الأبحاث المنشورة - (1994-2005) فى مجال الطاقة والبيئة

للأستاذ الدكتور محمد عبد الفتاح شامة

Published Papers (1994-2005)

on Energy and Environmental Protection

by Prof. Dr. M. A. Shama

1- "A Projection on the Future Demands and Capability of Offshore Technology" A.M.R.J. (Egypt-1976), Shama, M. A.,. (100%)

2- "A General Outlook to Offshore Technology", Egyptian Society of Marine Engineers and Shipbuilders, Forth seminar, Alexandria, April, (Egypt-1983), Shama, M. A., (100%)

3- "Costs of C02 Abatement in Egypt Using Both Bottom-Up and Top-Down Appr", Energy Policy, (USA-1994)Yehia El Mahgary, A. F. Ibrahim, M. A. F. Shama, A. Hassan, M. A. H. Rifai, M. Selim, I. Abdel Gelil, H. Kokor, Anhar Hegazi, A. Amin, F. Bedewi and Juha Forsstrom, (8%)

4- "Estimation of GHG Emissions in Egypt Up to the year 2020", World Resource Review, Vol. 6, No. 8, (USA-1994), Yehia El Mahgary, VTT-Energy, A. I. Abdel-Fattah, M. A. Shama, Alexandria, Faculty of Eng., M. Selim, I. Abdel Gelil, Anhar Hegazi, NREA, Egypt, M. A. Rifai, Azhar University, A. Amin, F. Bedewi EEA, Egypt, and J. Forsstrom, (11%)

5- "Technical Evaluation of Transport- Related GHG Abatement Techniques", AEJ, April. (Egypt-1995), Shama, M. A., and Hassan, A. (50%)

6- "Ship Casualties Types, Causes and Environmental Impacts", AEJ, April. (Egypt-1995), Shama, M. A. (100%)

7- "Ship Structural Failures: Types Causes and Environmental Impact", AEJ, July. (Egypt-1995) Shama, M. A., (100%)

8- "GHG Emissions Inventory for Egypt and Emission Mitigation Options",VTT, Energy, (Filand-1995), Yehia El Mahgary, VTT-Energy, Finland, M. A. Shama, A. F. Ibrahim and A. Hassan, Alex. University, Egypt, M. A. Rifai, Azhar University, Egypt, I. Abdel Gelil, M. Selim and H. Kokor, ECPO, Egypt, Anhar Hegazi, NREA, Egypt, A. Amin, F. Bedewi EEAA, Egypt, and Juha Forsstrom, VTT-ENERGY,Finland, (8%)

9- "The problem of corrosion of ship structures", MARINES 96, Second Conference, Cairo, October, (Egypt-1996), Shama, M. A., (100%)

10- "Impact on Marine Environment of Ship Structural Failures and Casualties", AEJ, Jan., (Egypt-1997), Shama, M. A., (100%)

11- "Energy and Env. in Eng. Education", AEJ, Vol.36. (Egypt-1997), Shama, M. A. (100%)

12- "Energy and Environment Dimension in Ship Manufacturing Processes", PRAD's 2001, Sept., 8th Int. Conf. on Practical Design of Ships and other Floating Structures, (China-2001). Shama, M. A., (100%)

13- "Life Cycle Assessment of Ships", Alexandria Engineering Journal, AEJ, (Egypt-2004) Shama, M.A. (100%)

14- "Life Cycle Assessment of Ships", IMAM 05, Sept. International Maritime Association of Mediterranean Sea, (Portugal-2005), Shama, M. A. (100%)

15- "Environmental Dimension in the Ship's Life Cycle", MARDACON 9, December, Int. Con. "Towards a Cleaner and Safer Maritime Context", (Egypt-2005), Shama, M. A. (100%)

Practical Design of Ships and Other Floating Structures
You-Sheng Wu, Wei-Cheng Cui and Guo-Jun Zhou (Eds)

ENERGY AND ENVIRONMENT DIMENSION IN SHIP MANUFACTURING PROCESSES

M. A. Shama

Department of Naval Architecture and Marine Engineering
Faculty of Engineering, Alexandria University, Alexandria 21544, Egypt

ABSTRACT

The main issues of energy and environment associated with shipyards manufacturing processes are presented. The direct and indirect demands of energy in the shipbuilding industry are clarified. The Life Cycle Analysis (LCA) in ship production is addressed with particular emphasis on the methods commonly used to reduce energy consumption and relevant harmful environmental impacts. The holistic approach of LCA is briefly outlined. The importance of rationalization of materials used in shipbuilding and ship scrapping is stressed. The modern approach of *Ship Design for Environment* is highlighted. The paper is concluded by stressing the importance of introducing the relevant energy and environment courses into the educational programs of Naval Architecture and Marine Engineering departments.

KEYWORDS

Shipbuilding, Energy, Environmental impacts, Pollution, Risk analysis, Life cycle analysis, Design for environment

1 INTRODUCTION

Awareness about environmental problems has increased significantly in recent years. There is now widespread appreciation of the serious health risks, degradation of natural resources, climate change and need for means of environmental protection. Energy consumption has adverse economic and environmental implications. Therefore, consumption of energy should be rationalized in order to improve the economics of the industry and protect the environment, particularly for energy intensive industries.

The shipbuilding and ship repair industries consume various types of energy for ship production and ship repair and therefore produce environmental problems. Identification of the size, scope and consequences of the harmful environmental impacts should receive some consideration. Solving pollution problems should be directed to pollution prevention, reduction and control. This philosophy should be reflected in the teaching curricula of the Faculties of Engineering. Future engineers should be properly equipped with adequate knowledge on energy and environment so as to understand and contribute to resolving the local, regional and global environmental challenges.

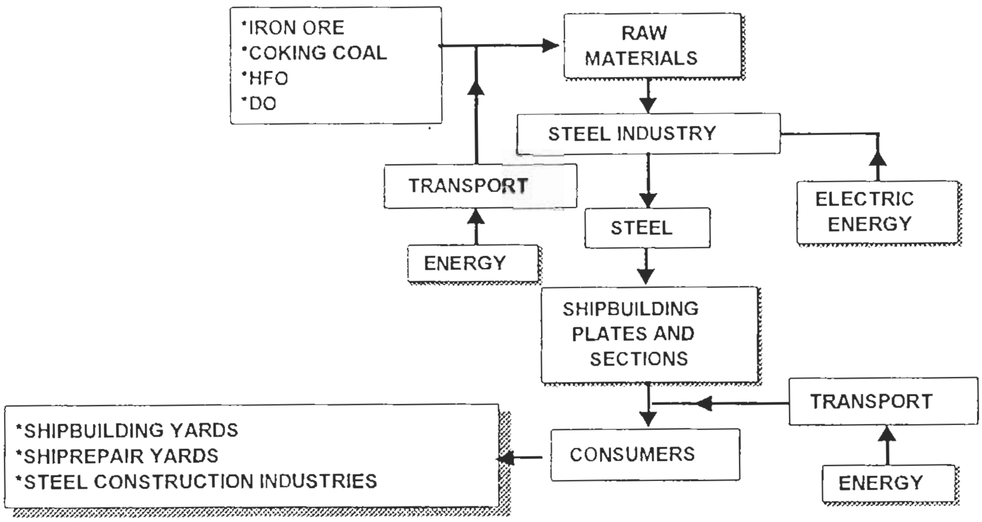

Figure 1: Indirect Energy used in Shipbuilding

2 TOTAL SHIPBUILDING SYSTEM

The total shipbuilding system is composed of several activities involving transportation, prefabrication, fabrication, post fabrication, outfitting, ship delivery and post delivery operations. The main elements of these activities involving environmental impacts are associated with the different materials used in ship construction, energy consumed in the various stages of fabrication, transport, construction, testing, maintenance and repair.

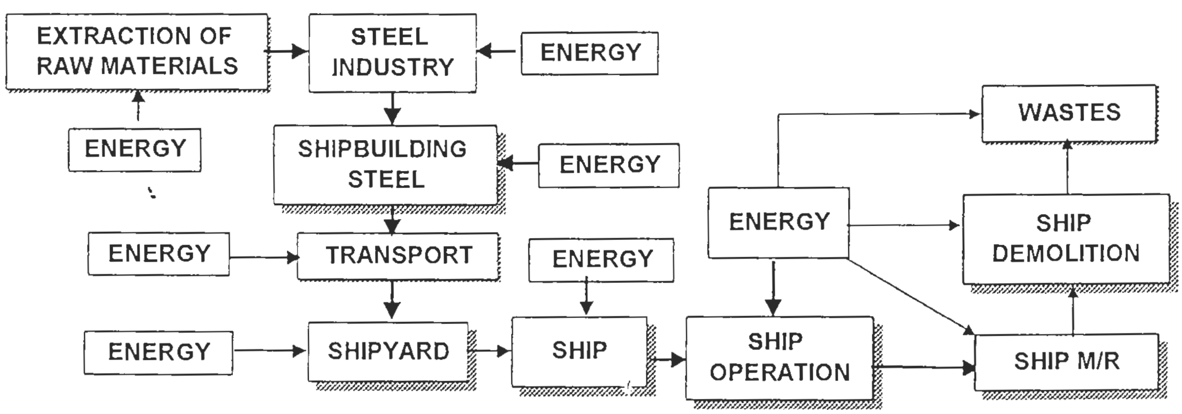

Figure 2: Demands for Direct Energy

3 ENERGY USED IN THE SHIPBUILDING INDUSTRY

The energy demands for the shipbuilding industry could be divided into *direct* and *indirect* energy. The indirect energy is required for the manufacture and production of steel plates and sections, manufacture of main and auxiliary engines, manufacture of equipment and fittings, production of welding electrodes and coils, production of paints, etc., see Figure 1. The direct energy is required for

the handling and transport of raw and fabricated materials, prefabrication and fabrication processes: cutting, forming of plates and sections, welding and assembly of steel plates and sections, construction of 2D and 3D blocks, assembly of blocks on berth/dock, outfitting and painting operations, tests and trials, see Figure 2. Figures 3,4 show the energy demands for ship plates forming and welding operations, (EE = Electric Energy, GE = Gas Energy).
For plate forming using line-heating method, acetylene is used for providing the required heat energy and CO_2 is the main polluting gas emitted. Assuming complete combustion of acetylene, the amount of emitted CO_2 could be estimated using the reaction equation for complete combustion as given by:

$$C_2H_2 \quad + \quad 2.5O_2 \Rightarrow \quad 2CO_2 \quad + \quad H_2O$$

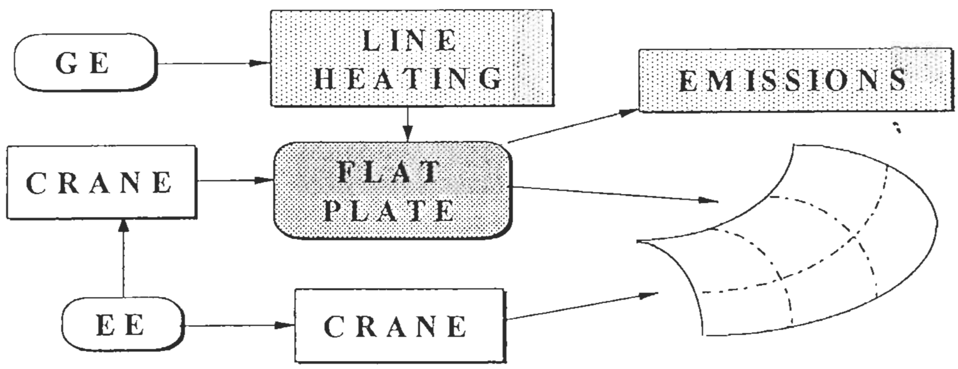

Figure 3: Energy Demands for Plate Forming, Line Heating

4 LIFE CYCLE ASSESSMENT IN SHIPBUILDING INDUSTRY

Life Cycle Assessment (LCA) adopts a holistic approach by analyzing the entire life cycle of a product starting with raw materials extraction processing and manufacture, materials transportation, product fabrication, transportation, distribution, operation, maintenance & repair and finally scrapping. The solid waste management hierarchy includes waste prevention, minimization at source, reuse, repair, recycle, incineration (with or without energy recovery) and landfill.

The holistic approach of LCA covers the energy consumption and associated environmental impacts over the entire life of a product. The main components of this holistic approach are:

- *Inventory analysis:* addresses the identification and quantification of energy and resources used and environmental releases to air, water and land.
- *Impact analysis:* addresses the technical qualitative and quantitative characterization and assessment of the ecological and human health consequences and resource depletion.
- *Improvement analysis:* addresses the evaluation and implementation of opportunities to reduce environmental burdens

LCA in the Shipbuilding Industry should include not only environmental impacts but should also include rational use of construction and outfitting materials, rational use of energy in all stages and phases of ship design, construction, outfitting, operation, maintenance, repair and finally ship scrapping. The main materials commonly used in the shipbuilding industry, which require rationalization are steel plates and sections, welding rods, castings, forged parts, timber, paints, etc. The rational use of these materials should not only reduce environmental impacts and energy consumption but should also have positive economic gains. The minimization of environmental impacts and wastes in ship construction could be achieved by the efficient use of all construction materials including steel plates, profiles, sections, welding rods, paints, etc. The measures commonly taken to save energy consumed in ship fabrication and construction are directed to the rationalization of inter-process transportation, reducing/improving bending & forming operations (2D and 3D forming), using large sizes of steel plates, particularly plate width, improving welding operations, improving accuracy of edge preparations, minimization of welding lengths, maximization of down-hand welding, minimization of cutting lengths of steel plates, widespread use of computer-aided marking and cutting, minimization of scrap using efficient methods of plate nesting, utilization of waste and minimization of rework.

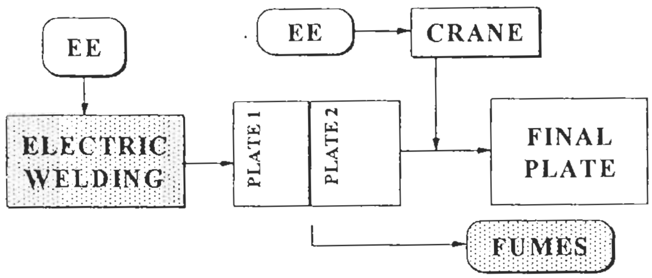

Figure 4: Energy Demands for Welding

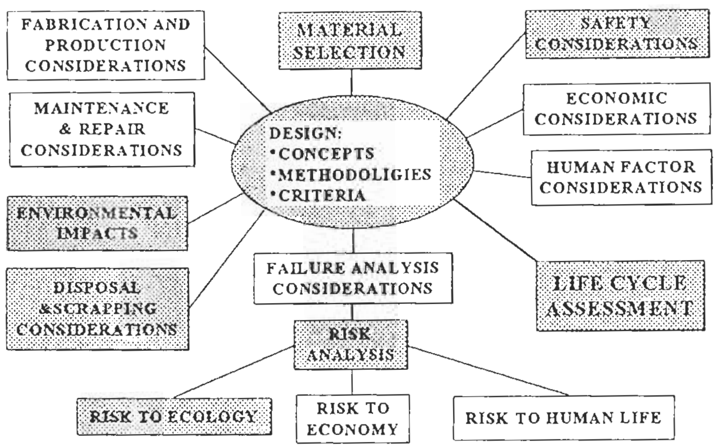

Figure 5: Holistic Approach of ship design

5 EDUCATIONAL ASPECTS OF ENERGY AND ENVIRONMENT IN SHIPBUILDING

A brief statement of the main energy and environment courses relevant to the shipbuilding and ship repair industries is given below. These courses should improve the awareness of future engineers about energy consumption and environmental impacts resulting from the manufacturing processes in the shipbuilding and ship repair industries.

6 THE ENVIRONMENTAL ENGINEERING SYSTEM

The course on Environmental Engineering System should include design, construction, operation, maintenance and repair (M/R) and scrapping. Design is one of the main courses given in Faculties of Engineering that has a close connection with the relevant issues of energy and environment. The environmental dimension should be an integral part of the holistic approach of ship design, see Figure 5. The main objective of this holistic approach is to make safety, economy and environmental protection an integral part of the ship design process. Unfortunately, the inadequacy of design for safety is appreciated only after serious accidents have occurred. Design for safety, therefore, should include risk to human life and risk to environment. Risk management should, therefore, be an integral part of the holistic design approach. In the maritime sector, tragic accidents causing environmental disasters have focused world opinion on ship safety and environmental protection through the introduction of the International Safety Management code, (ISM).

The Factor of Safety commonly used in Engineering Design should, therefore, include not only safety of the structure but should also take into account risk to human life and risk to environment, as follows:

$$\gamma = \gamma_X . \gamma_Y . \gamma_Z$$

γ = Total Factor of Safety

γ_X = factor taking account of the safety of the system

γ_Y = factor taking account of the risk to human life

γ_Z = factor taking account of the risk to ecology

It is evident that the irrational increase in the magnitude of the total Factor of Safety of ship structure will not only reduce the probability of structural failure, the cost of failure, the harmful impact to the environment but will also increase the initial cost of ship structure through the irrational use of materials and resources. This indicates clearly that the magnitude of the Factor of Safety should be rationally selected so as to satisfy the requirements of safety, ecology, economy and sustainability.

7 RISK MANAGEMENT

The course on Risk Management should cover hazard assessment, risk analysis, development of accidental scenarios that could potentially lead to fatalities/injuries, development of methods and actions to reduce/prevent risk, calculation of risk taking into account the likelihood of the scenario and the probable negative consequences. Risk assessment is the process of assigning magnitudes and probabilities to adverse effects resulting from human activities. Risk could be assessed by using the probability density functions of both Demand and Capability. In this case the options to reduce risk are: increase capability (sometimes very costly), decrease demand (sometimes not feasible), decrease variability and uncertainty of capability (possible), decrease uncertainty of demand (not always feasible).

8 ENVIRONMENTAL PROBLEMS

The course on Environmental Problems should cover the main types, causes, scope, consequences, prevention, reduction and control of the negative environmental impacts. The impact of industry on air pollution, water pollution, (rivers, coastal water, seawater, ground water, lake water), noise pollution, climate change, ozone depletion, etc. should also be addressed. The course should clearly indicate the consequences of irrational use of resources, expected climate change due to the increase of greenhouse gases, etc. The contribution of the shipbuilding and ship repair industries to the local, regional and global environmental problems should be also introduced and highlighted. Unfortunately, there is very limited data available on energy consumption in the various stages of ship production. Also, there is scarce data available on the various types of the negative environmental impacts resulting from the different stages of ship production.

9 ENERGY AND ENVIRONMENT

The course on Energy and Environment should cover environmental and economic benefits resulting from introducing methods of increasing efficiency of production processes, cost-effective methods of handling unwanted effluents and methods of waste reduction. The course should clearly indicate the importance of using methods for energy conservation, raising energy efficiency in the various ship production processes, energy saving techniques, minimization of total energy consumption, minimization of wasted energy, controlling the environmental problems resulting from energy consumption, using safer, cleaner and more efficient technologies and systems for ship production. The course should also cover energy saving methods in ship operation, maintenance & repair and ship scrapping.

10 WASTE MANAGEMENT

The course on Waste Management may include the environmental and economic benefits from life extension, waste prevention/minimization at source, re-use, recycle, recover, repair/upgrade, incineration, (with/without energy recovery), dumping and landfill.

Ship scrapping is becoming an important industry in several countries. The outcome of ship scrapping includes usable materials, engines, equipment, fittings, etc. The various activities and operations used in this industry should be rationalized so as to protect our natural resources, save energy consumption, minimize environmental impacts and waste. The expected growth of this industry necessitates a thorough examination of the main issues of energy and environment associated with this fast growing industry. Waste management in ship scrapping should not only have significant economic opportunities but should also have positive impact on environmental protection.

11 CONCLUSIONS

The main conclusions drawn up from this paper are:

- In spite of the limited scale of local, regional and global negative environmental impacts of shipbuilding and repair industries, the identification, quantification and control of these negative impacts should receive serious attention.
- LCA in the shipbuilding industry could be used to assist shipbuilding and ship repair companies to quantify, assess and identify opportunities to minimize energy consumption and its impact to the environment, and to realize cost savings by making more effective use of available resources.
- The rational use of shipbuilding materials should not only reduce the harmful environmental impacts and energy consumption but should also have positive economic gains.
- Waste management in ship scrapping should not only have significant economic opportunities but should also have positive impact on natural resources and environmental protection.
- The teaching of Design courses should be more comprehensive than that normally given in our Faculties of Engineering and should cover the main issues of energy and environment.
- The environmental dimension in ship design should be an integral part of a holistic approach of ship design that takes account of safety, economy and environmental protection.
- In order to improve local, regional end global environmental protection, future shipbuilding and ship repair engineers should be well equipped with the necessary knowledge and tools for energy conservation and environmental protection.

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