ShahzadAhmad, Annu Singh Patel / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue4, July-August 2012, pp.1068-1072

Environmental Life Cycle Assessment- A Successful Tool For Sustainable Development In Steel Industries

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Abstract

The Iron and Steel industry is facing a serious challenge today both in the developed countries as well as in the newly industrialized parts of the world due to the Energy price escalation, natural resource depletion, and wide-spread environmental degradation. In the present situation, the steel industry, as a highly material and energy demanding technology oriented sector, not only needs to address the obvious questions of profitability, innovation and adaptation to new technology but also has to refocus its attention on its overall responsibility to the society in terms of environmental performance. There is a realization that product design and consumer behavior can affect the overall environmental performance and efficiency of a product. Among the tools and methodologies available to evaluate the environmental, economic and social performance of materials and consumer products (including their impact on climate change and natural resources), life cycle assessment (LCA) provides a holistic approach that considers the potential impacts from all stages of manufacture, product use and end-of-life.

In this paper assessment result of environmental impacts in iron & steel -making system based on LCA (Life Cycle Assessment) will be presented. LCA is important tool in implementing the Environmental Management System (EMS). LCA is a technique for assessing the environmental aspects and potential impacts associated with the product or technology. LCA is an environmental assessment tool for evaluation of impacts that a technology or product has on the environment over the entire period of its life – from the extraction of the raw material through the manufacturing, packaging and marketing processes, the use, re-use and maintenance of the product, to its eventual recycling or disposal as waste at the end of its useful life. In this paper, special attention is given to handling and management of wastes and, therefore, wastes minimization initiatives through resources, recycling, reuse and ULCOS (Ultra Low CO_2 Steelmaking) for promoting Sustainable development in Steel Industries.

Keyword: LCA (Life Cycle Assessment), Recycling, CO_2 reduction, ULCOS (Ultra Low CO_2 Steelmaking), Steel Industry & Sustainable Development.

I. INTRODUCTION

The iron and steel industry is one of the largest industrial energy consumers, accounting for 20-45% of total industrial energy demand in many countries. It plays a significant role in the economic growth of developing countries. Recent years have seen rapid industrialization and infrastructure development leading to higher steel consumption and consequently increased production requirement in industrializing nations. Although production has increased mainly due to extended plant capacities and introduction of new factories, little attention had been paid to efficient energy utilization and environmental pollution control. The main causes for energy inefficiency and environmental pollution are outdated production technology in use, aged industrial infrastructures, lack of management skills and coal dominated energy structures. Therefore, there is a need for an integrated approach towards energy and environment management of the industry so that better energy efficiency and environmental friendliness can be achieved.

This Paper describes the environmental impacts in iron & steel -making system based on LCA (Life Cycle Assessment) & give special attention to handling and management of wastes and, therefore, waste minimization initiatives through recycling and reuse for promoting Sustainable development in Steel Industries.

Stainless Steel is a highly durable material used in many qualified applications. Like all materials, its production and use affect the environment in many different ways. Assessing the overall environmental impact of products requires an integrated approach that considers the product over its entire life cycle — Life Cycle Assessment (LCA). LCA has been welcomed by the stainless steel industry as a means to provide our customers with an accurate profile of stainless steel's environmental credentials. In addition, it serves as a valuable tool to assist stainless steel makers in their continuing drives to improve environmental performance even further. These include:

i. Developments to optimize environmental performance in steel making processes,

ii. The production of modern stainless steels and components that support customers' developments of environmental solutions.

II. LIFE CYCLE ASSESSMENT

LCA is an environmental assessment method for evaluation of impacts that a product, process or technology has on the environment over the entire period of its life –from the extraction of the raw material through the manufacturing, packaging and marketing processes, the use, re-use and maintenance of the product or technology, to its eventual recycling or disposal as waste at the end of its useful life. LCA, in particular, provides a new perspective on products and processes as it examines the industrial systems and evaluates their performance starting from the extraction of raw materials through all the varied operations until their final disposal as wastes back into the ecosystem.

Life Cycle Assessment (LCA) or commonly known "Cradle to Grave" analysis, has emerged as a powerful analytical tool for material development and product substitution to meet the twin objectives of resource optimization and sustainable development. LCA is a new way of looking at products and processes. Also called Ecobalance, it essentially seeks to determine the impact of a product or a process on the environment through its entire life cycle from the cradle to the grave.LCA is important tool in implementing the Environmental Management System (EMS). LCA is a technique for assessing the environmental aspects and potential impacts associated with the product or technology.

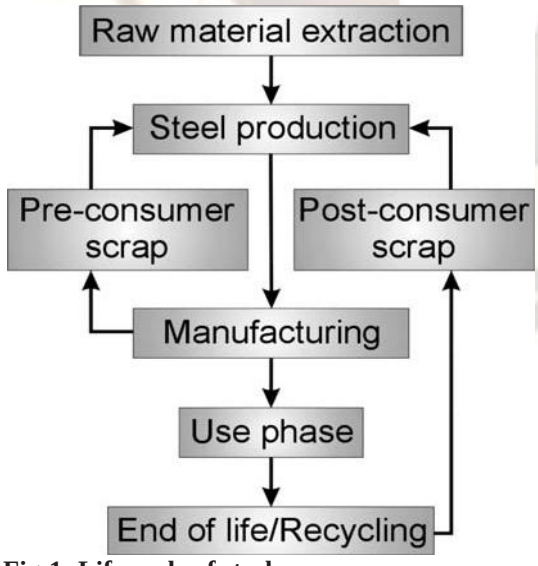

Fig-1: Life cycle of steel

III. LIFE CYCLE INVENTORY

Life Cycle Inventory (LCI) is one of the phases of a Life Cycle Assessment (LCA). LCI data quantify the material, energy and emissions associated with a functional system.

The LCI was initially a cradle-to gate study, where the analysis of data was from raw materials through to the stainless steel product at the works gate. After that developed a methodology for allocation of credits for recycling in order to assess accurate profiles of stainless steel products. LCI is essentially the backbone of any LCA and requires an exhaustive listing and quantification of energy and raw material requirements, air emissions, effluents and other environmental releases.

The LCI Study for Stainless Steel Products is one of the tools being used by the stainless steel industry to both improve the impacts of its own processes on the environment, and to work closely with its customers in improving the total impact of stainless steel-using products on the environment, over their complete life cycles.

IV. GOAL OF LCA IN WORLD STEEL

As the global body for steel, worldsteel is in a unique position to provide the most consistent and accurate information about LCA in the steel industry. worldsteel has been collecting life cycle inventory data from its member companies worldwide since 1995, with the launch of the worldsteel life cycle inventory (LCI) methodology and study. The worldsteel methodology provides a common basis of measurement of environmental and efficiency performance around the world. The LCI data quantifies 'cradle to gate' inputs (resources use, energy) and outputs (environmental emissions) of steel production from:

- extraction of resources and use of recycled materials,
- production of steel products to the steelworks' gate and
- end-of-life recovery and recycling of steel.

This data is used worldwide in LCA studies, not only by industry, but also by universities to ensure informed material selection decisions. The worldsteel programme helps to identify ways to improve the eco-efficiency of steelmaking. The third worldsteel LCI data collection was completed at the end of 2009. Its aims are:

- to provide up-to-date and consistent LCI data for steel products around the world,
- to increase the coverage of steelmaking sites within the new datasets and

- to determine global LCIs for additional steel products.

V. WORLDSTEEL'S LCA ETHODOLOGY AND LCI DATA HELP THE INDUSTRY TO:

- provide information to our customers, as well as their customers
- understand the contribution of steel to the environmental performance of product systems in different applications
- support technology assessment (benchmarking, determination and prioritisation of environmental improvement programmes)
- carry out impact assessments to reduce the impacts of its own processes on the environment and to work closely with its customers to gain knowledge about the total impact of steel-using products on the environment, over their complete life cycle
- increase public knowledge of the life cycle environmental benefits of using steel in applications and where it can be effective in improving environmental performance

VI. NEED FOR AN LCA STUDY FOR THE INDIAN STEEL SECTOR

The pervasive nature of the steel industry because of the magnitude of its operations and its intensive use of energy and raw materials is readily appreciated by all and, so is its potentially major impact on the environment. A major portion of the raw materials and other natural resources used in steel making get converted into and discharged as polluted air, water and solid waste at enormous energy and capital cost.

Steel production involves various processes that result in extensive consumption of natural resources. A material balance of a typical integrated steel plant indicates that the production of one tonne of finished steel product generates roughly 420 kg waste stream-mainly slag, dust and sludges. This is a clear pointer towards the need to address a number of technologies - related issues in the steel sector through integrative and diagnostic tools such as LCA so that timely interventions can help steel companies to increase their profitability and improve the quality of their products.

Optimal utilization of natural resources is now imperative for sustainable development and this is all the more necessary in the case of developing countries where development operations are still accompanied by avoidable waste of minerals energy, water and manpower. Considering that the concept of LCA could be gainfully used for drawing up raw material , energy conservation as well as pollution control and waste recycling plans in such a key sector such as steel.

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VII. BENEFITS OF 3R (RESOURCE, RECYCLING, REUSE) BY USING LCA METHODOLOGY

Depletion of steel resources is one of the major problems in the world. 3R measures including resource, recycling and reuse are very important practices for community and industrial activities. Life cycle assessment (LCA) is a scientific-based tool and can be used for quantitative assessment or for comparison of the environmental burdens for processes, products and 3R system by considering the whole life cycle perspective. The objective of this study is to quantitatively illustrate the benefits of 3R; especially recycling by using LCA methodology. The results of the study clearly show that 3R measures including resource recycling had a net gain on environmental benefits. 3R measures are effective solutions for waste generation and depletion of natural resources caused by the mass production and mass consumption of the present highly civilized social system. Resource recycling helps to prolong the lifespan of landfills and reduce the need for costly incineration. It also slows down natural resource depletion to ensure sustainable development of resource-intensive industries. In order to illustrate whether recycling is a good choice or not, Life Cycle Assessment (LCA) will be used to quantify the environmental burdens generated for the entire life cycle of the recycling system. Various recent LCA studies on the benefits of recycling and recovered materials are reviewed. Several LCA software programs, namely SimaPro, GaBi, and JEMAI-LCA Pro, are also used for this study. The aim of this study is to illustrate the benefits of recycling by comparing the recycled materials to the virgin materials.

VIII. FRAMEWORK OF LIFE CYCLE ASSESSMENT OF RECYCLING

LCA is a systematic method for evaluating the environmental burdens associated with a product, process or activity, by identifying and quantifying energy and materials consumed and wastes released to the environment.

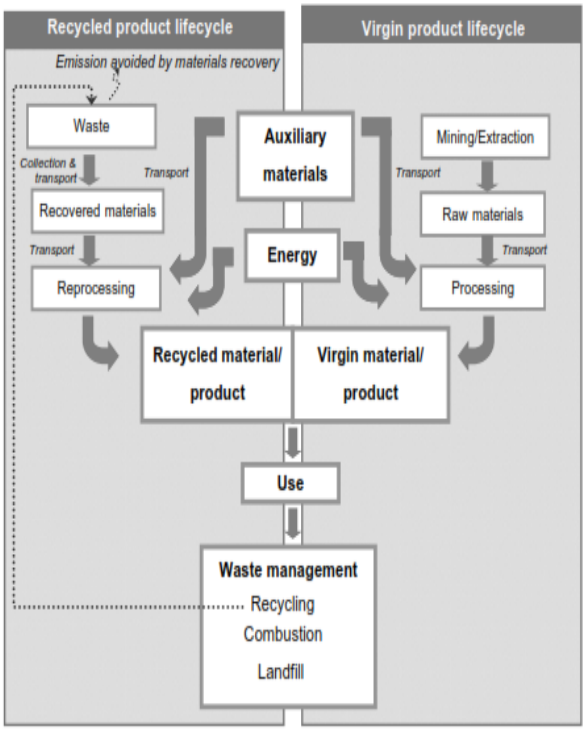

Fig- 2: System boundary of the recycled and virgin material/product

Based on the scope of the LCA for recycled materials/products comparing to virgin materials/products, the system boundary for supply chain model is shown in Figure 1. In the recycled material/product, the life cycle stages for which the emission data will be gathered are recycled material collection, reprocessing (including auxiliary materials and electricity), transportation, use, and waste management. For the virgin material/product, the life cycle stages are raw material extraction, processing (including auxiliary materials and electricity), transportation, use, and waste management.

IX. BENEFITS OF RECYCLING: USING SEVERAL LCA SOFTWARE PROGRAMS

Manufacturing processes including recycling are often very complex and convoluted. Additionally LCA is often required input-output data intensively. LCA software program can help to structure the model scenario, display the process chains and also present and analyze the results. Several commercial and public-domain LCA software programs are available. Among those are SimaPro, GaBi, and JEMAI-LCA Pro available at National Metal and Materials Technology Center and several universities in Thailand. The databases in those three software programs include production processes of virgin and recycled materials.

X. LIFE CYCLE ASSESSMENT IN ULTRA-LOW CO_2 STEELMAKING

Life Cycle Assessment (LCA) is considered as an appropriate method for assessing environmental impact and selecting new technologies to reduce CO_2 emissions for steel industry.

The European Steel Industry has created a group of industries and of research organizations that has taken up the mission of developing the breakthrough technologies – the ULCOS (Ultra-Low CO2 Steelmaking). The group develops a breakthrough steelmaking process that has the potential of meeting the target of reducing GHG (Greenhouse Gas) emissions. ULCOS (Ultra Low CO2 Steelmaking) is the world's initiative to reduce carbon dioxide emissions by 50 % with today's best routes from steel production by developing new breakthrough technologies. A new environmental Life Cycle Assessment (LCA) method has been undertaken in ULCOS as the most holistic approach of assessing environmental impact and selecting new technologies The ULCOS project is today the largest endeavour within the steel industry worldwide, proactively looking for solutions to the threat of global warming.

LCA analyses are performed in the frame of ULCOS project in the purpose of assessing of the influence of metallurgical processes on the environment and choice of new technologies. According to ULCOS interconnection between LCA and Aspen Plus is a powerful tool in the selection of new technologies for environmental friendly steel production.

Using Aspen Plus™ software, a physicochemical model has been developed for the integrated Steelmaking route. This model gives the possibility to carry out life cycle inventories for different operational practices in order to optimize the use of energy, to calculate CO_2 and other emissions and to control the mass and the heat balances of processes.

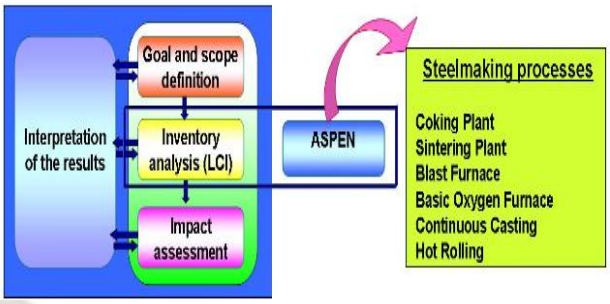

Fig-3: New methodological framework for LCI analysis.

XI. CONCLUSION

Environmental Life Cycle Assessment study in iron and steel industry is widely developing in the world. Life Cycle Assessment (LCA) provides a holistic approach that considers the potential environmental impacts from all stages of manufacture, product use and end-of-life. Life Cycle Assessment (LCA) or commonly known "Cradle to

Grave" analysis has emerged as a powerful analytical tool to meet the twin objectives of resource optimization and sustainable development. Life Cycle Assessment (LCA) is an appropriate method for assessing environmental impact and selecting new technologies (ASPEN PLUS™ Software) to reduce CO2 emissions and produced Ultra low CO2 steelmaking for steel industry. There are several LCA software programs, namely SimaPro, GaBi, and JEMAI-LCA Pro, are also used to illustrate the benefits of recycling by comparing the recycled materials to the virgin materials. That's why we can say that Environmental Life Cycle Assessment- A Successful tool for Sustainable development in Steel Industries.

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