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# A Review on Evaluating Green Manufacturing for Sustainable Development in Foundry Industries

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***Abstract*— Due to recycling of metals, most foundries have considered themselves as a part of the green technology before the term "green'' was even coined. But, actually, the foundry industry handles large quantities of processed waste materials and has the potential to emit a large quantity of carbon dioxide and other pollution in atmosphere. This immense pressure not only forcing foundry industries to be more ecologically sensitive but it also offers a huge opportunity to innovate in a sustainable manner. Indeed, it is widely accepted that green manufacturing is one approach; firms could adopt to get sustainable. This paper proposes an approach on how GM can support the initiative for sustainable development of foundries; it will be helpful to understand "How can we become a practical green foundry industry". This study will contribute in providing feedback to manage and improve the GM practices to better meet the need of the green foundry industries. This paper conclude that GM is a tool for achieving SD.**

***Keywords*—Green Manufacturing, Sustainable development, Foundry Industry**

## I. INTRODUCTION

In recent decade, there has been increased pressure on manufacturing companies to think beyond the economic benefits of their process and products and consider the environmental and social affects. [1] Toxic wastes and acid precipitation created by foundry industry are causing crisis for thousands of communities around the world. Even more ominous, global crises such as ozone depletion, greenhouse warming, deforestation and the loss of biodiversity are in one way or another rooted in corporate products and production systems. These environmental problems are sounding an alarm for the public. People are concerned about environmental degradation and worried about the continued functioning of the Earth's natural systems. The environmental liabilities we are leaving behind for the next generation may be more than they can handle. To address these concerns we need new economic and organizational concepts and practices. Sustainable development is a response to the ecologically destructive industrialization of the past. [2] Sustainability has been applied to many fields, including engineering, manufacturing design and economy. [3]

The companies practicing green manufacturing know the importance of implementation factors, but have failed to accomplish them today in totality.

Foundry sector in which casting technology is applied to process and give shapes to metals is one of the major industry sectors. Casting is used for various products from jewelry to manufacturing of heavy industry products. Foundries have long looked at themselves as the nation's recyclers. Since metals were first poured, it was recognized that recycling old iron castings was the easiest manner to remake another casting and reuse society's unwanted cast articles. Later steel and other metal scrape was introduced into our change mixes as an additional feedstock to achieve the same goal. Today because of recycling of metals, most foundries have long considered themselves as a part of green technology, but in reality foundry industry has yet to achieve the higher level of sustainability that the future will demand. The pollution related to foundries are important due to their high potential risk to environment and human health. The main waste from casting is the spent foundry sand, which is generated at very large quantities during core and mold preparation. [4]

### *A. Green Manufacturing*

The GM includes comprehensive meanings. Firstly, the concept of 'manufacture' relates to the total life circle of product. So the 'manufacture' here is a generalized concept. Secondly, the environmental problems relate to every counts of the manufacture process. So many relevant concepts such as green design, ecological process planning, green manufacture and so on are brought out. Thirdly, GM is a complicated system engineering problem. It needs to be surveyed from the view of system engineering. Finally, the essence of GM is a kind of sustainable development in the field of modem manufacturing. So GM is the only solution of sustainable development and it is also the enterprise's responsibility for the society. [6]

Green manufacturing (GM) is a term used to describe manufacturing practices that do not harm the environment during any part of the manufacturing process.

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It emphasis the manufacturing processes that do not pollute the environment or harm consumers, employees, or other members of community. GM stresses on reducing parts, rationalizing materials, and reducing components, to help make products more efficient to build. Green manufacturing highlights the road map of the industries for achieving performance improvement through sustainable development and its impact of organizational competitive outcomes. It also points out strength and weaknesses of sustainable development practices and overall organizational competitive outcomes using developed research instrument. [7]

### *B. Sustainable development*

The word "sustainable" is coined from the term sustainable development, as introduced in a report published by the United Nations' World Commission on Environment and Development, it is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", [8] sustainable development's goal is preventing unnecessary and further environmental degradation. Manufacturers are becoming increasingly concerned about the issue of sustainability. A system might be thought of as unsustainable when society consumes resources and produces wastes at a rate that exceeds nature's ability to transform industry and society wastes into environmental nutrients and resources. [7]

Hence, Sustainable development is a concept, which involves social, ecological and economic objectives, and requires to sustain the integrity of resources exploitation, the direction of investments, the orientation of technological development and institutional change. [9] Some of the benefits of green manufacturing are listed below [10]:

- Controls and reduces material waste in manufacturing cycles,
- Preserves capital and saves money,
- Improves productivity and increases cost savings,
- Helps drive and influence corporate behaviour both internal and external to ensure sustainability,
- Easy adaptability to changing rules in environmental regulations and legislation.

## II. Literature Review

Mikko Koho, at all has discussed about definition, objectives and challenges related to sustainable development.

Then, the views of Spanish companies on sustainable development are presented, based on the responses of a questionnaire survey. Further, these results are compared to a similar international study conducted by the American Management Association. The obtained results suggest that business strategy, values and top management support are essential enablers for realizing sustainability, whereas the primary challenges are problems with measurement and lack of customer demand. The results clarify the companies' current state and expectations with regard to sustainable development and are expected to assist both the industry and the academia on the way towards global sustainability. [11]

Sustainable development is a term applied to economic and social development that allows meeting the needs of present without compromising the ability of future generations to meet their own needs. [12] Sustainable development consists of three structural pillars, economical, social and environmental, and can be characterized by the social objectives, trying to realize a society based on the equitable distribution of natural resources; the voluntary acceptation of ecological limitations; and the search for economic efficiency. In brief, the concept of the sustainable development looks for an egalitarian development that respects the environment and moreover be economically possible (Fig.1) summarizes these three pillars.

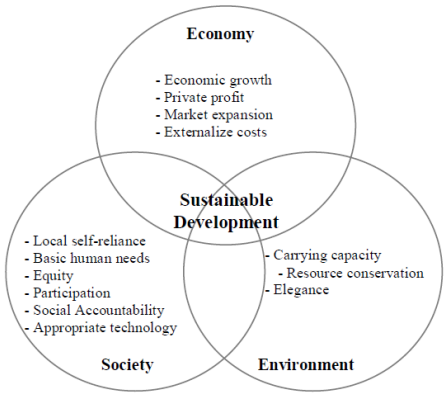


**Fig.1 Aspects of sustainable development [11]**

As stated in the previous section, sustainable development pursues its objectives through three distinct branches: social, economic and environmental. The Brundtland Report, socioeconomic report by United Nations in 1983 [12], details the main objectives of sustainability.

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From the social perspective, the fundamental objective of sustainable development is to meet human needs. For some, this entails constraints to consumption and giving up consumption levels that everyone cannot reasonably aspire. Also, population control may be required in the economically weak countries who cannot afford any reduction in per-capita resource use. In terms of economic objectives, economic growth is required in areas where the basic needs are not met. Finally, from the environmental perspective, development should not endanger natural systems that sustain life on the Earth: the atmosphere, water, soil and living beings. Environmental constraints have to be imposed to preserve the carrying capacity of the Earth, and the use of non-renewable resources should be as efficient as possible. [12]

For companies, sustainable development and related practices can provide competitive advantages such as better recruitment and retention of employees, cost savings, and improved corporate image and relations with stakeholders and financial returns. [13] Furthermore, sustainable manufacturing can open up a wider market in which to operate, and hence provide increase in sales and revenue and in number of customers. Additionally, it can conserve energy and reduce waste resulting in reduced costs for a company. Finally, at a more general level, sustainable development and related practices also reduce the risk of natural disasters such as climate change by checking atmospheric emissions. [14]

### *A. Cleaner Production*

Cleaner Production (CP) is used in conjunction with other elements of environmental management; it is a practical method for protecting human and environmental health, and for supporting the goal of sustainable development, Yacoub et al (2006). CP can reduce environmental risks and liabilities and lead to greater competitiveness. By demonstrating a commitment to Cleaner Production, companies can also improve their public image and gain the confidence of consumers. It aims at avoiding the generation of waste and emissions, by making more efficient use of materials and energy, through modifications in the production processes, input materials, operating practices and/or products and services. As a rough guide, 20-30% reductions in pollution can be achieved with no capital investment required, and a further 20% or more reduction can be obtained with investments, which have a payback time of only months. [15] Cleaner Production requires changing attitudes, responsible environmental management, creating conducive National Policy and evaluating technology options .[16]

R. Masike, and M.J. Chimbadzwa provides information about Cleaner Production opportunities within the foundry industry, to point the way towards greater profitability and improved environmental performance. This was achieved through Determining the current environmental status and environmental performance. [17] Exploring Cleaner Production opportunities through identifying, assessing and evaluating environmental aspects and impacts and ascertain the benefits of implementing Cleaner Production. Carrying out feasibility studies of Cleaner Production opportunities at foundry companies.

This study highlighted environmental aspects and impacts associated with industrial processes in sand casting foundries. To assist foundries in pollution prevention by devising clean technologies which maintain or improve the quality of the ambient surrounding. Cleaner Production and its opportunities to minimize material consumption, optimize production yield and to prevent polluting the air, water and land. The researchers reviewed how sand casting foundries can implement Cleaner Production and benefit from the created conducive environment as well as saved financial capital. The review gave an overview of the environmental aspects and impacts of foundry operations. It also outlined best practices to improve the energy, material, and environmental efficiency, and the product output of the operation. [17]

### *B. Green manufacturing in foundry*

Today the term “green” is ever before us. Green technology has spawned an entire new industry complete with con, engineering discipline, universal curriculum, magazine, T V channel. Whether we fully realize it or not, every aspect of our lives is now being affected by the existence of green technology and its future development. G. Gigante presented this term in very general manner, that how can we become a practical green foundry industry. He has given very simple six-step method to achieve continuous improvement.

1. Audit
2. Benchmarking
3. Possible solution/Reduction
4. Prioritize projects
5. Implement the plan
6. Measure the change

Once we have achieved the focus to think green in all aspects of our industry, we are open to the possibilities that were only waiting for us to seize them. This focus, along with the pragmatic application of existing technology, will guarantee that the foundry industry is recognized as a sustainable leader by other industries and the public. [5]

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### C. *Pollution prevention of Foundry Industry*

Like other manufacturing industries, foundries are looking towards the trends of the future to understand the challenges which will be faced in coming year. The resources considered (Fig. 2) are the material and energy inputs and outputs for mold preparation, metal preparation, casting, and finishing stages and their sub processes.

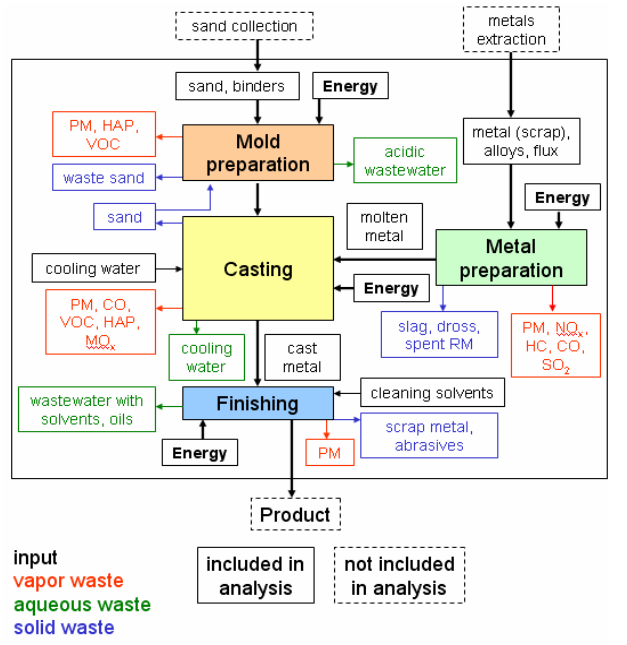


**Fig.2 System boundaries of Process flow for a typical sand casting [18]**

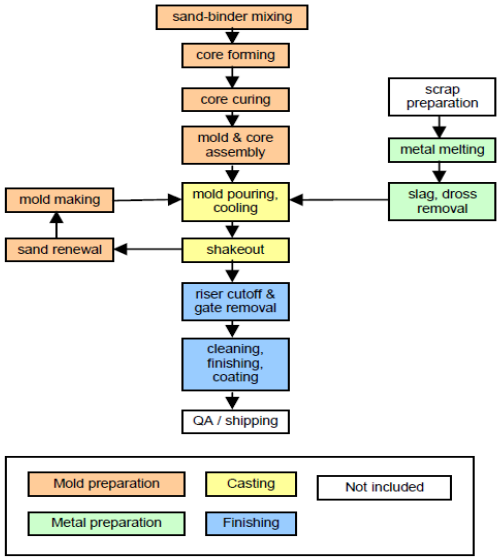


**Fig.3 analysis and materials flow of sand casting foundry [18]**

Stephanie Daluist and Timothy Gutoski carried out life cycle analysis of conventional sand casting manufacturing techniques. They have given complete process overview of sand casting process as shown in figure 3 and have mentioned how much energy and material used/required for sand casting process at every stage. This data is very much useful to take decisions about the part and the process ffect the magnitude of the environmental consequences of manufacturing. [18]

The foundry industry is the major contributor in pollution among all other industries in India. At present only few foundries in India have pollution controllable system. Most of these casting industries use cupola furnace that emits gases namely carbon dioxide, carbon monoxide, nitrogen dioxide, sulphur dioxide, suspended particle matter, dust and ash. Though, emission from single furnace is not considerable but it has huge impact if much such type of furnaces located in particular area. A inclusive study on the type of gas emitted, rate of gases and amount of pollution cause from cupola furnace is essential before design any emission controlling system. Hardikkumar Patil, Gajanan Patange, M.P.Khond have carried out investigation on furnace wastages on GIDC (Gujarat, India). The outcomes of research are based on data taken out from cupola furnace where the pollution measuring system was set up. [19]

### D. *Data Analysis Methods*

For over a decade, there has been a renewed focus on the impact of organizations and manufacturing on the natural environment. Increasingly, stakeholders including regulators, customers, shareholders, board members, and employees are asking or requiring organizations to be more environmentally responsible with respect to their products and processes. Cathy A. Rusinko [20] has studied the relationships between specific environmentally sustainable manufacturing practices, and specific competitive outcomes in an environmentally important but under-researched industry, the U.S. commercial carpet industry. Carpet manufacturing is an important industry to study for several reason term "green"' is ever before us. In addition to being under researched, carpet manufacturing has had a long history of heavy resource usage and environmental challenges. Study is carried out by taking sample from a number of different industries, [21] or from one large industry that belongs to a relatively small group of industries with products and/or processes that present significant environmental challenges (e.g., chemicals, oil refining, wood/paper pulp, etc.) [22]

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Minhaj Ahenad.A.Rehman, at all has highlighted road map of the company for achieving performance improvement through GM implementation and its impact on organizational performance. The case study helps in evaluating the company's GM implementation and overall business performance. Depending upon the critical success factors and performance measure a validated research instrument of GM factors is developed. To do so, research instrument was administered amongst forty one employees in the companies respectively and their responses were analyzed. Using the data obtained from a survey of industries in India, the identified factors were subjected to appropriate statistical tests to establish reliable and valid model. Statistical computing package SPSS 17.0 for Windows was used for reliability and validity analysis (Fig. 4) [23]

He has also contributed for corroborating green manufacturing framework for SD, specifically for Indian foundry industries. They have extracted the factors of GM environment from field data, to evaluate the factors which have positive impact on the organizational performance indicator. A diagnostic instrument has been designed to test in Indian industries that have implemented GM. Using a thorough synthesis of the GM literature, twelve critical success factors and six performance measure of GM practices and their variables have been developed. The identified factors were subjected to appropriate statistical tests to establish reliable and valid model. The twelve critical success factors are:

1. Organizational Capabilities
2. Green Design Initiatives
3. Green Standard Adaption
4. Suppliers Management
5. Technology Innovation
6. GM Planning
7. Green Purchasing and Marketing
8. Implementing RL
9. Top Management Commitment
10. Customer Focus
11. Green Disposal Initiatives
12. Process Management

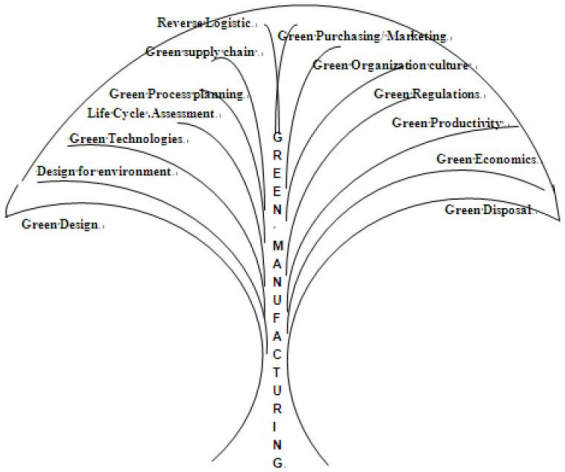


**Fig.4 Green manufacturing tree [23]**

A list of six performance review variables is as bellow:

1. Financial and Manpower variables
2. Operational Performance
3. Competitive Advantage
4. Continuous Improvement
5. Stakeholders' Enrichment
6. GSC Performance

## III. CONCLUSION

This study says there was lot of work carried out in the field of GM and sustainable development but still we need to go further. Green manufacturing is proven very valuable concept for abating industrial waste and emission. Economical benefits and competitive out comes can be achieved from preventing waste The aim of the GM is to enable the efficient use of resources and improve the environmental performance of foundry companies.

The benefits of implementing GM at foundry companies were ascertained, these include;

a) Reducing waste through efficient use of energy and raw materials.
b) Enhancing productivity and increasing product yield through greater efficiency.
c) Increasing profitability and quality of products.
d) Reducing the risks of environmental accidents and avoiding regulatory compliance costs leading to insurance saving.

From above we can conclude that Green manufacturing is the step to move towards sustainable development. And it is the best practice to achieve Sustainable foundry.

## REFERENCES

[1] Che B. Jounga, John Carrell and Prabir Sarkara. Categorization of indicators for sustainable manufacturing. Elsevier Ecological Indicators 24 (2012) 148–157.

[2] Paul shrivastava, stuart hart. Creating sustainable corporations. Business strategy and the environment, vol. 4,154-165 ,1995.

[3] Marc a. Rosen, hossam a. Kishawy, sustainable manufacturing and design: concepts, practices and needs, sustainability 2012, 4, 154-174; doi:10.3390/su4020154

[4] Yiigit Cisem. Life cycle assessment in ferrous foundry industry, January 2013

[5] G. Gigante. How can we become a practical green foundry industry. AFS transactions 2010 @ American foundry society, Schaumburg. IL USA

[6] yu zhonghua, wang zhaowei, study on the integration of green manufacture and total quality management, international technology and innovation conference 2006

[7] Minhaj Ahemad.A.Rehman, R. R Shrivastava, Rakesh. L Shrivastava, Validating Green Manufacturing (GM) Framework for Sustainable Development in an Indian Steel Industry, Universal Journal of Mechanical Engineering 1(2): 49-61, 2013

[8] Ejim-eze, emmanuel emeka, organizational learning and eco-innovation in automobile firms in a developing country: a focus on nigeria, 9th international ph.d. School on national systems of innovation and economic development, 20 to 31 May, 2013.

[9] Paul KOLTUN, Materials and sustainable development, journal Elsevier, 2010

[10] Chen Ying Jian, The Role of Green Manufacturing in Reducing Carbon Dioxide Emissions, 2013 Fifth Conference on Measuring Technology and Mechatronics Automation, 2012 IEEE

[11] Mikko Koho, Seppo Torvinen, Alexandre Torres Romiguer. Objectives, Enablers and Challenges of Sustainable Development and Sustainable Manufacturing. 978-1-61284-343-8/11/$26. @ 2011 IEEE (Fig.1)

[12] United Nations, "Brundtland report", Report of the World Comission onEnvironment and Development, 1987.

[13] American Management Association, "Creating a sustainable future", A Global Study of Current Trends and Possibilities, New York, USA, 2007.

[14] M. Shahbazpour, R.H. Seidel, "Using sustainability for competitive advantage", 13th CIRP International Conference on Life Cycle Engineering, pp. 287-292, The University of Auckland, New Zeland, 2006.

[15] Habil J. K, Staniskis Z, Arbaciauskas V, (2001), Introduction to Cleaner Production Concepts and Practice, The Institute of Environmental Engineering Kaunas University of Technology, Holmes

[16] Global Environment Centre Foundation (GEC) (2008), Cleaner Production Technology, Japan

[17] R. Masike, M.J. Chimbadzwa. Cleaner production options in sand casting foundries. International Journal of Sustainable Energy and Environment Vol. 1, No. 3, April 2013, PP: 25 - 47, ISSN: 2327-0330

[18] Stephanie Dalquist, Timothy Gutowski. Life cycle analysis of conventional manufacturing techniques: sand casting. Proceedings of IMECE2004: 2004 ASME International Mechanical Engineering Congress & Exposition November 13-19, 2004, Anaheim, California. (Fig. 2,3)

[19] Hardikkumar Patil, Gajanan Patange, M.P.Khond. Investigation of Pollution Emits By Cupola Furnace in Gujarat Foundry. International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue5- May 2013 ISSN: 2231.

[20] Cathy A. Rusinko. Green Manufacturing: An Evaluation of Environmentally Sustainable Manufacturing Practices and Their Impact on Competitive. IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, VOL. 54, NO. 3, AUGUST 2007.

[21] B. Menguc and L. K. Ozanne, "Challenges of the "green imperative": A natural resource-based approach to the environmental orientation-business performance relationship," J. Bus. Res., 2003.

[22] P. Christmann, "Effects of "best practices" of environmental management on cost advantages: The role of complementary assets," Acad. Manage. J., vol. 43, no. 4, pp. 663–80, 2000.

[23] Minhaj Ahemad.A.Rehman, R. R Shrivastava, Rakesh. L Shrivastava. Validating Green Manufacturing (GM) Framework for Sustainable Development in an Indian Steel Industry. Universal Journal of Mechanical Engineering 1(2): 49-61, 2013 (Fig.4)