Investigation Potential of Ship Recycling Model: Literature Research

Muhammad Riyadi[1], Eda Turan [2]
(Received: 28 November 2022 / Revised: 12 December 2022 / Accepted: 17 December 2022)

***Abstract*— ship recycling pays attention globally as it becomes a need for sustainable development. Industrialized countries begin to move ship recycling activities to develop nations where labor is paid cheaply, and safety and environmental issues are not as strictly enforced. This challenge is mostly the effect of high costs as it occurs in a standardized process. This paper aims to identify a design of a cleaner production concept to improve the ship recycling model, where the negative impact caused by ship recycling needs to be minimized immediately through a sustainable approach. In order to convert ship dismantling into Green Ship Recycling, there are several ship recycling regulations that can be used as standardization and development that must be carried out based on guidelines related to technology and facilities, material handling, worker and environment safety, ship recycling plans, and the layout.**

Keywords—ship recycling, ship recycling standard, ship recycling model.

I. INTRODUCTION

After reaching End of Life (EoL), a ship no longer has economic value. Ship waste requires a relatively large cost and space and results in environmental pollution. IMO (International Maritime Organization) stated that a ship should not be operated after 25 years old. In order to reduce the negative impacts of old and obsolete vessels, there is a need for action to increase its values and take care of its hazardous materials through recycling.

In contrast, not many countries in the world hold recycling End of Life (EoL) ships. Bangladesh, India, and Pakistan are the only main destinations for the dismantling of old vessels, which more than 80% are directed there. It was estimated that this industry is going to grow estimated 300 million Gross Tonnage (GT). This certainly has an impact on the economic aspect of the South Asian country which has a market share in the scrap metal processing sector, such as COVID 19. Global scale policies are needed that are not only beneficial from an economic point of view, but can also reduce negative impacts on supply chains and encourage sustainable development [1].

Choi et al. [2] analyzed a cost benefit and an environmental life cycle assessment to find out the impacts of the economic and environmental feasibility to three examples of end-of-life management. Countries which implement recycling according to standards, including the US, EU, China and Turkey. It was found that under standard recycling can provide higher benefits because labor costs and disposal of toxic materials are negligible, but standardized recycling can prevent the release of hazardous contaminants such as asbestos and oil into the environment while also offsetting the high demand for new materials that can be provided through recycling. It was suggested that beside considering economic aspects, the recycling process should pay attention to the standards in order to reduce environmental pollution as well as safety for workers and this can be done through a strict regulation. With the cost of cutting ships, the ship recycling industry become a very profitable business. Ship owners can also choose ship raw materials, such as interior equipment, electrical cables, engines, scrap metal, or pipes [3].

According to Hongkong Convention, the ship recycling yard must have a storage facility for hazardous material and an approved Ship Recycling Facility Plan.

This paper aims to identify strategies that can increase the competitiveness of ship recycling yards by minimizing costs incurred. The identification is followed by the design of a clean production concept to enhance the green ship recycling concept in reducing its structural complexity and limiting the use of hazardous materials to reduce recycling costs. It is very important to pay attention to the technical aspects according to the standards that must be applied in the ship recycling industry.

II. METHOD

This study used a qualitative approach aimed at identifying a design of cleaner production concept to improve ship recycling model. The study was conducted a literature review which initially through the gathering of documents, includes journal articles, conference proceedings, and reports. The data was analyzed and discussed.

III. ANALYZE AND DISCUSSION

Ship recycling is a need after a ship reaching its EoL which become a benefit for the ship owner while at the same time can be a threat to the environment. Ko & Gantner [4] in their study, evaluated the environmental

Muhammad Riyadi is with Department of Marine Engineering, Politeknik Maritim AMI Makassar (POLIMARIM), Makassar, 90121, Indonesia, mail: muh.riyadiftk@gmail.com

Eda Turan is with Department of Naval Architecture and Marine Engineering, Yildiz Teknik University, Istanbul, 34220, Turkey, mail: edaturan@yildiz.edu.tr

impacts quantification and local added value, also developed indicators of eco-efficiency. They found that Asian shipbuilding and offloading had to suffer a greater environmental impact while European shipowners reaped huge profits from the process.

Brazil, especially in the Amazon region, has a large enough potential for the ship recycling market. From the data obtained, 3.8 million tonnes of steel were detected from 5,319 End of Life (EoL) vessels. However, this is not balanced with facilities for ship recycling yard, therefore it has the potential to cause environmental and social impacts and will lose a considerable business opportunity. For example, there are about 340 ships in the next 25 years in Brazil that require recycling with an estimated market value of US $ 587 million while in the EU, in 2016 the value of vessels recycled was US $ 1.17 billion (US $ 250 / LDT). From the results of this study said that, recycling is a need as a solution for the rapid growth number of ships. Economically, recycling can support economic growth while for the environment, recycling can reduce the residue of hazardous substances from ships parked in rivers or ports. From this study it is concluded that Brazil will dominate the market of ship recycling if it is accompanied by an infrastructure that meets the standards of the Hong Kong Convention and European regulations [5][6]. Ship recycling is one of catalysts for the economy by providing 80-90% the needs of steel and generated huge employment. However, it has faced a challenge due to its negative impacts to environment and social aspects.

Hossein et al. [7] What is discussed in this paper is the impact of cutting old boats on workers and the environment. it is said that the cause of this is due to the absence of strict rules applied in the industry. Therefore ship recycling activity causes very high marine pollution due to chemical substances such as heavy metal, polycyclic aromatic hydrocarbons (PAH), and polychlorinated biphenyl compounds (PCB) which will threaten the marine ecosystem, especially from threats to human health. Unfortunately, ship recycling activities are still needed because there is always the potential for ships to reach EOL. Therefore, according to him, it is very important to pay attention to the technical aspects according to the standards that must be applied in the ship recycling industry.

Today's prior challenge is related to the under-standard ship dismantling process occupied by most ship recycling owner. This challenge mostly the effect of high costs as it occurs in the standard and strict process. This standard affects to higher cost, also with strict regulation results in a more systematic process.

Three main strategies found through this research was: (1) analysis of material flow to develop the the process planning of ship recycling in order to reduce the cost; (2) use of proven waste-to-energy (WtE) technology to increase ship recycling yard revenue through waste utilization; (3) ship design used the design-for recycling concept in reducing their structural complexity and limiting the hazardous materials assisting use to lower the recycling costs [8].

Hong Kong Convention (HKC) defines recycling as a process of ship dismantling at a ship recycling yard for reprocessing and reusing the components and material, taking care of the hazardous materials, until storing and treating materials and components. However, the HKC still has several weaknesses, such as with the exception of certain ship classes, for states of recycling to join the convention and its associated procedures including surveying and certification are given little incentive. In May 2009, the International Maritime Organization (IMO) has added the HKC as a measure to address growing concerns about the environmental, health and safety risks of ship recycling. This has resulted in a mismatch between existing legal instruments and ship recycling practices.

HKC for Safe and Environmentally Friendly Ship Recycling is a work procedure that complies with IMO standards which recognize issues related to ship recycling that are of international concern. Although there are still gaps, this effort is considered safe and environmentally friendly [9].

However, recycling comprises a process to extract and recover materials and it is not ended after ensuring its waste, disposal, and other hazardous material have been taking care. Recycling yard or facility should recycle old vessels consistently based on the standard and regulations. Activities include recycling need to be aware of worker safety and the environment. This standard formulates by some organization, for instance, the Basel Convention which focuses on hazardous materials, and Hongkong Convention which focus on environmentally ship recycling. Today's dismantling activities refer to the manufacture industry which gives supply to the metal industry and prepare used components for the wider market. The ship recycling industry has obligatory to define methods of the proper process (dicking, cutting, decoating, and material handling) [10].

Beside the huge need of recycling, in the other hand it also cause a damage to the environment. Neser et al. [11] found that the adverse effects occurred in the bay of Aliağa, one of Turkey's most important maritime zones, which is home to shipping activity, the shipbuilding industry, steel works and the petrochemical complex. Where the pollution that occurs is mostly petroleum due to ship scrapping activities. This article gives the result that Aliaga has the potential to contain toxic materials from the results of the TEL / PEL analysis carried out. This study examines the possibility of noise exposure impacting workers in ship recycling yard. An area mapping was conducted to determine the areas that have the highest level of risk and sources that result in noise exposure. Where the results of the studies carried out are then compared with the exposure standards determined by the European Union Physical Agent. From these results, under standard ship recycling cause many risks to the workers, one of them is hearing loss which may be happened if they do not protected by ear protection [12].

The condition of the shipbreaking yard is related to the flow of material in the Chinese shipyard. In China, it has a huge potential in the ship recycling sector, but the existence of policies along with market developments threatens the decline of this sector. Therefore the results of this study require China to evaluate the ship recycling

facility in an effort to maintain the sector, considering that the Chinese fleet has a potential demand in repair and restoration services, in this case ship recycling [13].

In the other hand, the state also need to consider tax for this industry. Sunfeng du et al. [14] gave example from China as one is one of the recycling destinations that pay attention to environmental health and worker safety standards but is less desirable because the cost is outweighed by recycling plants from developing countries. One of the reasons for the high cost of recycling in China is high taxes. In this paper, the environmental problems and economic impacts of China are analyzed, including the producer target and the price of recycled steel which has the potential to decline. It was recommended several solutions and strategies for China's ship recycling facilities. In this study, it examines the possibility of marine pollution around the waters of Aliağa which is caused by the density of ship recycling activities. by assessing the content of hazardous chemicals contaminated in these waters. The results of the study that marine pollution has occurred due to a lack of attention to pollution regulations in the industry, therefore strict supervision is needed for the long-term sustainability of the recycling process in the shipbuilding industry [15].

Recycling means turn rubbish or waste into value but wider definition to ship recycling mainly should be related to improving health, safety, and environment besides its economic values. Although, some studies found recycling process result pollution and harmful to human and environment, in the other hand, with obeying the standard, it enables to re-use valuable material and reduces the need for mining, a damage practice for the environment [16].

Ship recycling has been practicing a circular economy that converting energy waste, employment waste, and wealth waste [17]. Some countries work on recycling for commercial reason to make money from the waste of old vessels. With respect to the previous reason, learning from some countries who play the biggest role in recycling (India, Bangladesh, and Pakistan), it should not rely only on economic reasons, but obey the standard however it is more costly.

Reviewing the IMO rules regarding design attributes, the researcher collected and analyzed a recycled design consisting of three stages: (1) initial ship design, (2) design of layout and equipment items and (3) hazardous materials / systems onboard, from the three stages still need development with a holistic approach to reviewing the ship's recycling status, the three stages are analyzed and developed by discussing the roles and responsibilities of all parties involved in the design, construction, operation, repair, survey, conversion, lay-up and demolition [18].

Jain, et al. [19] developed a recycling model which started from shipbuilding, the following study analyzed a direct model by Veeke, Ottjes, and Lodewijks to recycling which divides it There are three main stages, namely the first stage of precutting, cutting, sorting and separating materials. Each stage is carried out in stages and sequentially. In this study, the assessment method of three-step risk used to reduce risk and improve safety at ship recycling sites carried out through a systematic pedagogical approach by production managers, safety officers, safety supervisors and expert monitors in order to minimize occupational risks in ship breaking and recycling yards.

Comparing those two models above, the former model is a comprehensive manner in providing sustainable development ships from the very beginning, while the second model mostly to provide a solution for the existing EoL ships. Furthermore, the former model can be completed by the second model, especially in the dismantling stage.

The previous research provides a method use scenario with consistent and validated results was performed in 35 ship recycling yards [20]. At the the first step, preparation of plan for safe ship recycling was done, followed by hazardous job tasks identification. The last was a deeper risk assessment and recommendations to minimize risk. Through these three-step risk the risks that can occur from each stage of recycling can be anticipated to minimalize risk from each recycling activities [21].

In the other hand, Hiremath et. al. [22] in their studies recommend a model of ship recycling plan typically used in Alang port, India. In this study, 241 vessels were sampled from six different types of vessels that are at risk of triggering emissions. This model provides information of tacit knowledge collection planning as well as in priority areas identified for developing interventions to minimize risks and environmental degradation, especially in non-formal, labor-intensive, and primitive industrial sectors.

Alam et al. [21] argued that there are several regulations for ship recycling that could be adopted for standardization. As the IMO regulate the global standard for the shipping industry related to the setting authority for the safety, security and environmental performance of international shipping. IMO has full responsibility for regulating issues regarding ship recycling as well as providing a description of problems caused by the process of design, construction and operation of ships that may affect the preparation for recycling on board. This study examines the impact of a regulatory framework complied with international instruments in tackling the recycling problem in Bangladesh. Through this study it can be concluded that if Bangladesh is one of the largest countries in ship recycling and is a country that can last a long time to meet the demand for iron ore and involves a lot of labor, at relatively lower costs, but with the greatest damage to the coastline as one of the greatest natural damage. Hence, Bangladesh is expected to change its policy or introduce a new legislative scheme based on the core values of the Basel Convention. The control of the disposal and cross-border movement of hazardous waste was regulated for the first time in regulations regulated through the Basel Convention. The regulation discusses how to prevent and control hazardous waste traffic. [23].

The related regulation was also discussed in the Hong Kong Convention which regulates environmentally friendly recycling of ships which aims to provide solutions related to ship recycling problems, as well as

the consequences of environmental and health pollution that occur at various ship recycling locations. The results of the convention are used as initial guidelines in drafting ship recycling regulations. [24].

According to Jain et al.[25], ship recycling which has met international standards, the operational costs are quite high, however, there needs to be a solution to become green ship recycling but the cost remains affordable. This study analyzes multidisciplinary scientific tools and techniques that can be used to make green ship recycling economically attractive to ship owners with HSE standards. It is recommended to apply a friendly recycling model which consider environment and worker safety, for instance green ship recycling. This approach is a ship recycling solution with a lower risk of environmental pollution and safety by applying Material flow Analysis (MFA) which allows shipyards to manage waste and resources better at a lower cost.

IV. Conclusion

A ship has a life span of an average of 25 years which becomes a sign of a ship's End of Life. This means the old ship should turn to the recycling process. However, the recycling process will only reach sustainable development if it meets the standard. Therefore, regular monitoring in the shipbreaking yards and optimization of the scrapping equipment and processes are vital for sustainable shipbreaking. To change Ship Breaking becomes a Green Ship Recycling Model, the development of which should be done based on guidelines such as facilities and technology, material handling, the environment, and the worker's safety, Ship Recycling Plan, and Layout. However, recycling comprises a process to extract and recover materials and it is not ended after ensuring its waste, disposal, and other hazardous materials have been taken care.

The role of the state and the government is very crucial in ship recycling industry. The most common flags selected in order to send ships for scrapping. It is necessary to implement strict regulations from the country to ensure ship-breaking activities meet environmental health and worker safety standards. The ship-breaking industry is a system of interconnection between the roles of Shipping companies, ship owners, ship classes, intermediaries, and ship breakers, all of whom are leading actors, are overall under the targets of the new ship recycling regulations, and focus on the problems when a ship changes flag state registration right before canceling. The results explain that there is a link between the selection of lists of ships and ships that will end their lives, the marking is solely for the purpose of scraping [26].

References

[1] S. M. M. Rahman, J. Kim, and B. Laratte, “Disruption in Circularity? Impact analysis of COVID-19 on ship recycling using Weibull tonnage estimation and scenario analysis method,” Resour. Conserv. Recycl., vol. 164, no. August 2020, p. 105139, 2020, doi: 10.1016/j.resconrec.2020.105139.

[2] J. K. Choi, D. Kelley, S. Murphy, and D. Thangamani, “Economic and environmental perspectives of end-of-life ship management,” Resour. Conserv. Recycl., vol. 107, pp. 82–91, 2016, doi: 10.1016/j.resconrec.2015.12.007.

[3] European Commission, “Financial instrument to facilitate safe and sound ship recycling__Final Report,” 2016. [Online]. Available: http://ec.europa.eu/environment/waste/ships/pdf/financial_instrument_ship__recycling.pdf.

[4] N. Ko and J. Gantner, “Local added value and environmental impacts of ship scrapping in the context of a ship’s life cycle,” Ocean Eng., vol. 122, pp. 317– 321, 2016, doi: 10.1016/j.oceaneng.2016.05.026.

[5] C. Benjamin and N. Figueiredo, “The ship recycling market in Brazil - The Amazon potential,” J. Environ. Manage., vol. 253, no. January 2019, p. 109540, 2020, doi: 10.1016/j.jenvman.2019.109540.

[6] E. S. Ocampo and N. N. Pereira, “Can ship recycling be a sustainable activity practiced in Brazil?,” J. Clean. Prod., vol. 224, pp. 981–993, 2019, doi: 10.1016/j.jclepro.2019.03.173.

[7] M. S. Hossain, A. N. M. Fakhruddin, M. A. Z. Chowdhury, and S. H. Gan, “Impact of ship-Breaking activities on the coastal environment of Bangladesh and a management system for its sustainability,” Environ. Sci. Policy, vol. 60, pp. 84–94, 2016, doi: 10.1016/j.envsci.2016.03.005.

[8] K. P. Jain, J. Pruyn, and H. Hopman, “Strategic guidance based on the concept of cleaner production to improve the ship recycling industry,” Environ. Syst. Decis., vol. 38, no. 2, pp. 250–260, 2018, doi: 10.1007/s10669-017-9654-5.

[9] K. P. Jain, J. Pruyn, and H. J. J. Hopman, “Critical analysis of the Hong Kong International Convention on ship recycling,” Int. J. Environ. Earth Sci. Eng., vol. 7, no. 10, pp. 683–691, 2013.

[10] N. Gregson, H. Watkins, and M. Calestani, “Political markets: Recycling, economization and marketization,” Econ. Soc., vol. 42, no. 1, pp. 1–25, 2013, doi: 10.1080/03085147.2012.661625.

[11] G. Neşer et al., “Polycyclic aromatic and aliphatic hydrocarbons pollution at the coast of Aliaĝa (Turkey) ship recycling zone,” Mar. Pollut. Bull., vol. 64, no. 5, pp. 1055–1059, 2012, doi: 10.1016/j.marpolbul.2012.02.019.

[12] R. E. Kurt, S. A. McKenna, S. A. Gunbeyaz, and O. Turan, “Investigation of occupational noise exposure in a ship recycling yard,” Ocean Eng., vol. 137, no. July 2016, pp. 440–449, 2017, doi: 10.1016/j.oceaneng.2017.03.040.

[13] B. Steuer, M. Staudner, and R. Ramusch, “Role and potential of the circular economy in managing end-of-life ships in china,” Resour. Conserv. Recycl., vol. 164, no. December 2019, p. 105039, 2021, doi: 10.1016/j.resconrec.2020.105039.

[14] Z. Du, H. Zhu, Q. Zhou, and Y. D. Wong, “Challenges and solutions for ship recycling in China,” Ocean Eng., vol. 137, no. January 2016, pp. 429–439, 2017, doi: 10.1016/j.oceaneng.2017.04.004.

[15] A. Yılmaz, B. Karacık, S. D. Yakan, B. Henkelmann, K. W. Schramm, and O. S. Okay, “Organic and heavy metal pollution in shipbreaking yards,” Ocean Eng., vol. 123, pp. 452–457, 2016, doi: 10.1016/j.oceaneng.2016.06.036.

[16] European Commission, Science for Environment Policy THEMATIC ISSUE: Ship recycling: reducing human and environmental impacts, no. 55. 2016.

[17] A. M. Hiremath and J. M. Vivek, “Circular Economy in Ship Recycling : An Indian Perspective,” no. March, 2018.

[18] K. Sivaprasad and C. G. Nandakumar, “Design for ship recycling,” Ships Offshore Struct., vol. 8, no. 2, pp. 214–223, 2013, doi: 10.1080/17445302.2012.669264.

[19] K. P. Jain, J. F. J. Pruyn, and J. J. Hopman, “Influence of ship design on ship recycling,” Marit. Technol. Eng. - Proc. MARTECH 2014 2nd Int. Conf. Marit. Technol. Eng., vol. 1, no. October, pp. 269–276, 2015, doi: 10.1201/b17494-37.

[20] K. Garmer, H. Sjöström, A. M. Hiremath, A. K. Tilwankar, G. Kinigalakis, and S. R. Asolekar, “Development and validation of three-step risk assessment method for ship recycling sector,” Saf. Sci., vol. 76, pp. 175–189, 2015, doi: 10.1016/j.ssci.2015.02.007.

[21] A. M. Hiremath, S. K. Pandey, D. Kumar, and S. R. Asolekar, “Ecological Engineering, Industrial Ecology and Eco-Industrial Networking Aspects of Ship Recycling Sector in India,” APCBEE Procedia, vol. 10, pp. 159–163, 2014, doi: 10.1016/j.apcbee.2014.10.035.

[22] A. M. Hiremath, A. K. Tilawankar, and S. R. Asolekar, “Eco-designing product service systems by degrading functions while

maintaining user satisfaction," J. Clean. Prod., vol. 87, no. 1, pp. 452–462, 2015, doi: 10.1016/j.jclepro.2014.09.031.
[23] T. Terekhova, "Updates on the developments under the Basel Convention Main outcomes of BC COP-14," 2019.
[24] "Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships," 2020.
[25] K. P. Jain, J. F. J. Pruyn, and J. J. Hopman, "Material flow analysis (MFA) as a tool to improve ship recycling," Ocean Eng., vol. 130, no. November 2016, pp. 674–683, 2017, doi: 10.1016/j.oceaneng.2016.11.036.
[26] J. I. Alcaidea, F. Piniella, and E. Rodríguez-Díaza, "The 'Mirror Flags': Ship registration in globalised ship breaking industry," Transp. Res. Part D Transp. Environ., vol. 48, pp. 378–392, 2016, doi: 10.1016/j.trd.2016.08.020