Chapter 10
A Portable Hydro Generator for Fishing Boats

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Abstract The use of modern and renewable technology is on the rise in a variety of fields. This can be seen in the use of water energy, wind energy, geothermal energy, water energy, and other renewable energy sources in different aspects of life and industry. In Malaysia, hydroelectric power generation from dam is commonly used to produce electricity for consumers. As for marine vessels in Malaysia, they usually use generators onboard to produce electricity. By applying the hydroelectric method to the fishing boat, fuel consumption and gas emission can be reduced. This study focuses on zone A class small fishing boats which commonly have no power sources installed onboard the vessel. Without a fixed power source installed, small fishing boats use portable generators and batteries as sources of electrical power. However, some small boats are not installed with any power sources onboard due to limited space and high weight. The primary objective of this study is to analyze the electrical power output generated from the hydro generator onboard small fishing boats by using the portable method mounted on the boat body, a suitable method to carry out the experiment.

Keywords Compact power source · Power generation · Renewable energy · Alternative energy

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A. Ismail et al. (eds.), *Advanced Materials and Engineering Technologies*, Advanced Structured Materials 162,
https://doi.org/10.1007/978-3-030-92964-0_10

10.1 Introduction

Energy is the most important sector for a country's growth. It is necessary for survival and essential for developmental activities such as education, health, transportation, and infrastructure in order to achieve a fair standard of living, as well as a critical factor for economic growth and jobs [1]. The three primary sources of energy are fossil fuels, nuclear power, and renewable energy. Renewable energy sources such as solar, wind, biomass, geothermal, and hydropower are used to reproduce energy and are therefore extremely useful in the fight against energy shortages [2]. Besides, non-renewable resources are facing depletion, strategic political control, and rising in costs which is causing renewable energy to become more competitive with non-renewable energy sources [3]. As a result of these issues, the use of renewable energy resources is becoming more common. Among the various sources of renewable energy, hydropower is the most important source of grid-connected energy in the world [4]. Hydropower alone provides about 16 percent of global electricity, with more hydropower projects planned to be implemented in the coming years due to the enormous benefits associated with it [5].

Hydropower is electrical energy generated by the flow of water which normally originates from stream, river, and ocean. This kind of energy has been harnessed since past centuries [6]. The efficiency of energy conversion in a hydropower plant varies depending on the flow rate and hydropower plant model [7]. Hydropower is a well-established and straightforward technology at which the water's potential energy is converted into kinetic energy, which spins a turbine that drives an electricity generator [8]. A hydro generator is also known as a tidal generator which makes it possible to take use of the kinetic energy that occurs around a ship hull to produce electricity. The principle is to capture and convert kinetic energy and flow-pressure energy of moving water to electrical energy at which the electrical energy can be supplied to the ships. The hydro generator is driven by the flow of water to produce power which does not rely in burning of fuel [9].

A portable hydroelectric generator consists of a flywheel that can be rotated from a flow of water, a drive shaft, and a generator. Taking advantages of water to generate electricity is a common practice and used globally such as in large-scale hydropower plants that use the potential energy of water stored in dams to run hydroelectric turbines [10].

10.2 Methodology

This part of the paper elaborates and explains about the steps, procedures, and details about the experiment that will be conducted. The process of experimental planning and execution to obtain the result and data is illustrated in the flowchart in Fig. 10.1. The methodology used to collect the primary data to method on processing the result and other related information which will be discussed for this research. It

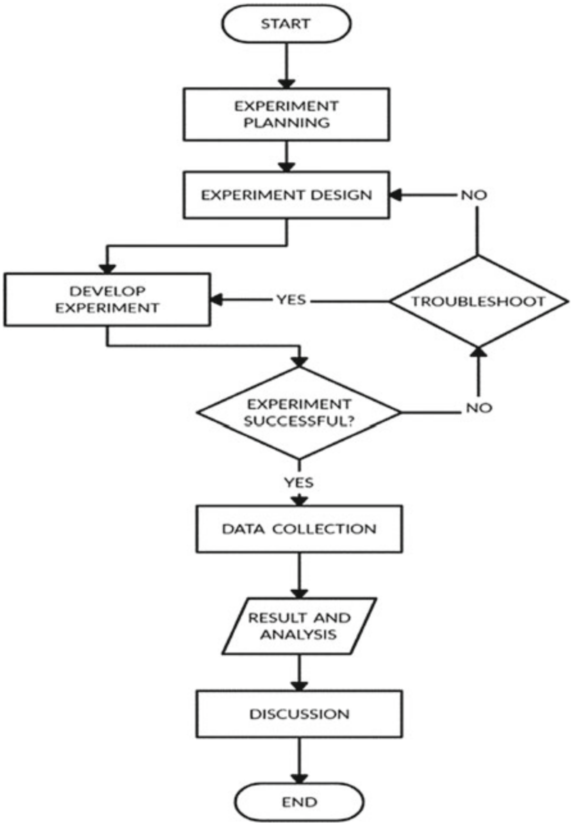

Fig. 10.1 Flow chart of experiment

also discusses on how the research is designed and what are the instruments used in conducting the study.

In general, this experiment is developed to obtain the data of power generation of a hydropower unit before analyzing it. Therefore, the methods used for this experiment are suitable to obtain the result for the project.

10.2.1 Experimental Parameters

Parameters or variables that will be used in this project, as well as their descriptions, will be described below. These parameters are required to differentiate and compare results from the experiment for analysis.

(a) **Speed of boat**

Different fishing boat speeds were used in this experiment and they were 1 knot, 2 knots, 3 knots, and up to 7 knots. This is to identify if the speed of the boat plays a major role for this experiment.

(b) **Number of turbine's blade**

Different number of turbine blades were used to determine the power generated. The type of propeller used was a crossflow type. The number of blades used are 12, 16, and 24 blades.

(c) **Diameter of inlet pipe**

The project was conducted with five sizes of inlet pipe diameters to act as a variety of this experiment and to show which will produce more power as it relates to the pressure. The sizes of pipe that were used are 1" to ½", 1 1/4" to ½", and 1 1/2" to ½".

(d) **Depth of Hydro generator unit from waterline**

The project was conducted with different depths of water generator unit to show which produces more power as it is related to the depth of water. The depths that were used are on the waterline, 0.5 m below the waterline, and 1 m below the waterline.

10.2.2 Development of the Experiment

This part shows the development of the flow of the experiment and the process refers to flow chart in Fig. 10.2. For this project, micro hydropower is used and there is only one type of specification at which only the number of blades is different as shown in Fig. 10.3. The micro-hydro power unit consists of a hard plastic casing and turbine that is connected to the winding coil by a shaft that will generate the electricity when rotating. The unit is mounted on a mild steel bracket with the boat hull. The complete experiment rig is shown in Fig. 10.4.

To conduct the experiment, there are several crucial steps that need to be done before conducting the experiment as shown in Fig. 10.2. It is also done to ensure that the experiment has taken precautious steps to avoid unwanted interference on the results. All the equipment and material used are assembled based on the experimental design and are tested for the functionality of the hydropower unit before continuing to begin with the experiment to make sure that the experiment is running smoothly without any possibilities of fault that will impact the results collected.

10.2.3 Method of Collecting Data

The voltage and current output of the hydropower unit are measured by a measuring device that is a multimeter for each of the variables, and the data is gathered and

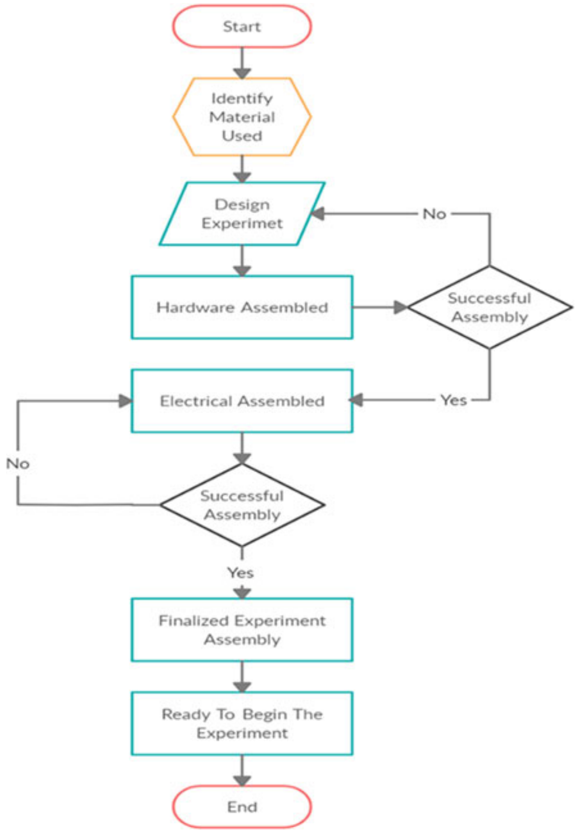

Fig. 10.2 Experiment development flow chart

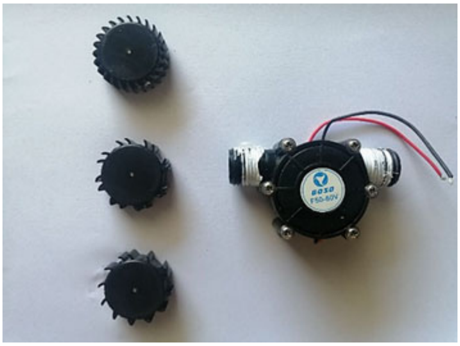

Fig. 10.3 Hydro generator unit with three different number of blades

plotted into a graph for further analysis. The steps to take the result are shown in Fig. 10.5.

The flowchart in Fig. 10.5 shows the collecting data procedures of the experiment. The flowchart describes the process to gain the data for the project parameters till

Fig. 10.4 Experiment rig

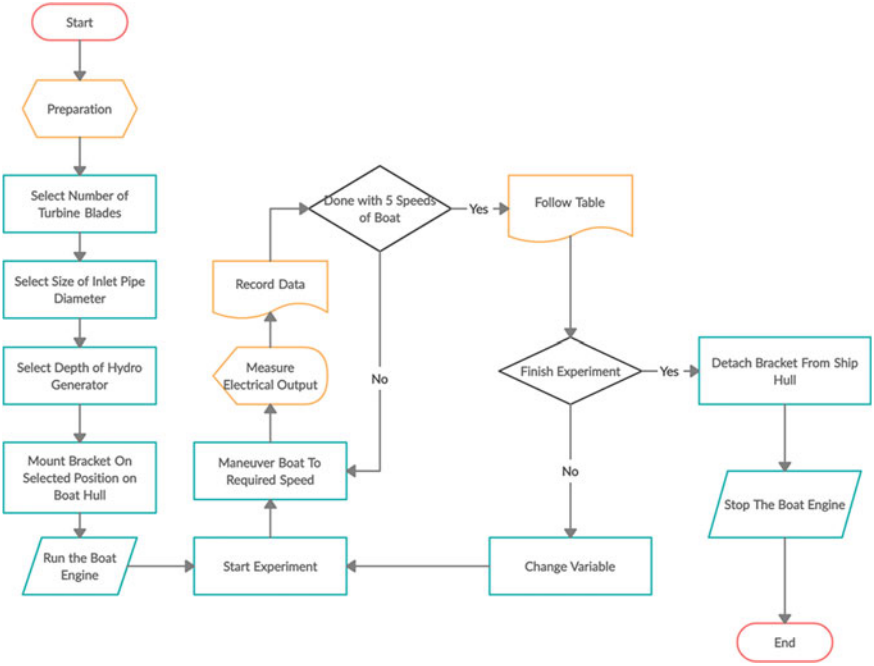

Fig. 10.5 Flow chart of experiment data collection

the data analysis obtained to be processed. Before the experiment starts, the turbine must be selected, attached the hydropower unit with the selected diameter of the inlet pipe, and fit the unit on the bracket at the required depth. Then, the bracket is mounted at the selected position on the boat hull according to Table 10.1. After all variables are selected, the boat engine is run and maneuvered to the required speed according to Table 10.1. The electrical output on the digital multimeter is recorded to take data according to Table 10.1. The experiment is continued by changing the variables that have not been done yet. The data are then transferred into a graph form

Table 10.1 Tabulation of data

No.	No. of turbine blades	Speed of boat (Knots)	Depth of waterline (m)	Diameter of inlet (inch)	mW
1	12	4	0	1”	
2	12	4	0	1–1/4”	
3	12	4	0	1–1/2”	
4	12	4	0.5	1”	
5	12	4	0.5	1–1/4”	
6	12	4	0.5	1–1/2”	
7	12	4	1	1”	
8	12	4	1	1–1/4”	
9	12	4	1	1–1/2”	
10	12	5	0	1”	
11	12	5	0	1–1/4”	
12	12	5	0	1–1/2”	
13	12	5	0.5	1”	
14	12	5	0.5	1–1/4”	
15	12	5	0.5	1–1/2”	
16	12	5	1	1”	
17	12	5	1	1–1/4”	
18	12	5	1	1–1/2”	
19	12	6	0	1”	
20	12	6	0	1–1/4”	
21	12	6	0	1–1/2”	
22	12	6	0.5	1”	
23	12	6	0.5	1–1/4”	
24	12	6	0.5	1–1/2”	
25	12	6	1	1”	
–	–	–	–	–	
108	24	7	1	1–1/2”	

for analysis purpose. Sensitive data analysis is used in collecting data and analysis for this experiment.

10.3 Results and Discussion

This part contains results and the 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 is recorded into a table and plotted into a graph for better analysis and comparison throughout the experiment.

10.3.1 Sources of Data

The experiment has been conducted using the method shown in part 3 that used Table 10.2 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. As the turbine rotor spins, the stator then produces the current as the magnetic field is cut. 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.

10.3.2 Result of Experiment

Figure 10.6 shows that the hydropower unit starts to produce a power output when the speed of the boat is greater than 3 knots. The speed of the boat below 4 knots cannot provide enough thrust to allow a high flow rate of water to flow through the turbine and to rotate the turbine blades fast enough to produce electricity. As shown in Fig. 10.6, the higher the speed of the boat which is causing a faster flow rate of the water to enter the hydro generator turbine inlet, the higher the power output produced from the hydro generator.

Based on Fig. 10.7, the hydro generator is mounted in three different depths which are 0, 0.5, and 1 m below the waterline of the boat. Result shows that the deeper the hydro generator, the higher the power output produced from the hydro generator. From a depth of 1 m, the hydro generator power output is the highest compared to 0.5 m and 0 m. This is due to a rise in hydrostatic pressure, which is the force of the liquid exerts on an object per unit area and this affects the rotation of the turbine

Table 10.2 Tabulation of result

No	No. of turbine blades	Speed of boat (Knots)	Depth of waterline (m)	Diameter of inlet (inch)	mW
1	12	4	0	1”	0
2	12	4	0	1–1/4”	0
3	12	4	0	1–1/2”	0.09
4	12	4	0.5	1”	0.06
5	12	4	0.5	1–1/4”	0.12
6	12	4	0.5	1–1/2”	0.45
7	12	4	1	1”	0.03
8	12	4	1	1–1/4”	0.03
9	12	4	1	1–1/2”	0.05
10	12	5	0	1”	0.02
11	12	5	0	1–1/4”	0.06
12	12	5	0	1–1/2”	0.3
13	12	5	0.5	1”	0.08
14	12	5	0.5	1–1/4”	4
15	12	5	0.5	1–1/2”	5.04
16	12	5	1	1”	0.12
17	12	5	1	1–1/4”	3.84
18	12	5	1	1–1/2”	5.1
19	12	6	0	1”	0.12
20	12	6	0	1–1/4”	0.35
21	12	6	0	1–1/2”	0.99
22	12	6	0.5	1”	0.2
23	12	6	0.5	1–1/4”	12.24
24	12	6	0.5	1–1/2”	13.75
25	12	6	1	1”	0.7
–	–	–	–	–	–
108	24	7	1	1–1/2”	45.24

blades. The deeper the hydro generator is placed, the greater the weight of the water pressing down on the turbine blades. Meanwhile, placing the hydro generator on the waterline produces a low power output due to insufficient water flow into the hydro generator. The power output is also affected by the existence of the wave motion of water.

Meanwhile, Fig. 10.8 shows the power output of three hydro generators with a variation in the number of turbine blades. It can be seen that the same trend of increasing in power output is obtained. But the hydro generator with 24 turbine blades produces more power output than 16 and 12 turbine blades. This happens

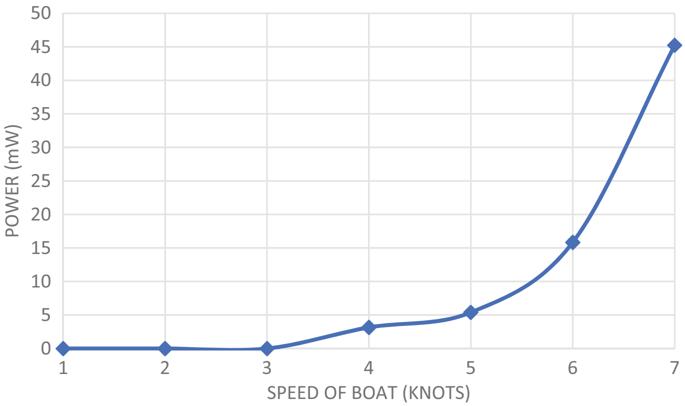

Fig. 10.6 Speed versus power output of hydro generator with 24 turbine blades and 1 ½" inlet diameter at 1 m depth

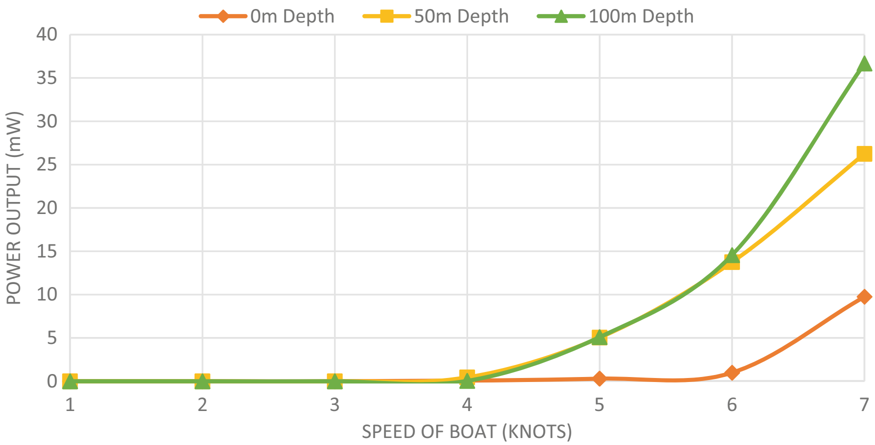

Fig. 10.7 Speed versus power output of hydro generator with 12 turbine blades and 1 ½" inlet diameter at variant depth of hydro generator

because in 24 blades turbine, more blades pick up the water stream when it enters the hydropower unit. As a result, it rotates faster than most to generate more electrical output.

Based on the graph in Fig. 10.9, the power output of a hydro generator with three different inlet scoop diameter sizes, which are 1,1 ¼, and 1 ½ inch, is shown. Result shows that the bigger the size of inlet scoop, the higher the power output produced by the hydro generator. This shows that the size of inlet diameter affects the power output produced. Bigger diameter of inlet allows more water to be scooped in and to flow through the hydro generator. Increasing the size of inlet diameter also allows bigger working pressure to act on the scoop and to produce higher velocity of water

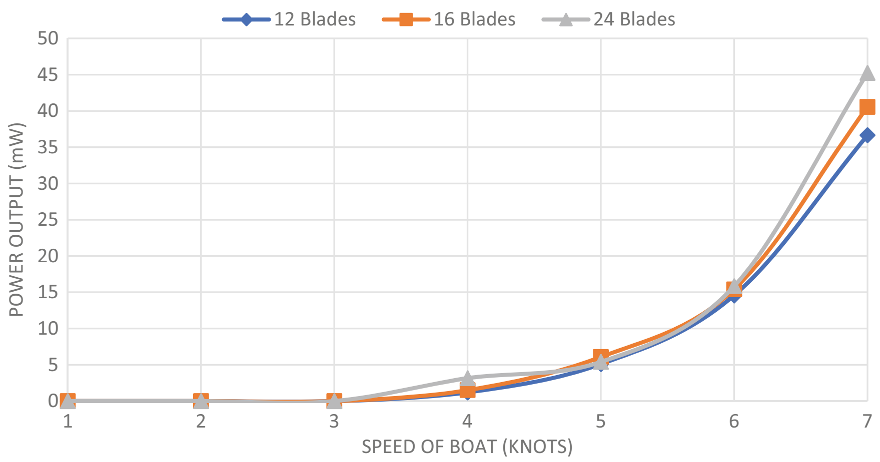

Fig. 10.8 Speed versus power output of hydro generator with inlet diameter size of 1 ½" and variant number of turbine blades at 1 m depth

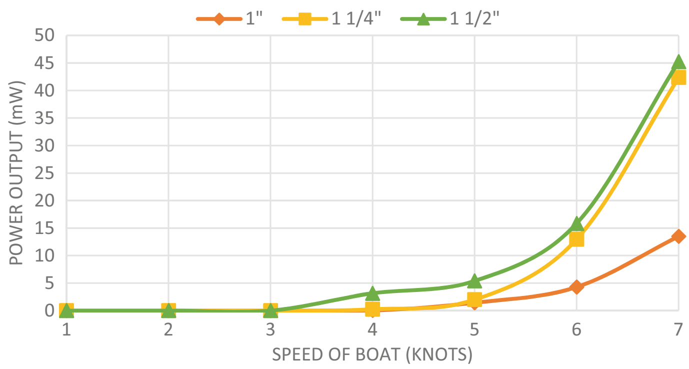

Fig. 10.9 Speed versus power output of hydro generator with 24 turbine blades and variant size of inlet diameter at 1 m depth

into the hydro generator and to push the hydro generator turbine. Meanwhile, in Fig. 10.10, the same hydro generator unit with a variant size of inlet diameter size is used on the waterline. Result shows that at the depth of 0 m, it cannot provide enough working pressure toward the inlet scoop to produce high velocity of water to push the hydro generator turbine blades.

Figure 10.11 shows the power output from the hydro generator unit with three different inlet scoop diameter sizes with different depth of water. The result shows that the performance of the hydro generator is affected by the size of inlet and the depth of the generator. The power output at 1 m depth has the highest value of the power output compared to 0 and 0.5 m. Thus, it shows that the bigger the diameter and deeper the depth of hydro generator, the more power output is produced by

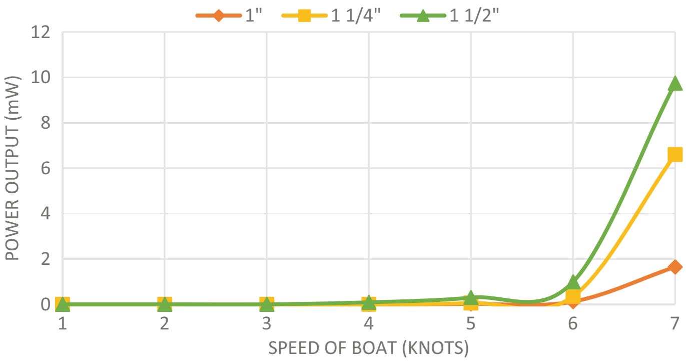

Fig. 10.10 Speed versus power output of hydro generator with 12 turbine blades and variant size of inlet diameter at 0 m depth

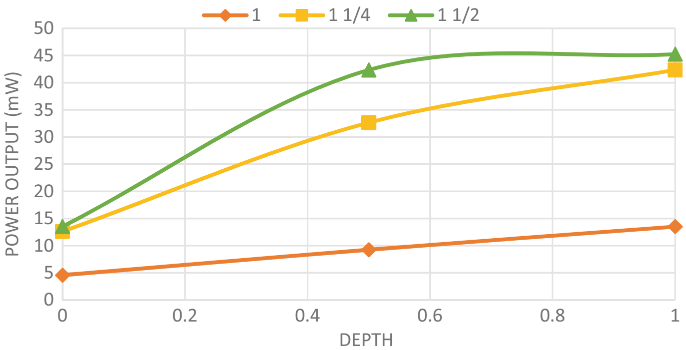

Fig. 10.11 Depth versus power output of hydro generator with 24 blades and variant size of inlet diameter

the hydro generator. Referring to Fig. 10.11, although the performance of the hydro generator is optimum when using the biggest diameter with deepest depth, the power will reach its peak at 45 mW. To achieve higher power, the diameter of the inlet and the depth of the hydro generator need to be increased.

10.4 Conclusion

In conclusion, this experiment was successful in achieving the objective which was to develop a portable hydropower for fishing boats, where this experiment was successfully fabricated using the materials and equipment selected in the methodology and adhering to the design to ensure this experiment works well. Next, it is to examine the hydropower unit's electrical power production. The results of this experiment can be found in the result and discussion part of paper, where graphs are plotted to demonstrate the contrast within the experiment's parameters and limitations. This experiment is carried out at a cost that is appropriate for all the chosen materials and design requirements.

Acknowledgements This research is conducted as one of the requirements that must be completed by the researcher that is supported by UniKL MIMET with guidance from experts, and for this, we would like to express our gratitude to anyone who was deliberately or inadvertently involved in the completion of this study. We also thank the readers for their positive feedback and helpful ideas in writing this paper.

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