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ENVIRONMENTAL IMPACTS OF SHIP DISMANTLING

– Screening for sustainable ways



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The purpose of this thesis was to study how ocean-going vessels are permanently withdrawn from operation by dismantling. The intention was to gain an understanding on how the ship dismantling has developed into the current state and what the near future holds for the industry. This thesis concentrates particularly on the impacts that ship dismantling has on the environment – nature and the human. The purpose was to find ways to reduce the environmental impacts.

The dismantling of a ship includes removing the equipment and breaking the hull. Ship dismantling meets many of the characteristics of recycling but on the other hand because of its adverse environmental effects it is rarely referred to as recycling. A very high recycling rate can be reached especially with tanker ships because the share of the ship's steel hull from the total mass of the vessel is significant.

There have been attempts to regulate the environmental impacts of ship dismantling since the late 1980s. The results have however been poor because the regulations have been easy to avoid. The creation of new stricter and internationally binding laws is very slow. Entering into force is even slower.

95 percent of all commercial vessels are dismantled in South Asia where the labour costs are low and the occupational safety and environmental requirements are minimal. The largest country in the field of ship dismantling is India. The most common method of ship dismantling is to beach a vessel during a high tide. During the low tide ships are cut into pieces manually with gas torches. The process takes place on unprotected beaches. Hazardous substances then spread freely into the ocean and the soil.

The decision of dismantling a ship is made when the maintenance expenses exceed the profits from operating the ship. The utilization rate of a ship is directly comparable to the global economy. During a global economic boom the operators try to avoid breaking their ships because of high freight rates. The ship dismantling industry works inversely compared with the global economy. During the recent recession a record number of ships have been scrapped.

KEYWORDS:

ship dismantling, ship recycling, environmental impact

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LAIVOJEN PURKAMISEN YMPÄRISTÖVAIKUTUKSET

Tämän opinnäytetyön tavoite on tutkia, miten kansainvälisellä tasolla valtamerialuksia poistetaan käytöstä purkamalla. Tarkoitus on saada käsitys, miten laivojen purkuala on kehittynyt nykyiseen muotoonsa ja miten sen odotetaan muuttuvan lähitulevaisuudessa. Työ keskittyy erityisesti vaikutuksiin, joita laivojen purkaminen aiheuttaa ympäristölleen – luonnolle ja ihmiselle. Tarkoitus on löytää keinoja, joilla alan ympäristövaikutuksia voitaisiin pienentää.

Laivan purkamiseen kuuluu varusteiden ja laitteiden poistaminen laivasta sekä jäljelle jääneen tyhjän rungon hajottaminen. Laivojen purkutoiminta täyttää monia kierrätykselle tyypillisiä tunnusmerkkejä, mutta toisaalta aiheuttamiensa ympäristöhaittojen takia laivojen romutukseen viitataan vain harvoin kierrätyksenä. Etenkin öljyä kuljettavien rahtialusten purkamisessa päästään erittäin korkeaan kierrätysasteeseen, koska niissä teräsrungon osuus aluksen kokonaismassasta on merkittävä.

Laivojen purkamisen ympäristövaikutuksia on säädelty 1980-luvun lopulta lähtien. Tulokset ovat kuitenkin olleet heikkoja, koska voimassa olevia määräyksiä on helppo kiertää. Uusien tiukempien ja kansainvälisesti sitovien lakien voimaan saattaminen on erittäin hidasta.

Maailman kauppalaivoista 95 prosenttia puretaan Etelä-Aasiassa, jossa työkustannukset ovat matalat ja työturvallisuus- sekä ympäristövaatimukset vähäiset. Yleisin laivojen purkumenetelmä on ajaa ne nousuveden aikaan rantaan. Laskuveden aikana laivat paloitellaan käsityönä polttopilleillä. Laivat puretaan suojaamattomilla hiekkarannoilla, jolloin vaarallisia aineita kulkeutuu sekä mereen että maaperään.

Kauppa-alus puretaan, kun sen käyttökustannukset ylittävät aluksen operoinnista saatavissa olevat tulot. Rahtilaivojen käyttöaste on suoraan verrannollinen maailmantalouteen. Korkeasuhdanteen aikana purkua vältetään viimeiseen asti, ja vanhoilla ja huonokuntoisillakin aluksilla liikennöidään korkeiden rahtihintojen takia. Laivojen purkuteollisuus elää siis käänteisesti maailmantalouteen nähden. Viime vuosien kansainvälisen taantuman aikana laivoja on romutettu ennätysmäärin.

Alan ympäristövaikutusten pienentäminen vaatii jatkossa kehitystä työtavoissa, laivojen dokumentoinnissa sekä lainsäädännössä.

ASIASANAT:

laivojen purkaminen, laivojen kierrätys, ympäristövaikutukset

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LIST OF ABBREVIATIONS (OR) SYMBOLS

DWT	Deadweight Tonnage
GT	Gross Tonnage
HKC	Hong Kong Convention (IMO)
HSE	Health, Safety and Environment
IHM	Inventory of Hazardous Materials
ILO	International Labour Organization
IMO	International Maritime Organization
LDT	Light displacement ton
MARPOL	Maritime pollution, International convention to prevent pollution of sea and environment produced by shipping
MEPC	Marine Environment Protection Committee (IMO)
NGO	Non-Governmental Organization
OECD	Organisation for Economic Co-operation and Development
PAH	Polyaromatic hydrocarbon
PCB	Polychlorinated biphenyl
PPE	Personal Protective Equipment
SPR	Ship Recycling Plan
SRR	Ship Recycling Regulation (EU)
WSR	Waste Shipment Regulation (EU)

1 INTRODUCTION

1.1 Background

This study is part of ECO-EFFI co-operation project which purpose is to develop methods and tools to estimate ships' eco-efficiency. The ECO-EFFI project is part of larger entity called SEEE – Ship's Energy Efficiency and Environment. SEEE is a FIMECC (Finnish Metals and Engineering Competence Cluster) project. The aim of this study is to deliver a report that presents the state, challenges and possibilities of ship dismantling today and give ideas on how to develop the industry in the future. Ships are dismantled to recycle the steel they are built of. It is a relatively young industry as there has been need to break ships made of steel only for around 50 years now. Until recent years the industry has been taking place mainly in the developing countries in Asia at the expense of nature and labourers but as the awareness about the industry has risen there is increasing pressure to invest in the sustainability of ship dismantling.

1.2 The purpose of the study

The purpose of the study is to determine on a general level how the ship dismantling industry works today, how the industry has developed into the current state and what role recycling has in the process. The intention is also to screen the impacts ship dismantling has on the environment and the people who are involved in the industry. The purpose is to compare the consequences that non-regulated dismantling in the developing countries and dismantling in the Western world following international agreements have. The target is also to estimate the development of ship dismantling in the future and draft the features of a "recycling-friendly" ship.

1.3 The scope of the study

Ship dismantling is a very complex industry to be discussed comprehensively. This is why the thesis will only concentrate on normal size commercial ships and exclude boats and other small vessels. Also military vessels will be excluded because, as they are owned by governments, the dismantling process of war ships is usually carried out in a different way than that of the open market. The study will focus on ship- and environmental technical main issues. Socio-economic aspects will be introduced but they will have lower priority. Some hazards of ship dismantling for human and nature will be brought up as examples but it is not the intention to concentrate specifically on them.

1.4 Research methods

The study will be carried out combining qualitative and quantitative research methods. The focus of the study is on how the ship dismantling industry works and what are the parties involved. Research material consists of rules and regulations affecting ship dismantling. Also conference papers regarding ship dismantling as well as related studies will be studied. It is also studied what ship dismantling could learn from the best recycling practices' of other industries.

2 HISTORY AND THE CURRENT STATE OF SHIP DISMANTLING

Ship dismantling is a process that includes actions from removing a vessel's equipment to scrapping the hull and other structures. Until the mid 1900s ship dismantling was a common practice in the ports of Europe although the number of dismantled ships was minimal compared to the current situation. After those days ship breaking began to move to Asia because of the demand for steel and lower labour costs. From the late 1960s to the early 1980s ship dismantling was performed in the more industrialized countries of the continent such as Japan, Taiwan and Korea. For the last 25 years global ship dismantling has concentrated on the developing countries in Asia. The number one ship breaker, by volume, at the moment is India. Other major actors are Bangladesh, Pakistan and China. (European Commission Directorate General Environment 2007, 21)

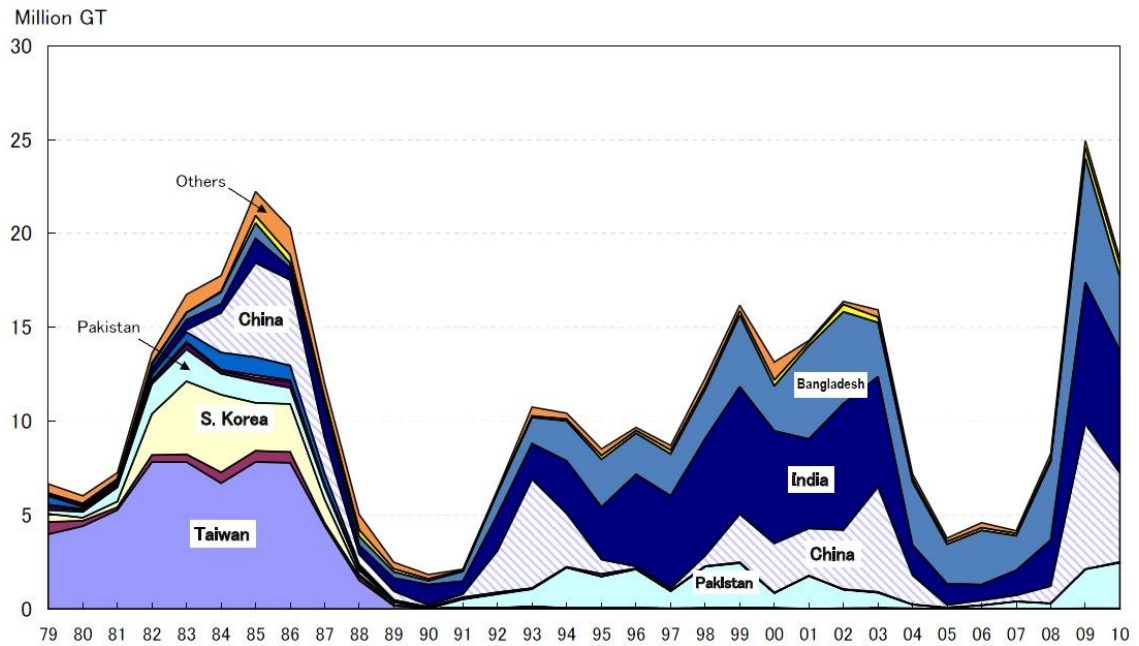


Figure 1. Development of ship recycling industry (The Shipbuilders' Association of Japan, 2012)

The industry has concentrated on Asia's developing countries for purely economical reasons. The ship owners could as well choose to recycle their vessels in environmentally friendly facilities in Europe, the USA or developed Asian countries but it would not make any sense to do that from financial perspective. By selling a ship to a breaking yard, for example in Bangladesh the ship owner can profit quite significantly from a ship considering the value that the ship has on the resale market. On the other hand, it is possible that the ship owner would even have to pay for recycling its vessel in a green recycling facility. (Commission of the European Communities 2007, 5-7)

2.1 An overview of the industry

Ships, like all commercial products at some point, reach the age when it is no longer profitable to repair or maintain them. In most of the cases this means that the ship will be dismantled, while there are no reasonable alternatives. Dismantling of ships is reasonable because simultaneously it is also recycling. The average life cycle for ships, from "cradle to grave", is around 25-30

operational years. Replacing older vessels constantly by new tonnage is natural in the commercial environment. While the fleet is renewed worldwide, ships are safer and more efficient to operate, designed more environmentally friendly and cause less risk to marine ecosystem and ship operators.

Although ship dismantling can be considered, from a restricted viewpoint, an environmentally friendly action the process itself endangers both the employees and nature because vast majority of ship dismantling is conducted on the beaches of India, Pakistan and Bangladesh under no or very little regulations. China is also one of the four major ship breakers in the world. The difference with the previously mentioned countries and China is that the dismantling methods used in China can be seen to some extent better from the viewpoint of nature and workers as the ships are mainly dismantled by piers. The pier facilities are more developed than beaches but do not fully correspond to shipyard conditions. (Commission of the European Communities 2007, 6-8)

Ship dismantling is a hot topic in the era of globalization and the rise of environmental values. The subject is also very political. The overpopulated Asian countries see ship dismantling as an economical opportunity while environmental organizations see a great ecological catastrophe. Depending on the source ship dismantling is referred to in different words. Parties that benefit from it often highlight the positive image of the industry and use expressions such as recycling. On the other hand, those who see it as a threat emphasize the negative side and use definitions such as demolition. In the end all these terms indicate to a process where a vessel is broken into pieces. (Kumar and others 2011, 1-2)

Green thinking has changed the world a lot in the last decades. It has had a great influence also on the shipping industry but so far the main concentration has been on the operational life of a ship. Tightening shipping regulations have forced shipbuilders to design more efficient vessels to operate environmentally and economically because it is the most obvious and apparent way to cut down emissions. Shipbuilding, shipping and ship dismantling are generally seen as

three very distinct phases because the operational life of ships is relatively long. (Commission of the European Communities 2007, 1-3)

Categorically there are a lot of different kinds of ships and obviously the effort needed to dismantle them differs significantly. For example, a single hull tanker and high ice class cruise ship can match each other in tonnage but because of its complex structure a cruise ship is far more difficult to dismantle. On the other hand, the interior materials such as furniture and kitchen equipment of the cruise ship are valuable on the second hand market. Due to these notable differences between ship types it is difficult to compare them universally.

2.2 International regulations concerning ship dismantling

Ship dismantling was for a long time a completely unregulated industry. This loophole in international regulations created a standard procedure for ship operators to dispose of their old vessels. In the past two decades awareness in the problems of the ship breaking industry has raised significantly and a need for developing environmentally sustainable ship dismantling is urgent. However, the ship dismantling is a global issue and therefore creating international rules and regulations is a very slow process. There are already agreements and conventions concerning the industry but they are, for the time being, mainly advisory by nature and their surveillance is ineffective. (Organisation for Economic Co-operation and Development 2010, 6)

2.2.1 Basel Convention

It was not until 1992 that the United Nations Basel Convention entered into force. The Basel Convention (on the Control of Transboundary Movements of Hazardous Wastes and their Disposal) is not addressed to ship dismantling but generally to control the movement and dumping of hazardous waste in the developing countries by companies from the developed countries. The Basel Convention was drafted in the late 1980s after the tightening regulations in the industrialized countries led to a notable increase in the costs of hazardous waste disposal. A search for less expensive ways to handle waste resulted in

shipping hazardous waste to the developing countries and Eastern Europe. So far there are 53 parties that have signed the Basel Convention, including the EU. Apart from two countries, Haiti and the United States of America, all parties have also ratified the convention. (Basel Convention 2013a)

Since the adoption of the original Basel Convention it has been developed by adding new content. Probably the most significant addition was made in 1995 when an amendment was made to the Basel Convention that prohibits exporting hazardous waste from the member countries of the EU and OECD. The amendment was added after political concern for increasing exportation of hazardous waste to the developing countries. This amendment is also known as the “Ban-Amendment” because of the prohibiting nature of the amendment. (Basel Convention 2013b)

2.2.2 European Union

The European Union (EU) has been a very active developer of environmentally friendly ship recycling. The EU together with its member states was among the first to sign the Basel Convention. In 1997 the European Parliament approved Waste Shipment Regulation (WSR) in which the commission and member states are advised to take certain actions immediately on the ship dismantling industry. The WSR implements the requirement of the Basel Convention on the control of transboundary movement and disposal of hazardous waste in the EU. The implementation also involved the Basel Convention amendment that outlaws exporting hazardous waste outside the OECD. (Commission of the European Communities 2007, 4-5)

Later on the European Commission published the Green paper on better ship dismantling in 2007. In principle the message of the Green paper is that the Basel Convention applies to ship dismantling. The Green paper presents possible actions with which the European Union could promote safe and environmentally sound processing of scrap ships everywhere in the world. It is, however, mentioned that the purpose of the Green paper is not to artificially create a large-scale ship recycling industry again in the EU, but to protect the

environment and human health worldwide by encouraging all stakeholders to openly discuss the challenges of ship dismantling and build the grounds for the future EU policies. (Commission of the European Communities 2007, 9-10)

2.2.3 Hong Kong Convention

At the beginning of the 21st century concerns rose that the Basel Convention was not efficient enough to control global ship dismantling industry, while it was not aimed at exporting scrap ships but hazardous wastes in general. In 2004 to improve the situation the members of the Basel Convention invited the International Maritime Organization (IMO) to draft binding requirements for environmentally sound ship dismantling. (Basel Convention 2013c). The Marine Environment Protection Committee (MEPC), a sub organization of the IMO, developed “Guidelines for the development of the ship recycling plan”. The goal of these guidelines was to create a concept of Ship Recycling Plan (SPR). Each ship would have its own SPR to help ensure that the ship is prepared to the best possible extent before its recycling, and that the safety of the ship, before the delivery, is considered. (Marine Environment Protection Committee 2011, 3)

The keystone of the new convention was introducing the Inventory of Hazardous Materials (IHM) also known as “Green Passport”. It is a vessel’s individual documentation of all harmful materials on board. The IHM will be required from all newly built ships and also from the existing ones within a transition period. Regular updating of the IHM will be mandatory and all repairs and conversions that the ship goes through shall be documented. (International Maritime Organization 2009, 15-17)

The parties of the Basel convention expressed their satisfaction on actions that the IMO had taken drafting the guidelines for the ship dismantling convention. It was noted though, that the duplication of regulations that have the same objectives should be avoided so the parties of the Basel Convention could join the new convention drafted by the IMO and be certain that there is no inconsistency between them. (Basel Convention 2013, 1-2)

In May 2009 a diplomatic conference was held in Hong Kong. There were representatives from sixty-three states, secretariats of the Basel Convention and of the International Labour Organisation (ILO). The IMO expected that the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (HKC) would enter into force as soon as possible. Both the EU and the parties of the Basel Convention (European Commission 2012, 4-5) have encouraged their member states to ratify the HKC to enable its entry into force. Although the HKC was adopted in 2009 it will take several years until any results will be seen in the ship dismantling industry, because the convention must be ratified by a sufficient number of flag and recycling states before entering into force. So far none of the major flag or recycling states has ratified the HKC. (International Maritime Organization 2013)

2.3 Environmental and social impacts of ship dismantling

It is commonly recognized that dismantling is the most reasonable way to deal with aged ships that are no longer profitable to use the way they were originally designed. There is a limited opportunity to convert ships to other intentions, for example floating storages or tourist attractions, but also then they require maintenance and cause other expenses. Overall conversions and other arrangements than dismantling only postpone the inevitable.

The greatest concerns in ship dismantling are directed at Health, Safety and Environment (HSE) violations. Although the industry meets many features that are characteristic to recycling it is hard to see ship dismantling practically as a sustainable action as it is handled on the beaches of Asia.

The transition of the ship dismantling industry from developed to developing countries is a consequence of demand for higher environmental and social standards in the Western countries. South Asian countries have gained remarkable competitive advantage on the ship dismantling market due to straitening environment and labour legislation in the developed countries while their own HSE standards are decades behind. (International Labour Organisation 2003, 1-5)

2.3.1 The environmental aspect

Possibly the greatest concerns about the ship dismantling industry are the environmental consequences. Some of the effects that ship dismantling has on the environment are immediate such as fires that produce toxic gases, but even more worrying are those long-term impacts generated by disregarding nature. Because the beaching method of the ship dismantling, in such large scale as it is today, is relatively young the hypothesis of the long-term influences on the environment are rather speculative. There is some research available on the immediate impacts, for example on the marine ecosystem near some ship breaking yards (beaches) of South Asia, but only estimations how long they will last even if the industry would begin to function according to the best practices suggested overnight.

The environmental impacts that the ship dismantling industry has can be divided in to three main categories. The emissions are transmitted to the atmosphere, marine environment and the soil of the ship breaking yards. Throughout the dismantling process the formation of toxic gases is significant. The ship hulls are cut into pieces by rather old-fashioned and inefficient methods. Labourers cut the hulls manually with oxygen torches. During the cutting phase a variety of emissions is released in the atmosphere. Firstly, the formation of carbon and iron oxides is obvious when they are blown, but because all surfaces of a ship are at least painted to avoid corrosion, practically always also more hazardous gases and fumes are developed during the cutting of the hull. What makes the situation worse for the atmosphere is that ships usually are heavily treated against corrosion and fouling. Anti-fouling paints are today strictly regulated, but we have to keep in mind that ships that are scrapped now were built in the mid-eighties on average when the use of toxic chemicals was, if not free, at least very mildly regulated. Organotins are toxins that are nowadays forbidden but were widely used in anti-fouling paints. Tributyl tin (TBT) is a notorious and most used organotin and it has been used in antifouling paints since the 1970s. One kilogram of steel treated with organotin-

containing antifouling paint consist 17-25 micrograms of TBT. The IMO banned these compounds worldwide in 2003. (Hossain 2006, 4, 18, 21)

The cutting of the hull is only one part of the dismantling process that produces emissions in to the air but also uncontrolled and controlled fires do so. For example, burning cables in open fires is an easy but at the same time irresponsible way to separate valuable metals from the insulation materials such as Polyvinyl Chloride (PVC). When burned PVC produces dioxin, hydrochloric acid vapour and thick smoke. Also uncontrolled fires are a common sight at the ship breaking yards of the developing countries. Uncontrolled fires are usually a consequence of explosions that occur during cutting when there is still fuel or flammable cargo residues inside the ship hull. If a scrap ship bursts into flames, the variety of emission in to the air is extensive. There are the above mentioned organotins, insulation materials such as PVC and asbestos, remaining in the fuel and cargo tanks and heavy metal debris.

It is notable that whether a ship is dismantled at a beach of a developing country or at a dock facility of a western country, it always happens under the open sky. Even if the best practices are followed, some amount of emissions will be emitted in to the atmosphere, but under controlled working environment the quantities are small. (Basel Convention 2013e, 1-2, 41-42, 56)

Another major threat to the environment careless ship dismantling causes is the one against the marine ecosystem. The ships are run ashore when the tide water is high and anchored to wait for the low tide. During the low tides when the vessels can be accessed by foot, ships are first emptied from all the machinery and equipment that is left in the ship and is worth the effort of dragging to the shore. Also the remains of fuel and other oily consumables such as lubricants and hydraulic oils are removed and rolled in barrels across the beaches. After the ship hull is cut, the detached steel plates are carried by the labourers to a collection point onshore, or if the plates or pieces of the hull are too large, they will be winched along the beach. Within this process large amount of material that is more or less toxic and definitely does not belong to the marine environment becomes entangled in the marine sediments in the ship

breaking yard area. Every time the tide comes in and goes out of the beach it sweeps a great deal of debris, heavy metals and toxic substances along with it. (Sarraf and others 2010, 5-6)

There is some research available on the contamination levels of the marine environment nearby the largest ship scrapping yards of South Asia. The surveys indicate that the main pollutants found nearby the ship dismantling yards are primarily heavy metals, petroleum hydrocarbons and bacterial contaminants. Out of these pollutants the most serious are the toxic and persistent heavy metals. In a study that was conducted in the intertidal zone of Alang-Sosiya, the largest ship dismantling yard of the world, fine and bulk fraction sediment was collected and the results were compared to reference samples that were collected 60 kilometers away from the scrap yard. The main observation of the study was that the enrichment of heavy metals was relatively high. The concentrations of heavy metals at Alang-Sosiya yard were even 19 times higher than in the reference samples. The enrichment was most intensive with zinc, manganese and lead. (Reddy, Basha, Kumar, Joshi & Ramachandraiah 2003, 1-4)

The third category of environmental impacts is directed at the soil of scrap yard area. Just like during the cutting phase in the intertidal zone the separation and further processing of the scrap materials is done on bare soil. Bearing in mind the fact that the ship dismantling yards in South Asia do not have any artificial ground structures such as concrete surfaced areas, all the environmentally harmful substances that are detached from the scrapped steel and other materials will be mixed with the soil ingredients. Different studies show that soil samples taken from Alang shipyard are contaminated with polyaromatic hydrocarbons (PAHs). There is more than one source that causes PAHs contamination in the soil. For example, the cutting of the hull segments that are winched on dry land continues in order to optimize the size and shape of the steel plates for reuse. The combustion process produces PAHs emissions that end up in the soil and the atmosphere. Another source of the PAHs is the open

fires used to burn waste. Even oil is used as a fuel to keep up these fires which increases the PAH contamination. (Kumar 2011, 18-19)

2.3.2 The social aspect

Besides nature without attention are also the labourers in the developing countries. While there is a lack of national and international rules and regulations, the doubtful safety and health conditions at the ship breaking yards in South Asia actually guarantee their dominance on global ship dismantling market. The ILO generally considers ship dismantling as one of the most hazardous professions in the world because of its heavy end disastrous nature. The latent health and safety hazards of the ship dismantling industry can be divided into two main categories. First, there are hazards that are caused by accidents that happen at the shipyard. Secondly, there are hazards that follow sustainable contact with deleterious substances. There are no reliable statistics available from the ship breaking yards in Asia about accidents or casualties. The lack of information is a sum of many factors. Obviously it is in the interest of the ship breaking operators to downplay the hazardousness of the industry. Another reason is that ship breaking yards such as Alang-Sosiya in India are so big and employ such great number of people that it is almost impossible to keep count on accidents or near miss situations, even if there was will to do so. (Organisation for Economic Co-operation and Development 2010, 40-41)

Many of the first category accidents are direct consequence of neglecting the safety of the labourers. One major cause of accidents during the dismantling is explosions when the ship hull is cut by gas torches. Explosions happen when ship fuel or cargo tanks are not properly cleaned and ventilated from the flammable gases and other burning substances. Also the falling of heavy metal plates and uncontrolled collapsing of the ship hull are common incidents. It is not unusual that these kind of accidents lead to the death of ship dismantling workers. Many of the accidents could be avoided by proper training of the workers. Training though is very limited and the lessons are learned the hard way. When the industry is so accident-prone, it is hard to imagine that very little

or no Personal Protective Equipment (PPE) is provided for the workers. (Organisation for Economic Co-operation and Development 2010, 41)

Ship dismantling workers are also exposed to hazards that are not immediate but have serious long-term impact on their health. This category of hazards includes workers being in contact with substances that are harmful to the health. Such substances are nowadays either entirely banned or closely restricted in ship building, but were used more freely when vessels, that are dismantled today, were built. As the influence of the long-lasting exposure to the toxic materials to the health of the workers cannot be seen until months, maybe years after, the diseases and deaths are not connected to ship dismantling in the statistics even if the connection seems obvious.

2.4 Economical aspect of ship dismantling

The current state of ship dismantling is dictated by global markets. The ship dismantling industry works the opposite way compared to the global economy. When the conditions on the freight market are good, the ship scrapping industry suffers from the lack of vessels because ship owners want to profit from the high demand for freight capacity and keep operating with their ships even if they were old and in a bad condition. On the other hand, when the global economy is in recession, as in the past few years, the ship dismantling market is booming while there is a lot of overcapacity on the freight market. (Sarraf and others 2010, 13)

The last phases of the lives of commercial ships often follow the same pattern before their dismantling. The dismantling process begins when the ship owner discovers that the maintenance costs of the vessel start to exceed the possible income or the vessel has become unwanted because of its age or poor general condition, in the second-hand market and therefore, is unlikely to be used anymore for commercial purposes.

The transition of the ship dismantling industry to the developing countries in Asia occurred for economical reasons. While the European countries and the

United States developed industrially it was no longer profitable to use professional labour to break ships as it was so much better business to build them. Ship dismantling has become a very important industry for the economy of the developing countries for many reasons. First of all, the industry offers work for tens of thousands of people nationally in countries that suffer from overpopulation, although it must be remembered that ship dismantling workers in this industry have to operate in very hazardous environment with low wages. Second of all, recycled steel is very important for the developing countries as they build their infrastructure. Therefore, the domestic demand for scrap materials is actually a remarkable price factor when it comes to the difference in scrap ship prices between South Asian countries.

2.4.1 Scrap ship prices

When the ship owner decides to sell the vessel for dismantling it searches for a cash buyer. The cash buyer is either a commercial broker or an operator of the scrap yard himself. The use of the cash buyer between the original operator of a ship and the scrapper is needed when the ship has to be “de-flagged”, for instance from an EU country to a non-OECD country to avoid the WSR. If the ship is to be dismantled away from its ordinary operation area, it usually takes cargo designated somewhere near where the scrap yard is located. The cargo for the final voyage is taken to cover the expenses of transportation to the other side of the world but also to hide the trails that indicate that the ship is going to be dismantled. The final voyage is usually done under the vessel’s own power. (Commission of the European Communities 2007, 5-7)

On the scrap ship market the cash buyer pays for a price in US dollars per light displacement ton (ldt) which approximately corresponds to the amount of steel the vessel consist of. In the 1990s the prices for scrap ships were quite stable and an average pay for ldt was around 150 USD. Since then the prices have increased constantly reaching the peak of even 650 USD/ldt in 2008. The prices increased because of the significant demand for scrap steel in Asian industry meanwhile there was a lack of ships to dismantle due to the economic boom of

the first decade of the millennium. During that time freight and charter rates were high and therefore, ship owners wanted to avoid selling their vessels for dismantling even if they were old and in a bad condition.

The market for ship dismantling is far more unstable than the shipbuilding market because ships can be sold for dismantling at a very short notice. Global recession at the end of the past decade affected tremendously the scrap ships prices. The demand for maritime transportation collapsed during the late 2008 and early 2009 and ship owners reacted by selling their vessels for dismantling. Scrap ship prices came down as much as 70% as a result of the fast increase in supply. The prices declined the most in the first half of 2009 when average rate was 200 USD/ldt.

Since the record low in 2009 the scrap ship prices have again been rising after the global economy started to gradually recover. At the end of 2011 when the global economy began to decline again the ship scrapping prices settled at the level of 500 USD/ldt. (Sarraf and others 2010, 19-23)

2.4.2 Impact on employment

The ship dismantling industry requires a significant amount of manual labour since the vessels are mostly broken by hand from start to finish. The industry creates economic growth locally and regionally because it employs directly such a large number of people. Despite the actual breakers ship dismantling also generates a great amount of additional indirect employment while there are separate distribution routes for virtually all accessories that a vessel has. Labour costs are one of the greatest factors in the revolution that the ship recycling field experienced at the end of the 20th century.

Like most of the statistics concerning ship dismantling in the developing countries also the industry's employment figures are more or less estimations because labourers are unorganized and the industry is very sensitive to economic fluctuation. While the economic cycles control as a whole they also generate temporary changes between the countries ship owners favor as they

plan to recycle their vessel. This is a consequence of different requirements for the scrap ships in the developing countries. For example, Bangladesh gained a market leader position in scrapping large tankers because it allows the worker to enter the ships before proper inspections to ensure they are free from flammable gases before the cutting is started. (European Commission 2007, 9-10)

Due to the cyclical nature of the industry and lack of western level of labour legislation, the status of employees is weak. The need for workforce changes constantly and it causes national migration in the developing countries. Instability and the hazardous nature of the industry has led to a situation that the labourers come from poor regions of the dismantling states. (Sarraf and others 2010, 1-3)

2.5 Global ship dismantling volumes

As mentioned earlier, the trends in ship recycling industry tend to be exactly the opposite to the rest of the global economy. When freight markets are booming over a high demand for transport capacity, ship scrappers are out of work. The same pattern also works the other way around, as the world economy has crumbled for the last four or five years the ship dismantling volumes have risen again to record levels. (Mikelis 2007, 1-8)

In fact, the year 2012 was all time record for the industry while the total of 57.5 million Deadweight tonnage (DWT) was dismantled in the world. At the moment India is the biggest ship breaker with 19.4 DWT (34%), Bangladesh comes second with 13.7 DWT (24%), China is third with 11.1 DWT (19%) and Pakistan fourth with 10.1 DWT (17%). That leaves only 3.2 DWT (6%) for the rest of the world and about 40% of this share belongs to Turkey alone. (Hellenic Shipping News 2013)

In the mid-1990s the global ship recycling volumes settled at the level of around 10 million Gross Tonnage (GT) while the number of recycled ships varied from 549 to 735. At the turn of the millennium the supply of scrap ships almost

doubled in terms of scrapped GT which increased to 19.5 million in the peak year of 1999. The number of dismantled ships ranged between 706 and 874 during that period, so more ships were dismantled during that period but they were slightly smaller. After that the global economy started booming and the ship dismantling industry fell to the level of early 1990s. In 2004 only 7.5 million GT was dismantled which is actually a fraction less than in 1992. The number of dismantled ships was still 615 so the unit size was still becoming smaller. (Mikelis 2007, 3)

The DWT unit describes the total carrying capacity of a fully loaded vessel and therefore, gives a misleading picture in this context. For example, a Panamax-class oil tanker can weigh 14 800 LDT which determines its value in the ship scrapping markets, but it is 80 000 in DWT. (Sarraf and others 2010, 3) The most common unit used in the ship dismantling statistic to report the size of a vessel is Gross Tonnage (GT) which refers to the internal capacity of a vessel measured in the unit of 100 cubic feet.

For the past two decades India has been most of the time the number one ship breaker in terms of tonnage. In the first half of the 1990s China held the market leader status for a couple of year and in the middle of the past decade Bangladesh was the leader for a few years, but once again India is the largest player in the industry. (Mikelis 2007, 8)

3 THE FUTURE OF SHIP DISMANTLING

There are great expectations on the future of environmentally friendly ship dismantling industry. The public opinion and awareness of the industry's character puts the stakeholders of ship recycling under constant pressure to improve the business to eco-friendlier direction. Shipping companies have

made the respecting of the environmental values a competition factor. For example, Maersk Group is already supporting the HKC even though it has not entered into force yet and the company started using IHM in 2007. (Maersk Group 2013)

Also international regulatory organizations such as the IMO and the EU are working on developing an efficient legislation. There are, though, different opinions whether the regulations should be tightly binding or more instructional by nature. The EU has more stringent approach that aims to statutory control while the IMO's view is based more on voluntariness.

3.1 Expectations for the development of ship dismantling volumes

As observed earlier there are two main factors that control the development of ship recycling volumes. Firstly, the global trends in the economy set the demand for freight markets which in turn determines the need for an actively operated fleet. For some years now there has been a downbeat in the global economy and that has set the ship recycling industry booming. It seems that at least for the western economies there is no easy way out of the recession but the newly advanced economies such as the BRIC countries (Brazil, Russia, India and China) show signs of economical recovery. The development of the BRIC economies already creates noticeable demand in freight markets. There is no question that the traditional western economies would not benefit from the rise of the BRIC countries, but also have their own economies running eventually. In this perspective it is expected that the volumes of ship recycling industry will decrease significantly.

The second factor that guides the ship recycling industry is the domestic demand for steel in the countries involved in the industry. However, the domestic need for scrap steel mainly affects the balance where the ships are broken within the industry rather than the total volumes globally. For the time being there is no substantial change in sight when it comes to the market shares of ship dismantling. India and China might be gaining some increase in the market shares due to the economical growth in other business sectors.

China and also some of the recycling facilities in India are likely to gain ground because they meet the standards set in the HKC by the year 2015. (European Commission 2012, 2)

On the other hand, Bangladesh is likely to remain in the price competition because there the scrap steel is usually just re-rolled before re-use, while in India and China a greater portion of the recycled steel is melted in electric furnaces in order to make new steel. Higher energy costs of processing the scrap steel cut the prices that India and China are able to pay for the scrap ships. (Mikelis 2007, 5)

It is also expected that there will be a regulation related peak in the recycling volumes of the ship recycling markets in 2015 when the transition period of the IMO regulation that bans single-hull tankers comes to an end. Also the full order books of the ship building industry at the beginning of 21st century are now creating overcapacity in the maritime transport sector, which will develop growth in the ship dismantling markets for the following years. (Sarraf and others 2010, 9) It is estimated that 1300 single-hull tankers will be scrapped by the year 2015. (Commission of the European Communities 2007, 7) A great part of those vessels has already been scrapped though.

3.2 International regulations and cooperation

There are high hopes for the conventions that are at the moment waiting to enter into force. Even though the HKC was implemented already in 2009 there is no sight of its entering into force because the criteria requires for example, ratifications from countries whose combined commercial fleet GT is at least 40% of the current world total. Therefore, the four biggest flag countries would be enough for ratification, but on the other hand, if eight biggest flag countries decide not to sign the HKC, it cannot be ratified. In addition, there is also a 24-month transition period after all the entry-into-force conditions are met. (Mikelis 2011, 53) The EU expects the HKC to enter into force in 2020 at the earliest (European Commission 2012, 4). This means that the development of the ship dismantling into a more environmentally friendly industry will take longer than it

was intended if it depends on the HKC. When the HKC will enter into force, the importance of the Basel Convention for ship breaking will decrease because it has been noted that the HKC offers at least the same level of environmental protection as the Basel Convention.

The EU has taken a strong role in developing the ship recycling industry. The EU has brought the content of the Basel Convention in its own legislation in terms of the WSR that also includes the so-called “ban-amendment” which prohibits the export of hazardous waste outside the OECD. The “ban-amendment” has not yet entered into force because of lack of ratifications. The EU is also planning to promote the environmentally friendly ship dismantling by creating its own Ship Recycling Regulation (SRR). The objectives of the SRR would be parallel to the HKC with some amendments concerning the EU member states such as avoiding the WSR by selling vessels to a non-OECD country before dismantling. (European Commission 2012, 4)

The problem with the EU being a forerunner in the environmental legislation is that it places its member states and companies that are operated in unequal position compared to non-EU countries, even though it is mentioned that the SRR should not create an economic burden. Also the past has shown the fact that strong regulatory guidance has increased the costs and therefore, relocated the industry to new countries, even continents, where the business starts again from scratch.

3.3 Environmental and social impacts of the future ship dismantling

The slow development, and in particular the slow entry into force, of international conventions has caused frustration especially in some non-governmental organizations (NGO). For example, in 2005 a group of three NGOs; Greenpeace, Federation for Human Rights and Young Power in Social Action published a report about the working and environmental conditions in Chittagong ship dismantling yard in Bangladesh. The report displays the hazards that the labourers and nature are exposed to. It is stated that in Bangladesh one worker gets killed every week and one injured every day. The

report is intensified with dozens of demonstrative pictures. (Greenpeace 2005, 1-64) These and thousands of other widespread images from the South Asian ship breaking facilities may have had more influence on the development of the industry in recent years than the never-ending political debate.

Without a doubt there has been progress in the HSE standards in the ship dismantling yards in the past two decades, but they are still far from acceptable in European standards. The use of PPE is still far from a common practice and formal training about ship dismantling is nonexistent so the workers may not have any idea of the hazards of the ship dismantling industry. (Organisation for Economic Co-operation and Development 2010, 41) Unfortunately disregarding the safety of workers and environmental values has been the key for making ship dismantling profitable for the past 20-30 years. It seems that a hard regulatory approach will be the only way to bring about change. In this respect it would be important to make the HKC legally binding as soon as possible.

3.4 Economical aspect of the future ship dismantling

The ship dismantling industry has seen very little competition in the last 20-30 years. Basically the traditional South Asian countries India, Bangladesh and Pakistan have dominated the markets. China has been involved as a major player as well, but its involvement has been somewhat occasional. At the moment it seems that China could defend its place in the ship recycling markets as it is environmentally the most advanced of the Asian ship breakers. (Sarraf and others 2010, 58)

Given the facts that western economies are in recession, there is overcapacity on the shipping markets and therefore, freight rates are low, and there are no signs of the ship breaking boom to decline in the near future. It will be interesting to see if the large shipping companies begin to act according to their values and start demanding higher standards from the ship dismantling industry. Would it affect the industry if the shipping companies started taking the initiative and begin to favor recycling facilities following the best practices even by Asian standards?

It is clear that there is not enough ship recycling capacity outside the ship breaking yards of the four market leaders countries and if they decide to continue without investing in environmentally sustainable methods, there is no place else for the shipping companies to recycle their vessels. If there are no sudden changes in the attitudes of either shipping or ship recycling industry, there is no reason why the market economy would not carry on as it is at the moment.

4 BENCHMARKING – WHAT CAN SHIP DISMANTLING BENEFIT FROM THE SOLUTIONS OF OTHER INDUSTRIES?

The ship dismantling industry has been more or less the same since it beached to South Asia about 25 years ago. Ships are cut into pieces manually with gas torches in the middle of sand and debris. The use of lifting cranes is limited and heavy metal plates are carried as teamwork. Is the labour in Asia really so cheap that it can beat the modern heavy automation in efficiency?

The problem with finding better practices for ship dismantling is where to look for comparable industries. For instance, there are very sophisticated processes used for recycling cars, refrigeration equipment and home electronics. In those processes virtually every phase and action is automated and the only thing that needs to be taken care of is that the supply of broken televisions or car wrecks never ends, automation will deal with the rest. But when it is about recycling a 15 000 ton oil tanker, how do you lift it on a conveyer belt and program robots to put it into pieces?

Of course, there are also dismantling processes where the size of the object to be recycled is comparable to ocean-going vessels. In these cases processes such as dismantling an airplane or industrial, transport and urban infrastructure can be seen as reference situations. The element of hazardous materials is also often involved in these examples but otherwise the differences to ship dismantling industry are perhaps greater than in recycling vehicle-sized or smaller goods.

4.1 Vehicle recycling

A good example of strictly regulated and supervised sector of recycling is the vehicle recycling industry. For instance the EU adopted an End-of-Life Vehicles Directive already in the year 2000 which sets boundaries starting from the materials used when building cars to recycling processes and facilities. The directive prescribes, among other things, that from the year 2015 on 95% of the weight of a vehicle must be recovered for reuse. (Commission of the European Communities 2000, 2-4)

The process of recycling a car begins with draining the harmful fluids such as motor and transmission oils, fuel and coolant. Tires are removed at this stage as well. Also other toxic substances such as batteries and refrigerant from the air condition system and catalytic converters will be removed before the dismantling of the car. If there are valuable core parts available they will be detached and sold on the second-hand market. (Kringe, Bodorf-Zimmer and Goldman 2005, 6-8)

After the pre-treatment all that is remaining of the car will be fed into a shredder. The shredder residues consist of ferrous and non-ferrous metals, plastics, rubber, glass, rust, textile fibers, seat foam and particles of paint and lacquer. The metals are separated from the other material using magnetism, machine vision, and air flow. The separation is also followed by the human eye and possible errors during the process are fixed manually. The metallic shredder residues will be melted and reused. Other suitable materials are used as energy waste in landfill sites.

There are many similarities between ship and vehicle recycling. The dismantling action is located in permanent facilities and the recycled items are brought to them, although ships are usually cruised on their own power and cars transported in larger groups. The pre-treatment process of cars is in principle quite similar to suggestions of pre-cleaning ships, but with cars much easier to complete due to the size difference. Also a large part of ships machinery is reused. Where the ship dismantling is far behind the vehicle industry is the use of automation. Basically the only machinery used even in the most advanced ship dismantling yards are cranes and other devices used to move the steel plates inside the recycling facility. The scrapping process of a car itself is very difficult to bring to ship dismantling. The eternal problem is the size of ships. A ship needs a lot of cutting work before the pieces could be fitted in any shredder. On the other hand, shredding a ship would not be even that smart because melting steel requires much more energy than re-rolling. If shredding would be considered an option, the shredders would have to be significantly stronger than those used to shred vehicles because material thicknesses are so much greater.

4.2 Airplane recycling

Aircraft recycling is perhaps a better benchmark for ship recycling because of the size factor, but otherwise the airplane dismantling may not have much to offer as the industry is in a turning point. The revolution of the materials used to build aircrafts is consistent because there are quite remarkable advantages available for making the aircrafts lighter. This has led to the use of composite materials which are difficult, in other words expensive, to recycle. (Engineering and Physical Sciences Research Council 2006, 3)

While the development in airplane building has been so fast in the past few decades a 30-year-old aircraft that is in a flying condition may have almost no value because it is so inefficient to operate compared to the new ones. The profitable part of recycling airplanes is to strip the aircraft from the equipment and sell it for reuse or as spare parts. After the valuables have been detached

from the frame of an aircraft, it is quite common that the remains of the airplane are left to an outdoor storage. These storages are located around old airports that are no longer in active use but are able to receive airplanes as their final destination. The adverse climate of the outdoor storage slowly degrades the condition of the aircrafts frames and decreases the value of the remaining airplane body. (Engineering and Physical Sciences Research Council 2006, 3-5)

The process of recycling an airplane begins exactly like with ships. The first steps of the process are also very similar. The aircraft is flown to the facility where the recycling will be carried out. The difference here is that these facilities are usually located in western countries. The biggest difference between these two processes is that while ships are dismantled to recycle the steel from which the hull is built and selling the equipment is extra, the case with airplanes is exactly the opposite. And because the frames of airplanes are built from rather exotic materials, it is common that they will not be dismantled at all but left to the mercy of weather conditions. After all the airplane dismantling industry could be considered even less developed than ship dismantling, but as the storing of the aircrafts is rather neutral from the environmental point of view there is no great concern for this.

4.3 Recycling different infrastructures of society

Different infrastructures of society such as factories, power plants, and building pieces of road network e.g. bridges are dismantled as they are shut down or replaced by new ones. They certainly are big structures like ships and hazardous materials are used in them also, but what about the scrapping process? Is there something ship recycling could learn from them?

Let us think of a power plant where energy is produced by burning fossil fuel. It is like an engine room of a ship in a larger scale, with the main engine and different auxiliary equipment. Perhaps the most obvious difference between recycling a ship or a power plant is that the power plant is always dismantled in the very same place where it has been working through its life. The logistic

network for the scrapped materials is then created case by case. Also the rules and regulations followed depend on the country where the facility is situated. Because of this the better practices are probably used due to stricter legislation no matter what industry surveyed.

Unfortunately this conclusion leads us again back to square one. It is likely that better practices are used throughout the recycling industry in western countries, but the use of them is not from free will, but strict regulations. Even if there are environmentally better practices available, it is highly unlikely that they would be used voluntarily, because without exception they would raise the costs and cut the revenues of ship recycling.

5 DISCUSSION

It has been made clear that ship dismantling as it is today is an industry where the profits are made by exploiting the labourers and the environment. Probabilities of large-scale ship dismantling actions to be seen in highly industrialized countries are very thin. It seems that the only thing that could lead to environmental and social development in the ship recycling industry is international legislation. It is a shame because it has already been seen that creating such extensive binding regulations is an extremely slow process and we might be facing another decade or even decades of wild ship dismantling in the beaches of South Asia before some development.

There could be one option for creating environmentally friendly ship dismantling capacity in larger scale. However, the little amount of attention this option has had in the discussion of developing ship recycling indicates that it would not be sustainable economically, not without any help in terms of regulations at least.

The option is reinventing the ship building yards that have been placed out of business in the heated ship building markets in the past. There the shipyard infrastructure already exists and also the logistic network for transporting the recycled materials is usually quite advanced, meaning that both road and railroad connections are already there.

5.1 Developing ship dismantling environmentally

It is difficult to imagine a better facility where to dismantle a ship than the one or equivalent to the one where the ship was originally built. In these docks ships can be separated from the sea and therefore, controlling the access of the harmful substances to the sea would be more manageable. The dockyard areas are also surfaced with strong and durable coating such as concrete or asphalt so the contamination of soil could be easily controlled as well.

A significant part of the environmental impacts of ship dismantling is caused by the energy consumption of the industry. Because the working techniques at the ship breaking yards of South Asia are not up-to-date in any way, the energy consumption of e.g. the cutting process is very high. By using automation in the cutting phase a remarkable reduction in the consumption of the cutting gases could be achieved. This would also help to recover more steel from the ships because the cutting process would be more accurate and therefore, excessive burning of steel would be easier to control.

5.2 Developing ship dismantling socially

While the greatest concern of the ship dismantling from the labourers' point of view is the hazardous nature of the industry, there are many ways of making it safer by improving the infrastructure of the ship recycling yards. The simplest thing to improve workers' safety in this heavy industry is to increase the use of cranes and other machinery used to move pieces of scrapped ship within the dismantling yard, which, however, is hard to achieve in beach conditions.

Another way of making ship dismantling safer not only for the workers but the environment as well, is developing the pre-cleaning phase. Now the pre-

cleaning is minimal because if the ships were properly cleaned from toxic materials, it would mean that they are no longer seaworthy. The unseaworthy vessels would have to be towed to the recycling facility which increases the costs and is a matter of maritime safety. Therefore, it would be beneficial if the pre-cleaning could be done in the same facility as the rest of the dismantling.

Of course, the use of PPE should not be forgotten. Even today it is not a standard that protective clothing including shoes, gloves and a helmet is provided to workers. With proper use of PPE and training of the workers serious accidents could still be decreased significantly.

5.3 Recycling-friendly ship

The condition of the recycled ship has great significance to the dismantling process. While most of the vessels that are recycled today were built in the era when the use of harmful coating and insulation materials was common in ship building, more advanced pre-cleaning methods are vital for environmentally friendly ship recycling. A proper pre-cleaning would reduce the hazardousness of the dismantling process for both labourers and nature.

Because complete pre-cleaning of ships before arriving at the final dismantling scene is unlikely, the importance of the documentation of individual ships is great. The introduction and development of the ship-specific IHM would help to reduce the risks involved in ship recycling. While the vessels go through much repair and maintenance throughout their lifespan, updating the IHM is as important as its introduction.

Obviously the type of a vessel also affects the difficulty of the recycling process. This is though a secondary factor because all ships need to be recycled at some point no matter if they are tankers or cruise ships. The type of the ship has, however, great importance at the time of dismantling because ships that are characteristically easy to dismantle such as oil tankers, are highly priced by the scrappers. From the environmental point of view there is little difference

between ship types because all of the older vessels contain hazardous materials.

6 CONCLUSIONS

There were several targets for this study. Firstly, the screening of the ship dismantling industry structures today and how it has developed to the current state. It is clear that in view of nature and labourers, the current practices in the ship dismantling yards of South Asia are not up to standard that could be expected in the 21st century. Although some development has occurred since the industry has been controlled by India, Bangladesh and Pakistan from the late 1980s, there is no chance that ship dismantling would be accepted in the western world in its current form in South Asia

Secondly, there would be ways to reduce the environmental impacts without increasing the costs of ship recycling significantly. The documentation of hazardous materials that the ship contains, developing the pre-cleaning of ships and training of the labour would improve the process environmentally and make it safer for the workers as well.

Due to the somewhat mysterious nature of ship dismantling, quantitative research of the industry is very difficult. Because it is common in the ship dismantling industry that different regulations are circumvented, comprehensive statistics are not openly accessible. Still, there is quite a lot of information from some parts of the industry available but sources must be evaluated carefully because research tends to serve the purposes of their subscribers.

One thing that is certain, though, is that if the change in to more environmental direction is left to volunteer consideration of ship operators and breakers, it may

never happen. Therefore, stricter international regulations are needed. Unfortunately, creating such internationally binding regulations is a very slow process and even though there is will to develop that kind of legislation, we will be facing poorly regulated ship dismantling in the following decades as well.

Because ship recycling is such a complex industry many questions remain unanswered after this study. In order to achieve more accurate results further research is needed, but it should be directed in to different sectors of the industry. There are two areas that should be studied separately: development of regulations that control the industry, and modernization of the working practices including the aspect of workers' safety.

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