

Role of Naval Architects in Ship Recycling

Sivaprasad K. and Nandakumar C. G.

Department of Ship Technology, Cochin University of Science and Technology, Kochi-682022, Kerala, India

Abstract: The paper identifies twelve elements of ship recycling and highlights their respective roles and duties in a proposed ship recycling system. The source and items of knowledgebase for ship recycling have been brought out. A new philosophy focusing clean and safe ship recycling namely *design for ship recycling* has been introduced based on principles such as ecofriendliness, engineering efficiency, energy conservation and ergonomics. The role of naval architects in ship recycling industry has been described based on the above factors. The paper brings out the role of naval architects in ship recycling the way it has been practiced worldwide and proposed by regulatory bodies. The authors have brought out the new concept of *design for ship recycling* and various aspects of it. The role of naval architects in the practice of this new design philosophy which is ready to be embraced by the maritime industry has been reiterated.

Key Words: Ship recycling, naval architect knowledgebase, design for ship recycling.

1. Introduction

The last life cycle stage of a ship is its dismantling at any of the ship recycling yard. Ship dismantling has been treated as a hull steel recovering operation, which involves no major engineering activity other than gas cutting of the steel components. Ships carry a wide range of material onboard which sometimes include hazardous materials like TBT, PCB etc.,. In some cases the cargo residues may be high pollutants to the marine environment. The case of obsolete French Aircraft Carrier, Clemenceau which carried quite a lot of asbestos as insulating material and arrived for dismantling at the Indian coast is a typical example. Basel Convention organised by United Nations Environment Program (UNEP) considers obsolete ship as a hazardous waste [2]. It has been the presence of such banned and polluting component in the ships ready for dismantling that brings the concerned industry to notice of environmentalists and the legal system. Once the media and the social activists get involved in this, various issues including the engineering aspects and the risks of dismantling operators came into limelight. Institutions like

International Maritime Organisation (IMO), regulatory bodies like the ship classification societies, the academics and the intelligentsia deliberated on this and efforts are made to give the dismantling of obsolete ships, the status of a decent engineering industry. The efforts of IMO and other stake holders of the maritime sector have brought out a significant change in the industry by introducing the concepts of recycling during the end of life activities of obsolete ships and designating the name ship recycling to end of life disassembly activities carried out as per IMO Guidelines on Ship Recycling [5] in a ship dismantling yard. Ship recycling is a wider concept compared to ship dismantling as it envisages the ways and means to identify and classify various products and processes involved in dismantling of obsolete vessels and to formulate best practices for carrying out various processes leading to clean and safe end of life operations. In this context it may specially be noted that IMO has defined ship recycling as the best option for all time expired vessels.

Ship as an industrially designed and constructed product is essentially an output of the efforts of naval architects. The role of naval architects in various life cycle stages except in ship recycling has been well established and their duties are performed in a

Corresponding author: Sivaprasad K., associate professor.
E-mail: sivaprasad@cusat.ac.in.

systematic manner. Very few research attempts have been made in the field connected with the role of naval architects in ship recycling: Alkaner et al. [1] have compared the similarities of ship production and ship recycling highlighting the role *design fors* such as *design for environment* and *design for dismantling* in ship design. This paper has envisaged the need of extending the life cycle stage of ships to the end of life dismantling, going beyond the conventional life cycle concepts. However no specific remarks has been pointed out showing explicit role of naval architects in ship recycling processes Dilok et al. [3] have discussed the characteristics of the product structure in shipbuilding and the concept of *design for dismantling* of ships. Though no direct reference have been made on the role of naval architects in end of life ship recycling activities, some of the suggestions included in the deliberations have proved the essentiality of having principles of naval architecture and shipbuilding incorporated in ship recycling. Shahid [7] has stressed the need of having some of the important naval architectural calculations as a part of preparations for ready for recycling certification. IMO in its historic resolution on ship recycling [5] incorporated design for recycling as one of the important ship recycling guidelines. The topics covered under the guidelines underline the role to be played by naval architects in the matters connected with sustainable ship recycling. Sivaprasad et al. [9] have presented the importance of allotting a sustainable index for all ships based on product features of ships such as environmental friendliness, safety aspects and naval architectural & ship design attributes.

2. Elements of Ship Recycling System

Ship recycling has to be conceived as the reverse engineering process of modern shipbuilding and some efforts have been made here to connect the missing links between ship recycling and modern shipbuilding. The combination of the roles played by the following major elements identified in the ship recycling domain

and their mutual interactions can be formulated as an ideal system of ship recycling.

Ship owner is either an individual or a firm who has got the legal ownership of the vessel just before she is dismantled. As on today the ship owner has no role and responsibility in the issues related to ship recycling. Once he sells the vessel to the ship dismantling broker, he simply vanishes from the turbulent scene to be followed. Role of obsolete ship owners ends with selling of the ship and the owner is not a party to any of subsequent ship recycling activities, for the time being in the ship recycling industry.

Ship Recycling Brokers are international agents who participate in the auction bid and take over the charge of the ship before it is delivered to the recycling site. Ship recycling broker is yet another intermediate owner of the obsolete ship and his role is limited to negotiation of bids in the early stages of ship recycling activity. They are, just agents seen in these business ventures, and are not concerned about any issues related to ship recycling other than the monetary benefits.

Ship Classification Societies are very active and authoritative in other life cycle activities of seagoing vessels since their inception. However, at present their role in ship recycling is limited to preparing proposals, attending meetings and conducting research studies.

Ship Recyclers are supposed to provide all infrastructural facilities which regard to safe and eco-friendly dismantling of vessels and they constitute a strong link in the ship recycling chain. They work closely with other promotional and statutory bodies to deliver safe and smooth ship recycling. Currently, most of the ship recyclers are just providers of plot and basic infrastructure to the next element in the recycling chain.

Ship Recycling Subcontractors provide manpower and machines for the actual dismantling. They are responsible for employing trained personnel for dismantling operations involving risk and hazard. The work force employed by the subcontractors, the biggest

contingent of the ship recycling, and they are called as ship recycling workers.

Statutory Maritime Bodies, which have otherwise lot of statutory powers, are not actively involved in the ship recycling issues. The obsolete ship loses the status of a sea worthy vessel and comes out from the purview of maritime regulatory bodies. At present statutory maritime bodies seldom appear in the ship recycling scene unless and otherwise requested by the concerned legislative bodies and courts of law.

Promotional Bodies provide land, expertise, infrastructural facilities, man power training, transport, logistics support to the ship recyclers and the subcontractors. They are the custodians of important statistics regarding ship recycling activities including the accident rates, pollution effect, health hazards etc.,.

Pollution Control Boards/Safety Councils work as advisory bodies at present. Their roles and responsibilities are limited as far as safe and clean ship recycling is concerned. These agencies now work in tandem with the promotional bodies to create a clean, safe and productive ship recycling system and at present they attain active partner status along with statutory maritime department type institutions.

Steel Re-Rollers enjoy maximum benefit out ship recycling in all the major ship recycling countries and they usually set the national agenda for ship recycling. This is the case with almost all major recycling nations. They do not seem to contribute back to the development of ship recycling infrastructure... Re-rollers are one of the powerful links in the chain and with the current information their role is yet to be defined clearly.

Supply Chain Brokers include the agents who purchase various equipment and other onboard items which are kept for auction by the recycler/subcontractor after dismantling. These auctioned items are sold out as pre-owned or pre-used items. Most of these item and equipment re enter the domestic and industrial market through shop/shelf.

Non Governmental Green Organizations are the

international organizations involved in green issues and are active in ship recycling. There is a constant pressure from these NGOs on ship recyclers. They are now targeting ship owners than the ship recyclers for the lack of eco-friendliness in the issues in ship recycling. The presence of these Green NGOs has significantly influenced the functioning of the ship recycling promotional bodies and the ship recyclers.

Worker Forums are the trade unions and similar associations involved in this industry. They are actively participating in all the issues related to improving the status of present day ship recycling from the point of view of worker welfare and green issues. However their voice is not powerful. If these worker forums couple their activities with stronger international NGOs working in ship recycling and gain stronger position in bargaining.

3. Duties of Elements of Ship Recycling

Duties of the above mentioned elements of ship recycling can be generally classified based on the technical and nontechnical content in their field of activity. Activities of the technical elements are further divided into categories such as ship recycling processes undertaken during pre-dismantling, dismantling, statutory & regulatory operations as well as technical procedures and dealings involved supply chain of recycled products. Agenda of various programmes of the voluntary organizations associated with ship recycling sector are of activist nature and the corresponding elements of the system can be treated as nontechnical.

The important duties of owners of obsolete vessels and vessel brokers who are involved at pre dismantling stage can be identified as arranging documents and drawings necessary for making their vessels ready for recycling. The process includes preparing comprehensive list of all mandatory certificates and documents as prescribed by Green Passport requirements and relevant data regarding conditions of various systems of the obsolete vessels. All important

drawings such as General Arrangement, Access Plan, Tank Plan, Painting Scheme etc., are to be refurbished and kept ready for before the ship is decommissioned. The owners shall recognize that the information generation has to be accomplished with an active support from naval architects with good experience in ship design and life cycle management. A systematic and thorough inspection procedure has to be undertaken by a team of marine experts lead by a naval architect to assess and arrange the “*as is*” condition information of the ship ready for recycling. They should also ensure that this exhaustive obsolete ship status data have to be passed on to the broker so that the same will reach the ultimate ship recycling destination.

Ship recyclers and ship recycling subcontractors are the major elements of ship recycling system who are actively involved in the actual dismantling process. Since these two elements have to take the blame of any untoward incidents that may occur during ship recycling, they have to be fully aware of steps involved in the ship recycling process. The ship recyclers attain key role in the ship recycling system with a major thrust on responsibilities leading to clean and safe ship recycling. Ship recycler is responsible for implementation of statutory and classification rules on ship recycling and thereby it becomes essential that the ship recyclers fully understand the importance of best practices to be followed during the dismantling. Presence of naval architects is seen as an essential requirement, as statutory and classification rules are better appreciated and interpreted by them. Apart from imparting proper training on clean and safe ship dismantling they can guide the recyclers and subcontracting work force regarding the recyclability aspects of the dismantled products. This will ensure effective ship dismantling as far as the subsequent supply chain activities is concerned. The ship recyclers should be mindful that proper process planning of ship dismantling can be achieved only with the active participation of naval architects with ample shipyard experience.

Statutory & regulatory bodies which are connected with ship recycling sector play an important role in inflicting major developments in promoting the present inferior industrial status of ship recycling industry. The statutory & regulatory bodies which participate in the ship recycling system are statutory maritime bodies such as state maritime departments, pollution control boards, industrial fire and safety inspectorates, maritime development agencies and ship classification societies representing the national and regional governments. These statutory bodies which are to be associated with the ship recycling industry have to recognize that they should work in a similar fashion like their sister departments operating in various other important ship life cycle stages such as design, construction, operation, repair and survey. The statutory & regulatory bodies linked with ship recycling can achieve a lively role only by involving naval architects and marine technology experts well experienced in various maritime industrial operations. Ship classification societies which are employing naval architects and marine engineers with sound marine technology background are not yet ready to deploy their human resources in day to day functioning ship recycling yards. These agencies should take initiative to distribute important functions related to ship recycling to naval architects who can contribute positively to improve the status of the industry with proactive steps to implement both short spanned ship recycling process planning & control and long term sustainable development oriented policy decisions [11] in this sector.

Steel re-rollers and dealers of other dismantled products are included in the supply chain category. They have a secondary role in the ship recycling system as they operate partially outside the actual ship recycling base. Still they should recognize their role in the process and participate actively in the ship recycling activities. Guidance from consulting naval architects and marine engineers can be better utilized by the supply chain operators for deciding the

recyclability options [10] of dismantled products such as steel items, main engine, onboard equipment and systems.

Organizations such as NGOs and ship recycling workers forums should develop strategic action plan that will ensure fruitful participation of interested and experienced naval architects to find solutions to their problems and to formulate new proposals for sustainable ship recycling aiming at improved industrial status.

Present day issues related to the performance of ship recycling yards can be partially attributed to nonparticipation of naval architects and marine technology experts in the core topics in ship recycling. The general approach of ship classification societies possessing substantial resources in marine technology is reported to be not promising and this situation has really created a vacuum in the ship recycling industry as far as involvement of naval architects are concerned.

4. Information, Knowledge and Expertise of the Ship Recycling System

Ship recycling is an engineering industry where various branches of knowledge such as science & technology, engineering, management, law, economics, commerce and political science have been involved. Information base of these branches of knowledge as applicable to the development of a comprehensive

knowledgebase of ship recycling and the expertise required for developing it have been identified and presented in Table 1. The role of naval architects as a knowledge engineer in ship recycling activities has been clearly brought out in this table. The duties of the element of the ship recycling can be effectively put into performance only with the personnel with knowledgebase as indicated above.

The knowledgebase of the ship recycling .system can be effectively utilized by the industry, if an expert system is made out of it. Computer based expert system helps to provide recommendations for improving the situation in the ship recycling industry domain by collecting and analyzing data from the ship recycling system domain.

An expert system can be developed for the ship recycling practices which generally has major elements, like, data base regarding ship (Ship Data), codes, regulations and guidelines (Rules) and disassembly processes in ship recycling (Practices). The information model for such an expert system which has been developed for ship recycling activities is given in Fig. 1 and the role of naval architects as source of knowledgebase has been rightly brought out in this. The details of the development of the expert system are available elsewhere [8, 13]. Recommendations for best practices in ship recycling have been envisaged as the output from the expert system.

Table 1 Information base identified for development of knowledgebase of ship recycling.

Information Base	Knowledge	Expert
Innovation	R&D	Naval Architects, Production & Structural
Environment	Pollution and Hazards	Ecologists
Safety	Human /System factors	Safety & Production Engineers
Production Technology	Technology of Dismantling	Naval Architects
Information	Knowledge Base Engineering	Naval Architects and IT Specialists
Recycling	Energy	Production Engineers
Management	Recycling, Planning and Plant Layout	Naval Architects
Marketing	Demand Forecasting	Market Research Analysts
Finance	Cost and Accounts	Economists, Accountants
Regulation	Rules, Acts and Laws	Lawyers
Green Topics	Socio-environmental Impact	Green Activists

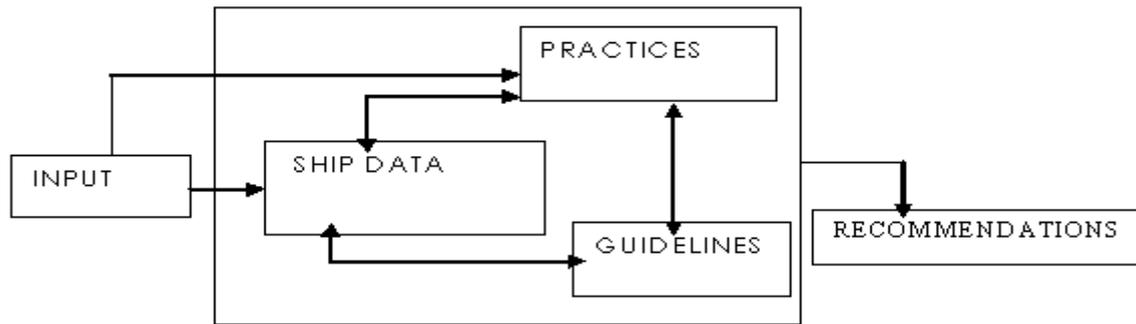


Fig. 1 Information Model of the Expert System.

5. Design for Ship Recycling Philosophy

In recent IMO conventions emphasis has been attributed to producing ships which are safe and environment friendly during their regular operation conditions [4]. Marine Safety Committee (MSC) a subsidiary of IMO in its 80th session calls for safety and environmental friendliness of the vessels in specific damage conditions too [6]. This requirement envisages a proper *design for recycling* which caters to the specific demands of IMO, i.e., minimizing marine pollution and reducing accidents causing loss of life and damage of property. The IMO guidelines on design for recycling of ships should be integrated with the ship life cycle system and can be called as *design for ship recycling* [12]

This *design for ship recycling* philosophy can be broadly based on the hull structural design, equipment manuals, knowledgebase on recycling, environmental factors, onboard materials, equipment & systems and general arrangement of ship.

5.1 Scope of Design for Ship Recycling

The scope of *design for ship recycling* in this context has been defined as various aspects that should come under the purview of *design for ship recycling* philosophy which will improve the efficiency of recycling of ships.

5.1.1 Design Philosophy

Happenings at the end of life of the vessels are not taken into serious consideration during initial stages of design and in the follow up activities in the life cycle by

the designers. Designers are still working around *design for production* and its contemporary *design fors*. Marine pollution related issues have created awareness among designers towards *design for environment*. Similar awareness has to be developed in recycling oriented design attributes as well. *Design for ship recycling* is the best way to address the environment and safety problems related to ship recycling. Implementation of *design for ship recycling* philosophy is essential for achieving sustainable development of international maritime sector.

5.1.2 Product Design and Development

Design for ship recycling envisages product design and development with easy parts and components assembly procedures. It gives more focus on integrated assembly of various identical parts. Simple product structure will always enable easy disassembly activities which in turn makes end of life dismantling of onboard equipment and parts less cumbersome. Dilok et al. [3] has discussed the characteristics of the product structure and concept of design for dismantling of ships. The scope of this concept has to be extended by incorporating five objectives of *design for ship recycling*, viz, environmental orientation and safety during operations, energy consciousness, use of state of art technology and ergonomics in all onboard operations including final and partial dismantling. Active and mandatory involvement of naval architects is essential for effective implementation of these attributes in ship life cycle operations.

5.1.3 Common Industrial Standards

Quality requirements of various industrial products for marine application are more stringent. Onboard systems are complex owing to the high standard of safety requirements and accessibility problems due to onboard space constraints. These characteristics of marine quality parts make recycling of equipment and components different from the common recycling processes adopted in civil construction. *Design for ship recycling* emphasizes common industrial product standards. Naval architects will have to seriously consider this concept while attempting different ship design spiral operations. Recycling activities and reusability of dismantled products with common standards can be easily compared. This will make recycling of ships less complex and more acceptable.

5.1.4 Product Standardisation

Product standardisation ensures improved quality and productivity in design and manufacturing in shipbuilding and this concept has been developed to support simplifying ship design procedures, minimizing different types of inventories in ship production, compatibility of component replacements in ship repair and ensuring implementation of essential international rules and recommendations by agencies such as IMO and IACS... This can be better achieved by introducing the fundamentals of naval architecture and shipbuilding in end of life ship recycling activities.

5.1.5 Process Standardisation of Ship Recycling and Proposing Best Practices

Standardisation of ship recycling process is as important as the product standardisation. For ship recycling to be more effective, both product and process standardisations should go in tandem. Process standardisation focuses on development of best practices for ship recycling operations. Ship recycling yard organisation, infrastructure support and lay out management of recycling yards constitute one part of the process standardisation. This part has been included in International Standardisation Organisation (ISO) standards [ISO/DIS 30000:2008]. This process standard covers all yard oriented issues in ship

recycling. Best practices for ship recycling activities, right from towing of the obsolete vessels to dismantling of the last component, constitute the second phase of the process standards. Process standards for the later part have been developed by Sivaprasad [8]. Ship General Arrangement (GA) design attributes such as accessibility, water/weather/fire tightness, availability of light, ventilation and features of materials and components act as fundamental frame work for the development of the best practices.

5.1.6 Environmentally Contraband Materials

Presence of environmentally contraband materials in hull structure, outfit items and machineries are considered as the most serious issue by the agencies involved in uplifting the status of ship recycling industry. Dets Norske Veritas has developed an onboard material inventory recording database, Green Passport addressing this special ship recycling issue. Participation of naval architects in the process of *design for ship recycling* can widen the scope of this inventory recording mechanism by proposing an extended green passport. Various characteristics of common onboard materials and cargo residues with respect to ship recycling activities can be prepared and can be used as an effective knowledgebase for safe and green shipbuilding.

6. Conclusion

The necessity for changing the ship recycling industry into sustainable industry based on 4E principles, i.e., ecofriendliness, engineering efficiency, energy conservation and ergonomics has been emphasized with due support from new concept of design of ship recycling. The role of naval architects as contributory elements to sustainable ship recycling and as the knowledgebase for ship recycling system has been identified and presented. The authors have brought out the new concept of *design for ship recycling* and various aspects of it. The role of naval architects in the practice of this new design philosophy

which is ready to be embraced by the maritime industry has been reiterated.

References

- [1] Das S. Alkaner, P. K. Smith, D. L. and P. Dilok, Comparative analysis of ship production and ship dismantling, in: Proceedings of the First International Conference on Dismantling of Obsolete Vessels, Glasgow September, 2006, pp. 3-17
- [2] Basel, Convention, Reports, Control of Transboundary Movements of Hazardous Wastes and Their Disposal, October, 2005.
- [3] P. Dilok, S. Alkaner and P. K. Das, Design for dismantling –Guidelines to facilitate reuse and recycling, in: Proceedings of the Second International Conference on Dismantling of Obsolete Vessels, Glasgow September, session-6, 2008, pp. 1-15.
- [4] S. Dimakopoulou, The IMO's work on ship recycling, International Conference on Recycling of Ships and Other Marine Structures, London, May, 2005, pp. 7-15.
- [5] IMO Guidelines-2003 Resolution A962 (23) IMO Guidelines on Ship Recycling, 2003
- [6] MSC 80/24 [2005] Report of Maritime Safety Committee on its eightieth session, May 2005.
- [7] M. Shahid, Ship recycling in Pakistan, International Conference on Recycling of Ships and Other Marine Structures, London, May 2005, pp. 39-48.
- [8] K. Sivaprasad, Development of best practices for ship recycling processes, PhD Thesis Submitted to Cochin University of Science and Technology, Kochi, India, 2010.
- [9] K. Sivaprasad, K. Dileep Krishnan and C. G. Nandakumar, Sustainable development index for ship recycling, Proceedings of Second International Conference On Dismantling of Obsolete Vessels, ASRAnet, Combined Universities of Glasgow and Strathclyde, Glasgow, September, 2008.
- [10] K. Sivaprasad and C. G. Nandakumar, Recyclability analysis of obsolete ships and products, Proceedings of Third International Conference on Dismantling of Obsolete Vessels, ASRAnet, Combined Universities of Glasgow and Strathclyde, Glasgow, September, 2010.
- [11] K. Sivaprasad and C. G. Nandakumar, Sustainable recycling of ships, in: International Conference on Recent Advances in Chemical Engineering, RACET_2011, Indian Institute of Chemical Engineers, Kochi Regional Centre and CUSAT, March, 2011.
- [12] K. Sivaprasad and C. G. Nandakumar, Design for Ship Recycling, *Journal of Ship and Offshore Structures*, available online at: <http://www.tandfonline.com/doi/abs/10.1080/17445302.2012.669264>, March, 2012.
- [13] K. Sivaprasad and C. G. Nandakumar, Expert system for ship recycling, *International Journal of Maritime Technology*, Royal Institution of Naval Architects, London (in press).