

SUSTAINABLE DESIGN APPROACH FOR BANGLADESH SHIP BREAKING INDUSTRY

Iftekhar Khan, Harun Chowdhury and Firoz Alam

School of Aerospace, Mechanical and Manufacturing Engineering
RMIT University, Melbourne, Victoria , Australia

ABSTRACT

Ship breaking is an important industry as it provides a lion's share of raw materials for major steel re-rolling industries in Bangladesh. However, due to unplanned development, poor occupational health and safety practices and awareness, the ship breaking yards create substantial environmental and occupational health and safety hazards. The ship breaking industry is a dilemma for Bangladesh as without it country's economic development will significantly suffer and on the other hand, continuation of current unhealthy practice will affect human life and environment. In this paper, we have reviewed current ship breaking practices and identified potential solutions for sustainable development of ship breaking industry in Bangladesh. We have also identified the key infrastructural elements which can be incorporated in ship breaking yard zones. The proposed sustainable design will ensure not only an environment friendly operation but it will also achieve enhanced productivity, safe work environments, and high profit margins for this vital industrial sector.

Keywords: Shipbreaking, Environmental Impact, Sustainable Design Approach, Sustainable Operation.

1. INTRODUCTION

Ship breaking industry is green as it facilitates the use of scrap metals and other machineries for vertical and horizontal recycling. It provides raw materials for national economic activities including industrialisation, construction, building and infrastructure development. For countries like Bangladesh shipbreaking industry is very crucial as it does not have any natural resource of iron ore. Though ship breaking is economically beneficial but it comes with a huge environmental and occupational health and safety cost. Ship breaking industries have been developed through unplanned and unscientific ways in most developing countries

Due to the unplanned ship dismantling process, the ship breaking industry creates environmental and occupational hazards. Recently, various government and judicial authorities of developing country especially Bangladesh have imposed restrictions on ship breaking activities upon raising concerns from various environmental organisations and workers' unions. On the other hand, ship breaking industry is a major source of employment, economic activities and raw materials for industrial and construction sectors for most developing countries. Therefore, sudden restrictions on ship breaking activities can cause a serious consequence in this vital recycling industry as it can make thousands of people jobless, affect economic progress, and increase greenhouse gas emission. By considering this dilemma, an optimal and sustainable solution for a ship breaking industry is urgently needed. Therefore, the primary

objective of this paper is to develop a sustainable and occupational safe yard design, operation procedure and required infrastructure for ship breaking industry.

2. BANGLADESH AND GLOBAL SHIPBREAKING ACTIVITY

The practice of ship breaking industry started in 1969 in Bangladesh [1]. But it did not get the global market at that time. Up to 1980s, the practice of ship breaking was concentrated in the industrialized developed nations like US and Europe. But due to high labour and operation costs, later this work has been shifted to developing countries, especially China, India, Bangladesh, Pakistan, Philippines, Vietnam, etc. This trend was started from 1980s. In 1970s and first half of 1980s some European countries such as Spain, Italy, Croatia have had significant ship breaking activities. The world's major ship breaking activities during 1977 - 2008 are shown in Figure 1. Till 1985, Taiwan was one of the major ship breaking countries however, the activity has drastically reduced to 2 ships in 1990 compared to 7,822 ships in 1985. A similar trend was also noted for South Korea. Its ship breaking dropped from 2,551 ships in 1985 to 4 ships in 1990. The fall in ship breaking activities in Taiwan and South Korea was primarily due to the rise of labour cost and stringent environmental and safety regulations. This has ushered in new opportunities for less developed countries with abundance of cheap labour such as China, India, Pakistan and Bangladesh. Although the ship breaking industry started to shape up in

Bangladesh but India has become one of the leading nations in the world in ship breaking surpassing China during late 1980s and early 1990s. In 1990s Pakistan was also very active in ship breaking activities but in later half of 2000s the ship breaking activity has reduced notably. During this period, Bangladesh gradually increased its ship breaking activity from later half of 1990s. The uprising trend continued and in 2005 it became one of the largest ship breaking countries (see Fig 1 & Fig 2).

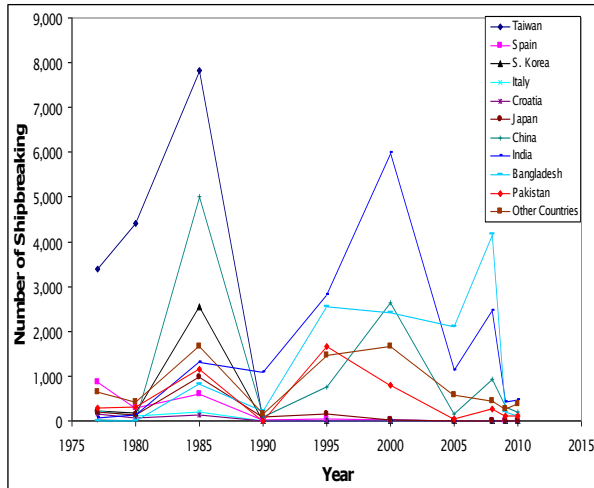


Fig 1. Ship breaking activities around the globe from 1977 to 2010, adapted from Shipbuilders' Association of Japan, 2010.

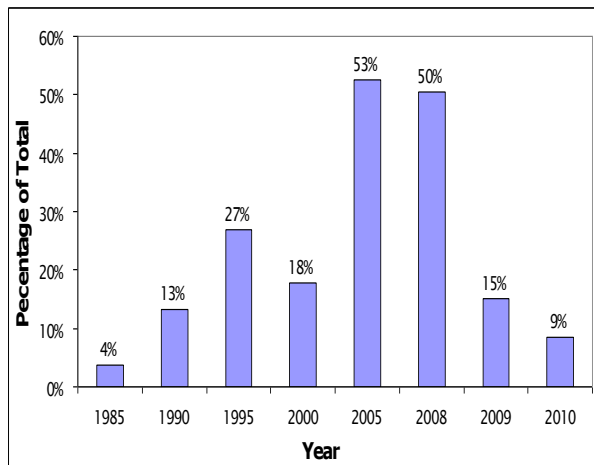


Fig 2. Percentage of total world ship breaking in Bangladesh from 1985 to 2010

In 2008 the number has doubled and it still accounts for the half of the world total ship breaking. The number of ship breaking has reduced drastically in following years of 2009 and 2010, mainly due to the global economic recession and rise in transportation cost. In the same time, due to certain embargo by the country's higher court expressing concerns that most ship breaking yards might not follow the country's environment protection laws and occupational health and safety. The sudden imposition of law does not allow local ship breaking yards and ship owners to prepare themselves to

comply with relatively stringent government rules and regulations.

3. SHIP BREAKING INDUSTRIES AND ITS ENVIRONMENTAL IMPACT

Ship breaking and ship recycling is a complex and hazardous process as it contains harmful chemicals, oils, and other harmful materials. The exposure of these materials to human and surrounding environment can have detrimental effect. Unfortunately, in most breaking yards in developing nations due to lack of awareness, employee training, protective equipment, loose regulations and cost savings, no systematic, organised and scientific method is being used in ship breaking. As a result, frequent explosions, accidents, and environmental pollution are often taking place in most ship breaking yards. For example, 95% of a typical empty ship (mass varies between 5,000 ton to 40,000 ton) is steel and coated with 10 to 100 ton of paint containing lead, cadmium, arsenic, zinc and chromium [1]. Furthermore, scrap ship may contain hazardous asbestos, several thousand litres of oil consisting of engine oil, bilge oil, various hydraulic oil, greases, etc. Oil tanker contains additional residual oil up to thousand cubic meters. However, most left over petrochemical product can be recycled and reprocessed for commercial uses if appropriate recycling process can be established, hence environmental and health damages can significantly be reduced and profit margin from ship breaking can also be increased. Hazardous working environment in shipbreaking industry in Bangladesh is shown in Figure 3. The major ship breaking hazards are briefly described in the following subsections.



Fig 3. Hazardous working environment in ship breaking

There is a significant portion of oil leakage to surrounding water and soil in every ship breaking yard in developing countries. The spilled oil mix with water and wash away to the sea and adjacent soil. This makes serious risk on fragile ecosystems especially on marine flora and fauna. Sea birds, fish, turtle, various sea mammals- all are directly affected due to pollution and their life cycles are shortened significantly. In addition, marine vegetation and coral life are under direct threat of oil pollution. In most developing countries including Bangladesh, fish is one of the important sources of protein. The shortage of fishes available in the coastal

regions can make the entire population of a country malnourished.

The oil and various harmful chemicals (e.g. spillage, floatable grease balls, ammonia, and metal rust) can damage the soil enormously. The pH level of soil can easily go up which is direct threat to many plants and vegetation. In addition, the binding properties of surrounding soil reduce significantly due to soil contamination, mechanical and excessive human activities. Therefore, the soil erosion in the coastal area increases notably. Furthermore, oil spilling may cause serious damage by reduction of light intensity, inhibiting the exchange of oxygen and carbon dioxide across the air-sea water interface and by acute toxicity. This may cause serious damage on the growth and abundance of marine organisms especially plankton and fishes. Another study undertaken by [5] on soil and sea water pollution from Fouzdarhat to Cumira coastal area near Chittagong, Bangladesh reported a high ammonia toxic in beach soil and water with increased pH. In recent study by [6] found some trace elements including Mn, Zn, Pb, Cu, Cd and Hg.

4. PROSPECT OF SHIP BREAKING INDUSTRY

Ship breaking industry has a great future and is an integral part of Bangladesh economy of prosperity. It has created direct and indirect jobs for millions of people across country and it is one of the driving forces for the economic development. Every piece of a scrapped ship is converted into reusable item therefore ship breaking industry in Bangladesh can be termed as a sustainable and green industry. As identified in [1], practically 100% of the ship is recycled. Therefore, for Bangladesh economic development and for the reduction of global environment pollution, the recycling process from scraped ships needs to be continued.

4.1 Current Ship Breaking Benefits

Bangladesh does not have any natural resource of iron-ore. It fully relies on import of this important element of Mendeleev's periodic table. On the other hand, importing virgin iron ores from overseas will significantly affect the country economic growth and prosperity as it will cost heavily country's exchequer. It is no doubt that ship breaking/dismantling provides Bangladesh with almost 90% of its steel product needs and saves huge hard earned foreign exchange and accelerates country's overall economic development. Countries several thousand steel re-rolling industries fully dependant on scrap metals from ship dismantling. According [8], the Bangladesh government earns revenue over 100 million US dollar from ship breaking each year (7.5% as import duties, 2.5% as yards tax). More than 25,000 people directly employed in ship breaking yards and over half a million in other activities related to the ship breaking are working across the country. Additionally, the ship breaking is a great source of various used and affordable materials for local use. Importing these materials from abroad can cost the country dearly and most probably out of reach by many ordinary people. Many items including lathe machine, shaper machine, drill machine, hydraulic press, motor,

pump, engine, boiler, heat exchanger, generator, compressor from medium to large size, electrical cable, circuit, electronics devices, electrical appliances, various steel parts such as anchor, chains, ventilation parts, pipes and pipe fittings, valves; sanitary equipment, furniture (beds, sofa, chairs, tables), batteries, insulation material, engine oil, fuel oil, hydraulic oil, etc. are readily obtained for local use from ship dismantling.

4.2 Future of Ship Breaking Industry

The ship-breaking industry in Bangladesh is likely to gain momentum in the next 10 years with the European Union's proposed accelerated phase-out of single-hull tankers (20,000 to 30,000 DWT – dead weight tonnage). Recent study shows there are more than 2,250 single-hull tankers of 5,000 DWT [till January 2004], which have to be scrapped. This is 25-30 percent higher than the estimate of peak volume of 2015. New regulations include a ban on carrying heavy grades of oil in single-hull tankers. European Commission (EC) has set strict time-tables to withdraw these single hull tankers within 2010 and 2015 [2]. The EU Parliament and council amended regulation 417/2002 to phase out single-hull tankers. Many of these ship breaking activities will be conducted in Bangladesh, India, China and Pakistan. Therefore, Bangladesh has a great prospect to gain economic benefit through ship breaking industry. State revenue from this industry in next decade and national economy will significantly be enhanced by the ship breaking.

5. IMPLEMENTATION OF SUSTAINABLE DESIGN APPROACH:

The way to eliminate environmental pollution and health hazard from the shipbreaking industries in Bangladesh is to apply the sustainable design approach. There are two perspectives to apply this sustainable design approach. First one is to design a sustainable work operation procedure of dismantling ships. Second one is to design a sustainable shipyard layout and infrastructure. In following subsections we have described both of these approaches.

5.1 Sustainable Dismantling Procedure

In order to develop sustainable, environmentally and occupationally safe ship breaking industry, we propose a methodology. A flow chart of the methodology is shown in Figure 3. It consists of 3 phases: Phase 1, Phase 2 and Phase 3. Each of these 3 phases is described in the following subsections.

5.1.1 Phase 1: Pre Dismantle Preparation

In phase-1, we identified the key pre-inspection and pre-cleaning features. This is the most important phase for ensuring environmental hazard free ship-breaking. When an imported ship enters the coastal area, a detailed inspection should be required.

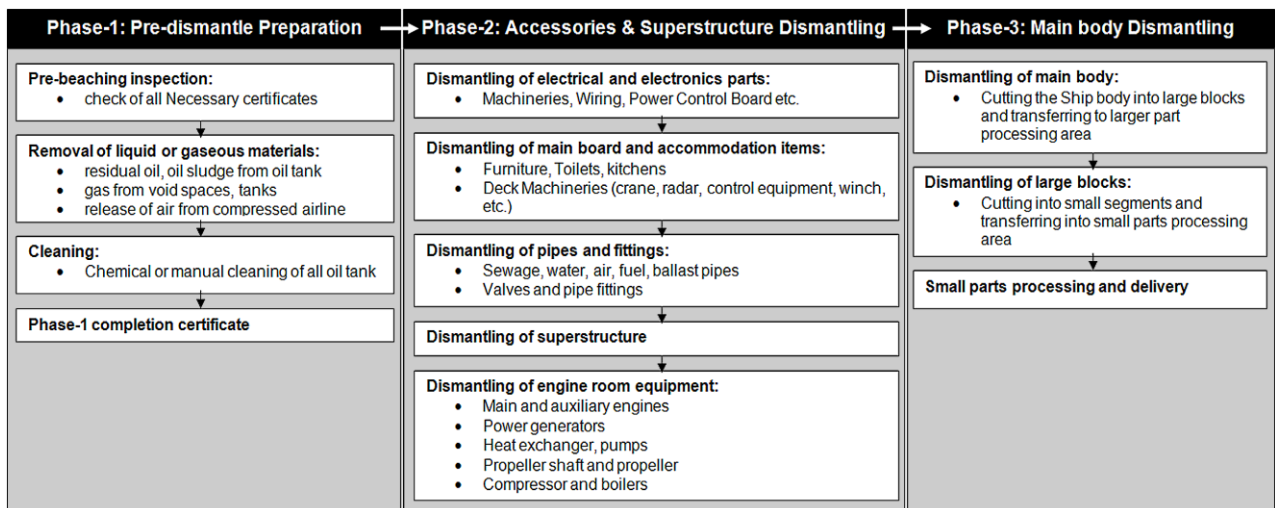


Fig 4. Phase wise dismantling procedure.

The inspection group can be made of representatives from Mercantile Marine Department, Department of Environment, Port Authority and Independent Environmental Monitoring Organization. The team will inspect all the necessary certificates and documentations. In this phase, all fuel, residual oil, oil sludge from the tanks must be removed safely. Nothing should be discharged to the sea and the atmosphere. The inspection body will also ensure the gas free certification, release of gas from cargo holds, void spaces, tanks. Toilet sewage, waste water, and so on should also be removed. Ballast water and fresh water should be tested whether they can be discharged in the sea without affecting the bio-diversity of the sea. The temperature of the hot water should be lowered before discharging into the sea. A specific guideline and test method should be implemented by the inspection authority. A specified amount of fuel oil should be left in the ship to drive the ship to yard dismantling area. After the beaching, the residual fuel oil should be removed before beginning any work. This should also be monitored by the inspection authority.

5.1.2 Phase 2: Accessories and Superstructure Dismantle

In phase two the dismantling of ship starts. In this phase, all parts and machineries will be removed from the ship. Electrical wiring is a major source of accident.

Initially, all electrical wiring, power control board, electrical machineries should be removed. Then all the furniture from accommodation, dining, kitchen appliances, toilet items should be removed. Afterward, the main deck machineries like crane, winch, capstan, bollard, pump, valve, life boat, radar, control equipment, navigation equipment, HVAC systems, and hatch cover should be removed. Later, all the pipelines such as sewage line, fresh water line, hot water line, bilge and ballast line, compressed air line, fuel oil line, lubrication oil line, sea water line, etc. should be removed. All valves, pipe fittings, pipe instruments should also be removed. After the completion of all mentioned above, the cutting and removal of the superstructure should be finished.

The super structure cutting includes the area from control room to accommodation and poop deck. The removal of super structure will open the top side of ship and allowing taking away all the equipment from engine room (e.g., main and auxiliary engine, power generators, heat exchanger, pumps, compressor and boiler). The propeller shaft, steering arrangement and propeller can also be detached from the ship. At the end of Phase 2, the only the main steel structural body of the ship will be left.

5.1.3 Phase 3: Main Body Dismantle

Phase 3 is the final stage of a complete dismantling process of the ship. It involves cutting and dismantling of the main body the ship. The main body needs to be cut in block by block segment. First the cutting should be done on fore peak and bow block. When the bow and fore peak blocks are removed, the wing tank or the left and right body of the cargo hold should be cut. Successively cutting should be started to the bottom tank. Cutting should be sequential from forepeak to aft peak of the ship. During the cutting each block area should be clearly specified. A thorough cutting plan should be devised and followed. During cutting, each block should be properly hoisted and well balanced by hanging from overhead crane, gantry crane or mobile crane. Each block should be shifted to large parts processing area. In large parts processing area, the block should be cut into pieces and shifted to small parts processing area. In the small parts processing area, further processing should be done according to customer needs and delivered by the adjacent transport way. By following these processes, it can be ensured an organized and efficient way of cutting the ship. It will ensure the safety of workers, surrounding environment, and increase productivity, efficiency and profit margin.

5.2 Design Layout of Ship Breaking Yard

One of the main reasons for environmental pollution, infringement of OHS and other incidents is the unplanned ship breaking in unconstrained beach area. In order to minimise or fully eliminate these concerns, a well-planned ship breaking yard with required infrastructure must be implemented. It will also increase productivity and pilferage significantly. A good

cooperation between government and ship breaking yards is needed to develop specialised zones in the coastal area for ship breaking activities by allocating land not more than minimum requirement under stringent OHS and environmental conditions. In order to develop a sustainable ship breaking yard, we propose a design layout. This design layout is shown in Figure 4. The layout design should include the following:

- a) The entire ship breaking regions must be subdivided into multiple plots and individual plot will be a ship breaking yard. Each yard must be separated from adjacent yards by appropriate boundary wall. All the ship breaking activities must be contained within the plot.
- b) Safe transportation of dismantled parts, machineries, steel plates and other commodities to and from the ship breaking yard zone must be ensured. Each individual ship breaking yard must have easy access to nearby main highway and rail network.
- c) Ship breaking yard zone must have a Central Waste Management plant. A drainage line from each channel is drawn, which flows to central waste treatment plant. Each yard must also have a solid waste area. The solid waste should be carried to the Central Waste Management Plant.
- d) A safe handling Centre for Asbestos and Hazardous materials is also required for each ship breaking yard.
- e) In order to improve workers occupational health and safety, productivity and wellbeing, leisure and recreational centre must be incorporated in the ship breaking yard.
- f) Appropriate material handling equipment including overhead crane, gantry crane must be available in each yard. In ship breaking yards of most developing countries especially in Bangladesh, one of the main reasons for serious accidents and work related deaths is the lack of mechanized material handling facility. Most work is done by manual hands which is dangerous and less productive. The Gantry Crane, Overhead Crane, Mobile Crane, Hauling Winch should be used for handling of the large to medium parts and machineries. A layout for this equipment is shown in Figure 4.
- g) The individual ship breaking yard should not destabilise the surrounding flora and fauna. Green vegetation must be developed around the ship breaking zone. Additionally, the yard must be protected from sea surge especially tropical cyclone and storm by enacting a barrier.
- h) Instead of breaking the ship directly on the beach, there should be a dry-dock or a channel type platform in the mouth of the sea-shore in each ship breaking yard, where the ship will enter during high tide. A lock gate can be provided in the channel. In Figure 4, the proposed channel for ship breaking is shown. When the ship enters in the channel the lock gate closes the channel and water pumps out and the ship stand on the platform. Large part of the ship can be dismantled here and the dismantled parts can later be moved to the designated place for further dismantling. This layout design will be effective and providing much needed sustainable ship breaking in Bangladesh. The design can be modified to fit other countries' ship breaking activities in accordance with their geographical and environmental needs.

- i) In each ship breaking yard there should be an OHS office. The office will look after the occupational health and safety of all activities undertaken in the yard. The location of the OHS office is shown in Figure 4. It will ensure whether the workers are working with proper safety equipment, all work is going on in accordance with safety procedure or not, safe handling of equipment and parts, certification of handling equipment, fire and emergency system, accident and injury handling, etc.

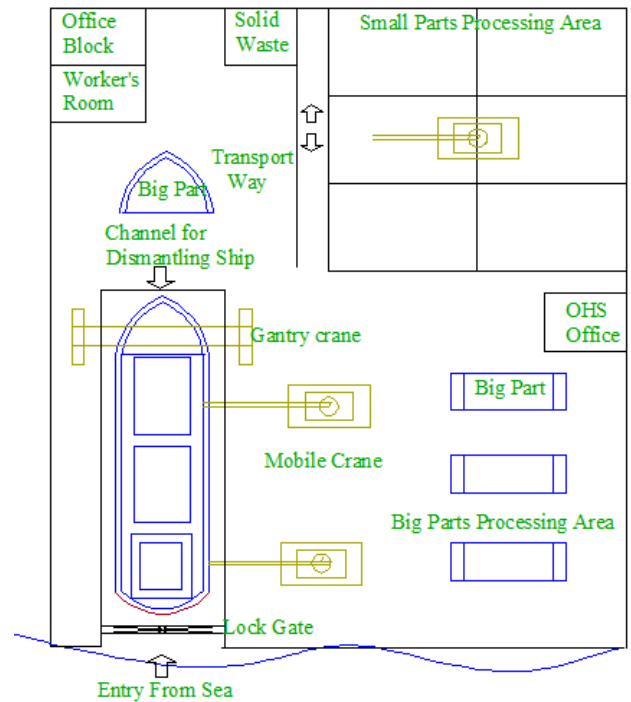


Fig 5. Layout design for sustainable shipbreaking yard.

6. CONCLUDING REMARKS

Shipbreaking industry is vital for the economic development of Bangladesh. It is a major source of steel for country's booming construction industry. It is considered to be green industry as it recycles and reuse materials and machines. However, the shipbreaking industry is currently being developed without any plans and creates a huge environmental and occupational health hazards. The primary reason for this unplanned development is believed to be due to the lack of awareness, government policies, and engineering know how. As the ship breaking industry has become an integral part of the nation's economical prosperity, the imposition of sudden ban on the industry will hinder the country's economic development immensely and also cause huge job losses. A sustainable ship breaking industry using well planned design of dismantling procedure and shipbreaking yard will ensure not only the further development of this vital industry but also environmental protection, productivity, and employees occupational health and safety. A close cooperation between different stakeholders such as various Government regulatory bodies, stakeholders of ship breaking industry, non-government environmental organisations and engineering experts is much needed to tap the huge potential of this vital industry.

7. REFERENCES

1. Hossain, M. M., Islam, M. M., 2006, "Ship Breaking Activities and its Impact on the Coastal Zone of Chittagong, Bangladesh: Towards Sustainable Management", Young Power in Social Action, Chittagong, Bangladesh
2. International Maritime Organization [Online], "Report 2003", Accessed: July 2010, Available: www.imo.org/newsroom/mainframe.asp?topic_id=758&doc_id=29
3. ILO, 2003, "Draft guidelines on safety and health in ship breaking. Interregional Tripartite Meeting of Experts on Safety and Health in Ship breaking for Selected Asian Countries and Turkey, Bangkok, 20-27 May 2003", International Labour Office – Geneva, pp 101
4. ILO, 2004, "Safety and Health in Ship breaking: Guidelines for Asian Countries and Turkey", International Labour Organization (ILO), Geneva.
5. Islam, K. L., Hossain, M. M., 1986, "Effect of ship scrapping activities on the soil and sea environment in the coastal area of Chittagong, Bangladesh" *Marine Pollution Bulletin* 17(10): 462-463
6. Siddiquee, N. A., Parween, S., Quddus, M. M. A., Barua. P., 2009, "Heavy metal pollution in sediments at shipbreaking area of Bangladesh", *Asian Journal of Water, Environment and Pollution* 6(3): 7-12
7. Shipbuilding Statistics, 2010, "Report of 'The shipbuilders association of Japan', October, 2010".
8. Young Power in Social Action, 2005, "Workers in Ship Breaking Industries: A Base Line Survey of Chittagong, Bangladesh", Young Power in Social Action (YPSA), Chittagong, Bangladesh

8. MAILING ADDRESS

Iftekhar Khan

School of Aerospace,
Mechanical and Manufacturing Engineering RMIT
University
Melbourne, Victoria 3083, Australia.
E-mail : S3315954@student.rmit.edu.au,