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Life Cycle Assessment in a Cold Rolling Mill Manufacturing Industry in India-A Review

Vishal Y. Bhise[1], Ajay Kashikar[2]
[1](Research Fellow-Master of Engineering, Dept. of Mechanical Engg., LTCoE, Navi Mumbai, India)
[2](Asst. Professor, Dept. of Mechanical Engg., LTCoE, Navi Mumbai, India)

***ABSTRACT**: The life cycle phases of rolls of cold rolling mill consist of extraction of raw material, manufacturing, use and recycling. During each phase of life it consumes several inputs in the form of resources like energy, material, water etc and emit outputs in the form of air, water & solid emissions which creates the heavy environmental burdon and leads to global warming potential, acidiphication, eutrophication etc. This paper gives the brief information about the history of LCA, views and definations of Indian and foreign authors, method of data collection, formulation of questions to identify goal and scope, formulation of the inventory, categorization of impacts and their evaluation. The paper mainly focuses on the methodology used for assessment which enables to measure the environmental performance of an individual product as well as overall performance of the firm which leads the company towards the journey of sustainable development.*

***Keywords:** Life cycle assessment, Life cycle inventory, Input-output models, Environmental impacts, Life cycle performance indicators, Life cycle decision making, Recycle modelling, LCA softwares.*

I. Introduction

In the today's world of greener economy and sustainably conscious society, It has become significant for industries to focus on minimization of the environmental impacts of products, occured due to various operations performed for it's creation. The influence of implementation of environmental policies framed by various worldwide organizations and government bodies, the industries look forward for the sustainable manufacturing. The current trend of zero emission has forced the industries to produce less harmful and eco-friendly products to sustain in the competitive market and to gain the higher market share & customer faith. In order to achieve this it is significant to evaluate the environmental performance of manufacturing firms. Therefore, professionals find the Life cycle assessment as one of the highly efficient tool which is used to evaluate the environmental impact of a product during its whole life cycle. Further, the aggregation of all products impacts can give the total environmental impact of the manufacturing firm.

In 1969, the first initiative about reducing the environmental impact was taken by Coka-Cola. They realized the impacts of beverage tin. In order to cope up the situation they combinely formed a team with local authorities to collect the aluminium tins and recycled them instead of using the primary raw material every time. As a result, they reduced the energy conservation by 90%.

During 1970's some policies were formed which used to focus only on single state of products life, such as production of a single problem such as waste water. Due to focusing on a single issue the another burdons were getting ignored, as a result these policies were ineffective. However, their main objective was to change the attitude of people towards the business and environment.

In 1979, The Society of Environmental Toxicology and Chemistry was founded. Basically, it was a non-profit professional society with objectives to promote the various approaches for solving the environmental issues and to implement & regulate the government policies of environment.

In the 1980's the lifecycle assessment became a vital tool to identify the behavior of a product throughout it's life cycle to assess the environmental impact of product. Also, in late 1989, The 'PE International' launched a Life cycle assessment software tool into the market, which consist of database of several economic sectors to assess the environmental impact of product as well as industry sectors.

In 1993, The international standard organization involved the professionals from Society of Environmental Toxicology and Chemistry (SETAC) to standardize the LCA procedure . First, they standardize

the 'Principles and Framework' in 1997 in the form of ISO 14040. Further in year 2006, they reviewed & complied it and finally brought ISO 14044 life cycle assessment 'guidelines & requirements'.

In year 2002, Society of Environmental Toxicology and Chemistry (SETAC), United Nations Environmental Program (UNEP), professionals & experts from government authorities, industries came together to jointly promote the life cycle assessment method all over the globe.

In 2012, The European commission joint research center's 'Institute For Environmental & Sustainability' published the International reference life cycle database in the form of handbook for various economic sectors of industries within the framework and guidelines of ISO 14040 and ISO 14044 life cycle assessment standards[16]

II. Life Cycle Assessment

Life cycle assessment is a tool to evaluate the environmental consequences of a Product/Project or activity throughout its entire life from extraction of raw material, use of material, disposal and it's composition back to the element. The sum of all those phases is the life cycle of a product. The LCA enables to track and monitor the environmental impact of products over the entire life and to recognize the factors of environmental impacts

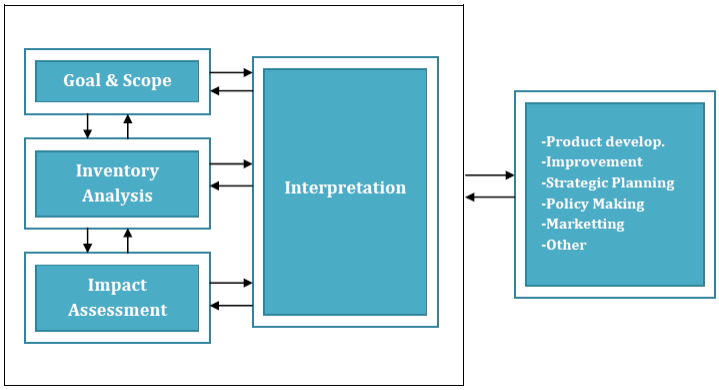

Figure 1. Life Cycle Assessment Framework (Source: ISO, 2006)

Cassiano Moro Piekarski defined, " Life cycle assessment is an entrepreneurial tool for firms to achieve sustainable results through of renewed vision about business management and green innovations" [3]. Arun kumar defined LCA " as a systematic analytical method to identify, evaluate and minimize the environmental impacts of a product through every step of it's life from transformation of raw materials into useful products and the final disposal of all products and it's byproducts" [2]. Stephen Finnegan, defined " LCA as a technique used for carrying out quantitative analysis of the environmental aspects of a product or service over its entire life cycle that allows for analysis of environmental aspects of a product and provides an assessment of the potential impacts on the environment" [6]. Darko Milankovic described " LCA as a basis for establishing an environmental policy and is generally used to guide the clean production, development of green production, and the environmental harmonization design" [4]. LCA Expert Jim Fava and N. Dasilva defines, " the LCA is a tool which assess the impacts of product on environment and human health through the life cycle of product, process and activity and enable the practitioners to model the entire product system." [15]

The life cycle assessment has its applications in various functions of organization. In Product development process, the LCA is used in decision making, planning and implementation of product development projects [3]. Yang & Chen, used the LCA tool for the development of eco-friendly products and evaluated the environmental performance of product during it's design stage [17]. In Improvement process the LCA helps to evaluate the environmental impacts of material and processes therefore, one can identify the harmful materials and the processes which can be replaced by another one having lesser or zero impact. In Strategic planning the LCA has the application in the design of supply chain in which the life cycle indicators are incorporated into the green supply chain building. The evaluation and identification of environmental burdons helps to frame the environmental policies in the manufacturing organization. In marketing the LCA have the application to develop a green marketing strategy based on the recyclability and reuse of the product. [3]

III. Literature Review

The process of finding out the various life cycle impact areas, their analysis & interpretation, current practices & case studies and databases requires a exhaustive literature review of the authors who have made the

research in the concerned area. Reputed journals from Science Direct and others were selected for literature survey. Articles, handbooks of national and international government authorities and reference books from year 2000 to 2013 were taken into account. Keywords like "Life cycle assessment, Life cycle inventory, Input-output models, Environmental impacts, Life cycle performance indicators , Life cycle decision making, Recycling models, LCA databases & softwares" were given more importance in literature study. About 2/3rd of research papers belongs to the year between 2010-2013. The below Pie chart shows the year wise distribution of literature review.

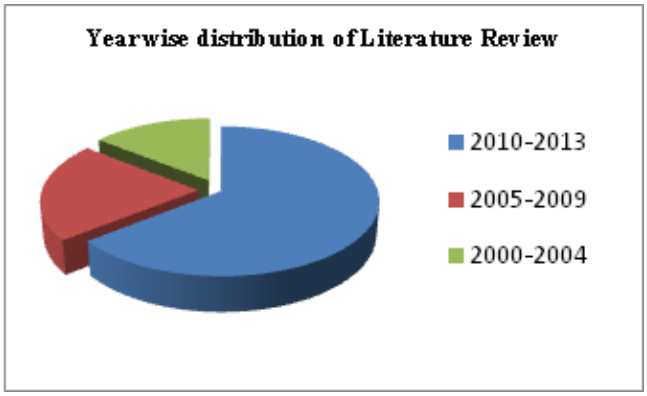

Figure 2. Year wise distribution of Literature Review

IV. Methodology

From last decade the efforts towards the development of LCA methodology has increased throughout the globe for the evaluation of the environmental performance based on the life cycle assessment of product. The International standard organization has developed and standardize the methodology for LCA across the world in the form of ISO 14040 series (ISO, 2006a & ISO, 2006b) [18] [19]. Following are the stages & techniques through which the life cycle of rolls throughout the life cycle is achieved.

1. Goal and Scope –

This phase consist of identification of the problem, scope and boundaries of the analysis. In order to achieve this the relevant questions and their answers are formulated which gives clear idea of the intended application. Following are some questions and their relevant answers to identify the goal and scope of this research.

- *On Which Product the research is to be carried out and why?*

The research is to be carried out on Rolls of cold rolling mill. The fast growth of manufacturing sector worldwide has created business opportunities but concurrently increased substantial environmental problems also. The burdens of air emissions, waste material, depleting resources occur at all stages of a product's life cycle. Awareness about environmental protection is growing all over the globe. Therefore, it is very important to assess the environmental performance of a product throughout the life cycle of it's various phases, so that from obtained results, the manufacturers can take the decisions related to material selection, process selection, and type of energy to be fed.

The Rolls of cold rolling mill are subjected to high compressive and torsional stresses. As a result, the rolls brakes/cracks at a point where the diameter suddenly reduces, as the stress concentration is higher at that point. It cannot be reused by applying welding or any other process and has to scrapped. Hence, new manufacturing of rolls is required to fulfill the need. This new manufacturing creates the heavy environmental and human health burdon through extraction of raw material, manufacturing process, use phase and recycling which consumes several inputs and emits outputs in the form of resources and emissions respectively. This burdon can be reduced by evaluating the environmental performance of product and accordingly taking the corrective actions in selection of energy use, material and processes.

- *What is the material of Rolls of cold rolling mill?*

  Alloy Steel. (Contents: C, Si, Mn, P&S, Cr, Mo, Ni)
- *What are basic inputs (Resources) and outputs (Emissions) of rolls during it's life cycle?*

  Basic Inputs: Material, electricity, non-renewable fuels, water etc.

  Basic Outputs: Usable product, airborne emission, solid wastes, water effluents and other releases.
- *What is the boundary of this Research?*

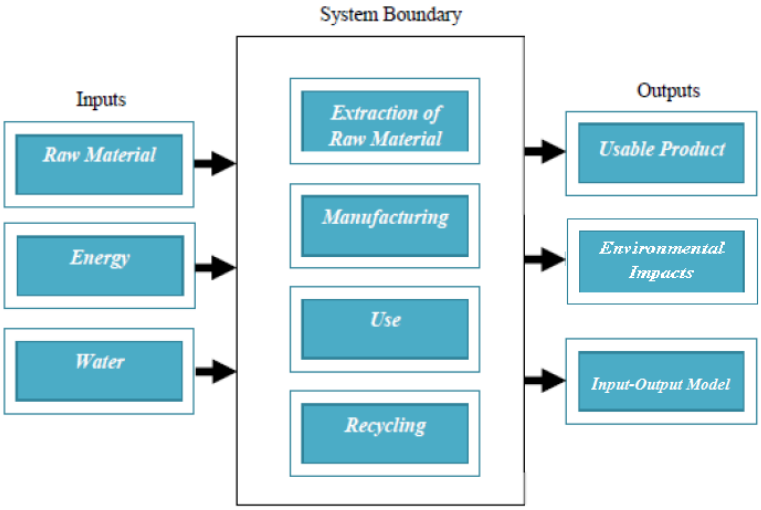

Figure 3. Boundary of Assessment (Source: World steel Association 2011)

The assessment is limited to the rolls of cold rolling mill only. Further, the impacts produced by rolls in LCA study are considered during extraction of raw material, manufacturing, use phase and recycling. In order to keep the analysis traceable, this LCA limit the scope of analysis only for the major inputs at each stage. In case all the minor inputs are to be taken into account then one has to approach different suppliers, which will lead to high cost, time and issues related to variable data. As a result, the LCA cannot deliver the expected results and becomes highly complex. From the above fig.3 we can understand the boundaries of this research.

- *In what way the input output model throughout the lifecycle can be formed?*

The rolls of cold rolling mill are assessed during the extraction of raw material, manufacturing, use phase and recycling. The inputs and outputs during each unit process are quantified and are evaluated for each phase of its life cycle with the help of GaBi software. From the fig. below we can understand the basic input-output model.

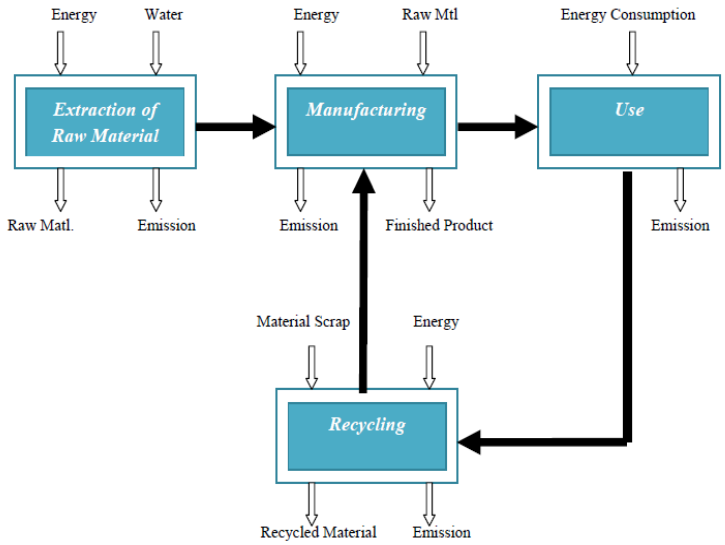

Figure 4. Input-Output model (Source: Tom N.Lighthart,2012)

2. Data Collection –

The data for raw material extraction and recycling phase is obtained from several national and international public databases, resource directory of European Reference Life Lycle Database (ELCD), International Reference Life Cycle Data System (ILCD), LCT forum, softwares tool GaBi , journal papers for variety of material/products and basic services that are needed in every LCA. [9] [20]

The data for manufacturing phase is obtained by actual self observations & calculations and conducting interviews of managers, engineers & workmen at factory, while the data for use phase is obtained from customers/end users of company by conducting interviews and addressing them a set of questionnaires.

3. Life Cycle Inventory –

The detail description of Life cycle inventory (LCI) has given in the ISO 14041 standards [2]. This is the most important phase and forms the base for LCA. Life cycle inventory deals with the development of the product system. The rolls during its life phase undergoes to extraction of raw material, manufacturing, use phase and recycling. During, each phase the product system requires several inputs in the form of resources like material, energy, water etc and outputs in the form of emissions & wastes like CO_2, SO_2, NO_X etc which creates heavy burdon on environment as well as on human health. Therefore, in this phase at each unit process the inputs and outputs of a product system are quantified. The process comprises of identification of the flows at input as well as output side and their respective quantitative data are obtained in relation to the functional unit. The functional unit is the reference unit of the measurement that quantifies the performance of the outflows of the product system. The main objective of inventory analysis is to perform mass and energy balances to quantify the material, energy and emission balances. Finally, the results of the inventory analysis is often a long list with disparate entries such as carbon dioxide, nitrogen oxide, chloromethane, mercury etc. [7] [10]

4. Life Cycle Impact Assessment –

The detail description of Life cycle impact assessment (LCIA) has given in the ISO 14042 standards. Impact assessment consist of classification, characterisation, normalisation and weighting. In classification various environmental impacts are classified into impact categories like Global warming potential, Acidiphication potential, Eutrophication potential, Ozone layer depletion potential, Abiotic depletion elements, Abiotic depletion fossil, Freshwater aquatic ecotoxicity potential, Human toxicity potential, Marine aquatic ecotoxicity potential, Petrochem.ozone creation potential, Terrestric ecotoxicity potential. The characterisation involves evaluation of the magnitude of the impacts under each impact category by converting the quantities under each category into equivalent quantities of a reference impact (e.g. methane into an equivalent amount of CO_2 under the global warming category) which gives one single impact indicator for each impact category. Further, optionally characterisation results may be normalised in order to relate the results to a reference value such as annual global or Europien extent of each impact. Finally, a weighting step may be performed in which priority weights are assigned to the characterisation or normalisation results and which may give one final score for each alternate product system [2] [4].

5. Interpretation –

The detail description of life cycle impact assessment (LCIA) has given in the ISO 14043 standards. It is the last stage of life cycle assessment where a final judgement and decision is outspoken, consist of identification, quantification, data check and evaluation of the information from the results of previous phases of life cycle inventory and life cycle impact assessment. It mainly deals with the meaning and robustness of the information obtained and processed in the previous phases, comprises of comparisons with previously published LCA studies on similar product, uncertainity, sensitivity analysis, data checks and external comments. The ultimate outcome of this phase is the identification of the conclusions and recommendations. [2] [8]

V. Conclusion

The life cycle assessment tool with an appropriate methodology alongwith the use of GaBi software tool enables to develop an input–output model of the product system for the rolls. The model works as a map which shows the flows to and from the system and their respective magnitude. The assessment enables to take the corrective actions in selection of material, energy use and the processes which imparts less harm to the environment and human health. Besides, LCA tool helps the management in strategic planning, product development, marketing and improvement. The same methodology can be applied to other products as well, and the aggregation of environmental performance of all products gives the overall environmental performance of the firm which helps the company in framing internal environmental policies accordingly. The environmental consciousness about the products, enables to take the competitive advantage, gain higher market share, obtain customer faith and good reputation in society.

References

[1]. James W. Levis, [2013] A generalized multistage optimization modeling framework for life cycle assessment – based integrated solid waste management, International journal of sustainable Resources, Conservation and Recycling, Vol. 73 (2013) pp.211– 228

[2]. Arun Kumar [2013], Methodology used for life cycle assessment of electrical generation through coal – fired thermal power plants in India- A Review, International Journal of Emerging Technology and Advanced Engineering Volume 3, Special Issue 3: ICERTSD 2013, Feb 2013, pages 545-548

[3]. Cassiano Moro Piekarski [2013], Life cycle assessment as entrepreneurial tool for business management and green innovations, Journal of Technology Management & Innovation, 2013, Vol.8,Issue 1.

[4]. Darko Milankovic, Brainsilav Milanovic [2013], Life cycle assessment of an intermodal steel building unit, RMZ|2013|Vol.60| pp.67-72

[5]. S.J. McLaren [2013], Scoping of Life cycle assessment studies: A missed opportunity? The 6th International Conference on Life Cycle Management in Gothenburg 2013.

[6]. Stephen Finnegan [2013], Life Cycle Assessment and its role in improving decision making for sustainable development, Engineering Education for Sustainable Development, Cambridge, UK. September 22 – 25, 2013

[7]. Tom N Lightart and Toon, M.M Ansems, [2012] Modelling of Recycling in LCA, Available from http: //www.intechopen.com/books/post-consumer-waste-recycling-and-optimal production/modelling-ofrecycling-in-lca

[8]. M.Karpagam, Geetha Jaikumar, [2012] A Book on Green Management, Ane Books Pvt. Ltd.

[9]. Javier Sanfelix [2012] The Enhanced LCA resources Directory: A tool aimed at improving life cycle thinking practices, International journal of life cycle assessment.

[10]. Goran Finnvedan, Michael Hauschild [2009], Recent developments in life cycle assessment, Journal of Environmental Management, page 1-21.

[11]. Ken Alston [2008], Cradle to Cradle Design Initiatives: Lessons and opportunities for preventions through design (PtD), Journal of Safety Research,Vol. 39,135-136.

[12]. Satish Joshi [2000], Product Environmental life cycle assessment using input output techniques, Journal of Industrial Ecology,Vol.3, Number 2&3.

[13]. United Nations Environment Programme [2002],Life Cycle Initiative homepage. <http://www.uneptie.org/pc/sustain/lcinitiative/home.htm>

[14]. World Steel Association [2011], Life Cycle assessment methodology report, 1-88.

[15]. N.dasilva, J.Fava [2009], Framework for a Life Cycle Assessment, Communications & Society Program, The Aspen Institute.

[16]. Life cycle assessment [1997], A guide to approaches, experiences and information sources, Environmental Issues Series no.6.

[17]. Yang, C.J., Chen, J. L. [2012]. Forecasting the design of ecoproducts by integrating TRIZ evolution patterns with CBR and Simple LCA methods. Expert Systems with Applications, 39, (3), 2884–2892.

[18]. ISO, 2006a. ISO 14040 International Standard. In: Environmental Management – Life Cycle Assessment – Principles and Framework. International Organisation for Standardization,Geneva, Switzerland.

[19]. ISO, 2006b. ISO 14044 International Standard. In: Environmental Management – Life Cycle Assessment – Requirements and Guidelines. International Organisation for Standardisation, Geneva, Switzerland

[20]. International Reference Life Cycle Data System [2012], Towards more sustainable production and consumption for a resource-efficient Europe, JRC reference report.