Jinggo: Jurnal Inovasi Teknologi Manufaktur, Energi, dan Otomotif
ESSN: 2963-8445
Received : Februari 2025
Revised : April 2025
Accepted : Agustus 2025

ECONOMIC PERSPECTIVE OF END-OF-LIFE SHIP MANAGEMENT

Izzul Fikry [a], Nanda Dwi Wuryaningrum [b*], Hayy Nur Abdillah [c], Prativi Khilyatul Auliya [d]
[a, b, c, d] Jurusan Teknik Bangunan Kapal, Politeknik Perkapalan Negeri Surabaya

E-mail koresponden: **nanda.dwi@ppns.ac.id**

Abstract

The lifespan of a ship is only in the range of 20 to 40 years. What to do after that period is an interesting point to review. There are three ship end-of-life strategies: ship life extension, ship recycling, and ship scuttling. This paper discusses a review of some of the research that has been done. Some of these studies discuss ship life extension, ship recycling, and ship scuttling. After reviewing some papers, it can be concluded that extending the operational life of the ship is something that can provide benefits to the shipowner under the condition of proper calculation and planning. Ship recycling is the most commonly used method, which required different costs, depending on the method used, whether the standard or substandard method. Ship recycling also plays a vital role in the economy and sustainable development. *Ship sinking is also a good method for charity and tourism.*
Keywords*: End-of-Life, Ship, Dismantling, Sinking, Extension of Operational Period*

Abstrak

Umur kapal hanya berkisar 20 hingga 40 tahun. Apa yang dilakukan setelah periode tersebut adalah hal yang menarik untuk diulas. Terdapat tiga strategi end-of-life kapal. yaitu ship life extension, ship recycling, dan ship scuttling. Paper ini membahas mengenai review dari beberapa penelitian yang telah dilakukan. Beberapa penelitian tersebut membahas mengenai ship life extension, ship recycling, dan ship scuttling. Setelah mereview beberapa paper tersebut, dapat disimpulkan bahwa memperpanjang masa operasional kapal merupakan hal yang dapat memberikan benefit terhadap pemilik kapal dengan syarat perhitungan dan perencanaan yang tepat. Ship recycling merupakan metode yang paling umum digunakan, dimana biaya yang dibutuhkan berbeda tergantung metode yang digunakan, yaitu metode standard atau substandard. Ship recycling juga memiliki peranan penting dalam perekonomian dan pembangunan berkelanjutan. Menenggelamkan kapal juga merupakan metode yang baik untuk kegiatan amal dan pariwisata.
Kata Kunci: End-of-Life, Kapal, Pembongkaran, Penenggelaman, Perpanjangan Masa Operasional

1. INTRODUCTION

There were 96,092 vessels registered on the Ministry of Transportation of the Republic of Indonesia in September 2021. Fishing vessels dominated with 47,841 vessels, followed by 43,575 cargo ships, and 46,76 passenger ships [1]. On a larger scale, there are around 1,800 ships out of 90,000 merchant ships that will retire worldwide [2]. This number is a large number, since the age of the ship is 20 to 40 years only [3].

Where will these ships go, then? There are several possibilities that are going to be done when the ship has reached out the age limit. Some of the things that can be done are dismantling, sinking, and extending the life of the ship. The end-of-life strategy is very important. The choice of end-of-life strategy will have an impact on the life cycle cost of the ship [4].

Extending the life of the ship means that modification and maintenance of ship's parts are needed to ensure the ship will operate safely [4]. The second way is by dismantling. Dismantling is done to reprocess the materials on the ship [3]. Another alternative is to sink the ship to the seabed as an artificial reef [3]. This paper will discuss the ship end-of-life strategy based on economic aspects.

2. LITERATURE REVIEW

2.1. Ship Life Extension

Extending the life of the ship is one way for shipowners to get more economic profit. By increasing the operating life of the ship, shipowners can postpone purchasing new ships [4]. It

happens because the cost of procuring a new ship is high, therefore, increasing the operating life of the ship is one of the alternatives chosen by shipowners [5]. One of the technical things that must be considered while extending the operational life of the ship is hull structure, where fatigue and corrosion have the largest percentage in causing modifications in the hull structure [4].

Economic factors are important to consider. Cost and profit considerations are the main things that must be considered in deciding ship end-of-life strategies [4]. By increasing the operational life of the ship, the shipowner would certainly face the increasing in maintenance and failure costs. Additionally, the possibility of failure will getting higher since the ship is operated beyond the usage limit [5]. To solidify the end-of-life strategy to extend the operational life of the ship. Liu proposed that we must pay attention to [4]:

2.1.1. Failure Risk

It is used to calculate failure risk of ship structures.

$$Rf = \sum_{t=1}^{t_{ext}} \frac{\left(C_f + C_l + C_{spill}\right).P_f(t)}{(1+r)^t} \quad (1)$$

Where:

t	=	Lead time since the time of EOL decision (year)
t_{ext}	=	Duration of Phases I and II (years)
Phase I	=	Remaining of ship operational life
Phase II	=	Desired extension of ship operational life
C_f	=	Monetary loss associated with structural failure cost
C_l	=	Fatality cost and environmental cost
C_{spill}	=	Oil spill cost
$P_f(t)$	=	flexural failure probability
r	=	Discount rate

2.1.2. Maintenance Cost

Maintenance costs depend on the corrosion and fatigue conditions of the ship's structure. There are several components that must be calculated, including repair and material costs, consumables costs, and also welding costs.

2.1.3. Net Operating Profit

$$NP_{op} = \sum_{t=1}^{t_{ext}} \frac{Rev - C_{op}}{(1+r)^t} \quad (2)$$

Where:

Rev	=	Annual revenue
C_{op}	=	Annual operating cost

2.1.4. Cost Benefit Analysis

To find out whether the end-of-life strategy will be successful or not, it can be determined by calculating the Benefit-Cost Ratio (BCR) and net present value (NPV [4]. To calculate BCR of an operational life extension (SLE), the following formula is used:

$$BCR_{SLE} = \frac{NP_{op}}{Rf + C_{una} + C_{main}} \quad (3)$$

Where:

C_{una}	=	Un-availability cost
C_{main}	=	Total repair cost

2.1.5. Net Present Value

Net present value is used to determine the opportunity to carry out investment in this extension of the operational period.

$$NPV_{SLE} = NP_{op} - (Rf + C_{una} + C_{main}) \quad (4)$$

2.2. Ship Dismantling

Ship dismantling is the most common solution for ships that have reached their operational limit [6]. The ships are dismantled and the scrap materials are recycled. In terms of time, ship dismantling is one of the longest-used methods. The global dismantling market dates back to the 20th century [7].

2.2.1. Ship Dismantling Method

A. Standard Ship Recycling

Standard ship recycling is a method that refers to applicable regulations. There are several regulations used in ship breaking operations, including the Basel Convention and the Hong Kong Convention [6]. The methods used in ship breaking are varied. There are three methods in standard ship recycling. The landing method is a method that uses a slipway to raise the ship to land [6]. Unlike the landing method, the alongside method does not use a slipway. The ship will be brought to the dock in sheltered water and will be dismantled by crane [6]. The safest way is to use the dry-docking method, where the ship will be put into a dry dock for dismantling [6]. The standard ship recycling method is widely used in the United States, European Union, China, and Turkey [6].

B. Sub-Standard Ship Recycling

Substandard ship recycling, as a method widely used in South Asian countries such as India and Bangladesh, is a method that does not refer to international regulations in ship dismantling. The method used in the substandard method is the beaching method, in which the ship will be beached to the shoreline and after that the ship will be dismantled [6].

2.2.2. Economic Analysis of Ship Recycling

In general, the economic factors of ship recycling have two main components, namely expense cost and benefit cost [6]. Expense cost is the cost that must be spend to do ship recycling. Expense cost consists of several main components such as; environmental regulation cost, worker safety regulation cost, government taxes, labor cost, ship purchase price, and overhead cost. To get net profit, it could be done by deducting the profit (light weight of the ship X the market price per ton of material) with expense cost [6]. The standard ship recycling method has different recycling costs.

A. Standard Ship Recycling

Most of the expense cost of ship recycling with the standard method is allocated for environmental and worker safety regulations. Those two components consume 50% of the expense cost, followed by labor cost with 30%, and ship purchase & overhead cost with 10% each [6].

B. Sub-Standard Ship Recycling

Figure 1 shows that labor cost on sub-standard ship recycling is much different from labor cost in the standard method [6]. From the data in Figure 1, it can be seen that the labor cost in the substandard method is very low since the payroll system in the substandard method is not in accordance with applicable regulations.

On the other hand, the price of ships to be dismantled and recycled depends on shipping costs, industry demand on steel and materials other than steel, and also depends on the shipbreaker [3]. The price of a ship to be dismantled depends on the use of the material. In 2014, the price of steel material for ships in India was around €350/long ton lightweight, while in Europe the price of steel material on dismantled ships was around €250/long ton lightweight [3].

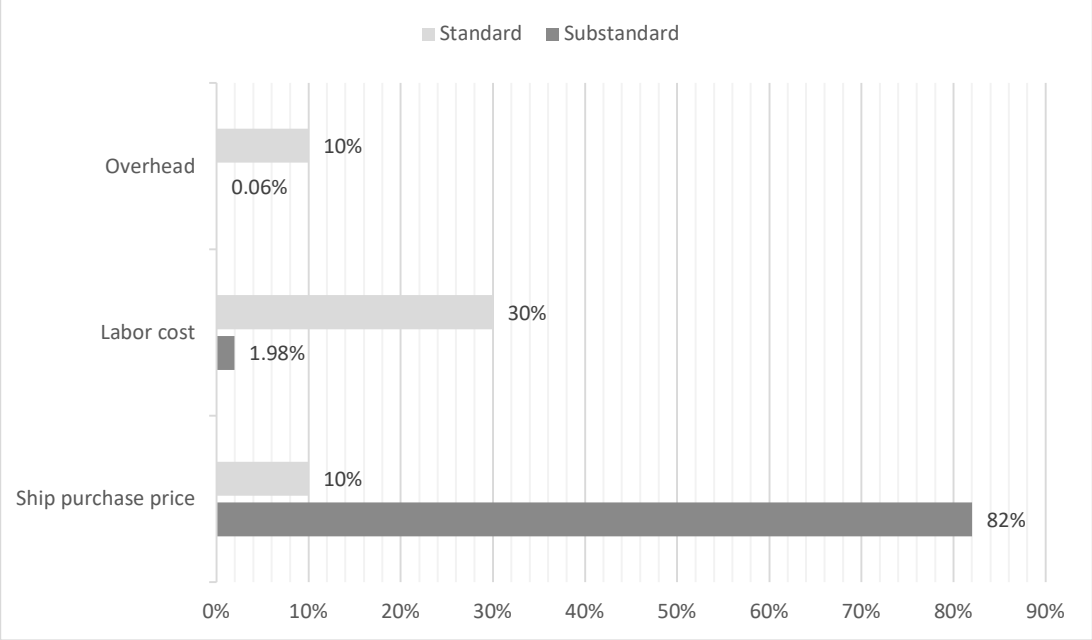

Figure 1. Expense Cost Difference

2.2.3. Ship Recycling to Improve Health, Safety, and Environmental Aspects in Ship Recycling Yards

Recycling decommissioned ships plays a vital role in the economy and sustainable development. India is a leader in the industry with its approach of converting waste into valuable resources. However, the process presents challenges in terms of Health, Safety and Environment (HSE). While the Hong Kong Convention (HKC) and European Union (EU) regulations have set standards for safer and more environmentally friendly ship recycling, there is a lack of concrete guidance on developing ship-specific recycling plans (SRPs). In a study examined six ships of different types being recycled in Alang, India, to develop SRPs and assess risks using what-if analysis [8]. The waste generated was classified based on the International Maritime Organization (IMO) guidelines, with findings that ship-breaking methods were relatively uniform across types. Key constraints included labor constraints, ship size, and changes in global steel prices. The average ship-breaking process for one ton of LDT takes about 1,762 man-days. Thus, it is important to improve the risk assessment approach and assist in regulatory compliance, by providing new insights into risk assessment and environmental impact mitigation strategies, which can help recycling facility owners improve efficiency and meet applicable legal standards, thereby promoting safer and more sustainable ship recycling practices in accordance with HKC and EU regulations [8].

2.3. Ship Sinking

Sinking is an alternative to ship dismantling. Ship sinking does not prioritize economic factors, therefore there are no conflicting interests. The function of ship sinking is useful for creating artificial reefs [3]. Ship sinking which functions as an artificial coral reef is a good economic move. Many tourists will come to visit the sunken ship. Some countries have successfully done it as an underwater tourist destination, including the Maldives, Egypt, Dominican Republic, and Fiji [3]. The type of sunken ship also affects the number of tourists visiting, for example, a sunken cargo ship will be less interesting than a sunken military ship or luxury ship. Meanwhile, a ship that has a tragedy story will be more interesting than a ship that was purposely sunk for an artificial reef program [3]. However, there are costs involved in sorting out hazardous materials. Choi revealed that there is a cost of approximately $309/light weight of the ship to do the ship sinking process, including the cost used for sorting PCB materials, towing and berthing, scuttling preparation, and execution of the sinking [6].

Ship scuttling, the deliberate sinking of ships, is employed for various purposes and involves complex environmental, economic, and forensic considerations. Environmentally, while scuttling can enhance marine habitats if properly cleaned and prepared, it also poses risks of pollution from residual fuel, asbestos, and heavy metals if decontamination is inadequate. Economically, scuttling may be less costly than ship recycling, especially in cases where reuse as a reef can support tourism and fisheries, but it forfeits the potential value of recovered materials. Forensically, scuttling requires strict regulatory compliance and documentation to ensure accountability, verify the ship's origin and ownership, and prevent illegal dumping or insurance fraud. Decision support must therefore weigh ecological impacts, long-term economic value, and legal transparency to determine whether scuttling is a responsible end-of-life option for maritime assets [3].

2.4. Ship Scrapping

The scrapping method for recycling ships, commonly known as ship breaking, involves dismantling decommissioned vessels to recover valuable materials such as steel, aluminum, and other reusable components. This process typically begins with the removal of hazardous substances like asbestos, oil residues, and other toxic materials to ensure environmental and worker safety. The ship is then cut into sections using gas torches or mechanical cutters, and the resulting parts are sorted for recycling or resale. Sustainable ship recycling practices are increasingly governed by international regulations like the Hong Kong Convention and the EU Ship Recycling Regulation to ensure safety and minimize environmental impact [9].

3. METHOD

This is a review paper on ship end-of-life strategies. At the beginning, researchers collected some articles related to the subject matter from various sources. Then, the researcher selected articles that specifically discussed ship end-of-life management in the form of ship life extension, ship recycling, and ship scuttling. After that, the researcher did analysis on the selected articles to draw a conclusion.

4. DISCUSSION

The price of purchasing quality used ships has increased by a factor of two to three over the past decade. It makes sense that ship owners have dramatically reduced their intentions for ship scrapping and instead have chosen to extend the commercial usage of older tonnage. The market for ship scrapping is driven by a number of variables. The supply of ships for demolition is mostly determined by the state of the freight market, the age and type of the ship, and existing and planned laws. The price of steel and the expenses related to the actual scrapping process directly affect market demand [10]. When the economics of their operations demand it, ships are sent for recycling; the disparity in prices reflects not only the labor and environmental costs associated with recycling ships but also, primarily, the varying internal demand and, consequently, the varying prices that recyclers receive for ship steel in each of these various economies [11]. In some countries, for example Bangladesh, 80%-90% of the national steel requirement is supplied by steel from ship scrapping [12]. This shows that demand for steel from ship scrapping is very high in the country.

From the three ship's end-of-life strategies, each strategy has its own advantages and disadvantages. When it comes to ship recycling, the spending cost depends on the region where the ship is dismantled. In South Asia, especially in India and Bangladesh, which do not apply international regulations in the ship recycling process, the costs required for workers and safety are very low. It proves that the level of workers' welfare and safety is not a great concerned. With minimal health and safety standards in the ship scrapping industry, it will certainly have an impact on the low costs required to carry out ship scrapping. These low costs are certainly something that can maximize profits [12]. However, it must be realized that the conditions of South Asian countries compared to China, the United States, and the European Union are certainly different. Choi found that there were around 22000 workers who depend on the ship breaking industry [6]. From this data, it is implied that the demand for work is very high, so if international regulations are implemented, it may increase labor costs, and can reduce net benefit costs. This may lead to a reduction number of labor to reduce the labor costs, because the business owners in the ship breaking industry certainly do not want to reduce their net benefits. Therefore, solving the problem of ship breaking processes that do not comply with regulations must be done wisely.

5. CONCLUSION

There are several end-of-life strategies that can be applied to ships that have reached the end of their operational life, such as extending the operational period, dismantling the ship, and sinking the ship.

Extending the operational period will increase the maintenance and failure cost. On the other hand, that strategy will be good if the cost-benefit are calculated correctly. So that the maintenance and failure costs can be fulfilled by the income derived from the increased operational period of the ship. Another strategy is ship recycling. Ship recycling is the most commonly used method, which required different costs depending on the method used, i.e. standard or substandard method. Moreover, it also plays a vital role in the economy and sustainable development. If the shipowner wants to do charity work, that is good for the environment and also for tourism, then ship sinking is the best way to go for ships that have reached the end of their operational life.

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