Chapter 18
Design of Green Ship Recycling Yards: A Review

Mohamad Suhaimi Samsudin, Ismail Zainol, Zulzamri Salleh, Siow Chee Loon, and Nuraihan Ismail

Abstract This article presents an overview of green ship recycling yard design. This article presents the basic process and method used in recycling yards. This article also provides an insight to the relevant aspects of yard facilities and layout design. This approach used for designing green ship recycling yards are briefly discussed. The last section of the article explains issues arise in green ship recycling and related works taken to overcome the issues including the prospect of systematic layout planning (SLP) as one of methods for efficient ship recycling yard design. Finally, it can be concluded that there is a gap in green ship recycling yard specifically on layout design that requires further work.

Keywords Green recycling yard · Design layout · Systematic layout planning

18.1 Introduction

Ship recycling is the process of dismantling and reusing the ship when the ship is no longer fit to continue its operation. In practice, when the ship lifespan is around

M. S. Samsudin · I. Zainol (✉) · Z. Salleh
Marine Engineering Technology Section,, Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Dataran Industri Teknologi Kejuruteraan Marin, Bandar Teknologi Maritim, Jalan Pantai Remis, 32200 Lumut, Perak, Malaysia
e-mail: ismailz@unikl.edu.my

M. S. Samsudin
e-mail: suhaimi.samsudin@s.unikl.edu.my

Z. Salleh
e-mail: zulzamri@unikl.edu.my

I. Zainol · S. C. Loon · N. Ismail
School of Mechanical Engineering, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia
e-mail: scheeloon@utm.my

N. Ismail
e-mail: nuraihan@graduate.utm.my

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22 years or older, it should not be operated anymore in which the upkeep cost later becomes uneconomical in accordance with IMO regulation [1–3]. These end-of-life (EOL) vessels are then retired and sold for scrap to the operators of ship breaker and recycling industry around the world. It involves a wide range of activities starting from removing all the equipment and items including hazardous materials from the ship, cutting down the whole structures to the size where it can be transported to recycling centers. Ship recycling is basically operated in growing nations where manpower, and land costs are less expensive, and labor and natural environment are less strict compared to the developing nations. The list of heading ship recycling countries highlights the domination of growing nations in this department, with Bangladesh, China, India, Pakistan, and Turkey leading the list and made up 70–80% of the world's gross tonnage of scrapped vessels [4–6].

Current practice involves labor intensive work and hazardous as most of the ship recycling industry employs manual labor to break ships. Such activity is normally carried out at substandard yards that are not accepted under rule and regulation due to improper facilities which create residue from hazardous materials and waste. This has urged many yard owners to turn their substandard yard to green ship recycling yard in order to comply with safety and health requirements. However, the issue is arising when the competitiveness level is reduced along the process of turning the substandard yard to green ship recycling yard due to extra cost of maintaining the standard as green yard. As the result, current green ship recycling operation is cost ineffective compared to conventional ship recycling yards. Despite the importance of the design aspect for cost effective operation, hitherto, there is a lack of review on design of green ship recycling yards. Thus, this paper investigated the issues and current research on green ship recycling yard design.

18.2 Ship Recycling Process

Sunaryo and Pahalatua [7] describe the processes of ship recycling activities in a ship recycling yard which involves large scale of activities. From extracting all equipment and items such as fittings and engine parts left on ship, to cutting down and recycling the entire ship's infrastructure before handling them to temporarily storage the hazardous materials. Finally, a complete disposal takes place at the safe dumping plant.

18.3 Ship Recycling Method

There are two prominent methods of breaking a ship, which are beaching and dry docking [4]. Others methods include slipway and floating or alongside. The selection of method commonly depends on many factors such as geographical factors, size of ship to be scrapped, facilities and technologies involved during the process [8].

Fig. 18.1 Beaching method. Reprinted with permission from Elsevier [8]

Ship breaking on beaches is the most common method of ship disposal and is also considered as one of the most life-threatening jobs in the world bodies [9–11]. It includes tearing down of the ship on dedicated ship breaking beaches. Thousand's tons of steel are scrapped and disposed by workers using minimum tools and safety precautions. The third world countries such as India, Pakistan, and Bangladesh have been operating this beaching method as shown in Fig. 18.1.

Dry dock is the ship disposal technique that aims at dismantling a vessel in a shipyard dock as illustrated in Fig. 18.2. This is the safest and cleanest method of ship disposals as the process takes place in dry docks. Though such technique provides zero chance of accidental pollution, the method is extremely expensive [8]. The less expensive method is using slipway or ramp as shown in Fig. 18.3. The ship is moved to shore from the water using a winch. On the other hand, the ship dismantling process is also being carried out in floating conditions using air bag method (see Fig. 18.4). EOL ship is berthed in quay side of seaports and shipyards for dismantling. The dismantling is done by cutting and removing the ship parts in vertical direction. Starting from top of the bridge and subsequently reaching the keel. The cutting peripheries do not come in contact with seawater, and ship stability must be carefully maintained. Most ship recycling facilities in China and Europe make use of this method.

18.4 Ship Recycling Yard Facilities and Layout

In general, ship recycling yards are sharing several common facilities with a typical shipyard such as berthing facility, docking equipment, handling machineries such

Fig. 18.2 Dry dock. Reprinted with permission from Elsevier [8]

Fig. 18.3 Slipway

crane and forklift, and cutting equipment. However, ship recycling yards require several prominent facilities for storing dismantle materials and wastes. The facilities that should be available in the recycling yard are such as storage tank, container, and proper drainage system which is most important in ship recycling to prevent any environmental issue. The storage tank is used to store any liquid such as water ballast from ballast tank, oil, and refrigerant need to fully covered and permanently roofed. A container is used to store any useful materials, electricals equipment, and other equipment that can be refurbished and sold. The drainage system is the most

Fig. 18.4 Floating. Reprinted with permission from Elsevier [8]

important in a green ship recycling yard to prevent any leakage during the process of dismantling a vessel.

In case of green ship recycling yards, it should comply with all applicable regulations and requirements such as the Hong Kong Convention (HKC) and Basel Convention (BC) to ensure it is environmentally friendly and safe to the workers. One good example of green ship recycling yards was proposed by Sunaryo and Pahalatua [7]. The author lists the common facilities that need to be considered and presented typical green ship recycling yard layout design as shown in Table 18.1 and Fig. 18.5, respectively. Some of important facilities are discussed in the following paragraph.

Table 18.1 List of common facilities [7]

1. Slipway (primary cutting)	11. Underground storage tank
2. Secondary cutting area	12. Facility garage
3. Structural parts storage open area	13. Internal road
4. Storage tank	14. Office
5. Machinery and outfits storage	15. Canteen
6. Electric and electronics storage	16. Clinic
7. Storage for materials containing asbestos	17. Parking ground
8. Storage for materials containing PCB‘s	18. Security post
9. Scrapping work facilities warehouse	19. Road
10. Garbage (not harmful) disposal area	20. Future expansion plant

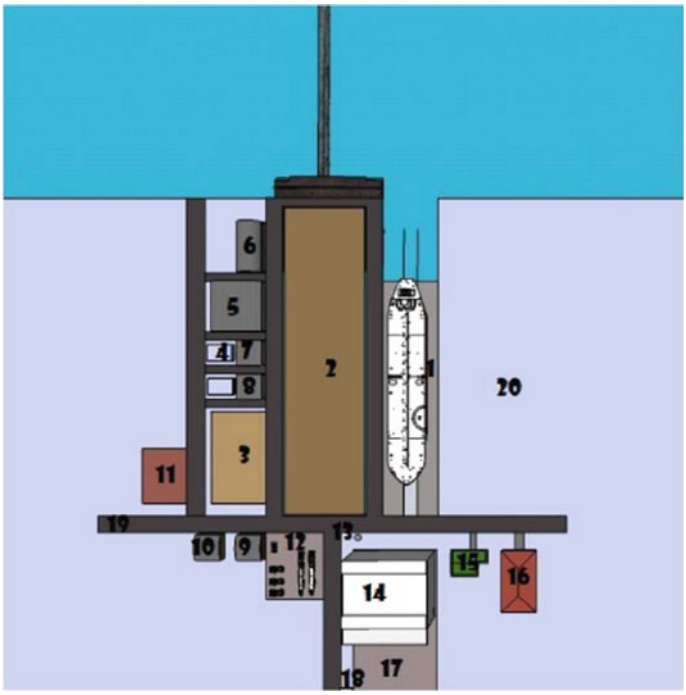

Fig. 18.5 Example of general layout for ship recycling yard. Reprinted with permission from Association of Naval Architects and Marine Engineers [7]

The primary area is the place where the ship is cut by a block assemblies or module. This allowed to reduce the harmful particles that enter the sea water. Secondary cutting area is where parts of the ship will be cut into the size that can be lifted by using forklifts. This area comprises a fully protected cutting area with an effective drainage system that ensures the flow of storm water runoff. The structural area is the place where all recycled ship parts are placed after being cut into small plates and classified according to their types. Meanwhile, chemical and liquids storage tank are provided to ensure that all liquids such as water ballast, oil, and hazardous waste are stored. Machinery and outfits storage are the place where all machineries such as main engines, pumps, generators, and others from the ship will be placed. The electric and electronics warehouse are the place where all these electrical appliances will be stored before the disposal process. Storage facilities containing asbestos will be stored using dry airtight containment and wet containment techniques. Storage containing PCB is where all equipment or appliances such as voltage regulators, switches, electromagnets, and circuit breakers that are categorized containing PCB is stored. Specific storage for PCBs and asbestos is important for safe handling and control as it can cause a serious health impact [2, 12].

18.5 Current Issues and Research in Green Ship Recycling Yards

The main issue in a green ship recycling yard is on its competitiveness. Current green ship recycling operation is cost ineffective compared to conventional ship recycling yards. Jain and Hopman [13] brought to the attention the issue on the price gap between green ship recycling and substandard yards. Several studies emphasize to improve green yard to be more competitive by reducing operational cost and increasing the efficiency of the recycling process. Later, work by Jain [14] focuses on improving the ship recycling process planning by proposing material quantification model and material flow analysis model. Similar effort continued by Sunaryo et al. [15] who carried out financial analysis to identify which business model is suitable for improving the economic situation and they discover that the service provider model has a prospect to provide internal rate of return of 17%.

Sivaprasad [16] suggested a further work on new ship recycling yard layout as to improve the ship recycling process. Welaya et al. [17] proposed a fuzzy model for economical and safe planning of a ship recycling yard. Sunaryo and Pahalatua [7] proposed the concept of green ship recycling layout (see Fig. 18.6) for capacity of recycling 30,000 DWT ship with an estimation of 15–20 ships that can be recycled annually. The author claimed that the proposed yard complies with existing national and international regulations. Mohd and Zainol [18] proposed the first conceptual design layout and green indicator for green ship recycling yard in Malaysia as shown in Fig. 18.7. His work was later continued by Fachry [19] who work on environmental friendly ship recycling yard specifically for recycling a general cargo ship, tug boat, and barge in Indonesia as shown in Fig. 18.8. However, Song and Woo [20] said that so far in many cases, design of a shipyard has been relying on the experienced engineers, resulting in sporadic and poorly organized processes. And thus, economic

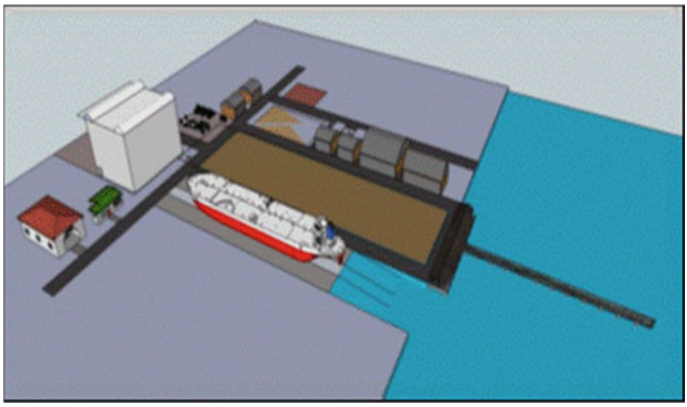

Fig. 18.6 Concept of green ship recycling layout. Reprinted with permission from Association of Naval Architects and Marine Engineers [7]

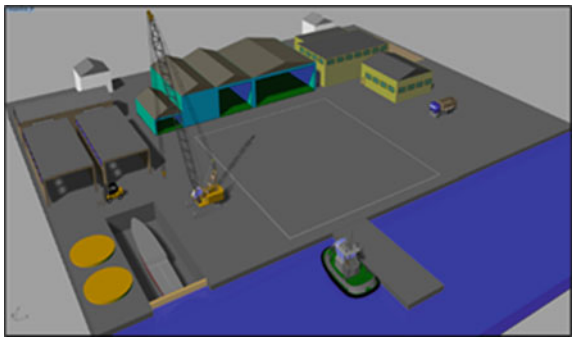

Fig. 18.7 Concept of green ship recycling layout in Malaysia. Reprinted with permission from UNIKL [18]

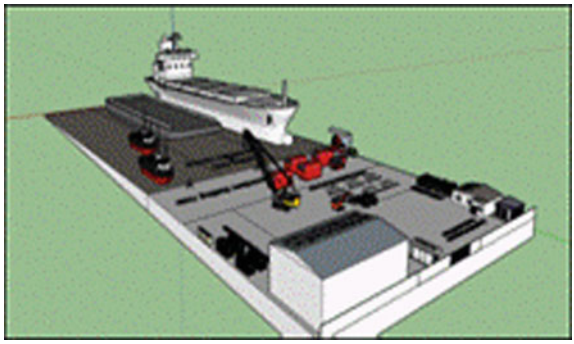

Fig. 18.8 Proposed ship recycling yard for general cargo ship, tugboat, and barge in Indonesia. Reprinted with permission from AIP Publishing [19]

losses as well as trials and errors in that accord have been pointed out as inevitable problems.

According to Janson [21], implementation of the green concept requires the optimization of the yard layout as to balance the related expenditure. In addition to research on ship recycling yard layout, various studies have been done in the past to improve the competitiveness of neighbor yard such in ship repair yard mainly emphasize on layout design [20–24]. Latest reference found in improvement of ship recycling layout design is from Gunbeyaz et al. [25] and Jayaram [26]. Gunbeyaz et al. [25] developed a framework for the ship recycling industry in order to improve and optimize the ship recycling procedures, whereby Jayaram [26] developed a methodology in the form of steps for generation of concept layouts of green ship recycling yards based on the SLP. The author identified a comprehensive list of activity areas required to be considered in the layout design. This is the most recent work in designing a ship recycling yard layout using a step-by-step approach which could be adapted easily for industrial cases. Significant reduction in operational cost to 10–30% can be seen just by planning an effective facility layout [27, 28].

18.6 Summary

This review paper described the current state of green ship recycling yard design and discussed the recent research taken to improve ship recycling yard design. It can be summarized that current works carried out, which are focused on efficient layout design, are still insufficient and application of SLP is promising. Hence, ship recycling yard layout design using SLP could be very interesting subject to be further studied to fill the price gap between substandard recycling yards and green recycling yards.

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