REVIEW ON SHIP RECYCLING INDUSTRY

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ABSTRACT

Ship dismantling for recycling, also known as ship scrapping, is a crucial component of the maritime industry. This expanding industry has a significant impact because it uses the large steel ships when they are no longer needed. The owners, shipyards, and recycling industry will all profit from this use. Several studies have looked into and addressed a few aspects and subcategories of this dynamic market. However, none of them has conducted a thorough review of the academic research studies on ship recycling that are currently available. Therefore, the purpose of this review is to provide a brief overview of the development of scholarly inquiry into the emerging subject of ship recycling. To that end, we conducted a systematic literature review of ship recycling topic on a sample of 100 papers related to that field. the objectives of that review are to identify the topics of academic research in that field, the employed methodologies, the main research challenges and directions in connection to ship scrapping. To achieve these objectives, we designed a methodology flow chart to be our frame work and throughout its steps we revealed some facts and conclusions based on 51 screened papers. The results demonstrated that Top leading countries in ship recycling industry are Pakistan, India, Bangladesh, China and Turkey. The results also demonstrated that the main research focus is concentrated on HSE impacts & challenges, operations and management. there is a lack of studies in areas related to design considerations, economic and legal issues. Moreover, almost no scientific research has been published in regarding with this industry implementation in Egypt. Based on the analyzed literature, the policy makers can make use of this information about research collaborations, groups, and directions to determine opportunities for investing and implementing ship recycling techniques that comply with standards in an efficient manner for environment, economy and safety insurance, moreover research investments could be influenced by this information in a way that make touchable advancements to that growing industry.

Keywords: ship recycling, ship scrapping, systematic literature review, environmental impacts, design for recycling, material flow analysis, Hong Kong Convention, EU regulations.

1. INTRODUCTION

Ship breaking, dismantling, scraping, demolition and ship disposal are expressions with a same meaning which ends at ship recycling yards. The ship recycling industry is a vigorous market which offers a huge profit to the ship owner, ship brokers and the cash buyers from selling ships as scrap. At the end of this loop between ship owner, ship broker and the cash buyer, the ship recycling yard buys the ship according to its light weight or light ship displacement from the cash buyer. Most of the ship owners prefer to sell their ships to the cash buyers directly because they pay the price of the ship as lumpsum to the ship owner and gain his commission. Moreover, the cash buyer associates the ship owner with the ship recycling yard, so he plays an important role between them to complete the deal between them.

The ship recycling industry starts after the second world war and it is situated in the industrial countries like Germany, Italy, United Kingdom, United States and Scandinavian countries till 1980. Recently, the ship recycling industry is transferred to another five countries which are India, Bangladesh, China, Pakistan, and Turkey.

The IMO has acknowledged that recycling ships is the best way to get rid of obsolete ships because it is seen to help to the economic and sustainable growth of society by releasing the Hong Kong Convention and the European Union recycling regulations (IMO, 2009). Additionally, the IMO's acceptance means that the ship recycling industry will create hundreds of thousands of jobs for skilled, semi-skilled, and unskilled workers in developing nations like Bangladesh, China, India, and Pakistan. Ship recycling also recovers millions of tons of scrap for recycling in steel factories.

In the ship recycling sector, there is a difference between yards that adhere to international regulations and safety standards, such as the Hong Kong Convention and the European Union Recycling Regulation, and non-compliant or subpar yards that charge more than the standard ship recycling yards. The high expense of enforcing health, safety, and environmental regulations, as well as worker exploitation in recycling yards and the requirements for worker welfare in conventional ship recycling yards, all contribute to this condition. As a result, the owner of the ship will not consider selling it to the typical ship recycling yards because of the price difference. In a nutshell, to fill this gap, the total cost of ship recycling process must be less than the revenue for the ship recycling yard so the yard will gain.

2. Methodology

Systematic Literature Review Method has been conducted on a data set of 100 papers related to ship recycling topics to reveal the leading countries working in ship recycling industry, also Main research categories and aspects have been determined. This facilitate revealing uncovered Research areas and knowledge gaps which recommend future work for scholars working in that field. Systematic Literature Review is a qualitative analysis that summarize and synthesize the findings of reviewing existing literature. It has been chosen because our data set is about 100 papers that can be processed manually through. Moreover, the scope of review is very specific. Figure (1) shows A Flow chart clarifying all the steps of our methodology.

2. ship recycling aspects

The following section provides a brief discussion of the electively selected research activities of open literature through the last 12 years. It is divided into 6 parts; Design considerations in ship recycling industry, Environmental impacts of ship recycling, Health safety and environment challenges, Economic aspects related to ship scrapping, Legal issues for ship breaking and Operations and asset management in ship demolition. The statement will always start with the problem definition for each paper, then methodology utilized and ended with the findings.

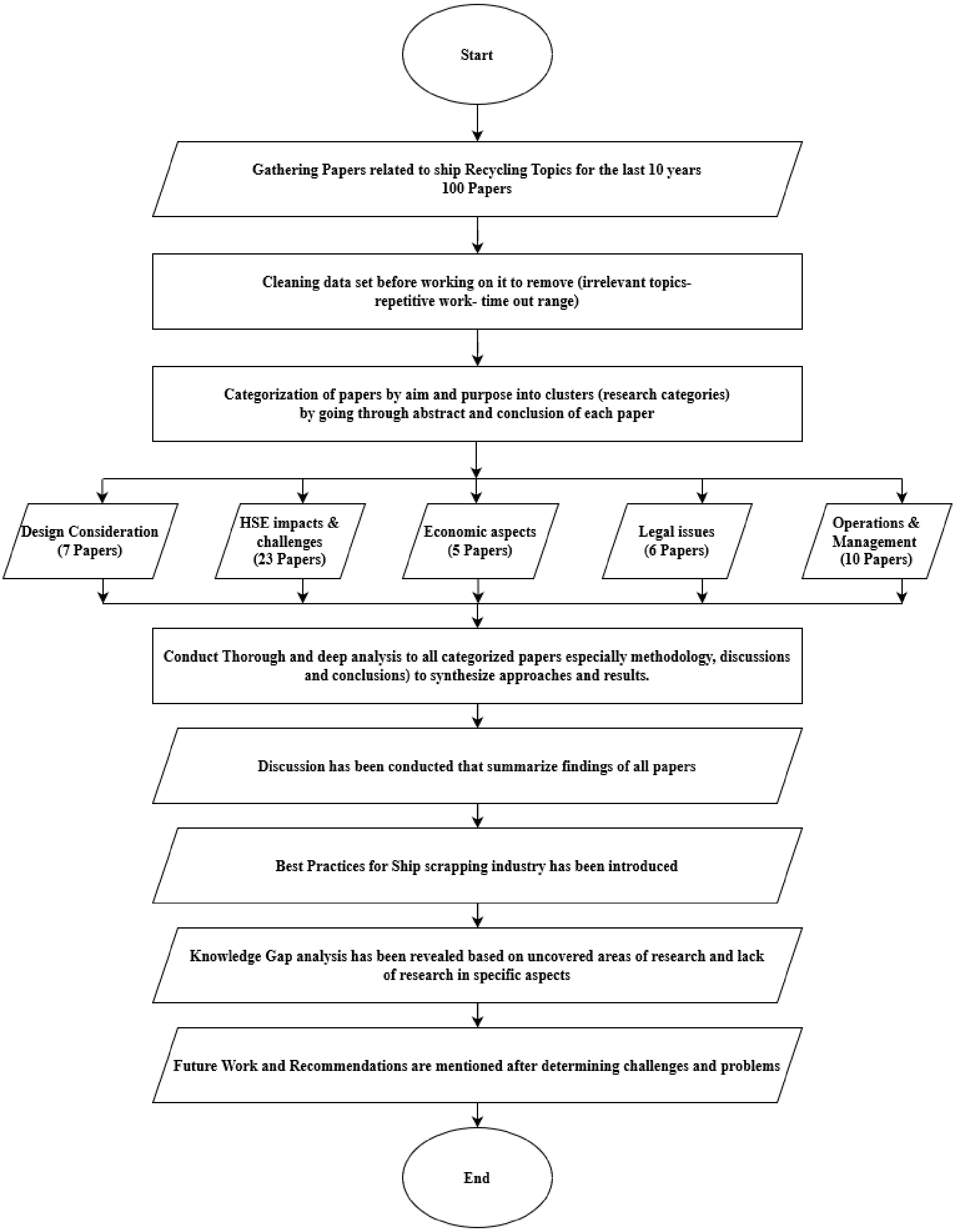

Fig 1. Methodology Flow chart

2.1 Design consideration.

Design is one the most important factor among other factors affecting the ship breaking industry success, the following paragraphs discusses the research effort from 2013 to 2020 including seven research papers. The design stated below includes ship design for future recycling, green ship recycling yard layout design and the design of ship recycling plan.

K. Sivaprasad et al. (2013) [1], K.P. Jain et al. (2015) [2] and K.P. Jain et al. (2016) [3] investigated the lack implementation of ship recycling industry in the basic principles of ship design. While S. Sunaryo et al. (2015) [4], p. Fariya et al. (2016) [5], S.A. Gunbeyaz et al. (2018) [6] and Sunaryo et al. (2020) [7] focused on the gap between green ship recycling yards and non-green ship recycling yards.

K. Sivaprasad et al. (2013) [1] conducted a recyclability analysis of ships presented as part of the implementation of the maritime industry's sustainable development philosophy. Furthermore, K.P. Jain et al. (2015) [2] conducted a scientific analysis of the ship recycling process and identified design and construction solutions that need to be considered to achieve safe and environmentally sound ship recycling. For the layout of a green ship recycling yard for Indonesian merchant ships, Sunaryo et al. (2015) [4] Conducted a design study. Additionally, K.P. Jaina et al. (2016) [3], for a vessel life cycle analysis he performed three reverse steps. Furthermore, S.A. Gunbeyaz et al. (2018) [6] performed an optimization study for each step of ship recycling by introducing a simulation model using ARENA software. Furthermore, S. Fariya et al. (2016) [5] performed a data processing study using the Analytical Hierarchy Process (AHP). Finally, a design review of the layout of the Green Ship Recycling Yard for general cargo and tugs and barges by Sunaryo et al. (2020). [7]
K. Sivaprasad et al. (2013) [1] advocated After considering the critical role in achieving clean and safe end-of-life ship dismantling, a new ship life model was created by adding several stages to the traditional life cycle. All of Sunaryo et al. (2015) [4], S. Fariya et al. (2016) [5] and Sunaryo et al. (2020) [7] Developing a simulation model for the layout of a green ship recycling yard, K.P. Jain et al. (2015) [2] developed a methodology to build a scientific model for optimizing ship recycling yards for cost-effective green ship recycling as shown in figure 2. Additionally, K.P. Jain et al. (2016) [3] proposed a new format for easy distribution to store such critical information for ship recyclers. Finally, in order to improve and optimize the ship recycling process, framework has been developed for the ship recycling sector using the S.A. Gunbeyaz et al. (2018) [6] ARENA simulation model.

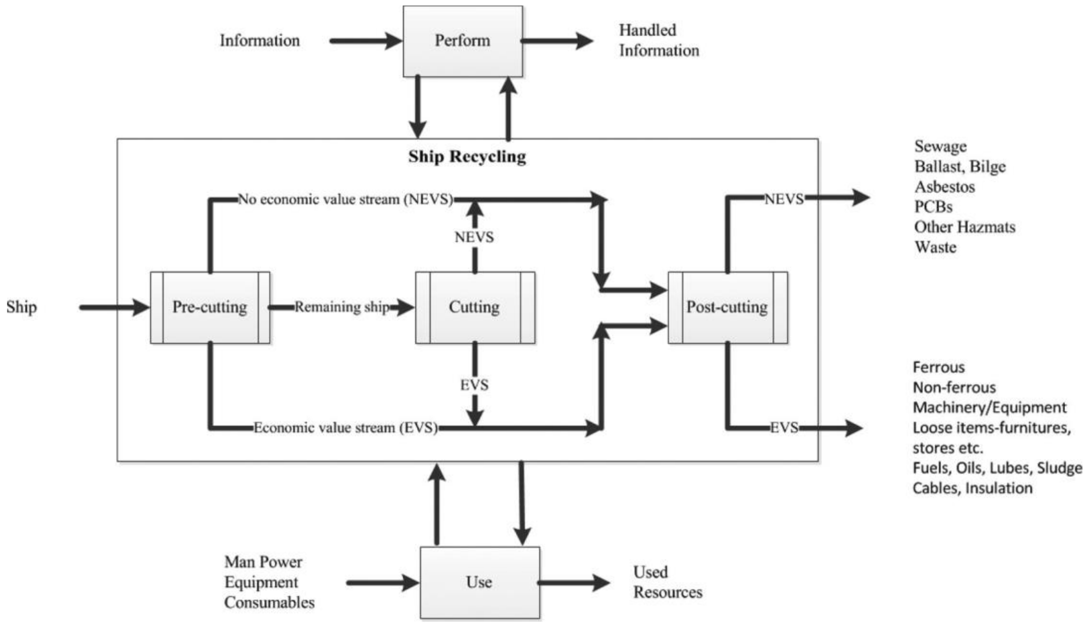

Fig.2 ship recycling process.

2.2 HSE Impacts & Challenges

The pollution which occurs due to substandard ship recycling process leads to harmful environmental impacts. The following research papers ranging from 2012 to 2021 includes 13 papers discussing different issues related to environmental impact problems.

S.M. Yahya et al. (2012) [8] investigated the environmental impacts of the shipbreaking and recycling industry in Bangladesh. As a result of unethical shipbreaking in South Asia, Yousri MA Welaya et al. (2012) [9] investigated the feasibility of building a ship recycling yard in Egypt. This is done to draw attention to worker health, safety and harm to the environment. Furthermore, Asma Binta Hasan et.al. (2013) [10] Potential enrichment of trace metals in the sea and groundwater from shipwreck activity along the Bay of Bengal in Sitakund and Upazila, Chittagong, Bangladesh. Asma Binta Hasan et al. (2013) [11] investigated that trace metal concentrations were higher around the shipbreaking area of Sitakund Upazilla in Chittagong, Bangladesh, than at control sites. Furthermore, Nathanel Ko et.al (2016) [12] introduced that there is a certain imbalance between the added value of scrapped ships and the distribution of environmental impacts over the life of the ship. In addition, Sohanur Rahman (2017) [13] discussed the current status of ship recycling in Bangladesh to overcome the negative impacts on environment and human life. In addition, Hasan Luhan Rabia et al. (2017) [14] Focused on Bangladesh's Ship Recycling and Recycling Industry (SBRI) to understand its current status, environmental impact, and workers' rights and safety. Learn about the Bangladesh Ship Breaking Association (BSBA) response to dirty and dangerous shipbreaking facilities. Furthermore, Damien A. Devault et.al (2017) [15] stated that management of decommissioned vessels is a serious problem as most Ship Recycling Facilities (SRF) are located in developing countries. As a result of a study by Zunfeng Dua et al. (2018) [16] uncontrolled disposal of hazardous materials such as asbestos and waste oil can have serious negative impacts on the environment and human health. Furthermore, Kanu Priya Jain et al. (2018) [17] showed that it is costly to apply waste management and recycling processes in 'environmentally friendly' ship recycling yards. Furthermore, Yucel Ozturkoglu et.al. (2019) [18] On the dynamic environment of ship recycling and the various significant risks that can result. In addition, significant hazardous waste from ship recycling was reported by Md. Jahir Rizvi et al. (2020). [19] The "beaching method" is particularly important because of its mode of operation. Finally, Qingji Zhou et.al (2021) [20] studied factors influencing green ship recycling to avoid pollutants in shipbreaking.

S.M. Yahya et al. (2012) [8] performed the following set of tasks: visits to scrap processing and refinery facilities, onshore and offshore sample collection and analysis of experimental data, on-site evaluations and interviews with stakeholders, including workers, shipyard managers and other stakeholders; and preparation of an EIA report from interviews with relevant stakeholders. Further, Yousri MA Welaya et al (2012) [9] A Fuzzy Logic Approach is Used to Assessment the Benefits of the Ship Breaking Yard through MATLAB ver. 7.6.0 with Fuzzy Logic Toolbox. Additionally, Asma Binta Hasan et.al (2013) [10] conducted a comparative study for seven seawater and seven ground water samples were collected from the ship breaking area of Sitakund Upazilla Chittagong, Bangladesh in February 2011 in order to trace element concentrations of seawater samples with the average abundance of elements in the Earth's seawater standard. Besides, Asma Binta Hasan et.al (2013) [11] carried out Sediment geochemistry analysis and conducted a correlation between trace elements of sediment samples Correlation matrix in order to indicate enrichment factor, the geo-accumulation index and the potential contamination index. Moreover, Nathanael Ko et.al (2016) [12] carried out by Life Cycle Assessment (LCA), for the quantification of the environmental impacts, local added value, for the quantification of economic impact and the method of eco-efficiency. On the one hand, Sohanur Rahman (2017) [13] carried out a comparative study for the overall ship recycling process in Bangladesh compared with the Rest of World on ship recycling activities through gathering data from different sources (references) focusing on ship recycling in Bangladesh. On the other hand, Hasan Ruhan Rabbia et.al (2017) [14] carried out an analytical study for the general overview of Ship Breaking and Recycling Industry (SBRI), the impact of environmental disaster, the problems involved in workers safety in order to find out the solutions of the challenges occurred in SBRI. In addition, Damien A. Devault et al. (2017) [15] conducted a comparative study of shipbreaking and sinking based on a review of environmental, economic and forensic aspects. Also, Zunfeng Dua et.al (2018) [16] On-site observations and investigations were conducted to consider disposal methods for hazardous materials. The survey was conducted at several ship recycling companies of various sizes, including the Yangtze River Shipbreaking Yard, Zhoushan Changhong International Ship Recycling Co., Ltd., and Tianma Ship Recycling Yard. In addition, interviews and surveys were conducted with managers of these ship recycling companies or people familiar with the process. Additionally, Kanu Priya Jain et.al (2018) [17] A financial analysis performed to quantify the waste generated in a ship recycling yard with an annual scrapping capacity of 1 million tons. Additionally, capital costs, operating costs, and revenues were determined to quantify changes in offer prices. Furthermore, Yucel Ozturkoglu et al. (2019) [18] Fuzzy DEMATEL method for analyzing causal relationships between economic and environmental risks. Furthermore, Md Jahir Rizvi et.al. (2020) [19] presented an alternative approach to current shipbreaking operations by creating a computer model of a portion of a shipbreaking site and analyzing it using a commercial software package from Multiphysics. Finally, the Qingji Zhou et.al (2021) [20] questionnaire was designed and conducted by scientists, managers, and workers in the ship recycling field. The data were analyzed based on structural equation modeling SEM using the proposed theoretical model.

All S.M. Yahya et al. (2012) [8], Asma Binta Hasan et al. (2013) [9] and Asma Binta Hasan et al. (2013) [10] found that ship debris was randomly staked to shore, leaving an accumulation of rusty metal debris on the ground. Furthermore, this analysis revealed that the sediments in the shipbreaking area were either slightly or heavily contaminated with the investigated trace metals according to the Igeo values. Furthermore, Yousri MA Welaya et al. (2012) [11] found that poor practices in the current disposal regime cause significant health, safety and environmental harm. Also, the fuzzy logic approach used to assess the benefits of the shipbreaking industry has proven to be suitable for decision making. Furthermore, the results of the research conducted show that the location of the ship recycling facility has no impact on labor and transportation costs. However, this will affect infrastructure costs. Also, Nathanel Ko et.al (2016) [12] found that the environmental impact per value added (inversely adjusted eco-efficiency) is higher at the production stage, especially at the disposal stage. Economic benefits also accrue during the use phase and remain in Europe reflecting the ship's purpose. Since ships are in use for a long time, most of the environmental pollution also occurs during the use phase, but it is emitted all over the world. As well as Sohanur Rahman (2017) [13] and Hasan Ruhan Rabbia et.al (2017) [14] state that there are no separate guidelines or regulations for shipbreaking in Bangladesh. Additionally, recycling shipyards do not employ shipbuilders and almost all ship dismantling is done with minimal guidance from engineers. Additionally, a Ship Recycling Plan as defined in accordance with Resolution MEPC196(62) must be drafted and submitted to the Authority for approval prior to recycling. During the recycling process, inspectors must check whether the recycling yard follows this process. However, Qingji Zhou et.al (2021) [20] showed that organizational and management factors have the greatest overall impact on environmentally friendly ship recycling. Environmental protection facilities and planning factors are followed by ship recycling technology and equipment factors. Additionally, Damien A. Devault et.al (2017) [15] found that while scrap provides employment and raw materials, it carries environmental, health and safety costs. Scuttling, on the other hand, offers opportunities for fishing and diving tourism, but requires proper management to avoid organic matter. and metal contamination. Plus, flag of convenience is inevitable tool for converting obsolete ships. 61% of the world's merchant fleet has such flags. Both Zunfeng Dua et.al (2018) [16] and Md Jahir Rizvi et.al (2020) [19] found that shipbreaking is widely associated with unsafe practices and pollution, PCB, glass fiber, rigid foam, waste oil, etc. Also, currently the ship design process "Design for Recycling" does not consider the recycling process. Similar to Kanu Priya Jain et.al (2018) [17], the results suggest that the return on investment for plasma gasification plants is relatively fast, with a reasonable increase in asking price under the specific scenario considered in this study. showed that it is possible. Finally, Yucel Ozturkoglu et.al (2019) [18] The first contribution of this study is to combine the TBL approach with risk management in the ship recycling industry. The second contribution analyzes the interrelationships between factors and proposes risk area proposals that recommend management implications for sustainable risk management in the ship recycling industry. Finally, the implementation of Green Supply chain management is proposed.

The non-green ship breaking process exposes the ship breaking workers to a serious risk on health and safety. Throughout the next paragraph, 10 research papers covering years from 2012 to 2021 discusses problems in health safety and environment.

Safety, health, and environmental concerns were addressed by N.M. Golam Zakaria et al. (2012) [21] It has been highlighted as a major factor in the challenges facing the ship recycling industry. It also briefly outlined the strengths, weaknesses, opportunities and threats of the industry from a global perspective. Furthermore, Paritosh C. Deshpande et al. (2012) [22] discussed pollutants emitted from plate cuttings at Alang, India. Pollutants either directly affect workers by polluting breathing zones (air pollution) or pollute intertidal zones and contaminate sediments when pollutants are released in secondary work zones receiving tidal forces. Furthermore, Paritosh C. Deshpande et al. (2013) [23] Also, a thorough understanding of the inputs and outputs of plate cutting operations at Alang, India, is essential to anticipate and control the health, safety, and environmental risks associated with ship recycling. Furthermore, Widha Kusumaningdyaha et.al. (2013) [24] point out that shipbreaking contributes to toxicants leading to ecological imbalances in exposed areas. Shipbreaking is also a dangerous occupation with the risk of poisoning from hazardous materials and accidents on the premises. Additionally, Karin Garmer et.al (2015) [25] showed that environmentally friendly and safe disposal of old ships is a major challenge today. He studied three-step risk assessment methodology to reduce risk and increase safety in ship recycling yards. Further, a study by Halvor Shyen et al. (2017) [26] describes the difficulties faced by ship owners, recycling facilities and governments in trying to recycle old ships in an environmentally sound manner. Shipbreaking puts the environment and recycling plant workers at risk. Furthermore, Rafet Emek Kurt et.al. (2017) [27] analyzed hazardous noise exposure in a ship recycling yard by identifying noise sources and quantifying potential impacts on workers. In addition, Sefer A. Gunbeyaz et.al (2019) [28] highlighted numerous accidents and fatalities in the ship recycling process due to lack of proper occupational health and safety (OHS) standards. Zheng Wan et al. (2021) [29] introduced that ship scrapping is a significant source of marine pollution during ship recycling. This includes toxic chemicals that can be released and pose great danger to both the environment and public health. Finally, Qingji Zhou et.al (2021) [30] found that for vessels that have reached the end of their economic life, considering hazardous materials and work processes, sending these vessels for recycling is a sustainable option. Therefore, it is important for ship recyclers to ensure the safety of their workers.

Research and field visits by N. M. Golam Zakaria et al. (2012) [21] were carried out at several well-known local shipyards. In addition, professional participation was conducted through questionnaires and interviews. Consultations and meetings were held with government agencies, shipbreaking associations and stakeholders to understand the current challenges and future vision. Furthermore, Paritosh C. Deshpande et al. (2012) [22] performed a mathematical model of estimation using a Gaussian air pollution model to quantify pollutant concentrations along the centerline of each cutter designed as a single point source. Furthermore, Paritosh C. Deshpande et al. (2013) [23] conducted a theoretical study to investigate the relationship between emission rate and resource consumption in the cutting process in ship recycling, based on field observations in Alang, India. Furthermore, Widha Kusumaningdyaha et al. (2013) [24] system dynamics approach Performed using Ventana simulation software (Vensim). The model was developed in three steps. The first step is to develop a system structure that characterizes its behavior. This is illustrated by creating a causal loop diagram. In the second step, a Flock Stow diagram is created and extended to show the nature of the dynamic behavior of the structure. In the final step the model structure is simulated and evaluated. In addition, Karin Garmer et.al (2015) [25] 3-step risk assessment was conducted at 35 ship recycling yards through questionnaire surveys and door-to-door visits. A data set of 8 risk indicators (4 risk indicators each before and after corrective action is implemented). Additionally, nine of her datasets were collected to document expert perceptions. A total of 44 datasets were collected and used to validate the risk assessment method. A risk matrix was also created. Also, Halvor Schøyenet.al (2017) [26], based on data gathered from a literature review, relevant document analysis, and semi-structured interviews with selected Norwegian industry participants, analyzed literature reviews, companies, websites and NGOs, documents, interviews. Additionally, a noise exposure study was conducted at an operational ship recycling yard by Rafet Emek Kurt et.al (2017). [27] This included a general noise survey, individual worker noise exposure measurements, and comparison of results to exposure limits. Measurements specified in the European Union Physical Effects (Noise) (EC 2003b) are defined. Furthermore, Sefer A. Gunbeyaz et.al. (2019) [28] organized a field survey involving several ship recycling yards, several government agencies, universities, and BSBA training center. A comprehensive data collection survey was then conducted, covering Bangladesh and international health and safety training and international practices, worker evaluation, shipyard training records and training content, and BSBA training materials. As a next step, IMO and ILO requirements for worker training were communicated to the Expert Group, who was asked to assess BSBA training. Finally, training evaluations have been condicted based on the documentation and what was reported, rather than looking at the actual implementation of the training. Furthermore, Zheng Wan et al. (2021) [29] In his research study of 22,500 scrap ship business records from 2000 to 2019, using factors suggested to scientists, managers, and workers in the ship recycling industry. Additionally, the conceptual model and research hypothesis, On the other hand, theoretical model has been conducted hypothesizing based on the structural equation model using survey data, and performed model suitability evaluation and SEM analysis.

N. M. Golam Zakaria et.al (2012) [21] found that ship breaking is an important activity in the economy of Bangladesh as it contributes significantly to the conservation of energy and resources in general. Furthermore, Bangladesh has no choice but to improve safety, health and the environment through extensive infrastructure and capacity development, and this must be based on the results of research work. Although Paritosh C. Deshpande et.al (2012) [22] found that 180 ship recycling yards located at Alang-Sosiya beach in the state of Gujarat on the west coast of India constitute the largest cluster in the world engaged in scrapping operations. In addition, each year, 350 ships are dismantled (an average of 10,000 tons of steel/vessel) with the participation of about 60,000 workers. It was recognized from the outset of this study that the potential environmental impacts and occupational hazards were comparable regardless of the method of dismantling (i.e., in any decommissioning or repair site layout), as well as the degree of mechanization and manual labor in the yard. In addition, Paritosh C. Deshpande et.al (2013) [23] found that sheet cutting accounts for almost 70% of the total labor employed in ship dismantling and recycling at Alang-Sosiya shipyards in India. In addition, analysis of the contributions revealed that 6.2 kg of fuel was consumed per km of shear plate per mm of plate thickness, the volume of paint released to the ambient air and the paint deposited on the intertidal sediments. are 0.9 and 1.34 kg per km of sheet cut per mm of sheet thickness, CO2 emissions are estimated to be 21.77 kg per km of sheet length per mm of sheet thickness, time spent in cutting action actual plate is 240 +- 27 minutes Burning time/(km of cutting length) (mm cutting depth) as shown in figure 3, and oxygen consumption per day is 28.5 +- 3.2 kg of oxygen/(km of cutting length) (mm depth of cut) as shown in figure 4. On the one hand, Widha Kusumaningdyaha et.al (2013) [24] The results can be considered in terms of regulation and policy implementation related to ship breaking and its aspects, especially in developing countries. On the other hand, Karin Garmer et al (2015) [25] found that there was no significant difference between the observed mean risk index based on field data and the indicated risk index, with no significant difference. There is a significant difference between expert risk perception and field personnel risk perception.

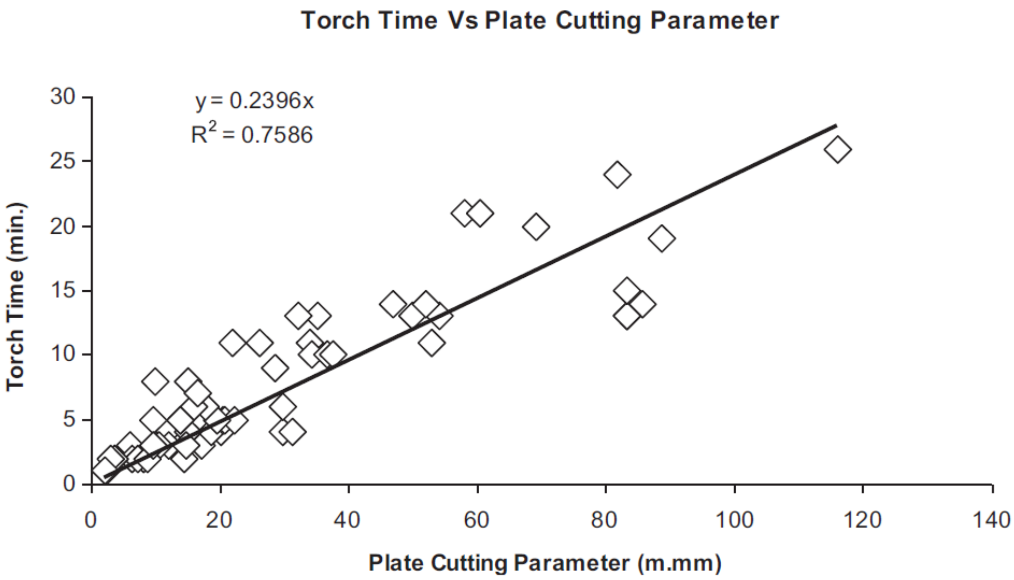

Fig. 3. Linear regression of Torch Time vs Plate Cutting Parameter. The slope (with 95% confidence interval), defined as Torch Time Factor, is 240 +- 27 min Torch Time/ (km cut length) (mm cut depth) and may be used to estimate the total Torch Time required for plate cutting for the entire ship.

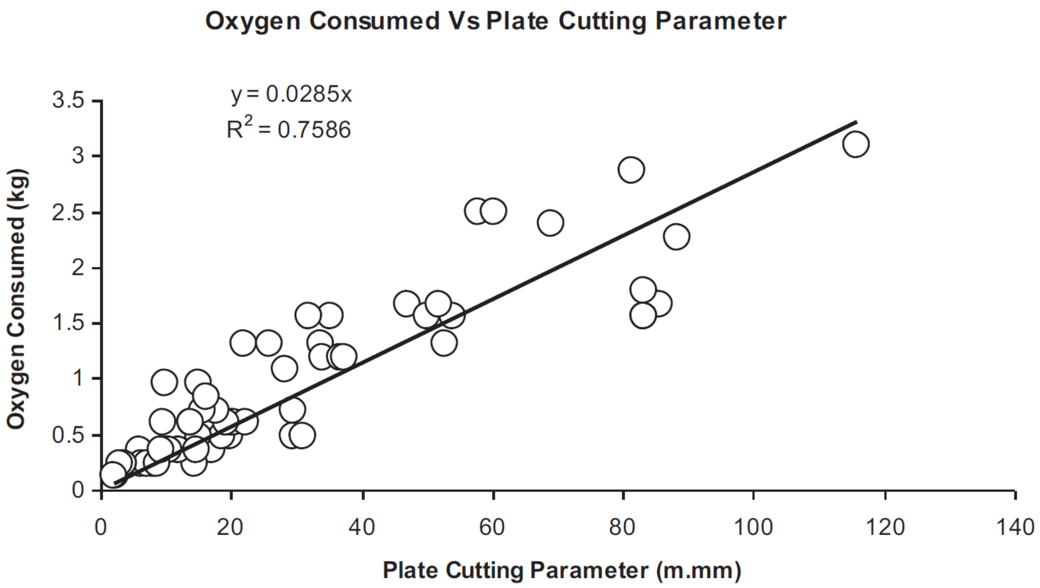

Fig. 4. Linear regression of Oxygen Consumed vs Plate Cutting Parameter. The slope (with 95% confidence interval), defined as Oxygen Consumption Factor, is 28.5 +- 3.2 kg Oxygen/(km cut length) (mm cut depth) and may be used to estimate the total oxygen consumed in plate cutting for the entire ship.

Halvor Schøyen et.al (2017) [26] and Sefer A. Gunbeyaz et.al (2019) [28] find that standardization is only possible through increased investment, i.e. in worker training, welfare, equipment and infrastructure. Furthermore, since ship breaking is not regulated internationally and shipowners frequently abandon their ships, much of the liability for environmental and safety issues at the shipyard rests with the shipyard. government. Moreover, Rafet Emek Kurt et al (2017) [27] the main finding of this study is that noise is a significant risk factor in ship recycling operations and that workers' hearing loss and injury is potentially serious. important for those who do not wear it or wear it incorrectly. hearing protection. Besides, Zheng Wan et.al (2021) [29] found that the phenomenon of "pollute first, clean up later" in developing countries is common. Thus, pollution control must be associated with international organizations setting higher standards and requirements. In addition, the improvement of the antifouling coating, used to kill algae and mollusks on the hull without the use of harmful chemicals, will reduce the impact on the marine ecosystem, increase the life of the ship by reducing corrosion, thereby significantly reducing the amount of waste generated.

Finally, Qingji Zhou et.al (2021) [30] hazardous materials and potential risks during ship dismantling process, the factors affecting workers' safety during ship recycling are proposed, including disposal of hazardous materials (DHM), dismantling operation safety (DOS), dismantling operation management (DOM), dismantling operation equipment (DOE), and safety awareness (SAW). Also, this study proposed and evaluated the factors affecting personal safety during ship dismantling which can enhance the existing literature on human safety analysis in ship recycling industry. Reliable findings were obtained based on inferential statistical methods.

2.3 Economic aspects.

The economic gains resulting from the scrapping of ships randomly, most of ship owners who want to scrape end of life ships leave the green ship recycling yards towards the non-green ones. The following research papers published from 2016 to 2020 includes 5 papers that introduce different drawbacks from an economic point of view.

Jun-Ki Choi et al. (2016) [31] examined the impact of substandard recycling practices in South Asian countries, allowing shipyard owners to outbid standard engineering recyclers and maintain profits as a result. lax environmental law enforcement. These non-standard technologies have the potential to release significant amounts of hazardous substances due to non-compliance with environmental standards. In addition, Zunfeng Dua et.al (2017) [32] studied the challenges faced by Chinese ship recycling companies as the ship recycling market suffered a downturn and stiff price competition from South Asian countries. Furthermore, Kanu Priya Jain et.al (2018) [33] explains that the implementation of international ship recycling regulations leads to increased costs for the ship recycling process, which is detrimental to the provision of high prices for ships. ship owner when buying a ship that has reached the end of its life. In addition, E. S. Ocampo et al (2019) [34] examines the legal, technical and economic aspects of ship recycling for Brazilian shipyards to do it in a sustainable way. Finally, Sunaryo et.al (2020) [35] conducted a feasibility study to assess which ship recycling green business model would be the most profitable in Indonesia.

Jun-Ki Choi et.al (2016) [31] analyzed using a cost-benefit analysis and a life cycle assessment between standard and substandard ship recycling methods. Additionally, Zunfeng Dua et.al (2017) [32] found that in this study he used a three-step approach: interviews, fieldwork, and literature review. Firstly, in-depth interviews were conducted to gather information on the current situation, economy, international regulations and domestic laws regarding ship recycling in China. Secondly, investigated ship recycling docks, ship recycling processes, shipyard designs and conducted field surveys to obtain information on ship recycling yard equipment and facilities. Third, the literature was extensively used to corroborate the findings of interviews and field studies. Additionally, Kanu Priya Jain et.al (2018) [33] performed a detailed analysis using material flow analysis software to apply the concept of CP to ship recycling. A two-step methodology is used to perform such an analysis. The first step is to conduct a detailed study of the concept of cleaner production and its benefits. The second step is to assess the applicability of clean production to ship recycling and develop appropriate strategies to achieve the goals of this study. Also, E S. Ocampo et al. (2019) [34] employed a statistical study based on data collected from ships recycled in South Asia in 2016 and data collected from the Brazilian fleet likely to be recycled within the next 25 years. In addition to conducting interviews with maritime sector experts, shipyard stakeholders and shipowners, perceptions of this activity in Brazil were determined. Finally, Sunaryo et.al (2020) [35] compared the two business models and used the results as considerations for calculating project investment and choosing the best business model for green ship recycling companies. A feasibility study was conducted to assess the financial aspects of the two companies. Fixed and non-fixed operating costs and depreciation charges, number of ships recycled and expected revenue assumptions, 20-year operating cash flow calculations, and business viability calculations based on selected investment criteria.

Jun-Ki Choi et.al (2016) [31] shows that recycling ships by standard methods can be profitable. While ship recycling by standard methods may provide only marginal economic benefits, it is the most environmentally friendly option. In addition, coral reefs have the lowest economic benefit because there is no revenue from recycled materials. Furthermore, Zunfeng Dua et.al (2017) [32] found that no specific enforcement mechanism exists in the Chinese ship recycling industry from a comparison between Chinese law and international conventions. In addition, China should put in place a legal framework to clearly define the roles and responsibilities of different agencies. Thus, the ship recycling industry will be operated according to international conventions. Furthermore, Kanu Priya Jain et.al (2018) [33] showed that three strategies were identified, namely material flow analysis to improve ship recycling process planning, waste-to-waste conversion technology. energy to improve earnings from ship recycling and design. -for-recycling to reduce the cost of the ship recycling process. The proposed strategies are classified into two categories, yard-based strategies and ship-based strategies. Furthermore, according to E.S. Ocampo et al. (2019) [34], 97% of the global ship breaking market is in South Asian countries, while the remaining 27 ships are recycled externally, indicating a shift in the countries that dominate the industry. He also mentioned that Brazil's fleet could be recycled over the next 25 years, with about 340 vessels having a market figure of $587 million. Brazilian shipyards are an advanced technical and environmental sector of the Brazilian economy. Local and global stakeholders advise Brazilian shipyards to expand feasibility studies and acquire skills to promote local ship recycling. Finally, Sunaryo et.al (2020) [35] found that the most profitable business model for green ship recycling enterprises is the service provider model. From financial solvency calculations, the carrier model offers a faster payback period of 3.74 years, a higher net present value of IDR 228,322,021,477.88, a ratio higher average return is 0.36, higher internal rate of return is 17% and higher profitability ratio is 3.82.

2.4 Legal issues.

The EU regulation and Hong Kong convention were not entered into force yet. Because of a number of legal constraints facing the implementation of these regulations. The following parts includes 6 research activities from 2010 to 2020 focusing on the legal aspects of the ship breaking industry poor implementation.

Y. C. Chang et al (2010) [36], E. Yujuico (2014) [37], G. A.Moncayo (2016) [38] and J. I. Alcaide et al (2017) [39] studied the implementation issues of the Hong Kong International Convention, 2009" and Regulation 1257/2013 of the European Union focusing on the disadvantages and inadequacies of ship breaking activities on the coasts of Asian countries from southern. While J. I. Alcaidea et al (2016) [40] studied the impact of registering ships in convenient countries just before recycling their ships, this creates a loophole to avoid strict national legislation. and international rules. In addition, J. Hsuan et al. (2020) [41] investigated how existing ship breaking regulations affect supply chain management through inter-organizational arrangements, affecting mining and material recovery. materials for reuse, especially steel.

Y. C. Chang et al. (2010) [36] conducted legislative research for the Hong Kong Convention on how to find parties affected by control. In addition, E. Yujuico (2014) [37] conducted a case study of a need-driven, aid-based strategy examining the possibility of funding improved ship recycling processes in South Asia. In addition, G. A. Moncayo (2016) [38] conducted a forensic investigation into the cradle-to-grave approach and inventory of hazardous materials that a ship must keep on board until it is dismantled. are positive elements of the emerging ship recycling regime. In addition, J. I. Alcaide et al (2017) [39] introduced a statistical study through an online survey of battery owners looking for necessary amendments to existing international conventions. In addition, J.I. Alcaidea et al. (2016) [40] used a multivariate statistical technique known as "simple correspondence analysis" to conduct an empirical investigation to determine the relationship between countries and the ship breaking industry. Finally, a qualitative exploratory study of how rules affect supply chain management through agreements between organizations was carried out by J. Hsuan et al. in (2020) [41]. The study takes into account imports and exports and the economic and ecological value pairs that in many respects govern these inter-organizational arrangements.

A reporting system built by Y. C. Chang et al. (2010) [36] and an audit system is described to identify violations. In addition, E. Yujuico (2014) [37] presented a comprehensive sequential framework for this trade that governs relevant sustainability principles, environmental regulations, and economic justifications. In addition, J.I. Alcaidea et al. (2016) [40] examined the association between vessel registries selection and ships approaching the end of their useful life and re-flagging only for demolition. In addition, J. I. Alcaide et al (2017) [39] The results indicate that there are significant differences in the way the ship recycling industry perceives the upcoming ship recycling standards within the EU. Furthermore, Moncayo, G. A. (2016) [38] Although the Hong Kong Convention and EU Regulation 1257/2013 on ship recycling are acknowledged to have some positive aspects, it is suggested that they present a step back in ship recycling regulation. Finally, J Hsuan et al. (2020) [41] analyze inter-organizational linkages in the ship recycling supply chain as shown in Figure 5, this study argues that transaction cost analysis and agency theory are two complementary theories.

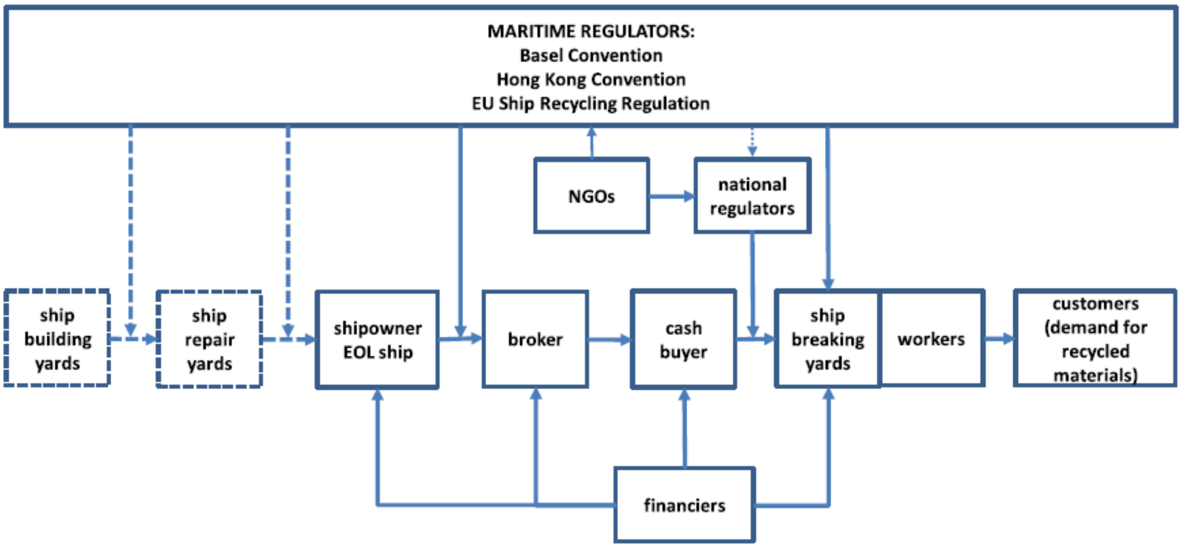

Fig. 5. The supply chain of ship recycling

2.5 Operations & Management.

The absence of specific guidelines for ship breaking and relevant information, results in decreasing the scrapping performance to the lowest level. The next paragraphs ranging from 2012 to 2020 includes 10 research papers which shows the defects facing the ship recycling industry due to bad management and operation.

K. Aoyama et al. (2012) [42] investigated the lack of specific instructions on how to dismantle substandard ships. While A. M. Hiremath et.al (2015) [43] points out that dismantling and recycling end-of-life ships in an environmentally friendly manner is a major challenge for shipowners, ship breakers and ship breakers alike. government agencies around the world. Furthermore, M. Sujauddin et.al (2015) [44] reported that the main obstacle faced by the ship recycling industry is the reluctance of stakeholders to disclose available but relevant information due to suspicions. suspected widespread. In addition, S.M. M. Rahman et al. (2015) [45] discussed the lack of coordination in the ship recycling industry in parts of Bangladesh and its effect on the flow of recovered metal resources. In addition, K.P. Jain et.al (2016) [46] also discussed bid spreads, but in this article the author focuses on estimating the weight of steel, as a percentage of possible light weight (LDT) based on the experience of the recycling site, or on expert opinion without resorting to any scientifically rigorous methods. In addition, S.M. M. Rahman et al. (2016) [47] discussed the environmental impacts, including the potential for global warming and the quality of human health and echo systems, due to other steel scrap handling practices. each other outside the construction site caused. In addition, K.P. Jain et.al (2017) [48], introduced that there is a supply price differential between "green" and non-green recycling yards due to higher ship dismantling costs due to compliance with international recycling regulations. and ship health, safety and environment (HSE Management System). While Jayaram S. et al (2018) [49] discussed the lack of a strategic direction plan for the ship recycling process in India as India is one of the leading ship recycling countries in the world and accounts for about 29% of the total number of ships. was recycled worldwide in 2017. Therefore, it is necessary to properly identify and allocate the responsibilities of the stakeholders to implement ship recycling in an efficient and sustainable manner. In addition, S. A. Gunbeyaz et.al (2020) [50] discussed how the operating costs of ship recycling yards will increase as new regulations are introduced, in order to survive in a competitive industry dominated by landfills. substandard and low cost. operating procedures must be performed. Finally, C. Benjamin et al (2020) [51] discussed how the number of studies targeting the Amazon region ship recycling market is incomplete and unsatisfactory. Furthermore, there is no plan to dispose of these vessels, which can lead to environmental and social damage and create business opportunities.

K. Aoyama et al. (2012) [42] conducted a simulation study of demolition on real ship structures. While A. M. Hiremath et.al (2015) [43] conducted a field survey to predict the emissions of 241 ships scrapped during 2011-2013 at the Alang port cluster while also predicting the amount of waste generated from dismantling. unloading of 6 types of ships (bulk carriers, bulk carriers, bulk carriers). cargo, containers, refrigerators and passengers). In addition, M. Sujauddin et.al (2015) [44] conducted a quantitative study of the data collected by visiting 20 shipyards, 3 rolling mills, 7 rolling mills in Chittagong. In addition to interviewing 400 private intermediaries to find out qualitative entries and exits from ship breaking yards. In addition, S.M. M. Rahman et al. (2015) [45] performed a statistical study using a questionnaire with a combination of closed and open questions, orally given to a number of representative groups to understand the relationship. relationship between social integration and resource flow. In addition, K.P. Jain et.al (2016) [46] conducted a quantitative study of the material composition of end-of-life ships using stability manuals and light-weight distribution documents on board. In addition, S.M. M. Rahman et al. (2016) [47] conducted LCA life cycle assessment to assess energy consumption and emissions when ships are transported from the country of origin for scrapping in Chittagong to recyclers. In addition, K.P. Jain et.al (2017) [48], discussed the general ship recycling process for bulk carriers (barrel ships), using material flow analysis. While Jayaram S. et al (2018) [49] undertook a study on a systems approach in the form of a linear scheme to implement ship recycling at a strategic level in India. In addition, S. A. Gunbeyaz et.al (2020) [50] performed a discrete event simulation study for alternative cutting technologies that were tested to evaluate their impact on production performance and cost. Finally, C. Benjamin et al (2020) [51] conducted a data analysis using fleet data from Brazil's national river transport agency for 5319 dismountable vessels.

K. Aoyama et al (2012) **[**42**]** proposed a planning system for a suitable ship-breaking process that considers worker safety and environmental as well as economic issues. Also, A. M. Hiremath et.al (2015) [43] provided the knowledge-based needed by individual yard owners for planning their short term and long-term activities in order to serve as an essential part of the management information system which will help in governance of cluster of ship dismantling yards. Moreover, M. Sujauddin et.al (2015) [44] found that the Oil tankers and bulk carriers have been preferred by Bangladesh's ship breaking industry because of their higher steel content. Moreover, introduced that by keeping organized records is critical to develop a comprehensive understanding of this industry. It was noticed that all of S.M. M. Rahman et al (2015) [45], K.P. Jain et.al (2016) [46] and K.P. Jain et.al (2017) [48] introduced a suitable tool to analyze and plan the ship recycling process using MFA for better waste management and resources in order to reduce cost. On the one hand, S.M. M. Rahman et al (2016) [47] suggested that a clear environmental benefit exists in recycling steel from ship scraps, relative to the use of steel from virgin ore. On the other hand, Jayaram S. et al (2018) [49] developed A guidance plan based on the present practice in the Indian ship recycling industry, new regulations and other factors which can improve the industry for achieving sustainable development and assist the stakeholders, especially the shipowner and the ship recycling yards, to coordinate and to execute various activities in an efficient manner during each stage of ship recycling. Besides, S. A. Gunbeyaz et.al (2020) [50] found that plasma cutting is a good alternative to oxyfuel cutting which used in cutting operation in the secondary zone of the ship recycling yards. Finally, C. Benjamin et al (2020) [51] found that Between 2005 and 2015, many vessels were built as a result of the boom in the shipbuilding industry, and these vessels will generate a significant growth in the ship recycling market starting in 2025 with an exponential trend as shown in figure 6. It means that two concentration poles of potential vessels exist in Brazil. One pole is in the north of the country and is linked to the considerable volume of vessels in the Amazon region and the lack of destination procedures and regulations for obsolete vessels. The second pole is in the southeast and is linked to the offshore market, under the influence of Rio de Janeiro.

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Fig.6. Projection of potential ship recycling market for the next 20 years in Brazil (Reference year: 2017).

3. Best Practices for Ship Scrapping

There are four methods for ship recycling "Beaching", "landing", "alongside" and "docking", the first one is refused from the HKC convention due to the large amount of hazardous materials which are landed on the mud. The next two methods also causing marine pollution but less than beaching method. While, the fourth method is the best practice for ship recycling which is applied inside the dock land but it needs large area with high cost.

4. CONCLUSIONS:

In this article, a Systematic literature review of 51 studies during the period from 2010 to 2021 on ship recycling was made. This literature analysis helps identify the top countries, the most popular journals, researchers and their collaborative links. The literature review further identified the categories of research studies and the methodologies employed. An analysis of the reviewed articles also identifies research challenges and directions for future research. In this way, this article provides a brief summary of the advances in ship recycling through scholarly publications. The main conclusions of this study are as follows:

- Top leading countries in ship recycling industry are Pakistan, India, Bangladesh, China and Turkey.
- 5 research categories have been defined:
    - Design consideration
    - HSE impacts & challenges
    - Economic Aspects
    - Legal issues
    - Operations & management
- there is a lack of research activities related to a number of topics.
    - There are only 7 published papers for the Design considerations in ship recycling industry topic, including design for recycling, green ship recycling yard layout design and recycling procedure design.
    - There are only 5 published papers for the economic research activities which may contribute effectively to the solutions of the problems facing the ship recycling industry.

- Egypt is one of the rich coastal countries, through which Suez Canal passes and surrounded by red sea and Mediterranean Sea, but it was found that there is an almost no research activities published in regarding with this industry implementation in Egypt.
- There is a gap in research activities regarding to the merging among traditional ship recycling methods, operation and management studies, environmental impacts and economic feasibility studies.

The findings of this analysis can be used by decision-makers to learn more about research collaborations, groups, and directions. The direction of upcoming research investments could be influenced by this information. Focused, innovative research can be conducted with the help of the identified and analyzed research studies, methodological difficulties, and suggested research directions. Therefore, it is anticipated that this review paper will aid in the development of research ideas, cutting-edge technical approaches, and general ship recycling advocacy. Future review studies might take into account some targeted research questions or concentrate on a more in-depth examination of any subject under consideration in this review paper.

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