization named PIMMAG. The reviews are from related journal, articles, and other online references, respectively. It is vital to analyze the challenges in the oil spill management as Malaysia is facing oil spill cases. The findings disclosed that the main challenges are human mobility, miscommunication, insufficient equipment, and unknown sources of the oil spill incidents.

Keywords Oil spill preparedness · Challenges · Response

I. C. Ishak (✉) · A. M. Arof
Maritime Management Section, Universiti Kuala Lumpur Malaysian Institute Marine Engineering Technology, 32200 Lumut, Perak, Malaysia
e-mail: ismila@unikl.edu.my

A. M. Arof
e-mail: aminuddin@unikl.edu.my

M. R. Zoolfakar
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur Malaysian Institute Marine Engineering Technology, 32200 Lumut, Perak, Malaysia
e-mail: redzuan@unikl.edu.my

A. S. Nizam
Department of Management and Humanities, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak, Malaysia
e-mail: shahrul.nizam@utp.edu.my

N. Jainal
Student Development Section, Universiti Kuala Lumpur Malaysian Institute Marine Engineering Technology, 32200 Lumut, Perak, Malaysia
e-mail: nurain@unikl.edu.my

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7.1 Introduction

The risk of unwanted accidents at sea is comparatively related to a growing number of commercial and maritime activities [1]. The accident vulnerability is linked to safety, environment, human, and installation of vessels [1]. The maritime activities have been acknowledged as the contributors in fostering development and associating evolution, plus, affording humanity in a form of mobility whether for trade, transport, or fishing among others [2]. Over the last 20 years, the risk of a large-scale oil spill incident is cumulative [3]. The oil spill incidents have been the key interest of countries and viewed as the most serious form of marine pollution, causing severe impacts on wildlife and their habitats [4]. The practices commenced to collect and transport oil to content this demand which involves a certain amount of risk of accidental oil spills occurring [5]. The Ministry of Transport [6] reported that shipping operation delivers with it the risk of ship incidents and collisions which could lead to the oil spills.

7.2 Sources and Consequences of Oil Spill

Oil spills are caused by several sources such as accidental leaks from ships and offshore oil platforms and they often result in exorbitant economic costs and devastating marine ecological degradation [7]. Oil spill from the ships and tankers which contain the transportation fuel used by the vessels or cargos such as crude oil, fuel oil, or heating oil are the significant sources of hydrocarbon inputs into the oceans, lakes, and rivers [8]. Malaysia is emphasizing the obligation of pollution control in respect of coastal and marine waters as the need to meet water quality objectives. Malaysia is also dedicated to meet the requirements of the quality environment fixed by the Quality Environment Act 1974 from the Department of Environment [9]. Once the oil spill incident occurs, it has engendered a negative impact on the marine environment as well as the maritime community at large.

The consequences of oil spill incidents on the environment and society can be overwhelming. The suffocating and toxic effects of oil on flora and fauna could contribute acute costs such as effects on public health, local economy through loss of tourism and aquaculture, and historically or culturally significant sites [5]. Once the pollution has saturated the water, it could cause damage to marine life, caused marine life to die, interrupted human health, and disturbed the ecosystems either on the sea or land. [10]. This oil spill was predicted to pollute a much greater area than primarily projected due to aggressive weather sceneries [11]. Even though the oil spill is infrequent to arise, once it has happened, it could lead to a catastrophic phenomenon and impairment of sea, environment, people, offshore activities, fisheries, and crop an immoral image of the country.

7.3 Data for Oil Spill Incidents

The data on the oil spill incidents in Malaysian water is shown in Table 7.1. The information was obtained from the DOE and the Marine Department for the year 2012 to 2018 [12, 13]. In April 2019, the Marine Department statistically described the cases of oil spill incidents in Malaysia into two categories, which involved the release of fewer than 50 tons or the discharge of more than 50 tons of the oil spill [12]. There were three cases portrayed in 2016 and 2017, which involved the discharge of 50 tons or more. Meanwhile, there were 64 cases stated for the discharge of oil less than 50 tons which have been classified as tier 1 oil spill incidents [12]. The oil spill incidents triggered adverse impacts to the socio-economy, fishery, mangrove, mussel farm, flora and fauna [14–18] and high costs of clean-up operations [19]. It also contributes to the damages in ecological balance, precedes the destruction of nature and the organism instantaneously or in the long term [20].

On another account, data accumulated from the DOE from 2014 to 2017 reported that there were 73 oil spill incidents [13]. All the cases reported by the DOE have been proclaimed as tier 1 or tier 2. Table 7.1 shows the detailed breakdown of oil spill cases reported by the DOE. It can be broken down into 16 oil spill cases in 2014, 15 cases in 2015, 20 cases in 2016, and 22 cases in 2017.

The oil spill cases in Malaysia from 2014 to 2017 are shown in Table 7.2. Based on the distinct data from Tables 7.1 and 7.2, both tables show that the data were assembled inversely by these two main related government agencies toward the oil

Table 7.1 Oil spill cases in Malaysia waters from 2012 to 2018 [12]

Discharge of 50 tons or more		Discharges of less than 50 tons	
Year	No of cases	Year	No of cases
2018	0	2018	6
2017	2	2017	3
2016	1	2016	20
2015	0	2015	8
2014	0	2014	10
2013	0	2013	6
2012	0	2012	11
Total	3	Total	64

Table 7.2 Number of oil spill cases in Malaysian water from 2014 to 2017 [13]

Year	No of cases
2017	22
2016	20
2015	15
2014	16
Total	73

spill incidents. Once the oil spill incidents occurred, the DOE has reported having collaboration with several organizations such as the Malaysian Maritime Enforcement Agency [MEA], Port Operators, Marine Department, Malaysian Royal Navy, Royal Malaysian Police, port authorities, fisheries department and the jetty operators. Generally, these agencies are related to oil spill incidents and response because they operate along the waterfront in the marine environment. In the cases of any oil spill incidents for Malaysia, the DOE is elected as the Chairman to the National Oil Spill Contingency Plan [NOSCP] and States Operation Committee [SOC]. Meanwhile, the Marine Department is responsible for serving as a technical expert in controlling and combating the oil spill incidents at sea by using the equipment or stockpiles available in the country. DOE requires the Environmental Quality of Act [EQA] 1974 and Economic Exclusive Zone Act [EEZ] 1984, which includes multi environment-related fields from 0 to 12 nautical miles at sea and the EEZ Act 1984 from 12 to 200 nautical miles to effectively enforce laws on oil spill throughout Malaysian waters [12].

7.4 Challenges of Oil Spill Incidents

However, the core problems that challenged the DOE in the oil spill issue are the absence of manpower or staff to cover its enforcement, including the frequently changing appointments of a new office which has required an officer to expand the scope of work by increasing the productivity and deterring himself, involves in any illegal tasks [12]. As the MMEA establishment is to hold out all federal deeds in the water, therefore the DOE faces a logistic problem as the organization does not have any assets at sea and must collaborate with the MMEA for assistance in resolving the issue associated with the oil spill incidents. On top of that, based on the reports on oil spill incidents at sea, most of the cases are from unknown sources and caused by illegal activities of ships along the Straits of Malacca and Singapore. Also, the inadequate stockpile of oil spill equipment significantly contributes to a major problem faced by the DOE in the process of cleaning-up activities [13].

Besides, there is one major key industrial player response team from a private organization which is known as the Petroleum Industry of Malaysia Mutual Aid Group [PIMMAG]. The organization was formed in December 1993 and up to 1st of September 2018, it has 28 registered members from oil and gas companies in Malaysia. Unfortunately, the PIMMAG will respond to only registered members in the stipulated time frame between 24 h to act at tier 1 of the oil spill incidents after been appointed by the ship-owner, agent, or terminal [12, 21–23]. This research examines the problem of disparity in the collaboration between the DOE and the Marine Department toward the oil spill response. Ideally, once the oil spill has occurred, the response members from numerous disciplines are interdependent and working together. The ad hoc team is made accountable for the emergency response to solve the oil spill incidents immediately [21–23].

Table 7.3 Reported cases of joint effort toward oil spill incidents

Year	Cases by tier level	Total of cases	Total number of cases collaboration with other parties
2017	6 Tier 1, 5 Tier 2	22	18 DOE, 4 collaboration 4 Marine Department, 1 PIMMAG, 1 Port Operator, 4 MMEA, 1 Royal Malaysia Police, 2 Royal Navy Malaysia, 0 Fishery Department
2016	3 Tier 1, 3 Tier 2	20	14 DOE, 6 collaboration 3 Marine Department, 0 PIMMAG, 3 Port Operator, 4 MMEA, 1 Royal Malaysia Police, 0 Royal Navy Malaysia, 0 Fishery Department
2015	2 Tier 1, 2 Tier 2	15	12 DOE, 3 collaborations: 2 Marine Department, 0 PIMMAG, 2 Port Operator, 1 MMEA, 0 Royal Malaysia Police, 1 Royal Navy Malaysia, 0 Fishery Department
2014	5 Tier 1, 4 Tier 2	16	6 DOE, 10 collaborations: 2 Marine Department, 0 PIMMAG, 7 Port Operator, 0 MMEA, 0 Royal Malaysia Police, 1 Royal Navy Malaysia, 1 Fishery Department

PIMMAG responses for non-member depend on the mutual agreement and the amount of payment. The Marine Department will respond at tier 2 and tier 3 and depending on the incident situation [12]. The Marine Department will be at tier 1 of the oil spill incidents for monitoring. None of the oil spill incidents in Malaysia have been declared beyond tier 1. Only the DOE has the authority in declaring the tier level. Nevertheless, the PIMMAG has a good working rapport with DOE and Marine Department but has not cooperated with these government agencies on various initiatives regarding the oil spill responses which did not incorporate their registered members. The reported cases of joint effort toward oil spill incidents are shown in Table 7.3.

7.5 Collaboration Efforts

As of 73 of the oil spill cases, it showed that 50 cases were handled solely by the DOE [12, 13]. There were 23 cases have collaborated with other responsible parties such as the Marine Department, MMEA, port operator, Royal Malaysia Police, Royal Navy Malaysia, and Fishery Department [12, 13]. There was only one collaboration involving the PIMMAG in 2017 at Pasir Gudang Port, Johor as shown in Table 7.3.

7.6 Response Time

The Marine Department will respond within 24 h after the oil spill incidents have occurred for tier 1 and tier 2 in Peninsular Malaysia and within 48 h in Malaysia West including Sabah and Sarawak [12]. Malaysia does not refer to any benchmarking country as a standard in the issue of the oil spill response time [12].

7.7 Conclusion

The statistic shows that there are a smaller number of collaborations in responding to the oil spill incidents among the main agencies especially the Marine Department, DOE, and PIMMAG. The PIMMAG responses only to their 28 registered members regarding the oil spill cases. The main issues raised by the DOE and Marine Department during the collaborations are miscommunication while sharing information on the data and facts about the oil spill incidents, and lack of expertise in determining an effective cleaning method. Additionally, lack of logistic and stockpiles by the DOE that solely depended on the Marine Department, and the need to face the unexpected events such as wind change, strong current and adverse weather further contribute to the difficulties that may affect the cleaning activities after the oil spill incidents [12, 13]. All these problems are required to be addressed promptly when facing the oil spill incidents to ensure a successful combating the oil spill incidents in Malaysia.

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Chapter 8
Ship Crash Prevention Toward Oil Spill Incidents

Ismila Che Ishak, Shahlin Johan, Aminuddin Md Arof, and Md Redzuan Zoolfakar

Abstract The elements that contribute to the oil spill incidents can be separated into human factors, technical factors, and natural factors. The human factors consist of fatigue, unsafe behavior, illegal releasing the oil to the sea, poor emergency planning response, and human activities. Meanwhile, the technical factors covered ship collision, vessel condition, engine oil problem, pipeline leak, loading and unloading activity, oil digging, and shipwreck. Besides, the natural factors cover tidal-flow, ocean-stream, and wind speed-driven advection, mechanical stretching, turbulent dispersion, and bad ocean environment. There are several precautionary steps to avoid and lessen the proportion of oil spill incidents at sea. This research concentrates on recognizing the effective precaution steps in protecting the marine environment from oil spill pollution. It covered two important elements such as ship operations and ship design. The choice of the respondents involved staff from one port at various levels, senior experienced respondents from the marine academic institute, and selected residents. A 70 questionnaire survey has been performed to accumulate significant and precise figures. The data is analyzed by using SPSS from 53 respondents. The findings reveal that the ship operations are granted the most important element in the efficiency of the precaution step to avoid the ship from the crash with the residual value at 25.5. Meanwhile, the ship design is the second criterion of the important precaution steps in the reduction of ship collision with the residual value at 20.5.

I. C. Ishak (✉) · S. Johan · A. M. Arof
Maritime Management Section, Universiti Kuala Lumpur Malaysian Institute Marine Engineering Technology, 32200 Lumut, Perak, Malaysia
e-mail: ismila@unikl.edu.my

S. Johan
e-mail: shahlin.johan@yahoo.com.my

A. M. Arof
e-mail: aminuddin@unikl.edu.my

M. R. Zoolfakar
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur Malaysian Institute Marine Engineering Technology, 32200 Lumut, Perak, Malaysia
e-mail: redzuan@unikl.edu.my

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Keywords Oil spill · Port · Prevention · Ship crash · Ship collision

8.1 Introduction

The total length of the Malaysia coastline is about 4600 km [1]. Malaysian water comprises more than 500,000 square km [1]. Thus, it is inevitably visible to high risks especially with an increase in shipping activities [1]. The registered Malaysian ships and foreign-registered ships calling at Malaysian ports have been recorded as more than 75,000 in 2017 [1]. The heavy and developing shipping activities reveal to a potential accident risk which precedes to oil and chemical spills. It has produced a negative effect, harm to our marine environment, and create destruction in the Malaysian waters [1]. Malaysia requires to follow the rule set by the Environmental Quality Act [EQA] 1974, Section 47 [2] and the Exclusive Economic Zone [EEZ] Act 1984 [1]. When there is an oil spill incident occurring, every single oil spill shall be reported to the Director-General [DG] of the DOE [3]. The EEF geographical coverage in NOSCP [3] is shown in Fig. 8.1.

There are several types of pollution such as pollution of air, noise, water, soil, light, thermal, and radiation. This research aims at water pollution that entails the oil spill. Pollution creates damage and disturbs several groups for instance environment, human, marine life [4]. Pollution is known as a global or universal challenge as it comprises numerous nations and influences human health. Any oil ship emissions that signifies severe hazard to the marine environment caused marine pollution [5]. The environmental pollution includes human and maritime actions and triggers challenges for the environment and leads to health crisis [6]. Many causes contribute to marine pollution, affect marine life, and produce serious harm to ecosystems and defeat

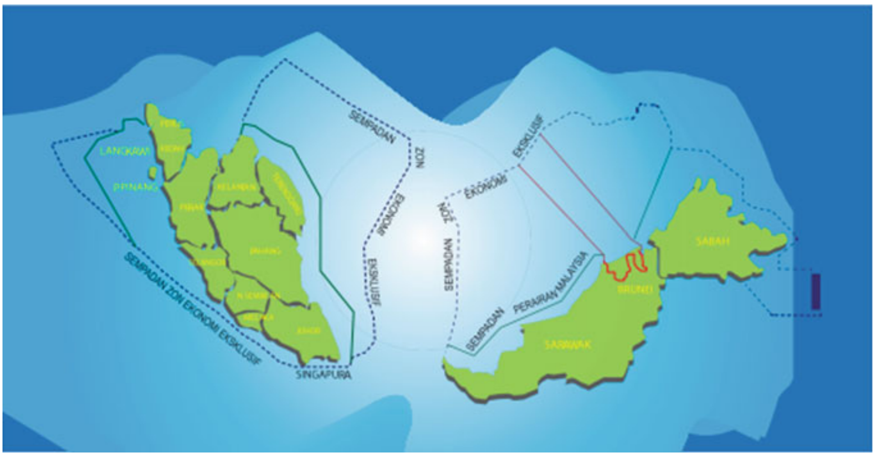

Fig. 8.1 The EEZ geographical coverage in NOSCP [DOE, 2014]

human society [7]. The oil spill occurred due to the negligence of human error or technical error [8].

8.2 Literature Review

A. Cases of Oil Spill Incidents at Johor

There are 73 oil spill cases that happened in Malaysia from 2014 to 2017 as shown in Table 8.1 [3]. Out of 73 cases mostly happened at Johor by 24 cases as shown in Table 8.2. Meanwhile, the causes were from several factors such as unknown sources, ship collision, releasing the oil to the sea, the problem of engine oil, pipeline leakage, loading and unloading activity, oil digging, shipwreck, and cutting activity of vessels. The oil spill incidents at Johor were declared for tier 1 and tier 2 levels. It has reported 6 cases that happened due to ship collision as shown in Table 8.3.

Oil spill incidents occurred at several places such as (a) Pelabuhan Tanjung Pelepas, (b) Kampong Tanjung Buai, Kota Tinggi, (c) Pengerang Terminal, Kota Tinggi, (d) Sungai Buntu, Pengerang, (e) Pengerang Kota Tinggi, (f) Jetty 4 ATT Tanjung Bin, (g) Horshburgh, Pulau Batu Putih, (h) Tanjung Piai, Pontian, (i) Bandar Penawar Kota Tinggi, (j) Perairan Tanjung Piai, (k) Terminal ATB, Sungai Pulai, (l) Pulau Tengah Mersing, (m) Pelabuhan Pasir Gudang, (n) Pulau Pemanggil, Mersing, (o) Rapid Pengerang, (p) Timur Laut Tompok Utara, Johor Timur, and (q) Parit Jawa, Muar [3].

B. Oil Spills Factors

The oil spill occurs either intentionally or accidentally and affects many areas and parties. Most of the cases of marine environments are made by humans either intentionally or unintentionally [9]. The existence of the oil spill happened due to

Table 8.1 The oil spill cases in Malaysia waters form 2014 to 2017 [3]

Year	2017	2016	2015	2014	Total
No of cases	16	15	20	22	73

Table 8.2 Summary of oil spill cases at Johor state form 2014 to 2017 [3]

Year	2014	2015	2016	2017	Total
No of cases	6	4	9	15	24

Table 8.3 The ship collision incidents for Malaysia from 2014 to 2017 [3]

Causes	2014	2015	2016	2017	Total
Ship collision	3	1	0	2	6

technical errors or human errors [10–12]. The technical error involves machinery or equipment, the fitness for service [FFS] of the fire-damage pressure vessel [13]. Meanwhile, the human error encompasses fatigue among crews, and ergonomic challenges from tons of work onboard and unsafe behavior [14]. It also could happen due to problems of vessel situation, ocean/coast environment, human errors, and emergency mechanisms [15]. The oil spill triggers detriment to several groups since the oil spill is able to circulate in a quick period due to added factor. There are several factors which affect the oil spill such as wind velocity, sea condition, current and tides, temperature, and atmospheric conditions [16]. Oil spill creates and it has threatened the side of the ocean and marine life. The spilled oil covers chemical ingredients that trigger destructiveness to life and human life. Several varieties of aquatic life are vulnerable when intermingling with spilled oil [17]. Once the oil pollutes the ocean, marine life could perish due to pollution. It also provides a long impact to the economy, human health, wildlife, marine ecosystem, marine animal, plant life, local industries, vegetation, and mangrove [10–12, 15, 18–20].

C. Ship Collision

A ship collision is the main type of marine accident [19]. Generally, the ship crash contains two substances either one a smacked vessel and a crashing object or two vessels crash to each other [21]. The crash is described as either one top-on or a side crash; the basic response varies significantly on comparative stance [21]. There are several factors related to shipping collisions. The factors are: (a) the property of crash: crash with a firm body, offshore platforms, or alternative vessels; (b) the power of the crash: speediness, dislocation, bow ship, draft, and comparative of the crashing vessels, (c) state of uncovered vessels: dislocation, draft, speediness, and comparative azimuth, (d) environmental circumstances: wind, waves, and current, and (e) volume of vessels construction in allowing the crash [21]. It is also known as the ship being surpassed by an additional vessel on a parallel track. The duration of the period for which a ship is subjected to risk and the possibility of a collision through a surpassing confront is also important. At sea in fog, ships frequently surpass severely close and this could lead to ship collision [21].

D. Skip Operation

Several factors lead to ship collision from ship operations. The specific effect weight shall be considered as the effect load instigated by an involuntary crash by the highest permitted service vessel in everyday business (9). Alternatively, the ship crash probability is due to (a) competency defects of the crew, (b) observation carelessness, (c) nonuse or improper use of the radar, (d) improper use due to dependency on VHF, (e) wrong judgment of the situation, (f) too few duty crew members to deal with the current situation, (g) ship occupies other ships' courses, (h) breaking local or international collision avoidance rules, (i) slow avoidance, (j) operation errors of the pilot, (k) sudden electric cutoff of rudder gear or the main engine, (l) abnormal off course environment or natural environment, and (m) chaotic traffic condition [22].

E. Ship Design

Ship design is known as a complicated effort involving the efficient direction of numerous subjects, of equally technical and non-technical description, and individual specialists disembark at significant design results [23]. The design of the ship or vessel is important [23]. The Oil Pollution Act 1990 [OPA 1990] and the International Convention on Prevention of Pollution from Ships [MARPOL] have included a hull configuration of oil tankers. OPA 1990 and MARPOL 1973/1978 discussed the double hull as essential in avoiding oil spills [24], highlighting the construction of a vessel with double hulls concerning the costs. The benefit of building double hulls includes a decrease in the oil spill. The drawback of building this double hull involves cost force for the construction and operation costs of double hulls. The need for building the double hulls have expanded even not all parties agree as it requires a supplementary cost in improving this double hulls design.

8.3 Methodology

A. Survey Method

This research involved the questionnaire dissemination method. The closed-ended questionnaires were circulated among respondents. A pilot test has been performed to verify the validity, reliability, and insight into the questions. The questionnaires contained four sections such as Section A: for detailed information of respondents which consists of general information such as gender, age, working experiences, and current position in the company. Meanwhile for Section B: covers on the two elements of the precaution steps in preventing ship collisions. A Likert scale of 1–5, which implies: 1—strongly disagree, 2—disagree, 3—neutral, 4—agree and 5—strongly agree, was used to express opinion among respondents to the desired questions [25]. The Likert scale questionnaire was established in 1932 [26] to evaluate viewpoints and the standard Likert scale is 5 or 7 points ordinal magnitude utilized by respondents to measure the extent to which they reach an agreement or argue with a report [27]. The questionnaire consists of 22 items, at which 11 items were used to measure the ship operations and 11 items to measure the ship design.

B. Population, Sample, and Respondents

The sample for this research contains 70 individuals, which covered staff at one port, former experienced staff in the oil spill, and nearby residents at the related port. The sample was derived utilizing descriptive research for the sample, which has to be between 10 and 20% from the total population [28]. 70 questionnaires were delivered, and 53 responses obtained. The total response rate was 75.71%. Meanwhile, 17 respondents or 24.29% of respondents were unsuccessful to return within the required questionnaire dissemination were not available during the distribution of the questionnaire. The breakdown is shown in Table 8.4 and the summary of the respondents is given in Table 8.6, respectively.

Table 8.4 Population, sample, and respondents

Parties	Population	Sample	Respondents
Port Authority	20	10	2
Port	20	10	2
The industrial-experienced staff of the marine working environment	10	10	10
Residents	40	40	39
Total	90	70	53

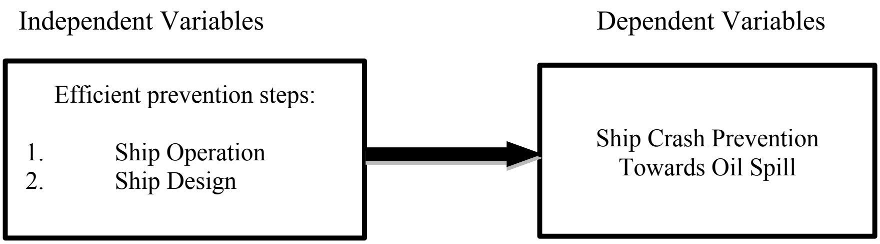

Fig. 8.2 Theoretical framework

C. The Theoretical Framework

The anticipated conceptual theoretical framework of the research which includes three effective precaution steps from the ship crash is illustrated in Fig. 8.2.

8.4 Data Analysis and Discussion

A. Reliability Test of the Pilot Test

A pilot test was organized among the industrial-experienced staff of the maritime institution in Lumut, Perak, and staff of the related Port Authority and Port company. Table 8.5 reveals the Cronbach's alpha of the pilot questionnaire for 19 elements at 0.636. The two questions that gave a Cronbach's alpha lower than 0.5 have been removed. The range of the Cronbach's alpha was from 0.500 to 0.636.

B. Respondents Demographic

The summary of the respondents demographic is shown in Table 8.6.

Table 8.5 Reliability statistics

Reliability statistics	
Cronbach's alpha value	No of elements
0.636	19

Table 8.6 Summary of the respondent demographic

Descriptions	Respondent	Percentage
(a) Gender:		
Male	36	67.9
Female	17	32.1
(b) Age (years old):		
18–25	23	43.4
26–35	11	20.8
36–45	13	24.5
Above 46	6	11.3
(c) Working Experiences (in the year):		
Less than 1	9	17.0
2–5	23	43.4
6–10	8	15.1
More than 11	13	24.5
(d) Current Positions:		
General Manager	3	5.7
Director	4	7.5
Manager	4	7.5
Supervisor	4	7.5
Technician	2	3.8
Clerk	2	3.8
Others	34	64.2

C. The Efficiency of Ship Operations

Table 8.7 shows that ship operations are an effective approach to avoid the ship from a crash that leads to oil pollution. The residual value for efficiency is at 25.5. It implies the leading value is the outcome where the ship operations are an effective protection step to avoid the ship to crash. The test statistics in Table 8.8 show the significant value which has 0.000 and is below the *P*-value.

Table 8.7 The efficiency of ship operations

Maintenance			
	Observed *N*	Expected *N*	Residual
Not efficient	1	26.5	-25.5
Efficient	52	26.5	25.5
Total	53		

Table 8.8 Test statistics for ship operation

Test statistics	
	Ship operations
χ^2	49.075[a]
df	1
Asymp. Sig.	0.000

[a]The significance value is applied to determine the relationship between the two variables of ship operation and ship design.

Table 8.9 The efficiency of ship design

Ship design			
	Observed *N*	Expected *N*	Residual
Not efficient	6	26.5	-20.5
Efficient	47	26.5	20.5
Total	53		

Table 8.10 Test statistics for ship design

Test statistics	
	Ship design
χ^2	31.717[a]
df	1
Asymp. Sig.	0.000

[a]The significance value is applied to determine the relationship between the two variables of ship operation and ship design

D. The Efficiency of Ship Design

Table 8.9 states that ship design is an effective approach to avoid the ship from the crash. The residual value for efficiency is at 20.5. It indicates the main value that the ship design is an effective protection measure to avoid the ship from the crash. Table 8.10 indicates the significant value at 0.000 and is below the P-value.

8.5 Conclusion

Between these two important elements in avoiding the ship from the crash, it shows that ship operations are the most important criteria to be focused. The ship operations such as changing courses in a combat condition are the extremely prominent variable, supported by variables for instance the officer of the watch action, condition evaluation, hazard discovery, individual situation, and exhaustion [29]. The smallest ship operations prominent variables include additional interruptions on the bridge,

bridge observation, maintenance schedules, and officer's exhaustion [29]. Nevertheless, the element of the ship design is the second element to be the focus after the ship operations in avoiding the ship from the crash which leads to the oil spill incidents. Thus, the objective of this research has been accomplished.

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Chapter 9
Analysis on Wave Generation and Hull: Modification for Fishing Vessels

Norfadhlina Khalid, Aqil Azraie Che Shamshudin, and Megat Khalid Puteri Zarina

Abstract This paper analyses the fishing vessel design in terms of wave generation and hull modification. The objective is to distinguish the fishing vessel designs between an existing hull and a modified one. This is then used for simulation via a CFD software to determine the better layout. The design is created in the Autodesk Inventor software based on the vessel particulars from the designated design. These designs are then transferred to the Flow3D software for the result. The configuration is done via a multi-block feature. Based on the literature, the deep V hull is proven to be more advantageous in rough conditions as it is more efficiently operational at a preferred velocity as opposed to the round bottom hull. The successful simulation outcome of this study is influenced by the different total number of mesh elements. The distinct sum of mesh elements impact on precision of the outcome, simulation outcome, mesh execution and resolution is achieved. Several suggestions are recommended on ways to run a CFD simulation successfully.

Keywords Hull · CFD simulation · Mesh element

9.1 Introduction

Primary and secondary waves surrounding a vessel characterise the wave system by a shifting vessel sailing on an unrestricted or restricted body of water. The central wave system constitutes the front wave, a lateral depression of water and a stern transverse

N. Khalid (✉) · A. A. C. Shamshudin
Maritime Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering, Technology Lumut, Perak, Malaysia
e-mail: norfadhlina@unikl.edu.my

A. A. C. Shamshudin
e-mail: aqilazraie77@gmail.com

M. K. Puteri Zarina
Student Development Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering, Technology Lumut, Perak, Malaysia
e-mail: puteri.zarina@fbk.upsi.edu.my

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wave while the secondary wave system principally constructs a wake track in which the ship sails with greatest intervention [1]. The boat type, the cruising pace, the vessel form and its geometry, the promulgated course, and its gap in relation to the restricted boundary create the wave altitudes and periods of intricately random vessels.

Several dimensions, i.e. the boat's draft, space to a slope, stretch and beam width, etc., shape the wind wave altitude and run-up-down flow rate. The success of empirical use of waterways has been shown in the literature with experimental equivalences for the discovery of suitable design factors being summarised by recent design guidelines. A travelling vessel is manoeuvred by a common external force, i.e. the wave. Vessels are put at risks with short wavelengths and precipitous waves. The complicated link between the wave energy and the changing aspects exacerbates the matter. Generally, small vessels can only handle small waves. A ship design can be improved via three alternatives, i.e. enhancement of the frame structure, acceptance of a standard design, modification of an existing model or development of a different one. The final two alternatives include enhancing the provisions for overt management, amending the front and stern structure and abridging the boat hull. However, the hull resistance will be compromised with reduced fuel use.

Despite the robust changes to the hull shape degree and propeller optimisation, the major sections of interest are still consolidated across shipyards. A hull form is created with a comprehensive system of model tests and computational fluid dynamics (CFDs) [2]. The hull form must be fully optimised. Shipyards normally prioritise the predetermined model draft and speed over the stabiliser draft efficiency with halfway load conditions being considered next to hull.

Damages to the hull are caused by the wave generation which affect the safety of fishing boats. Additionally, a hull may also be damaged by heavy weather making the hull short-lived. This happens when the wave creation from the hull is elevated creating microbubbles and air cavities. Fuel consumption may also be increased due to reduced friction which is not cost-effective to the fishermen. This research studies the model and evaluation of the fishing boat hull with the aim of producing the wave altitude focusing on the design and simulation on a 28-metre fishing vessel hull design.

9.2 Literature Review

A. Design Requirements

A fishing vessel is generally bigger than ordinary small fishing boats with more safety concerns at hand. The design of a vessel is determined by the resistance, seakeeping and stability appraisals. Moreover, the owner's needs are commonly a challenging feat to fulfil as the design is determined by various elements. It is therefore crucial for us to understand the link between a cluster of fishing boats and the links around them when designing boats for specific local fishermen population.

From the Fiber Optic Association (FOA) programmes between the 1970s and 1980s, it was found that there was no specific solitary assembly scheme of plan that was effective for the whole fishing systems in most nations when new models for fishing boats and new innovative moves were made for fishermen in developing countries.

B. Resistance Optimised Design

The resistance of floating entities on any water is affected by the hull parameters. When the necessary dimensions and sum constants have been determined, the resistance will depend heavily on the following vessel structure components:

- Circulation of displacement along the length, as represented by the curve of cross-sectional regions and the longitudinal centre point of buoyancy.
- Shape of the water plane, particularly in the fore body.
- Shape of the transverse regions, specially those close to the ends.
- Midship-section area coefficient.
- Type of stern; for e.g. raised counter, cruiser and transom.

Even though the effect of hull structure limits the established resistance, it is still challenging for creators to blend this in the early modelling process. One of the issues is the best parameter to choose in reducing the resistance. Changes in one parameter will affect others besides influencing the resistance rate. A need to provide a graphical sign to the model on ways to modify the initial design is thus compulsory.

C. Hull Forms

A vital facet in the fishing boat construct is the structure of the keel as it disturbs the permanence and navigability of the vessel. Good stability and navigability facilitate the ease in handling a boat. Hulls are commonly characterised by their shape. The three common hull dimensions are displacement, semi-displacement and planning. They are described as follows.

I. Displacement Hull

As it moves through the water, a displacement hull forces water through its bow and sides. The hull length stipulates the maximum speed of its displacement. As the structure forcedly moves on the sea, a bow-shaped wave is created. The hull will not move faster, albeit with extra power if the wave peaks harmonised with the trough generated at the stern. The stern squat improves when the hull is propelled tougher and the forward pace restricted. Compared to other hull forms, there is larger interior space in displacement hulls. This is because displacement hulls are fitted with comparatively small engines and low fuel utilisation. In addition, they are also balanced with solid operating economy.

II. Semi-Displacement

Semi-displacement hulls are a popular model as they are more common on big vessels with larger speed necessity. In comparison with the displacement hulls, semi-displacement hulls normally constitute neater bottoms, broader transoms and lighter displacement and are more powerful. The boat can ascend beyond the bow wave due to its flatter underbody. A semi-displacement hull is powered faster than a fully displacement hull by double the capacity with a suitable power capacity [3].

III. Planning

In order to create a hydro-dynamically lifted hull when moving with a flat bottom, planing hulls came into creation. Among the conditions to be considered in the creation of the planing hulls are the saturated exterior of the hull area and the stern squatting effect of the wave. It's reduced by the moving water shoving the flat surfaces out of the water.

D. Types of Hulls

The three common hull types for fishing vessels are the flat bottom hull, deep v hull and round bottom hull. The description of the three types of hulls is given below.

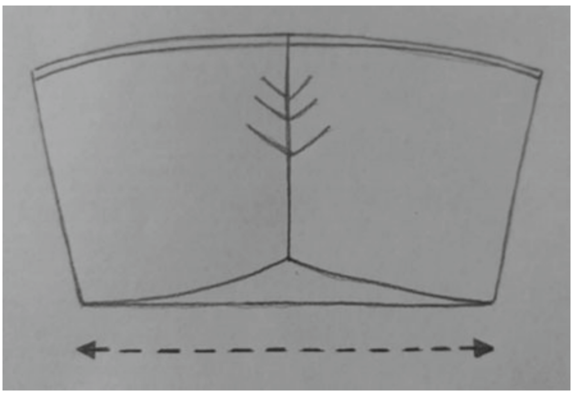
i. Flat Bottom Hull

A flat-bottomed boat is a vessel with a flat, two-chine hull which is popular in shallow areas, such as rivers. This is because there is less opportunity for it to embark on land. Its flat structure also makes it more stable in tranquil waters. As they do not perform well in uneven waters, especially at planning velocities, flat bottom boats are more commonly used in tranquil waters such as ponds, tiny lakes and streams. Amateur builders would find this hull type the most suitable as it is the simplest to construct with fewer tools and is less costly than more intricate-shaped hull designs. An example the sketch of flat bottom hull is shown in Fig. 9.1.

ii. Deep V Hull

Compared to the flat-bottomed or round hull boats, V hull is modelled to move at high speeds and slash through stormy waters, delivering a slicker ride. The V hulls are, however, not as efficient as flat or round bottom boats as they operate on larger engines for parallel speeds [4]. Many boats sold today have numerous V hull designs. However, its popularity can be attributed to their pleasant travelling and managing features, particularly on choppy waters.

Fig. 9.1 Flat bottom hull



The deep V-shaped hull is designed with a continuous surface from bow to stern with an edge down the centre portion. This layout forms the "V" shape when seen from the stern [5]. The angle between the surface of the hull at horizontal plane of twenty degrees or more is the boat's dead rise. Deep V hull boats normally create a large wake with a heavy spray. This type of boat also displaces much water at all velocities, which are aerodynamically and hydro-dynamically resistant but generally not economical. An example the sketch of a deep V hull is shown in Fig. 9.2.

iii. Round Bottom Hull

A displacement hull is also known as the round bottom hull. Vessels which are built with this hull structure can effortlessly sail through the water, particularly at leisurely velocities. However, it has the tendency to roll. This can be solved by building the vessel with a deep keel or stabilisers. Trawlers, canoes and sailboats are among vessels with round bottoms. Its velocity is limited due to the creation of the bow wave as the vessel moves on the water as compared to a planed hull that ascends beyond the water. Unlike the flat hull, a round bottom hull is more manageable. An example the sketch of a round bottom hull is shown in Fig. 9.3.

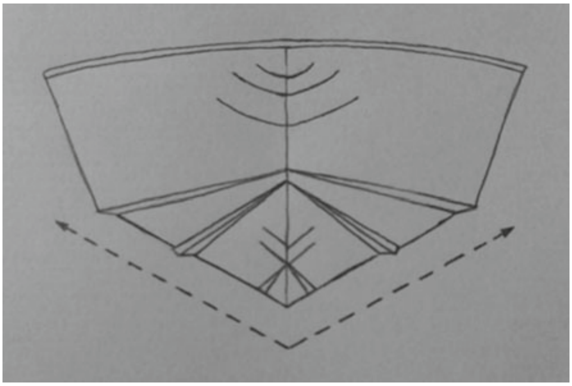


Fig. 9.2 Deep V hull

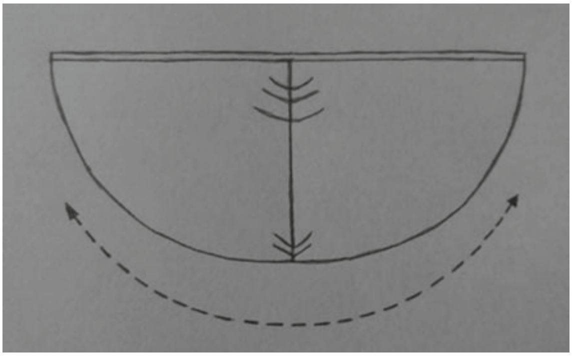


Fig. 9.3 Round bottom hull

E. Wave Generation

A wake for a boat is where water encloses or expands like a boat behind a shifting object. The wake creation relies on the layout and velocity of the craft. When energy is shifted from the velocity of the vessel to the wave passage across the water surface, the waves would move more evenly than the ship. The force of velocity on the wake was found to be negligible. Compared with the deep V-shaped hull, the flat bottom hull consistently generates greater waves. When a boat passes over the water surface, pressure differences are developed at the air-water interface and series of wave are then produced as well as friction on the water surface by the hull boat [6]. The large vessel tends to generate large drawdown and small wave height, while small vessel, such as pleasure craft generate small drawdown and large wave height [7].

Upon arrival on the bank, the highest scale of wake waves spawned by the three crafts in the testing oscillated between 6 and 133 mm. The wake created by the boat passage can be categorised according to a depth Froude number. The proportion of vessel velocity to the fullest wave speed in any water depth is the definition of this Froude figure.

Numerous aspects such as geometry of bowing, vessel draft procedure, naval distance and geometry of the boat determined the waves delivered by the craft traversing the water surface. Several dimensions of the craft (magnitude and velocity, structure, bank altitude), residue (type) and waves (altitude, time series, craft time, craft distance) stipulate the wake-induced wave sediment concentrations [8].

9.3 Methodology

The tasks in the process were carefully delivered to make the comparison between the deep V hull forms and round bottom and wave production.

A. Hull Form Generation

The hull design was created via the Autodesk Inventor 2020. In this research, the actual element was recorded near Pantai Remis Jetty, Perak. The facet was chosen from a fishing boat Type C. The parameters of the craft are as follows:

Length: 28 m

Beam: 6.6 m

Depth: 4.0 m

Figures 9.4, 9.5, 9.6, and 9.7 illustrate the detailed design of the deep V hull and round bottom hull from the perspective and body plan view, respectively.

B. CFD Simulation

Computational fluid dynamics (CFD) simulation is a computational programme that was used to perform a simulation for a design [2]. CFD was used to analyse and solve problems relating to fluid flow using numerical analysis and data structures.

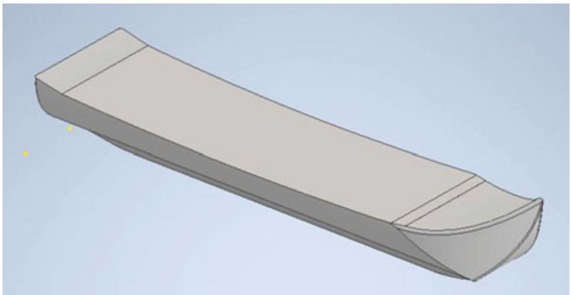


Fig. 9.4 Round bottom hull from perspective view

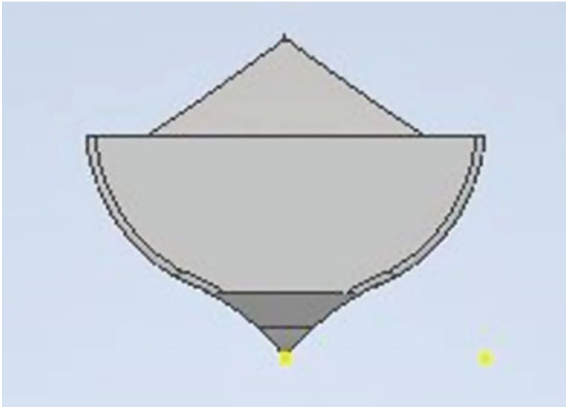


Fig. 9.5 Round bottom hull from body plan view

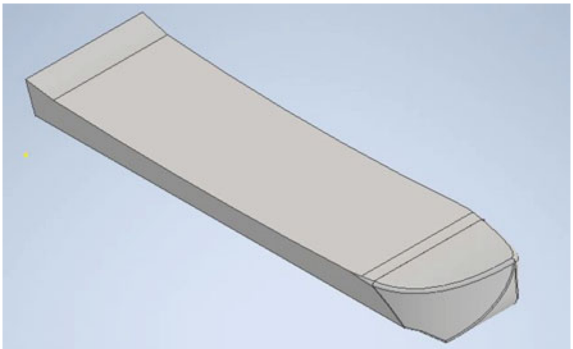


Fig. 9.6 Deep V hull from perspective view

An analysis was conducted to compare the ship's performance. The parameters of both ships were used as key details for the CFD simulation in the Flow3D software. The wave height condition during operation was predicted through this software. The process began with keying in all the details of the analysis.

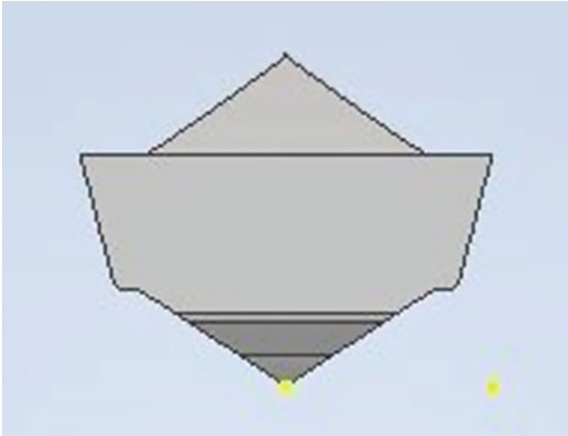


Fig. 9.7 Deep V hull from body plan view

The only variable in the simulation that was changed was the mesh element quantity and design types. Both denominators were changed to measure the wave altitude in those conditions. The central goal is to determine the optimal meshing number for the precise resolution of the simulation. The first step in the simulation process involved the conversion of the files for designs into the ".stl" file which was then imported to the Flow3D software. The multi-block feature was carefully chosen for the simulation. Both the ship particulars were then added precisely. The cell size was set to 0.2, 0.4, 0.6, 0.8 before analysing the resolution of the wave height.

9.4 Results and Discussion

The data was analysed using the design via the Autodesk Inventor showing the distinct results of the resolution between those mesh elements. The wave height was also acquired from the modelling process.

A. Grid Dependent Study

The grid dependent study is the crucial part to achieving the finest quantity of mesh elements for each hull and the element number determines the quality of the meshing. The mesh condition, on the other hand, ascertained the simulation time. The duration for the completion of the simulation relied on the quality of the mesh. Figure 9.8 shows the grid dependent study result for both hulls based on Table 9.1. The effect of mesh element number on the mean wave height is displayed in this illustration. The inconsistency in the results occurred in a range between 0.5 until 1.8 million mesh elements. This occurrence was due to poor mesh quality created by the small mesh element numbers. Consistency in the mean for the wave height analysis was achieved at 2 million mesh elements. The optimal mesh element quantity for both designs for simulation was 2 million.

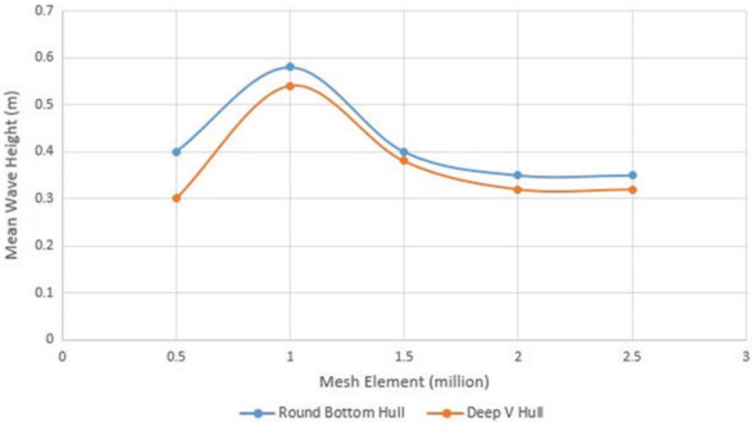


Fig. 9.8 The grid dependent study result for both hulls

Table 9.1 Grid dependent study for hulls

Mesh Element (million)	Mean Wave Height (m)	
	Deep Bottom Hull	Round V Hull
0.5	0.4	0.3
1	0.58	0.54
1.5	0.4	0.38
2	0.35	0.32
2.5	0.35	0.32

B. Wave Height Result

Table 9.2 shows the wave height as engendered from both hulls between 0 and 10 s. The result was documented at the second wave cycle between 5 s to 6 s. At 5.5 s, a high wave was generated by the round bottom hull at 0.58 m while the deep V hull showed 0.45 m of wave height at 6 s of simulation. So, it is proven that less wave height was generated by the deep V hull unlike the round bottom hull. The graph illustrates the 2 million mesh elements for time (s) vs wave height (m) of both designs. The wave height as shown in the graph was taken from probe number 3. The result was obtained from the 2 million of mesh element number of two distinct designs. The wave altitude was gauged at the second cycle at the ranges of 4 s and 6 s. The wave peak at cycle 3 was not readable as a result of a confrontation between wave rumination and creation which led to a wave cancellation (Fig. 9.9).

C. Resolution Results

Figures 9.10, 9.11, 9.12, and 9.13 display the different resolutions for the analysis. The mesh size determined the resolution and mesh element number. In this study, the quantity of mesh elements produced was ascertained by the mesh size. The results

Table 9.2 Hull generated wave height

Time (s)	Wave Height (m)	
	Round Bottom Hull	Deep V Hull
0	0	0
0.5	0.02	0.02
1	0.12	0.11
1.5	0.29	0.28
2	0.45	0.35
2.5	0.45	0.35
3	0.38	0.31
3.5	0.29	0.29
4	0.27	0.29
4.5	0.32	0.34
5	0.55	0.39
5.5	0.58	0.44
6	0.50	0.45
6.5	0.45	0.40
7	0.40	0.36
7.5	0.38	0.44
8	0.62	0.60
8.5	0.58	0.55
9	0.32	0.30
9.5	0.28	0.25
10	0.25	0.20

are separated into four resolutions of varying mesh sizes i.e. 0.2, 0.4, 0.6 and 0.8. Different total numbers of mesh element were found to have influenced the result as seen in the image on the different sizes of meshing. The duration of the result generation was dependent on the number of mesh elements.

From the observation, it was more difficult to obtain low result resolution because less mesh elements in simulation produced a rockier display. The distinct number of mesh elements also affected the result of accuracy, mesh performance, animation and resolution.

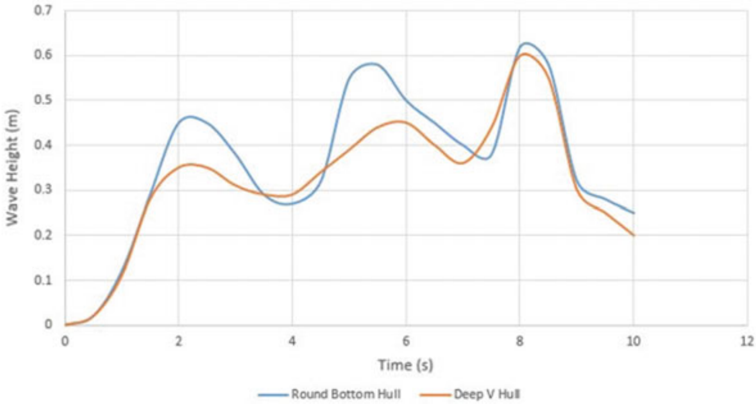


Fig. 9.9 Hull-generated wave altitude

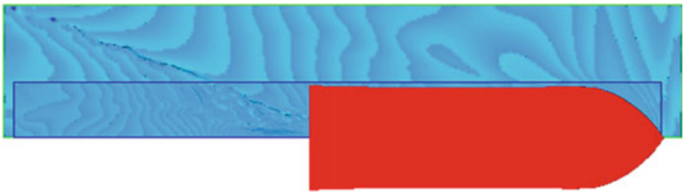


Fig. 9.10 Meshing of 0.2 size cell

Fig. 9.11 Meshing of 0.4 size cell

Fig. 9.12 Meshing of 0.6 size cell

Fig. 9.13 0.8 size cell meshing

9.5 Conclusion

The successful outcome of the simulation process is dependent on the mesh size which was used to run the replication process. The resolution and the precision of the result obtained are influenced by the varying sizes of meshing elements. The meshing element of 0.8 produces the lowest resolution and accuracy as opposed to other meshing elements with other measurements. Hence, the precision of the result depends largely on the quality of the meshing element. The result showed that the wave generation produced by the round bottom hull was higher compared to that by deep V hull which was 0.58 m and 0.45 m, respectively. Based on the result, clearly the deep V hull was better in minimising the height of the wave generation. Thus, the deep V hull is preferred to the round bottom hull.

9.6 Recommendations

Future research is recommended to increase the number of fine block meshing (total number of real cell) which would smoothen the wave configuration during the modelling process. Other properties such as pressure, loading and unloading, buoyancy forces and resistance of the vessel should also be considered. A better performing equipment (computer) which allows shorter time to complete the simulation should also be considered.

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Chapter 10
Technical Vocational Education Training Pathway for Post-secondary Autistic Students in Malaysia

Megat Khalid Puteri Zarina, Sairul Izwan Safie, Mohd Yuzri Mohd Yusop, Cordelia Mason, and Wardiah Mohd Dahalan

Abstract The Malaysian Ministry of Education aims for 75% of children with special needs to be enrolled in inclusive programmes by 2025 which are specially designed for autistic children aged 5–17. However, this rehabilitation programme is disadvantageous to a certain extent as it only caters for children below 18 years old with no clear post-secondary educational pathway for autistic learners between the ages of 18–25. The significantly growing number of children suffering from learning deficits such as those with autism spectrum disorder (ASD) is now globally researched with more importance being given to addressing this issue in countries around the world [1]. The number of children in special needs programmes has also increased greatly between 2006 and 2013 in Malaysia. Mentally challenged individuals are unique as they have skill sets that are valuable for their well-being and society at large. This awareness justifies their inclusive development movement and global efforts. Malaysia needs a clearer path for post-secondary technical vocational educational training (TVET) for autistic learners in Malaysia as an alternative to the purely

M. K. Puteri Zarina (✉)
Student Development Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: puteri.zarina@fbk.upsi.edu.my

S. I. Safie
Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology, Masai, Johor, Malaysia
e-mail: sairulizwan@unikl.edu.my

M. Y. M. Yusop
Maritime Engineering Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: myuzri@unikl.edu.my

C. Mason
Yayasan Universiti Kuala Lumpur, Jalan Sultan Ismail, Kuala Lumpur, Malaysia
e-mail: cordelia@unikl.edu.my

W. M. Dahalan
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: wardiah@unikl.edu.my

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academic-based education. This review of related literature in the TVET setting for the autistics will provide a deeper understanding of the needs of our autistic youths to ensure that they are not sidelined in their pursuit of higher education.

Keywords Autistics · Inclusive education · Post-secondary · TVET

10.1 Introduction

The significantly growing number of children suffering from learning deficits is now globally researched with more importance being given to addressing this issue in countries around the world [1]. The figure of children in special needs programmes has also increased greatly between 2006 and 2013 in Malaysia [2]. A deeper understanding of this issue is vital in order to address the far-reaching implications of this phenomenon on Malaysia's education system. Children or teenagers diagnosed with special needs are defined as "children or youth whose needs arise from disabilities or learning difficulties" [1]. A smaller-scale study by the Malaysian Health Ministry showed that 1.6 in 1000 18–26-month-old children, or approximately one in 62,512 has ASD. Our schools and society have recorded an increasingly common occurrence of autism spectrum disorders. The traditional model of alienating special needs children from mainstream education has shifted to what is currently known as "inclusive education" in the past decades. This framework is steered by the idea that all children, regardless of their differences, should get the opportunity to learn together. Technical and vocational education and training (henceforth, TVET) education is important as it not only provides all children with solid education but also a platform to reform intolerant attitudes and build a more all-encompassing society [1]. TVET access is a delicate problem for disabled individuals. The initiative for inclusive education TVET system has been introduced in many countries with limited choices for learners with special needs. However, the TVET settings are found to be segregated [3].

Inclusive education is a strategy that addresses diverse learner typology which in turn prevents marginalisation. Inclusion of the disabled persons in the society refers to the promotion and assurance that they are welcomed to pursue educational endeavours, training and employment with all the necessary support from all relevant parties [2].

It entails the concept that stipulates accessibility to all learning institutions for all learners, both abled and disabled. Research indicates that all advocates of inclusive education must ensure the identification and barriers that may inhibit education for all learners [4, 5]. Numerous studies have been extensively done in the Malaysian TVET scenario but none of them focuses on the preparedness of the higher TVET learning institutions in Malaysia to introduce the inclusive system to address the needs of autistic post-secondary learners.

Despite the apparent benefits of inclusive education for the disabled learners, gaps are still present in its implementation in Malaysian TVET/technical universities.

This paper aims to review the related literature in gauging deeper understanding of the needs and challenges of our autistic youths pertaining to post-secondary TVET pathways. This is crucial to ensure that they are not sidelined in their pursuit of higher education.

A. Definition of TVET

TVET is defined as "aspects of the educational process involving, in addition to general education, the study of technologies and related sciences, and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupants in various sectors of economic and social life" [6]. Throughout its development, numerous terms have been used to illustrate characteristics of TVET which include apprenticeship training, vocational education, technical education, technical vocational education (TVE), etc. [7]. TVET combines formal, non-formal and casual educational training that equip learners with the critical skills, knowledge and aptitudes necessary for employment [8]. Besides aptitude and technical knowledge, greater focus is directed at developing "softer" skills—communication, teamwork and negotiation. In order to ensure that the society has the accessibility to the continuing learning resources, TVET is offered in both public and private educational institutions, or through other forms of formal or informal structures.

B. Historical background of TVET in Malaysia

TVET was first established before Malaysia's independence. The establishment of technical and vocational schools started with the founding of a Trades School in Kuala Lumpur in 1926, which aimed at providing trades education to the youths then. The institution was later opened in Ipoh and Johor Bahru in 1930 with a branch established in Penang in 1932. Trades schools, through a three-year course, basically trained students the basics of carpentry, machinery repair works, electrical wiring and building construction. After independence, a massive emphasis was given by the government on TVET, as reflected in the First Malaysia Plan 1965–1970 up to the Tenth Malaysia Plan 2010–2015. Several upper-secondary vocational schools were founded during the First Malaysia Plan period. These schools mainly function to supply skilled technicians, craftsmen and artisans for the industrial, agricultural and commercial sectors [9].

TVET institutions are not restricted to vocational schools only. Several institutions such as the Polytechnics, Industrial Training Institutes (ITI), MARA Vocational Institutes (IKM), National Youth Development Corps (NYDC) and the Center for Instructor and Advanced Skills Training (CIAST) also function as providers of technical and vocational education and skills training [10]. In addition, the growth of foreign investments through transnational businesses in Malaysia also contributed to the emergence of new methods and technologies in production and a greater demand of a highly skilled and competent workforce. Consequently, two upper-intermediate skills training organisations were founded collaboratively with Germany and France, namely the German Malaysia Institute (GMI) and Malaysia France Institute (MFI) [10]. Student enrolment in technical and vocational schools had also increased in the 1990s. Hence, the streamlining and upgrading of sixty-nine secondary vocational schools (SMV) to technical schools (SMT) had been consciously included in the changes made to the TVET system in 1995. This reform was also extended to several other institutions which provided students with technical and vocational skills training, namely the Community Colleges, ITI's, polytechnics and MARA Vocational Institutes (IKM). All these efforts have not been in vain for the able-bodied students, however, there was not much luck for our students with disabilities, particularly autistic population in their post-secondary educational pathways.

C. Definition of autism

According to the American Psychiatric Association (2000), autism is a neurodevelopmental syndrome that is characterised by "deficits in social reciprocity and communication, and by unusual restricted, repetitive behaviours" [11]. Autism is an ailment that can be usually detected in infancy. This neurodevelopmental ailment is a diverse condition where no two autistic persons share similar profiles. It is a contrastive disorder demarcating extra abilities and shortfalls in a sufferer's social-communicative development that are often taken for granted. However, the complexities can be consistently measured across time, although the changes in specific behaviours may occur with development. An autistic child who can memorise alphabets and identify numbers may not respond to his name being called or trail a pointing gesture. Autistic adults normally have an array of characteristics from complete dependency on others to extraordinarily accomplished professions.

10.2 Literature Review

Kim (2017) conducted a case study on autistic Korean-American post-secondary students' experiences [12]. The study suggests that the students' experiences were shaped by the intersection of racism, multilingualism and ableism. The participants responded to their intersectional experiences by seeking to change their malleable traits, such as socio-economic status. While the participants of this study are minorities among minorities, a close examination of their lived experiences has meaningful implications for broader populations of students from diverse backgrounds.

Electronic-mentoring (E-mentoring) is a viable tool to encourage post-secondary education enrolment among youths with special needs [13]. This mechanism helps to characterise the distinctive impacts of the electronic coaching programme for Malaysian youths with special needs. Majority of the participants conceded the positive impacts of E-mentoring on their social, academic, identity and academic developments. TVET is considered as the means to reduce stigmatisation and discrimination by means of empowering persons with disabilities with constructing their confidence and shifting perceptions both for the disabled and the people around them. The ability to master technical or professional skills such as carpentry, computing or veterinary work proves that those trades are also suitable for disabled people. The need for a change of education setting from an academic-based one to vocational and self-reliance is highlighted by Hussain and Maarof (2017) [14]. The re-orientation is implemented through programmes that enhanced and expounded on the children's knowledge and living skills, namely Job Coach and The Southeast Asia Ministers of Education Organisation Regional Center for Special Education (SEAMEO SEN). The Job Coach programme is a national level project, a collaboration between the Ministry of Women, Family and Community Development of Malaysia and Japan International Agency (JICA) and the Job Coach Network Malaysia which was formed in 2006 [15]. TVET is offered by various institutions globally.

In Kenya, TVET training is conducted in TVET institutions in the North Rift Region. In Malaysia, there are boarding vocational schools for special needs students and also some secondary schools and training centres run by organisations. The Brunei Ministry of Education, under its Special Education Unit, has been implementing pre-vocational programmes in their secondary schools since 1999. The programme consisted of development of language and communication skills, personal management and social skills, development of practical knowledge, work-related skills and work-attachment experience. This programme is one of the examples of TVET programmes which are school-based and supported by the Ministry of Education [16].

A study by Adhikari (2018) found that disabled learners in Nepal who joined the typical vocational training faced some difficulties such as insufficient access to the facility [17]. The learners with visual impairments and those with hearing deficits often faced difficulty in following their instructors although they did not have similar problems in understanding the subject matter taught in the mainstream classrooms. Despite having supportive instructors, the learners with disabilities also found socialising and forming friendships a daunting social skill. The study also indicates that the existing inclusion practices were insufficient to resolve the needs of the disabled people. Nevertheless, the needs of differently abled people are more conveniently tackled by the inclusion system.

In another study that shows how technical and vocational education and training programmes in four East African countries successfully include intellectually and mentally challenged people, Ikenna et al. (2018) found three interrelated elements to the challenges and pathways to inclusion [18]. The challenges of inclusion may be culturally influenced such as debilitating perceptions towards mentally ill persons. Omission from primary school, inflexible curricula and unqualified teachers and vague guidelines are among the structural challenges to inclusion. Such inclusive practices for mentally disabled people in technical and vocational education and training programmes are thus severely hindered by culture and structure. Ikenna et al. thus suggested for pathways be made for a stronger policy with less rigid curricula, enhanced teacher training and more positive attitudes towards the practice of inclusion.

The purpose of establishing the TVET systems was to accommodate the nation's demands for vocational-based education besides bolstering the citizens' personal, social, civic and economic growth. Siwela (2017) posits that TVET could help provide disabled people with intermediate to high-level skills that would help create autonomous lifelong learners and set a basis for their higher education and assist their transition from school to work [19]. The design of this bridging foundation for TVET tertiary education should include both the able- and disable-bodied learners. Basically, the purpose of vocational education is to prepare learners to face the business world/working world. It also applies to persons with disabilities to prepare for their independence in the workplace. In some developed countries, people with disabilities are given training in the form of skills as the provision of his life later [20]. Thus, higher technical and vocational education and training (H-TVET) has been defined as an innovative education model which embodies the spirit of democratisation of knowledge and champions the continuous advancement of science, technology and trades [21]. It also encourages empowerment and self-reliance of youths. Exposing the autistic learners to HTVET may help them to be independent and self-resourceful. The combination of both elements of knowledge and hands-on skills in the learning processes as advocated by HTVET may benefit these autistic learners who have varied talents and advantages despite their disabilities. Various countries and UNESCO itself are aware of the importance of re-orienting the current basis of academic approach to a technical vocational one. However, much work still needs to be done and implemented to support TVET programmes for students with disabilities.

Umar and Rashid (2019) investigated the predictors of the success of disabled students in the implementation of inclusive education on their skills acquisition in agricultural science subject in a secondary school in Adamawa, Nigeria [3]. It was found that the highest contributing factor to the successful implementation of the inclusive system is parental involvement and adequacy of infrastructure in the school. The results were obtained by investigating the perception of 243 agricultural science teachers regarding the most effective predictive variable for the success of the inclusive system. The variables studied the predictive skills acquisition of students with learning deficits. Such variables found in this study may be helpful for the development of post-secondary TVET system for the disabled in our local institutions in Malaysia. TVET education providers for the disabled in Malaysia should take heed of the findings here to solicit a more active participation from parents and provide solid infrastructure in the campus to facilitate the learners' teaching and learning processes.

For a faculty to be equipped with satisfactory infrastructure for the disabled, in this case, the autistics, Zulhabri (2016) proposes that architects and consultants adopt suitable educational designing methods in constructing educational buildings for them. This is because research proves that the effectiveness of the learning outcomes of the autistic learners is partly attributed to the quality of the educational buildings and accompanying facilities. However, despite the sharp rise in the number of autistic learners in Malaysia, there are no clear policies or regulations for autism in the local TVET institutions. Zulhabri created a framework for the design of educational institutions for autistics learners. He identified two significant criteria to be considered in the designing process, namely enclosed construction and environmental benefits. The dimensions that are worth considering for ameliorative measure in the components of the building structure are colour, details and materials while the environmental elements should incorporate acoustics, ventilation and lighting [22].

The challenges pertaining to the inclusion of disabled learners in the TVET learning institutions remain a prevalent topic of research in several African states [23]. It was found that disabled students' enrolment in vocational education programmes in Kenya and Tanzania is inconsequential. This is due to their restricted accessibility to the services around the colleges. Similar barriers are rampant in Ethiopia where attitudes, environmental and institutional factors limit the disabled learners' involvement in TVET programmes there. Regardless of the supportive political willpower in the provision of special TVET needs of the disabled learners in these three African countries, its implementation still has room for further commitment from the policymakers. Limitations are also present in the legal instrumentation of the implementation strategies which continuously disrupt the disabled students' participation in the TVET system. Similar realisation of the rising needs of the disabled learners is present in Malaysia but very little is done to thoroughly address the issues particularly with regard to autistic learners.

Anuar et al. (2018) lament that disabled individuals in the society are every so often insufficiently presented in higher educational institutions in Malaysia [24]. This has posed numerous problems to these minority groups such as inaccessibility to academic services and facilities, and limited opportunities to partake in campus activities. All these limitations decapitate the learners' intellectual and psychological development. The focus of this study by Anuar et al. is the foregrounding of the role of the rehabilitation counsellors in educational institutions. These counsellors are found to play an instrumental role in assisting the disabled learners in their challenges during their academic pursuits. This research is beneficial for all educational institutions in Malaysia to identify the required aptitudes of the counsellors in accommodating the needs of the disabled learners. Among the skills and competencies that a rehabilitation counsellor should possess are adequate knowledge in the psychosocial and medical aspects related to disability. In addition, the counsellors too must be equipped with vocational and technological rehabilitative counselling skills.

All these research indicate the importance of TVET as a viable post-secondary educational avenue for the autistic learners, however, none, to our knowledge has been done to clearly show the existence of a post-secondary TVET educational platform for our autistic learners in Malaysia. In addition, none of the local studies have been done to determine a solid framework for a pathway for autistic learners to pursue post-secondary TVET education in Malaysia.

10.3 Challenges in the Implementation of TVET for the Autistics

Students with autism spectrum disorder (ASD) constitute an increasingly growing segment at the post-secondary level of education [25]. Understanding the unique attributes of this population is thus crucial. The first barrier concerns the challenges to successful academic pursuit among the autistic learners which are varied. The challenges are such as problems in understanding and responding to instructions, depression due to amplified self-reliance, unstructured planning and problems in completing academic tasks or assignments. In addition, another challenge also manifests in the form of a mismatch between the profiles of the disabilities with the TVET course components. Most of the TVET programmes all over the world still heavily blend knowledge of vocational skills and formal education. This has led to the failure of the autistic learners in satisfying the requirements of the TVET courses [26]. Cai and Richdale also found that although post-secondary autistic students felt that they were supported academically, they were left rather unattended to socially. This may have been attributed to some educators feeling inadequate to provide support service assistance to the students with ASD [27]. However, this should not be so as although the staff may feel incompetent in their skills to handle the requests for assistance, they are the rightful ones to help the ASD students [28].

An inclusive education system necessitates educational institutions to modify their practices and approaches to inclusion requires schools to change their practices to address the varied learning needs of all types of students which include those with disabilities. This is more appropriate than to expect the students adapt to the education system. On the contrary, a special school setting provides education to students with disabilities in a totally separate environment. This special arrangement is made with the assumption that these students are suggestively different from the abled-bodied. With this rather baseless assumption, the disabled students are thus being placed in a special social and educational setting [29].

All these barriers pose acute challenges to the successful implementation of post-secondary platforms for our autistic students. All relevant parties need to work together in making sure that the autistic group be given the appropriate scaffolding for their own sustainability.

10.4 Relevance of TVET for the Autistics in Malaysia

There is a pressing need for Malaysia to address the marginalisation of disabled people in the human capital sector, and to take necessary measures to reduce the significant social and economic impact on individuals and communities. This process constitutes the conscious effort to make TVET and skills systems as disability-inclusive if greater opportunities are to be provided to the autistics to develop their skills and qualifications, which are relevant to the local, regional and national labour markets. Abdullah (2013) highlights the initiative by the Malaysian Education Ministry through an augmented framework for disabled learners right from the primary to the tertiary level of education [30]. Job-related skills and positive psychological characteristics are the two critical skills that determine the employability of disabled people, employed and unemployed. Empowering our disabled community with the employability skills and psychological support is thus crucial [31]. With these features in mind, it is crucial that proper planning and transition schemes for employment be prepared for these students. Students with disabilities must also be trained with socialising, communication, problem solving and self-empowerment skills that enable them to engage in various settings both at schools and upon entering the society particularly after leaving secondary education. However, this study mainly concerns academic profiling for persons with sensory deficiencies, i.e. hearing impairment and visual disability for employability and not on any specific autism spectrum.

A study which focuses on the relevance of vocational and special education for children with special needs was carried out by Hussain and Maarof (2017) [14]. In this research, the importance of employability as a means of self-help for children with special needs is emphasised through the changes made to the educational landscape from academic-based education to vocational and self-reliance settings. This initiative is achieved by enhancing and developing the knowledge and living skills of children. This is a crucial orientation of special education to assist children in becoming independent adults. In order to accomplish this mission, barriers and issues must be addressed and tackled and opportunities be increased to ease the autistics' transition into adulthood.

10.5 Conclusion

There are currently insufficient vocational schools and training centres for students with disabilities in Malaysia, particularly autistic learners. Currently, a huge majority of autistic students in Malaysia may not be sufficiently prepared for transition into open employment and self-sufficiency, though they are equipped with academic and vocational training [2]. However, a successful school-to-work transition programme can provide the much-needed support for these students in terms of education and training for their employability and an acceptable quality adult life [32]. This review is relevant for educational practitioners, policymakers and other pertinent key stakeholders in the sector, to address the importance of a stable educational pathway for students with autism. Only by consolidating the educational programmes and services in Malaysia, can students with disabilities partake productively in the nation's development. Very few studies have been conducted on the readiness of the manpower and infrastructures of TVET institutions for the autistic group in Malaysia. With the rising figure of autism among our youths in the world, it is therefore imperative for the Malaysian government to take proactive measures in ensuring that the educational needs of the autistic students are met.

For students with disabilities that comprise difficulties in communication and social interactions, post-secondary enrolment consequences may differ greatly from those with less acute disabilities. Thus, consolidating the entry criteria, pedagogical approaches, teaching and learning materials and assessment methods is of utmost importance. In addition, strengthening the TVET manpower, both academic and supporting units to tend to the trainees with autism together with the non-autistic learners is another task worth focusing on. A special taskforce needs to be established in order to construct a solid framework which addresses the issues pertaining to the TVET programmes for our autistic students in the pursuit for post-secondary education.

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Chapter 11
Maritime Students' Perception of Mental Wellness

Megat Khalid Puteri Zarina, Saramurni Haryanti Abdul Hamid, Wardiah Mohd. Dahalan, Nurain Jainal, and Aminatulhawa Yahaya

Abstract Students at the tertiary institutions are commonly faced with numerous phases of transition and challenges. University life may present young students with multiple stress factors linked to transitional effects from high school to a new environment. Literature has proven numerous symptoms indicating common mental and psychological health problems such as stress, anxiety and depression experienced by tertiary students. One's psychological state may influence his/her perception about life. Adolescent wellness comprising that of the university students is a research area that is gaining an increased focus on. Being adolescents, these students are bound to undergo a critical stage of psychological and biological transformations which are normally influenced by the continuation or adoption of health-related behaviours. Nevertheless, a thorough analysis of the present literature reveals the dearth of coverage on adolescents' perspectives on the definition of wellness. This research is thus aimed at investigating the perception of a group of maritime bachelor's degree students in the northern part of Malaysia regarding their mental health and well-being as university students. A survey questionnaire was distributed to 90 undergraduates at a maritime university in northern Malaysia. By exploring the

M. K. Puteri Zarina (✉) · S. H. A. Hamid · N. Jainal
Student Development Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: puteri.zarina@fbk.upsi.edu.my

S. H. A. Hamid
e-mail: saramurni@unikl.edu.my

N. Jainal
e-mail: nurain@unikl.edu.my

W. Mohd. Dahalan
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: wardiah@unikl.edu.my

A. Yahaya
Maritime Management Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: aminatulhawa@unikl.edu.my

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undergraduates' understanding of the concepts of mental health and mental well-being, they can be guided to seek assistance for handling difficulties related to their well-being.

Keywords Mental health · Mental well-being · Adolescents · Maritime undergraduates

11.1 Introduction

Students at the tertiary institutions are commonly faced with numerous phases of transition and challenges [1]. These challenges come in various forms: having to live away from family perhaps for the first time ever in their lives, learning ways to be independent, forming new friendships, being financially decisive in addition to handling examination and assignments. Being adolescents, these students are bound to undergo a critical stage of psychological and biological transformations which are normally influenced by the continuation or adoption of health-related behaviours.

According to Kang [2], a person's wellness transcends mere physical health [2]. It embodies the combined states of physical, mental and spiritual well-being of a person comprising six interrelated dimensions. These six dimensions are social wellness, emotional wellness, spiritual wellness, environmental wellness, occupational wellness and intellectual wellness. Each of them shapes the quality of our lives:

- Social wellness is one's successful connection with others. This encompasses the ability to create and sustain healthy relationships with those around us.
- Emotional wellness is the ability to understand oneself and cope with the challenges in life. The ability to acknowledge and share feelings of anger, fear, sadness or stress; hope, love, joy and happiness in a productive manner contributes to our emotional wellness.
- Spiritual wellness is the ability to establish peace and harmony in our lives. The ability to develop congruency between values and actions and to realise a common purpose that binds creation together contributes to our spiritual wellness.
- Environmental wellness is the ability to recognise our own responsibility for the quality of the air, the water and the land that surrounds us. The ability to make a positive impact on the quality of our environment is in our homes, our communities or our planet contributes to our environmental wellness.
- Occupational wellness is the ability to get personal fulfilment from our jobs or our chosen career fields while still maintaining balance in our lives. Our desire to contribute in our careers to make a positive impact on the organisations we work in and to society as a whole leads to occupational wellness.
- Intellectual wellness is the ability to open our minds to new ideas and experiences that can be applied to personal decisions, group interaction and community betterment. The desire to learn new concepts, improve skills and seek challenges in pursuit of lifelong learning contributes to our intellectual wellness.

Although the term "wellness" is defined by physical, psychological and social well-being, it is not merely a "state" or "condition" as it actually encompasses the habitual practices of certain constructive activities. Wellness is therefore a dynamic process, which promotes the overall state of well-being [3]. A person enjoys self-gratification when he or she finds successful fulfilment of meaning in life, self-esteem, spirituality and opportunities for growth and development. All these are called personal needs [4]. The National Health Service (NHS) of The United Kingdom, in 2016, projected that there would be one million people suffering from mental health problems by 2021. Out of this figure, 70,000 are children and the youths [5]. Among the reasons cited for this phenomenon are stress, depression and anxiety as predicted to be prevalent in 20% of the sufferers [6]. A person who undergoes stress will normally suffer from both mental and general health imbalances as the natural responses triggered in the brain result in amplified production of neurotransmitter [7].

Adolescent wellness comprising that of the university students is a research area that is gaining an increased focus of. Nevertheless, a thorough analysis of the present literature reveals the dearth of coverage on adolescents' perspectives on the definition of wellness. This research is thus aimed at investigating the perception of a group of maritime bachelor's degree students in the northern part of Malaysia regarding their mental health and well-being as university students.

11.2 Literature Review

A local Malaysian mainstream newspaper, the New Straits Times dated September 2016 reported that the Ministry of Health voiced concerns regarding the state of students' mental health. The statistics revealed that mental health issues among Malaysian students must be attended urgently in order to alleviate more dire problems. The news report indicated an increase of one in every ten students in 2011 to one in every five students five years later. It was also cited that the primary causes of mental health issues among students were anxiety and depression besides the influence of illegal substances such as drugs [8].

Cases of suicide-motivated behaviours among university students are commonly triggered by their own psychological conditions which affect the way they perceive of their physical and mental well-being. Oyekcin et al. [9] examined the relationship among psychological signs, suicidal contemplations and perceptions of mental and physical well-being in university students [9]. An Internet-based survey was distributed to 4330 students at Onsekiz Mart University, Turkey. It was found that 15% of the respondents indeed contemplate committing suicides at least once in their entire life. The respondents' mental symptoms were also increasingly severe as they reported reduced mental and physical well-being with 28.2% of them found to be severely depressed and 33.1% were reported of experiencing acute anxiety. Such findings indicate that this problem may create similar effects on the group of maritime students in this study given the fact that youths around the globe may experience similar patterns of circumstantial elements where pressure and need for academic success is ranked among the most important things in life.

The need for understanding the roles of interconnectivity among the medical units in handling stress is also crucial. Mousse et al. [10] investigated the perception of 50 students aged 18 years old and above at the University of Wolverhampton about stress, the factors of stress and stress management [10]. The survey was held as part of pharmacists' campaign to reduce stress. It was found that stress impacted the individuals' lives. However, the participants were aware of the dangers of stress on them. Among the principal factors of stress faced by 55.6% of the male participants were work and emotional problems while 68.8% of the female respondents identified emotional problems as their biggest challenge to being stress-free. 55% of the respondents also chose financial obligation as the major cause of their stress. This study has provided ample knowledge for future pharmacists to assist better stress management among their patients.

In another research, Cook et al. [11] developed a universal preventive approach in efforts to avert mental problems and promote wellness among elementary school pupils in the south-eastern region of the United States [11]. Positive behavioural interventions and supports (PBIS) and social emotional learning (SEL) are two of the most commonly adopted and evidential approaches to tackle problems related to students' mental health. These two distinct prevention approaches are often used differently. Cook et al. were specifically determining how students' mental health is affected by the singular and combined effects of PBIS and SEL. As hypothesised, the combined treatment yielded better results in overall mental health performance of the respondents. Although this research was done on primary school pupils, this universal prevention framework may be a solution to help our youths at the tertiary institutions in tackling their mental health problems.

Chen et al. [12] conducted a study on five hundred and twelve university students in the Mainland China to analyse their perception of the relationship between their well-being and the learning environment [12]. It was revealed that a constructive learning environment surrounding a student is directly linked to satisfaction and affective conditions. This particular research shows that clear curricular structures, interpersonal correlation between students and adequate learning infrastructure are all factors that make university students mentally healthy. What Chen, Fan and Jury suggest is that higher learning institutions should consider implementing a well-planned curricula and efficient facilities to create a positive learning atmosphere for the students.

An effective social support system at the university with opportunities for spiritual well-being also guarantees life satisfaction and overall well-being among the students. Alorani and Alradaydeh conducted a study on 919 undergraduates at the University of Jordan [13]. Positive relationship was determined between the variables, i.e. spiritual well-being, social support and life satisfaction among the students. The study also indicates that when the students receive favourable social support, they are normally satisfied with their lives as university students. Having identified the elements that help create a positive living for university students, it would be imperative for tertiary institutions to embed elements of spiritual well-being in the educational programmes. In addition, universities should also be proactive in building facilities for religious practices on campus for the students.

Problem-solving and decision-making skills are among two criteria of mental wellness [14]. 30 female students from multiple disciplines of both social and hard sciences such as physical education, computer sciences, accounting and electric engineering were involved in the study. The respondents were required to respond to a Connor-Davidson Resilience Scale (CDRISC) questionnaire (2003) and 3-Ryff Scales of Psychological well-being questionnaire. These two tools were used to assess their resilience and strength against psychological burdens and threats. The findings showed that there is a difference between control and experimental groups in terms of resiliency, psychological well-being and mental disorder symptoms at the level of 1%. It could be deduced that the differences between the scores of the two groups showed that problem-solving and decision-making skills impacted the respondents' mental health and resiliency. What this particular study has informed us is the importance of a conscious effort to expose our students to the necessary skills to alleviate mental stress.

The literature review has provided the insight on multiple facets of mental well-being among our university students. However, there is a dearth of studies that investigate the perception of maritime university students about their own mental wellness. Hence, the purpose of this paper is to fill this gap.

11.3 Methodology

This study employed a quantitative approach. The data in this research were collected via a distribution of survey questionnaire to ninety students studying maritime-based academic programmes at a maritime university in the northern region of the peninsular Malaysia. The survey consisted of twenty-four items on Likert-type scale response with five anchors: 5-Almost always, 4-Often, 3-Half the time, 2-Rarely and 1-Never. The survey was distributed to ninety random students who were in their second last semester of an academic programme called Bachelor of Maritime Management (hon). The questionnaire was adapted from Massé et al. [15], which was aimed at seeking the respondents' perception about their mental well-being. The respondents' confidentiality was guaranteed as their identities were not required other than the crucial details like programme, semester, etc.

11.4 Results and Discussion

This section presents the results of the data analysis which involved frequency tabulation, mean and standard deviation analyses. The discussion will only be made on the items deemed most significant on the students' mental well-being.

Table 11.1 Statistical analysis for item "I am confident with myself"

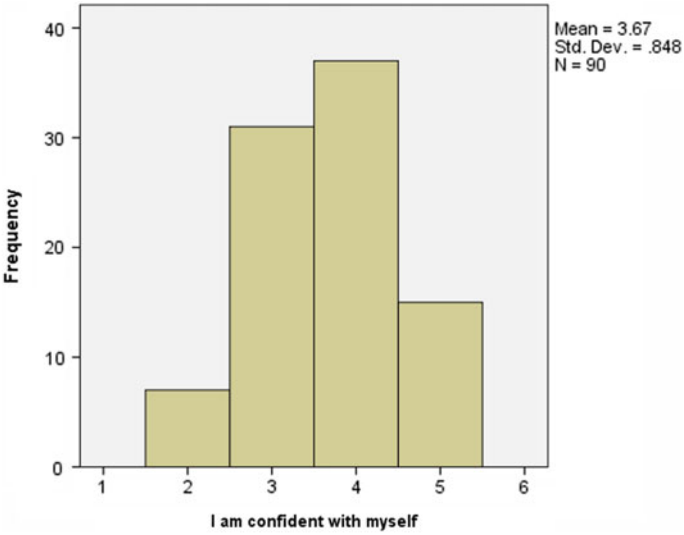


Table 11.1 shows the average response from the respondents for the item "I am confident with myself". Fifteen students in the survey felt self-confident almost always, thirty-seven reported feeling confident with themselves often, thirty-one of them felt so half the time, with only seven rarely felt so. The mean was 3.67 with a standard deviation (s.d. henceforth) of 0.8.48.

The response for the item "I feel satisfied with what I am able to accomplish - I feel proud of myself" (Table 11.2) was averaged at 3.69 (s.d. = 0.729). Only three students rarely felt satisfied with and proud of their accomplishments. Thirty-three of them felt so half the time. However, forty-three felt the satisfaction and pride often and eleven felt so almost always. Generally, the young respondents in this study felt that they were satisfied with their accomplishments which they were proud of.

The mean analysis of the item "I feel loved and appreciated" (Table 11.3) was 3.72 (s.d. = 0.835). Forty-five respondents felt loved and appreciated often and fifteen of them felt so almost always. Twenty-nine felt so half the time with only one rarely felt loved and appreciated.

Table 11.4 shows that the response to the item "I feel useful" was averaged at 3.58 (s.d. = 0.821). Thirty-seven often students felt useful with eleven almost always feeling so. Thirty-six felt useful half the time, five rarely felt useful and one never felt so.

The item that had the highest mean was "I have goals and ambitions" (mean = 4.24, s.d. = 0.825) as displayed in Table 11.5. Thirty-nine respondents admitted that they almost always had goals and ambitions. Thirty-eight often were ambitious, ten felt they had goals and ambitions half the time, two persons responded that they rarely harboured any ambitions or had any goals with one student never had any goals at all. These results show that the respondents were aware of their directions in life which suggests that they had a sound mind and mental wellness.

Table 11.2 Statistical analysis for item "I feel satisfied….proud of myself"

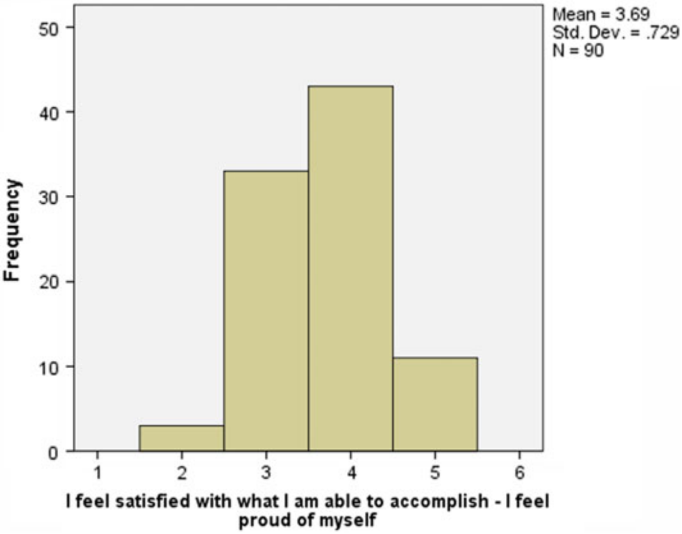
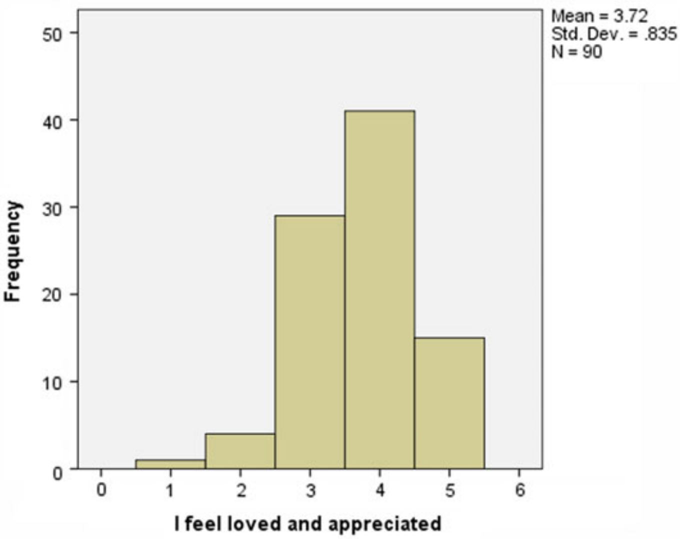


Table 11.3 Statistical analysis for item "I feel loved and appreciated"



The item whose mean was the second highest was "I find life exciting and I want to enjoy every moment of it" (mean = 4.18; s.d. = 0.894) as presented in Table 11.6 above. One respondent never found life exciting and he/she did not want to enjoy every moment of it, two students rarely found life exciting, seventeen felt so half

Table 11.4 Statistical analysis for item "I feel useful"

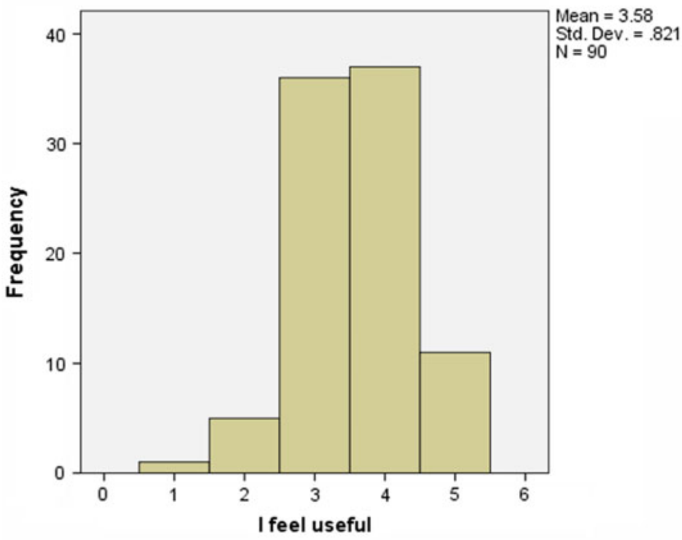


Table 11.5 Statistical analysis for item "I have goals and ambitions"

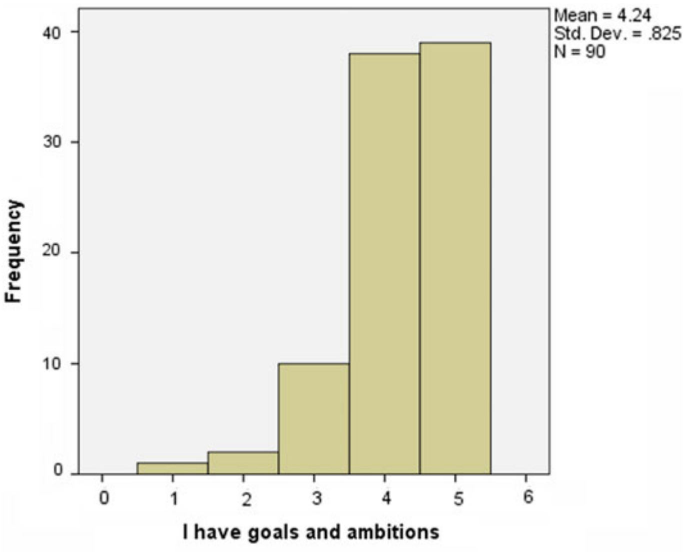
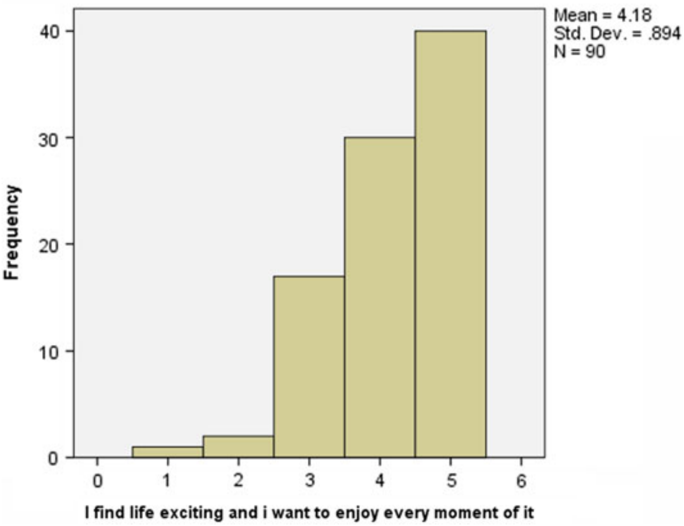


Table 11.6 Statistical analysis for item "I find life exciting …."



the time. However, thirty respondents often found their lives exciting and wanted to enjoy every moment of it and forty almost always found so.

The response for the item "I am true to myself" (Table 11.7) was averaged at 3.77 (s.d. = 0.900). One person in the survey was never true to himself/herself, five were

Table 11.7 Statistical analysis for item "I am true to myself"

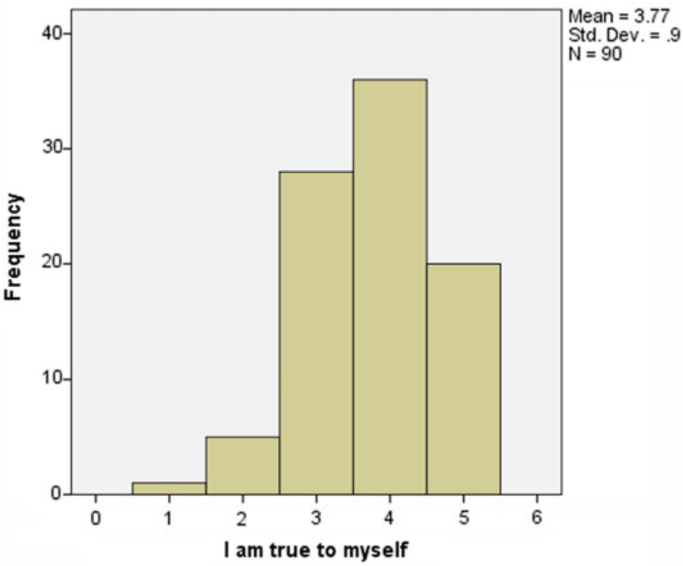
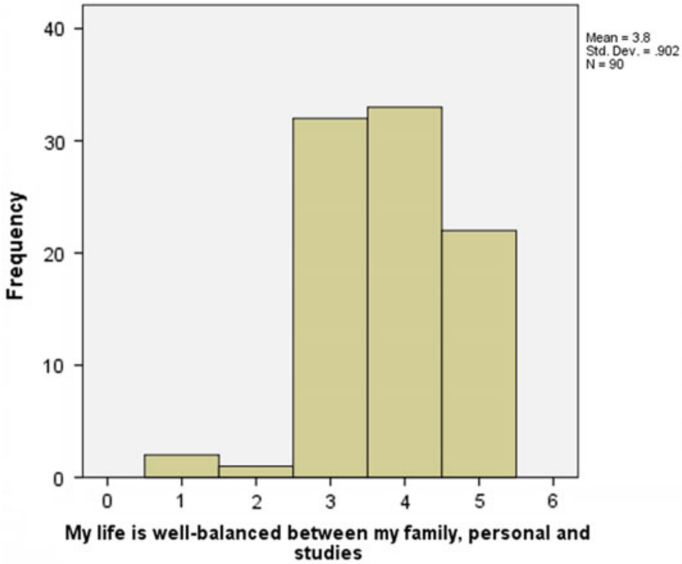


Table 11.8 Statistical analysis for item "My life is well-balanced...."



rarely true to themselves, twenty-eight were true to themselves only half the time. Nevertheless, thirty-six often were true to themselves and twenty others were almost always true to themselves.

The average response for the item "My life is well-balanced between my family, personal and studies" in Table 11.8 was 3.8 (s.d. = 0.902). Two students never felt that their lives were properly balanced between family, personal and studies. Only one person rarely felt so while thirty-two respondents found their family, personal and studies were balanced only half the time. However, thirty-three respondents often found that they could achieve a satisfying balance between their family, personal and studies and twenty-two almost always felt this gratification.

Most of the respondents perceived themselves as quite calm and level-headed (m = 3.66, s.d. = 0.823) as shown in Table 11.9. One respondent never felt calm and level-headed, six rarely felt so. Twenty-seven students only felt calm and level-headed half the time. Nevertheless, forty-five respondents often felt calm and level-headed and eleven almost always felt so.

The respondents were also found to feel good and at peace with themselves (mean = 3.99, s.d. = 0.786) as indicated in Table 11.10. Four students rarely felt good and at peace with themselves while sixteen others felt so half the time. A massive number of forty-seven students often felt good and at peace with themselves with the remaining twenty-three almost always felt equally positive.

The students in this survey too admitted that they were able to handle difficulties positively (mean = 3.78, s.d. = 0.804) from the data displayed in Table 11.11. Six respondents were rarely able to handle difficulties while twenty-three students faced

Table 11.9 Statistical analysis for item "I am quite calm and level-headed"

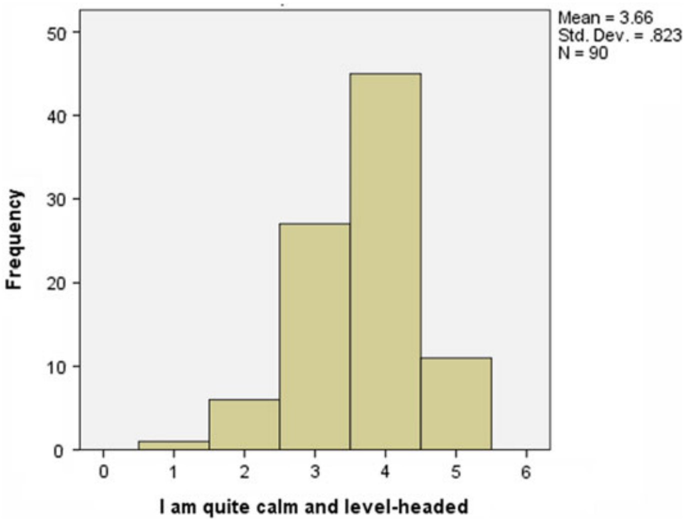
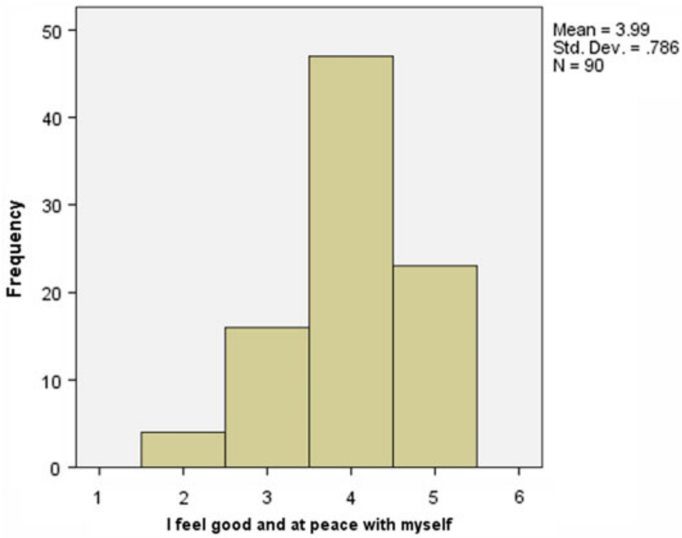


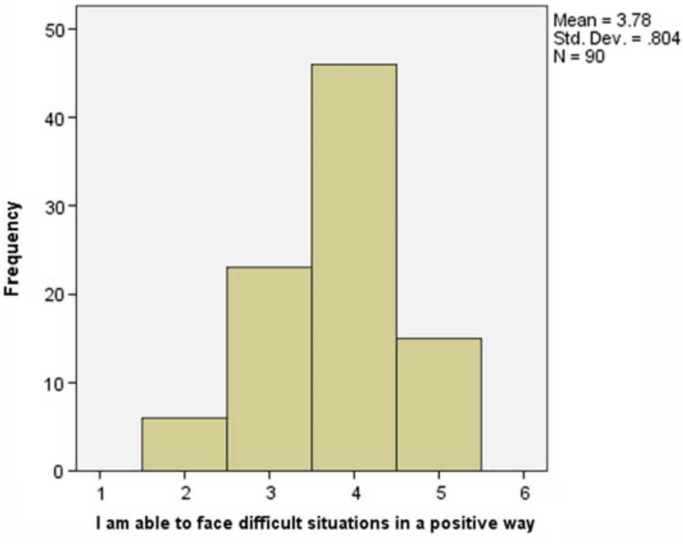
Table 11.10 Statistical analysis for item "I feel good and at peace with myself"



similar problems half the time. However, forty-six were often able to handle their problems well and fifteen others were able to do so almost half the time.

The response for the item "I really enjoy my life now" was averaged at 3.97 (s.d. = 0.841). This means that the students who took part in this survey were well-contented

Table 11.11 Statistical analysis for item "I am able to face difficult…."



with their lives, suggesting positive mental well-being (see Table 11.12). Two respondents never enjoyed their lives with two students rarely felt so. Fifteen respondents enjoyed their lives only half the time. A large group of forty-nine respondents in this survey admitted they often enjoyed their lives while twenty-two others almost

Table 11.12 Statistical analysis for item "I really enjoy my life now"

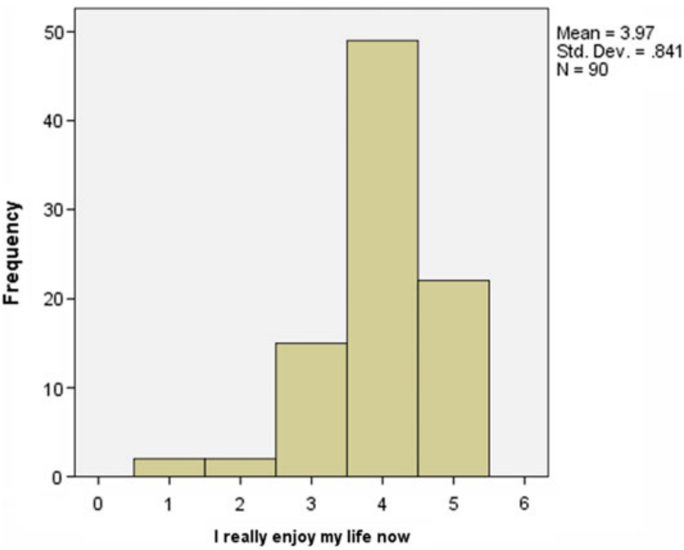
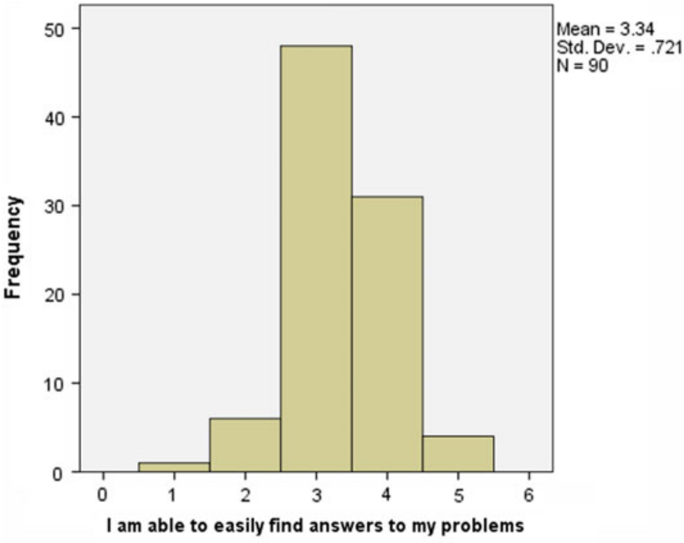


Table 11.13 Statistical analysis for item "I am able to easily find answers to my problems"

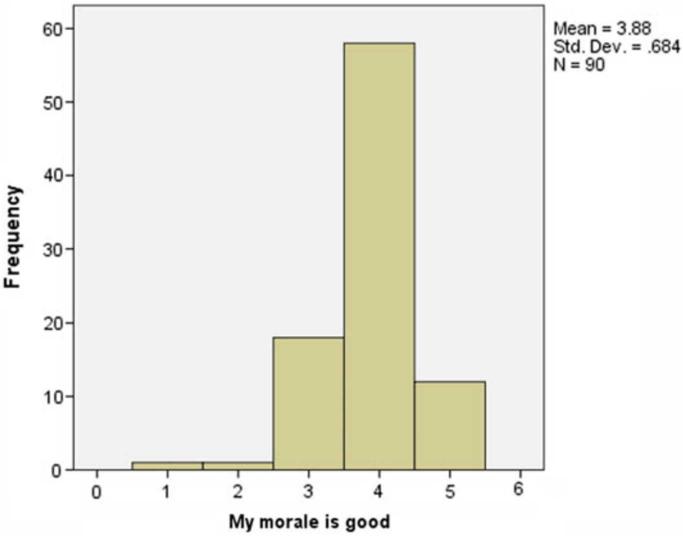


always enjoyed their lives. This positive response could have been induced by the supportive learning environment enjoyed by the students [12].

The item that averaged the lowest (mean = 3.34; s.d. = 0.721) was the item "I am able to easily find answers to my problems" (see Table 11.13). One student in the survey was never able to easily find answers to his/her problems. Six respondents rarely found answers to their problems too. Forty-eight of the respondents were only able to find answers to their problems half the time. Thirty-one were often able to solve their own problems while four of them were able to do so almost always. More than half of the respondents only managed to solve their problems half the time. This may be due to the respondents being young and rather immature to handling life issues and challenges as adolescents.

Generally, the students who responded to this survey believed that their morale was good which indicates a healthy mind and body to pursue their lives as university students (mean = 3.88, s.d. = 0.684) (see Table 11.14). One student never felt that his/her morale was good while one other person rarely felt so. Eighteen felt their morale was positive only half the time. Nevertheless, fifty-eight respondents often felt that their morale was good and twelve almost always felt so.

Table 11.14 Statistical analysis for item "My morale is good"



11.5 Discussion of Findings

The results obtained from the data analysis revealed that the students in the survey generally had a positive mental wellness. Most of them indicated that they had satisfactory grasps of the elements that constituted a person with a positive outlook on life. The item that yielded the highest mean is "I have goals and ambitions" (mean = 4.24, s.d. = 0.825) in Table 11.5 above. Seventy-seven out of the ninety respondents confirmed that they had goals and ambitions in life. A person who has a direction in life can be said to have a sound mental well-being. The statement of bearing life goals and ambitions is reflective of a purpose in life. This in turn predicts both health and longevity which suggests that one's ability to find meaning from life's experiences, especially when dealing with life's challenges and tribulations such as those faced by the students in this study. This ability may be a mechanism deployed by the person which underlies his/her resilience [16].

The item that yielded the lowest mean is the item "I am able to easily find answers to my problems" (mean = 3.34; s.d. = 0.721) (see Table 11.13). Although more than half of the respondents did have goals and life ambitions, the means of finding solutions to their problems were still elusive to them. Such weakness may have been attributed to their young age with little experience at all in handling life's turmoil and challenges. Lacking the ability to locate answers to their life problems, if left unchecked, may leave the students with feeling unhealthy, mentally. This is because living as residents at the university, exposing them to bizarre incidents and problems may pose too much a burden to them, emotionally. Problem-solving and decision-making skills are two criteria that determine students' mental health [14]. Thus, these students need to be educated with proper problem coping skills.

11.6 Conclusion

This study was geared towards investigating the perception of the maritime university students with regard to their mental well-being. There is dearth of research conducted on the maritime students' mental wellness. The main objective was to specifically determine the students' understanding of their own mental wellness conditions with all the challenges and adversities being university residents. Finding the crucial space for their mental wellness development is important for these students if they aspire to excel in life beyond the university realm. From the mean analysis results obtained from the survey, it was implied that the mental outlooks of these respondents were positive. The respondents in this study were generally aware of their life goals with most of them harbouring some form of ambitions. This is to say that despite the odds living away from home saddled with the accompanying challenges, these students were still mentally well and sound with the exception of a few. Those few students who displayed negativity about life may have experienced some form of preliminary triggers that led to their inability to feel positive about their lives. However, this small group of students should not be overlooked as they may need proper guidance and help to prevent them from resorting to dangerous measures to solve their problems such as being suicidal etc. All relevant parties such as the faculty members and counsellors should take pre-emptive measures to mitigate problems of mental wellness among our university students.

Addressing adolescents early in their college lives with wellness information particularly in universities presents us with multiple benefits. Such information does not only help these youths to wilfully engage in practising a lifestyle that highlights wellness early during adolescence, it will also assist them to alleviate an unhealthy lifestyle later on in adulthood. In addition, it is important to consider the students' understandings of the wellness concept when planning, designing, implementing and evaluating wellness programmes for the university students.

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Chapter 12
Optimization of Route Selection and Carbon Emission Release for Waste Collection Systems

Shaiful Bakri Ismail and Dzulhaqeem b Dzulkifli

Abstract In general, transportation is important to any industry in the world that involves the movement of goods from one destination to another. In waste collection systems, the movement of waste collectors using transportation is one of the main activities in handling waste management today. The activity of collecting waste involves the waste generated by the residential area, industrial area, and port area that consists of many types of waste such as domestic waste, food waste, plastics, industrials waste, metals, and waste that is generated by the manufacturing processes. Then by choosing the best route for collecting waste which is to define the shortest way that merges with the time of operation will reduce the operational cost of the company and at same time reducing the quantity of carbon emission release that impacts the environment. Thus, this research is a preliminary study to analyze the actual route that is usually selected and used by truck drivers by using optimization method called the traveling salesman problem (TSP) method. This method is used as a tool to decide the optional route for collecting waste by Majlis Perbandaran Manjung (Sitiawan district) to collect the waste generated by the Sitiawan residential area and Kg Acheh industrial area to the final destination which is located at Segari Landfill. The final result shows that by optimizing the routes selection, the suggested routes will show a lower distance of about 28.3% (29.18 km) and release only 15.95 kg Co_2 of carbon emission. The result shows a slightly significance and benefit to the company in reducing the cost of operations and time-consuming without underlook on the environmental aspect. However, this result depends on several variables that need to be considered such as the rest time, road closure, number of traffic lights, congestion, accident, peak time, and current situation during the process of collecting

S. B. Ismail (✉)
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumpur, Malaysia
e-mail: shaifulbakri@unikl.edu.my

D. b. Dzulkifli
Maritime Management Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumpur, Malaysia
e-mail: haqeemdzulkifli@sunikl.edu.my

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the data. All of these variables are different for any location and number of vehicle in one time.

Keywords Transportation · Waste collection · Optimization · Route · Traveling salesman problem

12.1 Introduction

Transportation seems to have a strong connection with economy development, social developments, and also to the security of a country. To create this convenient growth of transportation, it is essential to have a sustainable planning. Today, transportation has been an important role to ensure the movement of passengers and goods from one location to another. It is needed at most of the time for every people to travel to a place, to move goods and cargo, and other functions that help us in daily life. Besides that, transportation is also important for handling the waste management today.

The waste management transportation system is one of the main important sectors in the transportation sector that can be improved concurrently especially in reducing the operational costs. A lot of ways can be determined by transportation experts and specialist to minimize the overall operational costs in certain areas. One of the main target areas is residential areas, industrial areas, and ports where it becomes vital to collect domestic waste, industrial waste, and port waste. According to [1] stated that in Malaysia, the expanding population growth also increases the amount of solid waste generated from sources like domestic, industrial, and commercial sources which is becoming the crucial issue in this country. Therefore, choosing the best route is one of the main problems that are faced by the authorities. Poor performance of transport in residential and industrial areas will decrease the efficiency of the waste management system that can cause pollution to the environment.

The better planning in routes selection at residential and industrial areas can be solved by using the green vehicle routing problem (GVRP). The GVRP is according to [2], a green logistic initiative to suggest the best routes that meet the requirements to protect the environment and save costs. This optimization algorithm measures what are the best indicators needed to be considered in waste management systems to develop the best routes. The routes of waste collection at some parts of the district at Sitiawan, Perak, are selected by local authorities as a sample research. Then, all the indicators that effecting the process of waste collection systems are being verified and measured to solve the GVRP by using traveling salesman problem (TSP). TSP is one of basic optimization techniques that will analyze the algorithm of GVRP for controlling the execute time by use of a MATLAB programming and produce the number of best routes selection as references to reduce the actual daily routes usage but at the same time decreasing the amount of carbon emission release.

12.2 Literature Review

12.2.1 Transportation Management

Transportation management is different compared to industrial management because of their functions and the framework to ensure the efficiency of transportation [3]. The development of socio-economy in every country has demanded for effective transport systems especially in heavy industrial areas. Supply chain management is related to transportation management system that plans, executes, and optimizes the movement of goods and cargo.

Besides that, transportation management is also important for residential areas that produce cost and environmental emissions from solid waste collection systems [4]. The cost for handling waste in urban areas depends on the population, population density, location, labor cost, and other related factors which contribute to more than 40% cost for municipal solid waste management (MSW). These factors will also influence the result of this research which uses the Sitiawan urban area as the location. Transportation management in Sitiawan includes roads, railways, and waterways which contribute a lot to the development of the area.

12.2.2 Green Vehicle Routing Problem

The main goal of the green vehicle routing problem is to harmonize the environment and reduce the cost to meet the requirement in preserving the environment from pollution. A similar definition stated by [2] that GVRP is to produce the best routes that meet with the requirements needed to protect the environment and that are financially sound. According to [5], there are a few examples of variants of the vehicle routing problem that are used in handling multiple depots and harmonize the environment and reduce economic costs [6]. This leads to the research that refers to the transportation problems and concludes as green vehicle routing problems. The research in VRP relates to green logistic problems, such as time-dependent VRP as one of the variants related to GVRP that shows the minimization of emission. It is supported by [2] stated that the main focus of the GVRP is to find the best routes that give benefits to the environment and lowest cost.

12.2.3 Carbon Emission and Fuel Consumption

A study by [2] using the capacitated vehicle routing problem to analyze the CO_2 emission at targeted areas. The authors of this study have performed an optimization approach that reduces the emission while giving the lowest operation cost required. Besides that, [5] have similarly used the variation of GVRP to minimize the required distance and minimize the time taken for a complete route in their research. Certain aspects such as load, speed, and time-dependent speed are considered to optimize the best solution for routing. In addition, it was found that the minimization of cost in vehicle routing leads to higher fuel consumption needed for the vehicle even the cost of hiring the driver is decreased. The solution for the limitation is to come up with a speed optimization procedure which gives the excellent speed for minimum fuel consumption since it is not accurate to consider a fixed speed in the calculation of fuel consumption because it is less realistic when it comes to real driving conditions.

12.2.4 Waste Collection System

The definition of waste management is the collection of unwanted materials that occurred during construction [1]. In Malaysia, solid waste is produced as 30,000 tons every day. Sadly, from that amount only 5% is recycled. These statistics show that problems occurred for Malaysia in land and air pollution for the environment. It is important that residential and industrial areas especially in Malaysia initiate the improvement of environmental policies that lead to green environment especially in waste management.

A research by [7] found that higher economic development and people population will result in a greater amount of solid waste produced. If there is no proper management of solid waste, it will turn into one of the main causes of environmental pollution degradation to many urban areas. In addition, the report stated that waste management for urban areas will be effected if there is low collection coverage, limited transport facilities, low performance of suitable recycling plans, and disposal facilities such as the landfills.

12.3 Methodology

12.3.1 Traveling Salesman Problem

The aim of the traveling salesman problem (TSP) is to give the best solution with large amount of data and fast result by selecting the most suitable solution. TSP is an optimization method that helps to conclude the best route with minimum distance traveled. The elements are the set partitioning formulation where each possible vehicle route serves as a subset of customers and to find the least cost set of routes serving each customer exactly once. By the definition, with the main objectives to find how many routes, probably the shortest routes by given numbers of nodes (cities) and with the same starting and last destination [8, 9]. Other than that, the challenge in this method is to make the minimum length of traveling. Therefore, this is a similar pattern as the schedule for waste collection that collects the waste at different nodes and the same starting and end location. Thus, this research used the application concept of TSP described by [10]. This research determines the issues of scheduling buses and the output shows the pattern of bus loading based on the total routes and distances that were traveled by the buses. Certain requirements need to consider that no bus is overloaded and that the time consuming does not exceed the maximum allowed policy. In this case, the start and end point is the same location which is at Majlis Perbandaran Manjung (MPM) traveled with the number of nodes at Sitiawan district (residential and industrial location) and the capacity of the garbage is not more than 11 tones according to the truck capacity. This research used the simplest heuristic algorithm to solve the TSP using the concept by [11]. The algorithm is defined as below:

1. Choose a random node and set it as the starting node.
2. Find the shortest edges connecting the starting node and an unvisited node and go there.
3. Mark the current node as visited and previous current node as visited.
4. If all the nodes are visited, then terminate.
5. Return to the starting node.

12.4 Result and Discussion

Data are collected in several sections that effect the data analysis process. All the data are collected based on the objectives which are set for the research that implement transportation optimization method solving the green vehicle routing problem. One of the aims is to identify which are routes that can be used by the selected drivers that are concurrent with the daily routes selection. It will help the drivers to manage the operational time during collecting the waste at the Sitiawan district. The primary industries within Sitiawan are rubber production, manufacturing of rubber gloves, palm oil production, mineral ores, fishing, fisheries, and shipbuilding. This activity was partly attributed to the development number of residential and industrial location that leads directly to the planned township of Seri Manjung. MPM provided more than ten garbage trucks that covered the area of Sitiawan as well as Manjung. This research covered the area of Zone A of the Sitiawan district. The truck is scheduled to collect the waste at same route for Monday, Wednesday, and Friday. With the same routes, Zone B covered for Tuesday, Thursday, and Saturday. The management rotates the duty based on the Zone A or Zone B.

12.4.1 Actual Route

Table 12.1 shows the locations and routes covered by the trucks for daily collection. The selection of routes is made based on the schedules that are given by considering the easiest way to reach each of the destinations. The consideration of choosing the

Table 12.1 Nodes of actual routes by AFN 575 Truck

Nodes	Location	Latitude	Longitude	Distance (km)
1	MPM	4.21831	100.698	4.3
2	Netto Nixon Dentist Clinic	4.21061	100.668	1.7
3	Tmn Arasu	4.21014	100.696	1.73
4	Tmn Bunga Ros 2	4.20753	100.697	1.2
5	Kg. Bintang	4.20898	100.695	1.54
6	Tmn Raja Shariman	4.20777	100.697	1.44
7	Tmn Limau	4.20972	100.694	0.9
8	Tmn Maju Indah	4.20678	100.692	1.5
9	REST	4.21499	100.697	1.59
10	Tmn Suria Jaya	4.20638	100.69	1.3
11	Tmn Bintang	4.20638	100.69	1.59
12	Tmn Pelangi 2	4.20647	100.687	9.77
13	Painting Workshop	4.24681	100.664	0.1
14	Leopad	4.24619	100.666	3.1
15	Lumut Lee Marine	4.2541	100.678	1.2
16	Sapura Energy	4.24571	100.575	28.22
17	Segari Landfill	4.39993	100.597.18	42.11
18	MPM	4.21831	100.698	end

routes is made by the driver which has the easiest road to use that have minimum limitations such as closed roads, small roads, congestions, traffic lights, and shortest road. These roads are important for MPM because of the area consisting of residences that generate waste from daily activities. In addition, it is also important to organize large amount of waste especially generated by restaurants and shops that are collected daily by MPM. Initially, the location of collection for this truck is in the Sitiawan area and nearby from each location.

Besides collecting waste in the residence area, this truck also collects waste from industrial companies from the Kg Acheh industrial area, Sitiawan. Even though the truck does not involve in port waste, but it is responsible for industrial waste by factories in the area such as plastics, packaging waste, and papers. The actual route is presented in a graph using MATLAB software by inserting the latitude and longitude of nodes from the motion study. Figure 12.1 shows the actual route that is used by the truck to collect waste from Sitiawan, Kg Acheh industrial area, and Segari landfills.

The coordination of area in collecting the waste is determined by the driver which considers the best selection of roads to be used to arrive at the destination. The driver will pick the most less time consuming, less congestion, and road condition to complete the route. Based on Table 12.1, the area is picked by the driver and recorded

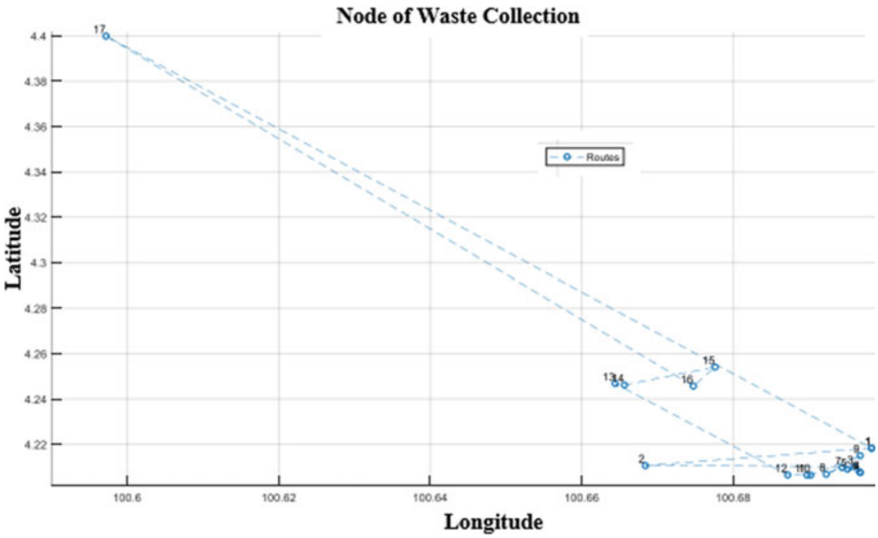

Fig. 12.1 Actual routes

in the data. In addition, the total distance traveled by this truck is 103.29 km. Usually, the average weight and capacity of the truck which can be loaded is 11 tonnes.

The weight of the truck after collecting the waste is heavy because it is packed and loaded with food waste and other materials that make the compactor fully stored. Heavy vehicles give a major contribution to the carbon emission that consumes a lot of fuel to move as proven by [12]. The carbon emission has a few variables such as driving style, weather conditions, congestion, and weight.

12.4.2 Route Suggestion by TSP

Using the mathematical modeling of the TSP in the MATLAB software, the new suggested route is generated with different arrangements of nodes. The new selection of routes is calculated and applied to the data collected and is shown in Table 12.2.

From the result, it is suggested that the truck should dispose the waste collected at the middle of the schedule. The truck will need to dispose the remaining waste collected after reaching the Segari Landfill on the next day included in the new schedule. The graph shown in Fig. 12.2 is the calculation of the new route selection using the TSP method. The method is measured in several elements which are distance and location. The new route selection decreases the total distances traveled that support the GVRP in transportation. TSP provided 28.3% less km which less about 29.18 km compared to the actual routes.

Therefore, TSP suggested higher efficiency in routes usage. The differences can be seen in Fig. 12.2 because the nodes of waste collection are different. The odd

Table 12.2 New routes (nodes selection)

No	Nodes	Location
1	City 1	MPM
2	City 3	Tmn Arasu
3	City 5	Kg. Bintang
4	City 7	Tmn Limau
5	City 9	REST
6	City 11	Tmn Bintang
7	City 13	Painting Workshop
8	City 15	Lumut Lee Marine Engineering
9	City 17	Segari Landfill
10	City 16	Sapura Energy
11	City 14	Leopad
12	City 12	Tmn Pelangi 2
13	City 10	Tmn Suria Jaya
14	City 8	Tmn Maju Indah
15	City 6	Tmn Raja Shariman
16	City 4	Tmn Bunga Ros 2
17	City 2	Netto Nixon Dentist Clinic
18	City 1	MPM

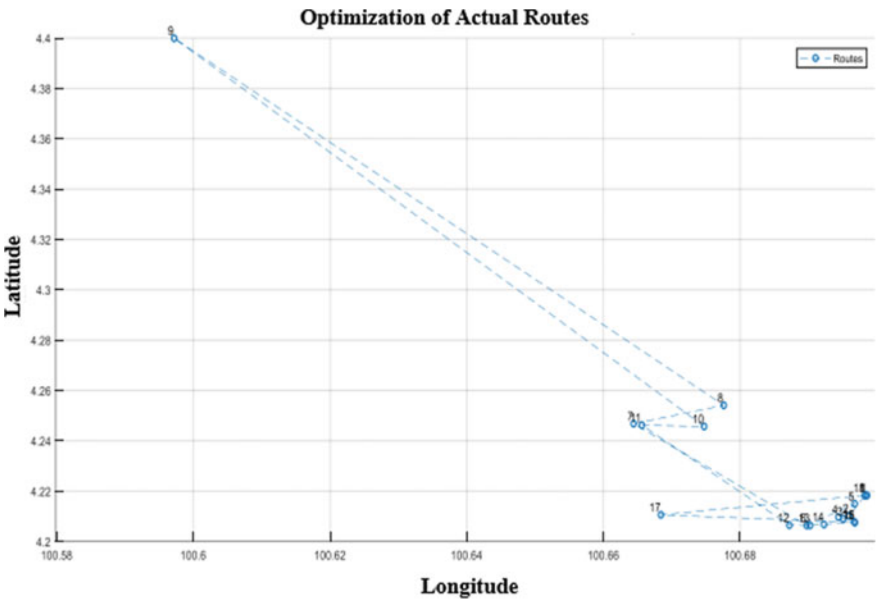

Fig. 12.2 Optimization of the actual routes

nodes (numbers) which are 1, 3, 5, 7, 11, 13, 15, and 17 are suggested as the first nodes covered for the waste due to the peak time and road condition. This area is located far from the nearest school and nearest residential area. It will probably effect the process of collecting waste and the speed of the truck in order to avoid accidents and poor road congestion due to industrial activities. Other than that, collecting the garbage at the remaining nodes at the afternoon session will avoid the peak hours of road usage. Nevertheless, the final location to dump the waste is located at the Segari Landfill which is convenient to select the nearest nodes to the last nodes.

12.4.3 Result of Carbon Emission

The suggested route is the route that is defined and measured by using the TSP method while the actual distance route is the result that is obtained from the motion study that was conducted mutually with MPM Sitiawan. Estimated distance is the route based on the estimated distance traveled from interview session which is 100 km per route. Based on [12], carbon emission also depends on other variables such as driving style, road condition, and distance traveled.

In this research, carbon emission from the estimated distance each day obtained from the interview session from respondents is about 21.52 kg CO_2. After the actual distance was taken from the motion study, the total carbon emission was 22.23 kg CO_2 which is higher compared to the estimated amount. The implementation of optimization in the GVRP will reduce the carbon emission produced from the waste collector truck. From the result, the new route selection has the total distance of 74.11 km which gives 15.95 kg CO_2 of carbon emission. The total difference of carbon emission using the new route is lower than about 28 percent (%) from the actual route distance by the truck.

12.5 Conclusion

The main goal of this research was to create an efficient management of waste collection that is cost-effective and lowers the carbon emission which gives benefit to the organization and environment. Toward the end of this research, it gives the better route selection using an optimization method and lower carbon emission produced during the waste collection process. Besides that, the data in this study measured the actual route used in collecting waste, route schedules, waste collector truck behavior, and cost projected by the organization in minimizing the cost needed for the operation. Furthermore, this research will contribute to other organizations and companies that deal with waste collection in choosing the best route for their activity.

From observation, this research produced a new suggestion of route that can give less carbon emission and cost reduction. This research can be applied to other areas of study such as industrial management, supply chain management, transportation management, waste collecting in ports, and courier service in urban areas. However, the need of having better green transportation is essential in this era because worry because of an increasing number of pollution. The domestic waste management is another area that need have improvisation in terms of disposing the waste. Furthermore, the condition of the road especially in landfill area is needed to improve the safety level due to the dangerous inclining road that put the life of the workers at risk. In addition, the location of the disposal area is not relevant for the trucks from Sitiawan to deliver which is far from the city.

12.6 Recommendation

This research provides a further development that can be done in the future to improve the GVRP in transportation. This research will require a lot of time to collect the exact and various data in order to get better results of new route suggestion. The limitation of time during conducting this research suggests that a longer period of conducting this research is needed. The hard process of getting permissions to enter the industrial area or company that works with waste collection management influences the time needed to make this research a success. In addition, this research can also be done by using other optimization methods to get the new suggested route. Reducing carbon emission and moving toward green transportation can be achieved by using other optimization methods. Different methods will give different results in route optimization. Next, the benchmark data and actual result of this research can be used in other areas of activities such as port waste management, courier services, supply chain management, logistics activities, and transportation management. Any activities that involve movement of vehicles can use optimization in determining the best route to use that give the lowest cost and pollution to the environment. Furthermore, the efficiency in transportation is vital for the company to have the lowest cost of operation to generate more profit from their services.

Besides that, recommendations on the initiative of disposing the domestic waste are needed to save the world from heavy pollution. Dangerous materials and chemicals are dumped at the landfills together with other kinds of waste that can release hazardous chemicals into the air. Activities in recycling the waste to materials that can be re-used need to be improved and further actions must be taken to have an efficient waste management. The increasing number of daily waste daily worries the impact on the world in the future for the next generation. It also is recommended that further safety measures and improvements need to be done for the road usage of the trucks. The road that is used by the trucks is dangerous and in bad condition which can lead to accidents. The government needs to take action on the improvement of road quality to reduce the risk of accidents during the waste collection period.

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Chapter 13
A Design of a Dielectric Resonator Antenna for Higher-Order Mode in the Shape of Rectangle for 5G Application

Shaiful Bakri Ismail, Muhammad Farihin b Abdul Aziz, and Mohd Najib Mohd Yasin

Abstract In this paper, the rectangular-shaped dielectric resonator antenna (DRA) operating on higher-order mode for the fifth generation (5G) communication applications is designed and presented. The millimeter-wave band was considered as a potential carrier frequency that is important to be one of the 5G technologies. The millimeter-wave band around 20–300 GHz was chosen to offer a large bandwidth, high gain, and minimum size to support higher data transmission in wireless communication. The proposed DR antenna is excited by using a microstrip feed line and designed at the operating frequency of 28 GHz. The Rogers RT/Duroid 5880 material having a thickness of 0.254 mm and a dielectric constant of 2.2 is used for the substrate. The commercial CST microwave studio (CST MWS) software is used for the optimization and simulation of the antenna design. In this research, the result is based on different dimension of the rectangular-shaped antenna by decreasing 2.9% and 1.1% the value of height and width respectively, but the value length is increased about 3.6% from the benchmark antenna design. The results indicate that the proposed antenna design produced a better performance about in the range of 1.5% to 7.2% in regard to return loss, bandwidth VSWR, gain, and directivity. Thus, the proposed antenna design is suitable for future 5G wireless communication applications.

Keywords 5G communication · Dielectric resonator antenna · Higher-order mode · Microstrip feed · Millimeter wave (mm-wave)

S. B. Ismail (✉) · M. F. b. A. Aziz
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: shaifulbakri@unikl.edu.my

M. F. b. A. Aziz
e-mail: mfarihin.aziz@s.unikl.edu.my

M. N. M. Yasin
School of Microelectronic, Universiti Malaysia Perlis, Arau, Perlis, Malaysia
e-mail: najibyasin@unimap.edu.my

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13.1 Introduction

Nowadays technology in wireless communication started to grow rapidly. This evolution is increasing due to new generation of data network, i.e. 5G that has been newly introduced [1]. Starting from analog (1G) to digital (2G), then continuing with the (3G) that provided high data rate and (4G) with cellular wireless communication systems that were mostly launched in every country [2]. Besides, there are some problems that had been faces in 4G technology such as high energy consumption, limited bandwidth, and spectrum crisis. To solve these problems, the millimeter-wave band around 20–300 GHz was used to offer a large bandwidth, high gain, and minimum size to support in data transmission in wireless communication. The millimeter-wave band was considered as a potential carrier frequency that is important to be one of the 5G technologies [4]. One of the antennas that were developed to enable operate in 5G applications, especially for bringing more transmission capacity and bandwidth is dielectric resonator antenna (DRA) [3].

The dielectric resonator antenna gives various advantages such as reduced radiation efficiency and low bandwidth impedance because of lossy silicon substrate materials. This antenna usually has a physical properties such as small size, low weight, and low cost [3]. These properties gave many advantages when designing an antenna as they can easily develop the use of the antenna in various applications. The dielectric resonator antenna covers a greater bandwidth as well as lower losses compared to microstrip patch antenna which makes it very suitable for applications at and over the millimeter-wave frequency [5].

The miniaturized antennas come from different shapes such as rectangular, hemispherical, cylindrical, and hybrid antennas. The two most common shapes of dielectric resonators antenna used are cylindrical and rectangular. But the advantage of using the rectangular shape is that it has three independence geometrical dimensions (i.e., length, width, and height). Rectangular structures are proposed to provide more versatility since two of the three dimensions can be changed freely for given resonant frequencies and associated by low degree of significance of differences compared to other shapes [3]. Basically, the shape of this antenna is essentially defined by a few parameters such as height, width, and depth of DRA and dielectric constant.

Higher-order mode essentially supports for high frequency and high gain [8]. The higher-order mode is one of the methods that is used to increase or optimize the value of gain for the DRA. Other than that, there were some other method that are used to increase the gain of the DRA such as stacking DRAs on top of each other, creating a shallow pyramidal horn, positioning a circularly polarized DRA within a circular cavity and the deployed dielectric superstrates as additional structures. The higher-order mode excitation is the simplest method of gain enhancement as compared to other techniques [9].

Thus, this research is aimed at proposing a better DRA design in rectangular shaped form for 5G application. According to [2], the frequency of 28 GHz achieved a wide impedance bandwidth and good return loss covering the targeted 5G bands. In this research, the antenna is proposed at an operating frequency of 28 GHz and we used the antenna design in [13] as benchmark design for proposing new alternative antenna designs. The proposed antenna design will change the dimensional values in order to increase the antenna performance. These results show the comparison performance in return loss, bandwidth, VSWR, gain, and directivity. The CST Microwave Studio 2019 software use to design the respective RDRA according to the proposed specifications while MATLAB were used to calculate the dimensions of RDRA.

13.2 Literature Review

13.2.1 Shape of Dielectric Resonator Antennas

Basically, the shape of this antenna is essentially defined by a few parameters such as height, width, and depth of DRA and dielectric constant [7]. There are a lot of shapes that can be formed in designing (DRA) such as rectangular, cylindrical, hemispheric, and circular cross-predominant. The different shapes provide different performance for different parameters likes permittivity, impedance, resonant frequency, and coupling mechanism [5]. According to the varying measurement of parameters, there will be various analytical models to analyze its configuration. The two most common shapes are the cylindrical and rectangular ones. Besides, the rectangular DRA is distinguished by a low degree of cross-polarization. This advantage makes the rectangular shape are more effective than cylindrical in designing the shape of an antenna [3]. However, there are some other complex shapes such as spherical, hemispherical, cross-shaped, and super shaped that are rarely used in designing an antenna because of difficulties in designing or fabricating. All dielectric design could be a radiator at a specific frequency by implementing the right technique that suitable to use [6].

13.2.2 Type of Feeder

To obtain the performance of the desired antenna, the so-called feeding mechanism is the method that is used to excite the antenna [10]. There are various feeding mechanisms required for designing such a type of dielectric resonator antenna system. This feeding mechanism is very important for the antenna society with a wide range of applications for the antenna. Due to the numerous feeding required to excite the DRA, a good procedure of selecting the best feeding mechanism is needed at millimeter wave frequencies [11]. The four most popular feeding mechanisms used are microstrip line fed, coaxial probe fed, slot/aperture couple fed, and co-planar waveguide (CPW) feed. Based on the list of feeding technique*s* that are used in developing DRA, microstrip line are very effective and efficient because of as it can be mounted directly above the microstrip line without the need to drill or cut a hole in the ground plane [3, 10, 14].

13.2.3 Basic Antenna Parameters

A dielectric resonator antenna is characterized by various factors such as high efficiency, compact size, and wide operational bandwidth. To meet the characteristics or specifications, it needs to refer to several parameters. The basic parameters of an antenna include the radiation pattern, directivity, gain, bandwidth, return loss, and voltage standing wave ratio (VSWR) [15].

(a) *Radiation Pattern*
Radiation pattern is a visual expression of an antenna's radiation properties. The radiation pattern is commonly known as a mathematical function of the antenna's radiation properties as a function of the space coordinates [6, 16]. It is provided an information how an antenna directs the energy it radiates.

(b) *Directivity and Gain*
Directivity is referred to as the ratio of radiation to the intensity that would be obtained if the antenna recognizes the power. Gain means a measure that is describing the performance of an antenna. However, both are closely related to each other [12]. Antenna gain is a more important specification than directivity, as it takes in account all the losses and it's a product of directivity and efficiency [16]. The efficiency is being measured by losses of the antenna due to manufacturing faults, resistance and other related factors.

(c) *Bandwidth*
The term bandwidth is classified as the frequency range in which the outcomes of the antenna occur according to certain characteristics. It is typically measured in unit of hertz (Hz) [6]. It is referring to the range of frequencies over which the antenna can operate correctly.

(d) *Return Loss*
Return loss is the power which signifies the total power that is lost to the load and reflect from insertion of a device in the transmission line [6]. Therefore, the value of return loss is equal to voltage standing wave ratio (VSWR) where the function is to represent the communication between the transmitter and an antenna [12].

(e) *Voltage Standing Wave Ratio*
The voltage standing wave ratio (VSWR) is an indication of the amount of mismatch between an antenna and the feed line connecting to it. Highest power transfer between the transmitter and the antenna must carry out for the antenna to perform effectively [6]. When the impedance of the antenna (Zin) matches with the transmitter (ZS), it will transfer maximum power. According to [12, 16], the maximum power transfer theorem, it can only be transmitted if the transmitter impedance is a complex conjugate of the antenna impedance being

considered. If the matching criterion is not met, some power may have been reflected, resulting in the generation of standing waves, which can be defined by VSWR.

13.3 Methodology

13.3.1 MATLAB Software

The aim of the MATLAB software is to give the best solution for calculating the dimensions of the antenna and to produce a numerical analysis to determine the resonant frequency. The calculation is based on the parameters of length, width, height of the rectangular DRA (RDRA) and the permittivity of the material. Basically, MATLAB is high-performance language for describing scientific computing to merge computation, visualization, and programming to solve the mathematical problem [17].

13.3.2 CST Microwave Studio Software

CST Microwave Studio or in short a for CST MWS is a tool that is used to design 3D electromagnetic fields accurately for devices with higher frequencies such as antennas, filters, planar, and other function related. Besides, CST also can simulate and solve all the electromagnetic problem for low frequencies as well as some other mechanical problems [18].

It commonly offers two types of solvers which are the frequency domain and time domain. Other than that, it also offers further solver modules for certain applications. In this research, the main software to design the antenna is by using CST Microwave Studio (2019).

13.3.3 Antenna Geometry

The proposed antenna geometry is shown in Fig. 13.1 obtained from designing in CST Microwave Studio. The proposed design specifications were taken from the antenna design in [13] and we modified the antenna dimensions length, width, and height. These three independent geometrical variables were changed to increase the performance of the antenna in terms of return loss, VSWR, gain, and directivity. In designing the RDRA, resonant frequency is an essential parameter to determine the performance of the antenna. Choosing the suitable frequency will allow the antenna to perform at the highest outcomes. The resonant frequency can be predicted by using the formula in Eq. (13.1). The design specifications of design (1) are shown in

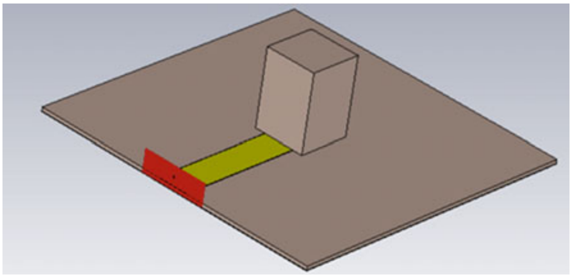

Fig. 13.1 Proposed antenna design

Table 13.1 Optimized dimensions of the proposed DR antenna

Parameters	Proposed Design
Length, a (mm)	3.63
Width, b (mm)	3.46
Height, d (mm)	4.95
Substrate Length, S_L (mm)	20
Substrate Width, S_W (mm)	20
Substrate Height, S_H (mm)	0.254
Thickness Conductor, Ht (mm)	0.035
Width Feed, Wf (mm)	2.1
Length Feed, Lf (mm)	9.83
Resonant Frequency Estimation (GHz)	25

Table 13.1.

$$f_0 = \frac{c}{2\pi\sqrt{\varepsilon_r}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 + \left(\frac{p\pi}{d}\right)^2} \tag{13.1}$$

13.4 Result and Discussion

We used the CST Microwave Studio Software to design and simulate the benchmark design and proposed design. The dimensions between both designs were different in terms of its length, width, and height of DRA as shown in Table 13.1. The results of the S-parameter, VSWR, gain, and directivity were taken as they are the most important parameters to determine the performance of the antenna in 5G application. The results for the simulated antennas are presented in Table 13.2.

The simulated S-parameter of the RDRA is presented in Fig. 13.2 as well as the result in Table 13.2. The return loss for the proposed antenna design is −37 dB at 28 GHz. While the return loss for the benchmark antenna design is −32 dB at 28 GHz. This shows that the proposed antenna design is better than the benchmark

Table 13.2 Summarized results

Parameters	Proposed Design	Benchmark Design
Resonant Frequency (GHz)	28	28
Return Loss (dB)	−37	−32
Bandwidth (GHz)	1.1	1.0
VSWR	1.0	1.0
Gain (dBi)	6.3	6.1
Directivity (dBi)	6.8	6.7

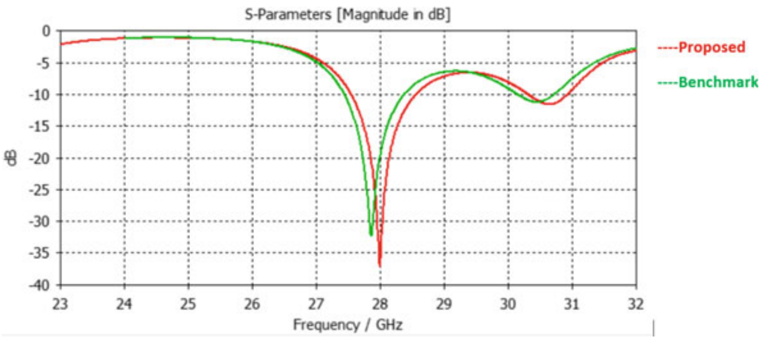

Fig. 13.2 S-Parameter graph result

antenna design about 7.2% in terms of return loss. A better return loss is indicated by higher return loss numbers, and that is better for the antenna.

Figure 13.3 shows the simulated VSWR curve as a function of frequency. The bandwidth of the VSWR shows the result of 1.0 for both proposed antenna designs and benchmark design antenna, respectively. The value should lie between 1.0 and 2.0. Thus, both designs have achieved the desired value of the VSWR. The lower the

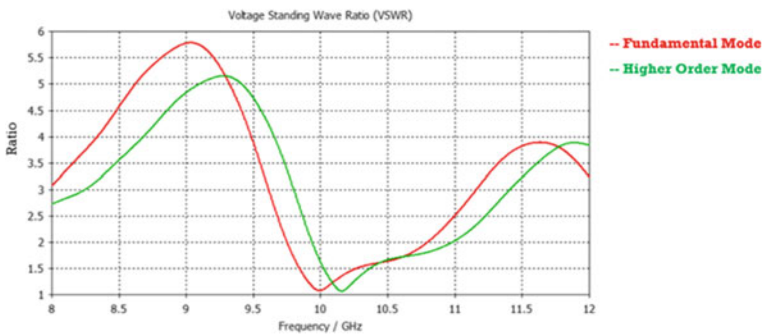

Fig. 13.3 VSWR graph result

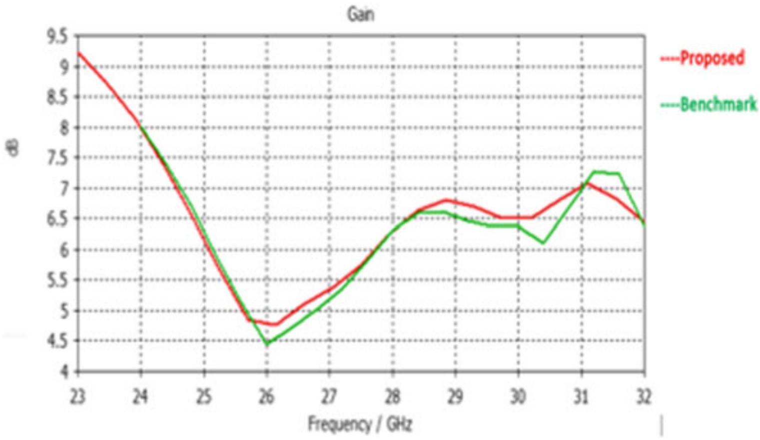

Fig. 13.4 Gain graph result

VSWR is, the better the antenna is impedance-matched to the transmission line and the higher the power delivered to the antenna.

The simulated gains are shown in Fig. 13.4. The gain achieved for the proposed antenna design and benchmark antenna design is 6.3 dBi, and 6.1 dBi, respectively. To meet the 5G requirement the antenna should gain at least 12 dBi. Both designs are achieved in this in millimeter wave applications as millimeter wave is a part of 5G application. The proposed antenna design increase about 3.2% value of gain compare to benchmark antenna design.

Antenna gain is the ability of the antenna to radiate in any direction. If an antenna could be made as a perfect sphere, it would radiate equally in all directions. At the same time, the antenna gain is closely related to the directivity. Figure 13.5 shows the result of the directivity for the proposed and benchmarks antenna design. The proposed antenna design gives about 1.5% better value in directivity compared to the benchmark antenna design. High in directivity, antennas can transmit and receive information over greater distances.

13.5 Conclusion

Based on the results obtained above, the proposed antenna design achieved the best result in terms of return loss, bandwidth, VSWR, gain, and directivity compared to the benchmark antenna design. These results are based on different dimensions of rectangular-shaped antenna. In this research and analysis, the dimensions of the RDRA are varied by increasing and decreasing between 1% and 4% the geometrical

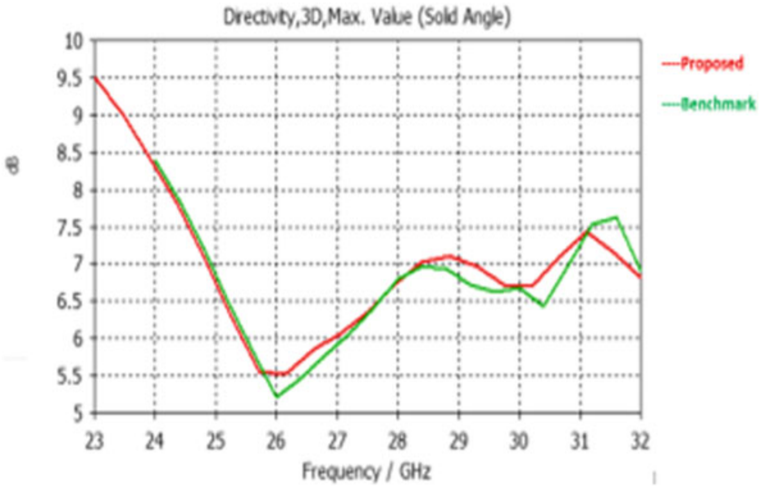

Fig. 13.5 Directivity graph results

dimensions of height, length, and width of the proposed antenna. This will effect on antenna performance for better value of return loss, bandwidth, VSWR, and gain. In this research, by comparing the benchmark antenna dimensions, the value of the antenna height and width are decreased about 2.9% and 1.1%, respectively, but the value length is increased about 3.6%. Toward the end of this research, the proposed antenna can be used to operate in 5G applications and is ready for the next stage, i.e., the fabrication process. Besides that, the effects of multiple dimensions in rectangular shape, the results will be different. A better value in the dimensions of antenna will produce the best results suitable to operate for 5G applications.

13.6 Recommendation

This research provides a further development that can be done in the future to improve the performance of an antenna for 5G application. The feeding technique used is the important part to excite the antenna. The proper feeding will maximize the performance of the antenna. Besides, the recommendation on the suitable material used is needed to make the antenna perform on its best results.

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Chapter 14
Development of a Solar Tracker Using Servo Motor and Light Dependent Resistor for Electrical Boats

Wardiah Mohd Dahalan, Arif Fikri Kamil Firdaus, Megat Khalid Puteri Zarina, and Noorazlina Mohamid Salleh

Abstract Solar power is one of the natural sources available in most countries. This gives a definite advantage to the tropical countries that experience hot weather to use solar energy to generate electrical power supply. However, the generation of electricity using solar irradiation is costly and it can produce its maximum capability only at peak hours which is 12 pm to 3 pm in a day. In order to overcome this disadvantage, researcher has developed a mechanism called the solar tracker. The solar tracker will track or trace the position of the sun from the morning until evening and manoeuver accordingly to get maximum exposure. By doing so, the solar panel can obtain its maximum capability in the morning and evening although the time is not in peak hour. A solar tracker can also increase the solar output from 5% to 20% depending on the tracker and weather. This project extends the development of the solar tracker by building a portable solar tracker by using a servo motor and a light-dependent resistor (LDR). The average voltage, current, and power output between this solar tracker and a fixed solar panel show more than 50% improvement. The percentage of the output between these two panels has been calculated to show the rate of improvement.

Keywords Dual-axis portable, solar tracker · Four-quadrant system · Servo motor

W. M. Dahalan (✉) · A. F. K. Firdaus · N. M. Salleh
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: wardiah@unikl.edu.my

A. F. K. Firdaus
e-mail: areffikri95@gmail.com

N. M. Salleh
e-mail: noorazlinams@unikl.edu.my

M. K. Puteri Zarina
Students Development & Campus Lifestyle Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: puteri.zarina@fbk.upsi.edu.my

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14.1 Introduction

Nowadays electrical boats have been used for certain industries due to their economic concept by not polluting the environment especially in the tourism industry. Electrical boats use batteries as their main power supply. The battery needs to be charged regularly to ensure continuous power supply. However, to increase the power electrical supply for the boat, the battery actually needs another support or supply so the boat can work for a longer time period. To solve this problem, the best supply that supports the battery is solar irradiation. Solar irradiation can be considered as one of the economical, renewable, and free sources of energy supply that can support the battery.

Since the solar set is inexpensive and affordable, it can be considered as the best alternative. However, if the solar panel is fixed or static to one position, it will not be able to absorb the maximum input from the sun. To increase the efficiency of solar absorption, the solar tracker has been developed by which it moves the solar panel toward the position of the sun. Some research and journals mentioned that a solar tracker can increase the efficiency of the solar panel about 20–40%.

There are many techniques and concepts used to build solar trackers. The different techniques and concepts made will produce different results. The method used in this study is based on a servo motor and the light-dependent resistor as the technique to move the solar tracker. Usually, a servo motor is used in remote-controlled boats.

The servo motor is known as one of the high torque motors that will spin the motor smooth and fast and this will give a huge advantage in remote control boats. The light-dependent resistor will be used as the solar sensor. The four-quadrant sensor system techniques are used to catch every angle of the sunlight. For the operation of the solar tracker, the Arduino UNO will be used. Arduino is one of the newest technologies that can be programmed to work on it. With this concept idea, it can produce a quality solar tracker for hybrid electrical boats.

The previous work [1] conducted a research on how to improve the power saving by using a solar tracker. In their study, they used several methods to build their solar tracker. Firstly, for the microcontroller, analog comparator (AC), analog to digital converter (ADC), universal synchronous asynchronous receiver transmitter (USART), and timer were used. In order to control the direction of the solar panel, some microcontrollers are using pulse width modulation (PWM).

Another researcher [2] in his journal title solar tracking system did a research on how the solar tracker improves the efficiency of the output of solar panels. The research discussed about the process to make the solar panel from DC power supply to a light-sensing circuit. The tracker then controls and finishes at the stepper control that moves the solar panel.

In the project [3], the researcher presented a solar tracking system by carrying out an experiment to show a comparison between a dual-axis solar tracker and a fixed solar panel. In this project, the equipment used was a battery, charge controller, LDR, stepper motor, and DC motor. Meanwhile, researcher in [4] has used two methods on their methodology which are the open-loop control technique and close-loop control technique for automatic sun tracker system. Basically, the open-loop control technique uses the voltage calculation to control the servo motor either the voltage increases or drops while the close-loop technique uses the LDR that will send the data to move the motor [5].

In another investigation [6], the researcher applied a hybrid method where the open loop technique and the close-loop technique were combined together. The solar panel will use the close loop when the LDR is fully functioning and when the weather is cloudy where the LDR cannot detect the sun properly, open loop technique will take over to control the solar tracker by calculating the voltage.

Meanwhile in [7], a comparison was made between the open loop and the close-loop techniques. Using the stepper motor and microcontroller, the researcher builds up both solar panels. The result of both techniques has been recorded in table format for comparison. Meanwhile, a group of researchers [8, 9] conducted a research and project to compare the efficiency between fixed solar panels, single-axis and double-axis solar panels. The approach used a stepper motor, Arduino NANO, and GPS module to build the solar tracker. The advantages of a GPS solar tracker are that it can move the solar panel by following the azimuth of the sun. This researcher then compared the result between the GPS solar tracker and the fixed solar panel.

Based on the previous works, many researchers had a similar objective and different methods. However, every research has its own advantages and disadvantages in order to produce better results.

14.2 Methodology

Figure 14.1 shows the block diagram of the project. Based on the block diagram, the process starts with the sun location. The LDR will use the four-quadrant technique sensor system to detect the location of the sunlight. After that, the LDR will send the data to the Arduino UNO and the Arduino will then control the motor to move the solar panel based on the sun position.

Figure 14.2 shows the four-quadrant sensor system that uses four LDR. It will separate the LDR into four positions which are north, south, east, and west. The reason that the LDR is being separated is to prevent the input which is the intensity of sunlight from being mixed together. The intensity of light at all LDR is probably the same at 12 pm because the sun is on top of the solar tracker so the LDR will get

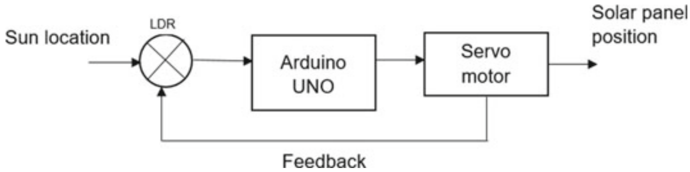

Fig. 14.1 Block diagram project

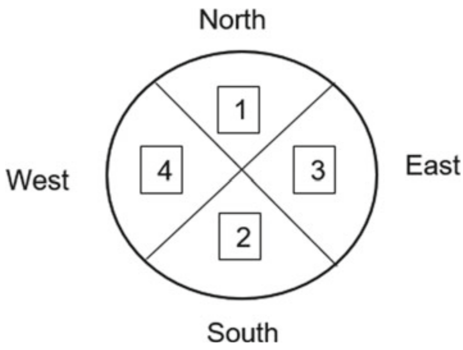

Fig. 14.2 Four-quadrant sensor system

the same intensity of light. If the intensity of light at LDR 1 and 3 is the same, the solar tracker will be between the north and east position and the same goes to other LDR that have the same intensity of light.

The PCB circuit etching in Fig. 14.3 is designed based on the circuit project. It needs some creativity when designing the PCB board. If the PCB circuit failed to design, some cables might be failed to work because of the wrong connection or the connection is intercepted. To design the PCB circuit, there are more than one software tool that can be used. Some software might not have Arduino inside it and needs to be downloaded.

After designing the PCB circuit, it needs to be converted to the PDF format and printed on plastic paper. After printing, some equipment needs to be used in the university lab where the printed PCB circuit will be transferred to the PCB board. After finishing to prepare the PCB, some holes need to be drilled on the PCB board based on the design in electronic parts such as resistor, Arduino, and LDR can be attached on the PCB board. Electronic devices that are attached to PCB board need to be soldered to make it fully functioning.

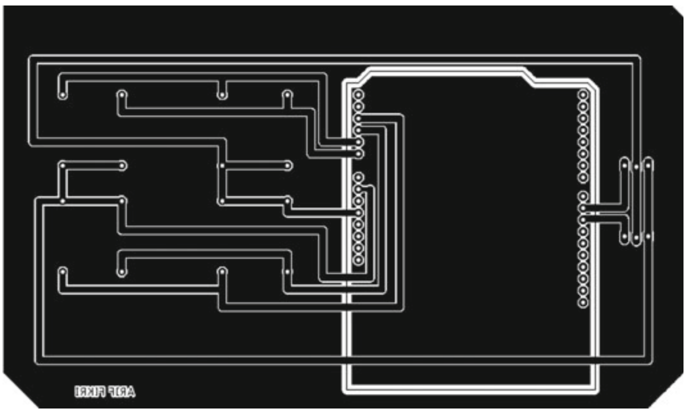

Fig. 14.3 PCB circuit etching

14.3 Design Specification

The design circuit for the solar tracker is using the software EasyEDA as shown in Fig. 14.4. The software uses many electrical and electronic components but it is easy to use. From the circuit, the Arduino UNO is the center of other components connected since Arduino UNO is the microcontroller that controls the solar tracker. The Arduino UNO has an output of 5 V will connect to all other components. The LDR will go through the resistor of 1 k ohm to control if there is an overflow of current on the circuit from the LDR input. The signal or input data for the servo motor are received from the Arduino pin 9 and pin 10 leg. All ground connections are connected together. Meanwhile, 3D paint is a software program on Microsoft 10 that can be used to design something in 2D or 3D. The object can be rotated 360 degree. It also can maximise or minimise the size of object depends on users. The scale or dimension can be label using 2D draw or 3D.

Based on Fig. 14.5, it shows the four component parts of its lower body, horizontal motor base with wheel, vertical motor handler, and solar base holder. For the vertical motor handler which consists of the solar base holder and horizontal motor base, it is made from Perspex board because Perspex board is easy to cut and design. It is also durable and does not require any maintenance. For the lower body, it will use a high-quality plastic box because the box is durable and waterproof to protect the circuit inside the body. Lastly, for the arm handler it will use a metal rode for durability and easy to adjust the length.

Based on Fig. 14.6, the hardware design is shown from its front view. The lower body part has 20 cm length and 8 cm height. The lower body needs to be large enough to balance the project. The height is 8 cm to make it large enough so the electronic circuit and horizontal servo motor can be installed inside it. The horizontal motor

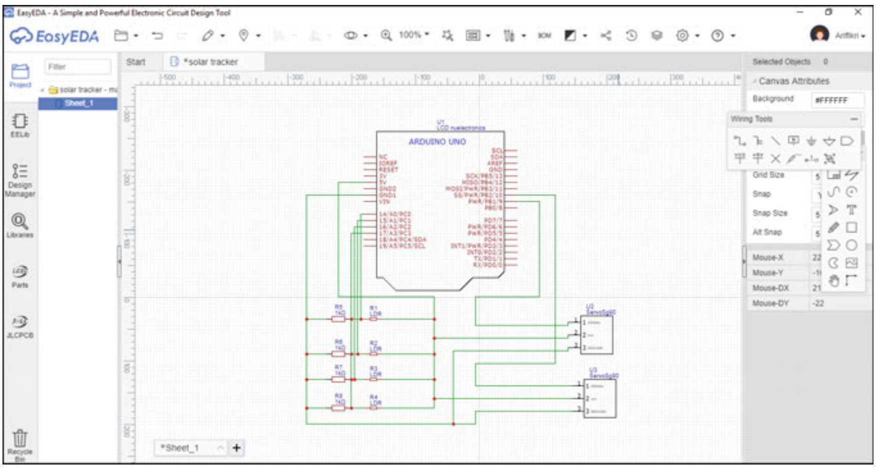

Fig. 14.4 Design circuit of solar tracker

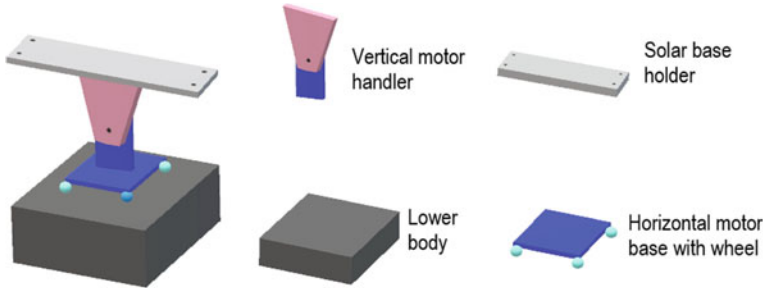

Fig. 14.5 Design hardware of project

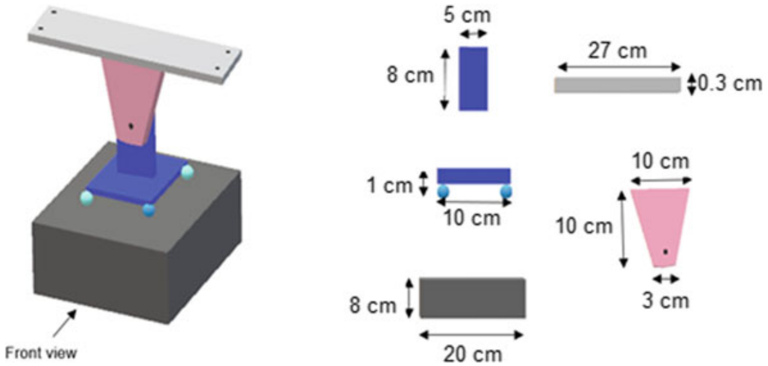

Fig. 14.6 Front view design of project

base with wheel has 20 cm length and 1 cm height. The vertical motor body has 8 cm height and 5 cm length. The vertical motor handler is 10 cm high, the lower part has 3 cm length and upper part is 10 cm length. For the solar base holder, the length is 27 cm and 0.3 cm in thickness.

Figure 14.7 shows the side view of solar tracker design. From the front view, the lower body size is 15 cm length and has same 8 cm in height. The horizontal motor base with the wheel has the same dimension from front view. The vertical motor body has 0.5 cm thickness and vertical motor handler has a thickness is 0.9 cm. From the side view, the length of the solar panel is 10 cm.

14.4 Result and Discussion

The solar tracker is attached to solar charger and is charging the battery as shown in Fig. 14.8.

Based on the objective of this research, it was successfully built and developed based on the design and methodology. The solar tracker can function well. The second

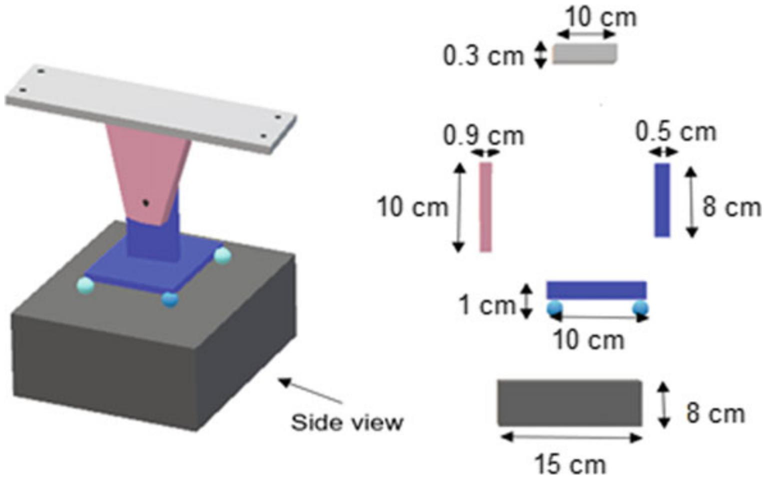

Fig. 14.7 Side view design of project

Fig. 14.8 Solar tracker

objective which is to analyze the performance of the solar tracker for output of the solar panel is being analyzed by the percentage of the solar tracker output compared to the fixed solar panel. The performance of the solar tracker output is analyzed and compared to the fixed solar panel.

All performance data are set by coding in the Arduino Uno which acts as a mother controller of this project. By using the four-quadrant LDR concept on the solar tracker, each LDR will compare the intensity of the light and will give the data to the Arduino. In the coding of the Arduino, each intensity level will move a minimum of 20 degree and a maximum of 270 degrees. The speed of the servo motor is 0.14 s/60 degree at a supply of 4.8 V. But due to some load on the servo motor, the speed has been reduced a little bit. The movement performance of this solar tracker is not very smooth and has a small delay when changing the movement. As an example, from north to south there is 0.2–0.8 s delay when changing the position. Some LDRs do not track the light properly if the light is too close to the LDR. As the result, the solar panel sometimes will move choppily.

The third objective of this project is to record and compare the voltage, current, and power output between the solar tracker and fixed solar panel. All data have been recorded in the table for two consecutive weeks. The data are recorded from 8 am to 6 pm every day and the data are used to calculate the average output power produced and the percentage of difference between the solar tracker and the fixed solar panel.

The average output between the solar tracker and the fixed solar panel was taken during 14 days and is shown in Table 14.1. The average voltage is taken from 8 am until 6 pm during 14 days. The highest voltage at day 1 for the solar tracker is 10.07 V and the lowest is at day 10 where only 6.92 V were produced at that day in that day.

Table 14.1 Average output voltage of solar tracker and fixed solar panels

DAY	Solar tracker (V)	Fixe d (V)
1	10.07	9.39
2	9.94	9.32
3	8.33	7.68
4	8.96	8.37
5	9.24	8.44
6	8.16	7.96
7	7.09	6.65
8	8.16	7.85
9	9.42	8.85
10	6.92	6.68
11	9.18	8.66
12	7.54	7.3
13	8.18	7.68
14	9.55	9.04
Average	8.62	8.13

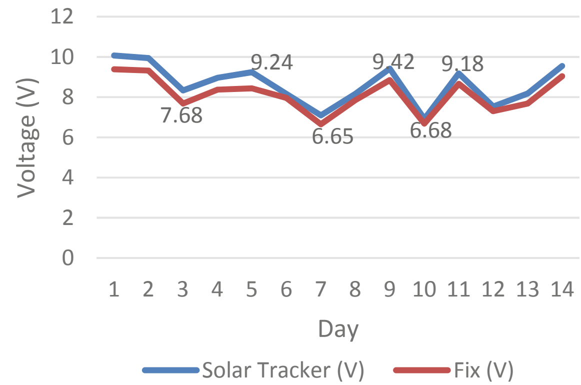

Fig. 14.9 Average output voltage

The fixed solar panel also got the highest voltage on day 1 which is 9.39 V and the lowest on day 7, which only produces 6.65 V.

All the values below the average are affected due to overcast or raining weather. The average voltage of the solar tracker in 14 days is 8.62 V and fixed solar panel is 8.13 V. Both solar panel voltages are being taken by using a multimeter. As stated in the methodology section, the solar panel can produce maximum of 14 V during a sunny day. To calculate the percentage of the voltage output, the formula is output over input times 100. So, the percentage voltage produced by solar tracker on these 14 days is 61.57% while the fixed solar panel produced 58.07% from the maximum voltage. The difference in percentage produced between these two types of solar panels is 3.5%.

Figure 14.9 shows graphs of the results based on Table 14.1. Basically, this solar panel only has an average production of 8 V per day, but with the solar tracker it can produce up to 10 V during a sunny day. From the graph, solar tracker can produce higher than 8 V every day except for day 7, 10, and 12. However, the fixed solar panel produces more than 8 V which is below average. On day 10, both solar panels produced a voltage below 7 V because of overcasting weather and raining.

Table 14.2 shows the result of the current produced by both solar panels. From the table, the difference between the solar tracker and the fixed solar panel is 0.05 A at which the average solar tracker produced 0.73 A and the fixed solar panel produced 0.68 A in 14 days. The highest current produced by the solar tracker is on day 1 which is 0.87 A while the highest by fixed solar panel is 0.8 A. The lowest current produced by the solar tracker is at day 10 which is 0.59 A. The same holds for the fixed solar panel that only produced 0.58 A.

Both solar panels produced a low current on day 10 which is below 0.6 A due to a rainy day. The current taken from the solar panel was measured using a multimeter. As stated in Sect. 14.3, the maximum current output of this solar panel is 1.5 A. The percentage of current produced by the solar tracker is 48.66% while the fixed solar panel is 45.33% while the solar tracker is lead 3.33% from the fixed solar panel.

Figure 14.10 shows the graph of the results obtained from Table 14.4. From the graph, both methods produce a current between 0.6 A–0.8 A. On day 6, 8, and 10, the

Table 14.2 Average output current of solar tracker and fixed solar panel

DAY	Solar tracker (A)	Fixed (A)
1	0.87	0.8
2	0.83	0.75
3	0.81	0.6
4	0.73	0.66
5	0.76	0.69
6	0.66	0.65
7	0.62	0.57
8	0.65	0.64
9	0.8	0.73
10	0.59	0.58
11	0.78	0.74
12	0.65	0.62
13	0.67	0.64
14	0.83	0.78
Average	0.73	0.68

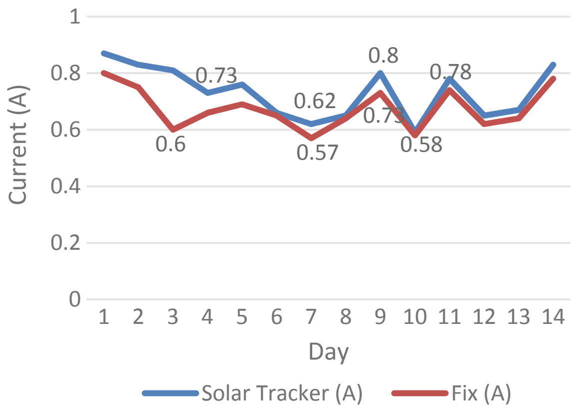

Fig. 14.10 Average output current

current produced is almost the same value due to overcasting and raining weather that interrupt the advantage that the solar tracker can use. Table 14.3 shows the comparison of the average output power between solar tracker and the fixed solar panel. The total average power produced by the solar tracker in 14 days is 7.81 W while the fixed solar panel is 7.26 W. The highest power produced by the solar tracker is on day 1 which is 9.76 W while the fixed solar panel is on the same day which is 8.77 W.

The lowest power produced by the solar panel is on day 7 which is 5.53 W for solar tracker and 5.03 W for the fixed solar panel as indicated in Table 14.3. There is no device that uses to check directly the power from both solar panel. The result of power per day is calculated by result voltage × current per day. The maximum power from this solar panel is 20 W. By using formula output over input times 100, the average percentage of power that the solar tracker can produce in these 14 days is 39.05% while the fixed solar panel can only produce 36.30%.

Table 14.3 Average output power of solar tracker and fixed solar panel

DAY	Solar tracker (W)	Fixed (W)
1	9.76	8.77
2	9.11	8.24
3	7.43	6.76
4	7.63	7.08
5	8.33	7.36
6	7.65	7.41
7	5.53	5.03
8	7.22	6.94
9	8.49	7.89
10	6.49	6.26
11	8.22	7.76
12	6.92	6.72
13	7.6	7.15
14	8.9	8.3
Average	7.81	7.26

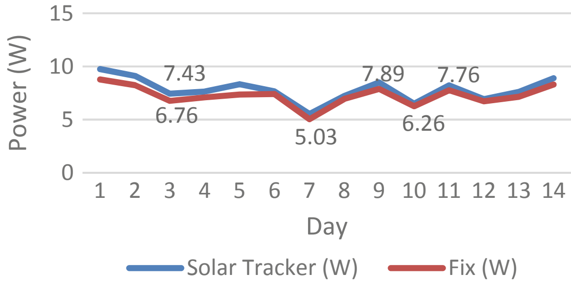

Fig. 14.11 Average output power

Based on Fig. 14.11, it shows the line graph result produced from Table 14.3. On day 7, the power produced on both solar panels is below 6 W which is lower than other days.

Based on Table 14.4, it shows the voltage result, current, and power output of the solar tracker and fixed solar panel. The highest output is at 12 pm. Both solar panels produce the same power which is 17.68 W. At 8 am, the voltage of the solar tracker starts with 4.44 V compared to the fixed solar panel that starts at 2.8 V. The current at the solar tracker started at 0.4 A and produced 1.78 W compared to fixed solar panel that only produced 0.2 A current and 0.56 W power. This happened because at 8 am, the sun is on the position where fixed solar panel cannot absorb all the sunlight compared to the solar tracker that tracks the sunlight and faces the solar panel directly at sunlight. The difference between the solar tracker and the fixed solar panel at 8 am is solar tracker lead 1.22 W power. Solar tracker can maximise the performance of the solar panel by absorbing the full sunlight in the morning. It proves that the solar tracker can improve the efficiency of solar panel based on this

Table 14.4 Output voltage, current, and power of day 1

Day 1	Solar tracker			Fixed solar panel		
Time	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
8:00 AM	4.44	0.40	1.78	2.80	0.20	0.56
9:00 AM	7.79	0.70	5.45	6.20	0.50	3.10
10:00 AM	10.21	0.90	9.19	9.30	0.80	7.44
11:00 AM	12.31	1.00	12.31	11.90	0.90	10.71
12:00 PM	13.60	1.30	17.68	13.60	1.30	17.68
1:00 PM	13.58	1.20	16.30	13.55	1.20	16.26
2:00 PM	13.33	1.10	14.66	13.32	1.10	14.65
3:00 PM	12.34	1.00	12.34	12.34	1.00	12.34
4:00 PM	10.09	0.90	9.08	10.09	0.90	9.08
5:00 PM	9.31	0.80	7.45	7.31	0.70	5.12
6:00 PM	3.81	0.30	1.14	2.90	0.20	0.58
Average	10.07	0.87	9.76	9.39	0.80	8.87

result. The same goes at 6 pm on day 1; the solar tracker can produce more power which is at 1.14 W compared to the fixed solar panel which only produces 0.58 W. From this result, the solar tracker can perform better in the morning and evening because the solar tracker's surface can face the sun directly while the fixed solar panel cannot do that. At 12 pm in day, both solar panels produce the same result and nearly achieve 100% of their capability performance. Both solar trackers produce 97.14% from their maximum capability of 14 V. For the current output, both solar panels produce 86.66% from their maximum capability 1.5 A and 88.4% from 20 W power.

The lowest output produced by both solar trackers is at 6 pm where it is almost sunset. The percentage of the produced solar tracker voltage from the maximum capability is 27.21% while the fixed solar panel is 20.7%. The difference in percentage is 6.51%. At 6 pm, solar tracker only produces 0.3A which is only 20% from the maximum capability while the fixed solar panel produces 0.2A which is only 13.33% from maximum capability. The difference that the solar tracker can produce is 6.67% more compare to fix solar panel.

For the total average in day 1 from 8 am to 6 pm, the voltage produced by the solar tracker which is 10.7 V reached 76.42% from the maximum capability while the fixed solar panel is 9.39 V, only reached 67.07% of its maximum capability with the different of 9.35% that was produced by solar tracker. The total average current produced by the solar tracker reached 58% from the maximum it can produce while the fixed solar panel produced only 53.33%. So the different current output from both solar panels is 4.67% which is led by the solar tracker.

For the average percentage of power output produced by the solar tracker is 48.8% while the fixed solar panel is 44.35%. So the solar tracker can produce extra 4.45% power output compared to the fixed solar panel in day 1 from 8 am to 6 pm.

14.5 Conclusion

Solar irradiation is one of the alternatives to get free energy. From this research, it is proven that using a solar tracker will increase the output of the solar panel. The more efficient the solar tracker, the better its performance to increase the output of the solar panel until it reaches the maximum output from morning to evening. The method which utilizes two servo motors will generate more electric power as the solar tracker is more likely to move according to the position of the sun. Solar irradiation is known as a free source that can be utilised in from tropical countries such as Malaysia. Instead of using many solar panels, the solar tracker is one of the good alternatives to improve and increase the efficiency and output of the solar panel. Solar irradiation is free source but it is a bit costly. Furthermore, the maintenance of solar tracker is free.

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Chapter 15
Barnacles Growth Monitoring at KL Paus Hull Using Scilab Programming

Zulzamri Salleh and Abdul Rahman Harun

Abstract The aim of this research is to monitor the growth of barnacle at the KL Paus hull vessel part using Scilab programming (image processing). Barnacles paste on the hull of a ship might effect the resistance of the vessel, increase friction and can reduce the vessel's speed. The ship must then be put in a dry dock to have the bottom scraped. From the results, it is shown that barnacle grew drastically for three consecutive months and the analysis form the Scilab Blob analysis found the indicated grey, dark and red intensity with true pixel increased by 30%. The edge detection image was also able to find the starting of the barnacle growth with small size. The monitoring of the barnacles is difficult if no proper instrument and analysis processes are used. It is now commonly accepted that using computers simulation and data analysis have become widespread throughout differences areas of engineering applications. By using the Scilab software, we analysed the photos of barnacle growth that were taken frequently for 3 months.

Keywords Barnacle · Image processing · Scilab

15.1 Introduction

Mainly unwanted colonisation organisms such as marine biofouling are common on immersed structures and they rapidly grow in the sea. In marine, barnacles are the main problem marine transport such as boat, ship and sub-marine vehicles because need periodically blasting and cleansing process [1]. The barnacle is a small saltwater animal with a protective shell-like covering. There are more than 1,000 species around the world. The effect of barnacles on the hull of a ship might decrease the performances such as the drag of the vessel, friction and this can reduce the vessel's

Z. Salleh (✉) · A. R. Harun
Maritime Engineering Technology Section, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology Lumut, Perak, Malaysia
e-mail: zulzamri@unikl.edu.my

A. R. Harun
e-mail: rahman_harun88@yahoo.com

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speed and hence increases the fuel consumption to offset the higher friction [2, 3]. The ship needs to go through a certain processes at a dry dock to have the bottom scraped [4]. To prevent barnacles from clinging to ships, antifouling reagents could be used as the hulls are either treated with chemical such toxic paint containing tin or copper or are coated with plastic layer. The monitoring of the barnacles is difficult if no proper instrument and analysis processes are used during this investigation. Early detection and recognition of marine growth are possible ways to use the learning and deep convolutional neural network (CNN) approach [5]. The barnacles monitoring can be done by observing their growth using the image processing method [6]. Therefore, computer modelling and data analysis have become very useful nowadays. In this research, the growth of barnacles is monitored using Scilab programming (image analysis) at the K.L PAUS vessel, especially at the hull part as shown in Fig. 15.1.

The growths of barnacles are drastically increasing when they are breeding on the hull part as shown in Fig. 15.2. This problem has caused damage to ship owners. By introducing Scilab software, the picture of barnacle can be analysed that was frequently captured in several month activities [7]. The growth of the barnacles is monitored from the time being. Scilab software is considered a free software alternative to MATLAB, hailed very often as the language of technical and scientific computing. MATLAB has found a permanent place not only in the curriculum of applied science and engineering studies, but also in research and the development

Fig. 15.1 K.L PAUS vessel hull

Fig. 15.2 Barnacles growth at hull surface

area. Scilab closely mimics functionalities of MATLAB software and is emerging as an effective alternative. The functionality of Scilab comprises a large collection of toolboxes suitable for applications in science and technology fields.

The Scilab Image Processing Design Toolbox (IPD) is used for image processing, for example, detection of surface defection in QC, detection of anatomical landmarks in medical surgery, number of cells and classification of regions in remote sensing activities [6]. The process might be involved in image processing such as to generate the images by using optical cameras, ultrasound, x-ray machines and other imaging devices [5]. The format of images must be created in a digital format. There are some basic methods involved to distinguish between objects and background and to describe regions in digital images.

In this study, several photos of barnacles that stick on the KL PAUS hull surface were analysed using the Scilab software. The surface area of this vessel is very important and the constant contact condition with the seawater level may result undesirable additional friction that needs to be considered. Barnacles growths were monitored frequently and taken once a month for duration of three-month monitoring.

15.2 Methodology

15.2.1 Selection Area at Hull

It is to ensure that this research of monitoring the barnacles growth at K.L Paus hull using the Scilab programming (image processing) is smoothly running without any problem or misunderstanding during collecting data. The sample picture of barnacles at the K.L Paus hull part has been taken to fulfil this research requirement to complete with success. From this sample picture, the pilot test produced the collected data to be analysed to meet the standard and requirement of this research. Then the sample picture of barnacles is revised until the suitable picture of barnacle is produce for this research. Figure 15.3 shows that diver has taken the photo of barnacles at the KL PAUS hull.

15.2.2 Data Processing and Analysis

The growth of barnacles can be observed clearly during clear seawater condition. The data has been collected for three months monitoring and analysed using the Scilab software. The data of photos for each month has been compared, and new barnacles growth has been identified for each month when checking their pixels numbers.

Fig. 15.3 Diver under taken the photo of barnacles

15.3 Results and Discussion

All the images taken within three months were analysed and have been illustrated in Fig. 15.4. From the results, it can be seen that the barnacle growth drastically increased throughout this period. The Scilab tools have performed four analyses on the captured images; namely, blob analyses, edge detection, gradient analyses, and histogram graph. Each function is very important for image processing analyses particularly. The blob analysis is to find the different images between the surface hull and seawater level. The result from these analyses was produced three categories such as different red, grey and blue (RGB) images. The representative samples can be seen in Fig. 15.4 which shows the blob analysis.

Barnacles are entirely darker than the background. Therefore, these two objects can be detected by searching these comparatively dark regions. The barnacles are starting to grown up when the surface of vessel has plenty of space area wihtout detriotation from others plant. The red image is of higher intensity image while the grey is a greyscale shown in Fig. 15.5 and the blue is the filtered image showed in Fig. 15.6. Objects can be found in a logical image by searching the connected areas of true pixels. The pixels of each connected area are mapped to an integer number greater than zero. All pixels of the same area have the same number whereas pixels belonging to different areas have different numbers. All false pixels are mapped to zero.

Edge detection analysis is one of the main analysis methods for object determination in Scilab. The objects in the sample image can be demarcated against the background by their edges. It is possible to detect the edges, select points within the areas surrounded by edges and apply the watershed transform to detect the areas between the edges. A gradient image is calculated from the grey-level image. Another important part in image processing is the edge detection analysis to define the edge of the barnacle growth from the sample photo taken. The difference of barnacle edges can be seen on the three samples taken for different months. From the photo, it can be seen that the growing up of the barnacle from the edge detection shown in Fig. 15.7.

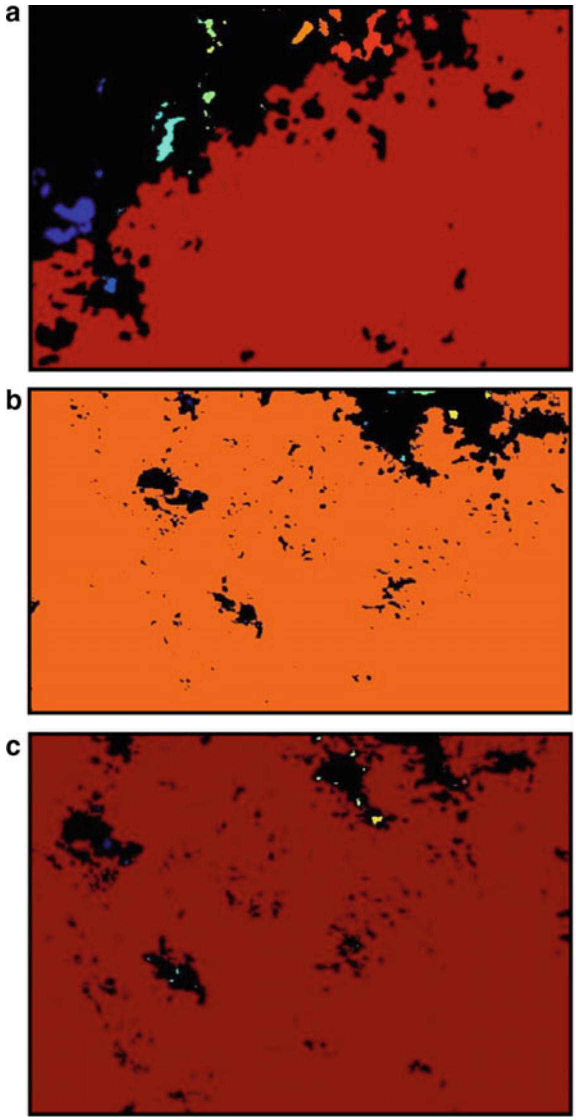

Fig. 15.4 **a** Blob analysis photo of 1st month. **b** Blob analysis photo of 2nd month. **c** Blob analysis photo of 3rd month

From the edge detection analyses, we can see that the black colour of the image refers to the KL Paus hull and the grey colour is a barnacle. The more value of grey colour the more barnacle growth. On the beginning of the month, it can be observed that the grey colour is the peak of the barnacle and it shows that the barnacle is starting to growing up and to fill the area. It is also shown the edge of the barnacle, beginning of month the photos shows that the barnacles are starting to grow and at the end of three months it can be seen that edges of barnacle are growing up drastically as shown in Fig. 15.8.

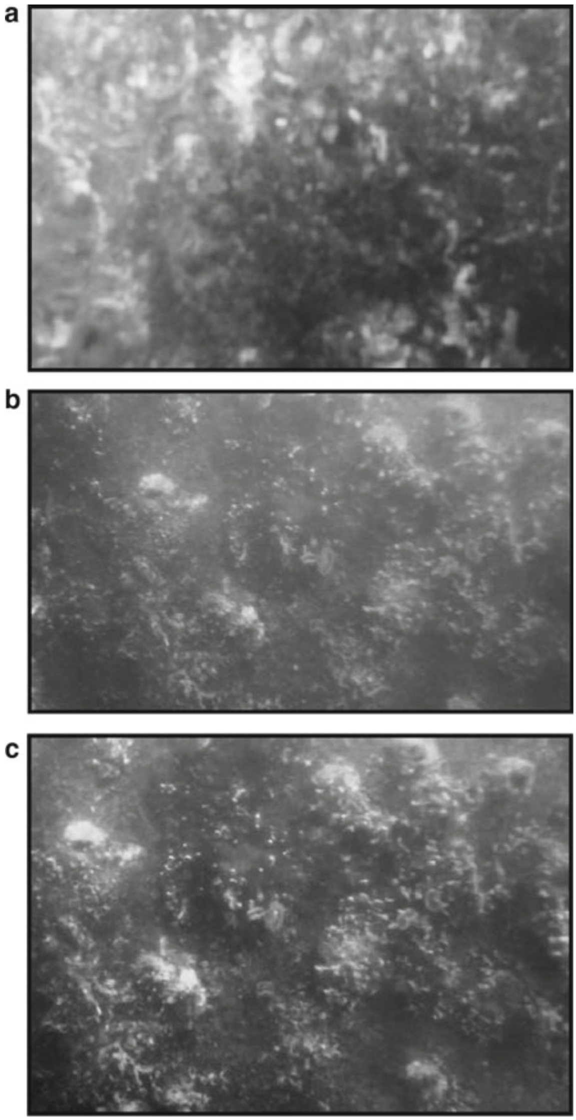

Fig. 15.5 **a** Greyscale image detection of 1st month. **b** Greyscale image detection of 2nd month. **c** Greyscale image detection of 3rd month

These barnacles have changed their colours based on the surface of the hull. Some image colour properties were compared and it can be seen that images have the best quality due to the clarity of seawater at that particular time. At a different time, the barnacles continued to grow even though effected by the sea level (low and high tide). The white colour shows the growth of new barnacles and it can be depicted by histograms using Scilab programming. With the function of blob analyses, all images can be represented by three basic colours, i.e. red, grey and blue. From the above figures, the differences of barnacle growth in the period of three months can

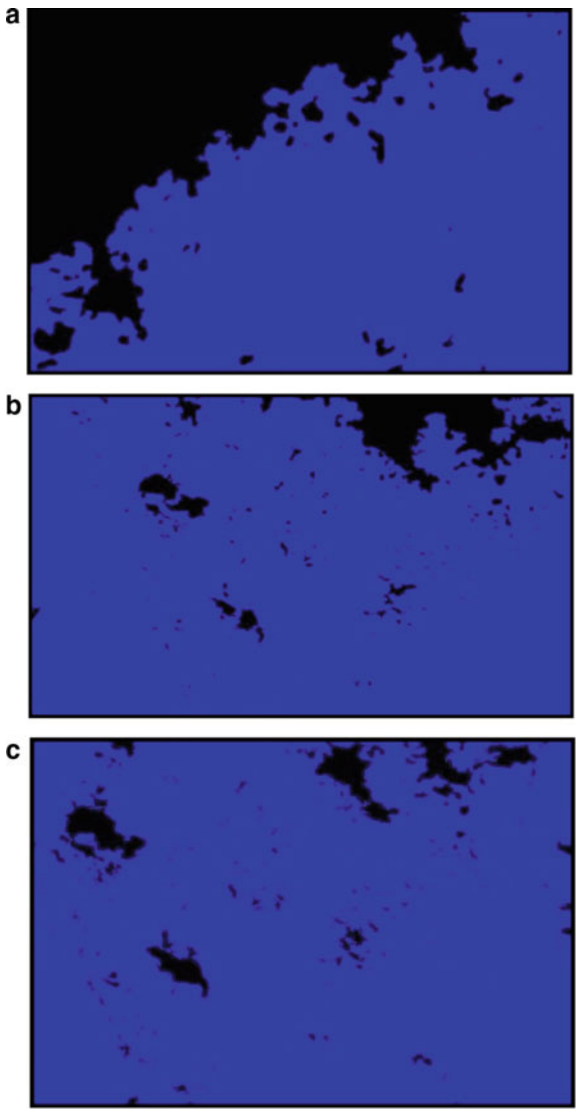

Fig. 15.6 **a** Blue image detection of 1st month. **b** Blue image detection of 2nd month. **c** Blue image detection of 3rd month

be traced and identified. Basically, barnacles started to grow in the first month (black colour depicts the barnacles).

Based on the from intensity histogram analyses, it can be observed that the growth of the barnacles from first, second and third month can be depicted. Beginning from the first month to the third month, the number of peaks continued to increase aligned with the barnacles growth.

Figure 15.9 relates to the first month and the graph indicates three peaks but only shows one peak with a pixel amount of 1500 pixels. The following month image

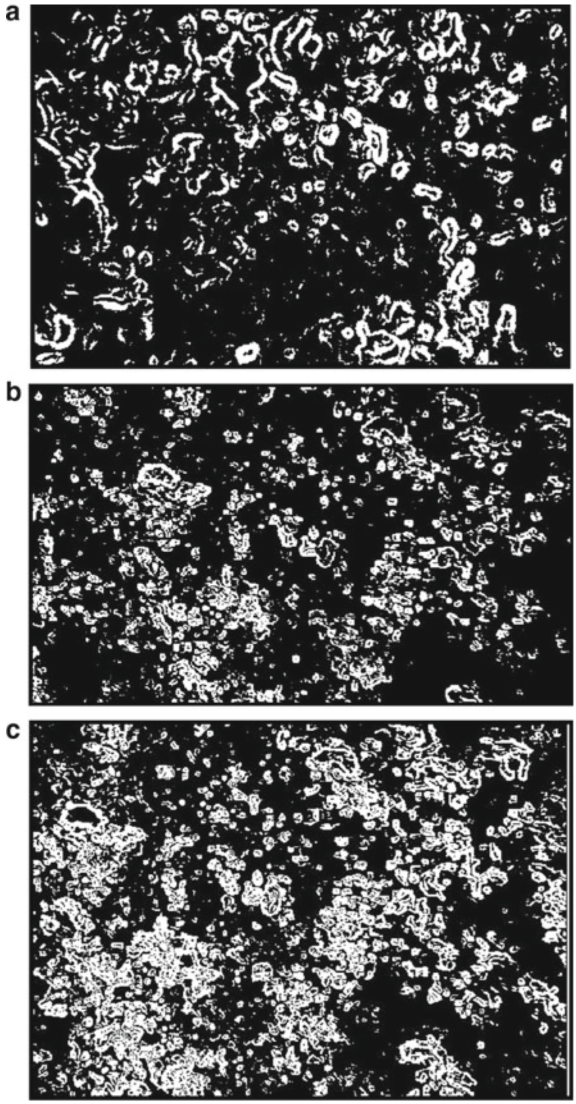

Fig. 15.7 **a** Edge image detection mode of 1st month. **b** Edge image detection mode of 2nd month. **c** Edge image detection mode of 3rd month

(Fig. 15.10), it can be seen that the four peaks occurred in the graph with attaining a maximum value of 2600 pixels. Finally, Fig. 15.11 shows the histogram result analysis at which several number of peaks were made on an image captured at a higher peak with 2950 pixels. It can be seen that the barnacles were starting to have a higher growth rate and the graph now has four peaks, doubled the number of peaks in the graph generated from captured image in second and quadrupled that of the first month. As conclusion finding, it can be estimated that the barnacles have grown

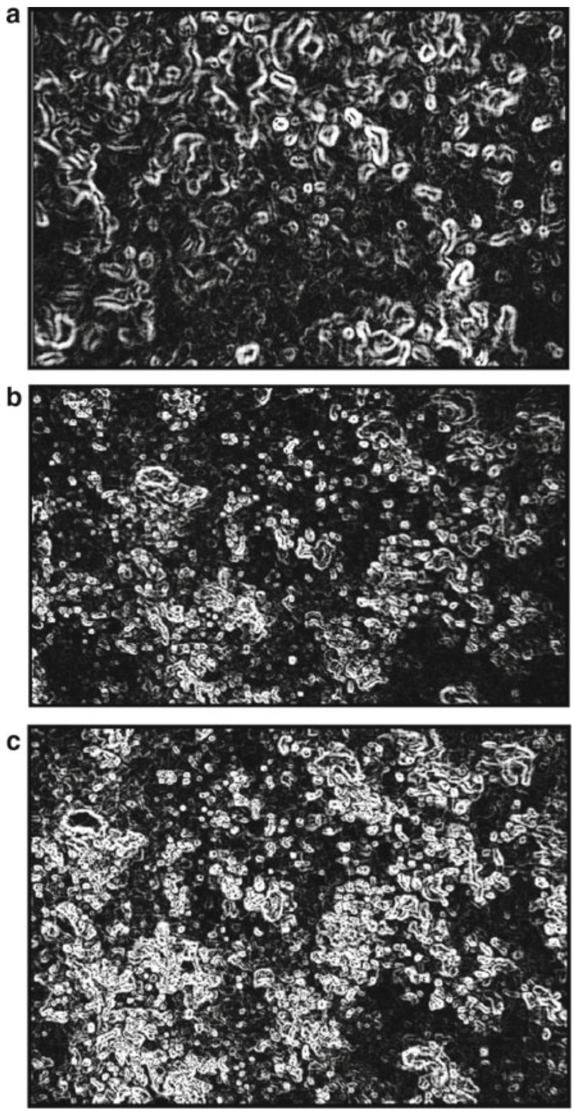

Fig. 15.8 **a** Gradient image detection of 1st month. **b** Gradient image detection of 2nd month. **c** Gradient image detection of 3rd month

to about 30% within 3 months since the first month, achieving a maximum growth rate in the third month at a value of 2950 pixels.

The numbers of peaks increased from month to month. This shows that the numbers of new barnacles' growth increase and the existing barnacles become larger and bigger. The line in the range between 0 and 50 in the first month (Fig. 15.9) graph shows the value (existing of barnacles) but in second-month graph, there is no value that means the existing barnacles are dismantled. This may be caused by several factors, they are:

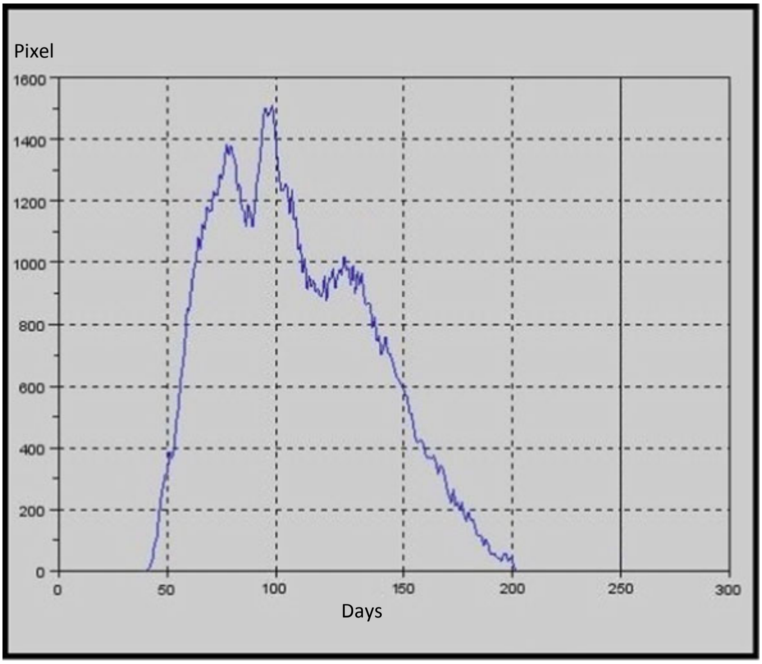

Fig. 15.9 Total pixel captured at first month

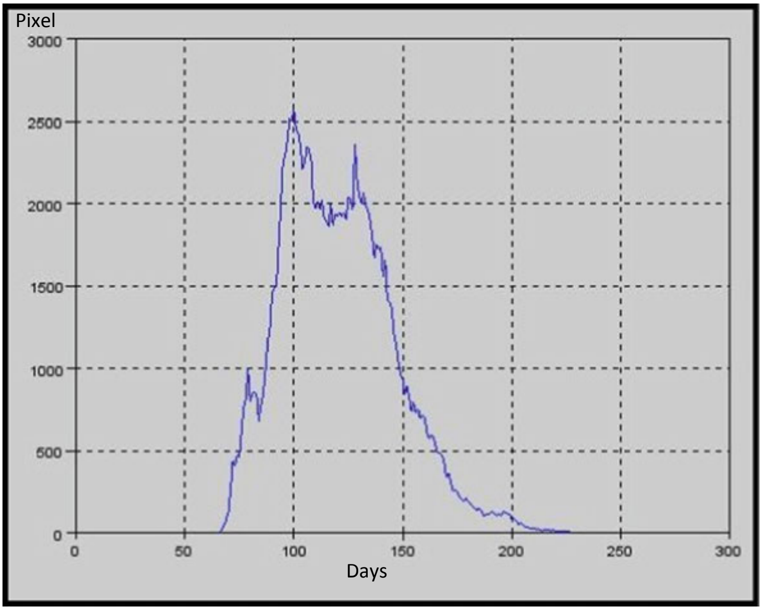

Fig. 15.10 Total pixel captured at second month

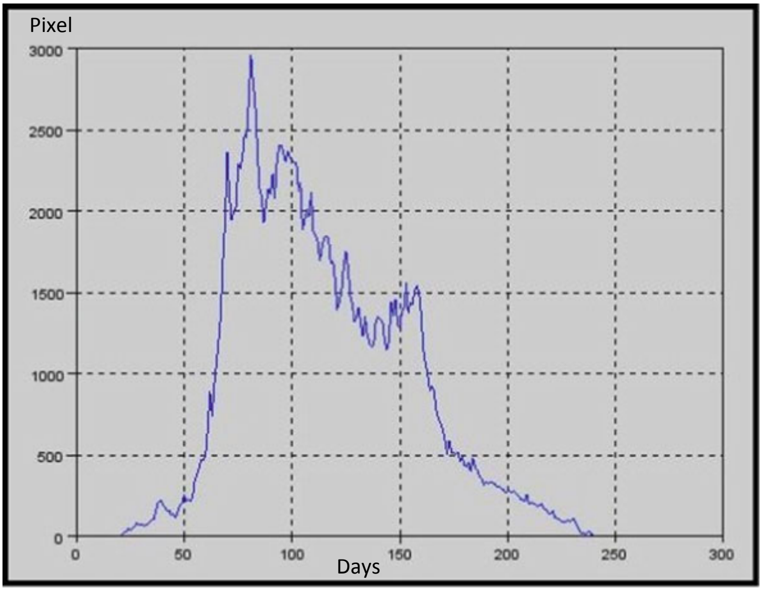

Fig. 15.11 Total pixel captured at third month

i. Water condition—The water contains oil and chemical that effect the life cycle and growth of the barnacles.
ii. Weather condition—Rain and hot weather effect low also the high tide of the seawater.

From this observation, the vessel needs to do the hull service and maintenance because the barnacles in highest level effect the vessel performance.

15.4 Conclusion

The conclusion remark in this research is that the marine industry is one of the larger heavy engineering industries. There are many software packages and programing languages used in this industry, some require the payment of expensive licence fees. Scilab is the one of the way to reduce cost in this industry since this software is free and can be downloaded from the Internet, its function is similar to the MATLAB software, Scilab also can be used for calculation in similar way as MATLAB, on the image processing analysis, various type of analysis can be performed with this software, such as sonar, hull inspection and etc. Based on three analyses that have been made, it can be said that the growing up of the barnacle is about 30% of the three months of observation. This research investigated the growth of barnacles and the obtained results will help ship owners and especially the marine industry to know more details about the growth of these barnacles.

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Chapter 16
Mitigating Engine Exhaust Emission Using Solenoid as Replacement for the Engine's Block

Md Redzuan Zoolfakar and Muhamad Ammar Muhsin Din

Abstract The emissions produced by hydrocarbon engines are one of the main sources to air pollution and climate change. In order to mitigate those problems, the emission produced by the engine can be eliminated by replacing the fuel in the engine's block with solenoid. The model operates on solenoid with various speed settings of the engine. No emission was generated during the operation and the combustion-related part of the engine are removed, thus, reducing the overall weight of the engine. Waste heat is dissipated at the power transistor, solenoid, and piston due to losses such as ohmic resistance and eddy current. Due to nature of the solenoid which is similar to an inductor, this engine is expected to best operate as low-speed engine.

Keywords Solenoid engine · Electric engine · Zero emission engine

16.1 Introduction

Technically, an emission is an action which is releasing anything such as gases and particulate matter out into the open such as open air from various sources [1]. Even the human body has emissions such as sweat, drool, and gas. One of main contributors for air pollution and threat to climate change is the combustion of fossil fuel that is causing emissions which are the working principle of the internal combustion type engine and steam turbine that is widely used in transportation & energy industry [2]. In 2010, road transport alone accounts for 42, 16, 15, and 29% of total NOx, VOC, PM, and CO emissions, respectively [3]. Motor vehicles, industries, aircrafts, and areas of high population densities are identified as the main sources of emission [4].

M. R. Zoolfakar (✉) · M. A. M. Din
Marine and Electrical Engineering Technology, Malaysian Institute of Marine Engineering Technology, Perak, Malaysia
e-mail: redzuan@unikl.edu.com

M. A. M. Din
e-mail: ammarkonyen@gmail.com

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With current development of engines, the ways of reducing emission are using the motor or hybrid engine.

A solenoid engine is similar to conventional internal combustion engine except, it operates sorely on electrical power and no combustion process takes place while the internal combustion engine operates on fossil fuel. The operation of the solenoid engine and reciprocating engine is the same but the engine block was replaced with solenoid while all other parts of the engine were kept the same.

16.2 Experimental Setup

The operation of the new engine should be similar to the convectional internal combustion engine. To perform the test, the setup is separated into three part, i.e., designing, fabricating, and testing the engine's prototype.

16.2.1 Engine Design

The type of engine design used is the V-type engine arrangement which can be seen in Fig. 16.1. This construction has few advantage in terms of the solenoid engine which is the length required to house an inline 6-cylinder inline engine will house a V12 cylinder engine. This allows for a greater displacement compared to the inline cylinder which means that more power and more torque can be produced at a lower engine speed as the power stroke is coming from two sides of the crankshaft.

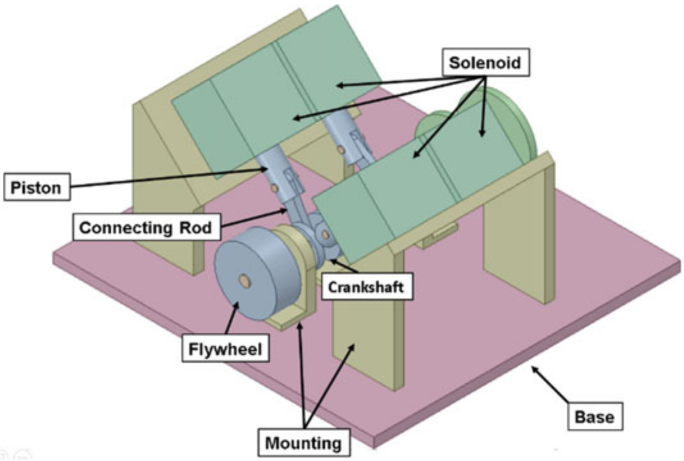


Fig. 16.1 Designed solenoid engine's prototype

16.2.2 Schematic Design

The schematic design is based on an operation block diagram as shown in Fig. 16.2 for a solenoid. Similar circuits are repeated for each solenoid. A set of components is identified and selected based on their functionality to satisfy the shown flowchart.

To operate as stated in the block diagram in Fig. 16.2, the circuit is designed using a comparator, operational amplifier with non-inverting gain control configuration, power amplifier, solenoid and sensors as shown in Fig. 16.3.

The comparator is necessary for eliminating false positive signal from the sensor. The maximum controllable gain for the voltage amplifier for the load is set to be

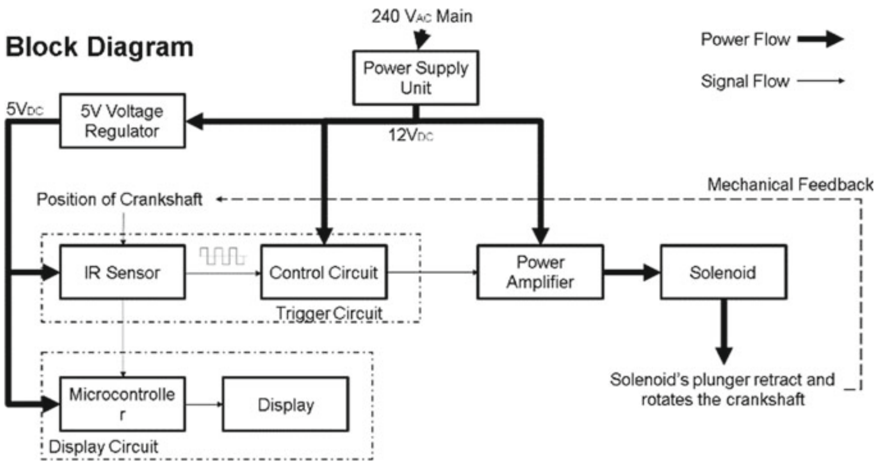


Fig. 16.2 Circuit block diagram

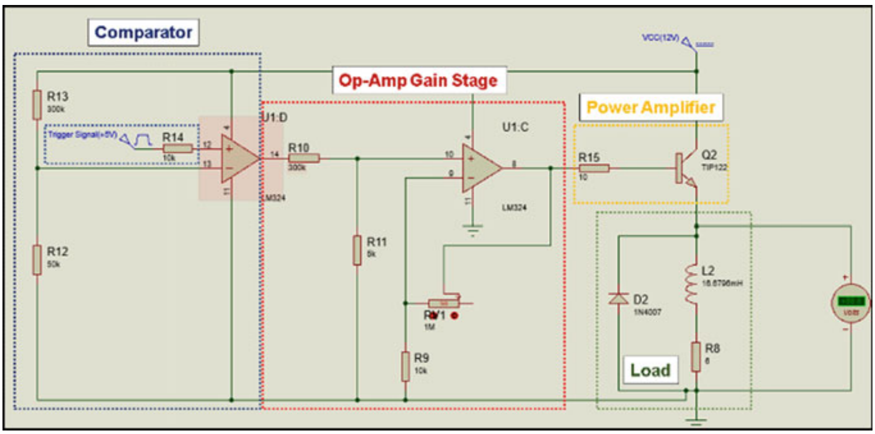


Fig. 16.3 Schematic design depicting each component used within its block diagram

approximately 19 dB. The load of the circuit is the solenoid where it will be turned on based on the position of the shaft. The circuit will deliver a square wave type modulation to the solenoid. The principle of operation for the circuit is similar to the internal combustion engine timing operation.

The operational amplifier that was used is the LM324 while the power amplifier uses the TIP122 transistor. A comparator was included to avoid false-positive signals from the sensor. A 12VDC is used for power supply and an L7805 5 V regulator is used to reduce voltage from 12 V to 5 V for the sensor and tachometer. The sensor used is an infrared sensor which is used to detect the position of the crankshaft while avoiding any contact and are installed in front of the flywheel. The flywheels are modified so that both of them operate similar to the rotary encoder principle. An auxiliary component which is a 5 V fan is installed to cool down the power transistor.

16.2.3 Fabrication of the Prototype

The finished engine prototype is included with bearings and ring locks to minimize friction and ensuring that no loosening joint will occur. Lubrication is added to further reduce losses from friction. The design of the fabricated prototype is modified but the concept and operation is unchanged as shown in Fig. 16.4. A light weighted flywheel is used to ensure faster engine revolutions as the output is measured in terms of rotational speed.

16.2.4 The Procedure and Data Collection

The operation of the solenoid engine should work as shown in the flowchart in Fig. 16.5 where when the sensor detects a certain position, the solenoid will turn on. The solenoid will be triggered by the IR sensor. The control system block diagram is shown in Fig. 16.6 where the operation of the engine can be controlled by adjusting gain to vary the voltage across the solenoid thus delivering different amount of torque to the crankshaft.

The data collected is the engine speed in rev/min, value of current entering circuit to determine the power consumption and the effective varying voltage across the solenoid. The data collected is the average of three tests. The tests and analyses are conducted are done after the prototype is functioning correctly.

The engine's speed is calculated by the microcontroller which is an Arduino Uno that is programmed to comply with the flowchart shown in Fig. 16.7. The microcontroller will detect how frequent the sensor is turned on and off in one second and will multiply it by 60 to obtain the revolutions per minute. The power consumed by the circuit can be calculated by using the Ohm's law which is:

$$P = I \text{ x } V \tag{16.1}$$

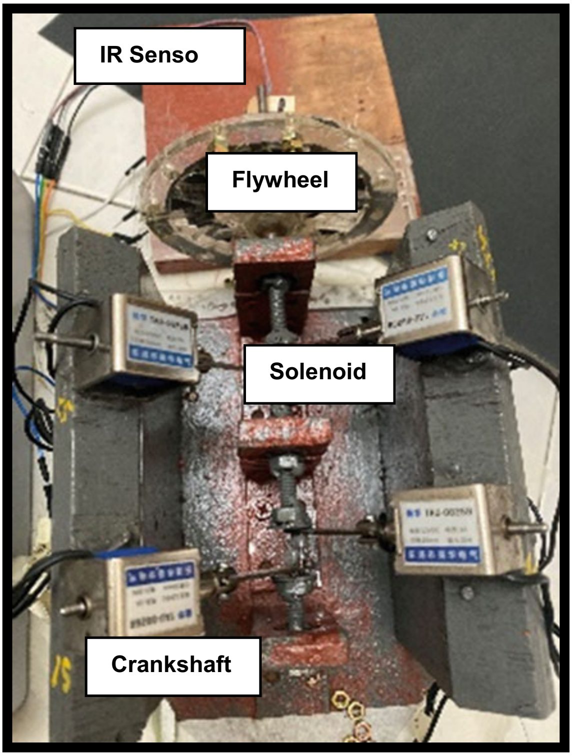


Fig. 16.4 Finished fabrication with installation of the solenoid

where P is the power, I is the current, and V is the voltage.

The voltage across the circuit is kept constant at 12 V and the total current consumption can be measured by using a multimeter connected serially between the circuit and the power supply's live cable.

16.3 Results and Discussion

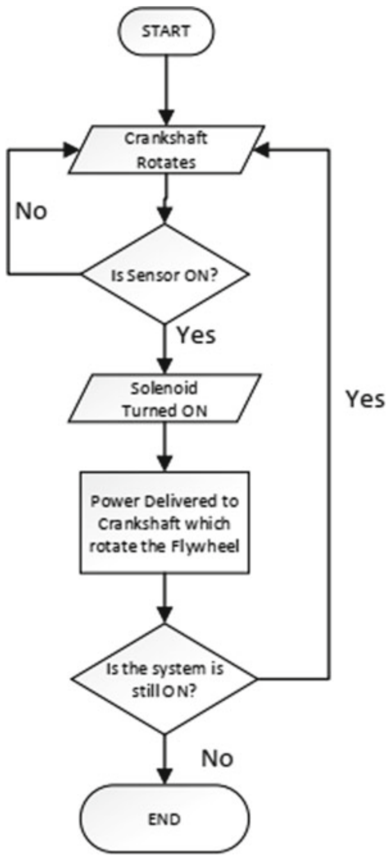
16.3.1 Collected Data

The obtained results from the test are shown in Table 16.1.

16.3.2 Analysis of Gain Vs Power Consumption

The graph of gain against power consumption is shown in Fig. 16.8. As shown in Fig. 16.8, as the gain increases, the voltage across the solenoid and current through

Fig. 16.5 Flowchart depicting the operation of the prototype



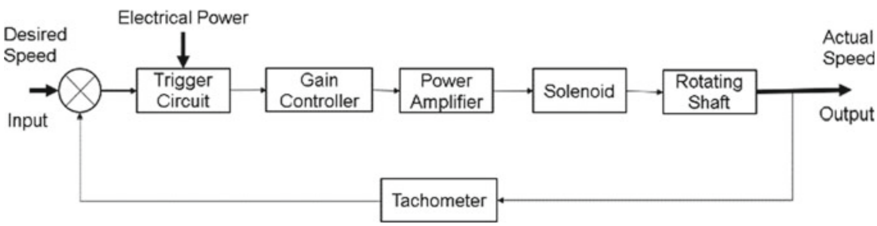


Fig. 16.6 Engine speed control system

the solenoid increase which means that the power delivered to the circuit increases. The control circuit, microcontroller, IR sensor, and fan uses a fixed amount of power ranges from 6 to 10 W so all increase in power is caused by the solenoid's power up and power amplifier. Higher quantity of solenoid yields higher maximum power consumption and higher rotational speed.

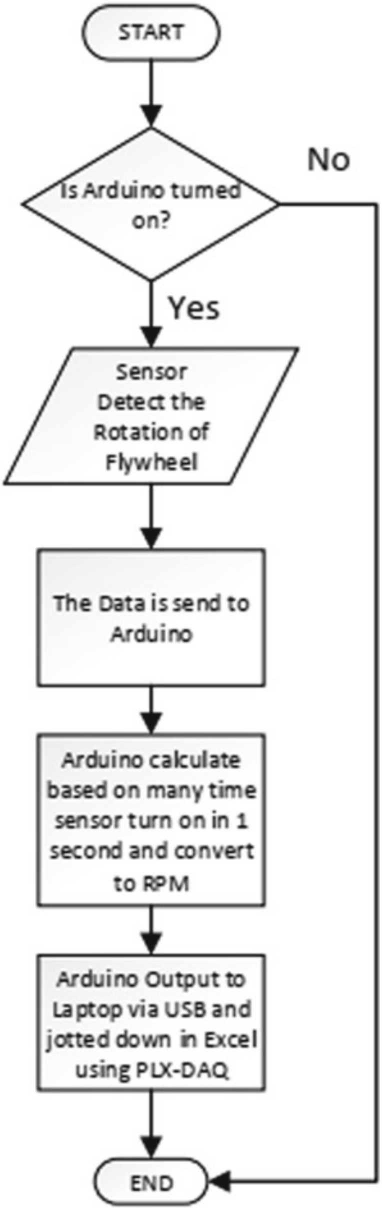


Fig. 16.7 Flowchart depicting the operation of the tachometer using Arduino

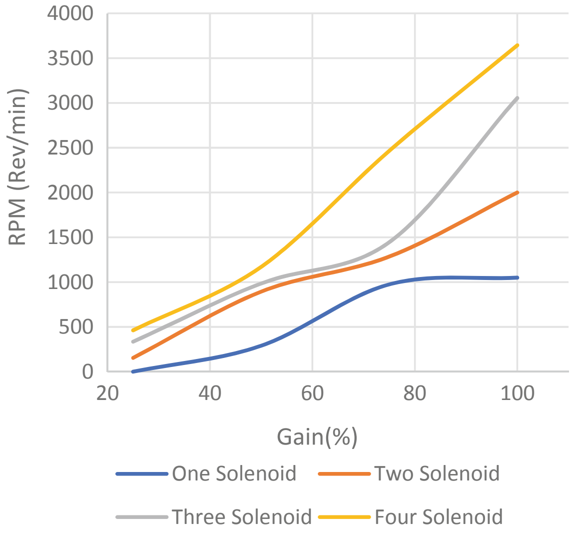
16.3.3 Analysis of Gain vs Engine Speed

As shown in Fig. 16.9, higher gain yields higher RPM of the engine for 0 to 100% gain. This is caused by the gain which directly controls the value of voltage across

Table 16.1 Obtained results from the table

Gain (%)	Solenoid quantity	Current (A)	Power (W)	RPM (rev/min)
25	1	0.52	6.24	0
50		0.66	7.92	290
75		1.01	12.12	975
100		1.04	12.48	1050
25	2	0.63	7.56	154
50		1.00	12.00	894
75		1.45	17.4	1285
100		1.58	18.96	2000
25	3	0.77	9.24	335
50		1.21	14.52	986
75		1.72	20.64	1445
100		2.03	24.36	3056
25	4	0.85	10.2	462
50		1.39	16.68	1171
75		2.32	27.84	2466
100		2.52	30.24	3644

Fig. 16.8 Graph of gain against power consumption



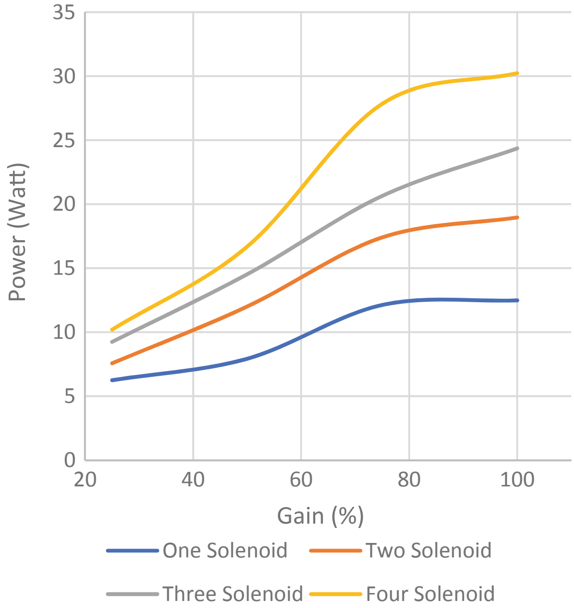


Fig. 16.9 Graph of gain against engine speed

the solenoid and higher solenoid's voltage gives stronger plunger pull thus generates higher RPM. When more cylinders are used, the tachometer measures a higher rotational speed which correlates directly to the RPM similar to the number of pistons in internal combustion engines. When the number of pistons is increased, the RPM are higher if all other variables (size of engine, flywheel weight, etc.) are constant due to higher power being delivered to the crankshaft. From Fig. 16.9, the engine's speed did not appear to be linear. This is caused by the harmonic distortion which effects the performance of the solenoid at high speed. Those harmonic distortions change with the variation in modulation method, modulation ratio, and switching frequency [5–7] but for this case, the switching frequency is greatly varied based on the engine speed while the modulation method is kept constant.

16.4 Conclusion and Recommendation

In a nutshell, the prototype demonstrates the effectiveness in eliminating emission by using electrical power instead of the combustion of fuel. The designed engine's prototype is a two-stroke engine at which the first stroke is a power stroke when the voltage is applied to the solenoid and another stroke is when the solenoid is switched off. Some heat is dissipated from operation of the engine at the solenoid and the piston caused by eddy current and ohmic resistance. Due to the nature of the solenoid which is similar to an inductor, the model is expected to operate effectively at low engine speed at high power magnitude. Since no combustion is present, the engine's overall weight can be reduced by removing combustion-related parts.

For the operation of the engine, a limit switch with cam, rotary encoder or higher reliability optical sensor can be employed to increase the accuracy of the solenoid's switching timing. In terms of power consumption, the power consumed by the solenoid can be reduced by utilizing the pulse width modulation (PWM) with high or moderate duty cycle or using regenerative braking to improve the efficiency. The harmonic distortion of the solenoid should be taken into account when an electronic system is designed to improve the effectiveness of the solenoid at high magnitude and high switching frequency.

The analysis can be further improved by measuring the power output of the engine to find the efficiency of the prototype and using an oscilloscope to measure the frequency response and performance of the solenoid at different frequencies as the inductor acts as an open circuit at very high frequencies. By replacing the plunger with a two-pole magnet, the engine can become a one-stroke engine as the solenoid can push or pull the magnet by alternating the voltage supply across the solenoid to alternate the magnetic field around the solenoid. The solenoid shows a potential difference when switched off so the leftover charge in the solenoid can be redirected to a battery to save energy and improving the efficiency.

16.5 Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Chapter 17
Underwater Noise Study Toward Propeller Rotation

Md Redzuan Zoolfakar and Mohammad Shafiq Mohammad Khairul

Abstract The public concern about the effect of underwater noise toward marine life has been increasing for years where the main contributor of anthropogenic noise is commercial shipping. This has a negative impact on the marine life where the responsible body such as the International Maritime Organization (IMO) and others have set a certain guideline for reducing underwater noise. This report will discuss how the rotation of propellers affects the underwater noise. The primary objective of this study is to analyse the effect of underwater noise generated from rotation of propellers by using a suitable method to carry out the experiment. There are several parameters used in this experiment such as the number of propeller blades, the propellers size, the speed of the motor (rpm), the depth of the measuring device, the horizontal and vertical position of the measuring device.

Keywords Decibels · Propeller rotation · Underwater noise · Cavitation · Propeller

17.1 Introduction

The marine life comprises animals, plants and other organisms that live within sea water or brackish water of coastal estuaries. The initial vertebrates that live exclusively in water appeared in the form of fishes [1]. Basically, the marine life influences the nature of the planet and yields oxygen and sequesters carbon. Shorelines are part or portion formed and protected by marine life and even new land is created by some other marine organisms. Marine terms come from Latin mare it means ocean or sea. Marine habitats initially evolve most of the life forms and it is approximately about 90% of the living space in the world. There is a short summary and perception on

M. R. Zoolfakar (✉) · M. S. M. Khairul
Marine and Electrical Engineering Technology, University Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: redzuan@unikl.edu.my

M. S. M. Khairul
e-mail: shafiqkhairul95@gmail.com

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the topic of underwater ambient noise that is of interest to a various set of activity, biological and physics professionals concerned in its analysis [2].

Anthropogenic noise from shipping is the most persuasive source of noise [3] and since the 1960s, the noise is increasing gradually in magnitude in the deep sea parallel with the growth. The continuation of the noise from shipping may have effect to marine species both through continuous exposures to vessel routes [4]. Anthropogenic noise has the possibility to actuate a stress reaction on marine fauna, characterized as "the physiology, behavior and hormone changes that verdict from acquaintance to a stressor" [5]. A response to noise may also result in hypoxia, the mixture of the exposure to unusual noise may effects the health or leads to death and influences the fertility of surviving animals and a decrease in their regenerative success may have important effects at the level of population [6].

The results of anthropogenic noise on marine species and habitats, and in view of to what extent the emitted sound lasts, it is able to distinguish between impulsive and continuous anthropogenic sound [7]. This study focuses on the underwater noise level. It confirms that anthropogenic noise is connected with the possibility to have adverse fitness outcomes with respect to initial life phases [8].

Nowadays, the concern of public about the effects of underwater noise on marine mammals has progressively increased over the past few eras and commercial shipping is one of the main contributors to anthropogenic noise [9]. It has longer wavelengths and its peaks need high pressure in comparison to high-frequency wave creating it more capable of long-range propagation [10]. The study of URN on commercial shipping with regard to the improvement of potential guidelines and regulations to be applied in the future has been supported by the Marine Environment Protection Committee (MEPC) [11].

The performance of the propeller is observed based on the characteristic and the results will assessed and compared with each of the variables used. The objective of this study is to design an experiment regarding noise level generated by the propeller rotation and to analyse the noise level generated from the rotation of propeller.

17.2 Methods

In general, this study required to construct an experiment to collect data and to analyse it. It also describes the sequence flow of the project and the planning proposed in order to obtain the expected outcome. It includes the flow chart on how to gain the data for the project parameters up to the data analysis processes.

This experiment is conducted in several steps to get the result where it starts with planning, the implementation, and the collection of data. All of the data will be analysed and will plotted a graphs to show the comparison result for each of the parameters.

17.2.1 Experiment Planning

In this section, the Fig. 17.1 shows the planning of the experiment where it starts with the experimental parameters, the equipment and device selection and the design of the experiment.

There are 6 parameters used in this experiment to get the result. The first is the number of propeller blades. There are 3 different numbers of blades for each propeller which consist 2, 3, and 4 blades of the propeller and each number of propeller contains 3 different sizes where the size of propeller is the second parameter. For two and three blades, it consists of 40 mm, 44 mm and 48 mm in diameter of the propeller and for four blades, it consists 50 mm, 55 mm, and 60 mm in diameter where the size of the propeller is the second variable of this study.

The third is the position of the measuring device. There are two different positions of the measuring device which is horizontally and vertically. For the horizontal position, it consists of three distances, i.e., 100 mm, 200 mm, and 300 mm, respectively.

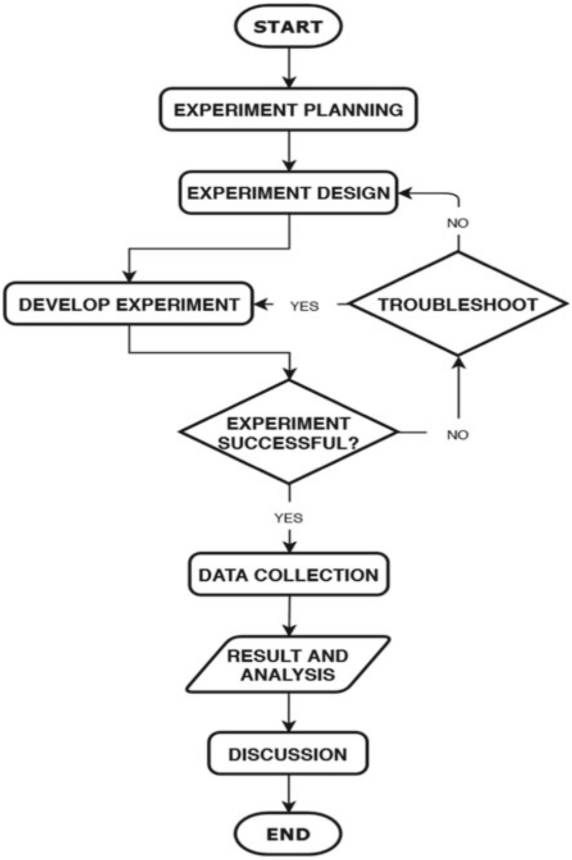


Fig. 17.1 Flowchart of the experiment

For the vertical position, it consists of three positions which is at the center of the propeller, port 100 mm, and starboard 100 mm and this is the fourth variable in this study.

The fifth parameter is the depth of the measuring device where there are four different depths of the measuring device, i.e., 30 mm, 60 mm, 90 mm, and 120 mm in depth.

The last variable is the speed of the motor. There are four different revolutions per minute in this experiment, i.e., 300 rpm, 600 rpm, 900 rpm, and 1200 rpm.

Next is the equipment and device used in this experiment. For the hardware component, this experiment consists of a tank to store the water and mounting for the propeller and motor. For the electronic component, an Arduino board is used as micro-controller and other components such as a diode, transistor, resistor, and connecting wire where it is connected to the bread board. A 12 V DC motor is used and this experiment is using a 9 V rechargeable battery to support the electronic component. A LCD panel is used to display the value of the rpm set in the Arduino board.

17.2.2 Implementation of the Experiment

This section covers the hardware component assembling and electronic component assembling. The assembling component flowchart shown in Fig. 17.2.

For the hardware component the mounting for the motor and propeller is made from wood that has been cut in suitable length to be able for the motor and propeller to sit in a place as shown in Figs. 17.3 and 17.4.

Later the mounting is installed in the tank and ready to connect with the electronic component thus to begin the experiment as shown in Fig. 17.5.

For the electronic component, all the components are connected together through the breadboard. It is tested first before connecting it with the motor and propeller as shown in Figs. 17.6 and 17.7.

After the circuit is tested without fault, it is ready to be assembled together in the tank as shown in Fig. 17.8.

17.2.3 Method to Collect Data

Table 17.1 is used to show the collected data. The information of the independent variables is shown in Table 17.2 and the details of the propeller size and numbers of the blades is shown in Table 17.3.

The experiment has been conducted using the method shown in Sect. 17.2. The graph is plotted based on the result in Table 17.4 to show the comparison for each of the parameters.

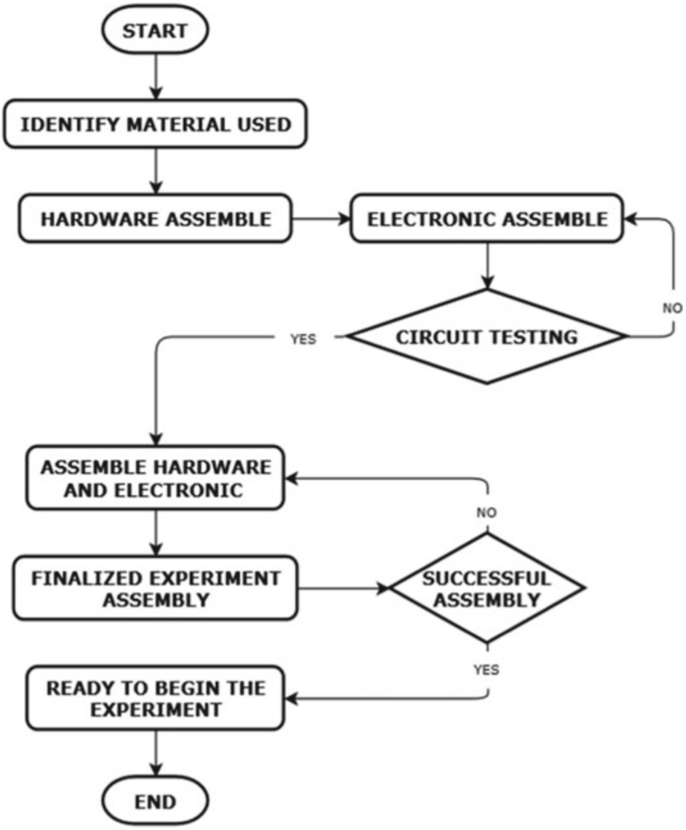
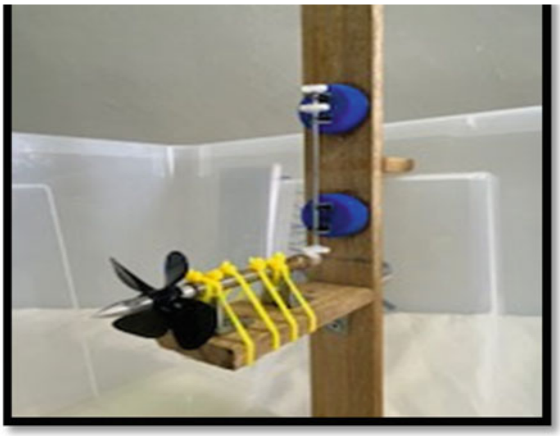


Fig. 17.2 Assembling component flowchart

Fig. 17.3 Shaft mounting



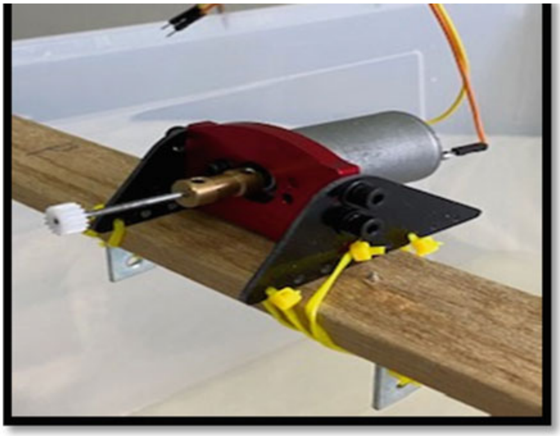


Fig. 17.4 Motor mounting

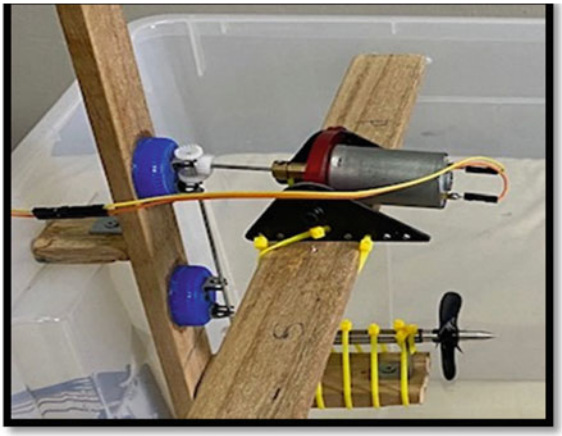


Fig. 17.5 Shaft and motor in tank

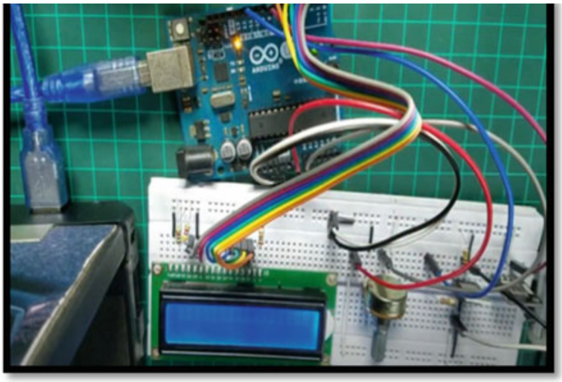


Fig. 17.6 Electronic component installation

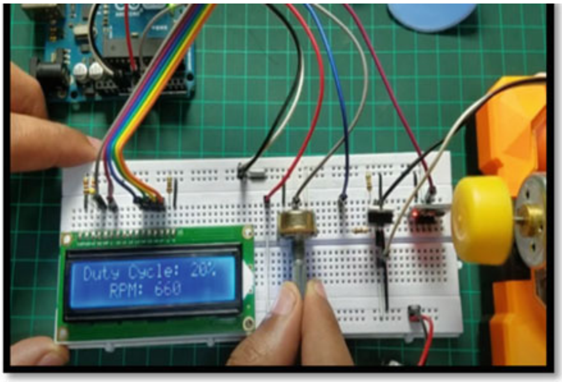


Fig. 17.7 Electronic component testing

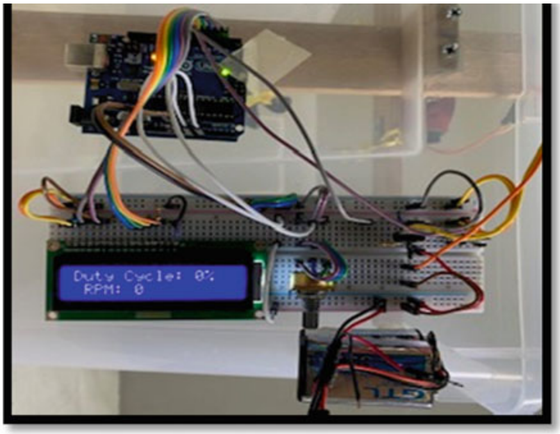


Fig. 17.8 Installation component in the tank

As from the results, underwater noise is created by forming of bubbles from the rotating propellers. When the propeller rotates, many bubbles form in the water. These formed bubbles are known as cavitation and when these bubbles blow or pop, they create an acoustic sound. Even low rotation of propellers creates thousands of bubbles and that is why the propeller rotation creates noise underwater.

As data from the Table 17.4, this experiment tells that each parameters show a different noise level. In practice, the underwater noise level differs from surface noise because the noise travel faster in the water. So, with the same amount of sound occurring at the surface, it will give a higher noise level in water.

Based on the graph shown in Fig. 17.9 it shows that high revolutions per minute will give a high noise level because the faster the propeller rotates, the higher the cavitation occur. When more cavitation occurs, the more bubbles are created and more bubbles to explode over a range of frequencies thus will create a sound.

As high revolutions per minute creates more bubbles, the different in depth in this experiment does not change dramatically. The noise created by the rotations is called

Table 17.1 Data table

No	No of blades with size (mm)	RPM	Horizontal distance (mm)	Vertical distance (mm)	Depth of measuring device (mm)	Noise level (dB)
1	2 blade 40 mm	300	100	C, 0	30	
2	2 blade 40 mm	300	100	C, 0	60	
3	2 blade 40 mm	300	100	C, 0	90	
4	2 blade 40 mm	300	100	C, 0	120	
5	2 blade 40 mm	300	100	L, 100	30	
6	2 blade 40 mm	300	100	L, 100	60	
7	2 blade 40 mm	300	100	L, 100	90	
8	2 blade 40 mm	300	100	L, 100	120	
9	2 blade 40 mm	300	100	R, 100	30	
10	2 blade 40 mm	300	100	R, 100	60	
11	2 blade 40 mm	300	100	R, 100	90	
12	2 blade 40 mm	300	100	R, 100	120	
13	2 blade 40 mm	300	200	C, 0	30	
14	2 blade 40 mm	300	200	C, 0	60	
15	2 blade 40 mm	300	200	C, 0	90	
16	2 blade 40 mm	300	200	C, 0	120	
17	2 blade 40 mm	300	200	L, 100	30	
18	2 blade 40 mm	300	200	L, 100	60	
19	2 blade 40 mm	300	200	L, 100	90	
20	2 blade 40 mm	300	200	L, 100	120	
21	2 blade 40 mm	300	200	R, 100	30	
22	2 blade 40 mm	300	200	R, 100	60	
23	2 blade 40 mm	300	200	R, 100	90	
24	2 blade 40 mm	300	200	R, 100	120	
25	2 blade 40 mm	300	300	C, 0	30	
26	2 blade 40 mm	300	300	C, 0	60	
27	2 blade 40 mm	300	300	C, 0	90	
28	2 blade 40 mm	300	300	C, 0	120	
.	.	.	.	.	.	.
.	.	.	.	.	.	.
1296	4 blade 60 mm	1200	300	R, 100	80	

Table 17.2 Details for propeller size and numbers of blades

Number	Detail
1	2 blade size 40 mm
2	2 blade size 44 mm
3	2 blade size 48 mm
4	3 blade size 40 mm
5	3 blade size 44 mm
6	3 blade size 48 mm
7	4 blade size 50 mm
8	4 blade size 55 mm
9	4 blade size 60 mm

Table 17.3 Variable list

Variables	Number of variable
Number of blade	3
Size of blade	3
Speed of motor	4
Horizontal position of measuring device	3
Vertical position of measuring device	3
Depth of measuring device	4

blade-rate lines that can help identifying the characteristic of a ship's size and even the ship's hull.

At a depth of 60 mm, it also indicates the highest noise level because at this depth, it is parallel with the depth of propeller. The deeper the measuring device, the lower the noise level.

As shown in Fig. 17.10, when the rotation speed of the propeller increases, it will create more cavitation and thus generates more noise. It shows that high revolutions per minute gives high a noise level and this increase exponentially from 600 rpm to 1200 rpm, respectively. And, the farther the measuring device, the lower the noise level because the sound started to lose its vibration energy thus the noise level decreased.

The closer to the measuring device, the higher the noise level. This is because the tendency of the noise level to decrease is likely to happen as noise is created from vibration and the farther the vibration goes, the lower the noise level.

Figure 17.11 shows that with the increasing number of blades of propeller also the noise level increases. This is because the higher number of blades, it generates more cavitation. As the propeller rotates, the blade creates the cavitation. So three and four blades produce more cavitation than two blades while four blades produce more than three blades and that is why the propeller with size nine has the highest noise level compared to other sizes. The deeper the measuring device, the lower the

Table 17.4 Result table

No	No of blades with size (mm)	RPM	Horizontal distance (mm)	Vertical distance (mm)	Depth of measuring device (mm)	Noise level (dB)
1	2 blade 40 mm	300	100	C, 0	30	55.0
2	2 blade 40 mm	300	100	C, 0	60	55.3
3	2 blade 40 mm	300	100	C, 0	90	54.9
4	2 blade 40 mm	300	100	C, 0	120	54.7
5	2 blade 40 mm	300	100	L, 100	30	54.7
6	2 blade 40 mm	300	100	L, 100	60	55.0
7	2 blade 40 mm	300	100	L, 100	90	54.6
8	2 blade 40 mm	300	100	L, 100	120	54.5
9	2 blade 40 mm	300	100	R, 100	30	54.2
10	2 blade 40 mm	300	100	R, 100	60	54.8
11	2 blade 40 mm	300	100	R, 100	90	54.4
12	2 blade 40 mm	300	100	R, 100	120	54.3
13	2 blade 40 mm	300	200	C, 0	30	54.8
14	2 blade 40 mm	300	200	C, 0	60	55.1
15	2 blade 40 mm	300	200	C, 0	90	54.7
16	2 blade 40 mm	300	200	C, 0	120	54.5
17	2 blade 40 mm	300	200	L, 100	30	54.5
18	2 blade 40 mm	300	200	L, 100	60	54.8
19	2 blade 40 mm	300	200	L, 100	90	54.4
20	2 blade 40 mm	300	200	L, 100	120	54.3
21	2 blade 40 mm	300	200	R, 100	30	54.0
22	2 blade 40 mm	300	200	R, 100	60	54.6
23	2 blade 40 mm	300	200	R, 100	90	54.2
24	2 blade 40 mm	300	200	R, 100	120	54.1
25	2 blade 40 mm	300	300	C, 0	30	54.6
26	2 blade 40 mm	300	300	C, 0	60	54.9
27	2 blade 40 mm	300	300	C, 0	90	54.5
28	2 blade 40 mm	300	300	C, 0	120	54.3
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.	.	.	.	.	.	.
1296	4 blade 60 mm	1200	300	R, 100	80	66.7

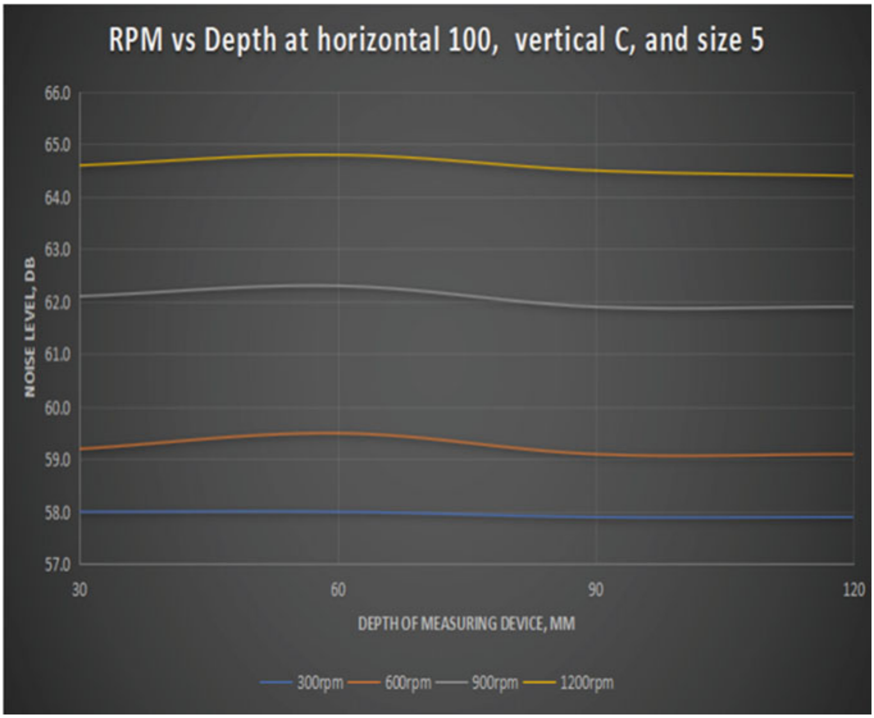

Fig. 17.9 Rpm of motor vs depth of the measuring device at 100 mm horizontal position of measuring device and 0 mm vertical center position of measuring device with 44 mm 3 blade propeller size

noise level where at 120 mm depth, it shows the lowest noise level compared to 30 mm, 60 mm, and 90 mm.

Based on Fig. 17.12, high revolutions per minute show the higher noise level and as mentioned in Fig. 17.11, more cavitation is created with higher speed of the propeller rotation thus will generate high noise level. As mentioned in Fig. 17.7, the larger the size of the propeller, the higher the noise level together with the higher the number of blades, the higher the noise level. This is because a high number of propellers and a larger size of the propeller create more cavitation. The noise level at size number 4 shows that it decreases because at size number 3, it is two-blade propeller with 48 mm in diameter while at size number 4, it is a three-blade propeller with 40 mm in diameter

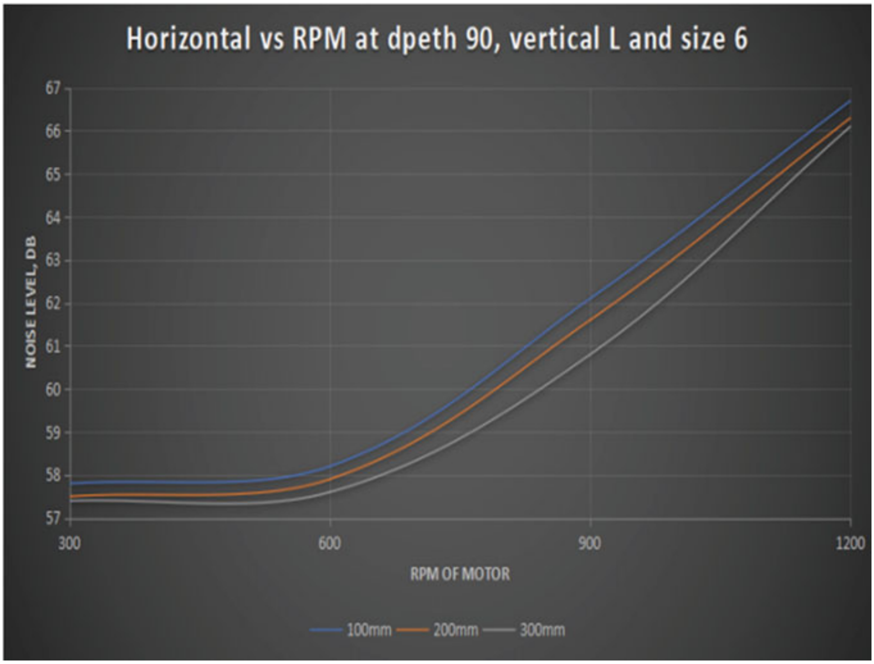

Fig. 17.10 Horizontal position of measuring device vs rpm of motor at 90 mm depth of measuring device and 100 mm vertical left position of measuring device with 48 mm 3 blade propeller size

17.3 Conclusion

This paper reports on the experimental investigations to predict the noise level based on the RC scale tests carried out at the UniKL MIMET's campus. Noise can be defined as an unwanted energy which causes to seemingly appear everywhere especially on land and oceans and it has different levels of impact toward the surrounding. Anthropogenic noises have risen during the last few decades due to increasing human activities thus also been proven that anthropogenic noise gives the worst effect toward marine life. This is due to the sound that came from human activities that caused to harm the harmony of the ecosystem in the ocean.

For the methodology of this experiment, it is essential that the equipment used in this project must follow all the crucial steps before, during, and after conducting the experiment and cannot be skipped or ignored as the steps are very important to determine the result. Also for the data collection, materials, and equipment used in this experiment are important because this experiment has conducted more than two methods with different materials and equipment before it get as perfect as it can be.

Next, the result graphs show different parameter shows difference in each result and each data gathered is important to make a comparison between each graph and when analyzing the data, it is important to follow the sequence step by steps to

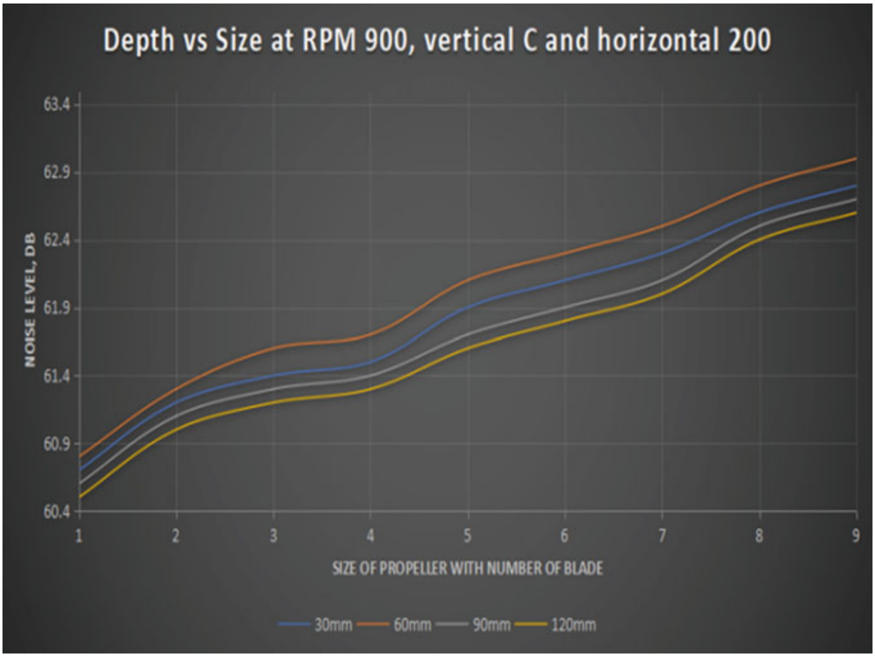

Fig. 17.11 Depth of measuring device vs size of propeller at 900 rpm with 0 mm vertical center position of measuring device and 200 mm horizontal position of measuring device

ensure the data gathering and data analyzing is smooth and to avoid any unwanted interference during the experiment. The parameters that affect most the underwater noise level are the speed of the propeller rotation, number of propeller blades and size of the propeller is affecting the noise level while the distance between the horizontal and vertical position of the measuring device between propellers and the depth of measuring device has an effect in determining the underwater noise level.

Last but not least, this experiment is considered successful in achieving its objectives, which is to design an experiment regarding the noise level generated by the propeller rotation. The experimental setup was successfully fabricated with the materials and equipment selected in Sect. 17.2 and following the design to ensure that this experiment works well. Next is to analyses the noise level generated from the rotation of the propeller. The result of this experiment can be found in Sect. 17.3 where the graphs are plotted to show the comparison within the parameters and limitation of the experiment. This experiment is conducted with affordable costs with all the selected materials and design needs.

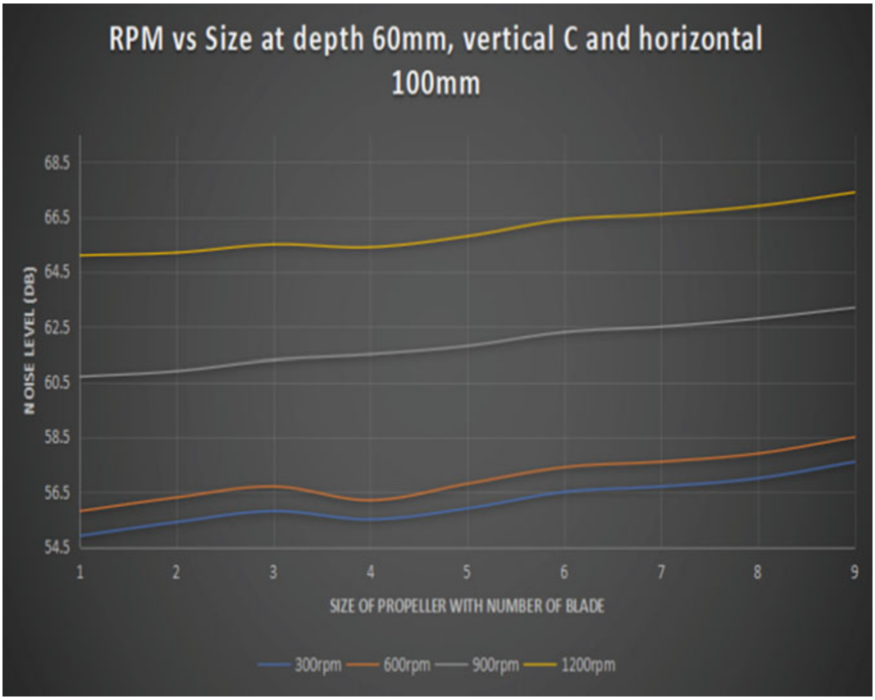

Fig. 17.12 Rpm of motor vs size of propeller at 60 mm depth of measuring device and 0 mm vertical center position of measuring device with 100 mm horizontal position

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Chapter 18
A Water Hyacinth Harvester

Md Redzuan Zoolfakar and Ismail Ibrahim Chacha

Abstract Water hyacinth (Eichhornia crassipes) is a free-floating plant, which grows up to three feet in height. It has thick, waxy, rounded, glossy leaves, which rise well above the water surface on stalks. Water hyacinth is among the major problems currently facing lake Victoria which is the second-largest freshwater lake in the world by area and directly supports a population of more than 40 million East Africa's (Tanzania, Kenya, and Uganda) inhabitants. In addition to that, the lake is source of the river Nile. Navigation, eco system, fishing industry, tourism, crop production, and livestock keeping are among the socio-economic impacts resulting from invasion of water hyacinth on lake Victoria. In this paper, a manual water hyacinth harvester is constructed, tested, and analysis.

Keywords Water hyacinth · Water weed · Water hyacinth harvester · Lake Victoria · Eichhornia crassipes

18.1 Introduction

Lake Victoria is the second-largest freshwater lake in the world by area and supports a population of more than 40 million East Africa's (Tanzania, Kenya, and Uganda) inhabitants. Furthermore, it is the source of river Nile and covers an area of 26,828 square miles (69,484 square kilometers) and has a depth of 270 feet (82 meters). In addition, lake Victoria has more than 200 species of fish including tilapia and Nile perch which are the most economically salient [1]. Lake Victoria extends over 412 km from North to South, between latitude 0°30'N and 3°12'S, 355 km from West to East between longitudes 31°37' and 34°53'E. It is situated at an altitude of 1,134 meters above the sea level, and has a volume of 2,760 km^3 [2]. The lake

M. R. Zoolfakar (✉) · I. I. Chacha
Marine and Electrical Engineering Technology, University Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: redzuan@unikl.edu.my

I. I. Chacha
e-mail: ismaelchacha@yahoo.com

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plays so many roles to the society surrounding it including: (1) supporting livelihood of people living within its shores, domestic use such as drinking, cooking, washing clothes, irrigation purposes, marine transportation, in industries, and for sports, (2) It is the main source of river Nile, which is the lifeline of Egypt, (3) it is the habitat of tilapia, Nile perch and other 200 more species of fish, (4) its wetlands provide shelter to various bird species, insects, and thus preserves biodiversity, (5) helps fight poverty by creating employment in fish industry and transportation for people living its environs, and (6) acts as eco-tourism center [3].

18.2 Literature Review

18.2.1 What Is Water Hyacinth

Water hyacinth is a free-floating plant, which grows up to 3 feet in height. It has thick, waxy, rounded, glossy leaves, which rise well above the water surface on stalks. The leaves are broadly ovate to circular, 4–8 inches in diameter, with gently incurved sides, often undulate. Leaf veins are dense, numerous, fine, and longitudinal [4].

18.2.2 History of Water Hyacinth

Reference [4] elaborates that the water hyacinth is native to the northern neotropics of South America and later distributed to North America, South America, East Africa, and Asia. "The Water hyacinth was introduced from its native home in South America to various countries by well-meaning people as an ornamental plant; to the US in the 1880's. It was introduced in Egypt in about 1879. It spread to the Congo, the Nile and lake Victoria in the 1950's. It became introduced to Asia in 1888, and to Australia around 1890."

18.2.3 Description of Water Hyacinth

- Floating waterweed up to 65 cm tall.
- Root system is extensive (up to 1 m) feathery, black to purple.
- Leaves are round, bright to dark green, up to 5–10 cm in diameter.
- Leaf stalks of young plants are swollen into spongy, bulbous structures; mature plants have elongated leaf stalks.
- Flowers are light purple with darker blue/purple and yellow center, 4–6 cm long, 3.5–5 cm wide.
- Flowers are in dense spikes above plant.

- Fruit capsules are 10–15 mm long, contain up to 300 seeds.
- Seeds are egg-shaped, 0.5–1.5 mm long [5].

18.2.4 Effects of Water Hyacinth

18.2.4.1 Effects of Water Hyacinth to Navigation

Due to the invasion of water hyacinth, boats, ships and other marine vessels cannot navigate well. Water hyacinth affects navigation, water flow, recreational use of aquatic systems, and poses of mechanical damage to hydroelectric systems.

Reference [6] reported that, proliferation of water hyacinth has hampered water transport and growth at inland ports on lake Victoria, which has a mean depth of 40 m and covers 69,500 km^2. Limited lake transport has reduced the business potential of the ports of Kisumu in Kenya, Bukoba, Entebbe, Port Bell and Jinja in Uganda, and Mwanza in Tanzania.

18.2.4.2 Effects of Water Hyacinth on Fishing Industry

In lakes Kyoga, Albert, and Victoria, the massive growth of water hyacinth is causing serious disruption to commercial fishing due to its obstruction of fishing and landing sites. It is also believed that its presence along the shores has had a major impact on tilapia nesting, through lowering the dissolved oxygen above such sites and shading [7].

18.2.4.3 Effects of Water Hyacinth on Livestock

A study done by potential rich dairy cattle breeds known as Fogera breeds shows that the shore area of lake Tana is rich in submersing grass (including hippo grass) which feeds lots of cattle for the surrounding inhabitants. Nonetheless, due to the expansion of water hyacinth and its competition with the native species the submerging grasses and other native species become devastated. This affects a lot of cattle which are directly and indirectly dependent on the grass around the lake. Some respondents purchase supplementary feeds for their cattle because the grass on the grazing lands around the lake has been destroyed by the invasive water hyacinth [8].

18.2.4.4 Effects of Water Hyacinth on Crop Production

According to reference [8], water hyacinth also affects the production of crops. The study shows that mat of water hyacinth during flooding and wave time makes rice production frustrating by totally covering the rice field. One thing that most of the interviewed farmers gave strong emphasis was that water hyacinth is making the farmland more compacted due to its long root that made the farm land difficult to plough. The collected water hyacinth (heap) had noticeable impact on farm management due to a large place taken and making the farmland fragile. Farmers in the study areas sow crops when the water starts to shrink with simple adjustment of the plot. This will cause the farmers to spend more on hiring additional laborers to cultivate and control the weed. Hence, it is time consuming. Reference [8] stated that, "Based on the survey, 19 laborers in average are required to clear 0.25 ha of land for recession agriculture, which were not needed before water hyacinth infestation."

18.2.4.5 Effects of Water Hyacinth to the Ecosystem

Water hyacinth has effects on our ecosystem as it competes with native plants for space, nutrients, and sunlight. Moreover, it also affects diversity, distribution, and abundance of life in aquatic environments.

The study also shows that water hyacinth leads to de-oxygenation of the water and enhances evapo-transpiration, thus affecting all aquatic organisms. In addition, death and decay of water hyacinth vegetation in large masses creates anaerobic conditions and production of lethal gases [8].

18.2.4.6 Effects of Water Hyacinth to the Tourism Industry

The presence of water hyacinth in lakes, swamps, rivers and other sources of water can pose a threat to tourist attraction to that source of water. "The presence of water hyacinth in the lake Toba region threatens the beauty of one of the tourist destinations Indonesia pride. The content of nutrients in the lake Toba which is high because of the activity of the agricultural waste thrown directly into lake Toba adds to the growth of water hyacinth. By looking at the state of the lake Toba which threatens the growth and beauty of Eichhornia crassipes is very high is a problem that must be solved together" [9].

18.2.5 Several Ways of Controlling/Eliminating Water Hyacinth

There are several ways of controlling water hyacinth from multiplying themselves. Some of the ways of controlling this weed can be by harvesting, aquatic herbicides, and biological control agents. Locally, the best way to manage water hyacinth is to prevent it from becoming established. Plants purchased at local nurseries should be disposed of away from waterbodies.

- Prohibiting the plant to be used as an ornament

In some countries/states, water hyacinth is prohibited to be planted and it is against their rules. “Planting of this species in the State of Florida (U.S.) is prohibited by Florida Department of Environmental Protection (Hunsberger, 2001)” as reported by [10].

- Swamp Devil and Harvester

Reference [11] described a swamp devil mechanical machine as a heavy-duty aquatic vegetation cutter that features tow blades at the front which measure 2.4 meters across. The harvester had a 234-horsepower engine and can easily shred trees up to 15 cm in diameter. After cutting the weed, it will collect and remove the portion of the chopped debris.

The harvester can carry up to four tons of harvested weed on board in a single load. This will depend on the weight and volume of the water hyacinth and the distance to the shore, the harvester can potentially remove 16–32 loads of chopped hyacinths in eight hours.

- Biological control

Water hyacinth can also be controlled by biological means. This can be done by introducing organisms such as the water hyacinth weevil, water hyacinth moth, and native moths which feed on water hyacinth. In additional, these organisms feed off the leaves of water hyacinth and by doing so will reduce the spread and growth of water hyacinth.

According to reference [12], “three biological control insects were imported, studied, and released to control invasive water hyacinth, a floating macrophyte that was introduced to the U.S. during in the late 1800s. Together, these insects reduce the size and vigor of water hyacinth, and reduce flower and seed production. Individually, however, they are not able to control water hyacinth.”

Furthermore, “Control of other aquatic weeds including water hyacinth, hydrilla, Eurasian watermilfoil, water lettuce and giant salvinia has been less successful. Multiple factors play a role in the failure of some biocontrol agents to reach their full potential. For example, the Neohydronomus weevil has provided successful biocontrol of water lettuce in other countries, but has failed to control water lettuce in Florida, possibly due to predation of the weevil by imported fire ants.”

- Manual remove of water hyacinth

Water hyacinth can be manually removed because the plant floats in water and its roots are not into sediments. This is the easiest and cheapest way of controlling this weed. “Manual removal by hand or machine is a simple and cost-effective control for water hyacinth when dealing with small infestations. Because the plant floats and usually is not rooted into sediments, the removal of the plant is relatively easy. Hand removal should be done as soon as possible to minimize the chance of seed production” (Aquatic Invasive Species Quick Guide Water Hyacinth.

18.3 Methodology

This chapter describes the steps, procedures, and the process undergone to design and construct the water hyacinth model. In addition, it also describes the sequence flow of the project and the planning proposed in order to obtain the expected outcome. It includes the flow chart on how to gain the data for the project parameters up to the data analysis processes.

Two experiments of methodology were applied, which are the data collection and analysis from the experiments. Subsequently, methods used for this research are lined up to provide a result within the research.

18.3.1 Materials Used for Production of a Water Hyacinth Harvester Model

The following are the materials used in the production of the water hyacinth model:

1. Aluminium plate

   Was used for hull construction of the model.

2. Welding rods

   Aluminium filler rods were used to weld the hull of the water hyacinth harvester model.

3. Bolts and nuts

   Were used in assembling all the parts together to make a complete water hyacinth harvester model.

4. Round iron bar

   Round iron bars were used for deck railing construction.

   The deck railing is for safety of the person working with the water hyacinth harvester.

5. Chain

   It was used for holding the tyre fender.

6. Sprocket chain

   Sprocket chain was used to connect the engine together with the propeller mechanism at the aft of the water hyacinth harvester model.

7. Sprocket bearing

   Sprocket bearing was connected together with the propeller mechanism at the aft of the model.

8. Bearing

Bearing was put in the paddling mechanism and used to support smooth paddling.

9. Marine paint

Marine paint was used to paint the whole model after fabrication.

The paint was to avoid rusting of the model and helps to make the model good looking.

10. Synthetic rope

Synthetic rope was used to connect the steering wheel with rudder. It was also used to tie the anchor.

Furthermore, the rope was used to tie the model and secure it when berthing.

11. Polystyrene box

Polystyrene box was used to add on buoyancy of the model.

12. Used car tyre

Used car tyre was used to create a fender used to absorb the kinetic energy of the model prevent damaging itself from other vessels and berthing structures.

18.3.2 Fabrication

In this sub-chapter, steps taken in constructing of the water hyacinth model as shown in Fig. 18.1 will be explained.

- Measuring and marking

This was the first step. Here the aluminium plate was measured by using a tape measure, square ruler and it was marked by using a scriber and marker pen.

Fig. 18.1 Water hyacinth harvester model before painting

Fig. 18.2 Water hyacinth harvester model painted and left to dry

- Cutting and welding

After measuring and marking of the aluminium plate, then by using an electric grinder, the plate was cut into pieces and welded together.

The hull of the model was constructed initially, followed by the paddling mechanism, propeller mechanism, water hyacinth collection box after being harvested, then water hyacinth cutting mechanism, operator's chair, hand railing, propeller wheel blades to connect with the mini-engine, then propeller wheel adjuster to tight or make loose the sprocket belt or fan belt, mini-engine flywheel pulley, mini-engine foundation, rudder and lastly the steering wheel.

- All parts were assembled together before painting and all mechanisms were tested.
- The next step was to separate all the parts, paint them and re-assemble them together as shown in Fig. 18.2.

18.4 Results and Discussion

This chapter presents the findings of this study, which were obtained from the various analyses. The collected data was categorized into three categories, namely, draft analysis, sprocket analysis, and propeller analysis.

18.4.1 Draft Analysis

The water hyacinth harvester model as shown in Fig. 18.3 was put floating into water and the initial draft was recorded. The recorded initial draft was 105 mm aft of the model.

Then the time was recorded used by the model to travel a 10-meter distance.

Fig. 18.3 Draft analysis of the water hyacinth harvester model

Table 18.1 Draft analysis

Draft analysis	Distance traveled - 10 m	
	Draft (mm)	Time (s)
1	105	115.76
2	115	93.37
3	125	81.85
4	135	71.6

Some weight was added on top of the model to immerse it until a draft of 115 mm aft and again time was recorded for the model to travel within the same 10-meter distance without changing the propeller or sprockets.

The process was repeated with additional 10 mm draft immersion for two more times and data was recorded.

Four different drafts and the corresponding travel times for a constant of 10-meter distance was recorded as shown in Table 18.1.

A draft-time graph was plotted and the data was interpreted as shown in Fig. 18.4.

- As the draft changed from lower to higher, the speed increased and time taken for the model to travel a distance of 10-meter was reduced.
- Time taken for a distance of 10 m with different draft depth is as follows:

1. Draft 1 at 105 mm (aft) = 115.76 secs
2. Draft 2 at 115 mm (aft) = 93.37 secs
3. Draft 3 at 125 mm (aft) = 81.85 secs
4. Draft 4 at 135 mm (aft) = 71.6 secs

- Therefore, draft number 4 at a depth of 135 mm (aft) was noted to be most effective.

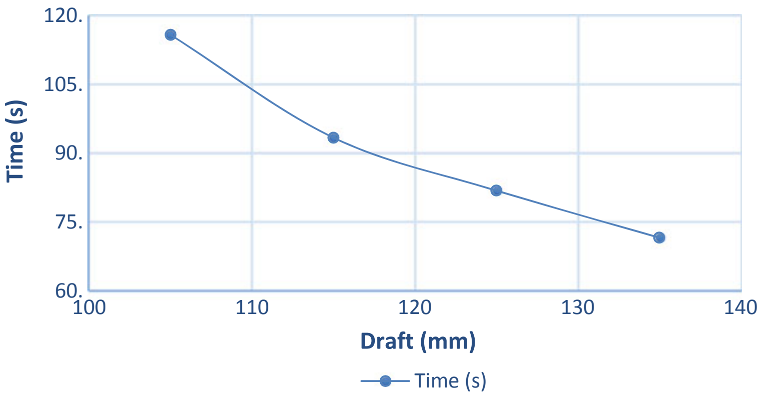

Fig. 18.4 Draft analysis graph

18.4.2 Sprocket Analysis

- Diameter of three different sprockets as shown in Fig. 18.5 were measured and recorded.
- In addition, number of teeth of the three sprockets was recorded as shown in Table 18.2.
- Sprocket number 1 was fixed to the engine flywheel and connected to the paddle wheel sprocket with sprocket-chain aft of the model.
- Time was recorded for the model to travel a distance of 1 m as shown in Table 18.3.
- Time was reset and recorded again for the model to travel 2 meters.
- Without changing the sprocket, the process was done 10 times by adding 1 m each time the time was reset.

Fig. 18.5 Sprockets used for sprocket analysis

Table 18.2 Dimensions of sprockets used in sprocket analysis

Sprocket 1	Sprocket 2	Sprocket 3
Diameter = 101.29 mm	Diameter = 138.97 mm	Diameter = 171.91 mm
No of teeth = 24	No of teeth = 34	No of teeth = 42

Table 18.3 Sprocket analysis result

Distance (m)	Sprockets		
	Sprocket 1	Sprocket 2	Sprocket 3
1	10.05	8.73	7.14
2	20.07	17.4	14.06
3	30.11	26.43	21.3
4	40.11	34.86	28.52
5	50.23	42.67	34.93
6	60.36	52.25	42.52
7	70.45	61.09	49.9
8	80.02	69.74	57.12
9	90.36	78.02	64.23
10	100.03	87.06	71.6

- After the tenth time, sprocket number 1 was removed and sprocket number 2 was connected to the engine flywheel and the same procedure was done and time was recorded.
- Lastly, sprocket number 2 was removed and sprocket number 3 was connected to the engine flywheel and the same procedure was done and time was recorded.

As the diameter of the sprocket changed from smaller to bigger, the speed increased and the time taken to travel at a constant 10-meter distance was reduced as shown in Fig. 18.6.

Time taken for a distance of 10 m with different sprockets is as follows:

- 1. 101.29 mm (d) = 100.03 secs
- 2. 138.97 mm (d) = 87.06 secs
- 3. 171.91 mm (d) = 71.6 secs.

Therefore, sprocket number 3 with a diameter of 171.91 mm was found to be the most effective.

18.4.3 Propeller Analysis

- Length and width of the original propeller blades connected together with aft sprocket was measured and recorded.

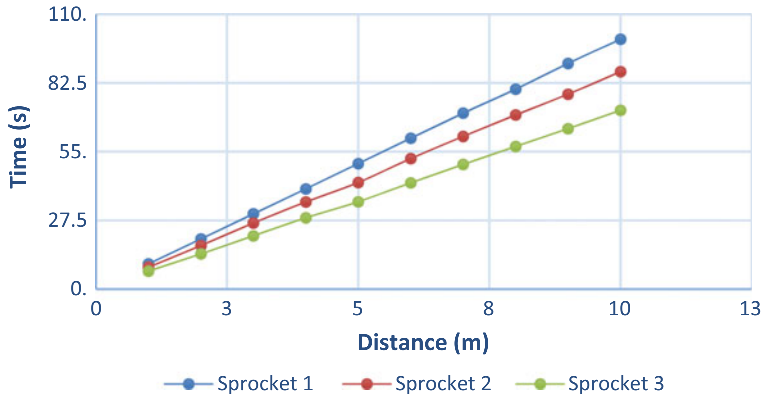

Fig. 18.6 Sprocket analysis graph

- The number of the propeller blades was six.
- Two holes were drilled on each propeller blade.
- Second set of propeller blades were made from plastic.
- Each blade with an additional 10 mm length and 10 mm width of the original size of propeller blades.
- Third and last set of propeller blades were made from plastic too.
- Third set of blades had an additional of 10 mm length and 10 mm width of the size of the second propeller blades as shown in Fig. 18.7 and Table 18.4.
- Water hyacinth harvester model was fixed with propeller number 1 to the aft of the model, in this case is regarded as the original propeller too.
- Time was recorded for the model to travel a distance of 1 m with the original propeller.
- Time was reset and the recorded again for the model to travel 2 meters.
- Without changing the propeller, the process was done 10 times by adding 1 m each time the time was reset.
- After the tenth time, propeller blades number 2 were added and tighten with plastic straps and the procedure was repeated and time was recorded.

Fig. 18.7 Different propeller blades used for propeller analysis

Table 18.4 Propeller analysis results

Distance (m)	Propellers		
	Propeller 1	Propeller 2	Propeller 3
1	12.04	9.25	7.14
2	24.96	18.4	14.06
3	36.84	27.72	21.3
4	47.96	37.12	28.52
5	60.72	46.24	34.93
6	72.44	55.48	42.52
7	84.5	64.7	49.9
8	96.3	74.06	57.12
9	108.62	83.15	64.23
10	120.56	92.14	71.6

- Lastly, propeller blades number 2 were removed and propeller blades number 3 were added, tighten with the plastic straps and the same procedure was done again and time was recorded.

The recorded data is shown in Table 18.4. The propeller analysis graph is shown in Fig. 18.8.

As the size of the propeller changes from smaller to bigger (in length and width), the speed increased and time taken at a constant distance was reduced.

Time taken for a distance of 10 m with different sizes of propeller is as follows:

- 1. Propeller 1 = 120.56 secs
- 2. Propeller 2 = 92.14 secs
- 3. Propeller 3 = 71.6 secs

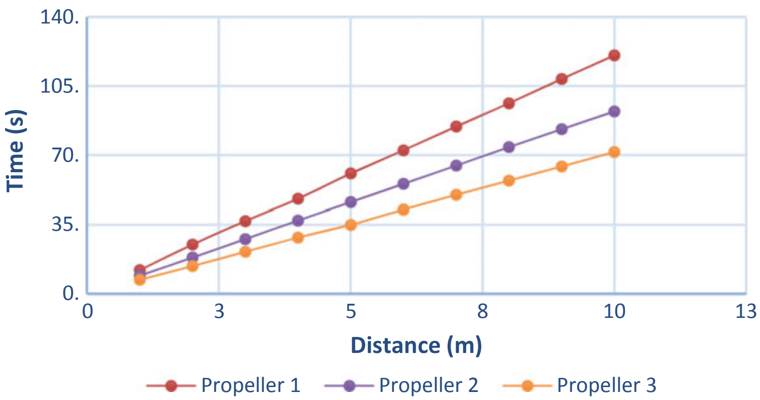

Fig. 18.8 Propeller analysis graph

Therefore, propeller number 3 with a length of 64 mm and a width of 40 mm was found to be effective.

18.4.3.1 Result Analysis Summary

1. Deeper the draft resulted into decrease in time taken to travel at a constant distance due to high water resistance.
2. Larger propeller blades resulted into an increase in the harvesting rate and reduced the time taken in harvesting.
3. Larger sprocket diameter resulted in increased speed and harvesting rate.

Therefore, the prototype should be constructed with larger propellers, larger sprockets and maximum draft depth should be taken into consideration when designing it.

18.5 Conclusion

Water hyacinth has more negative impacts compared to the positive impacts to the society. Therefore, the society can benefit a lot when water hyacinth is controlled.

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Chapter 19
On the Hydropower Energy Generation from Pipelines

Md Redzuan Zoolfakar and Muhammad Haziq A. Majid

Abstract The primary objective of this study is to analyse the electrical power output generated from water flow in pipelines by using a suitable method to carry out the experiment. Hydroelectric power generation is widely used in Malaysian to generate electricity for consumer. As it comes with the function of a dam that collects water and the water flows from high level to low level that passes through turbine to generate electricity based on their capacity. For ship usage itself, the electricity is generated using diesel generators. If one applies the principle of hydroelectric power generation on ship, one can reduce the fuel consumption and dependency toward the generator. As pipelines are widely used in ship systems, there is always pressure in it no matter type of fluid in it. Moreover, only little alteration must be made to the system when applied by ship owners. The system consists of a turbine inside the pipeline connected to the shaft that rotates the rotor to generate electricity that can be stored using batteries or distributed for ship usage.

Keywords Hydropower · Renewable energy · Power generation · Crossflow turbine · Pipeline

19.1 Introduction

The power generation in ships is always a major issue as it contributes to fuel consumption and emission toward environment [1]. Many new are created to reduce or minimize the issue by new technologies. For example, solar panels are being used but this is not enough to generate power for the whole vessel and in addition it is quite expensive to equip a ship with this technology. Next, the shaft generator was introduced to make benefit of the rotation of the propeller shaft from the main engine. But

M. R. Zoolfakar (✉) · M. H. A. Majid
Marine and Electrical Engineering Technology Section, University Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: redzuan@unikl.edu.my

M. H. A. Majid
e-mail: haziq.majid@s.unikl.edu.my

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it comes with big issue for a ship in service to be equipped with, it as it the ship need to dry dock and need to make new layout for the engine room to accommodate the shaft generator. Even though the power generated from the shaft generator is sufficient for the whole ship and there is no need to use the diesel generator. It makes the load of the main engine increase and the fuel consumption increases proportionally.

The usage of a small generator powered by the flow of water that continuously flows in the pipeline is a great idea as it is already implemented in commercial use and proven to be efficient. Therefore, by placing a unit that consists of a turbine or propeller, shaft, and the motor it can certainly generate electricity.

19.2 Literature Review

A review of existing literature has been carried out to support the research undertaken in this chapter. This literature review provides general information pertaining to the power generation and the best parameters to implement hydropower in pipelines. In addition, this chapter also illustrates the problems and solutions to complete this research.

19.2.1 An Overview of Power Generation

In modern perspective, power generation started when Michael Faraday and Joseph Henry invented a primitive electric motor that was based on the theory of induced current when a wire is moving near a magnet where a current is produced which lead to the principle of generator nowadays [2]. Then invention occurred when the idea to make the moving wire a continuous magnet to produce a constant current [3]. Therefore, mechanical energy needed to be converted into electrical energy because modern power generation systems are equipped with a turbine that rotates the stator [4]. The mechanical energies of a rotating turbine moved by various resources and systems can be divided into renewable and non-renewable energy [5].

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes or even in many, many lifetimes. Most non-sustainable power sources are non-renewable energy sources: coal, oil, and gaseous petrol. Carbon is the principle component in non-renewable energy sources. Consequently, the timespan that petroleum products framed around 360–300 million years back is known as the Carboniferous period [6].

Every single petroleum product is shaped along these lines. A huge number of years prior, even before the dinosaurs, Earth had an alternate scene. It was secured with wide, shallow oceans and swampy backwoods [7].

Plants, green growth, and tiny fish developed in these antiquated wetlands. They ingested daylight and made vitality through photosynthesis. At the point when they passed on, the living beings floated to the base of the ocean or lake. There was vitality put away in the plants and creatures when they died.

After some time, the dead plants were squashed under the seabed. Rocks and other silt heaped over them, making high warmth and weight underground. In this condition, the plant and creature remain inevitably transformed into non-renewable energy sources (coal, flammable gas, and oil). Today, there are immense underground pockets (called supplies) of these non-sustainable wellsprings of vitality everywhere throughout the world.

19.2.2 Renewable Energy

According to Lora Shinn et al. [8], renewable energy is a stated that renewable energy is sustainable power source, regularly alluded to as perfect vitality, originates from common sources or procedures that are continually renewed. For instance, daylight or wind continue sparkling and blowing, regardless of whether their accessibility relies upon time and climate. Then as world still depend on non-renewable energy to produce electricity, there is a goal to increase the usage of renewable energy by 2030 to reduce the emission. This goal has been started by developing a country as first step toward that goal [7].

According to [9] at the International Energy Congress in 2012, it was stated that the most significant sustainable energies of vitality in Malaysia are biomass, hydro and solar. Biomass assets, for example, palm oil deposits, wood build-ups, and rice husks that can be utilized for heating and power generation.

19.2.3 Hydropower

The use of streaming or falling water is one of the effective methods of producing energy. This can be done by building dams around rivers. Hydroelectricity is referred to as this operation. The theory uses the constant water flow to drive the turbines, allowing the use of the kinetic energy of the flowing water [10]. Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32% of the global hydropower in 2010. China is the largest hydroelectricity producer, with 721 terawatt-hours of production in 2010, representing around 17% of domestic electricity use [11]. In Malaysia, the hydropower energy becomes one of the most important sources to generate electricity in Malaysia for consumers.

19.2.4 Crossflow Turbine

In small-scale hydropower generation, cross flow turbines (CFT), also known as Banki or Ossberger turbines, are commonly used. The main characteristics of this turbine are a simple construction and operation, low operating and capital expense and fairly independent flow rate performance [12].

By using the optimum profile of the leading edges of the blade profile such as flat tip, round tip, pointed tip, and oval tip were analyzed to ensure which one is better in the amount of rotation [13].

A drum-shaped crossflow turbine uses an elongated, rectangular-section nozzle on a cylindrically shaped driver, guided against curved vanes. This looks like a blower of the "squirrel cage." The crossflow turbine enables twice the water to flow through the blades. The first pass is when the water flows to the inside from the outside of the blades; the second pass is back out from the bottom. The stream is guided to a small portion of the runner by a guide vane at the turbine entrance. The crossflow was designed to accommodate larger flows of water and lower heads than the Pelton turbine [14].

19.2.5 Liquid Flow

Water flow is part of the physics of water and deals with dynamics of fluids. Fluids like gasses and moving liquids are called fluid flow. It involves moving a fluid that is subject to unbalanced forces. The movement persists as long as there is an operation of unbalanced forces.

For example, if you pour water from a mug, the speed of water over the lip is very high, the lip is moderately high, and the bottom of the mug is very low. The unbalanced force is the gravity, and as long as the water is available and the mug is tilted, the flow continues.

For fluid flow or called flowrate, Eq. (19.1) shows the volume of fluid replaced in a given interval of time and this is called the fluid flow equation [15].

$$\dot{\mathrm{m}} = \rho \mathrm{AV} \tag{19.1}$$

Where, $\dot{\mathrm{m}}$ is the mass flowrate, ρ is the density, A is the area, and V is the velocity.

For comparison of different sizes of pipe, this will result in a difference of the water flow with the velocity as can be seen in Table 19.1.

Table 19.1 Difference between pipe size and water flow

Pipe size (inch)	Maximum flow (gal/min)	Velocity (in ft/s)	Head Loss (ft/100 ft)
2	45	4.3	3.9
2.5	75	5.0	4.1
3	130	5.6	3.9
4	260	6.6	4.0
6	800	8.9	4.0
8	1600	10.3	3.8
10	3000	12.2	4.0
12	4700	13.4	4.0
14	6000	14.2	4.0
16	8000	14.5	3.5
18	10000	14.3	3.0
20	12000	13.8	2.4
24	18000	14.4	2.1

19.3 Methodology

This chapter will elaborate and explain about the steps, procedures, and details about the experiment that was conducted. These experiments were described in the flow of planning and execution to obtain the result and data. It describes on how the process to gain the data for the project parameters till the data analysis obtained was processed.

In general, this project or experiment was constructed to obtain the data of hydropower power generation unit. The methodology was applied which was collecting the data and analysis from this experiment. Therefore, the methods used for this experiment are suitable to provide the result for the project.

19.3.1 Parameter of Experiment

Parameters are also known as variables that were used in this project and are listed down below as well its explanation. The parameters are required to differentiate and compare results from the experiment for analysis.

19.3.1.1 Pump Power Rating

Different pump power ratings were used for this experiment, i.e., 6 W, 8 W and 10 W. This was done to differentiate how the power of the pump, a brushless submersible pump, plays a major role for the experiment.

19.3.1.2 Position of Pump

The experiment was conducted with two positions of the pump that is before and after the hydropower unit that will generate the electricity. This was done to differentiate the produced power for the suction and discharge outlet of the pump.

19.3.1.3 Diameter of the Used Pipe

The project was conducted with two size of the pipe diameter to act as the variety of this experiment and to show which will produce more power as it is related to pressure. The sizes of the pipes that were used are 1/4″ and 3/4″.

19.3.1.4 Number of Turbine's Blades

Different numbers of turbine blade were used in order to determine the power generation. The type of the used propeller is a crossflow type. The number of blades used are 12, 16, and 24 blades.

19.3.2 Experiment Design

19.3.2.1 Free Fall Sketching

Free fall sketching in Fig. 19.1 is to show how the situation of this experiment was conducted that is two tanks separated by 0.5, 1.0 and 1.5 m in height for each experiment with the hydropower unit placed in between.

19.3.2.2 Actual Experiment Sketching

On the other hand, the actual experiment sketching shows how the experiment with the presence of a pump with two positions, that is before and after the hydropower unit placed, is being conducted.

a. Hydropower unit before the pump with a variation of 1/4″ and 3/4″ diameter of the PVC pipe (as shown in Fig. 19.2).
b. Hydropower unit after the pump with a variation of 1/4″ and 3/4″ diameter of the PVC pipe (as shown in Fig. 19.3).

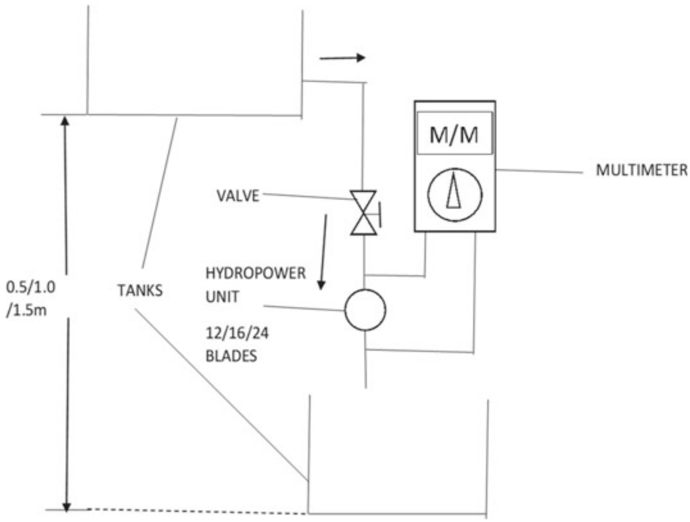


Fig. 19.1 Free fall sketching

Fig. 19.2 Sketching of hydropower unit placed before pump experiment

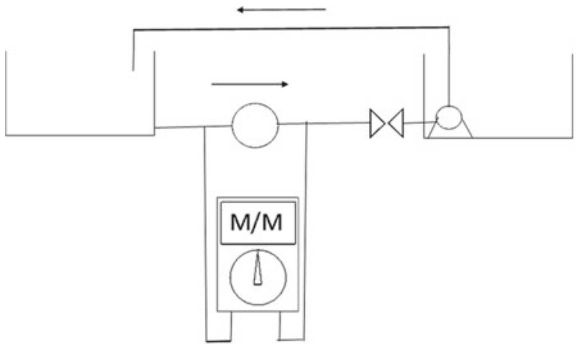
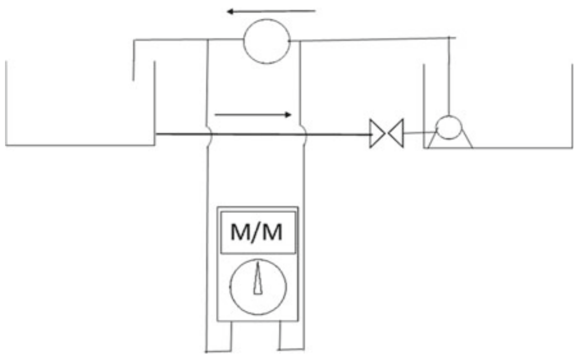


Fig. 19.3 Sketching of hydropower unit placed after pump experiment



19.4 Data Analysis

This chapter contains the result and the corresponding discussion for the project experiment that has been conducted and completed successfully. This chapter is divided into several sections according to the variables to explain the data of the result. Each data set is recorded into tables and plotted into graphs for better analysis and comparison throughout the experiment.

19.4.1 Sources of Data

The experiment was conducted using the method shown in Sect. 19.3 that used Table 19.1 to collect data and the result gathered to form a graph to show the result. The graph is plotted based on the parameters to show the comparison for each of the parameters.

As from the results, power output is created when water flows into the hydropower unit and makes the turbine turn. This action makes the stator and rotor of the electrical generator spin where it creates the current. From there the current is distributed by wire. Various parameters were used to identify the best situation to generate electricity.

This experiment tells that each parameter shows a different power output. In theory, the greater the water flow, the greater the electrical current produced.

19.4.2 Free Fall Power Output Data

From the graph in Fig. 19.4, it shows that the power output of the hydropower unit for free fall is greater when the distance between two tanks were higher. As shown, all three numbers of blades produce more electrical output at 1.5 m compared to other height recorded and plotted.

Meanwhile, in the experiment of the 3/4″ diameter pipe for free fall experiment shows same trend with 1/4″ diameter but lower in electrical power output as shown in Fig. 19.5. This happens because the surface area of the 1/4″ diameter is smaller and this creates more pressure than 3/4″ diameter. Moreover, the pressure also comes from gravity forces where the formula of ρ x g x h, applies. Thus, the higher the distance between two tanks will create more pressure, thus increasing the water flow to the hydropower unit.

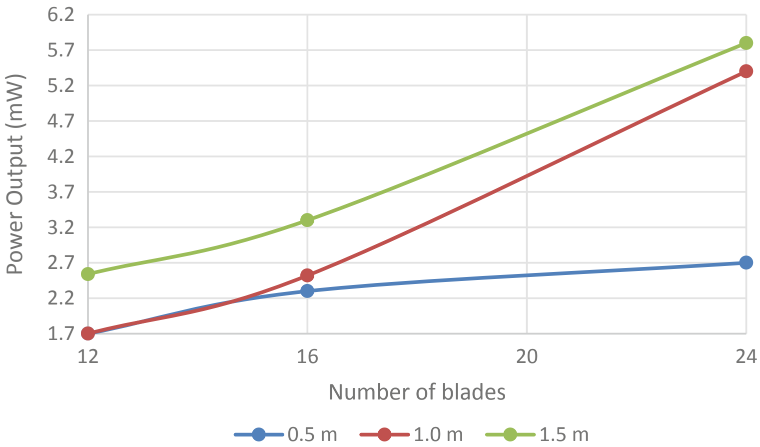


Fig. 19.4 Height vs Number of blades at 1/4″ diameter

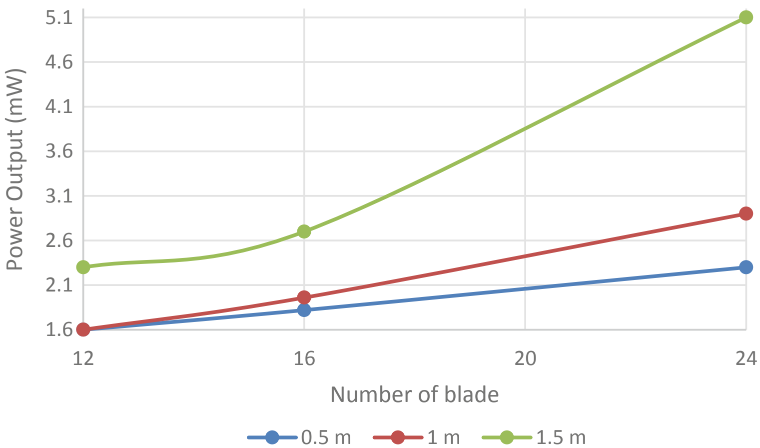


Fig. 19.5 Height vs Number of blades at 3/4″ diameter

19.4.3 Actual Experiment

From the graph in Fig. 19.6, it was concluded that a smaller diameter produces more electrical energy. Moreover, the hydropower unit is placed after the pump. Therefore, it created an additional force of pressure to the water flow as the pump purpose to boost it. So, the 1/4″ diameter produces more electrical output compare to the 3/4″ diameter for all pump power rating.

Based on the graph in Fig. 19.7, it shows that the hydropower unit placed after pump will generate more electricity than when it is placed before the pump. The data collected were drastically different from each other. As example, the hydropower

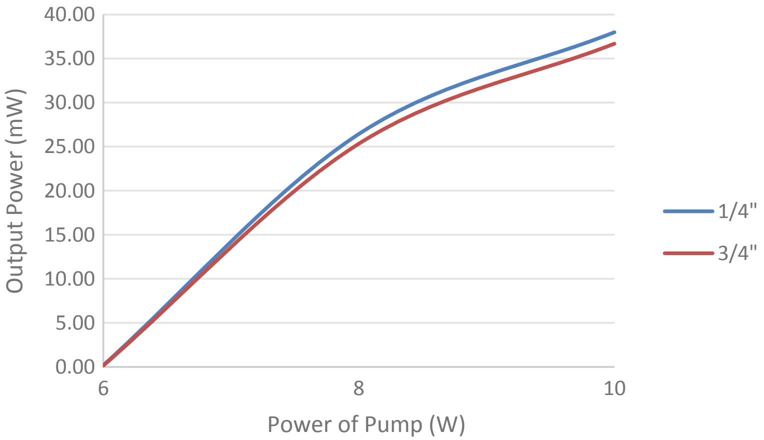


Fig. 19.6 Diameter of pipe vs Power of after pump at 24 blade

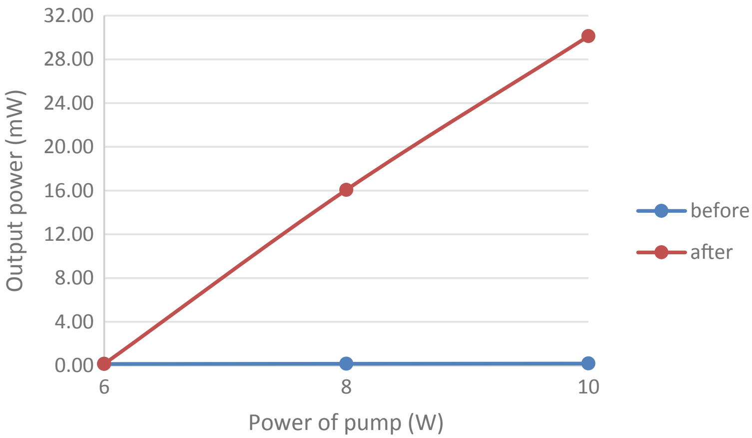


Fig. 19.7 Position of pump vs power of pump at 3/4″ diameter and 16 number of blades

unit placed after the 10 W pump produced up to 30 mW of electricity compare to the hydropower unit placed before the 10 W pump that is below 0.2 mW. This is because the pump boosts the water flowrate before entering the hydropower unit this produces a faster rotation to generate electricity.

As shown in the graph of Fig. 19.8, when comparing the number of blades, the higher the number of blades, the higher the power output. For each 6, 8, and 10 W pump, respectively, where the hydropower unit was placed after it recorded that 24 blades produced more power output compared to 12 and 16 blades. This occurs because more blades are available to pick the water stream that hit it when entering the hydropower unit. So, it rotates more than else to produce a higher electrical output.

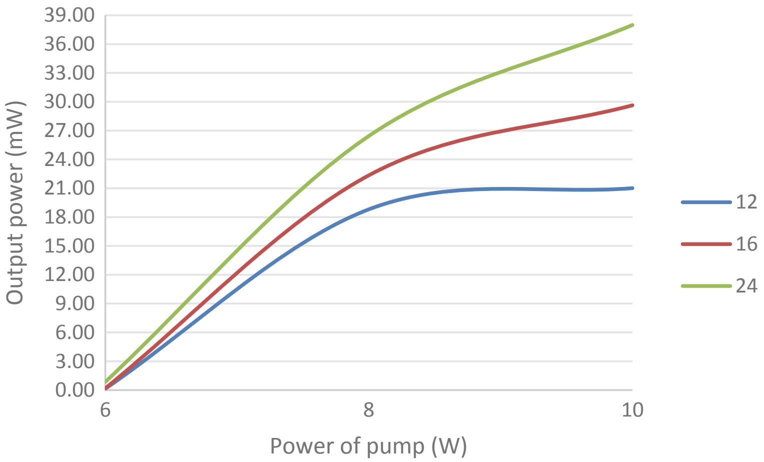


Fig. 19.8 Power of pump vs number of blades at after pump and 1/4″ diameter

As shown in the graph in Fig. 19.9, pump power rating also effects the data for the electrical power output. The 10 W pump will produce more electrical power output for the hydropower unit compare to the 6 W and 8 W pump. This higher pump power rating will increase the flowrate of the water in the pipeline whether it is before or after the hydropower unit. So, when the flowrate of water is high, higher electrical power output can be produced.

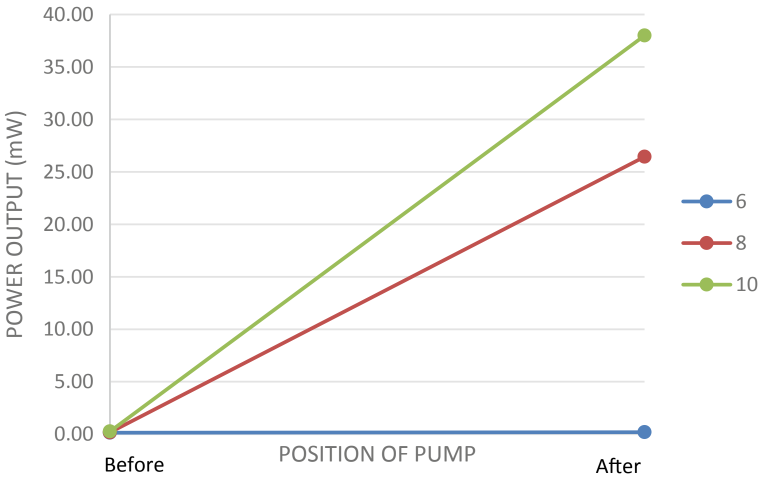


Fig. 19.9 Power of pump vs position of pump at 1/4″ diameter and 24 blades

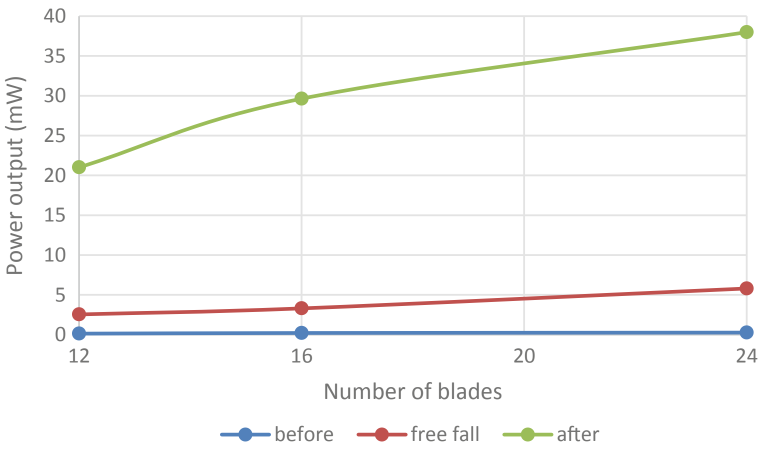


Fig. 19.10 Situation of experiment vs Number of blades at 1/4″ diameter and 10 W pump

19.4.4 Comparison Between 1.5 m Free Fall and Actual Experiment

Figure 19.10 shows the comparison of the before and after placement of the fall of 1.5 m can produce more electrical power output compared to the case when the hydropower unit is placed before the pump. Meanwhile, for the experiment with the hydropower unit placed after the pump always recorded a high value of electrical power output. This is because the pressure acting from 1.5 m free fall is higher than the pressure of the pump created at before placement for the hydropower unit. This occurs as the pump experiment conducted at the both level for the tanks.

19.5 Conclusion

This experiment is successful in achieving the objectives as stated in Sect. 19.1 which is to develop hydropower in a pipeline where this experiment successfully fabricated with the materials and equipment selected and following the design to ensure this experiment works well. Next is to analyse the electrical power output generated from the hydropower unit. The result of this experiment can be found in Sect. 19.4 where the graphs are plotted to show the comparison within the parameters and limitation of the experiment. This experiment is conducted with and effective suitable cost with all the selected materials and design needs.

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Chapter 20
Anti-fouling: Affection and Efficiency

Md Redzuan Zoolfakar and Muhammad Amirul Afiq Jesmin

Abstract This paper studies the efficiency of a self-polishing anti-fouling paint when subjected to different parameters. Results and mechanism of the self-polishing anti-fouling paint are presented and described. Different types of binders for paint were used for the understanding and parameters such as underwater depth, thickness of paint and sun-orientation were compared over 60 days.

Keywords Binders · Copper acralyte · Self-polishing anti-fouling · Silyl acralyte · Zinc acralyte

20.1 Introduction

For more than 2000 years, some of the disadvantages of marine bio-fouling have been recognized and fought. It has been said that early Phoenicians and Carthaginians used copper sheathing on ships hulls. Meanwhile, other ancient cultures used wax, tar, and asphalt [1, 2]. Plutarch (45–125 A.D.) also cites seaweed removal, percolate, and filth from the sides of the ship to make them go through the water more easily [1].

In fact, as stated by [1], Before the eighteenth century, lead sheathing may have been the most widely tried and tested method for ship bottom defense. Despite papers certifying such a material's bad anti-fouling impact, lead coverage was likely sufficient for safeguarding the wooden bottom ship from microbial deformation. Subsequently, the lead coverage was take in turn with wooden sheathing.

Typically, the hindmost was painted with different concoction, for example, tar, grease, and brimstone with huge covers, placed compactly that the covers formed a kind of metallic sheathing.

M. R. Zoolfakar (✉) · M. A. A. Jesmin
Marine and Electrical Engineering Technology, Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: redzuan@unikl.edu.my

M. A. A. Jesmin
e-mail: afiqjesmin@gmail.com

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In 1625 [1] there is first document concerning the use of copper as an anti-fouling agent. It used a combination of compounds [1]. The first usage of copper coverage was recorded by HMS Alarm in 1758, and its achievement prompted some other vessels to copper. Copper was widely used around 1780 within the British Navy.

After the advent of iron ships late in the eighteenth century, copper sheathing was discontinued [3, 4]. The reasons were that the anti-fouling efficiency was not always certain [1]. Various methods were tested, including zinc and tin alloys, followed by copper-coated wood sheathing. Non-metallic sheathings, such as felt, cloth, rubber, and tiles were also suggested [2].

Felt soaked in tar were also used to separate the iron hull from the copper sheathing [1]. Wooden sheathing, which well-suited was tried over the ship bottom, but discarded because of its high cost [1]. The renewal curiosity in the use of anti-fouling compositions was the historical importance and gave birth to iron ships.

20.2 Anti-fouling Paint Concept

It is possible to classify chemically active anti-fouling technologies into three main categories: Insoluble matrix paint, soluble matrix paint, and self-polishing paint. All of these techniques are directed at the same target, the controlled release of bio-active molecules, but function by different chemical processes, many of which remain poorly understood.

Tin-based self-polishing paints are the most effective anti-fouling paints in terms of long-term service life quality. In such paint, to release the anti-fouling agent, the biocidal compound is chemically bonded to the binder, gradually hydrolyzes or dissolved in water.

Shortly after the identification in the early 80s of the adverse side effects of tributyltin [TBT] based compounds on non-target species, tin-free alternatives have been developed and dominate today's market. Chemists from industry and university research laboratories are currently working to improve this so-called tin-free, self-polishing paint to equal the efficacy of anti-fouling paint containing TBT.

20.2.1 Marine Bio-fouling

Marine fouling on surfaces immersed under seawater can be defined as the undesirable accumulation of microorganisms. The adverse effects of this settlement are well documented in the case of vessels.

A rise in the pace of dry-docking activities can be observed. During this method, a large quantity of toxic waste is also produced [1, 5]. It introduces species into non-natural settings and it can be invasive or non-native species [6, 7].

The high frictional resistance due to the roughness produced results in weight an increase and decreasing in manoeuvrability [16]. Higher fuel consumption is required to compensate for this, resulting in enhanced emissions of damaging compounds [8]. It may also involve the need for heavier and less powerful equipment. The rise in fuel usage can be as high as 40% [9] and the general cost of travel is as high as 77% [1].

20.2.2 *Economic and Mother Nature Impact*

According to the International Maritime Organization, by 2020, the worldwide trading vessels will burn about 500 million tons of fuel per year, which accounts for about 90% of global product trade by referring to MARPOL Annex VI, IMO,

Sub-Committee on Bulk Liquids and Gasses 2007. According to [10], compared to a predominantly fouling-free hull, the potential lack of fouling protection on vessel hulls could add up to around 70% in propulsion energy.

If this is translated into easy-to-understand units, extremely effective anti-fouling [AF] protection will save more than USD 150 billion annually in 2020. In regards to the inspection, maintenance and repair of immersed surfaces, each of these variables contributes to enormous cost consequences. Unfortunately, the only undesirable impacts of fouling are not excessive financial expenses and the emission of greenhouse effect.

It is now apparent that one of the marine species most prevalent vectors to be implemented in non-native settings is via shipping. Fouled ships can be regarded as “biological islands” that harbor bio-fouling communities within their hulls that could possibly infest any waters the vessel is traveling through [11].

Some of these species have life cycle characteristics that can render them a nuisance due to the correct environmental circumstances. The effects of such can be, on the one side, by means of directly or indirectly competition with indigenous species, effect on greater trophic concentrations, habitat change, and changes of ecosystem domain. While, if flipping the coin, financial and social through cost of loss of ecosystem features, impact on human health as well as control measures.

20.2.3 *Marine Bio-fouling Phase*

The organisms that participate in marine bio-fouling are primarily the naturally occurring [1]. It is also recorded that on fouled structures an abundant species was found, and [12] subsequently increased in number of species. However, it only comprises a very small share of the known marine organisms. Due to only certain species are able to adapt to the man-made conditions and will stick strongly enough to prevent washing away.

Ships are a case in point for a specific setting. It can only dominate forms adapted to withstand large variations in conditions such as temperature, water course, and salt content [2]. Conventionally, the fouling procedures have been seen as consisting of multiple specific periods [5, 7].

Settlements of bacteria are rapidly growing on this modified surface. The organisms are first adsorbed reversibly primarily by a physical process and then adhered to [5, 7] along with protozoa and rotifers to build a microbial bio-film [1]. This arrangement provides microorganisms with increased defense, toxins, and environmental modifications, as well as easier encapsulation of the required nutrients.

For this purpose, under static conditions, a bio-film [9] can cover any surface, even covered by biocides. Some consequences from this on anti-fouling is that biocidal dissipation levels can be altered because of increased diffusion resistance and environmental shifts (e.g., pH and alkalinity). These deduce that the need for experimental testing to gauge the actual behavior of an anti-fouling paint once it is submerged.

The transformation from a microbial bio-film to a more complicated environment is seen as the third step of fouling. In addition to the growth of macro algae, the final stage includes the encampment and development of huge marine invertebrates [13]. Typical characteristics of macro fouler include fast metamorphosis, fast rates of development, low preference for substrates, and strong adaptability to distinct settings.

The appearance of molecules and species in film is acknowledged as having an effect on organism settling [9]. The mechanism behind this is that they can serve as nutrient for toddler organisms, discoloring and dull shiny surfaces that prevent fouling as well as improve surface alkalinity, favor adhesive deposition, and altering surface-free strength to affect the tenacity of the attachment [8].

Bio-fouling local severity relies on a big amount of parameters. Some of these are determined by the circumstances of water and rely on the vessel's geographical place and working pattern. These parameters cannot therefore be altered to regulate the fouling organisms' development. There is no question that temperature is one of the parameters of most significance. It is acknowledged that fouling is typically heavier in areas with elevated water temperatures [1].

In areas where significant variations in the seasonal temperature occur, the growth of many species during the low-temperature period is fully suppressed and during the few hot months only one generation can be produced. In tropical climates, where the seasonal adjustment in circumstances are comparatively small, fouling will continue throughout the year without interruption. Extensive analysis of the sterilizing causes of elevated temperatures on various artificial structures was conducted (e.g., Pipe systems). It cannot however be extended to the shipping industry [9].

Solar radiation as well plays a decisive part in the uppermost layers of the seas, and hence in the vessel bio-fouling. As well as modifying temperature and salinity, it has a strong effect on plant photosynthesis levels and thus influences animal nutrition [1]. Dirty waters can affect either without an intermediary by toxicants or inaccidentally the photosynthesis.

Suspended matter can produce substrates which are unsuitable for many types of attachment [1] and may also interfere with livestock feed using water filtering. Meanwhile, other pollutants can supply abundant nutrient and thus improve fouling.

Specifically, marine bacteria and aquatic species are less abundant in inland waters compared to coastal waters. Another parameter influencing fouling severity is depth, but it does not impact vessels because they are always floating on surface waters. Not to mention, the interactions among the various species also alter the fouling cycle. Bacteria can cause substantial mortality to their hosts in host-associated bio-film because of degradation of the host tissue, and improve dragging of their hosts [4].

Additionally, bacteria can fight for nutrients, prevent exchange of gasses, obstruct sunlight, and even promote that can inhibit attachment [2]. Other parameters depend on the ship's configuration, which can be a priori altered. For example, [14] notes that fouling did not occur significantly at speeds greater above 6 kn [3].

Too low speed is inhibiting nutrient intake, while too fast flow rates increase shear and turbulence which affect nutrient encapsulate of bio-films. According to [1], bio-film formation was swift and their viscosity increased in turbulent flows compared with bio-films created under reduced flow circumstances. Thus, it can be added that in this pattern a limit is expected, because higher speeds often entail higher levels of bio-film detachment.

Unfortunately, the water flow from sailing speed cannot be changed to a large degree, and depends on the type of ship. However, the design of the substratum, which naturally impacts adhesion processes, relies on coating surface characteristics and a coating can be optimized for anti-fouling purposes.

20.2.4 Algae as Organisms That Foul

Algae can settle and grow on a wide range of surfaces, both natural and man-made. They are rapid colonizers and numerous species cannot compete with it. Marine organisms on submerged man-made structures are responsible for major economic costs and the recent recrudescence of algae in the environment has seen an increase in the observed fouling phenomenon. The resistance penalty for ships is known to increase by 11% in the presence of a light micro algal slime to 34% in the case of macro algae colonization [5].

Marine organism colonization of immersed structures can cause significant damage such as steel surface corrosion, reduced ship speed as a result of increased drag [1]. Authors of [2] measured the effect of algal fouling on the hulls of ships and found that the resistance penalty was increased by 11, 20, and 34% respectively, in the presence of light slime, heavy slime, and macro algae, and increased production of CO_2, NO_x, and SO_2 (related to increased fuel consumption).

20.2.5 Climate Change Projected to Have an Effect on Bio-fouling

In the coming decades, there will be profound changes in the marine environment, such as elevation of water temperature and ultraviolet radiation, increases in salinity, and declines in pH due to acidification. Such changes will not only affect the survival of fouling, but will also change the characteristics of microbial communities.

Current anthropologically caused by climate change, which is only a fraction of expected changes in the decades to come, has already prompted major responses in the biota of the Earth [15]. Such climate changes are largely caused by greenhouse gas emissions. Global surface temperatures of air and sea have risen by 0.6 °C–0.8 °C over the past century [15]. Ocean warming results in ice melting and an increase in the intake of freshwater causing sea level to rise by about 2 mm per year and the global mean level is projected to rise by 0.09 m to 0.88 m during this century [15].

The increase in carbon dioxide (CO_2) in the atmosphere results in an increase in its ocean concentration. Continuous CO_2 intake is expected to decrease oceanic pH, reducing by 0.3–0.5 units over the next 100 years and by 0.3–1.4 units over the next 300 years [15]. Decreasing pH will have a striking impact on marine calcifying species, while soft body organisms can benefit from such changes.

20.2.6 Marine Domain

No greater effort has been paid to the effect of water parameters on effectiveness of anti-fouling paints. Recently, it has shown that chemical responses are essential factors in efficacy of anti-fouling paints and can be greatly affected by marine domain conditions [12]. The mentioned Anti-fouling paints are focused in releasing many biocides that are linked together.

The open literature includes several credentials to the effect of marine water framework on anti-fouling paint quality. For deduction, the salinity number influences the dissolution in TBT-SPC paints [14], feedback of major binder parts such as rosin [14] as well as TBT group division [7].

Also significant is the temperature effect, as it defects the chemical reactions and transport procedures of chemically active anti-fouling paint operation. In the case of rosin-based paints, as reported by [14], the pH effect is even more crucial.

It may be likely that water ions, pH, and temperature will play a huge decisive role in the responses associated with tin-free biocide-based coatings, since they originate from similar procedures to those of TBT-SPC paints. In addition, several of these parameters affect the extent of the bio-fouling and hence the anti-fouling conditions and the environmental fate of the toxicant released.

20.2.7 Anti-fouling Paint Development

Based on the aim of disseminating a toxicant in a polymer vehicle, a multitude of paints were created in the mid-1800s. Popular anti-fouling materials were copper oxide, arsenic, and mercury oxide. Turpentine oil, naphtha, and benzene are an included solvent as well. James McInness used copper sulphate as an anti-fouling binder in 1860. At the same time a paint, which was mixture of rosin and copper compound was produced simultaneously in Italy [1].

In 1906, the U.S. Navy Yard at Norfolk investigated hot-plastic and other anti-fouling paint [1]. The manufacture of the bottom paint of the first U.S.A ship started after the success of spirit varnish paint. From there, various varieties of red mercury oxide paints were used, suspended in grade A gum shellac.

The U.S. Navy replaced the shellac type anti-fouling paints with a coal-tar formula around 1926. The inexpensive, abundant, and successful candidate of the ever increasing costly and scarce high-grade gum shellac was discovered to be rosin. A hot-plastic paint has been created at the same time. Using copper or mercury oxides as toxic substances enhanced the efficacy of these carbon-tar-rosin and shellac paints [1].

Hot-plastic paints at the ship's site required some paint heating equipment, making installation difficult, making it easier to apply a "cold-plastic paint" [1]. Such paints have already significantly minimized fouling, and have been extended for repainting purposes [1].

Significant modifications took place in the anti-fouling paint sector after World War II. Examples of these modifications are the appearance of fresh synthetic petroleum-based resins with enhanced mechanical properties or enhanced security and health concerns which have caused the abandonment of organo-mercurials and arsenicals as well as introduction of airless spraying [12]. The presence of organotin also enhanced the efficiency of anti-fouling paints during this era and seemed to fix the issue of fouling definitively.

Van de Kerk and his colleagues provided the first study in the mid-1950s on the anti-fouling opportunities of highly toxic TBT [13]. The excellent anti-fouling properties of the TBT were discovered and marketed in the early 1960s. Organotin was initially used as co-toxicants in high-performance copper paints, but was being used increasingly in all-organotin systems.

These biocides were not subject to a paint binder at first, but persisted in "free association type" [9]. The paints can then be divided based on the chemical behavior of the binder, and describe by its water solubility.

20.2.8 Self-polishing Paint

Significant changes took place in the anti-fouling paint sector after World War II. A massive leap forward in anti-fouling results was the addition of highly poisonous organotin for example, tributyltin oxide (TBTO) to rosin-based paints. This efficiency was further enhanced when the organotin release rate was lastly regulated by the tributyltin self-polishing co-polymer paints.

20.3 Methodology

This section describes and proceeds in determining the corresponding properties, field testing, and analysis in the process of conducting experiment. It also describes the sequence flow of the project and proposed planning in order to achieve expected outcome.

In general, it required to construct a field testing site to collect data and analyse it. The methodology of field testing was applied which involved data collection and analysis from the field are testing. Subsequently, methods used for the field testing were lined up to provide the results within the project.

20.3.1 Binders

The type of anti-fouling paint that is used is a Self-polishing co-polymer. However, there are three different binders considered: Copper-acralyte, Zinc-acralyte, and Silyl-acralyte. Each paint will be painted on specimens with three different thicknesses by strictly following the paint TDS guidelines. This means in regards to its primer, thinner, surface preparations, and dryness time. All three binders are associated with the following paints brand: (1) Copper-acralyte will be Jotun Seaforce 90 and Chugoku Sea Grandprix 220 HS, (2) Zinc-acrylate will be Chugoku Seaflo Neo CF Z, and (3) Silyl-acralyte will be Intersmooth 7465si and Jotun Seamate M.

20.3.2 Thickness of Paint

Different thicknesses of anti-fouling paint are used in order to determine the efficiency of the anti-fouling paint for a given thickness. Thickness of anti-fouling will be based on ASTM D3623-78a and paint manufacturer guidelines.

20.3.3 Underwater Depth

Different depths are used to immerse the test specimens. The reason is to correlate the efficiency of anti-fouling paint under different depths of water. The depth that is used is ranging from minimum of 0.3 m to maximum 3 m based on ASTM D3623-78a.

20.3.4 Sun-Orientation

Test specimens are subjected to different sun-orientations which means one side of the test specimen will always face the sun while the other side will always remain from the sun. This is to check the correlation of growth of algae affecting the efficiency of anti-fouling coating.

20.3.5 ASTM A36 Mild Steel

Test specimens are made from mild steel ASTM A36 which has a medium low-carbon percentage in it, which is the standard steel being used for testing anti-fouling panels in shallow submergence. The dimension of mild steel is 6 mm (Height) × 250 mm (Length) × 200 mm (Width).

20.3.6 Sandblasting

ASTM D3623-78a specifies the parameters to be used in order to obtain a near-white surface finish with a profile of 25–38 μm. Parameters in sandblasting are: size of grit for sand is 46, pressure 620 kPa, angle 90°, distance from surface, 75–125 mm, nozzle size, 9 mm.

20.3.7 Data Table

Test specimens are evaluated for surface fouling and physical condition of the anti-fouling paint for an interval of four days using the data table in Table 20.1.

Fouling Rating (F.R) is the fouling present on the test specimen which is intact during inspection. The procedure to calculate the F.R. is described in the following. Award each test specimen which is free from any bio-fouling a percentage rating of 100. Reduce the rating to 95 when there is any bio-fouling occurring. If mature forms of fouling are present, obtain the rating by subtracting from 95 the sum of the number of individuals' present and percent surface covered by.

Anti-Fouling rating (A.F) is the condition of the anti-fouling coating and it records qualitative descriptions of the coating. The procedure to calculate the A.F. is described in the following. Award an anti-fouling coating test specimen having no defect a percentage rating of 100. Subtract the percent surface affected by the coating from 100 to obtain the rating of imperfect films.

Overall Performance (O.P) is the lowest percent rating of the two preceding values.

Table 20.1 Data table

Independent variables					Dependent variables		
Binders	Days	Sun-orientation	Thickness	Depth	F.R	A.F	O.P
Jotun Seaforce 90	1	Yes	1 layer	0.5 m			
	1	Yes	1 layer	1 m			
	1	Yes	1 layer	2 m			
	1	Yes	2 layer	0.5 m			
	1	Yes	2 layer	1 m			
	1	Yes	2 layer	2 m			
	1	Yes	3 layer	0.5 m			
	1	Yes	3 layer	1 m			
	1	Yes	3 layer	2 m			
	1	No	1 layer	0.5 m			
	1	No	1 layer	1 m			
	1	No	1 layer	2 m			
	1	No	2 layer	0.5 m			
	1	No	2 layer	1 m			
	1	No	2 layer	2 m			
	1	No	3 layer	0.5 m			
	1	No	3 layer	1 m			
	1	No	3 layer	2 m			

20.4 Result and Discussion

Over the 60 days period of experimentation, data were calculated and tabulated and the results are projected in the form of graphs. The graph is plotted based on parameters so comparisons can be clearly seen for each of the given parameters. As from the results, O.P is chosen as it reflects both F.R. and A.F., therefore it shows the best binders in terms of fouling rating as well as paint condition itself.

From the experiment, each parameter clearly showed that it affects the growth of marine bio-fouling on a specimen. Due to the fact that marine bio-fouling is an organism, it requires a perfect condition for it to grow and mature.

Figure 20.1 reflects all binders against parameters such as depth with constant thickness of coating as well if specimens are facing the sun. Copper-acralyte shows the worst degradation in O.P. due to poor resistance to crack and peelings. Thus, it effects the paint hence marine growth is able to attach to the specimens. Self-polishing paint works by hydrolysis reaction where the outer surface of paint will be washed off like a soap and reveals new the surface to combat marine bio-fouling. But, if the paint condition is deteriorating therefore its ability is also degraded.

Each paint manufacturer has its different paint scheme for their anti-fouling self-polishing paint. It clearly can be seen on the Technical Data Sheet (TDS) where

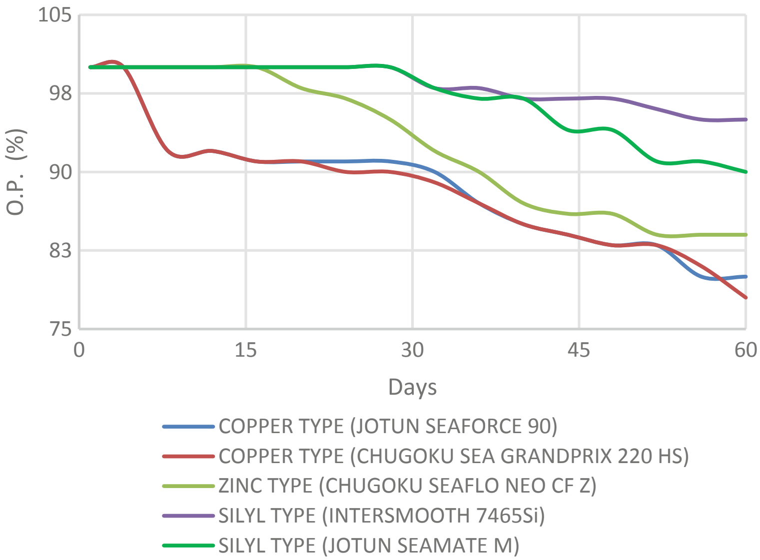

Fig. 20.1 Binders vs days with one layered thickness of paint while facing sun at 0.5 m depth underwater

all have a different recommended paint thickness. Therefore, the parameter of paint thickness arises in order to relate the thickness of paint with combating marine bio-fouling. As Fig. 20.2. indicates, a higher thickness of paint has a higher efficiency in combating bio-fouling. But, even so it arises in O.P., different binders show different values as binders' reaction is different from each other. Silyl-acralyte is able to achieve a higher O.P due to its capabilities in controlling the release of biocide compared to other binders.

Marine bio-fouling is dependent on sun as other organism behaves. Due to the fact that bio-fouling needs photosynthesis hence the sun is a requirement. It does not mean without sun there will be no marine bio-fouling but it will be less prone. Figure 20.3. shows the relation between sun and growth of bio-fouling.

20.5 Conclusion

Field testing can be considered successful as the objectives had been achieved which is to analyse the efficiency of anti-fouling paints against bio-fouling when subjected to different parameters. Next, we were able to create a working field test regarding anti-fouling affecting growth of the marine bio-fouling. Lastly, we analysed the results obtained from the field testing.

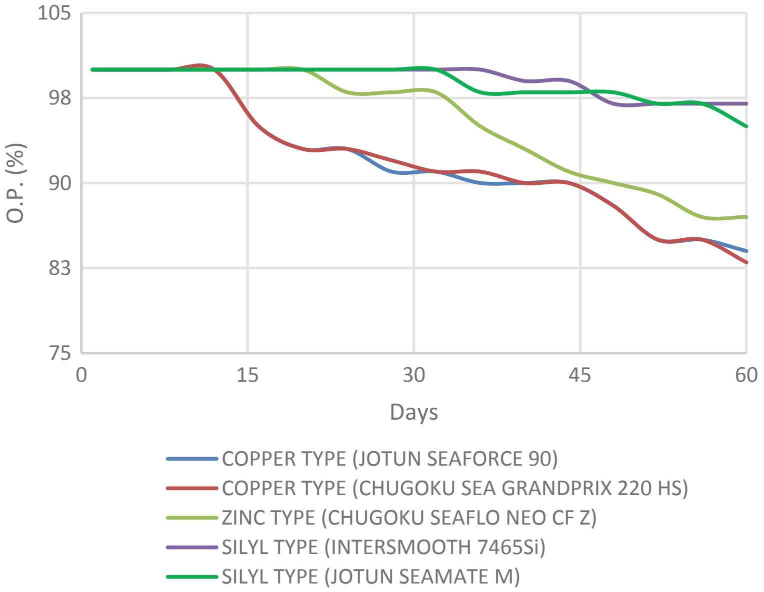

Fig. 20.2 Binders vs days with 0.5 m depth underwater while facing sun with three layered thickness of paint

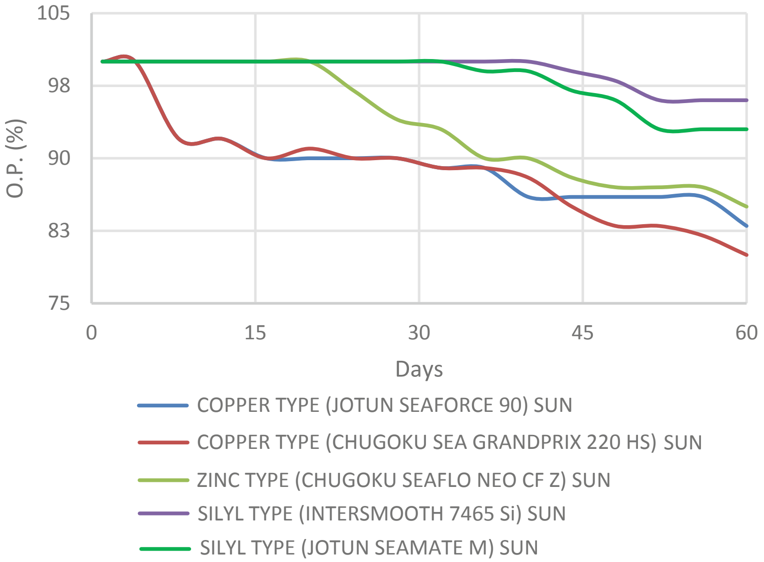

Fig. 20.3 Binders vs days at 0.5 m depth underwater with two layered thickness of paint with sun-orientation

The results show that marine growth occurs tremendously on 0.5 m depth underwater because of greater sun penetration for better photosynthesis as well as abundance of diet nutrition. For better protection, three layered thicknesses of paint is one step ahead against marine bio-fouling compared to other thicknesses. This is not surprising at all because a higher thickness means more layers before it run off. However, caution needs to be taken because the paint sticks on surface which rely on the paint primer itself. In terms of binders, Silyl-acralyte shows greater capabilities in combating bio-fouling due to its inherent characteristic in controlling the release of biocide.

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Chapter 21
Green Port Indicators: A Review

Aminuddin Md Arof, Amayrol Zakaria, and Noorul Shaiful Fitri Abdul Rahman

Abstract Unlike the shipping sector that has witnessed concerted international efforts to address sub-standard ships, similar action has not been seen in the port sector. Other than the efforts taken by the European Sea Ports Organisation that has produced various environmental guidelines to seaports located in the European Union, most efforts to become green or environmentally sustainable are arguably unilateral in nature. As interest in ensuring greener shipping began to accelerate after the implementation of Annex VI of the International Maritime Organization's MARPOL Convention in 2003, the interest to extend its effect on greener seaports has begun to be seen. This resulted in an increase on green port studies beginning 2010. Therefore, the aim of this paper is to review the accessible literature on green ports and to identify the indicators or determinants that were normally addressed to ensure their green performance. Literature search was done through the google scholar search engine using the keywords "green port" and "sustainable port" to identify the relevant literature. Subsequently, a qualitative content analysis technique was used on the 27 identified articles in order to merge the various findings into suitable categories.

Keywords Green port · Sustainable port · Marine environment · Coastal environment

A. M. Arof (✉) · A. Zakaria
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: aminuddin@unikl.edu.my

A. Zakaria
e-mail: amayrol@unikl.edu.my

N. S. F. A. Rahman
Department of Logistics and Management, International Maritime College Oman, Sohar, Oman
e-mail: noorul@imco.edu.om

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21.1 Introduction

More than 80% of global trade are carried on board ships and handled through seaports of the world. Therefore, without an efficient seaport and shipping network, the continually increasing demand to move international trade would not be effectively met. As port traffic continues to grow, the question of how to ensure long-term sustainability of the port sector is becoming an important issue at international level. Responding to the sustainability and environmental challenges, many developed economies have taken unilateral actions to implement green port policies and legislation in their countries and it has been argued that since 2010, the green port concept has been applied as a new paradigm that has become synonymous with sustainable port [1]. It has also been argued that ports and their stakeholders can use their associations with green improvements to explore commercial benefits through positive branding and corporate savings. Therefore, developed economies such as Europe have translated their environmental concerns into the European Sea Ports Organisation (ESPO) Environmental Code of Practice in 1994 that was subsequently enhanced into the ESPO Green Guide in 2012 [2].

A Green port is defined as a product of the long-term strategy for sustainable and climate-friendly port infrastructure development [3]. Similarly, it can also be defined as those that place priorities on pollution prevention, clean technology, clean shipping and clean port services [4]. It is a contemporary trend of port development. Sustainability in terms of the green port concept consists of three key elements: ecological balance, port economic stability and social development [5]. The concept of green ports advocates with port to minimise or eliminate harms to the environment and to improve the port's efficiency. All of these positive effects will eventually affect worker's health and social stability, and also increase economic development. For a port to achieve green port status, it has to adhere to the green port concept and measure the port's green performance.

There are many negative impacts from port operations. These negative impacts come in various forms such as pollution and environmental degradation. As the operations are continuous, the ports are generally aware of the pollutions that are emitted to the natural environment [6]. These negative effects can be mitigated by implementing the concept of green port. A green port uses systems and technologies that prevent the environmental pollution and enable to eliminate or reduce the negative impact of port activities on the environment [5]. Despite the awareness, most port systems use outdated energy consumption measurement technology that does not contribute to energy efficiency, environmental protection and sustainable development [6]. Nowadays, a port requires an updated or advanced technology to measure the port energy consumption. Energy and environmental management systems enrich business processes with new knowledge about energy consumption and allow stakeholders to better understand their activities and processes [3]. Scarcity of resources is a challenge in the development of green port since ports require more resources to develop or improve. According to [5], the concept of sustainable port rationally uses natural resources of the environment. Therefore, the development of green port is beneficial to the environmental resources in the foreseeable future. Environmental planning is important in determining how sustainable seaports are built and developed [6].

21.2 Aim

Studies on green ports seem to increase after 2010. Most green port studies have generally focused on evaluating the benefits of green port implementation, identifying managerial and policy tools required for green ports, transnational initiatives and strategies to improve the green port performance and determining priority green port determinants in order to improve green port performance. The aim of this review paper is to identify the main determinants for improving the green port performance, thus contributing to the fourth category of green port literature. Since ports are involved in activities that are not exactly similar to each other, the presentation of a general list of main determinants or indicators will assist the port management to select those that can provide a significant impact towards achieving a green port status.

21.3 Identification of Important Green Port Indications

Green port indicator is used to measure the port's green performance. The indicators can be identified through several methods. The indicators can form a significant measurement avenue to evaluate the port's status. There are several indicators in ports and it varies depending on the characteristics of ports such as the types of cargo handled, size and locality. At present, the number of research concerning green port indicators is still limited although research on green port has generally increased after 2010. In an earlier study, [7] argues that detrimental effects on the port environment are caused by identified port activities, which include oil spills, waste dumping in the water, cargo spills by chemical carriers and tankers, air pollution from bulk cargo handling, noise and vibration from cargo handling activities, ballast water discharge, collision and stranding of vessels. Hence, necessary measures must be taken to minimise the detrimental effects of those activities. A study by [8] has identified the green criteria of a seaport (GCS) using the Factor Analysis (FA) to evaluate port's green performance. The study was conducted on five ports in Korea. The factor analysis was conducted based on the criteria suggested in other previous research. The research has resulted in the development of green criteria of a seaport (GCS) to evaluate the port's green performance. The GCS consists of fifteen indicators grouped into five main categories. Category one is easing the environmental burden; involving the utilisation of alternative fuels, incentives of pollution reduction, using renewable energy, and recycling of dredging sand recycling. Category two involves environmental friendly method and technology development of construction, whilst the third category involves utilisation of resources and wastes inside a port. The fourth category deals with efficient planning and management of port operation involving the introduction of a port environment management system, expansion of prevention facilities of ocean pollution and an efficient construction plan. The final category is port redevelopment with the introduction of a waterfront concept which involves the introduction of environmental impact assessment (EIA), and creation of artificial sandbars and wetlands.

A year earlier, the authors of [9] espouse determinants to consider for Greece to develop a port with green status. The first determining factor involves measures to prevent air pollution such as fully comply with regulations, installing air monitoring station for monitoring pollution emitted, modernise cargo handling equipment, using filters and friendly fuel to reduce fuel emission, provide shore power and used wet suspension. The second factor is to reduce soil and sediment pollution followed by an improvement in water quality through development of a storm water pollution prevention program, cleaning the paved roads, connect the contaminant water to the sewage treatment plant and installing sensors for pollution risk. The fourth factor is improving the marine life through periodical environmental studies and tracking indicators of habitat quality. The fifth factor is the reduction in energy consumption by enforcing energy efficiency policies, installation, maintenance, usage and storage of renewable and eco-friendly forms of energy, and conduct energy consumption studies. The sixth factor is the reduction of noise pollution followed by an improved weather monitoring by establishing weather station networks. The last two factors are modern environmental perspectives for green ports by using geographic information system (GIS) environmental monitoring and adopting sustainable practices through recycling, using solar energy or hydroelectric power and applying energy efficiency plans [9].

The authors of [10] in their case study on the Kaohsiung harbour argue that by adopting an onshore power supply (or known as cold ironing) system and speed reduction to 12 knots within a 20 nautical mile zone could reduce nitrogen oxide (NO_x) by 49.2%, sulphur dioxide (SO_2) by 63.2% and particulate matter (PM) by 39.4%. Moreover, by preventing ships at berth from using their auxiliary engines, greenhouse gas (GHG) emissions involving carbon dioxide (CO_2) and hydrocarbon (HC) would also be reduced by 57.2 and 29.2%, respectively [10]. [10] also argue that green port concept requires an efficient leadership, relevant policies and regulations, innovations, and an environmental energy efficient and sustainable development management system. A subsequent study by [11], has evaluated port's green performance on three major ports in Asia, which are Shanghai, Hong Kong and Kaohsiung. The study identified 17 green port indicators through a brainstorming session with academicians. The indicators were later reviewed and grouped into five areas namely air pollution management; aesthetic and noise pollution management; solid waste pollution management; liquid pollution management and marine biology preservation. By applying the analytical hierarchy process (AHP) method to identify the weightage of each indicator, the research results indicate that the top three important actions to improve the green performance are air pollutant avoidance, using electrically powered equipment, and encouraging the use of low-sulphur fuel [11].

In another study, [12] have investigated the factors for operating a green port. The study evaluated three ports in Taiwan namely Kaohsiung, Taichung and Keelung. The authors referred to previous studies and have identified 13 factors based on five dimensions for green port operations. The five dimensions are environmental quality; use of energy and resource; waste handling; habitat quality and greenery and social participation. The results of the empirical study from the research show that the top five attributes of green port operations are hazardous waste handling, air pollution, water pollution, port greenery and habitat quality maintenance. The result is then used to evaluate the three ports green performance. Additionally, by referring to a study by [11], authors of [13] have successfully discovered 15 key performance indicators that can be used to evaluate the green performance of Egyptian ports. Using the AHP method, top four indicators identified are air pollution avoidance, oil spill contingency plan, reducing road vehicle CO_2 emissions and hazardous cargo management. The authors propose a Green Port Performance Index (GPPI) that was subsequently used to evaluate the ports performance based on the top indicators. Additionally, it was argued that the proposed index can be used on ports of any country to ensure compliance to their environmental law [13].

In another study, authors of [14] conclude that energy management is important in achieving sustainability, and more attention must be paid on energy issues in port management. The researchers highlight the importance of renewable energy and encourage the installation of equipment to generate renewable energy. They also emphasise on the development of biofuels in ports as it can be seen as an opportunity for the ports since the world demands eco-friendly fuels. They argue that energy management is important to achieve port sustainability. Therefore, port management must give more attention on energy matters. The researchers express their views towards the importance of renewable energy and encourage the installation of equipment for generating renewable energy from the wind, wave and geothermal energy. Based on a case study on the European ports of Genoa and Hamburg, the researchers encourage installing solar panels on the wide flat surface such as storage areas and warehouses to generate solar energy. They argue that these installations and commitment towards renewable energy can leave a positive impact on ports. Additionally, carbon capture and storage (CCS), material recycling and waste disposal may influence the port's reputation. The production of biogas and electricity can be obtained from waste by converting it into thermal energy. The development of biofuels in ports is also an opportunity for the ports as the world demands eco-friendly fuels [14].

In a research published in 2014, the authors of [3] espouse the problem in achieving green port status is because the majority of the workers tend not to see or feel the link between their action or behaviour and their companies' energy performance and impact on the environment. They argue that energy efficiency is largely linked to investments in new equipment [3]. In their case study on the Port of Koper, Slovenia they discovered that in order to be successful in achieving green port status, a proper selection of the initial projects is vitally important in order to make the green concept alive. Additionally, the involvement of a multi-disciplinary team from all departments in the port is also crucial. The implementation of the green port projects must be supported by an intelligent energy and environmental management system to enable those involved are updated with previous and present performance to ensure their effectiveness [3]. In their evaluation of two Asian and two European leading ports, authors of [4] argue that the most common green tools used by port authorities and public regulators are managing ship traffic, cargo handling and storage activities, as well as port expansion and industrial activities. This is because ports are driven by international conventions that place a higher weight on curbing pollution from ships. They argue that less initiatives were seen in the area of intermodal hinterland connections [4].

Authors of [15] investigated the status and trends in the environmental performance involving 79 European ports on issues related to environmental management, environmental priorities and current environmental monitoring practices. Based on their survey to support their "Port Performance Indicators: Selection and Measurement" (PPRISM) project in 21 European countries, it was discovered that the top five environmental priorities among European ports are air quality, garbage/port waste, energy consumption, noise and ship's waste. Other priorities are relationship with local community, dredging operations, dust, port development (land work) and water quality [15]. Although, some of the priorities have shifted as compared to earlier surveys conducted by the European Sea Ports Organisation beginning 1996, it has been argued that dredging operations, dust, port development and water quality have consistently appeared as the top priorities among European ports[15]. Authors of [16] propose the data envelopment analysis (DEA) and panel data estimation models as an approach to assess the efficiency of green ports. They also argue that the deployment of computer and control systems within vehicles laid the foundation for an emission reduction strategy. Additionally, the advance of intelligent logistics and smart transportation will improve the fuel economy that will lead to the choice of cleaner energy [16].

Authors of [15] have identified ten specific components of environmental management and eleven environmental monitoring indicators. The eleven environmental monitoring indicators are air quality, water quality, soil quality, sediment quality, terrestrial habitats, noise, marine ecosystems, energy consumption, water consumption, carbon footprint and waste management. The three indicators of green shipping obtained from the results are onshore power supply, differentiated fees for clean shipping and LNG bunkering. Two techniques were used in this research to identify and select the indicators. Firstly, a bottom-up method was used to assess the current indicators applied by the ports. Secondly, a top-down approach mainly focused on legislation and regulations as well as valuable opinions and suggestions from port communities. According to [17], Vietnamese ports need to emphasise on sustainable development for their expansion and improvement projects. They argue that the criteria for environmental management should be divided into two dimensions, which are internal and external. Ports should use integrated technology equipment for efficiency and reduce cost and time. Collaboration with business partners in computer aided operations is necessary to reduce time and supply chain collaborations to improve stakeholder relations. Furthermore, the utilisation of cleaner port technology equipment is necessary. Periodic collaboration through business meetings with shipping companies for environmental issues is necessary. Port expansions activities should consider sustainable projects with urban authorities to evaluate projects and effects on inhabitants around the ports area. Internal social programs proposed are employee welfare, education and training for management that are related to reduction of potentially damage environmental practices and lead for environmental performance improvement [17].

According to [18] in their study involving Brazilian public ports, there are four main innovations in port environmental management. The first is cooperation with external parties such as UNESCO and specialised companies. The second innovation is improving the internal pipeline of the port, followed by marine biology preservation at port entrance sediment and coastal erosion control, as well as wetland and marine habitat preservation in the port area. The fourth factor is organisation and management training or education for employees and working level, good communication with the local government, establishing managerial organisation for green port development and regular and exclusive budgets for green port performance [18]. On the other hand, author of [19] conducted a review on 18 articles involving green port and condensed green port performance criteria into five groups namely air pollution management, liquid pollution management, solid waste and other pollutants management, aesthetic and noise control management, and lastly marine biological preservation.

In a research done by [6], the modernisation of the waste management system is one of the methods to develop a green port. Examples of green measures mentioned by the researchers are the use of renewable energy for port operations and activities; recycling and reuse of materials; implementation of policies similar to the reduction of the emissions of harmful substances; and landscape design of a port, which includes the plantation of trees to absorb noise and pollution. It has also been argued that the importance of open discussions such as forums with environmental organisations related to environmental activities in order to obtain efficient, high quality guidelines and management recommendations. Moreover, the researchers suggest to establish networking among the ports to exchange experience and knowledge regarding green development. The researchers utilised the qualitative content analysis method to complete their research [6]. Additionally, author of [20], argued that environmental aspects play a vital role for ports as they can gain support from the community and attract trading partners and potential investors. They suggested three approaches to reduce maritime GHG, namely through technical measures, market-based instruments measures and operation options measures. The researchers also argued that on-road and off-road vehicles are the major emissions contributor of the terminal. Technical measures composed of efficient ship hulls, energy-saving engines, more efficient propulsion, use of alternative fuels such as biofuels, scrubbers to trap exhaust emissions and onshore power supply. Market-based instruments are divided into two main categories, namely; carbon levy schemes and emission trading. Operational options measures comprised speed optimisation, optimised routing and improved fleet planning. Based on the outcome of their research on the port of Long Beach and Istanbul's Marpot terminal, they concluded that the major contributors to the total emission in terminal are on-road and off-road vehicles [20].

Authors of the study [9] have listed 21 indicators for green performance evaluation with six sections, which are liquid pollution management air pollution management, noise control, low carbon and energy saving, marine biology preservation and organisation and management for three major China's ports. Among the 21 indicators are a fuel spilling contingency plan, sewage treatment, hazard waste management, ballast water polluting control and waste dumpling management. They are followed by dust control and encouraging use of low-sulphur fuel, cold ironing, regulation on the emissions of toxic gas, annual plan for air pollution management, reducing noise and vibration from cargo handling, equipment and the vessels and using renewable energy resources such as solar heat and wind power. Additionally, using substitute energy and energy-saving devices, applying new energy-saving working processes, using on deck power, port entrance sediment and coastal erosion control, wetland and marine habitat preservation, training or education for employee at working level, good communication with the local government, establishing managerial organisation for green port development, and finally regular and exclusive budgets for green port performance. Recent studies indicate that government guidelines in terms of training and education are the most significant and essential components to evaluate the green port performance. The problems are lack of access to collect data from the ports and also information on guidelines of green port criteria evaluation for becoming "green". Hence, the ports have to get a better understanding on the method to implement a comprehensive approach for Chinese port sustainability practices to improve green performance. Government can take initiatives to promote sustainability by allocating special grants and funds to encourage and motivate Chinese ports for better green performance [9].

According to [21], in their study involving the handling of bulk cargo, the use of technological measure for prevention of the dust emanation during dust material transportation is unavoidable. Dust prevention by perforated wind dust screens is used in Canada, China and several other countries. Depending on the direction of the wind, it functions as wind protection when located upwind from the stack, whilst it functions as dust prevention when located downwind from the stack [21]. The dust problem can also be reduced by using standard container for handling bulk cargo. The box type bulk cargo handling reduces missing cargo compared to open storage. Five indicators are proposed for green operations in dry bulk terminals, namely treat dust production materials at dispatch point with special liquid solutions, watering stacks at open handling points of materials, frequent dust removing and area cleaning, installing wind dust protection screen at port area and container cargo handling system of delivery materials [21]. Additionally, author of [22] in their study on toxic air pollution in United States' 20 biggest container ports discovered many challenges in the measuring port efficiency due to the heterogeneity characteristics of port activities. They argued that although ships are becoming more efficient, they are the largest in port source of toxic air pollution contributing about 70% of sulphur oxide (SO_x) and 50% of PM [22]. Author of [23] espouse six green port concepts based on their study on six ports in Turkey, Europe and the United States.

The first concept is air quality that aims to reduce air pollution and improve the air quality at the port areas by using the shore electricity as power source. Next is monitoring the wildlife by tracking several indicators of habitat quality including the abundance of birds and the number of fish species found in the harbour during periodic biological surveys. Hence, ports also have to plan for restoration programs for rehabilitation area and should conduct a biological periodic survey after every construction. Third, the water quality needs to be measured by its own parameters for water quality study. Fourth, the community relation for sustainable environment must be improved in order to complete for EIA. Public broadcasting can be used as a channel to gain awareness for the public on the protection of the environment. Managing waste material by recycling and reuse is also important as another strategy to protect the ecological environment. Finally, sustainability should be adopted as a new concept to reduce pollution through the recycling method. According to [5], the green port concept will contribute towards the concept of sustainable development, which means a port development that meets the needs of the present and future generations. They espouse efficiency of resources, low emission of dusts and other harmful substances, low emission of noise and economy of land use as the contributors to green ports. Additionally, they propose eight important assumptions to achieve a sustainable port concept as addressed in Table 21.1. Meanwhile [2] utilised the drivers, pressures, states, impacts and responses (DPSIR) framework to integrate different perspectives on environmental, social and economic issues in their study on green port. In addressing the pressures on green ports, they argue that dust pollution, water pollution, solid waste pollution and noise pollution are the main stress inflicted by ports daily operations [2]. Therefore, in order to identify the pressures, ports must be able to identify volume of waste gas emission involving SO_2, NO_x and inhalable particles. Similarly, volume of waste water discharge per throughput, amount of solid waste residual per throughput and average noise level of port need to be considered [2].

A more recent study by [24], propose the environmental performance indicators (EPIs) to access to the environmental aspect of a container seaport through their evaluation of Laem Chabang port in Thailand. According to the authors, green port becomes a trendy seaport activity, and EPIs are important for the assessment of environmental criteria. The authors propose several green port indicators by applying the entropy method in support of the efforts by the Port Authority of Thailand in promoting green ports. The top five indicators are total Kjeldahl nitrogen (TKN) in wastewater, chromium in soil and sediment, total suspended particles (TSP) in the air, phytoplankton biodiversity and zooplankton biodiversity. The authors argue that the EPIs can be used as a tool for green port evaluation that could be applied not only to Laem Chabang port but also to any container port that is interested in achieving the green port status [24]. Additionally, [1] in their examination of green port practices by the port of Bremen and the main ports of West Africa shortlisted 12 green practices implemented by the ports as highlighted in Table 21.1. In their study on the challenges faced by cruise ports, [25] identified waste management and various forms of emissions that include air and noise since cruise ships are large emitters due to their large hoteling loads. Therefore, they espouse on the concept of cold ironing, utilisation of diesel oil to replace heavy fuel oil, renewal energy sources

Table 21.1 Summary of greenport research

No	Author	Research area	Findings	Method	Region
1	[12]	Port planning and development	Activities the cause detrimental effects to port environment are: a. water pollution (oil spills, waste dumping, cargo spills by chemical carriers and tankers) b. air pollution through bulk cargo handling c. noise pollution (vibration from cargo handling) d. collision and stranding of vessels	Not revealed	General
2	[9]	Green port	Factors to achieve green port: a. Air pollution prevention (compliance with regulations, air monitoring stations, modernise cargo equipment, use filters and friendly fuels, shore power and wet suspension) b. Soil and sediment pollution prevention c. Improvement in water quality (storm water pollution prevention, cleaning paved roads, connect contaminant water to sewage treatment plant and sensor for pollution risk d. Improvement of marine life (periodical environmental study and habitat quality tracking) e. Reduce energy consumption (energy efficiency policy, renewable and eco-friendly forms of energy, energy consumption studies) f. Reduction of noise pollution g. Improve weather monitoring, GIS environmental monitoring and adopting sustainable practices	SWOT analysis	Europe
3	[14]	Green port	Development of Green Criteria of a Seaport (GCS) to evaluate port performance with 15 indicators grouped into five categories: a. Easing environmental burden (utilise alternative fuels, incentives for pollution reduction, renewable energy and recycling of dredged sand) b. Environmental friendly method and technology for construction (improvement of port facilities and equipment, breakwater system, less noisy construction method) c. Utilisation of resources and wastes (resources recycling and development of industries in ocean waste disposal) d. Efficient planning and management of port operations (prevention of ocean pollution and efficient construction plan) e. Port redevelopment with waterfront concept (EIA and creation of artificial sandbar and wetland)	Factor analysis	East Asia

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
4	[8]	Green port	Actions to achieve green port: a. Provision of onshore power supply (cold ironing) b. Speed reduction to 12 knots within 20 nautical miles from port c. Efficient leadership, relevant policies/regulations, innovations, energy efficient and sustainable development management system	Case study	East Asia
5	[11]	Green port	Identified 17 green port indicators divided into five groups: a. Air pollution management b. Aesthetic and noise pollution management c. Solid waste management d. Liquid pollution management e. Marine biology preservation	Brainstorming session	East Asia
6	[22]	Green port	Identified 13 factors as guidelines for green port operation. Top five factors are: a. Hazardous waste handling b. Air pollution c. Water pollution d. Port greenery, and habitat quality maintenance e. New measures to reduce port service time through minimising disruption and maximising efficiency	Fuzzy AHP	East Asia
7	[24]	Green port	Four top indicators for green port: a. Air pollution avoidance b. Oil spill contingency plan c. Reduce road vehicle CO_2 emission d. Hazardous cargo management	Fuzzy AHP	Africa (North)
8	[18]	Energy management in port	Factors for efficient energy management: a. Installation of equipment for generating renewable energy from wind, wave and geothermal energy b. Wide flat surface such as storage areas and warehouses that can be used for the installation of solar panels c. Carbon capture and storage, material recycling and waste disposal d. Conversion of waste into thermal energy or used to generate biogas and electricity e. Development of biofuel	Case study	Europe

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
9	[4]	Green and sustainable port infrastructure	Factors to ensure success of initial green port projects a. Development awareness among the workers on the relationship between their actions and the environment b. Proper selection of initial projects to make green concept alive c. Involvement of multi-disciplinary teams in green projects d. Green port projects to be supported by intelligent energy and environmental management system	Case study	Europe
10	[16]	Green port	Main activities performed: a. Managing ship traffic b. Cargo handling c. Storage activities d. Port expansion e. Port Industrial activities Neglected important activity: a. Managing intermodal hinterland connections	Case study	East Asia and Europe
11	[19]	Green port	Top five environmental priorities among European ports: a. Air quality b. Garbage/port waste management c. Efficient energy consumption d. Noise management e. Ship's waste management Other priorities: a. Relationship with local community b. Managing dredging operations c. Dust prevention d. Sustainable port (land work) development e. Water quality	Survey questionnaire	Europe
12	[13]	Energy Efficiency for Green Port	1. Propose DEA and PDE models as an approach to assess the efficiency of green port 2. Deployment of in-vehicle computer and control system laid the foundation of emission reduction strategies 3. Advance of intelligent logistics and smart transportation improve the fuel economy	Data Envelopment Analysis (DEA) and Panel Data Estimation (PDE)	East Asia

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
13	[20]	OSH and Environmental performance in ports	Identified 11 environmental monitoring indicators: a. Air quality b. Water quality c. Soil quality d. Sediment quality e. Terrestrial habitats f. Noise control g. Marine ecosystem h. Efficient energy consumption i. Efficient water consumption j. Carbon footprint management k. Waste management	Bottom-up and top-down methods	Mostly Europe
14	[25]	Sustainable port development	Criteria for environmental management: a. Use integrated technology equipment for efficiency, reduce cost and time b. Collaboration with business partner in computer aided operations c. Utilise cleaner technology equipment d. Port expansions should consider effects on inhabitants e. Training of employees that lead towards improvement in environmental performance	Semi-structured interview	East Asia
15	[6]	Port environmental management	Main innovations in port environmental management: a. Cooperation with external experts b. Improving internal pipelines c. Marine biology and marine/wetland habitat preservation d. Sediment and coastal erosion control e. Training and education of employees at working level f.. Establish green port organisation	Qualitative and quantitative analysis	Latin America
16	[5]	Green port performance criteria	Main performance criteria: a. Air pollution management b. Liquid pollution management c. Solid waste and other pollutants management d. Aesthetic and noise control management e. Marine biology preservation	Qualitative content analysis	General

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
17	[21]	Green port	Methods to develop green port: a. Modernisation of waste management and facilities (e.g. use of renewable energy and recycling and reuse of materials) b. Policy on reduction of the emissions of harmful substances into the atmosphere c. Landscape design which includes trees that absorb noise and pollution d. Engagement with experts and networking with other ports to obtain efficient, high quality guidelines and management recommendations	Qualitative content analysis	Croatia
18	[3]	Green port	Three approaches to reduce maritime greenhouse gases: a. Technical measures—efficient ship hull, energy-saving engines, efficient propulsion, alternative fuels, scrubbers and onshore power supply b. Market-based measures—Carbon levy scheme and emission trading c. Operation options measures—speed optimisation, optimised routing and fleet planning including management of on- and off-road vehicles	Case study	Asia (Turkey) and North America
19	[26]	Green port (performance evaluation)	21 indicators divided into six sections: a. Liquid pollution management (oil spill contingency plan, sewage treatment, waste management, ballast water control, waste dumping management) b. Air pollution management (dust control, use of low-sulphur fuel, cold ironing, control of toxic gas emission annual air pollution management plan) c. Noise control (noise reduction and vibration from activities, equipment and ships) d. Low carbon and energy saving (renewable energy resources through solar heating and wind; substitute energy and energy-saving device; apply energy-saving work processes; use on deck power) e. Marine biology preservation (protect port entrance sediment, coastal erosion control, wetland and marine habitat preservation) f. Port organisation and management (training and education for employees, communication with local government, green port development organisation, exclusive budget, grant/fund from government)	Delphi	East Asia

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
20	[6]	Bulk cargo handling	Five methods to minimise dusts in bulk cargo handling: a. Treatment of dust materials at despatch point with special liquid solutions b. Watering stacks at open handling point c. Frequent dust removing and area cleaning d. Installing wind dust protection screen in port e. Utilise container cargo handling system for bulk	Not revealed	Europe
21	[17]	Air Pollution in ports	Ships are main contributor of air pollution in ports consisting: a. 70% of SO_X b. 50% of PM	DEA	North America
22	[23]	Green port	Six green port concepts: a. Air quality (using shore electricity) b. Wildlife monitoring (tracking indicators of habitat quality e.g. birds and fish species) c. Water quality (establish parameters for water quality study) d. Community relations (improve public awareness) e. Reuse of waste material f. Adopt recycling concept to ensure sustainability	Not revealed	Asia (Turkey), Europe and North America

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
23	[15]	Green and sustainable port	Main factors for green port concept: a. Efficiency of resources b. Low emission of dusts and harmful substances c. Low emission of noise d. Economy of land use Conditions for sustainable port: a. Actions to prevent/reduce air pollution b. Actions to prevent/reduce sludge and soil contamination c. Effective improvement of water quality d. Limiting the impact of port activity on aquatic and land ecosystem involving fauna and flora e. Effective technology that limits energy consumption or/and using renewable energy sources f. Real reduction of noise and vibration g. Monitoring and analysis of weather changes affecting port operations and environment h. Research and Development to expand green growth prospect for port	Qualitative content analysis	East Asia
24	[7]	Green port development	Stress created by port activities: a. Dust pollution b. Water pollution c. Solid waste pollution d. Noise pollution Responses: a. Volume of waste gas emission (SO_X, NO_X, PM) per throughput b. Volume of waste water discharged (treated or not) per throughput c. Waste residues (solid and semi-solid) produced from port activities d. Average noise level of port	DPSIR framework, AHP, evidential reasoning	Asia

(continued)

Table 21.1 (continued)

No	Author	Research area	Findings	Method	Region
25	[2]	Green port	Five main indicators to evaluate green port performance: a. Total Kjeldahl nitrogen in waste water b. Chromium in soil and sediment c. Total suspended particles in the air d. Phytoplankton biodiversity e. Zoo plankton biodiversity	Entropy method	East Asia
26	[10]	Green Port	Green strategies: a. Establishment of Office of Environment and Sustainability Affairs b. Nature conservation c. Improving water quality d. Reduce air emissions e. Reduce impact on climate change f. Waste reception facility g. Environmental Ship Index (Discount 15% for ship that meets ESI) h. Paperless port policy to expedite processes i. Adoption of ISO 140,001 EMS j. Port dues and fines k. Oil spill management l. Ballast water management	Interview	Europe and Africa (West)
27	[1]	Green Cruise Ports	Externalities for cruise shipping: a. Waste reception for waste and garbage – Oily bilge water – Sewage – Solid waste – Non-sewage waste water b. Control of emissions in port: – Diesel generator exhaust – Ventilation inlets/outlets – Pumps and reefers	Not revealed	Europe

and LNG as alternatives [25]. A summary of 27 previous studies that were published mostly between 2011 and 2019 is condensed in Table 21.1.

Gleaning through Table 21.1, it can be observed that a variety of research methods have been utilised for green port research. Among the most popular methods are case study, AHP/Fuzzy AHP, DEA, interview, content analysis and survey. Most of the research is also focussed on findings in container and general cargo terminals with only one research that is focussed on dry bulk terminals and another research on passenger terminals. Most of research studies are focussed on a particular geographical region whilst four studies focus on two or three regions. From the 27 papers reviewed, 13 papers focus on Asia involving ports in East Asia and Turkey. 11 papers address the ports in Europe and three papers cover ports in North America. The coverage for ports in other regions are barely minimum and present an excellent gap that can be explored for future research.

21.4 Most Research Green Port Indications

In order to determine suitable indicators for green ports, a qualitative content analysis was performed on the 27 selected publications. The text identified has been coded into a suitable number of categories or themes that can assist in a better understanding of the main green port determinants. Based on the content analysis, the most popular determinant covered by green port research is air pollution management, which was addressed in 25 publications that were reviewed. Among others, this category deals with dry bulk cargo handling, modernisation of cargo handling equipment, on- and off-road vehicles management, cold ironing, use of scrubbers and alternative fuels for ships, electrical powered land vehicles, control of speed and effective control of toxic gas emission. On the other hand, water pollution management was addressed in 16 publications. This category covers sub-categories such as handling of oil and cargo spill, sewage treatment, handling of ballast water, liquid waste management, maintenance of water quality. The third most frequently covered category is preservation/improvement of marine life with 11 publications. It covers areas that include periodical environmental study, habitat tracking and preservation, preserving marine ecosystem, wetland habitat conservation, and monitoring of phytoplankton and zooplankton biodiversity.

The next popular research area in the green port study is noise pollution management that was covered in 10 publications. This is followed by soil and sediment preservation (nine publications), management of solid waste and garbage (nine publications), utilisation of green technology (eight publications), preservation/improvement of coastal habitat (seven publications) and cooperation with external parties (six publications). Next areas that received coverage in five publications are effective coordination and regulatory measures, efficient port development, and environmental awareness and training. Other areas that were covered in more than one publications are recycling/management of wastes and resources (4), monitoring changes in weather/climate (3), incentives and fines (3), landscape design

(2), measures to reduce port service time (2), adoption of quality standard (2) and management of hazardous cargo (2).

21.5 Conclusion

In retrospect, it is easy to comprehend why air pollution management is the most frequently research green port indicator in the recent years. This is because, it coincides with the current research in green shipping especially on the various initiatives to adhere to Annex VI of the Marine Pollution (MARPOL) Convention. Besides air pollution, the other popular indicators or determinants that are commonly studied in green port research are water pollution, preservation/improvement of marine life and noise pollution. Water pollution and noise pollution are also two common areas that are generally studied in environmental research. It is also interesting to note that soil and sediment preservation, management of solid waste and garbage, the prospect of utilising more green technology, as well as the preservation and improvement of coastal habitat have also been considered by many researchers as among the important factors that must be addressed by ports in order to become more sustainable in the long run. Notwithstanding the preceding arguments, it is worthy to note that although the other indicators did not receive much coverage in the contemporary green port literature, it does not in any way signify that those indicators are less important. In fact, it presents green port researchers with an opportunity to further explore into those indicators and contribute towards the enhancement of green port as a body of knowledge.

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Chapter 22
Experimental Study of Friction Stir Welding on Dissimilar Thickness of Aluminum Plate Butt Joints

Achilles Enchangan Ulak Anak Mancha, Azman Ismail, Fauziah Ab Rahman, Megat Khalid Puteri Zarina, and Bakhtiar Ariff Baharudin

Abstract The joint is made by two different plate thicknesses: 1.5-mm thickness of AA5052, and 3-mm thickness of AA5083. The tool used is surface-hardened H13 so that it can soften and be mixed with a solid phase weld mechanically. The travel speed is in the range between 340 and 695 mm/min and the rotational speed in the range between 352 and 653 rpm. The tool tilt angle is tilted at 2°. The research output demonstrates the relationship between the welding parameters and mechanical characteristics of these joints. This study aims to determine the suitable parameters and configuration for joining two dissimilar plate thicknesses together with the friction stir welding process.

Keywords Friction stir welding · Dissimilar thickness · AA5052 · AA5083 · Welding parameters

22.1 Introduction

AA5052 is an aluminum-magnesium alloy that can be coldly hardened. It is not heat-treatable to a greater resistance and has excellent fatigue properties [1]. AA5083 is the

A. E. U. A. Mancha · A. Ismail (✉) · F. A. Rahman · M. K. Puteri Zarina · B. A. Baharudin
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: azman@unikl.edu.my

A. E. U. A. Mancha
e-mail: achillesenchanganulak@gmail.com

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

M. K. Puteri Zarina
e-mail: puteri.zarina@fbk.upsi.edu.my

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

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strongest and most widely used non-heating alloy. It has high welding characteristics and excellent resistance to maritime corrosion, high fatigue and fracture resistance. Thus, the utilization of these materials is common in welded assemblies such as pressure vessels, and used in marine application such as superstructure, boiling plants, aircraft, and cryogenic tanks.

However, it should not be used in corrosive environments at temperatures above 60 °C. If exposed to the adverse conditions, intercrystallite and stress corrosion cracking will occur especially due to unsuitable thermal treatment of arc welding processes [2]. Therefore, the suitable joining process to be used is friction stir welding (FSW). FSW was developed and patented in 1991 by The Welding Institute (TWI) and has developed ever since and is commonly used in manufacturing practices [3].

In general, FSW is a solid-state joining process that uses a high rotating tool to soften materials with frictional heat and stir them together soundly [4]. FSW works in similarity to the concept of friction welding (FW) except it uses a high rotating tool [5, 6]. This paper studied the effects of welding parameters on tensile strength of the friction stir welded plates with dissimilar thicknesses of the AA5052 and AA5083 butt joint.

22.2 Experimental Procedure

The dissimilar plate thickness and grade AA5052 and AA 5083 were used in this study [7, 8]. These workpieces dimensions were 200 mm × 100 mm × 1.5 mm and 200 mm × 100 mm × 3 mm, respectively. The tool geometry used for this study was made of AISI H13 high carbon steel with a 15 mm diameter of shoulder, 5 mm and 0.9 mm of pin diameter and length, respectively, that has undergone a surface-hardening process. The plunge depth and dwell time were set at 1.4 mm and 120 s accordingly. The welding parameters used in this study are shown in Table 22.1. Besides, the specimen was placed at a non-stepped position as shown in Fig. 22.1, where a customized backing plate was placed under the specimen.

The visual inspection was conducted to detect for possible voids or imperfections such as incomplete penetration, lack of fusion, toe flash, linear misalignment, underfill, irregular width, irregular surface, cavity, and hook according to ISO 25,239:2011

Table 22.1 FSW parameters

Specimen No.	Tool Rotational Speed (rpm)	Tool Traverse Speed (mm/min)
DTS001	352	340
DTS002	490	340
DTS003	653	340
DTS004	653	495
DTS005	653	695

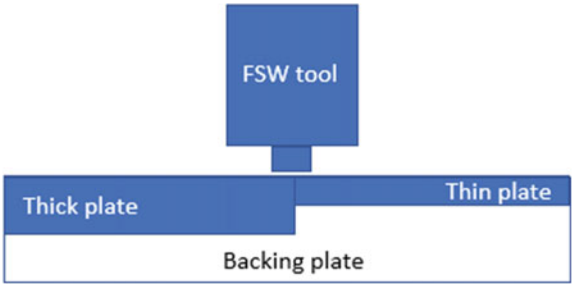


Fig. 22.1 Non-stepped FSW setup

[9]. Meanwhile, the tensile test was performed according to ASTM E8 [10]. Three tensile specimens were prepared for each weld. The tensile tests were performed by using Instron universal tensile test machine. In addition, a macrostructure examination was conducted based on ASTM E340-15 [11] by using an optical microscope with 5× of magnification.

22.3 Results and Discussion

There were several inspections or measuring methods to generate specific data for this study. These can be categorized into three sections such as follows:

a. **Visual Inspection**
   Table 22.2 shows the surface finishing and weld cross section for each FSW specimen. A visual inspection is performed to establish whether the specimens were acceptable to perform for the next stage of examination. The DTS001 and DTS002 gave a smooth weld surface with some toe flash. Meanwhile, DTS003, DTS004, and DTS005 showed rough surfaces and some cracks were detected based on ISO 25,239:2011 [9]. This might be due to an imbalance in heat distribution which occurred between these plates joining of dissimilar thickness.
b. **Tesnsile Strength**
   The tensile strength for both base metals was measured at 250.263 MPa as shown in Fig. 22.2. Based on this figure, the tensile strength for other specimens was measured between 60 and 112 MPa. The specimen of DTS001 gave the highest tensile strength at 112.191 MPa compared to the specimen of DTS004 which yielded the lowest tensile strength at 60.94 MPa. Imbalanced distribution of heat on retreating and advancing side caused the crack to appear thus causing these lower tensile strength. The same Fig. 22.2 shows the comparison results of tensile strength for friction stir welded (FSWed) joints and base metal.
c. **Macrostructure inspection**
   The results of macrostructure inspection of the friction stir welded cross-sectional area were obtained for the selected five different specimens. The results are tabulated in Table 22.3. As displayed in Table 22.3, it is shown that both of

Table 22.2 Friction stir welded joints

Specimen Number and Welding Parameters	Weld Surface	Weld Cross Section (AS) (RS)
DTS001 352 rpm 340 mm/min		
DTS002 490 rpm 340 mm/min		
DTS003 653 rpm 340 mm/min		
DTS004 653 rpm 495 mm/min		
DTS005 653 rpm 695 mm/min		

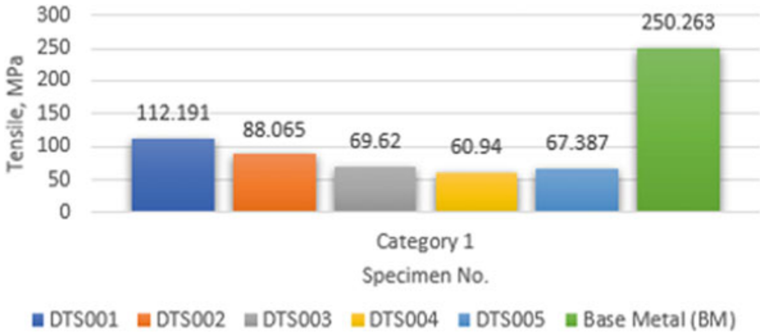
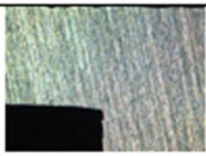
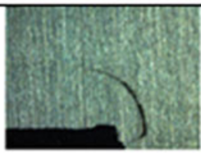
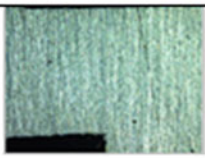


Fig. 22.2 Tensile strength of FSWed specimens

Table 22.3 Macrograph of specimens at mid-section

Specimen Number	Macrograph at mid-section
DTS001	
DTS002	
DTS003	
DTS004	
DTS005	

the specimens, DTS001 and DTS002 were in good condition. Meanwhile some micro cracks were detected on the specimen of DTS003, DTS004, and DTS005 thus introducing lower tensile strength as shown in Fig. 22.2 previously. This might have occurred due to incompatible welding parameters used. In addition, the dissimilar thickness might have given a big gap of uneven heat distribution between the advancing and retreating sides [12, 13].

22.4 Conclusions

The conclusions from this study can be drawn as follows:

a. The dissimilar plate thickness of aluminum can be joined by the friction stir welding process but somehow, due to improper matching of welding parameters, this may end up with some cracks as detected on DST003, DST004, and DST 005.

b. Tensile strength with a minimum of 60.94 MPa and a maximum of 112.19 MPa was found for this dissimilar thickness joining by the friction stir welding process.

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Chapter 23
An Improved Simple Sweep Line Algorithm for Delaunay Refinement Triangulation

Normi binti Abdul Hadi, Anis Farhani, and Wardiah Mohd Dahalan

Abstract This paper is focused on simple sweep line algorithms with Delaunay refinement triangulation to create 2D triangulation. A new algorithm is proposed where the main idea is to add circumcircle properties into the simple sweep line algorithm. Since the Delaunay triangulation itself still generates poor quality of triangles, this paper applies the Delaunay refinement to enhance the triangulation. Next, this paper observes the percentage of bad angles to analyze the quality of the triangles and the flipping number required for each set of points to analyze the efficiency of the algorithm. At the end of this research, all objectives are achieved where an improved simple sweep line algorithm with Delaunay refinement triangulation is obtained.

Keywords Sweep line algorithm · 2D Delaunay triangulation · Delaunay refinement

23.1 Introduction

A triangulation is defined as a technique to calculate the distance between any two points, or the relative position of two or more points [1]. The aim is to produce a mesh where the points act as vertices of a triangle. Voronoi diagram or also known as Dirichlet tessellation can be obtained from a triangulation since it is a partition of a plane into regions of each polygon [2]. It contains exactly one generating point for each polygon and this point is close to other points of a given set of objects. A

N. b. A. Hadi · A. Farhani
Universiti Teknologi Mara, Shah Alam, Malaysia
e-mail: normi@tmsk.uitm.edu.my

A. Farhani
e-mail: anisfarhani96@gmail.com

W. M. Dahalan (✉)
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: wardiah@unikl.edu.my

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circumcircle is a circle with all the vertices of the triangle lie on the boundary of the circle [3].

23.1.1 2D Delaunay Triangulation

Delaunay triangulation is a triangulation method where it works as an automatic generation algorithm to solve simplex meshing problems where it maximizes the minimum angles of triangles. Proposed by Boris Nikolaevich Delaunay in 1934, the 2D Delaunay triangulation was the most well-known triangulation due to its property and also it optimized several other geometric criteria related to interpolation accuracy [4]. The basic aim for this technique is to maximize the minimum angle among each triangle in the triangulation and it tends to avoid the skinny triangles in order to obtain the results.

There are many types of algorithm which have been introduced for creating Delaunay triangulation such as incremental algorithms [5, 6], divide and conquer algorithms [7, 8], gift wrapping algorithms [9] and sweep line algorithms [10]. Introduced by Fortune (1987), the sweep line algorithm takes the shortest time compared to incremental, divide and conquer, sweep line, gift wrapping, advancing front and convex hull algorithms [11]. Hence, this study focuses only on the sweep line algorithm for constructing the Delaunay triangulations. There are many versions of the sweep line algorithm that have been introduced by a few researchers such as Zalik's sweep line, sweep circle and simple sweep line algorithms [12, 13]. This research presented a new type of algorithm by improving the simple sweep line algorithm.

23.1.2 2D Delaunay Refinement

A Delaunay refinement is best defined as a meshing algorithm that refined and maintained the Delaunay triangulation by inserting vertices until the mesh meets element quality and size [14]. The main idea is to remove the bad triangles by satisfying bound of angles, edge of lengths and the number of triangles from small to large sizes. This is due to the fact that the Delaunay triangulation still does not solve the problem of triangular mesh generation although it maximizes the minimum angle. There are two reasons why this problem arises. First, skinny triangles may appear anyway and second, the Delaunay triangulation of domain's vertices might not satisfy the domain's boundary. However, the Delaunay refinement can solve both problems by introducing Steiner points as new vertices [15].

23.1.3 Simple Sweep Line Algorithm

Simple sweep line algorithm is applying Lawson's legalizations where it often gives rise to wrong triangulation especially when developing a large dataset. This is because many skinny triangles may exist within the collinear vertices produced by collinear points from Lawson's local optimization procedure (LOP). Moreover, there also can exist four circular points which require a multiple refinement process to solve the problems. The skinny triangles effect the solution where it can cause an issue to the elements of the triangle. The small angle of skinny triangles can produce other angles to be too large and cause poor conditioning. Hence, for those reasons, the simple sweep line is slower than Zalik's algorithm but faster compared to the sweep circle algorithm [12] in terms of processing time in order to obtain the triangulation.

Therefore, this study proposed a new algorithm and it is compared mainly with the simple sweep line algorithm to make an improvement for constructing the triangulation. The main idea of the improved simple sweep line algorithm is to add circumcircle properties into the simple sweep line technique. By introducing a few properties in creating the initial triangulation, the quality of the triangles in the triangulation is improved by reducing the number of bad triangles and maximizing the minimum angle in all triangles. At the end of the process, this project looks forward to the less percentage of bad angles and high quality of the triangles in the triangulation.

23.2 Methodology

23.2.1 Creating Initial Triangulation

Once the initial triangle of the polygon is obtained, the next step is finding the initial triangulation by expanding the triangles where all vertices in the points set are connected before applying the sweep line algorithm. This is the improvement step from the current simple sweep line where three main properties have been proposed by this study to avoid poor quality in order to obtain the initial triangulation. Starting from the initial triangle, the new vertices need to go through these three properties respectively as below in order to create the next triangles.

i. Checking the intersection between two segments of triangles.
ii. Choose an angle $\theta^\circ \geq 60^\circ$.
iii. Choose the maximum angle θ°.

23.2.1.1 Checking the Intersection Between Two Segments of Triangles

This study is using the Barycentric interpolation to find the intersection between two points in order to compute the next triangle. The Barycentric interpolation is best defined as to locate points relative to existing points rather than to an origin and known as the local coordinates.

The new vertices are inside the triangle if all values of P are positive otherwise, the new vertices are outside the triangle and do not have any intersection with any segments. Let P be the new vertices to be considered as below;

$$P = (-1)\frac{\begin{vmatrix} 0 & t_0 & t_1 & t_2 \\ P_x & a_x & b_x & c_x \\ P_y & a_y & b_y & c_y \\ 1 & 1 & 1 & 1 \end{vmatrix}}{\begin{vmatrix} a_x & b_x & c_x \\ a_y & b_y & c_y \\ 1 & 1 & 1 \end{vmatrix}} = \alpha t_0 + \beta t_1 + \gamma t_2 \text{ where } \alpha, \beta, \gamma \neq 0 \tag{23.1}$$

Point (t_0, t_1, t_2) is the Barycentric coordinates where it is homogeneous, hence Eq. (23.2) is always true.

$$t_0 + t_1 + t_2 = 1 \tag{23.2}$$

The next vertices are selected if and only it does not intersect with any segments of the triangle. Hence, these two vertices are all set to be connected as an edge and create the new triangle.

23.2.1.2 Choose an Angle $\theta° \geq 60°$

As for the next move, only one triangle will be selected since the new vertices can create more than one triangle. The angles of all possible new triangles will be calculated and by applying these properties, the chosen triangle is the triangle with an angle from new vertices that has more than 60°. The idea of this property is based on the formula of small angle approximation where 1 rad $\approx$ 57.2958. The purpose is to tend to avoid the skinny triangles in order to produce the quality of triangles.

Let $\theta°$ be the angle between point $A(x_1, y_1)$ and $B(x_2, y_2)$ and $\theta°$ can be obtained by applying the dot product rule as below;

$$A * B = |A| * |B| * \cos\theta° \tag{23.3}$$

$$\theta° = \arccos\left(\frac{A * B}{|A| * |B|}\right) \tag{23.4}$$

where $A * B$ can be solved as equation

$$A * B = (x_1 * x_2) + (y_1 * y_2) \tag{23.5}$$

$$|A| * |B| = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{23.6}$$

Equations (23.5) and (23.6) explain how to apply the formula by expanding the equation of the dot product between two points. If there is no such angle $\theta° \geq 60°$, then only the third property is required.

23.2.1.3 Choose the Maximum Angle $\theta°$

This stage is only qualified if and only if there is no such angle $\theta° \geq 60°$ among all triangles. Thus, the maximum angle of the new vertices will be chosen to compute the next triangle. However, this will lead the triangulation to produce poor quality of triangles. Hence, it is proven that bad triangles may exist in the Delaunay triangulation although it maximizes the minimum triangle. This step requires each point to fulfill these three properties before to create the next triangle for the triangulation. The process of expanding the triangles is continued until the initial triangulation is obtained and continued with the checking process in the next step.

23.3 Analysis of the Results

23.3.1 The Efficiency of the Improved Simple Sweep Line Algorithm

The efficiency of the algorithm for this project is based on the flipping number required for each algorithm in creating the triangulation. The lower the flipping number applied, the higher the efficiency of the algorithm to create the Delaunay triangulation.

Figure 23.1 observes the two types of algorithm which are SSL and ISSL with DR triangulation that exhibit the increasing pattern for the number of flipping process. Based on the increasing pattern, the SSL produces the lower number of flipping process compared to the ISSL with DR triangulation for each data set in creating the triangulation. The number of flipping process between SSL and ISSL algorithm is decreasing without applying the DR triangulation. However, the amount is increasing right after the proposed method applying the DR triangulation into the ISSL algorithm. This is because of the improvement that has been made on the SSL algorithm which required new points by DR triangulation into the triangulation which are the Steiner points and caused the increasing total number of triangles. Hence, the number of triangles that require Lawson's technique is increased since more triangles that are not locally Delaunay appear in the triangulation. To sum up, the SSL algorithm is more efficient compared to the ISSL algorithm with DR triangulation.

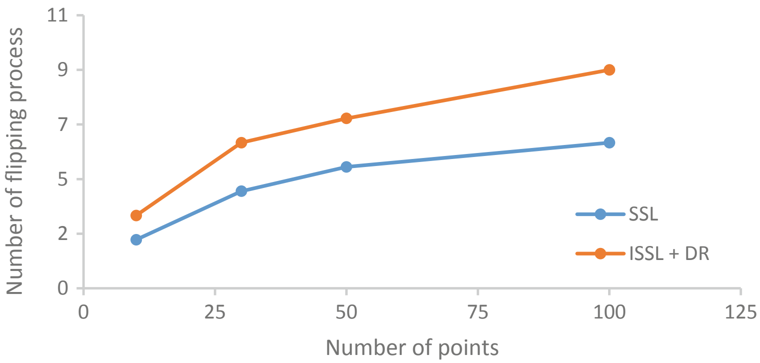

Fig. 23.1 The number of flipping process for SSL algorithm and ISSL algorithm with DR triangulation

23.3.2 The Quality of the Triangles

The quality of triangles can be concluded by calculating the percentage quality of the triangles by using the formula below. This paper came out with this new formula where the idea is from the Euler formula.

$n =$ Total number of points.
$a =$ Total number of vertices on boundary of convex hull.
$M =$ Total number of angles for all triangles in the triangulation.
$m =$ Total number of bad angles in the triangulation

$$\text{Quality of triangles (\%)} = \frac{3(2n - 2 - a) - M}{m} \times 100$$

Figure 23.2 summarized that this project managed to increase the quality of triangles successfully by reducing the percentage of bad angles for each data set of points. By

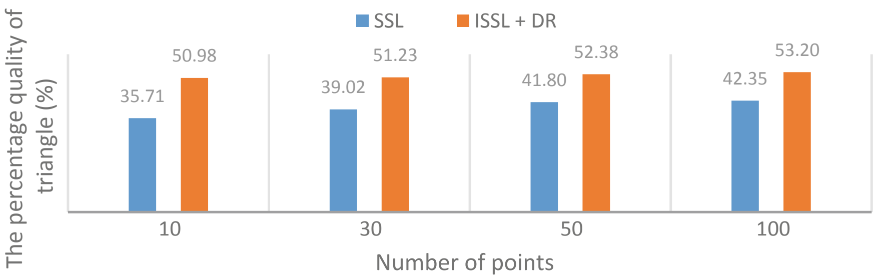

Fig. 23.2 The percentage quality of triangle for SSL algorithm and ISSL algorithm with DR triangulation

applying the circumcircle properties, most of the triangles satisfy the properties of the triangles where no such point is inside the circumcircle. DR triangulation is applied on the Delaunay triangulation since skinny triangles may appear anyway. By inserting the Steiner point from the circumcenter of the poor quality of triangle, it manages to improve the better quality of triangulation. This is important since it can avoid any error to occur in initializing the triangulation. To sum up, the ISSL algorithm with DR triangulation produces a higher quality of triangles for the triangulation compared to SSL algorithm.

23.4 Conclusion

This paper intends to obtain a triangulation while maintaining the properties of the Delaunay triangulation. New circumcircle properties have been introduced into the initial triangulation to manage to decrease the amount of skinny triangles. The number of the flipping process is decreasing for the ISSL algorithm and proved that the ISSL algorithm is better than the SSL algorithm. However, after the ISSL algorithm is applied to the DR triangulation technique, the number of the flipping process is increasing. Hence SSL has a higher efficiency compared to the ISSL. Next, the percentage of bad angles is decreasing in identifying the quality of the triangles. There are two types of bad angles that have been used for this project. First, angles that have less than 60° for comparison between SSL and ISSL algorithm. Second, angles that have less than 30° for comparison between ISSL algorithm with and without DR triangulation. Both comparisons show that the percentage of bad angles is reduced for each data set of points. In conclusion, the proposed algorithm, ISSL algorithm with DR triangulation, produced a higher quality of triangulation but lower efficiency compared to the SSL algorithm.

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Chapter 24
The Effect of Increasing Travel Speed at Constant Rotational Speed on the Formation of Friction Stir Welded AA5083 Butt Joints

Ahmad Fatihi Azhar, Azman Ismail, Darulihsan Abdul Hamid, Fauziah Ab Rahman, Bakhtiar Ariff Baharudin, Megat Khalid Puteri Zarina, and Achilles Enchangan Ulak Anak Mancha

Abstract In order to find out the optimum input in terms of travel speed, the experiment was conducted by having a constant rotational speed with the increment of travel speed. These variables were selected based on the pre-setting speed available on a universal milling machine of Milko 37. Different welded specimens were produced by employing travel speeds of 29, 44, 54, 67, 86 mm/min, and constant rotational speed of 910 rpm. The tilt angle of tool at 3°, tool shoulder diameter of 20 mm, and threaded cylindrical tool pin were utilized in this experiment setting. With the increment of travel speed at a constant rotational speed (RPM), varying contact conditions at the material interfaces were created. The result obtained for this research were taken from visual analysis on surface and cross section of every joint. Based on this result, the optimum travel speed for constant rotational speed (910 rpm) is 29 mm/min.

A. F. Azhar
Royal Malaysian Navy, Perak, Malaysia
e-mail: fatihi_azhar@yahoo.com

A. Ismail (✉) · F. A. Rahman · B. A. Baharudin · M. K. Puteri Zarina · A. E. U. A. Mancha
Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Perak, Malaysia
e-mail: azman@unikl.edu.my

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

M. K. Puteri Zarina
e-mail: puteri.zarina@fbk.upsi.edu.my

A. E. U. A. Mancha
e-mail: achillesenchanganulak@gmail.com

D. A. Hamid
Kolej Universiti Poly-Tech MARA, Kuala Lumpur, Malaysia
e-mail: darulihsan@kuptm.edu.my

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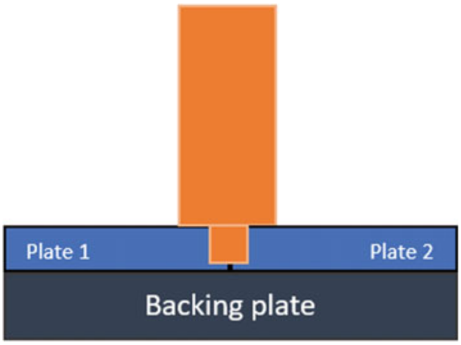
Keywords Friction stir welding · AA5083 · Butt joint, macrostructure · Milling machine

24.1 Introduction

Welding is the most crucial process in manufacturing and fabrication industries. In 1991, the evolution of friction stir welding (FSW) technique was discovered by Wayne Thomas, TWI Ltd [1, 2]. This is to overcome the problem faced by using conventional techniques which indirectly improve the mechanical properties of the joining material [3, 4]. The FSW process generates heat from the frictional force through a high rotating non-consumable tool that plunges into the specimen surface. The butted specimens were joined together in a plastic mode [5]. The milling machine is most similar to this friction stir welding machine. The tool consists of two important parts such as pin and shoulder. The pin works as joining tool by stirring the soften material while the shoulder generates heat from the surface of the shoulder. In this present study, the process of butt joining started with two plates which are clamped together by utilizing a fixture. This fixture is needed in order to prevent the specimens from gaping aside during the process of plunging and joining. The tool is rotated at high speed and slowly plunges by force into the specimen until the tool's shoulder makes contacts with the surface of the specimen. Before applying the desired transverse speed, the dwell time is required in order to achieve the plasticized mode. Slight flash usually forms around the tool shoulder showing that the material is soft enough for the joining process. The FSW process leaves an end hole at the end of the weld created by the pin of the tool after it is withdrawn from specimen while the tool is still rotating. The FSW schematic process of butt joints is shown in Fig. 24.1 [6]. The investigation has been made to understand the effect on different welding speeds toward the quality of AA5083 aluminum by using the FSW process.

Fig. 24.1 FSW process



24.2 Experimental Setup

This research was conducted at UniKL MIMET, Malaysia by using a milling machine and a special design clamping system fixed to the working table. A specimen plate of AA5083 grade was selected and the whole dimension of the specimen (356 mm × 204 mm × 5 mm) was based on AWS D17.3, a specification for FSW of aluminum alloys for aerospace [7]. The tool high carbon steel H13 is chosen due to its easy machinability material compared to others [4]. It can be used to operate at 600–1500 RPM which is within the rotation speed required [8]. This material is classified as a hot working high carbon steel tool with good tensile and wear resistance properties [9].

The universal milling Milko 37 machine is an analog and conventional type machine, which means that the input for this machine is fixed at a certain parameter. The input does not have the same interval. This machine is now upgraded from single function of milling (remove uneven surface) to become a FSW unit machine. It is able to perform the butt joint configuration for this research. The Milko 37 universal milling machine is shown in Fig. 24.2.

A clamping system that was suitable for the condition of the machine was needed. Therefore, a specially designed fixture was fabricated with an adjustable thickness of the specimen to be used in further analysis. This jig was bolted to the working table to prevent any movement while the process in running. The clamping fixtures were fabricated at UniKL MIMET fabrication workshop, Lumut, Perak. The 1 inch thick plate was the base plate of the clamping fixtures to eliminate distortion on the clamp itself. The base plate and the clamping fixtures were assembled for the experimental setup as shown in Fig. 24.3.

The tool was fabricated based on the review of article on basic tool design; flat shoulder with a diameter of 15 mm, straight cylindrical threaded pin with diameter

Fig. 24.2 MILKO 37 universal milling machine

Fig. 24.3 FSW experiment setup

5 mm, and pin's length of 4.5 mm [8]. H13 tool steel was selected due to its machinability with high wearing resistance properties [4, 10]. The tool then was hardened to 52 HRC in order to ensure that no fracture occurs during the FSW process. It was attached to the spindle of the milling machine as shown in Fig. 24.4.

The material selected for this study was 5 mm thick aluminum AA5083. The plate was cut in 356 mm length and 102 mm width. The aluminum surface was cleaned with a power brush in order to remove the oxide layer on the surface which may cause an error in the result. The specimen was milled to remove uneven edges that could cause gaps and misalignment to the welds area.

Table 24.1 shows the details of the parameters for this experiment. The rotational speed was fixed at 910 rpm. Other parameters such as the tool tilt angle and dwell

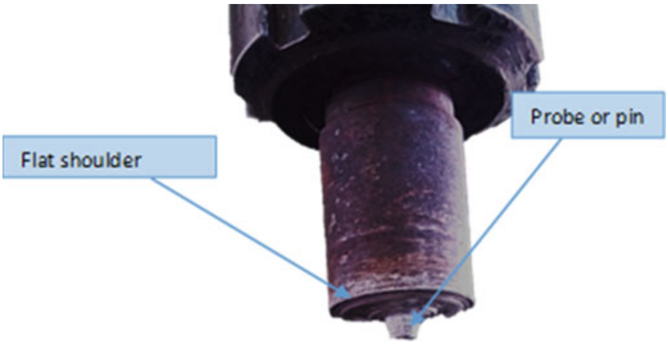


Fig. 24.4 FSW tool—threaded pin and flat shoulder

Table 24.1 Welding parameters

Sample	Welding parameter		Remark
	Travel speed (mm/min)	Rotational speed (RPM)	
#1	29	910	Variation in travel speeds, but constant in rotational speed
#2	44	910	
#3	54	910	
#4	67	910	
#5	86	910	

time were also kept constant at 3º and 30 sseconds, respectively. The cross sections of this friction stir welded samples were inspected by an optical microscope [9].

24.3 Result and Discussion

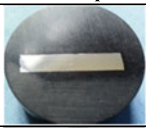
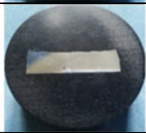
Tables 24.2 and 24.3 show the conditions of the surface of the welded specimen with varied travel speed and the root appearances after 100 × zoom respectively.

Comparing the five samples in Table 24.2, only Sample #3 has a crack line on the weld surface. Smooth weld surface represents rotational and travel speed which matched the compatibly for generating sufficient heat for joining to occur but insufficient plunge force prevents the plowing effect therefore causing the wormhole to increase with the increment of travel speed. After 100 × magnification, it shows only that one sample is perfectly joined without any wormhole which is set at 29 mm/min of travel speed at a constant rotational speed of 910 rpm.

Table 24.2 Weld surface finishing

Sample	Weld surface finishing	Remark
1		(29 mm/min) Smooth surface
2		(44 mm/min) Smooth surface
3		(54 mm/min) Rough surface and crack
4		(67 mm/min) Smooth surface
5		(86 mm/min) Rough surface

Table 24.3 Macro images

Sample	Mounted cross cut sample	Microstructure (100x zoom)	Remark
1			(29 mm/min) No defect
2			(44 mm/min) Wormhole
3			(54 mm/min) Wormhole
4			(67 mm/min) Wormhole
5			(86 mm/min) Wormhole

24.4 Conclusion

Increasing the travel speed for a constant rotational speed creates varying effects on the material interface. The results can be summarized as follows:

a. The welding parameter at 29 mm/min travel speed and 910 rpm of rotational speed shows a good joining quality.
b. The welded surface conditions do not determine the size of the worm hole produced.
c. The increase in travel speed corresponds to the increasing wormhole size produced.

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Chapter 25
An Experimental Study on Friction Stir Welding of AA5083 Tee Lap Joints

Muhammad Fadhli Makhtar, Azman Ismail, Iliani Mohd Ikram, Fauziah Ab Rahman, Bakhtiar Ariff Baharuddin, Megat Khalid Puteri Zarina, Darulihsan Abdul Hamid, and Achilles Enchangan Ulak Anak Mancha

Abstract The present work investigates the feasibility of the friction stir welding on the tee lap joint configuration using a conventional milling machine, Milko 37. The experiment was conducted in order to analyze the joining capability with different rotational and transverse speeds. In this experiment, a customized jig had been used to tightly clamp the specimens altogether with a tool of 20 mm shoulder diameter and 7 mm cone shape pin length. The results showed that the joining made by the lowest rotational and transverse speeds give better joining capabilities compared to the highest speeds.

Keywords AA5083 · Aluminum plate · Tee lap configuration · Milko 37 · Friction stir welding

M. F. Makhtar
Marine and Offshore Department, TLT Power Sdn Bhd, Lumut, Malaysia
e-mail: fadhlimakhtar@tltpower.com

A. Ismail (✉) · F. A. Rahman · B. A. Baharuddin · M. K. Puteri Zarina · D. A. Hamid
Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Perak, Malaysia
e-mail: azman@unikl.edu.my

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

B. A. Baharuddin
e-mail: bakhtiarab@unikl.edu.my

M. K. Puteri Zarina
e-mail: puteri.zarina@fbk.upsi.edu.my

D. A. Hamid
e-mail: darulihsan@kuptm.edu.my

I. M. Ikram
Bid Planning, Estimation and Proposal, Sapura Energy Berhad, Lumut, Malaysia
e-mail: Iliani.ikram@sapuraenergy.com

A. E. U. A. Mancha
Kolej Universiti Poly-Tech MARA, Kuala Lumpur, Malaysia
e-mail: achillesenchanganulak@gmail.com

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25.1 Introduction

The history of friction stir welding (FSW) began in the 1990s. It was invented by Wayne Thomas and patented by The Welding Institute Ltd (TWI) in December 1991 in England [1–3]. FSW is an environmentally friendly welding process and it could be classified as green technology welding technique due to no additional material required, no fumes, gases and low-energy input required to join the plate compared to the fusion welding technique [4–6]. The philosophy of FSW is quite simple when the third body tool produces heat and mixes the materials to produce high-quality joinings [2, 7]. Figure 25.1 illustrates the friction stir welding process operating setup. The tool rotates in the clockwise direction and travels along the weld line of the specimen [2].

The FSW technique can improve the mechanical properties of the welded specimens [6–10]. In FSW, the welding parameters such as tool rotational speed, transverse speed, tilt angle, tool shoulder diameter and tool pin diameter play a vital role on the strength and microstructure of the welded specimens. Since the emerging of the friction stir welding in the 1990s, most researchers take the opportunity to investigate the effects of the friction stir welding process on material and tools [11]. Most of them use a simple butt joint and rarely use the tee lap joint configuration in the experiment [1, 12–15]. This present study is to run an experimental investigation in order to observe the effects of the rotational and transverse speed on tee lap joints using the FSW technique.

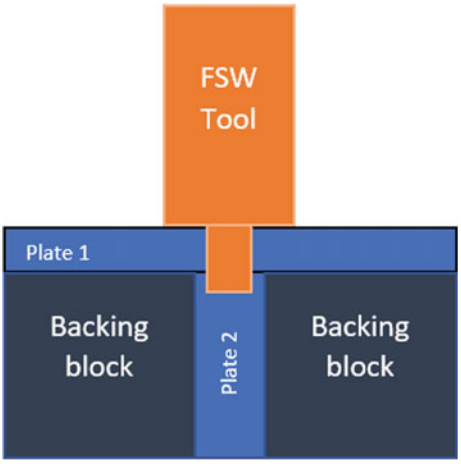

Fig. 25.1 Schematic illustration of FSW process

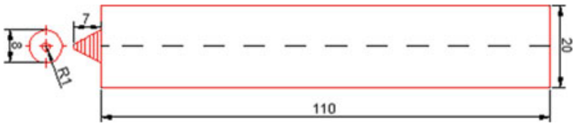

Fig. 25.2 Schematic illustration of tool design

25.2 Materials

Aluminum alloy (AA) 5083 grade was selected for this experiment. AA5083 is a high-strength aluminum and widely used in various fields especially in manufacturing, aerospace and marine industry [16]. It has also high resistance to corrosive environments such as seawater and industrial chemical [17, 18].

High carbon AISI H13 type steel was selected as a tool material due to its machinability and hardening ability with the heat treatment process [19]. It could be categorized as a hot worked tool with decent tensile and wears resistance properties [20]. The design and dimension of the tool are summarized and illustrated in Fig. 25.2.

25.3 Experimental Procedure

The FSW process on aluminum alloy 5083 in tee lap joint configuration was conducted by using a Milko 37 conventional universal milling machine as shown in Fig. 25.3. The various preset rotational and transverse speeds which were

Fig. 25.3 Universal milling machine MILKO 37

Table 25.1 Welding parameters

Process Parameters	Values
Tool rotational speed (rpm)	490, 910 and 1700
Welding speed (mm/s)	16, 29 and 44
Tool tilt angle (°)	2
Tool Shoulder Diameter (mm)	20
Tool Shoulder surface	Flat
Pin Length (mm)	7
Pin Profile	Standard cone
Tool Material	High Carbon steel (H13)

available on this machine enabled the joining to occur. Table 25.1 indicates the welding parameters used in the experiment. The plate was cut into two sections consisting of horizontal and vertical plates. The dimension of the horizontal plate was 158 mm x 137 mm x 5 mm, while the dimension of the vertical plate was 158 mm x 98 mm x 5 mm. Both plates were clamped onto the specialized fixture as shown in Fig. 25.4. The high rotating tool pin was inserted in the plate and the tool shoulder contacted with the plate which generated the heat. Hence the material reached a kind of soft state and no melting was observed. As the material softens, the tool moved along the weld line to form the joining between these two plates. In order to obtain a good quality of joining, several parameters need to be considered especially on geometrical and technological parameters. These parameters play an important role

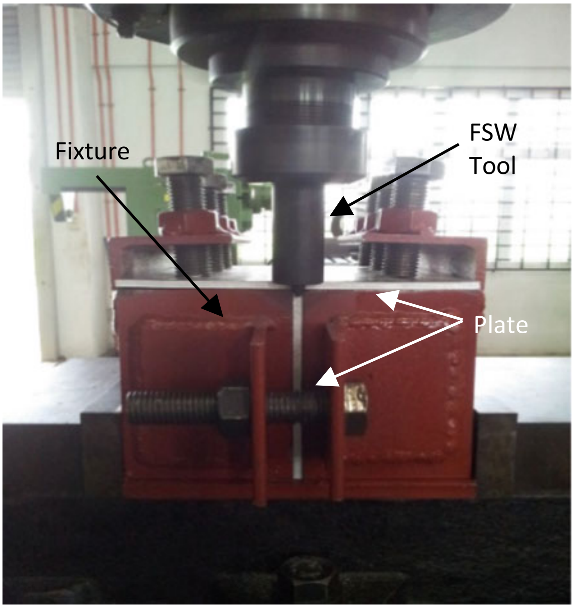

Fig. 25.4 Experimental setup

which need to be emphasized during the experiment [13]. It will affect the mechanical properties of the weld specimen such as tensile strength and microstructure.

25.4 Results and Discussion

The welded specimen was inspected for their surface appearance and cross sections.

25.4.1 Surface Appearance of Welded Joints

The surface appearance of friction stir welded tee lap joint plates for different rotational and transverse speeds is represented in Fig. 25.5. The weld produced by the lowest rotational and transverse speeds at 490 rpm/16 mm/s and 910 rpm/16 mm/s showed a smooth welding surface without any lateral flash on the retreating and advancing side. Meanwhile, the welding produced by the highest rotational and transverse speeds showed a rough weld surface with literal flash at the retreating and advancing side. It is due to the fact that the weld speed and heat produced by the tool shoulder were insufficient. Hence, the welding parameters influence the surface appearance of the welded joints.

25.4.2 Cross-Section Inspection of the Weld Zone

Based on Fig. 25.6, the cross section for the first experiment setting (490 rpm and 16 mm/min) showed sufficient penetration without any defect either on the advancing or retreating sides. The same goes for the second experiment setting (910 rpm and 16 mm/min). However, for the last three settings, the cross sections showed a wormhole occurred on each weld zone either on the retreating or advancing side. Insufficient frictional heat supplied is the main cause of this condition due to high rotation and increment of transverse speeds.

25.5 Conclusion

Based on this experiment, the lowest rotational and transverse speeds yielded the best parameters for the tee lap joint configuration. The weld produced by the combination of welding parameters of 490 rpm 16 mm/min and 910 rpm 16 mm/min were observed to be in good shape of the joining with defect-free cross section.

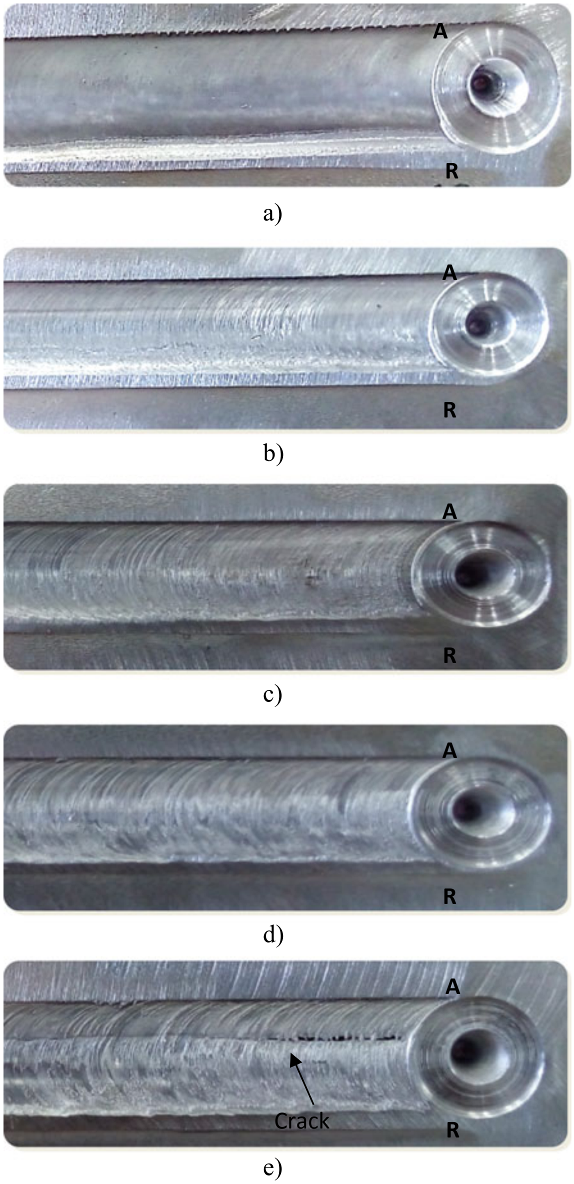

Fig. 25.5 Comparison on the surface appearance of weld zone on different rotational and transverse speeds **a**. 490 rpm and 16 mm/min **b**. 910 rpm and 16 mm/min c. 1700 rpm and 16 mm/min **d.** 1700 rpm and 26 mm/min **e.** 1700 rpm and 44 mm/min

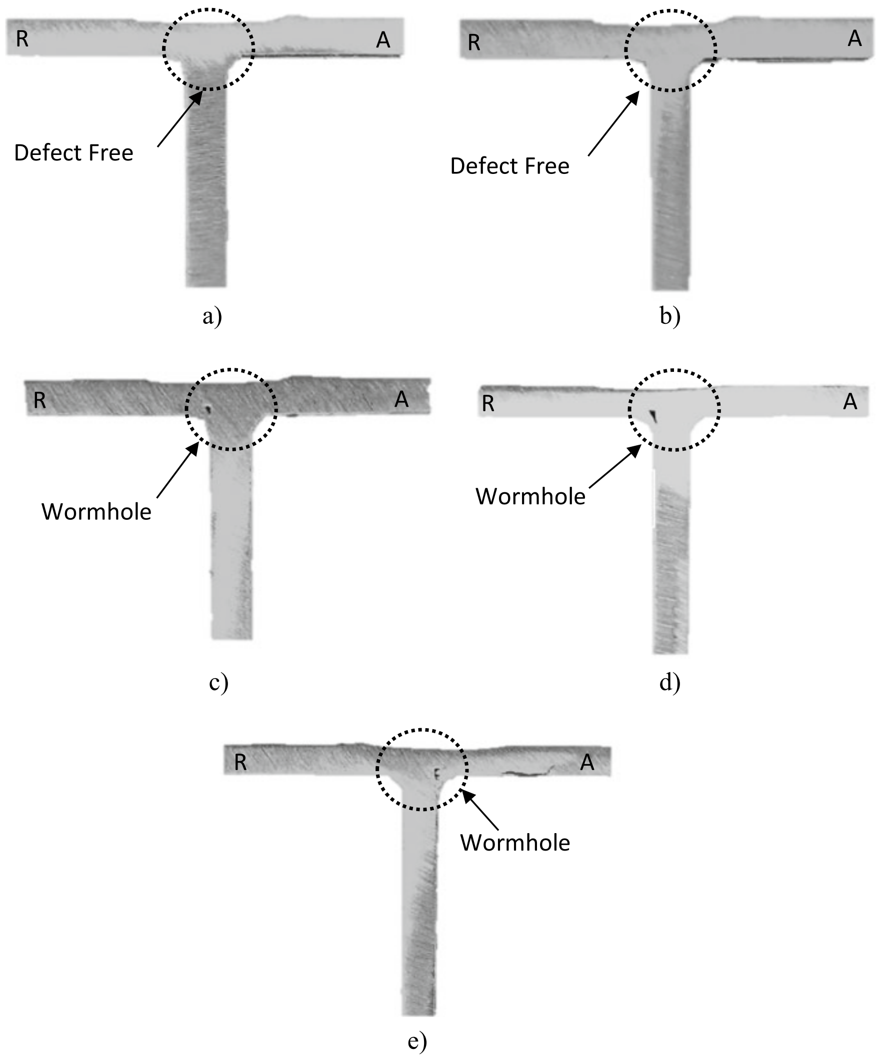

Fig. 25.6 The cross sections on different rotational and transverse speeds **a**. 490 rpm and 16 mm/min **b.** 910 rpm and 16 mm/min **c.** 1700 rpm and16 mm/min **d.** 1700 rpm and 26 mm/min **e.** 1700 rpm and 44 mm/min

Acknowledgements The authors would like to acknowledge the Universiti Kuala Lumpur for the facilities and funding provided for this project.

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Chapter 26
Experimental Study on Mechanical Characterisation of Hybrid Material Lamination (HML) Subjected to Flexural Strength

Muhammad Afiq Mohd Shuhaimi, Azman Ismail, Fauziah Ab Rahman, Bakhtiar Ariff Baharudin, Megat Khalid Puteri Zarina, Darulihsan Abdul Hamid, and Achilles Enchangan Ulak Anak Mancha

Abstract Composite materials have been a subject of interest with various special types of advanced materials during the last decades. Hybrid material lamination consists of layers of fibreglass and thin layers of aluminium sheets bonded by epoxy resin. The main objective of this research paper is to study the mechanical behaviour of hybrid material lamination (HML) under flexural loads. This research material is mainly focused on marine applications. Hybrid materials were investigated by experimental approaches based on the ISO standard and compile with the Det Norske Veritas (DNV) rules and regulations. The results were compared. The experimental results were found to exceed and met the requirement of the DNV rules and regulations.

M. A. M. Shuhaimi · A. Ismail (✉) · F. A. Rahman · B. A. Baharudin · M. K. Puteri Zarina · A. E. U. A. Mancha
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: azman@unikl.edu.my

M. A. M. Shuhaimi
e-mail: fiq_kaydey11@yahoo.com.my

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

M. K. Puteri Zarina
e-mail: puteri.zarina@fbk.upsi.edu.my

A. E. U. A. Mancha
e-mail: achillesenchanganulak@gmail.com

D. A. Hamid
Kolej Universiti Poly-Tech MARA, Kuala Lumpur, Malaysia
e-mail: darulihsan@kuptm.edu.my

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26.1 Introduction

Fibre-reinforced polymer (FRP) or *Fibre-reinforced plastic*, is a composite material made of a polymer matrix reinforced with fibres. Instead of paper, wood or asbestos being utilised, there are other available options such as glass, carbon or aramid. The polymer used is usually an epoxy, vinylester or polyester thermosetting plastic, and phenol formaldehyde resins. FRPs are commonly used in the aerospace, automotive, marine and construction industries [1, 2].

Most composites have strong and stiff fibres in a matrix which is weaker and less stiff. Composite materials are engineered or naturally taking place of two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct within the finished structure. Glass fibre-reinforced epoxy composites result in a smart combination of physical and mechanical properties which cannot be obtained by monolithic materials [1, 3, 5].

The combination of the fibre and metal composite technology combines the advantages of metallic materials and fibre-reinforced matrix systems. Metals are isotropic because they have a high bearing strength and impact resistance and are easy to repair. Full composites have an excellent fatigue characteristic and have high strength and stiffness [2, 4]. By combining these two materials, an improved material with high strength and stiffness can be achieved.

The composite materials are widely used due to vast availability and cost-effective material processes. The interest was focused on lightweight materials with a strength improvement for marine application. The combination of the composite material or FRP with the metal gives a new characteristic of the material.

26.2 Materials and Methods

26.2.1 Materials

The fibreglass material epoxy resin and perforated material had been used for fabrication of the hybrid material composite. This selection of material in this experiment is the important part because the data will be compared to marine rules for composite boats. All the materials used are marine grade including the E glass type fibreglass, epoxy resin and perforated marine sheet metal.

26.2.2 Fabrication and Testing of Composites

An infusion resin system was used as fabrication technique for this hybrid material. These stages can be divided into three sections which covers the flat panel fabrication, specimen preparation and product testing.

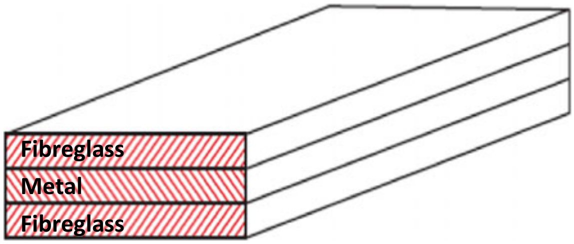

Fig. 26.1 Ply layer arrangement

The flat panel was developed on a smooth surface. A releasing agent was then applied on the flat surface and a cut ply of glass fibre was placed at the top of the smooth surface. The ply must be installed with a correct layer type as shown in Fig. 26.1. The material was infused by an epoxy resin with hardener and let for a few hours to cure properly.

The preparation of this specimen was based on the guidelines of ISO 178. The flexural specimen with a dimension of 10 mm × 80 mm was used for a 3-point bend test. Three various thicknesses of the specimen were formed including 3 mm, 7 mm and 9 mm thick. The thickness of the material is depending on the number of sandwich layers.

The flexural test measures the force required to bend a beam under three point loading conditions. The obtained data are usually used for materials selection of parts that will support loads without flexing. Flexural modulus was used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at specified temperatures that simulate the intended end user environment.

26.3 Results and Discussion

As of the fabricated composites, the test specimens are prepared based on ISO standard and were tested to assess their flexural strength. The number of layers and thickness applied can be found in Table 26.1. Meanwhile, the product outcome of the process is shown in Fig. 26.2.

Table 26.1 Specimen specification

Specimen thickness (mm)	Number of sandwich layers
3	2
7	4
9	6

*Remark: 1 sandwich containing 2 layer of fibre and 1 layer of metal

Fig. 26.2 Fibre laminates

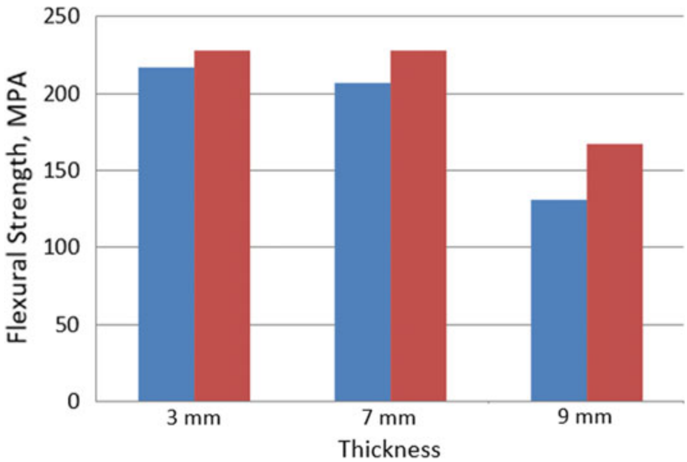

Fig. 26.3 Flexural strength

The flexural strength for various composites is shown in Fig. 26.3. The flexural strength of the composites varies from 130.667 MPa to 228 MPa and the maximum value is obtained for the composite with 7 mm thickness of hybrid steel. The flexural strength decreases while having the high ratio of metal in the hybrid material.

26.4 Conclusion

The experimental investigation on the flexural behaviour of reinforced HML composites with different thicknesses has been carried out. The following conclusions can be drawn from the present work were:

1. The thickness of the composite will affect the result of the flexural strength. A higher metal ratio in lamination will decrease the flexural strength.
2. The configuration with 7 mm thicknesses of hybrid material lamination has the maximum flexural strength.

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Chapter 27
Experimental Study on Self-Supported Friction Stir Welding on AA5083 Plate Butt Joints

Mohamad Aidil Azrul Abdul Razak, Azman Ismail, Fauziah Ab Rahman, Bakhtiar Ariff Baharudin, Mohamad Azlan Khalili, Mohd Yusri Mohd Rahim, and Mokhtar Awang

Abstract Friction stir welding (FSW) has initially been introduced by the TWI in England as an alternative welding method. This research is carried out to determine the optimum welding parameters that contribute to the least root deformation. The rotational speeds of 910 rpm, 1280 rpm and 1700 rpm are used. Meanwhile for the edge preparation, butt, stepped and angle are considered. The selected pin profiles are cylinder, square and triangle shapes. The experiment is tested with nine trials by changing the various combination of welding parameters. A 5 mm thick AA5083 plate was used as specimen materials. The result is gained by measuring the root deformation under the optical microscope at the joining part. This study is determining the optimum welding for the self-supported friction stir welding at less effect of root deformation for AA5083 plate butt joints.

M. A. A. A. Razak · A. Ismail (✉) · F. A. Rahman · B. A. Baharudin
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: azman@unikl.edu.my

M. A. A. A. Razak
e-mail: aidilazrul97@gmail.com

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

M. A. Khalili · M. Y. M. Rahim
Japan-Malaysia Technical Institute, Bukit Mertajam, Pulau Pinang, Malaysia
e-mail: azlan@jtm.gov.my

M. Y. M. Rahim
e-mail: yusri@jtm.gov.my

M. Awang
Department of Mechanical Engineering, Universiti Teknologi PETRONAS, Tronoh, Perak, Malaysia
e-mail: mokhtar_awang@utp.edu.my

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Keywords Self-supported friction stir welding · Aluminum plate AA5083 · Root deformation · Analysis of variance

27.1 Introduction

The process of friction stir welding (FSW) utilizes frictional heat generated between the tool and the work piece to soften and joining two metal parts together. The rotation of the pin produces enough heat to soften the material. The rotation and translation of the tools produce the mixing of materials [1]. Manufacturers have the problem to carry out friction stir welding due to a lack of information on suitable welding parameters and settings. Suitable parameters will produce good welding results. The parameters needed in FSW are the welding speed, rotational speed, axial force, and tool geometry [2]. To carry out this FSW process, all the suitable parameters need to be set properly [3].

The non-consumable tool was fabricated using the high carbon high chromium H-13 steel to weld the aluminum plate [4]. Five different tool pin profiles were fabricated, namely cylindrical, tapered cylindrical, triangular, square and hexagonal were used in the experiment to choose the most efficient welding tools to perform the welding process [5]. If insufficient heat generated, the FSW tool stuck in the material while doing the welding process and the welding process cannot be continued. A wormhole can appear due to a lack of heat to cause proper material flow [6].

ANOVA is a short term for analysis of variance, and it is known as a general linear model (GLM) that is widely used for creating any factorial designs for any experiment. Factors of one or more that contribute to the experiment are categorized in factorial design [7]. ANOVA is mainly focusing on the F-tests of main effects and interaction of the desired experiment. This ANOVA is used to analyze and support the experimental work by using model comparison and model selection accordingly [8].

In engineering and science field, the signal to noise ratio (SNR) is commonly applied to measure by comparing the level of background noise with the level of signal. This method is implemented to interpret the experimental result from the factors of all levels [9]. Usually the greater the SNR, the stronger the signal or information in the signal relative to the noise or distortion. The application of SNR is the efficient approach that is commonly used for data interpretation. SNR can be computed in time or frequency domain [10].

27.2 Experimental Setup

The Taguchi method was applied to analyze the process parameters that need to be used for this experiment. The Taguchi method is implemented by using the design of experiment based on orthogonal arrays to analyze certain variables in certain number

Table 27.1 Welding parameters

S. No	Rotational speed (rpm)	Edge preparation	Tool pin profile
1	910	butt	1
2	910	stepped	2
3	910	angle	3
4	1280	stepped	1
5	1280	angle	2
6	1280	butt	3
7	1700	angle	1
8	1700	butt	2
9	1700	stepped	3

Table 27.2 Tool pin profiles

Number tool	Description of the tool	Length of the pin (mm)	Inner diameter of the pin (mm)	Outer diameter of the pin (mm)	Diameter of the shoulder (mm)
1	Cylindrical tapered	4	3	5	20
2	Square tapered	4	3	5	20
3	Triangular tapered	4	3	5	20

of experiments. By using Taguchi method, the number of the experiment tested will decrease significantly [11–13].

All the experimental work was carried out on AA5083 flat panels by using the manual milling machine with all the parameters as shown in Table 27.1. Meanwhile, the shapes of pin profiles used are shown in Table 27.2. Then, the friction stir welded specimens were cut specifically at the welded parts using the EDM wire cut machine. After that, these small size specimens were mounted using the hot mounting press. Then all the specimens were put under the optical microscope for root deformation measurement. The location of root deformation on specimen is shown in Fig. 27.1. This measurement will be further analyzed by using analysis of variance (ANOVA) via minitab 19.

27.3 Result and Discussion

Table 27.3 shows the root deformation measurement for each specimen. Based on this measurement, the SNR value for each specimen was calculated. The SNR values were proceeded for analysis of variance (ANOVA) in order to determine the major

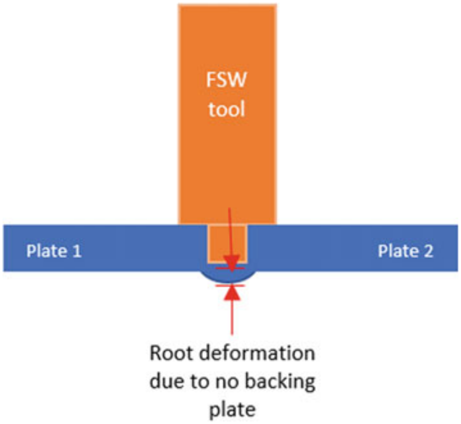

Fig. 27.1 Root deformation during FSW process

Table 27.3 Root deformation and SNR of each specimen

S. No	Rotational speed (rpm)	Edge preparation	Tool pin profile	Root deformation (mm)	SNR
1	910	butt	1	2439.345	−67.746
2	910	stepped	2	2646.939	−68.455
3	910	angle	3	2448.764	−67.779
4	1280	stepped	1	2681.653	−68.568
5	1280	angle	2	3074.512	−69.756
6	1280	butt	3	2171.637	−66.736
7	1700	angle	1	2730.872	−68.726
8	1700	butt	2	2523.044	−68.039
9	1700	stepped	3	2730.872	−68.726

contribution that affect the quality of joints in terms of less root deformation which can be seen in Table 27.4.

From Table 27.4, the high percentage is at the edge preparation which gave a major contribution of 47.2% to the weld joint quality in terms of less root deformation. The next factor that contributes lesser effect is the tool pin profile at 26.4% and the

Table 27.4 ANOVA Table

Source	DF	Adj SS	Adj MS	F-value	P-value	Contribution (%)
Rotational speed	2	39,974	19,987	0.43	0.701	7.898
Tool pin profile	2	133,622	66,811	1.43	0.412	26.401
Edge preparation	2	238,779	119,389	2.55	0.282	47.177
Error	2	93,759	46,880			18.525
Total	8	506,134				

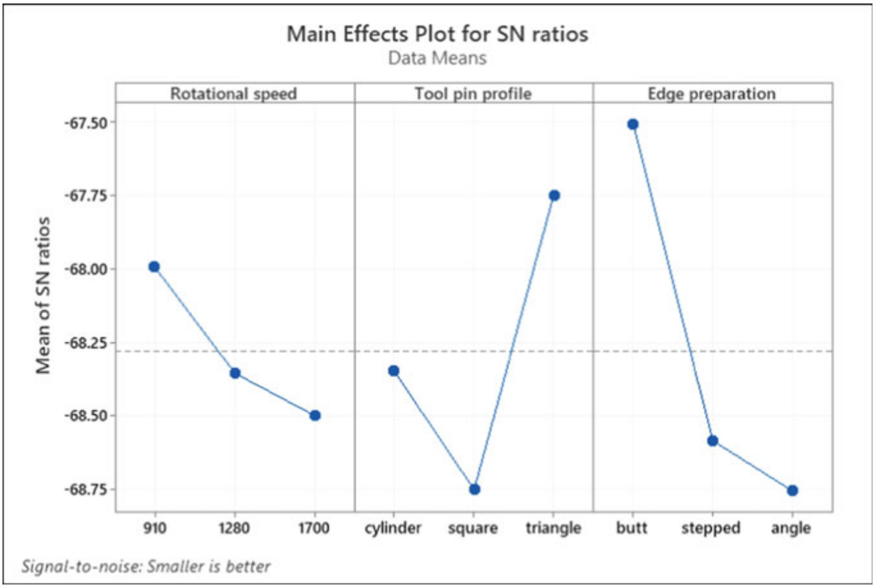

Fig. 27.2 Main effects plot

rotational speed at 7.9%. The error of the experiment is still low at 18 percent so that the experiment can be accepted.

Figure 27.2 shows the main effect plots. These graphs show the optimum combination of welding parameter which gave the smallest amount of root deformation. Based on Fig. 27.1, it showed that the optimum combinations were the rotational speed of 910 rpm, triangle pin profile and closed butt joint edge preparation for the least root deformation.

27.4 Conclusion

The optimum welding parameters for self-supported friction stir welding was achieved by selecting the rotational speed of 910 rpm, triangle pin profile and edge preparation of closed butt joint.

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Chapter 28
Optimization of Welding Parameters for Self-Support Friction Stir Welding (SS-FSW) on AA6063 Pipe Joints

Mohammad Azhan Mohd Najib Lotpy, Azman Ismail, Fauziah Ab Rahman, Megat Khalid Puteri Zarina, Bakhtiar Ariff Baharudin, Mokhtar Awang, and Darulihsan Abdul Hamid

Abstract The use of the friction stir welding (FSW) process with the needs of inner mandrels or backing plates will limit the further application for industrial needs. Therefore, the self-support friction stir welding (SS-FSW) technique is used to run the joining process without the inner mandrel or backing support especially for pipes. In order to execute the experiment, the AA6063 pipe with 89 mm of outside diameter and 5 mm of wall thickness was utilized in this experiment setting. Several edge preparations were used such as butt, scarf and stepped joint. In addition, the different pin profiles were also used: cylindrical, rectangular and triangular shape. The selected rotational speeds were 910 rpm, 1280 rpm and 1700 rpm. The Taguchi L9 orthogonal array was used to minimize the number of experiments as it is difficult to conduct a high number of experiments to find out the level combinations. The height of deformation was measured and analyzed further by the use of a statistical

M. A. M. N. Lotpy · A. Ismail (✉) · F. A. Rahman · M. K. Puteri Zarina · B. A. Baharudin
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: azman@unikl.edu.my

M. A. M. N. Lotpy
e-mail: aannajib96@gmail.com

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

M. K. Puteri Zarina
e-mail: puteri.zarina@fbk.upsi.edu.my

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

M. Awang
Department of Mechanical Engineering, Universiti Teknologi PETRONAS, Tronoh, Perak, Malaysia
e-mail: mokhtar_awang@utp.edu.my

D. A. Hamid
Kolej Universiti Poly-Tech MARA, Kuala Lumpur, Malaysia
e-mail: darulihsan@kuptm.edu.my

A. Ismail et al. (eds.), *Advanced Engineering for Processes and Technologies II*, Advanced Structured Materials 147,
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tool, i.e. analysis of variance (ANOVA) via Minitab 19. As a result, the optimum parameters were 910 rpm of rotational speed, rectangular pin profile and stepped joint of edge preparation, with the minimum height of deformation at 542.25 μm. The pin profiles were the major factor that can affect the output with a 62.38% of contribution. The future works will be continued until the elimination of the requirement of inner mandrel or backing plate in the use of FSW process can be achieved.

Keywords Self-support friction stir welding · AA6063 · Pipe · Deformation · Taguchi method

28.1 Introduction

Friction stir welding (FSW) was discovered and established in 1991 by The Welding Institute (TWI) in Cambridge, United Kingdom. FSW utilizes the high-speed rotation friction method to join material. The joint can be produced below the melting temperature without the use of any filler wire. This method is suitable for joining a material that is difficult to weld such as aluminium. This new method has a variety of excellent advantages that have already been used for various industrial applications such as trains, ships, automobiles and civil engineering structures for aluminium alloys [1].

According to Akbari et al. [2], most of the previous FSW research concentrated on the lap or butt welding of flat surface plates, and only a very small number of investigations investigated the FSW process method for joining pipes. FSW pipes cannot be joined by standard milling machines. The development of special fixtures is one of the most difficult tasks for welding pipes by the FSW process. In addition, in this weld configuration, due to a small radius of curvature, the contact between the tool and the workpiece differs from the configuration of the butted plate, resulting in a distinctive temperature history and, consequently, a different microstructure and mechanical properties. Figure 28.1 shows the cross view of the schematic process.

Chen et al. [3] had studied the FSW of small-diameter AA3003 and pure Cu pipes. They used a special welding device that is very different from the one used for the FSW of lap or butt of flat plates. They established the distinctive history of temperature due to heat accumulation as a significant feature of small-scale FSW pipes. In addition, the mechanical properties of welding, including tensile strength, ductility and hardness, change accordingly along the welding line. Lammlein et al. [4] stated that the FSW of a small-diameter pipe gave high tensile strength and sound internal and superficial appearance.

FSW is a friction welding variant that produces welding between two or more materials by heating the material displacement caused by the rotational tool which transverses the weld joint. The AA6063 aluminium also has a very good welding characteristic and can be used in temperature ranges from 500 °F to a maximum of 950 °F of hot work. The FSW joining process occurred below the melting point,

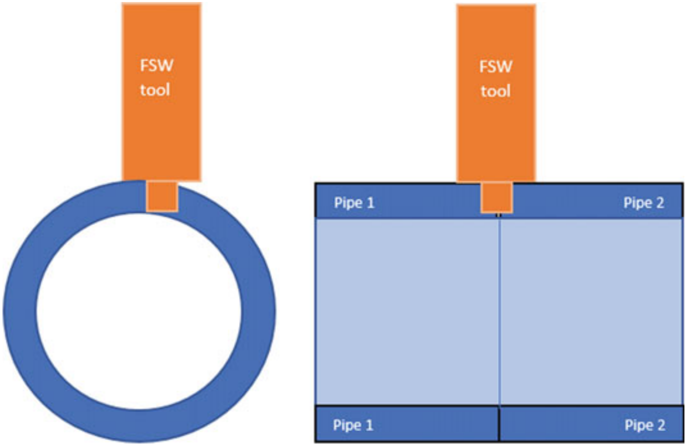

Fig. 28.1 Cross-section view of FSW setup for pipe joining with no internal support

several joint defects caused by melting such as porosity, grain boundary cracks and segregation of alloys can be removed or reduced accordingly [5].

The heat produced by friction between the tool and the workpiece increases the temperature, particularly in the area near the interface. Approximately 90% of the heat is obtained from friction between the shoulder and the workpiece, whereas 5% is obtained from the probe (pin) and the remainder is collected from the plastic strain produced in the base metal [6]. FSW is ideal for flat panels and tubular shapes as technology is advancing nowadays as stated by Ismail et al. [7]. A lot of research has been done on flat panels but a few have been developed for tubular forms such as pipes for various studies [8–11].

28.2 Experimental Procedure

An AA6063 pipe with 89 mm outside diameter and 5 mm of wall thickness was used in this experiment setting. Three levels of welding parameters were selected for this experiment. Table 28.1 shows the FSW process parameters and their levels. The welding parameters such as rotational speed, tool pin profile and edge preparation can

Table 28.1 Welding parameter and level

Welding parameter	Unit	Level 1	Level 2	Level 3
Rotational speed	RPM	910	1280	1700
Pin profile	–	Cylindrical	Square	Triangular
Edge Preparation	–	Butt joint	Stepped joint	Scarf joint

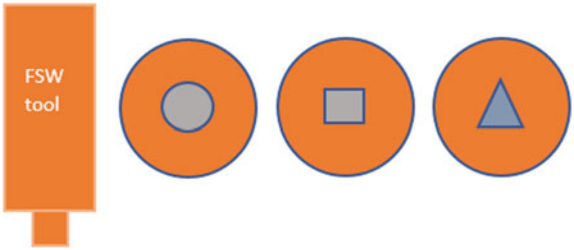

Fig. 28.2 Pin profiles

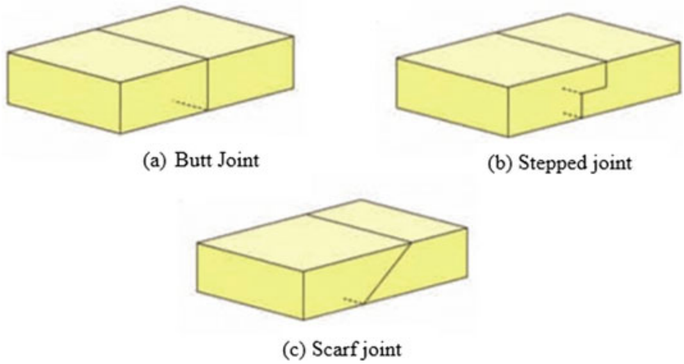

Fig. 28.3 Edge preparation

affect the quality of the FSW joints. The pin profiles and edge preparation selected for this experiment setting are shown in Figs. 28.2 and 28.3, respectively.

For the selected parameter setting, the distance of the deformation was measured by using an optical microscope. The location for each deformation is shown in Fig. 28.4. The measurement may vary and it is depending on the parameters applied. This measurement will be used for further analysis. Table 28.2 shows the design of experiment (DOE) setup by using the Taguchi's L9 orthogonal array and then analyzing by using Minitab 19.

28.3 Result and Discussion

Without the inner mandrel, the deformation occurrence cannot be avoided but the impact could be controlled with a proper setting. Figure 28.5 shows the macro image on the deformation section for each specimen and Table 28.3 shows the analysis of the deformation gathered from the experiment. Based on these results found, Minitab 19 is used to analyze the data in order to determine the optimum welding parameters based on the measurement of deformation. Meanwhile, Table 28.4 shows the analysis of variance (ANOVA) of the results.

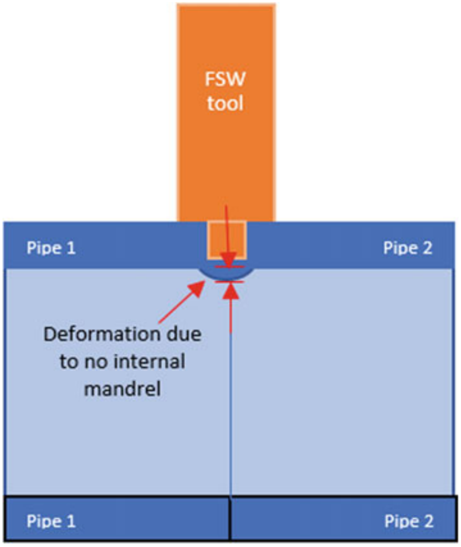

Fig. 28.4 Deformation measurement due to no internal mandrel provided

Table 28.2 Design of experiment setup

Specimen number	Input Parameter (I.P)		
	Rotational speed	Pin profile	Edge preparation
1	910	Cylindrical	Butt
2	910	Square	Stepped
3	910	Triangular	Scarf
4	1280	Cylindrical	Stepped
5	1280	Square	Scarf
6	1280	Triangular	Butt
7	1700	Cylindrical	Scarf
8	1700	Square	Butt
9	1700	Triangular	Stepped

Based on Table 28.4, it shows that the tool pin profile has the highest percentage of contribution at 62.38%. This proves that this parameter setting is the main parameter in affecting the deformation of the specimen due to no backing plate used. Meanwhile, the rotational speed and the edge preparation contribute at 18% and 13.51%, respectively. The optimum parameter can be determined by referring to the response table for S/N ratios which is shown in Table 28.5. A similar representative is illustrated in Fig. 28.6.

Both results show that the optimum parameters with minimum deformation are a rotational speed of 910 rpm, tool pin profile of square and the edge preparation of stepped joint.

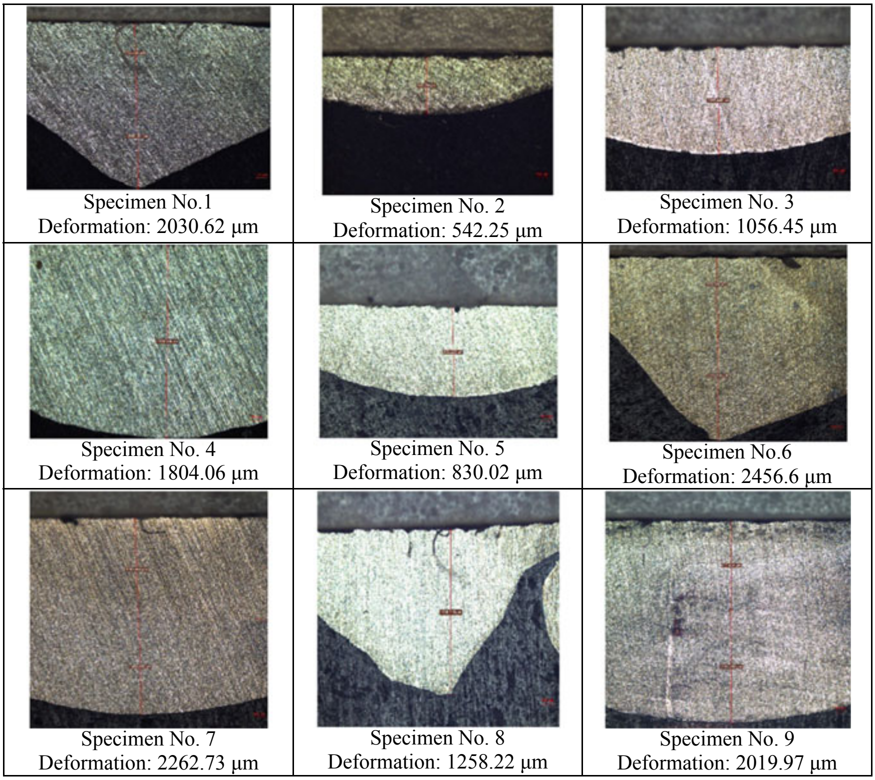

Fig. 28.5 Measurement of deformation due to different welding parameters

Table 28.3 Experimental results

Specimen number	Deformation (μm)	Signal to noise ratio
1	2030.62	−66.153
2	542.25	−54.684
3	1056.45	−60.477
4	1804.06	−65.125
5	830.02	−58.382
6	2456.60	−67.807
7	2262.73	−67.093
8	1258.22	−61.995
9	2019.97	−66.107

Table 28.4 ANOVA table

Factor	Degree of freedom	Sum of squares	Mean of squares	*P*-value	Contribution (%)
N	2	665,837	332,918	0.253	18.00
P	2	2,306,963	1,153,482	0.089	62.38
E	2	499,684	249,842	0.311	13.51
Error	2	225,753	112,877		6.10
Total	8	3,698,237			

Table 28.5 Respond table for S/N ratios

Level	Rotational speed (RPM)	Pin profile	Joint configuration
1	**−60.44**	−66.12	−65.32
2	−63.77	**−58.35**	**−61.97**
3	−65.06	−64.80	−61.98
Delta	4.63	7.77	3.35
Rank	2	1	3

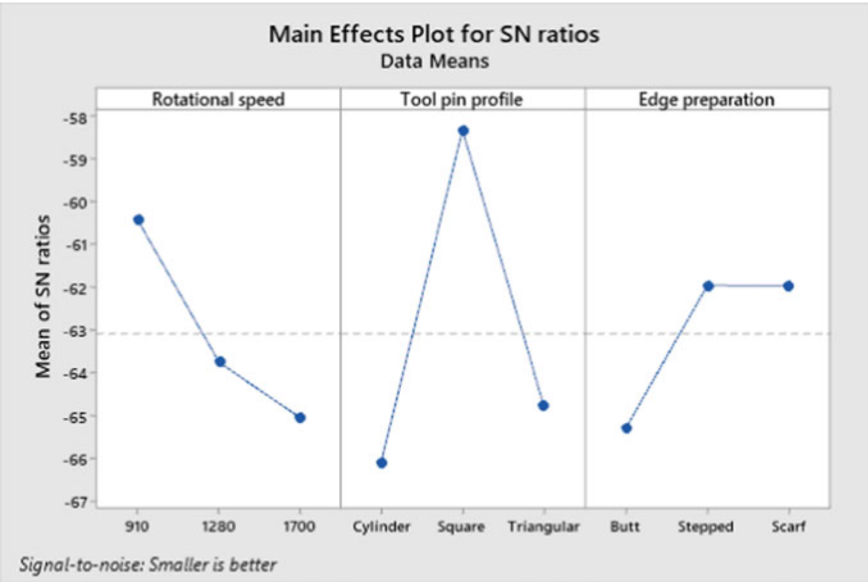

Fig. 28.6 The optimum welding parameters

28.4 Conclusion

The Taguchi and ANOVA methods were used in this study to evaluate and obtain the optimal condition for friction stir welding of AA6063 pipes without the backing support. The conclusion can be drawn as follows:

a. The pin profiles were the major factor that can affect the deformation with the contribution of 62.38%.
b. The optimal parameter of friction stir welding for AA6063 pipes was 910 rpm, squared pin profile and stepped joint edge preparation. The result of the deformation at this parameter was 542.25 μm.

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Chapter 29
Experimental Study of Friction Stir Welding on AA5052 (1.5 mm) Thin Plate Butt Joints

Tuan Muhammad Nurkholish Tuan Anuwa, Azman Ismail, Bakhtiar Ariff Baharudin, and Fauziah Ab Rahman

Abstract In this study, a detailed practical investigation to determine the tensile strength of a thin aluminum plate joint and to produce a good thin aluminum plate joint. The purpose of this study is to run and find the right formula of rotational speed (rpm) and travel speed (mm/min) for the friction stir welding (FSW) process on an aluminum thin plate AA5052 1.5 mm plate joint. The optimum parameters for this research are at 910 rpm rotation speed with 340 mm/min travel speed and 2° angle. The tensile strength that had been collected can achieve up to 85% of the base metal (BM). The tool geometry was design with a pin diameter of 1.4 mm, shoulder diameter of 6 mm, and length of 20 mm. The results show that FSW improves the mechanical properties of welded joints compared to other welding processes.

Keywords Friction stir welding (FSW) · Aluminum alloy (AA5052) 1.5 mm thin plate

29.1 Introduction

Friction stir welding (FSW) is a method or process which uses a non-consumable welding tool to join two workpieces that face each other without melting the workpiece surface [1]. The welding tool is used to generate friction for heating the material

T. M. N. T. Anuwa · A. Ismail (✉) · B. A. Baharudin · F. A. Rahman
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: azman@unikl.edu.my

T. M. N. T. Anuwa
e-mail: tmnurkholish@gmail.com

B. A. Baharudin
e-mail: bakhtiarab@unikl.edu.my

F. A. Rahman
e-mail: fauziahabra@unikl.edu.my

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until the metal joins in solid-state. The combination of heat generated by friction and consequent plastic deformation being the main causes of fusion.

Besides, the development of FSW by TWI in the UK is better compared to gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW). It is because the FSW method is free from various types of defects. The conventional milling machine MILKO 37 is chosen to innovate and become a FSW machine to run the process. One of the limitations is the existence exit hole at the end of the joining process by FSW. Nowadays, FSW is also found in modern shipyard, trains, automotive, and aerospace applications [2].

The FSW process is suitable for various joining configurations such as butt joint and lap joint [3]. This welding process requires no edge preparation. No shielding gas is required for the materials such as aluminum at which this process only generates friction from the non-consumable welding tool. A backing plate was mostly needed before the material is welded to the parts so that the faces are rigidly fixed to each other to be welded [4].

29.2 Experimental Setup

The work is performed using distinct parameters to achieve the optimum configuration of the parameters in terms of performance, macrostructure, and tensile strength. Each parameter used during the operation will produce good outputs. The chemical composition and mechanical properties of the AA5052-H32 delivered by Atlas Steels are given in Table 29.1. The welding parameters used are shown in Table 29.2.

Table 29.1 Chemical composition of AA5052

Element	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
AA5052-H32	0.25	0.40	0.10	0.10	2.2–2.8	0.15–0.35	0.10	–

Table 29.2 FSW parameters

Specimen No	Rotational speed (rpm)	Travel speed (mm/min)
1	490	695
2	490	495
3	490	340
4	910	340
5	1280	340

Table 29.3 FSW tool design

Tool design	Type of tool	Length of pin profile	Width of pin profile	Concave shoulder
Set 1	Concave Shoulder with Hemisphere Pin	0.9 mm	5 mm	Height – 0.4 mm Width – 5 mm

29.2.1 Friction Stir Welding Tool

The tool design is an essential factor because the strength of the welding can be enhanced by a good instrument. It is safer to have the material as a high carbon tool steel, tough enough, at the temperature welding. The penetration of the pin tool depth is referring to the thickness of the specimen. In the present study, the tools design is shown in Table 29.3.

29.2.2 Friction Stir Welding Process

Two plates with dimensions 50 mm $\times$ 200 mm were butted up against each other and clamped down using the welding jigs structure. The pre-settings rotational speed and travel speed of the FSW Tool are been adapted by the MILKO 37. The tool is slowly being plunged into the workpiece at 2° angle.

The tool creates the frictional heat on the work piece. The heat produced by the mechanical mixture of the material produces a softening of material without reaching its melting point. The tool then travels along a welding line joining the materials. The material is then consolidated into the welding joint and an exit hole is left at the end.

29.2.3 Tensile Testing

One of the most fundamental mechanical testing process is a tensile strength test. Tensile experiments apply the tensile force (pulling) to a substance and calculate the reaction to the tension. This dictates how solid a substance is and how long it will lengthen. Properties that are directly measured are the ultimate tensile strength (UTS) and the maximum elongation (EL %).

29.2.4 Macro Structure Testing

Researchers can evaluate the macrostructural areas of FSW joints, and the result of macro testing is obtained from the selected parameters. Macrostructure testing is one of the NDT method which only can be done under a microscope or a very high resolution camera. The lens that had been used in this project is 50 × zoom scale by using the optical microscope.

29.3 Result and Discussion

Surfaces of the welded specimens have been recorded and evaluated for each selected parameter. All welded specimens were visually inspected by referring to the ISO 25239. The results of welding outputs are shown in Table 29.4.

The tensile strength result is shown in Fig. 29.1. It is generally proved that the FSW joints have superior properties of tensile strength which can achieve up to 85% strength compared to the base metal, BM. The reason why the FSW joint performs better joining in terms of strength is the superior mechanical characteristics of the weld joints [5].

Table 29.4 Visual inspection result

Specimen	Weld surface	Description
1		Less Smooth weld surface with little flash, no defect in welded joint, good weld penetration
2		Smooth weld surface with little flash, no defect in welded joint, good weld penetration
3		Smooth weld surface with more flashes at the side, no defect in welded joint, good weld penetration
4		Very smooth weld surface without flashes, no defect detected. good weld penetration
5		Smooth weld surface with little flash, no defect in welded joint, good weld penetration

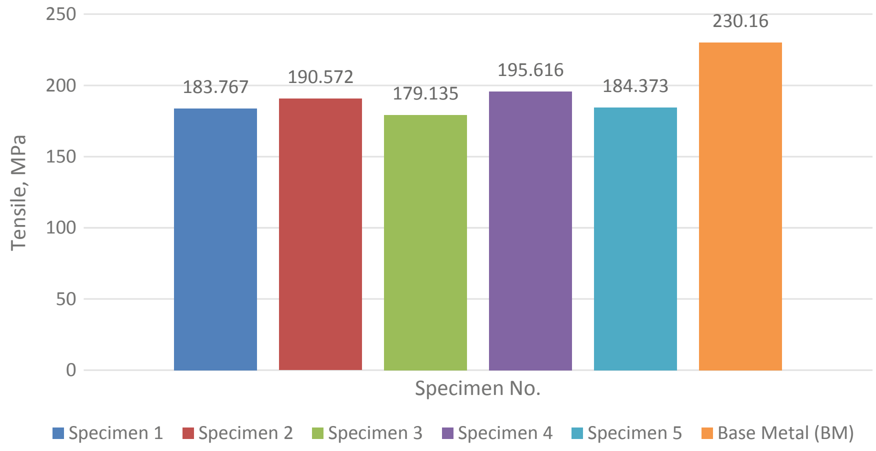


Fig. 29.1 Tensile strength result

Macrostructure testing is one of the non-destructive testing (NDT) method which only can be done under a microscope or very high resolution camera [6]. This testing is done to find the micro defects that cannot be detected by naked eyes. After been observed by using the optical microscope, the result and analysis is described in Table 29.5.

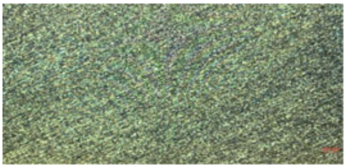
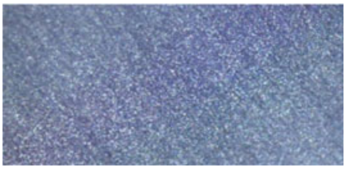
Based on the result that has been recorded, there is slightly different values in terms of strength [7]. The specimen with parameter of 910 rpm with travel speed 340 mm/min gives the longest elongation with 0.031 mm/mm compared to other parameters. Using this parameter setting can achieve up to 85% strength compared to the base metal of AA5052. It shows that this method of joining and parameter setting gives a good welding joint.

In terms of maximum load strength, the maximum result recorded is at 910 rpm with a travel speed of 340 mm/min gives 2053.972 N. The result for elastic material property is at 28,483.07 MPa. Based on the tensile strength, it has been recorded that the highest tensile strength obtained is 195.616 MPa.

The sizing standard is referring to the ASTM E340-95 standard. The cutting process for both specimens was also be done at JMTI premise. After been inspect using the optical microscope, it appears slag inclusion in specimen 3 and specimen 5.

Overall, the parameter setting of 910 rpm with a travel speed of 340 mm/min is the perfect combination which gives no defect on the welded joint. However, a gear malfunction of the MILKO 37 during the welding process caused some vibrations which gave some impact on the welding surface. The macrostructure of parameters at 910 rpm with a travel speed of 340 mm/min on the other hand shows a free defect welded joint and higher tensile strength capability.

Table 29.5 Macrostructural result

Specimen	Macrostructure on WNZ	Description
1		Less smooth weld surface, slag inclusion occurred in welded joint which can be accepted under ISO 25239-5, good weld penetration
2		Very Smooth weld surface, no defects occurred in welded joint, good weld penetration
3		Welding imperfection appeared, slag inclusion which can be accepted under ISO 25239-5
4		Very smooth weld surface, no defects occurred in welded joint, Good weld penetration detected
5		Weld imperfection appeared, slag inclusion can be accepted under ISO 25239-5

29.4 Conclusion

Based on these results, several conclusions can be drawn as follows:

1. The friction stir welded joints show the best mechanical properties in terms of tensile strength when compared to the BM. The FSW joint exhibited higher strength values which can be achieved up to 85%.
2. The parameters setting at 910 rpm with a travel speed of 340 mm/min, 2° of tilt angle, and dwelling at 120 s produced a fine and smooth friction stir welded surface.

3. A good thin Aluminum plate joint can be produced by using parameter settings at 910 rpm with a travel speed of 340 mm/min. The joint produced by this setting gave the highest tensile strength compared to other weld that obtained approximately 195.616 MPa. The tensile strength produced by this joining technique can be achieved up to 85% strength from the BM.
4. The lowest tensile strength of AA5052 was produced by Specimen 3 with approximately 179.135 MPa which only 78% strength of the BM. All the specimens obtained a result which is more than the best result which is more than 78% strength of BM.

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Chapter 30
5G: Performance on the Enhancement of the Asymmetric Arithmetic Coding with Space Time Frequency Block Coding MIMO

Mohamad Zuhairi Saleh, Noorazlina Mohamid Salih, Hazwani Mohd Radzi, Mohd Shahrizan Mohd Said, Izanoordina Ahmad, and Azlina Idris

Abstract The rising demand of 5G technology in the year 2020 has a priority to provide high-speed user capacity with minimum probability of error (noise interference) in wireless communication services. The 5G system model should deploy a unique channel coding technique so-called the enhancement asymmetric arithmetic coding (EAAC) to compress the data and gain signal efficiency as new-found block codes that is related to the traditional arithmetic coding (AC), at which the received signal is expected to have an ultrafast speed transmission, good voice quality, and high network capacity. The EAAC coding technique is embedded with multiple input multiple output (MIMO) system which is formulated to the increase spatial diversity and is considered in measuring the performance of the space–time–frequency block codes (STFBC) system model that supports wireless communication technology efficiently.

M. Z. Saleh · N. M. Salih (✉) · H. M. Radzi
Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Malaysia
e-mail: noorazlinams@unikl.edu.my

M. Z. Saleh
e-mail: zuhairi23joey@gmail.com

H. M. Radzi
e-mail: hazwani@unikl.edu.my

M. S. M. Said
Universiti Teknologi MARA Cawangan Perak, Seri Iskandar, Malaysia
e-mail: mohds665@uitm.edu.my

I. Ahmad
Electronics Technology Section, Universiti Kuala Lumpur British Malaysian Institute, Gombak, Malaysia
e-mail: izanoordina@unikl.edu.my

A. Idris
Wireless Communication Technology (WiCOT), Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
e-mail: azlina831@uitm.edu.my

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Keywords 5G technology · Enhancement asymmetric arithmetic coding (EAAC) MIMO · Probability of error · STFBC

30.1 Introduction

The growth of wireless communication nowadays is because of the demand from the user to communicate at any distance and any time. The revolution from 4 to 5G communication is mandatory due to the growth of wireless communication nowadays [1]. This revolution is because the 5G technology offers high-speed user capacity, good voice quality, high-speed data transmission, ultra-low latency, low power consumption, and tolerance to noise [2, 3]. The 5G technology is capable to provide data transmission of more than 1 gigabyte per second (Gbps). This is superior to 4G which is just 200 megabytes per second (Mbps). This 5G technology is also capable to support millions of wireless communication devices at ultra-speed and this affects the economy of a country by ushering into the fourth industrial revolution (I.R 4.0). Autonomous vehicles, object tracking, and virtual reality is the technology that can be achieved from this 5G technology.

The system performance's improvement has decided to use the multiple input multiple output (MIMO) technology [4]. MIMO is a wireless communication antenna technology which is using multiple antennas on both the transmitter and the receiver sides. The MIMO technology has gained interest in wireless communications because without additional bandwidth or transmit capacity, it enables significant improvements in data rate and link range [4]. In addition, MIMO allows many users to be served at the same time. Thus, the main advantages of MIMO are to be able to provide efficient spectral performance and high energy efficiency of cellular networks [5].

A complete wireless system model of STFBC-MIMO that deployed EAAC as a block coding technique has been further improved with the usage of a digital filter at the transmitter system. By adding the digital filter, it causes higher peaks to the average power ratio (PAPR) to the signal before it is being transmitted. Based on the previous work, PAPR can be eliminated with the combination of STFBC-MIMO and the arithmetic coding (AC) technique, but it however, causes high computational complexity and affects the system model.

In general, to satisfy the diversified and high demands of the coming 5G cellular networks, orthogonal frequency division multiplexing (OFDM) looks insufficient to provide 5G with efficient and reliable networks, and thus, the authors in [6] and [7], stated even OFDM is the most advanced modulation scheme technique, it still has a deficiency in the system which is difficult to respond simultaneously to the needs of various types of services and related channel characteristics. Secondly, although OFDM delivers high spectral efficiency, the out-of-band emission (OOBE) still occurs inside the OFDM system. Besides, OFDM fails to create a near-perfect alignment of time frequencies. In order to overcome the deficiency of the OFDM system, the researcher in [6] mentions a new modulation scheme which is filter orthogonal frequency division multiplexing (F-OFDM) in their research. At each transmitter, the proposed F-OFDM uses the spectrum shaping filter to remove side lobe leakage and a bank of filter at the receiver for inter-user interference rejection. The researcher in [8] stated that it is expected that the benefits of using F-OFDM in the MIMO system, which is the interference produced between the signals will be smaller, lower the bit error rate and increase the spectral efficiency, as signals can coexist better.

30.2 Design Methodology

Figure 30.1 shows the overall block diagram of the system that deployed the EAAC channel coding to overcome the issues of high PAPR which is the high error in multiple transmissions. The mathematical representation of Eqs. (1a) and (1b) algorithm show that the inputs of the transmitted signal have been successfully transmitted to the receiver.

$$\text{Transmitted Signal} = \text{Coding: C(X, S)} \rightarrow \text{(X, 0)} \tag{1a}$$

$$\text{Received Signal} = \text{Decoding: D(X, 0)} \rightarrow \text{(X, S)} \tag{1b}$$

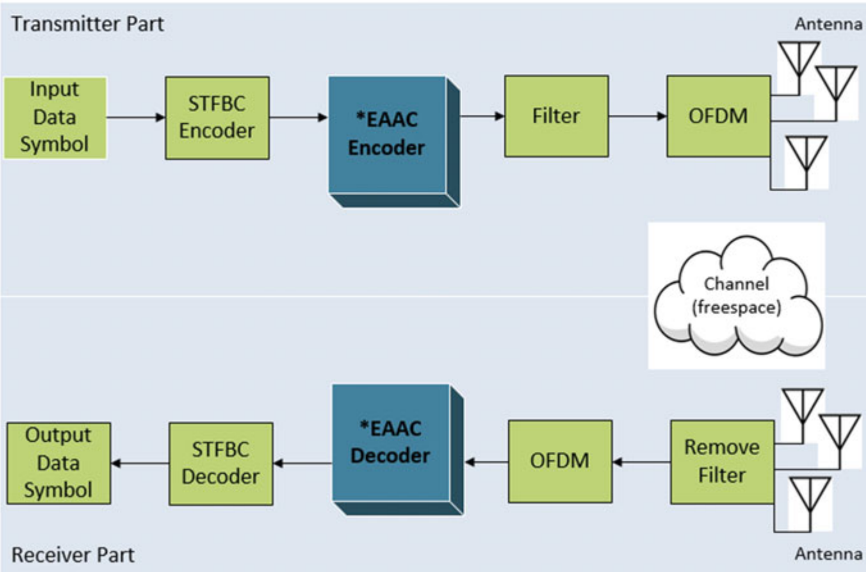

Fig. 30.1 STFBC MIMO F-OFDM with EAAC technique

The need for better compression increases with the increasing amount of data transfer nowadays. Huffman coding (HC) introduced by David A. Huffman in 1952, and arithmetic coding (AC) are the two most known coding algorithms. Although HC is easy, it usually does not compress as well as AC [9]. Arithmetic coding, however, requires more computing power, which is not always present in low power embedded systems [9]. Researcher Jarek Duda [10], presented a unique method to entropy coding. A family of generalizations of standard numeral systems that are suitable for encoding equiprobable symbol sequences into asymmetric numeral systems (ANS) to be optimal for freely selected symbol probability distributions. It has some similarities to arithmetic coding, but in selecting a range, it extends these ranges evenly over the entire interval instead of encoding symbols. This technique is much simpler where instead of using two states to define the range, this method needs only one state to define the range. There are practical findings for the binary case, the asymmetric binary system (ABS) [11]. Formulas that provide a highly accurate entropy encoder for which the probability of symbol distribution will freely change. However, for the general case, instead of using formulas ANS initially uses the pseudorandom number generator to distribute symbols with supposed statistics. The accuracy can still be very high, but the drawback is that it needs to be reinitialized as the probability distribution changes. The benefit is that a few bits in one use of the table will get compression rates like in AC and transfers like in HC during encoding and decoding [11].

30.3 Results and Discussion

There were several measuring methods to validate the simulation results for PAPR improvements that are mainly solved by using the EAAC technique that is mentioned in this study. This can be classified into two sections such as follows:

a. **Bit Error Rate (BER) Measurements**
   Referring to Fig. 30.2, the system observed to have AAC at SNR 9.9 dB and proved to have lower BER as compared to AC and HC as verification elements. This indicated that the new AAC reduced the probability of error of the system when input and output are said to be compared (Tables 30.1 and Table 30.2).
   Meanwhile, Fig. 30.3 shows the elements of BER at the clip rate 10^{-1} which gives the value of 8.55 signal-to-noise ratio with 100 number of users and made comparison with input and output system model.
   The analysis stated that, with STFBC MIMO F-OFDM, the study proved to have new AAC to reduce BER in the system.
b. **PAPR Measurements**
   Figure 30.4 shows the PAPR measurement at the transmitter with 8.5 dB using AC as compared to HC for verification elements. In specific, the system has improved the reliability of signal transmitting as compared to HC. A further requirement

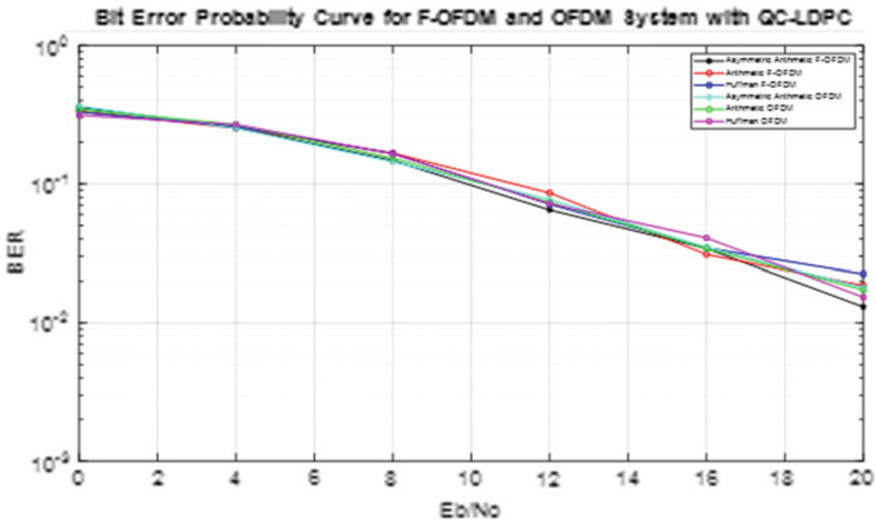

Fig. 30.2 BER measurements with digital modulator QC-LDPC

Table 30.1 BER measurements with QC-LDPC for both F-OFDM and OFDM

Result of BER at clip rate 10^{-1}		
Coding Technique	F-OFDM (Eb/No)	OFDM (Eb/No)
Asymmetric arithmetic	9.9	10.35
Arithmetic	11	10.3
Huffman	10.4	10.45

Table 30.2 BER Measurements with LDPC for both F-OFDM and OFDM

Result of BER with LDPC at clip rate 10^{-1}		
Coding Technique	F-OFDM (Eb/No)	OFDM (Eb/No)
Asymmetric arithmetic	8.55	9.65
Arithmetic	9.43	9.32
Huffman	9.2	9.54

is to apply the technique to multiple users with multiple block coding techniques (Table 30.3).

30.4 Conclusion

A new AAC coding technique, the so-called EAAC has the advantage in reducing the PAPR measurements for the STFBC MIMO F-OFDM system model that supports

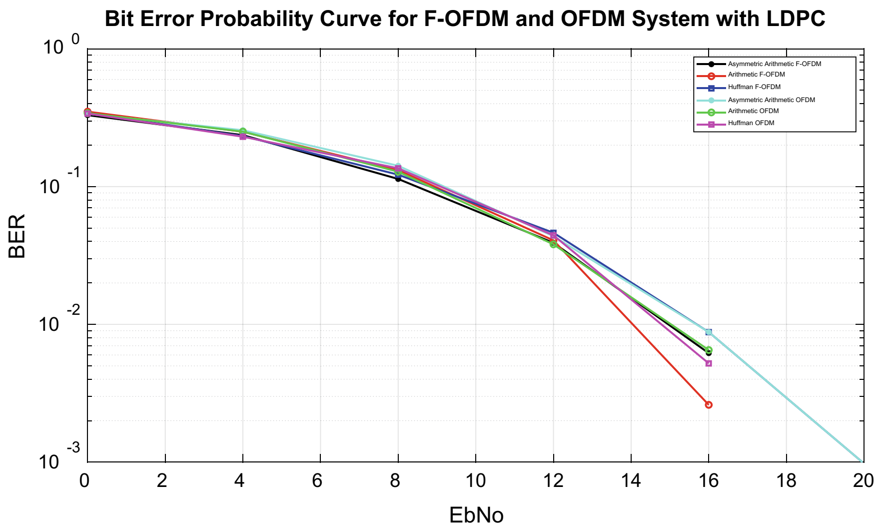

Fig. 30.3 BER measurements for LDPC digital modulator

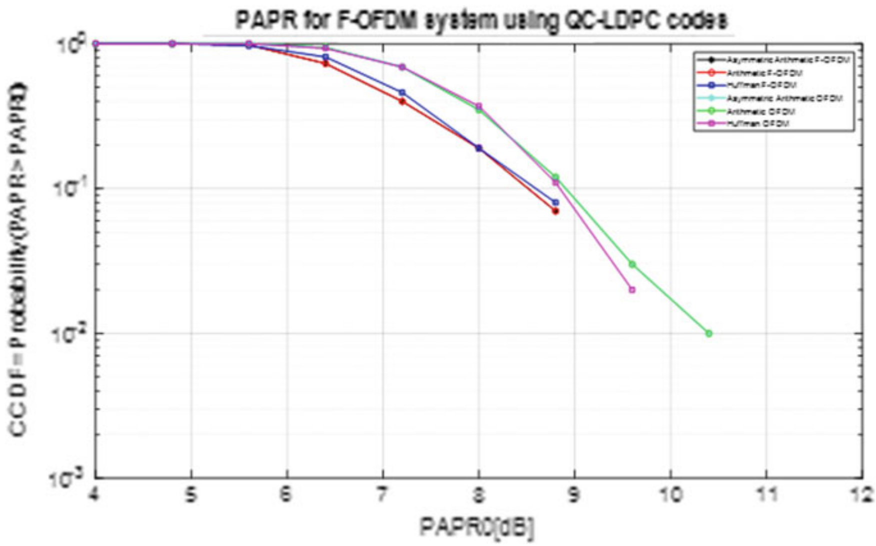

Fig. 30.4 PAPR measurements for the system

the applications of 5G network. Thus, the research is further improved in refining the new EAAC technique.

Table 30.3 PAPR measurements for the system

Result of PAPR at clip rate 10^{-1}		
Technique	PAPR OFDM in dB	PAPR F-OFDM in dB
Arithmetic	8.9	8.5
Huffman	8.8	8.6

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Chapter 31
Lane Detection Using Image Processing for Driving Assistance

Atzroulnizam Abu, Mohd Rohaimi Mohd Dahalan, Ahmad Zawawi Jamaluddin, and Dzul Fadhli Hisyam Mat Daut

Abstract The number of traffic accidents and injuries continues to increase year by year which causes loss of life and assets. The key facts from the World Health Organization (WHO), approximately 1.35 million people die each year as a result of road traffic crashes. Under this condition, to reduce the number of deadly accidents, the lane detection system is applied in an autonomous vehicle to increase the vehicle safety and passenger safety. The lane detection is one of the computer vision-based systems for driver assistance, as it uses an existing lane marking where the image is captured by the onboard camera mounted in the rear-view mirror facing the front of the vehicle. The proposed algorithm that has been created can detect a lane marking under variable condition of the road such as in the case of urban roads or highways with different printed marks as solid or dashed lines. Furthermore, the algorithm is designed for real-time applications.

Keywords Image processing · Lane detection · Edge detection · Hough transform · Lane detection

31.1 Introduction

Lane detection is an essential part of the vision-based driver assistance systems of intelligent vehicles. This driving assistance reduces road accidents, enhances the

A. Abu (✉) · M. R. M. Dahalan · A. Z. Jamaluddin · D. F. H. M. Daut
Marine and Electrical Engineering Technology Section, Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Lumut, Perak, Malaysia
e-mail: atzroulnizam@unikl.edu.my

M. R. M. Dahalan
e-mail: mrohaimi@unikl.edu.my

A. Z. Jamaluddin
e-mail: azawawi@unikl.edu.my

D. F. H. M. Daut
e-mail: dzulfadhlihisyam@gmail.com

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safety of the driver and passenger, and reduces road traffic. The important technology on the intelligent vehicle nowadays is being applied in different types of lane detection, which is lane departure warning, lane-keeping assistance, lane centring and others.

The lane departure warning is a system that warns the driver if the vehicle leaves its lane using visual, audio and vibration warning. The system itself can be set to warn the driver when the vehicles are crossing out of lane marking or give an early warning before crossing the lane marking. The lane-keeping assistance is a system that warns the driver when no action is taken; then it will automatically take action to ensure the vehicle stays in their lanes. The actual application applies a torque to the steering wheel to prevent unwanted motion out from its lane marking. The lane centring is a system that continuously controls the steering wheel to keep vehicles in the lane centre. The system itself controls the wheel to keep the lane centre with information on the lane geometry.

The basic idea is to develop an algorithm for detecting the lane marking to assist the driver. The algorithm that has been created can detect a lane marking in the variable condition of the road such as in the urban road, highway or the city with different printed marks such as a solid or dashed line. Furthermore, it is designed for real-time applications. The challenging task that involves lane detection is to eliminate the noise that occurs and it needs to detect the correct pattern of the line in different road situations.

31.2 Related Works

The driver assistance for lane detection is using various techniques, one of them is lane marking such as the colour-based method proposed by Chin and Lin [1] which specified the colour information and extracted the landmarks. They have proposed a new method based on the colour information which is applicable in complex environments. The first step is to choose the region of interest (ROI) to find out a threshold by using a statistical method in the colour image. Then the threshold is used to distinguish possible lane boundaries from the road. The colour-based segmentation is used to locate the lane boundary by using a quadratic function to accomplish it.

Chiu and Lin [2], the authors purposed a method of edge detection by matching the potential candidates of the road line or boundary. This study used a real-time lane detection algorithm in complex conditions which included coloured lane marks and roads with special traffic marks. The hyperbola model algorithm is being presented in the methodology used. The edges that have been used in this algorithm are formed by the canny edge detector.

Another method has been introduced by Habib and Hannan [3] by using the Hough transform function, which can detect line and road boundaries in different light conditions and shadow effects. The road images were taken under normal daylight conditions and this has a minor effect on the contrast and the intensity of the image. The image was taken during the daylight, i.e. light directly obtained from the sun, whereas the effect of the shadow of any object interfering with the road image contrast is minor. The accuracy of processing the image for the standard threshold value is high. An accurate Hough transform graph and Hough transform peak value for 17 road images were obtained.

Hardzeyeu and Klefenz [4] were also using the Hough transform methodology but with an advanced computer vision technology in order to develop a sufficient and robust system for driving assistance. The Hough transform has been used by the authors as pattern recognition to enhance the locating image shape performances. The main advantage of this method is that it is tolerant to gaps in the feature boundary description and relatively is unaffected by the image noise. The Hough transformation is being applied after the contrast adaptation is executed.

Chang and Lin [5] represent the vision module for lane detection in a difficult situation such as bad weather conditions, shadow effect and fog. The canny edge detector is applied to investigate the boundaries where the boundary image is divided into sub-images in order to remove the noise. This sub-image is being applied with the high contrast of colours for the road surface, and then a multi-adaptive thresholds method is being applied for each block. The results are significantly better to solve the different problem part of the image that has a different contrast of lane marking.

31.3 Methodology

In this section, the overall procedures of implementation, see Fig. 31.1 for details. The algorithm used in this project was developed by using the MATLAB software.

31.3.1 Image Capture

Method 1 requires a raw image that is taken from the camera. The camera is mounted inside the vehicle before the windshield with a 45-degree position, taking an image of the centre of the road. The captured image shows the painted road line, including the surrounding or the background from the vehicle. This is the main input image that is required to be executed with the image processing software. The image is called from its folder and is then saved in a pre-determined directory. The image must be saved in the format of jpg and gif formats, as only this format can be read by MATLAB. The original image is being reduced to 620×480 pixels to reduce the processing time (Fig. 31.2).

Fig. 31.1 Flowchart

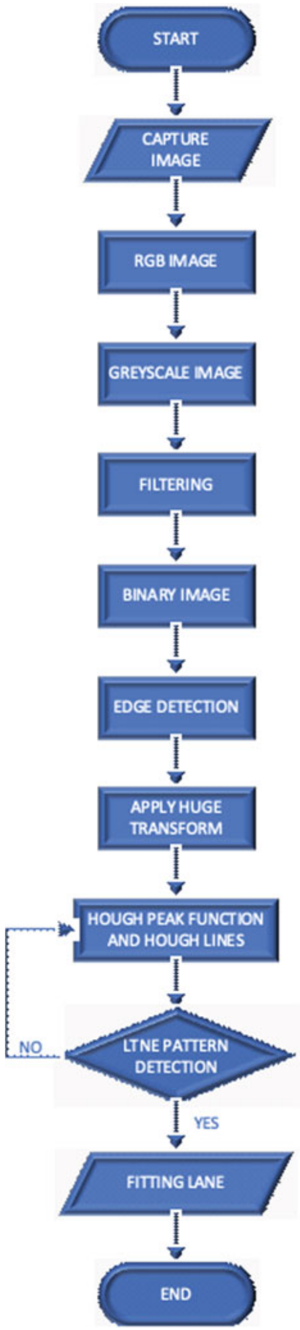


Fig. 31.2 Capture image

Fig. 31.3 Image enhancement

31.3.2 Image Enhancement

Image enhancement is one of the processes to develop or adjusting digital images by changing the brightness of an image, sharpen a pixel in an image, remove noise and other features so that the result of an image is more suitable for being used in an image processing analysis. The aim of the image enhancement is also to improve the visual quality so that the image that appears is sharp and is easy to implement in the edge detection process without affecting the quality of the original image (Fig. 31.3).

31.3.3 Grayscale Image

The colours involved in this process are red, green and blue. Then the next process is by applying a grayscale to the image. The system itself works on a grey level image by using a MATLAB function by converting it from RGB to the grayscale image. This process will provide the exact value of the RGB pixel on every point of the image. The image that has been converted to grayscale is to retain the colour information and segmentation from the road boundaries. If using the colour image, it will affect the processing time and it is difficult to apply the edge detection as the information is

Fig. 31.4 Grayscale image

not accurate. The image itself contains trees, shadows and other unwanted features. Therefore the image is converted into a grayscale image to eliminate the unwanted features. Furthermore, in the grayscale image, the processing of the image is minimal compared to the colour image (Fig. 31.4).

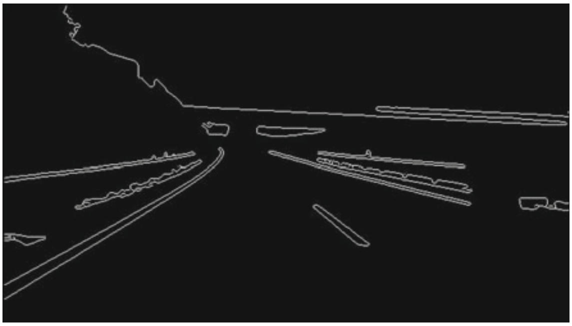
31.3.4 Filtering

Noise has become the most destructive influence to image processing as the information that has been gained is not accurate. So, the next process is to eliminate the noise from the image itself. The idea is by eliminating the shadows and trees that appear in the lane detection when applied to the edge-detection. The shadows and unwanted features can be eliminated by analysing the image using the median filter. It will remove all unnecessary edge points caused by the noise. After completing the filtering process, the noise contained in the image will be converted to a binary image before applying the edge detection (Fig. 31.5).

Fig. 31.5 Filtering noise

Fig. 31.6 Binary image

Fig. 31.7 Filtering noise



31.3.5 Binary Image

The binary image consists of only black and white (BW) pixels which replace all the pixels in the input image. A luminance with a value greater than one will represent the white image, and the value zero will represent the image processing image. By converting the image from grayscale to a binary image, the image processing is minimal compared to the coloured image (Figs. 31.6 and 31.7).

31.3.6 Hough Transform

Hough transform is an important part of the lane detection as it is a method in detecting the straight lines as it is unaffected by the image noise and represents a reduced processing time in finding a line in the images. Furthermore, Hough transforms are generally used as the technique to identify the features in the image which is the line pattern of the road that is obtained from the edge detection which consists of the parameter's description in each line segment (Fig. 31.8).

The basic parameters equations of the Hough transform are representing the straight line and convert it to the image in the parameters space.

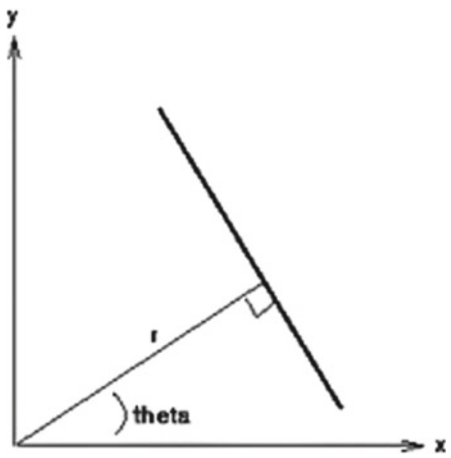


Fig. 31.8 Parametric description of straight line

The Hough transform functions are also able to be implemented to detect a group of pixels in a straight line. The Hough transform method can easily detect the road line or any edge boundaries even if the line is broken. In Fig. 31.9, the brighter pixels represent the coordinates (ρ, θ) in the space and the generated lines are fixed in many points.

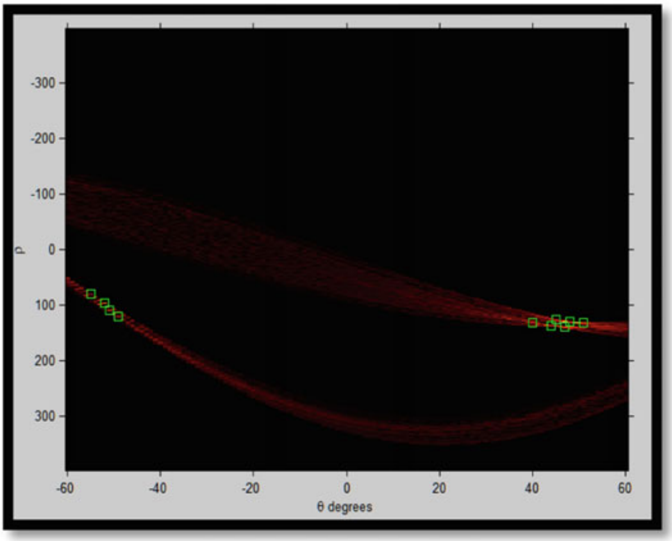


Fig. 31.9 Detecting the peak pixel on the Hough Transform

31.4 Experimental Results

The pixel resolution used in this experiment was 620 × 480 in the early stage because of the fact that the processing time can be reduced and the entire process gets faster. As the result, the images produced were of low quality because the number of pixels has been reduced but it was still acceptable. In the image enhancement, the numbers of the pixels in the picture are being sharpened by removing the noise and by adjusting the brightness of the image. All the results are shown in Figs. 31.10, 31.11, 31.12, 31.13 and 31.14 using the same algorithm but different videos to analyse the pattern marking on the road surface. The lane detection focused on how to track the lane edge frame by a frame-based approach on the existing pattern of the road geometry. The final output is obtained as shown in Figs. 31.15, as the lane detection followed the white line on the road surface.

Fig. 31.10 Original image, pattern lane detection

Fig. 31.11 Original image, straight lane detection

Fig. 31.12 Original image, curve lane detection

Fig. 31.13 Original image, yellow lane detection

Fig. 31.14 Original image, dim light lane detection

31.5 Conclusion and Recommendation

Through this project, various stages were implemented in regards to lane detection and applied to an autonomous vehicle. The research study was focused on the methodology of the project in lane detection, beginning with the captured image and finish with the system that is able to detect the printed lane marking in the image.

Fig. 31.15 Original image, daylight lane detection

The system was being tested to get the initial result based on the scenario of road video sequences.

The idea to gain accurate lane detection is by understanding the methodology involved and implement it step by step, as this system can detect the printed lane marking that is presented in the image. This system is also able to process various road markings, a shadow in various weather conditions and various road conditions in the complex road geometry. The lane detection must work in various conditions as the main objective of this research is to develop an algorithm in detecting the lane marking to assist the driver and also to develop a new methodology for image enhancement for the driving assistant. The system also must be able to overcome the problem that occurs in the system.

The lane detection processing time is slow after the image is captured in high resolution (1280 $\times$ 720) that produced a higher number of pixels in one image. The image is applied as one of the vision-based approach methods is divided into sub-images to eliminate the noises. This step is also to reduce the lane detection's processing time as this action is only focusing on the potential straight line's parameters.

Furthermore, the algorithm is an edge-based variant and is sensitive to the edge information in the image that has been provided and detected any type of bright pixel that appears in the image. To avoid unwanted edge-based detection, the Hough transform is applied in the image as in lane detection. It also improves the robustness of the algorithm. The Hough transform is generally used to identify the features in the image, which is the line pattern of the road that is obtained from the edge detection, which consists of the description of the parameters in each line segment. Therefore, several stages need to be done to complete the algorithm of lane detection and implement it as a real-time application.

The Hough transform contains the most useful information to set a point defined over the parameters space. Thus, it is recommended to identify and gain the shape of a long straight-line road before applying the Hough transform to do accurate detection of the lane. The next recommendation is to implement the processing time to the high-resolution image without affecting the quality of the image and the processing time of the lane detection.

The future expectations can develop and implement the lane detection into any gadget or smartphone and it can be implemented as a real-time application.

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