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Recycling Of Decommissioned Naval Fleet

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Abstract:

Main characteristic of ship recycling is the interdisciplinary nature of the engineering processes associated with it. These processes are multidimensional and have certain shortcomings, which make ship recycling a complex industry. The product design and life cycle stage management of naval fleet differ from that of merchant ships, still they also reach the same destination for dismantling. This demands implementation of new methodologies being implemented in merchant ship recycling, in naval ship recycling field as well. This paper presents two important ship recycling design and development tools, viz., Design for Ship Recycling and Recyclability Analysis which would add to the effectiveness of clean and safe recycling of naval fleet. Application of Design for Ship Recycling concept in naval ship design has been discussed. The concept of Recyclability Analysis of products and equipment with respect to ship recycling is presented as a guideline.

1.Introduction

International Maritime Organisation (IMO) the maritime agency of United Nations, which has been actively involved in maritime environmental protection and safety has defined Ship Recycling as the best option for "time expired vessels" [1]. Ship recycling is a maritime industrial activity involving series of technological processes which aim at safe and clean demolition of obsolete vessels. In fact the Second World War produced a different kind of fleet of vessels called "obsolete fleet" in countries such as United State, United Kingdom and Germany. Decommissioning of this fleet opened up a new type of maritime industry called "obsolete vessel scrapping". These observations from the international maritime history throw light on the significant contributions from naval sector in the development of ship recycling as a modern engineering industry.

In the United Kingdom, the ship breaking (former usage for ship recycling) industry was performing in its peak during post world war periods and Japanese ship scrapping industry recorded its maximum output just after Second World War [2]. The pioneering efforts on scientific ship scrapping came from the US defense agency dealing with disposal of large fleet of obsolete naval vessels immediately after the Second World War [3].

Many ships built two to three decades ago contain hazardous substances/ materials such as Polychlorinated Biphenyl (PCB), toxic paints such as Tributyltin (TBT), asbestos and heavy metals spread all over the hull and super structure of the ships. Handling and disposal of these materials are risky operations. Occupational health hazards and safety during removal are identified as the important potential threats during ship dismantling. The need of the hour is to formulate an efficient mechanism to facilitate clean and safe ship dismantling operations. Contributing operations are to be framed such a way that this all important objective is facilitated with better engineering efficiency, lesser environmental impact and higher economic benefits. Situations have since changed and fresh look at the present status of ship recycling as practiced today is essential for developing new strategies in this field.

2.Recycling Issues Of Naval Vessels

Dismantling does not appear as an aspect in the life cycle of ocean going vessels at present and this adds to the complexity. The activities involved in ship recycling have been identified and available elsewhere [4]. Schematic diagram of the flow of activities is shown in Figure 1. This is particularly true in the case of naval vessels. Disposal

procedures of obsolete naval fleet become more complicated compared to commercial ships due to several inherent naval architectural characteristics of the vessels and the fleet management polices followed by the naval force like,

- Additional decommissioning procedures to be followed for out-of–service vessel
- Presence of weapons and other classified equipment
- Presence of explosive and classified warfare
- Longer operational life of naval vessels

The naval architectural characteristics that make dismantling of warships different from the conventional merchant ships are attributed to,

- Presence of relatively large amount of non eco-friendly insulation, deck covering, ceiling and bulkhead paneling items.
- Highly streamlined hull shape with minimum flat bottom, presence of passive and active fins and domes fitted on outboard of the hull.
- More number of living and service compartments with minimum access
- Congested machinery room with numerous non standard equipment

These factors can be included as issues related to ready for recycling and some of the related aspects have been discussed under the following subheadings.

2.1.Vessel Ownership And Ship Recycling Brokers

The decision of decommissioning of naval vessels is influenced by several factors unlike the commercial interest as in the case of other merchant ships. The decision on decommissioning of naval vessel is not influenced by any type of recommendations or guidelines from any type of international maritime agencies. Naval vessels which are built under memorandum of understanding with foreign countries will have special reference to decommissioning, which may impose restrictions on recycling or reuse of hull construction materials and onboard equipment. Due to these restrictions, recycling of hull and onboard items may not be carried out as it is done in the case of merchant ship recycling.

2.2.Hull Shape And General Arrangement Of Naval Vessels

If permitted by the naval ship recycling policy the most efficient way to recycle decommissioned naval vessels is by beach method. Beach method of ship recycling involves beaching of the decommissioned vessels in shallow waters and wide sand

beaches available in the coastal regions and dismantling process of the ships are carried out as a disassembly process of hull structure and onboard equipment. The dismantled products are buffered in the same beach and later moved to a storage yard. The vessels are hauled further into the beach as she gets lightened after removal of hull parts and equipment. The hauling in operation will be spread over a number of stages. This operation should be considered as potentially unsafe as the sliding contact area between the bottom hull and beach sand will be less due to the extreme "V" shape of the hull. . Beaching process of the vessels with "V" shaped bottom will be more risky and more specialized beaching processes will have to be formulated.

Usually the General Arrangement of naval ships will be a set of thickly packed cabins and spaces. Tanks and void spaces will be narrow with minimum access standards. Dismantling operations will be tough due to the space constraints. Adding to the difficulties of the dismantlers more outfit items and installation will be present in these confined spaces. Due to excess curvature of side shell, dismantling operations like gas cutting, paint removal and free falling may not be as easy as they are done in conventional merchant ships.

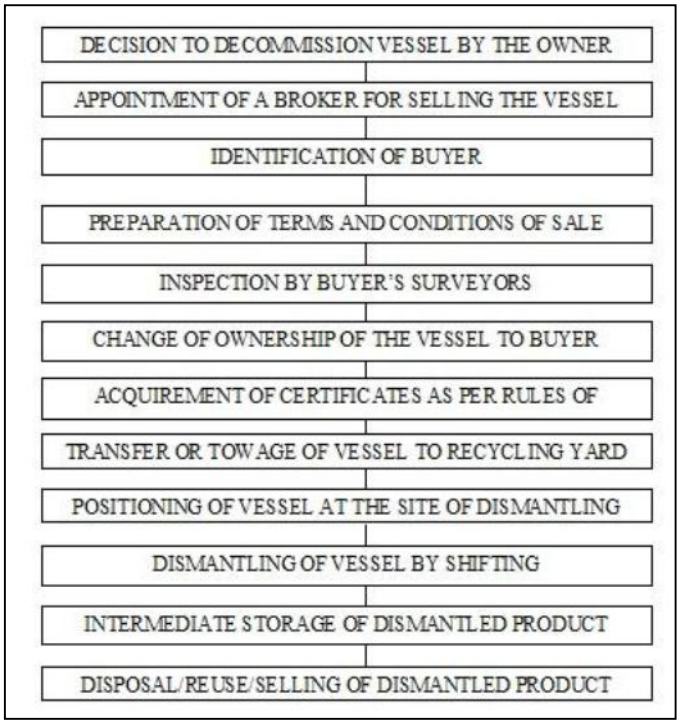

Figure 1: Schematic Diagram of Flow of Activities in Ship Recycling

2.3.Onboard Outfit Installations And Materials

Unlike merchant ships naval ships carry many more outfitting item such as equipment, systems, explosive armaments, paneling materials and specialized weapons. In hull material also special types of alloys may be present. The present day practice of recording and reporting of hazardous materials as suggested by IMO cannot be directly implemented in recycling of naval vessels.

2.4.Life Span Of Naval Vessels

Naval vessels in general serve more numbers of years at sea due to high standards of design for various seaworthiness factors. As they are subjected to less severe sea conditions during their life time, these vessels may stay active in the fleet for more periods. So present day naval ships in active service may be carrying some of the materials such as PCB, TBT, Asbestos etc. which are banned by international agencies.

3.Getting Ready For Recycling

Activities in the present practice of decommissioning of naval vessel are identified and presented in Figure 2 [3]. The current practice of preparing for "ready for recycling" of naval ships has the following drawbacks namely, limitation of the entire preparation to end – of – life stage; the preparation is limited to listing and reporting of onboard materials and systems and omission of facilities and capacities of recycling yards in the recycling plan.

In order to eliminate these drawbacks and to facilitate efficient ship recycling processes, a methodology of recycling covering the entire life cycle stages of vessels has to be implemented. This methodology also has to focus incorporation of salient features of naval architecture and ship building in its frame work. IMO has issued certain guidelines in this direction [1] i.e. implementation of design for recycling for facilitating sustainable development. These guidelines for ship recycling can be used to focus recycling of naval vessels also.

4.Design For Ship Recycling

Various 'design for concepts' such as design for recycling [5], design for environment [6], design for dismantling [7] and design for repair and surveying [8] are involved in Design for Ship Recycling and those focus on efficient end-of-life cycle issues such as disposal, dismantling and recycling. Design for recycling methodology cares for the

end-of-life cycle activity more than the other major life cycle activities [5]. However the actual benefits of adopting design for recycling are fully received during the last life cycle stage of a product. The application of design for recycling will become essential as the naval vessels should ultimately go to one of the commercial ship recycling yards operating elsewhere in the world, if flag state does not have any special ship recycling facilities.

IMO guidelines for ship recycling give broad definition of design of ships for facilitating recycling. The outline of the definition given by IMO is s follows:

"Design for ship recycling is a set of design tips which include proper design/selection of structural parts, equipment, material and knowledge base that will facilitate the following,

- Clean and safe partial/ full dismantling of ships
- Maximum use of recycled products/parts in ship production
- Reduction in number of inseparable components/parts in onboard equipment assemblies".

A modified definition of design for ship recycling incorporating, features of life cycle stages , which are instrumental in sustainable development, has been presented by the authors as,

"Design for Ship recycling is a set of design and development activities spread over the entire life cycle stages of a ship, incorporating ideas for design/selection of structural parts, equipment, material and knowledge base that will facilitate clean and safe partial or end of life recycling of ships and her components". This definition will help for the practical implementation of design for ship recycling in shipbuilding.

Modeling the life cycle stages of a ship is the first step of implementation of design for ship recycling. Conventional life cycle stages include only design, construction and operation. A schematic of the proposed life cycle stages has been given in Figure 3, which incorporates recycling also.

Based on these four lifecycle stages, a model for life cycle stages for ship recycling is given in Figure 4 which can be put into practice for naval vessels.

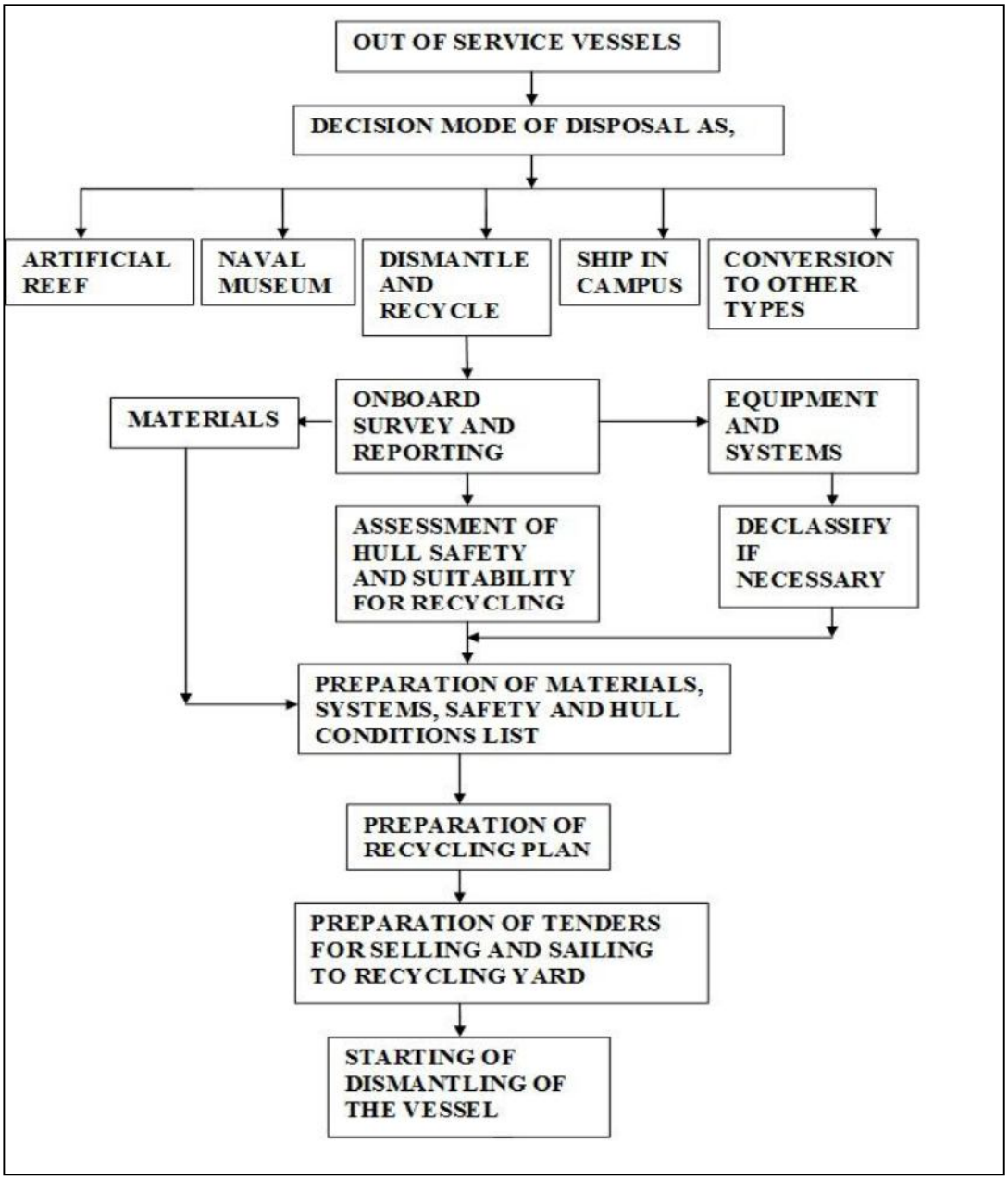

Figure 2: Flow of Activities in Recycling of Naval Vessels

In the concept design stage itself various steps regarding ship recycling activities will be considered. In this context ship recycling does not always mean end-of-life activity involving total dismantling of the vessel. Ship recycling can be any type of partial dismantling also. Conversion has to be treated as a partial dismantling and sale of vessels to another country or putting them for some other defense operations within the country involve conversion and subsequently fall in the category 'partial dismantling'.

Survey, both by a common ship survey wing, warship overseeing team and external defense agencies are considered in the life cycle. Operationally dormant stage corresponds to stage after decommission and waiting for the actual mode of disposal. Activities in these stages like Green Passport [IMO 2003] preparation, safety assessment of onboard handling operations play vital role in design for ship recycling.

Guidelines on design for ship recycling have been given in elsewhere [4]. These guide lines are modified suitably to formulate design for recycling of naval vessels, and presented in Table 1.

5.Implementation Of Design For Naval Vessel Recycling

Design for ship recycling is a sustainable development mantra driven design philosophy and is not a one time activity in shipbuilding .As effective implementation can be achieved by the detailed analysis of life cycle stages based on naval architecture expertise the importance given to end-of-life activities with a positive influence of clean and safe recycling. The knowledge base available with modern Information Technology attributes like expert system can be made use for this purpose. The usability potential of products and parts which are entering their end-of-life stage has to be identified and highlighted in the recycling activities.

Each type of naval vessels has different life cycle stage features. Since most of the naval design are classified documents the life cycle management is completely confined to defense logistics.

6.Recyclability Analysis

Besides the application of expert system, recyclability analysis is another tool that can be used in this context. Scientists, engineers and technologists have been trying to find various solutions to tackle the ever increasing threat from accumulating unusable and waste products and components from the marine industry. In this context it is worthwhile for the designers to look into the concept of recyclability of obsolete ships and components. Recyclability analysis will help the designer to identify the components/equipment which is more likely to be refurbished and then reused at the end of their life. Ships and offshore structures are massive structural units which contain considerable amount of hazardous materials. They produce huge quantity of hazardous waste and other non-reusable materials. Recyclability analysis of ship's hull and other onboard items will be helpful in sorting out major issues caused by such structures while

in operation, partial dismantling and during end-of-life dismantling. The scope of recyclability analysis of such structures span over the entire life cycle of the structures and it will be a continuous process. Recyclability analysis acts as good tool even during selection of a component/equipment in the initial stages of design. Functional and economical criteria are also being considered along with this analysis.

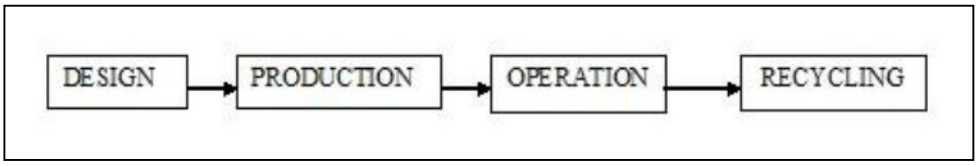

Figure 3: Life Cycle Stages of ships

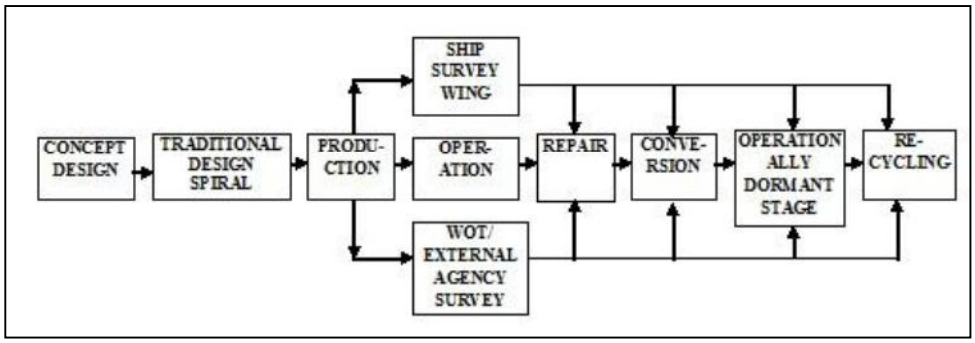

Figure 4: Proposed Model of Comprehensive Life Cycle of Naval Vessels

Recyclability analysis starts with identification of eligibility of materials present onboard. In this step a detailed study of the present environmental and occupational safety status of each and every material present onboard is made. If possible the failure status may be predicted using available techniques. Rules and regulations existing on the use and recycling of the materials may be thoroughly referred for assessing the status. Recycling or reuse option for an equipment /component is made after a recyclability analysis based on environment impact criteria.

The same is used to take decisions on how to minimize the quantity of materials dispatched for land fill. Statutory and surveying agency representative may also be consulted in case of exceptional interim to be included in the design. Since the life cycle of a vessel extends up to 20 years and sometimes beyond, the analysis is not as easy as it appears. Some indexing methodology has to be adopted for finding out the characteristic of a component/equipment with regard it its recyclability.

Sl. No	Ship design attributes	Major areas to be addressed	Design recommendation
1.	Preliminary Ship Design	Structural design	- Easy and safe removal of hull and out-fit while dismantling
		Material selection	- Use of recycled materials - Minimize usage of materials difficult to separate into individual elements.
		Ship recycling knowledgebase	- Preparation of Green Passport - Design and development of Recycling plan.
2.	Design of outfitting items and layout	Equipment design	- Easy removal and safe access - Use of recycled materials as parts and components
		Selection of equipment	- Maximization of usage of reconditioned/recycled equipment
		Ship Recycling documentation	- Ship Recycling plan with detailed equipment removal and dismantling description
3.	On board Hazardous substances system design	Material selection	- Minimization usage of hazardous and potential pollutants materials in onboard system and equipment
		Waste management system	- Develop production system design which minimizes routine and end of life waste generation. - Design and Development of waste treatment and efficient waste disposal system.
		Ship Recycling Knowledge Base	- Preparation of Green Passport - Equipment product specification documentation to support Green passport implementation. - Use of sustainable development indices indicating the green point of equipment, components, hull parts

Table 1: Recommendations for Design for Naval Vessel Recycling Based on IMO Guidelines

The onboard materials are categorized on the basis of direct reusability, possible recycling capacity, non-conversional energy generation capacity and land filling nature

of the components [7]. These are the four major recyclability options for a dismantled product. After the categorization is done based on the options of the dismantled components, the information generated should be compiled and edited. For the direct reuse of components assessment is made on the reuse capacity after a fixed period of continuous onboard usage. Potential buyers are identified and a list is generated for further use. An environmental and safety index can be assigned to the components at this stage itself. In the case of recyclable components, best practices for recycling can be generated and documented. These best practices are described in detail elsewhere [9]. These documents will be helpful for facilitating clean and safe recycling of the components during partial or end-of-life recycling stage. In this category also potential recycling agents are to be identified and located. All these activities should constitute a recycling plan for each individual recyclable component. Intermediate assessment and up gradation of the plan should be an essential part of recyclability analysis. Similar procedures are done for dealing with onboard materials which can be used for generally non-conventional energy after they are dismantled from the ship. No onboard material should be left untouched in the recyclability analysis. All materials which can be used only for land filling are to be identified in a rigorous manner. Components in this category form the biggest threat to the sustainable development. The problem associated with land filling of these materials should be specially noted and documented effectively. Rules and regulations in this regard are to be carefully examined before arriving at a feasible land filling plan.

Since many aspects regarding naval ships on the recyclability mentioned above are classified information, the scope of this naval application rests on the hands of navy.

7.Conclusion

As more and more indigenously developed designs are appearing in the naval fleet, application of design for ship recycling will be rather effective. Computer based data generation and compilation is an essential activity in this approach and an active support from a Decision Support System is also desirable for integrating various naval and commercial standards while attempting various naval ship recycling issues.

This paper addresses the issues related to recycling of naval vessels. Various stages of ship recycling and importance of them in naval vessels have been discussed. The necessity for implementation design for recycling philosophy has been highlighted with proper emphasis on role of naval architect expertise and recyclability analysis.

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