EXPERT SYSTEM FOR SHIP RECYCLING

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K Sivaprasad and **C G Nandakumar**, Cochin University of Science and Technology, Kochi, India

SUMMARY

Ship recycling has been considered as a low technology industry. It has been established that there are more than a dozen stake holders in ship recycling having their own interests and roles. Apart from this, most of the ship recycling activities are carried out with poor infrastructure support and without adhering to proper safety and environmental standards. A Knowledge-based support is the need of the hour for improving the status of ship recycling industry. Knowledgebase support in the form of a computer based expert system encompassing entire ship recycling activities is considered as a very useful step in this direction. This paper presents the need for a user friendly expert system for ship recycling process. Two important functions of the expert system have been presented, one for the Administrators, the stake holders at the helm of the ship recycling affairs and second one for the Users, who execute the actual dismantling have been presented.

1. INTRODUCTION

Ocean going ships are massive in size and complex in their constitution. A ship in general have a life span of more than 20 years and the life cycle of a ship starts from concept design and ends in recycling [1]. A schematic showing the life cycle stages of ships is given in figure.1. Well developed technologies and management techniques are available to support various activities of all the life cycle stages of a ship except recycling. The importance of ship recycling has been realised and taken up by various maritime agencies. International Maritime Orgnisation (IMO) defines ship recycling as the best option for all 'time expired or obsolete' ships [6]. A modified definition of *design for ship recycling* has been presented by the authors as, "Design for ship recycling is a set of design and development activities, incorporating ideas for design/selection of structural parts, equipment, material and knowledgebase that will facilitate clean and safe partial or end of life recycling of ships and her components"[14]. From among the Beach Method, Buoy Method and Dock method, the most commonly adopted method of ship recycling is the beach based method where obsolete ships are beached in shallow sea basins with long shelf bed and high tidal variations. Beach based method is an economically viable method as practiced in Asian countries owing to the low infrastructure support required and the possibility of low technology application in the recycling process [12].

2. INVENTORY OF HAZARDOUS MATERIAL

The diverse materials found in ships range from the most commonly used mild steel to the most hazardous radioactive materials. At present ship recycling is graded as a low technology industry with limited infrastructure and support facilities. There is no proper flow line practiced in the yard resulting in low productivity, higher risk rates, potential pollution during dismantling, handling, storage and re-entry of poor quality dismantled parts and components into the fresh product market. A low technology industry located in a remote coastal belt with low safety standards attracts only semi-literate and unskilled workforce. This workforce lacks general engineering orientation and awareness on safety and environmental issues. In the ship recycling industry the engineers and authorities are faced with the serious problem of lack of data for undertaking tasks, like major repair, refit, conversion etc.

IMO has successfully intervened in this critical area and has made it mandatory for all ships to have a list of inventory of all the onboard materials, which is named as Inventory of Hazardous Material [2]. Preparation of Inventory of Hazardous Material is considered only as the beginning of the creation of knowledgebase for assuring clean and safe dismantling of obsolete ships. An effective knowledgebase on ship recycling is lacking in the scene and establishment of a comprehensive knowledge data base is felt as an essential pre-requisite for improving the quality and productivity of the ship recycling industry. [9].This knowledge data base can be further used to develop a user friendly computer based expert system for ship recycling.

3. BEST PRACTICES IN SHIP RECYCLING

Formulation and implementation of Best Practices are essential for all industries to improve the quality and productivity. Ship recycling is no exception to this. Moreover application of Best Practices is an urgent need to pull out this industry from the status of being a risky and pollution generating one. Best Practices in ship recycling may not be strictly a part of the stringent rules and regulations, but it should be a set of voluntary measures taken by the industry to contribute to the sustainable development of the maritime industrial sector. These practices are considered by DNV [4] as the best possible option to improve the quality of ship

recycling industry. The proposed best practices include the following,

- Development of conceptual model of *Design for Ship Recycling* incorporating naval architectural content and integration of this in ship design
- Development of user friendly expert system for ship recycling processes
- Generation of schedule of estimation of ship recycling work content
- Allotment of sustainable development index based on green and safety aspects of ships

A detailed account of implementation of design for ship recycling methodology as Best Practice in ship recycling activities has been brought out by Sivaprasad [2010]. The most effective way of generating best practices is in the form of a user-friendly expert system which addresses the issues related to ship dismantling. The issues related to the allotment of sustainability development index based on various aspects such as environmental friendliness, safety during operations and energy conservation of onboard systems are described elsewhere [3],[7],[15].

4 SCOPE FOR EXPERT SYSTEM FOR SHIP RECYCLING

Though there is ample scope for developing a computer based expert system in ship recycling, only a few attempts have been made so far in the related fields. Sibal [13] has described the process of development of a software tool and associated knowledgebase in ship recycling giving special emphasis to costing, database of recycled parts, technologies used in the cutting processes and waste processing. Karpowicz et. al [9] have elaborated the need for a proper and efficient knowledgebase to support healthy ship recycling activities all over the world. Koumanakos et. al [10] have considered various factors and steps involved in ship recycling, and propose an information framework that supports dynamic simulation of decision making for the scheduling of dismantling of obsolete vessels. Gramann [5] has given an overview on the background of data management and development of an appropriate tool incorporating the needs and requirements related to the new legal instrument by IMO on ship recycling. Karacapilidis et. al [8] have presented a noteworthy paper on development of a web based decision support system for planning of dismantling activities for ship recycling yard which provides an insight into the analytical modeling ship recycling operations focusing on collaborative modeling and management of ship dismantling yard activities.

Computer based experts system tools are highly useful for those who sit at the helm of affairs of the ship recycling activities as they can get easy and accurate access to the relevant decision support regarding complex ship recycling processes. The focus of an efficient and smooth recycling should be the end users who may not be as technically sound as a production engineer or naval architect. The aim of this paper is to reach to the bottom level of ship recycling processes by offering the support of knowledge based expert system for ship recycling.

In order to make expert system software more effective and user-friendly, the potential users of the software should be identified. Like any other maritime industry, ship recycling has also many stake holders. Ship recycling is an engineering industry where a number of science, technology & engineering branches find their applications. The expert system for ship recycling should be versatile enough to address the problems and to offer respective solutions as 'Best Practices'. The major stakeholders of the ship recycling system have been identified and their important interactions are depicted in figure. 2.

As shown in the figure. 2, the centre of ship recycling activities is the ship recycling yard where most of the dismantling activities are carried out. However ship recycling activities commence right from decommissioning of ships, a decision taken by the owner. Thereafter many important procedures, commercial as well as technical, are undertaken before the actual dismantling is done. In between the decommissioning decision and actual dismantling of the obsolete vessel, many stake holders come into the ship recycling scene. Efficient ship recycling is possible only by close interaction between the stake holders. A knowledgebase support is essential for coordinating smooth interaction among the participating stake holders and that is what is additionally achieved with development and implementation of a computer based expert system.

4.1 STRUCTURE OF THE EXPERT SYSTEM

The knowledge based expert system has been developed for application in ship recycling and has been named Ship Recycler Recommender (SRR). Schematic diagram of the structure of Ship Recycler Recommender (SRR) is shown in figure. 3. It has three components viz., knowledgebase, processor and output system. Inputs consist of main particulars of the ship, general information regarding year of build, ship classification details, onboard materials and systems present, information regarding cargo and fuel oil carried by the vessel and special features of the vessel, if any. These inputs which are entered into the expert system are analysed and processed to generate recommendations as the output. This output will be in form of two reports which are 'Best Practices for ship recycling 'and 'Handling Recommendations for onboard materials' where the latter is named as 'Extended Inventory of Hazardous Material' as the

recommendations are developed as an extension of the existing Inventory of Hazardous Material concept.

4.2 ARCHITECTURE OF THE EXPERT SYSTEM

Ship Recycler Recommender (SRR) is a web based General Adviser type expert system. It deals with issues associated with beach based ship recycling. The application interfaces with the web server software as well as the database engine at the system level. User actions on the website are passed on to the web server which in turn relays the result of the action to the web browser of the User. The SRR leverages the Dot Net platform and JET database engine to serve requests through Microsoft Windows based Web server. On the server side, the web application is hosted on windows based web server called Internet Information Services 6.0 and connecting to a local Microsoft Access database. The web server shall be listening on the web standard port, port 80. The system being a web based application, clients shall be able to use the software on Internet Explorer 6 (or the later versions) with cookies enabled. The client computer should have an Internet connection in order to be able to access the system. A Windows PC which runs IIS 6.0 should be used as server. This server will accept all requests from the client and forward SRR specific requests to the Container with ASP.Net 2.0 hosting SRR.

4.3 IMPLEMENTATION OF THE EXPERT SYSTEM

SRR is a one off its kind web based software. It is an expert system in its role of suggesting how things need be done in a complicated scenario. SRR allows users to generate ship specific recommendations accurately using an intuitive web based Graphical User Interface.

When a ship is required to be beached, SRR will generate ship specific recommendations considering economical, environmental and health and safety Aspects. It would also generate recommendations for reusing / adding value to the scrap generated. These recommendations will be based on ship type, age, any specific equipment and data from the Extended Inventory of Hazardous Material (EGP) and also from all relevant applicable rules and regulations. SRR will have provision to incorporate the updates in the rules and regulations in ship recycling implemented by various agencies.

Very detailed engineering specifications on dismantling are not in the purview of SRR. The ways and means to accomplish the tasks are the responsibility of the supervising engineers and foremen. Local rules and practices are not included in SRR as it is not commonly available. However the users can incorporate these rules with the help of the administrator of SRR.

Ship Recycling Yards, Owners and Ship Classification Societies can use this software, which will be available on a web server. This means stakeholders around the world can have a piece of the action. Users will have usernames and passwords for logon and once logged in they can generate reports for a specific ship.

User interacts with the SRR through predefined QUESTIONNAIRE. The QUESTIONNAIRE constitutes the major web interface mechanism of the software. The entire ship recycling processes and information regarding onboard materials are moulded into a QUESTIONNAIRE form and presented in the main web interface input. Apart from this, main particulars of the vessels are included in the interface. Each QUESTION appearing in the input format either represents a main particular of the vessel or a related activity associated with ship recycling. For example, presence of mercury as an onboard material is noted by a QUESTION, “is mercury present in any of the equipment onboard?’. If the answer is “Yes”, the data is accepted and the same is connected to RULE(S) regarding handling of mercury, material data record of mercury, a spread sheet containing possible locations where mercury can be present as a component/part in equipment. RULES constitute the main decision support database of Ship Recycler Recommender. These are a set of information and recommendations as guidelines which contain the Best Practices part of ship recycling processes. Figure. 4 shows the set of RULES applied to a sample SRR ship recycling report generation exercise on the extreme left side of the SRR main page screen.

Effective implementations of the recommendations provided by SRR in the form of ship recycling reports will certainly benefit the performance of the ship recycling yards. SRR is not a production version and has some limitations which can be resolved in later revisions.

4.3 (a) Web Interface of the Software

Provisions are made in the program such that the input details can be provided by the User as well as the Administrator. Administrators in addition to being able to create reports, can also modify the report generation RULES as well as add or delete new ship recycling activities and are able to modify user interface. Ship classification societies, ship recycling promotional bodies can be treated as the Administrators of the software, where as ship recyclers, their contractors, pollution control bodies and dismantled product logistic providers can be its Users. For instance, if a new practice for handling a hazardous onboard material is introduced, the same can be incorporated as a RULE in the expert system structure by the Administrator. This additional rule will be made available to the User when he logs in after the administrator modifies the expert system utility. The main page of web interface of SRR

is given in figure. 4. This web interface is available both to the Administrator as well the User. This page gives details regarding the type of vessels for which SRR can be applied (under the heading 'Vessels') and the activities for which the 'Best Practices' can be generated (under the heading 'RULES'). The activities listed under 'RULES' can be further expanded by clicking on the relevant texts. Users can start the task of generating ship recycling report of their vessel by clicking on to 'New' button given under generate 'Reports'. Already generated reports (and inconclusive previous report generating sessions) are also listed in the main page. Administrator can add new RULES and vessels using this main page. Detailed descriptions of important functions of SRR are discussed in the following sections.

4.4 GENERATION OF SHIP RECYCLING REPORT

User can log into SRR and click on the desired ship type for which he needs a ship recycling report. The User can create a report for a new vessel by answering the relevant queries available in the SRR input interface. A detailed ship recycling activity report consisting of Best Practices for ship recycling activities for which inputs have been entered and a detailed recommendation on handling of onboard materials (Extended Inventory of Hazardous Material) will be generated. This report can be used as the basic reference document for the recycling activities to follow on that particular ship. Options for 29 ship types listed in the Lloyds World Fleet Statistics [11] are provided in the system. 59 onboard materials covering IMO guidelines A 962(23) and common bulk cargoes are incorporated in the database of the present system. The main web interface input screen of selected ship type 'Bulk Carrier' for the new report generation is given in figure. 5.

Two additional report generation options are also provided to make the software more user- friendly. The User can go through already generated reports and can continue a report generation session which was to be concluded in the previous attempt.

4.4 (a) Adding/Editing/Deleting RULES

'RULES' constitute the main database of Ship Recycler Recommender. These are a set of guidelines and recommendations which contain the Best Practices applicable to a particular ship recycling activity. Ship recycling activities which appear as QUESTIONs in the user input web interface are connected to these RULES and the 'Best Practices' for the activities are generated. RULES can be added, edited or removed as per the data available on new developments in the ship recycling field. Relevant information associated with safe and clean ship recycling can be uploaded as attachments with the RULES. The attachments can be of various types including flow charts, spread sheets, document repositories, video formats etc. The web interface sheet depicting the editing of RULES is shown in figure.6.

The display order of the RULES also can be changed if the administrator feels so, for the user-friendliness of the software.

4.4 (b) Adding New QUESTIONS

The interface mechanism is a set of QUESTIONS prepared and incorporated in the database of SRR. Knowledgebase of ship recycling processes and onboard materials may change from time to time in tune with the new technological developments in shipbuilding. New statutory and other rules and regulations come into force frequently in the international maritime sector. These factors will influence the ship recycling processes also. In this context frequent updating of database and corresponding RULES in the SRR software becomes necessary. New QUESTIONS can be added, if required by a new development in ship recycling, in the software. This updating can only be carried out by the Administrator. Addition of QUESTIONs can be done by entering 'new report' interface screen and activating 'add new' button. The same button can be used for editing and deleting the QUESTIONs which become irrelevant in the wake of new developments. The input data can be specified as numeric value, "Yes/NO" type or multiple selections. New QUESTIONS or edited QUESTIONS should be saved for making it as a part of the program. Similar input procedures as in the case of adding new QUESTIONS are followed in editing/ deleting existing QUESTIONS. Editing a QUESTION is necessitated by changes in rules and regulations in international shipbuilding and ship recycling operations.

4.5 OUTPUT OF THE EXPERT SYSTEM SOFTWARE

The user output will contain recommended Best Practices for relevant recycling processes and Extended Inventory of Hazardous Material explaining details regarding handling of various onboard materials present in the vessel. One of the items in the ship recycling report generated by SRR for a vessel i.e., 'Best Practices' (initial part of the text only) for removal of asbestos from the vessel is given in figure.7.

5 CONCLUSIONS

A pioneering effort has been made to develop a model of ship recycling adopting systems approach in the present study. A web based user-friendly knowledge based expert system operational in a PC enviornment has been developed for Ship recycling. The implementation of SRR has been successfully accomplished in web based and user friendly manner

with multi-user support facilities. The expert system has been designed in such a way that the administrators of the system can make suitable modification and make it updated with the latest situation in the field. The input to the expert system includes main particulars of the obsolete vessel, year of build, builder and classification details, information regarding various onboard materials and systems, and hull, structural and outfitting components. The output of the expert system is in the form of Ship Recycling Report. The report has two parts, i.e.,'Best Practices' for ship recycling processes and 'Extended Inventory of Hazardous Material' for handling recommendations of onboard materials.

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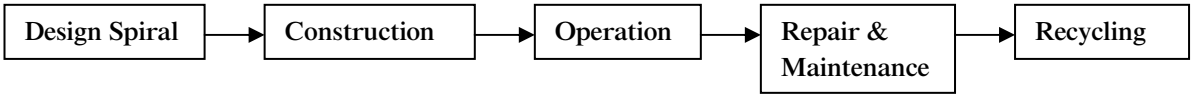

Figure.1 Modified Model of Life Cycle Stages of Ships Alkaner [2006]

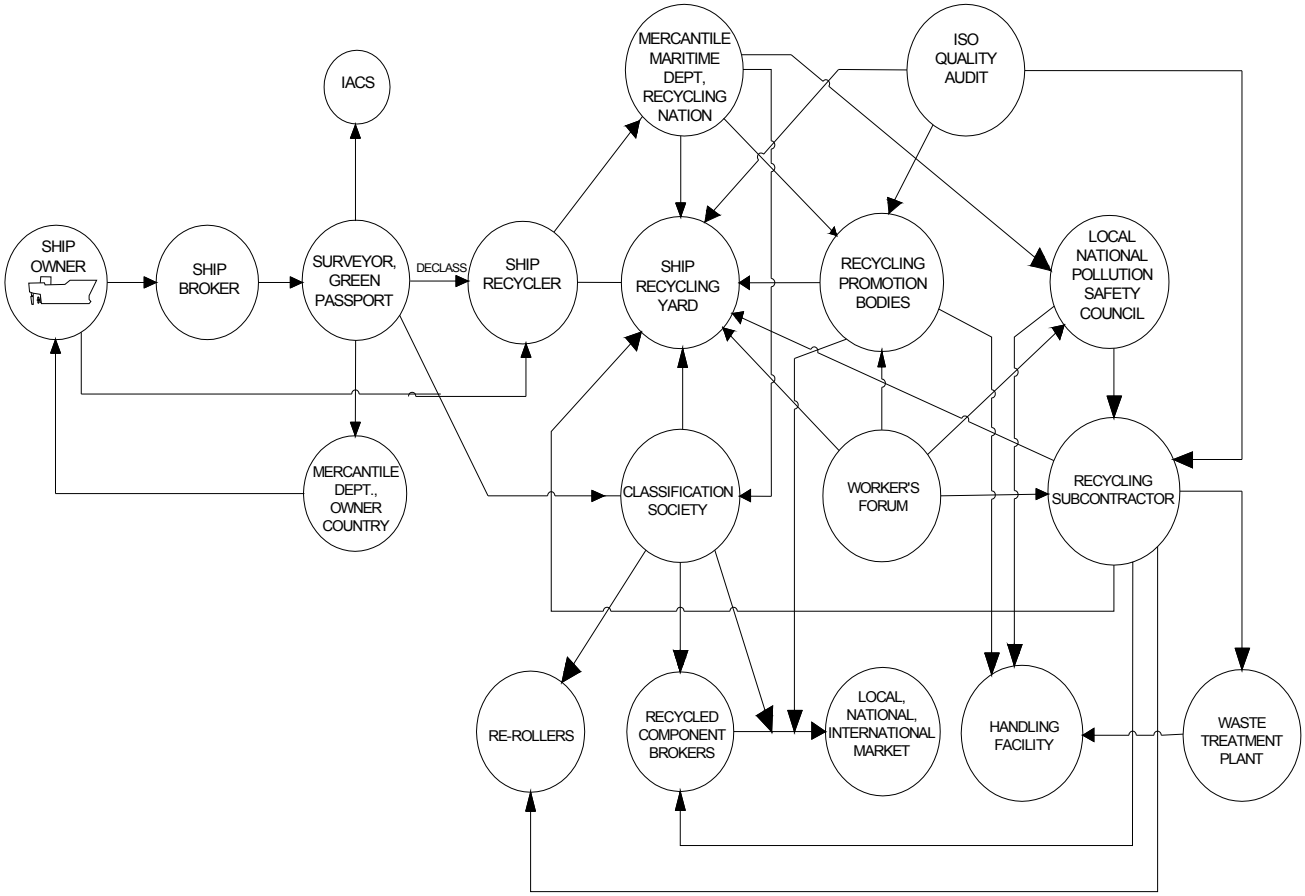

Figure.2. Proposed Systems Analysis of Ship Recycling Activities

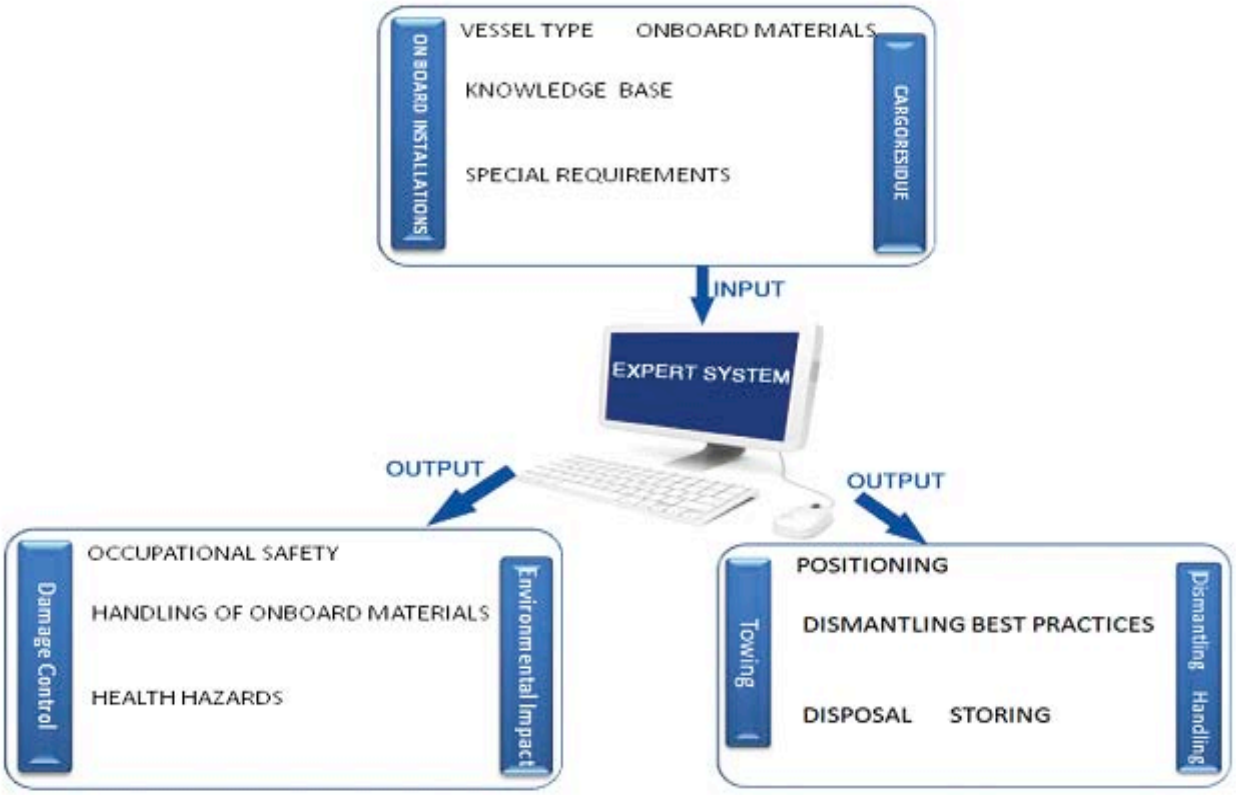

Figure. 3 Structure of SRR

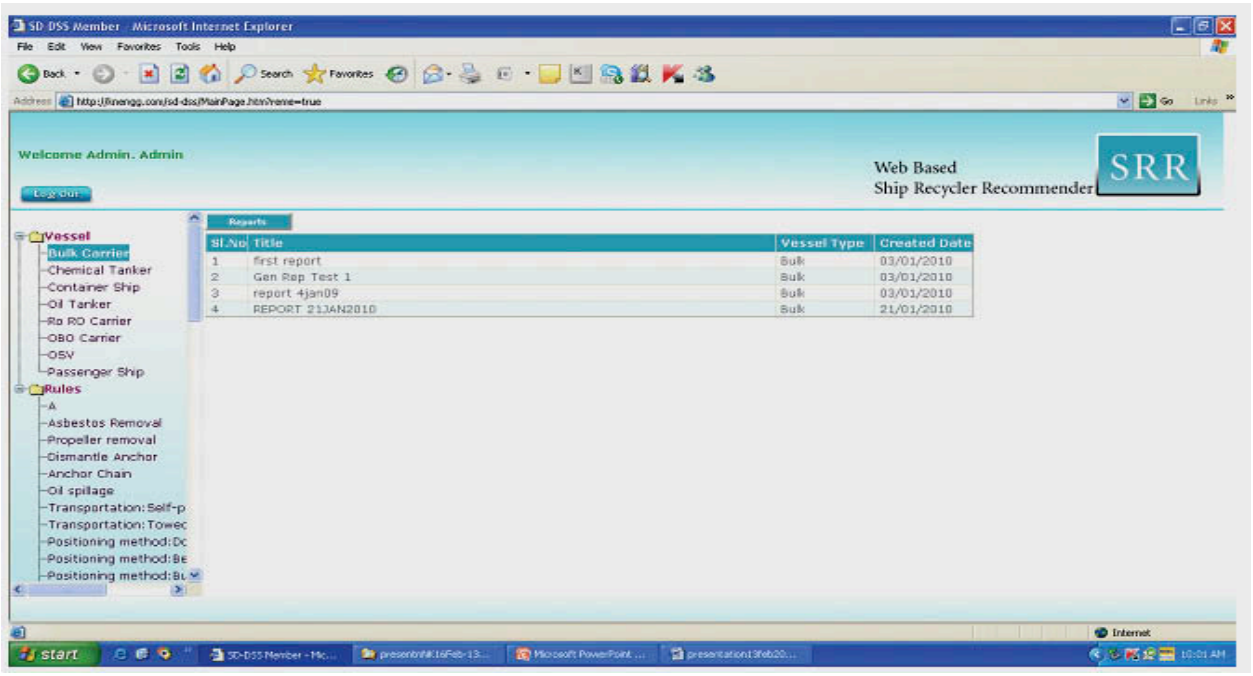

Figure. 4 Main Web Interface Page of SRR

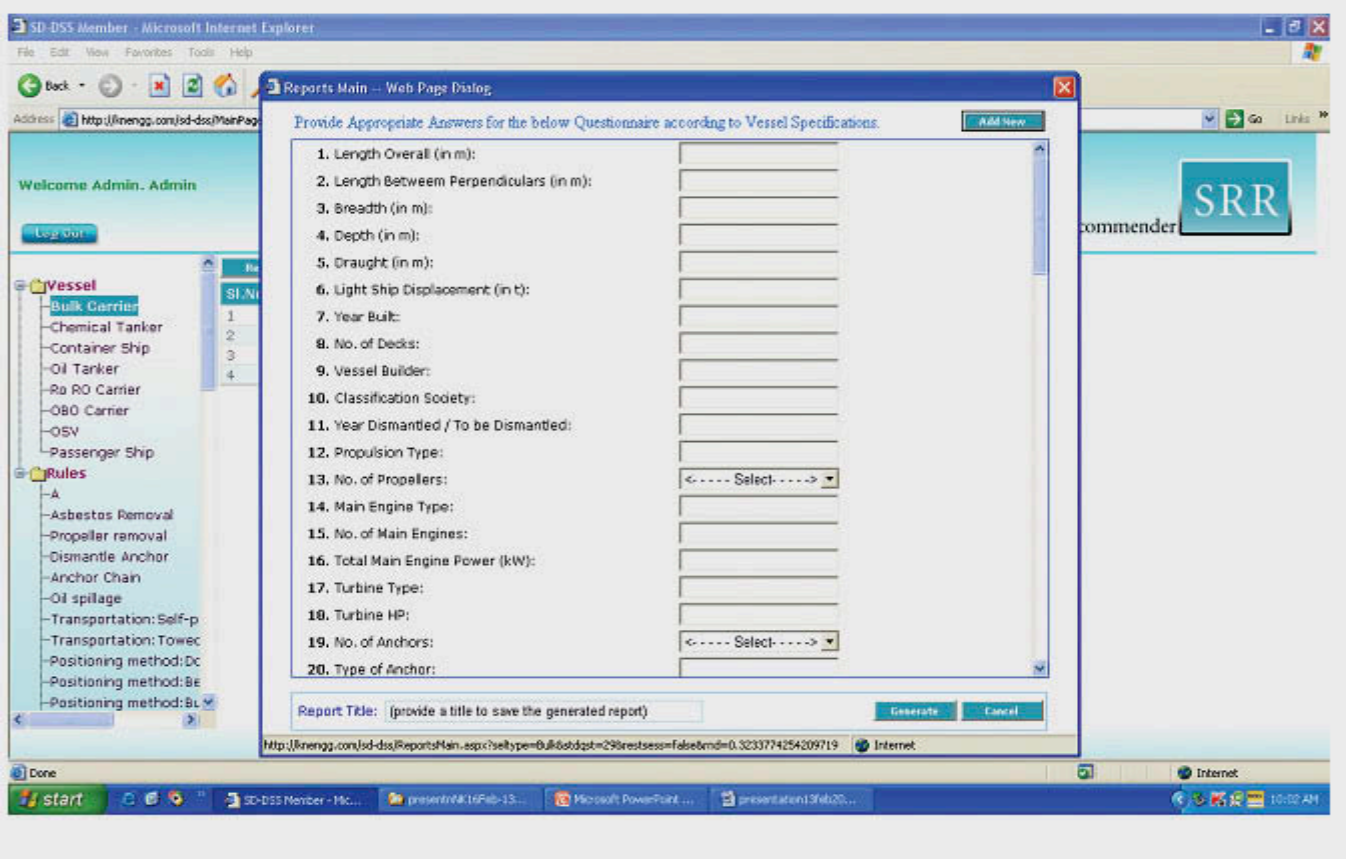

Figure. 5 Ship Data Input Window of SRR

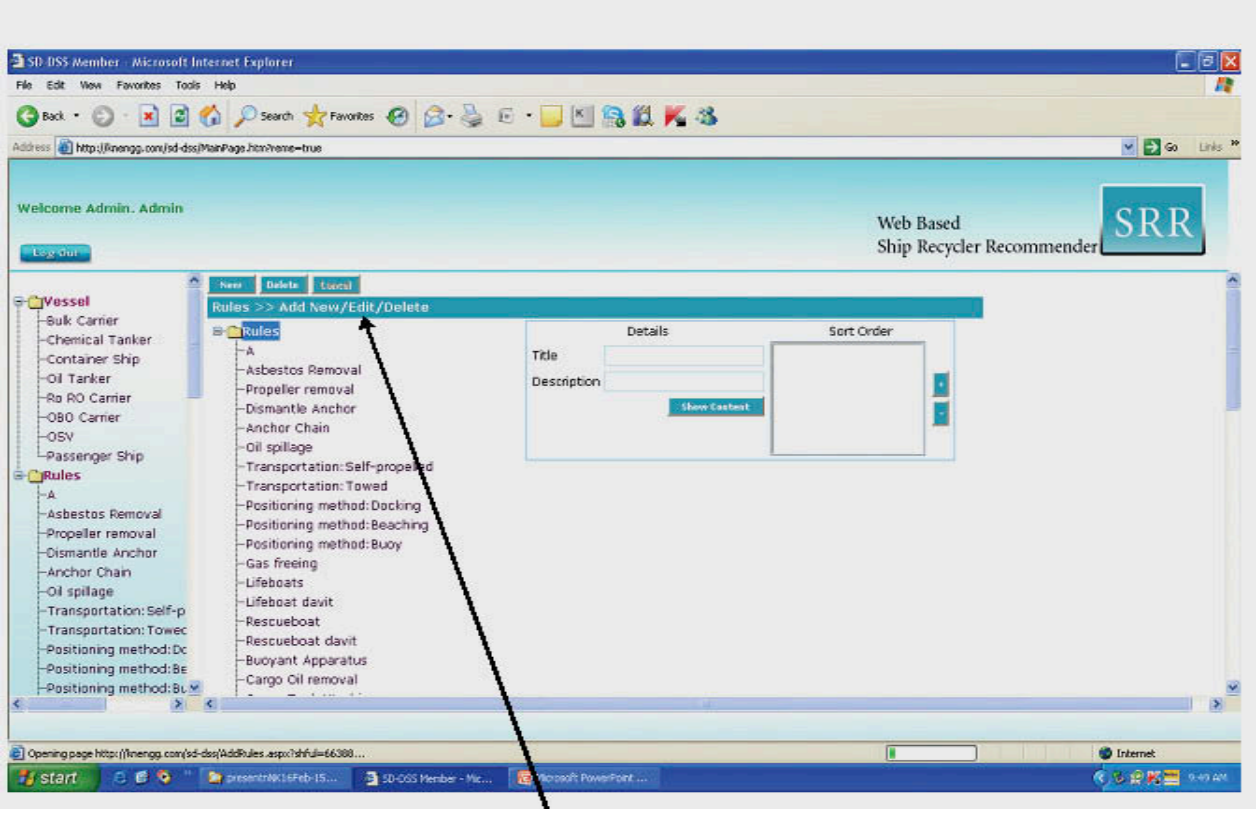

Figure. 6 Window for Adding/Editing/Deleting of the RULES

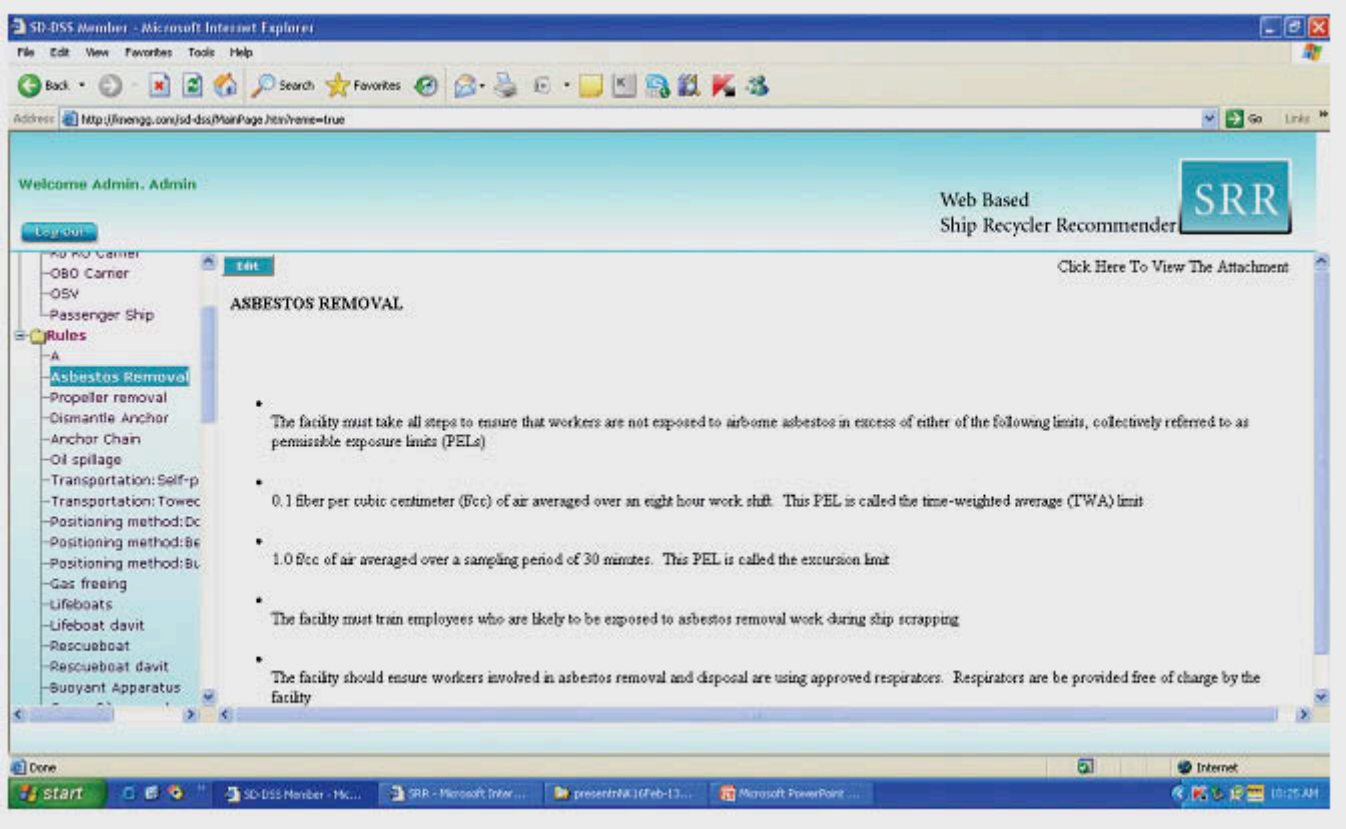

Figure. 7 Output of SRR: Ship Recycling Recommendations (Removal of Asbestos)

