

# Innovation for a greener manufacturing

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**Abstract**—Traditional manufacturing system which were in practice since ages does not take into account the damages caused to our environment. Manufacturers are engaged in relentless exploitation of natural resources for producing goods with the sole aim of earning profits. Such a system puts up intense pressure on scant resources available and leads to further environmental degradation. This paper highlights the role of greener manufacturing practices which emphasize the use of novel approaches for design, production and operation for a sustainable future. An integrated approach is required to analyze the impact of various manufacturing parameters with the aim of minimizing environmental damage. Manufacturers are going in for eco-innovations for transformation the production process and increasing green productivity of resources.

## I. INTRODUCTION

Environmental responsibility has grown steadily as a corporate concern for the past decade. Increasing laws and regulations, coupled with the recognition that developing more friendly manufacturing operations is the need of the hour have put green manufacturing at or near the top of most companies' agenda. Green manufacturing has become a challenge for industries in the current trend of globalization and environmental awareness. The central objective of manufacturing is the combination of economic and ecological efficiency, which is achieved through cleaner production. The environmental and resource parameters are integrated in product development, process technology, and systems management to gravitate towards the optimization of resources and efficiency of operations. Environmental protection measures have to be linked to productivity and quality improvements to gain acceptability and to rationalize their implementation

Green manufacturing involves manufacturing processes in which the resources which have relatively lower environmental impacts than the existing ones are used. It eliminates or minimizes waste in the form of energy, emission, hazardous chemical and solid waste. Green manufacturing includes source reduction, recycling and green product design. Source reduction is broadly defined

to include any actions reducing the waste initially generated.

Melnik and Smith[1] defined green manufacturing as “a system that integrates product and process design issues with issues of manufacturing planning and control in such a manner as to identify, quantify, assess, and manage the flow of environmental waste with the goal of reducing and ultimately minimizing environmental impact while also trying to maximize resource efficiency”. Green Manufacturing (GM) is the intersection of product development and manufacturing practices with environmental issues and concerns. The greater the overlap between these areas, the greater the extent to which manufacturing practices recognizes and embodies environmental issues, concerns, and practices. The manufacturing industry is focusing on innovations in the field of energy, process and products in their operations for reducing their negative impact on environment.

## 2 Motivation for adopting Green Manufacturing

The motivation for experimenting and adopting innovations in Manufacturing has varied across sectors. The main forces behind this are

- Increasing cost of energy
- Growing input costs
- Increase consumer awareness for Green products
- Introduction of new environmental and waste management laws
- Technological advances which open up new commercially viable business opportunities
- Non-replenish able nature of resources
- Stricter government regulatory pressures

The development of green manufacturing requires newer approaches for design, production and operation for energy savings and reduced environmental impact. Manufacturers are going in for eco-innovations for transformation of production process operations in following ways:

### 3.1 Employing Green energy

The conventional resources of energy are depleting very fast and the cost of energy is also increasing/ The efficient use of energy for the industrial and other applications has assumed a great importance due to problems of emission green house gases also with thermal power plants .Employing Green energy includes

- All aspects of energy management, and the modeling & control of energy management systems
- Renewable energy, alternative energy, with real-time power monitoring, environmental monitoring,
- Asset management, asset utilization, and energy reduction / optimization,

The automobile and transport industry have taken steps to reduce emissions and other environmental impacts related with fossil fuel consumption. They have focused on increasing energy efficiency of vehicles and development of alternate fuels. Power industry has innovated with the use of carbon sinks for reducing green house gases .IT companies are setting up energy efficient data centers to reduce electricity consumption Manufactures today follow a green supply chain practices ,so as to reduce their carbon imprints.

### **3.2 Green Process Design**

Green process design is a process for assessing and evaluating the environmental, occupational health and resource consequences of a product through all phases of its life, i.e. extracting and processing raw materials, production, transportation and distribution, use, remanufacturing, recycling and final disposal (Alting L,1993) Green process design is an optimization problem by maximizing the added value and minimizing the resource consumption and waste dispersion activities at different stages of manufacturing. It emphasis the role reducing, replacing and recycling of resources, to mitigate the problems of rapid industrialization

LCA which involves a detailed study of the various environmental parameters at different stages of the product The variants of Life cycle analysis (LCA) for an eco-balanced process design approach are suggested by various researchers are give in table 1.

Table 1 Characteristics of various LCA approaches

S. NO	Green process design approach	Characteristics
1	Cradle-to -gate	Partial assessment - manufacturing to factory gate
2	Cradle -to - Cradle	Biometric approach to the design of system
	Gate-to -Gate	Looks at value added in production chain
3	Well -to Wheel	Efficiency of fuels consumed
5	Life Cycle Energy Analysis	Total life cycle energy consumption is analyzed

The metal and mineral industry has in recent years significantly increased its environmental performance through a number of energy-saving modifications and the re-design of various production processes. These have often been driven by strong external pressures to reduce pollution and by increases in the prices and scarcity of raw materials. For example, the development of advanced high-strength steel vehicle designers and steel makers and enabled the production of stronger steel for the manufacturing of lighter and more energy-efficient automobiles Electronic industry is enhancing the recycling capabilities of components appliances Electronic industry is increasing using LCA approach to minimize the emission of harmful fumes..Companies are manufacturing products that are biodegradable and does not pose the problem of disposal associated with them. Several strategies in the areas of process planning, machine design, and machine operation are being deployed to develop green machine tools. Before exploring different solutions, a life-cycle energy analysis is first presented to guide subsequent investigation. The results of this analysis provide a range of the environmental impact of the use of machine tools in different types of manufacturing facilities.

### **3.3 Green Product Design**

Researchers have analyzed different stages of a product's life and developed techniques and logistics to improve the design of the product from an environmental perspective. These techniques, all

together, are referred as the design for environment (DFE) (Fiksel J 1996). This is based on the philosophy of integrating manufacturing and design operations for making products environmentally benign. By the use different DFE principles the problems of environmental impact are addressed at the design stage only. Various researchers have advocated use of different strategies to achieve these goal which are listed below

S. No	Characteristics	Impact on Environment	Researcher's
1	design for energy conservation	Reduced carbon emission	Hesselbash (1998) Henshaw J. W.(1994) Issacs J A 1996
2	design for minimizing the discharge of hazardous byproduct	Improves waste management	
3	design for disassembly	lower Ecological Impacts	
4	Design for recycling	Enhanced eco-efficiency	
5	Design for remanufacturing or part recovery	Increased Sustainability	

Manufacture today alter design technologies so as restrict the use of hazardous substances in electrical and electronic equipments .It contribute to the protection of human health and allows for environmentally sound recovery and disposal of waste electrical and electronic equipment Consumers goods manufactures fallow a star rating system to indicate the energy consumption of their appliances .HVDC lines are being designed which have lower transmission losses. Newer plastic product are being manufactured which allows for easier recycling. Automobiles manufactures are designing hybrid vehicles which will have environmental impact,

### 3.4 Integration Lean and Green Manufacturing practices

Many leading companies have implemented Lean Manufacturing Programs which yield increased efficiency, reduced costs, improved customer response time, and more. Others have adopted “Green” Programs resulting in reduced energy consumption, waste generation, and hazardous materials usage. Gary G. Bergmiller, et. al. (2009) highlights that models for both Lean and Green manufacturing include management systems, waste identification, and implementation of waste reducing techniques (WRT) to achieve desired business results. Studying known Lean companies, it is confirmed that strength of management system correlates with WRT implementation which correlates with business results for both Lean and Green Programs. Geoff Miller et. al.(2010) recommended that integrated lean tools and sustainability concepts aid in the elimination of waste have helped the company meet ever increasing customer demands while preserving valuable resources for future generations.

### 3.5 Green Supply Chain Management

As per Handfield R (2005) Green supply chain management(GSCM) is designed to incorporate environmental considerations into decision making at each stage of an organization’s materials management and logistics functions until post-consumer disposal . Vachon S (2007) highlights the tangle linkages between green supply chain practices such as environmental collaboration with suppliers, environmental monitoring upon suppliers, environmental collaboration with customers, environmental monitoring by customers and the selection of environmental technologies . GSCM impact on relationship conditions existing between a customer and its suppliers were highlighted by Simpson D (2007).

### Conclusion

The paper highlights various innovative approaches which are influencing the achievement of an environmentally friendly manufacturing. Green manufacturing advocates changes in the processes, products and practices Green manufacturing entails s

all phases of product's life cycle from design, production and distribution phases to the use of products by the end users and its disposal at the end of product's life cycle. Green process design is an optimization problem of maximizing the added value and minimizing the resource consumption and waste dispersion activities at different stages of manufacturing. With the use different design for environment principles the problems of environmental impact are addressed at the design stage and products are designed to be environmentally benign. Model for both Lean and Green manufacturing management systems highlights waste identification, and implementation of waste reducing techniques to achieve desired business results. Environmental considerations must be taken into account in decision making at every stage of an organization's materials management and logistics functions.

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