



An Overview of Recent Green Manufacturing Initiatives

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Abstract—Amongst all manufacturing industries, automotive industry is considered as one of the most strategic industries. This industry has rich resources in the largest manufacturing enterprises, but also is much responsible to contribute significant source of climate impact resulting in global warming. Thus, technocrats in this field, particularly those, who have ethical thoughts have come forward to evaluate sustainable manufacturing performance in this industry. In this paper, we discussed various general and environmentally conscious manufacturing processes to reduce wastes. Various green operation initiatives and the use of natural fibers like vegetable, jute and hemp etc. for manufacturing automotive parts have been discussed.

Keywords—Automotive, Global warming, Green Manufacturing, Green Operation Initiatives, Natural fibers

I. INTRODUCTION

Untimely rain and other climate changes are the burning issues the world facing these days. Greenhouse gas emissions, especially CO₂, are the main reasons for global warming. In production and consumption of goods the energy with respect to greenhouse gasses are emitted. Moreover, storage and transportation are equally responsible in the contribution of emissions. As awareness increases, an individual feels the accountability of his own carbon footprint. The environmental effect of a product will back fire to the importance on their list of decision making criteria. The awareness put the pressure back to the companies like automotive sectors making lean and go green concept. In this way the cost will be reduced. Reduction in cost will minimize the emissions and global warming will get reduced considerably. Automotive companies have also considered strategic initiatives such as Agile Manufacturing system, Lean

Manufacturing System, Flexible Manufacturing System, Cryogenic Manufacturing System, Dry Cutting Machining, Minimal Quantity Lubrication (MQL) and Solid Lubricant Assisted Machining etc., to compete globally and respond to dynamic customer demand. Natural fibers are also increasingly used to reduce burden on globe. Moreover, environmental and sustainability management system is also described in this paper. Sustainability is becoming a progressively more significant issue amongst companies around the world. It is a critical and timely topic[1][2].

II. THE CONCEPT OF GREEN MANUFACTURING

Green Manufacturing is the concept of manufacturing products without damaging the surroundings during any part of the manufacturing process. It emphasizes the exercise of processes that do not contaminate the environment or harm consumers, human resources, or other members of the area. Green Manufacturing addresses a number of manufacturing matters, including recycling, preservation, waste management, water supply, environmental safety, regulatory fulfillment, pollution control and a range of other related issues[3].

Recently, serious concern with the Poly Chlorinated Biphenyl (PCB) manufacturing has been observed because of health issues caused by the concerned processes. Due to harmful effect on health, certain industries like automotive, construction and power among others that employ resource-intensive operations also create considerable dangers to the surroundings[3].



III. GREEN MANUFACTURING AND GLOBAL WARMING

Due to the increased concern about global warming and the consequences of polluting industries for the global environment, manufacturers are looking for realistic solutions that can be implemented to sustain Green Manufacturing practices. Normally, consumers are in dark, that the products they use are safe and don't have effect on environment. It is the time to have closer look by the consumers and the manufacturers at the manufacturing processes. To reduce the global warming and minimize the endanger to the environment the manufacturing practices must consider the green aspects for their products[3].

IV. GENERAL MANUFACTURING PROCESSES

1) *Agile Manufacturing*

Gunasekaran describes Agile Manufacturing as “capability to survive and prosper in a competitive environment of continuous and unexpected change by reacting quickly and efficiently to varying markets, driven by customer designed products and services.” Gold-man have a little diverse definition, with Agile Manufacturing allowing companies to be capable of operating usefully in a competitive environment of continually and unpredictably changing customer opportunities. Automotive companies are attracted to Agile Manufacturing systems, because of the potential for equipment reuse and equipment investment cost reductions over the time[4].

2) *Flexible Manufacturing Systems (FMSs)*

The guarantee of equipment reusability has been associated with Flexible Manufacturing Systems (FMSs). Goranson defines a flexible system as a production system capable of dealing effectively with a specific scope of product variation. A FMS, as defined by Askin and Standridge, refers to a set of Computer Numerically Controlled (CNC) machine tools and supporting workstations that are connected by an automated material handling system and are controlled by a central computer. Shim and Siegel described a FMS as a Computer Controlled Process Technology suitable for producing a reasonable variety of products in a moderate flexible volume[4].

3) *Lean Manufacturing*

Lean Manufacturing is the implementation of the concept that anything which does not create value in the manufactured goods is to be eradicated. Lean Manufacturing is focused on doing the right tasks, at the right place, at the right time, in the right quantity to achieve perfect workflow while eliminating waste and with the talent and flexibility to change[5].

4) *Rapid Prototyping Manufacturing*

In this age of competition when new products are introduced in the market, the entrepreneurs enjoy more profit and higher market share. Simultaneously, the production should be quick and of high quality. So, new technology that considerably speeds up the iterative product development process, is the concept of Rapid Prototyping (RP). The cost reduction may be up to 50% and reduction in processing time up to 75%, hence waste is minimized and is considered as sustainable manufacturing[6].

RP refers to a group of commercially available processes which are used to create solid 3D parts from CAD, from this point onwards all the processes will be referred to as Layer Manufacturing Techniques (LMTs). Rapid manufacturing uses LMTs for the direct manufacture of solid 3D products to be used by the end user either as parts of assemblies or as stand-alone products[7].

V. ENVIRONMENTALLY CONSCIOUS MANUFACTURING AND FRIENDLY MACHINING

The manufacturing industry is one of the main roots of ecological pollution. Therefore, minimizing the ecological impact of the manufacturing trade has become an important topic for all the manufacturers. There is a growing interest in Green Manufacturing also called Environmentally Conscious Manufacturing (ECM). The current focus on Green Manufacturing is different from the traditional focus on pollution control. Here, the stress is on Life Cycle Assessment (LCA). Products or processes are seen as interacting with the environment, and could have chain reaction effects on environmental pollution. The use of cutting fluid during a machining operation is very much required. The main factors those statutes the ranges of cutting fluid are (1) the machining process, (2) cutting tool material and (3) work material. Moreover, dry machining, Minimal Quantity Lubrication (MQL), Cryogenic Machining and Solid Lubricant Assisted



Machining, will certainly an impact on waste reduction and hence will be treated as sustainable manufacturing[6].

VI. GREEN OPERATIONS INITIATIVES

There are two approaches

(A) Practices, Activities of the Operations Function, Objectives and Main benefits

a) Green Operations Practices

Green building
Eco-design or design for environment
Green supply chain
Greener manufacturing
Reverse Logistics
Innovations

b) Activities of the Operations Functions

Production capacity planning
Product and processes development
Supplier relationship and in-bound and out-bound logistics.
Manufacturing (production)
Supplier relationship, logistics and after sales

All activities and beyond operations including business model designs.

c) Objectives

Enhance environmental presentation during construction and operation of an industrial place considering sustainability of the production site, water and energy effectiveness, resource and materials use, indoor surroundings quality, innovation and design process.

Consider the product's life cycle in order to design more environmentally friendly products and environmentally sound processes.

Incorporate environmental criteria and concerns into organizational purchasing, decisions and long-term relationship with suppliers.

Increase efficiency continuously and integrate 4R's in the production: Reduce, Reuse, Remanufacture and Recycle.

Plan, implement and organize backward flows during process and after use of finished goods, mainly to end of life products.

Improve goods and services and increase profitability

d) Main benefits

Higher employee efficiency, reduction in health and safety expenses, improvements in indoor ecological quality, reduction in maintenance cost, energy and water savings and better waste management in construction and operation phase.

Enhancement of reusability, recyclability and remanufacturing possibilities, reduction on the use of dangerous substances, first mover advantages, (royalties, access to green market niches, etc.), decrease of final disposal costs, higher eco-efficiency and eco-effectiveness.

Sharing risks and pressures along the supply chain transfer of environmental technologies and consequently waste and cost reduction in the supplier's operations.

Better economic, environmental, social and economic performance through reduction of waste and therefore costs.

Reduction of environmental burdens on the final disposal, reduction of land fill and environmental liability costs, (re)use of valuable components of an end of life product.

Eliminate unnecessary processes, sources of pollution, waste etc.[8].



(B) Ecological Aspects and Impacts of the Automotive Trade

Category: Local, regional, Global type of effect is negative

Activity

Activity

PRODUCTION

JOB OFFERS

Building construction and operation

Ecological Aspects: Employment

Ecological Aspects: Land use, Energy, water and material consumption

Ecological Impact: Increased happiness

Ecological Impacts: Depletion of natural resources and pollution

Category: Local, regional, type of effect is positive

Category: Local, regional, Global and the type of effect is negative

Activity

ECONOMIC CONTRIBUTION

Activity

Ecological Aspects: Trade of goods and services, spin-offs

MANUFACTURING PROCESSES

Ecological Aspects: Emissions of harmful substances

Ecological Impact: Flow of capital, people's needs met

Ecological Impacts: Depletion of natural resources and pollution

Category: Local, regional, Global, the type of effect is Positive

Category: Local, regional, Global and type of effect is negative

Activity

INFRASTRUCTURE

Activity

Ecological Aspects: Roads, parking spaces, bridges etc.

LOGISTICS

Ecological Aspects: Shipping, Air and Road

Ecological Impacts: Depletion of natural resources

Ecological Impacts: Pollution of sea and air, traffic congestion

Category: Local and regional, the effect is Negative

Activity

FUEL CONSUMPTION



Ecological Aspects: Air emissions

Ecological Impacts: Air pollutions

Category: Local, regional and Global, the effect is Negative

Ecological Aspects: Land fill disposal

Ecological Impacts: Depletion of natural resources and soil contamination and has negative effect at regional level [8].

Activity

MOBILITY

Ecological Aspects: Mobility of people and goods

Ecological Impacts: Location transfer of people and goods at regional level and Congestion and accidents at local level

Category: Regional, Local

Positive for location transfer of people and goods and Negative for congestion and accidents

Activity

END OF LIFE:

Collection, dismantling, reusing, remanufacturing and recycling

Ecological Aspects: Energy consumption, Avoidance irresponsible disposal, Re-use of material

Ecological Impacts: Depletion of natural resources and pollution at regional level and it has negative type effect.

Conversion of natural resources at local level and it has positive effect

Activity

END OF LIFE DISPOSAL

VII. GREEN OPERATIONS INITIATIVES IN THE AUTOMOTIVE INDUSTRY

To improve environmental performance, other parameters like marketing campaigns, production capacity expansion, quality improvement, etc. must also be touched upon. Some of the environmental issues are also not clear e.g., investment or cost feasibility, quality requirement and customer satisfaction etc. On the other hand, public anxiety, legislation, probable cost reduction and improved company icon may be sufficient motivation to improve environmental performance. Beamon shows how environmental management evolved from the pollution control and risk management in 1970s to pollution prevention in 1980s to subsequent implementation of systematic product and process management. ISO 14000 series launched and the emergence of life cycle and industrial ecology evolved. Further evolution of environmental management has led to its recognition as a key area for companies wanting to be competitive in the modern global economy. For all these reasons, environmental and sustainability management decisions are in fact strategic subjects. Yet, there is currently no clear classification of green operations or environmental decision support model to help decision makers in developing their environmental strategy [8].

VIII. THE AUTOMOTIVE INDUSTRY AND THE ENVIRONMENT

The automotive industry has made remarkable positive contributions to the world economy and people's mobility, but its products and processes are a significant source of environmental impact. To better understand the relationship between the automotive industry and the environment, the main environmental aspects and impacts of the activities in this industry, together with a basic assessment based on the suggestions of ISO 14004 has already been discussed above in "Green Operation Initiatives". Total world production of cars reached more than 53 million units in 2007 and if commercial vehicles are included, this increases to 73.10 million units. Top countries in terms of production are Japan, USA, China, Germany and South Korea. In 2008, the main global manufacturers were General Motors (GM),



Toyota, Ford, Volkswagen and Honda. If only passenger cars are considered, then Toyota was the chief producer, followed by General Motors (GM) and Volkswagen. In recent times, there are approximately three-quarters of a billion cars worldwide and, if the trade continues to manufacture cars at the present rate, there will be two billions cars on the road by 2050. The rise in number of cars will certainly require tremendous greener research work to save globe[8].

IX. AUTOMOTIVE COMPONENTS AND FIBER COMPOSITES

In the design of recent materials for the furniture, construction, packaging and automotive industries, the environmental and economical parameters are playing very important role. Natural renewable resources used to prevent further burden on the globe for light non-abrasive and low energy renewable requirements, the fibers have many properties[9].

X. AUTOMOTIVE WITH VEGETABLE, JUTE AND HEMP FIBER

1. Vegetable fiber

Vegetables fibers, recently are used as strengthening of thermosetting fibers and thermoplastic polymers such as polyester polypropylene, polyethylene and epoxy to produce may be called as “friendly” composites.

In Brazil one can find many kinds of fibers such as Sisal Jute, Coir and Curaua, all of them are already associated with commercial applications. Brazil has potential to produce about 10,000 ton/year of vegetable fibers that can be found cultivated, becoming a source of income for several local communities. Marsh made an interesting qualitative comparison between natural and glass fibers pointing out the advantages in use natural fibers[9].

2. Jute fiber

To replace glass fiber, in the last few decades, the Jute fibers have raised interest with regards to use as reinforcement within the composite materials.

The automotive manufacturing is one of the most loving users of natural composite materials in their products in interior applications such as door panels and trunk liners etc. According to DEFRA’s report it is expected an increase of the

use of natural fibers in automotive components at about 54% per year, as American and European car manufacturers have already been using them to achieve Environmental Directives. In USA, automotive companies are implementing natural materials. About 1.5 million of vehicles are already using vegetable fibers such as jute, hemp, kenaf as strengthening of thermoplastic and thermosetting polymers[9].

3. Hemp fiber

Hemp is generally known as high growing varieties of the cannabis plant and its products which include fiber, seed and oil. Hemp is refined into products such as hemp seed food, hemp wax rope, resin, cloth paper, pulp and fuel. Moreover, hemp fibers are extensively used to manufacture the automotive components in countries like USA, Canada and Europe etc. [10].

IMAGES OF HEMP OR CANNABIS PLANT AND ITS FEW APPLICATIONS



Fig. 1 Image of leaves and stem of Hemp or cannabis plant, Courtesy: Wikipedia, Wikimedia



Fig. 2 Image of Hemp plastic interior of a car door, Courtesy: Wikipedia, Wikimedia



Fig. 3 Image of Hemp fiber automotive parts,
Courtesy: Purdue Agriculture



Fig. 4 Image of Hemp fiber automotive bonnet,
Courtesy: Gardner Publications Inc.

XI. THE HEMP AUTOMOBILE INDUSTRY, USA, CANADA AND EUROPE

As of now, the hemp fiber for car parts is not yet established in the USA. Efforts are on to establish such industries in various states. Campaign to incorporate Hemp fiber into the manufacturing process is in progress by Michigan Industrial Hemp Education and Marketing. Project has been at the forefront by this firm. In Kentucky, one of the leading companies has started effort to legalize the Hemp manufacturers for car parts, who would use Hemp fiber composite to make dashboards of the cars. In Canada and Europe, the use of Hemp fiber is reasonably accepted. Canada has also started its own fielding industry. Recently, the government of Canada has assured \$95,000 towards various Hemp businesses, e.g., Calgary startup, composite plastic and Hemp fiber in electric car parts [11].



Fig. 5 Image of Hemp cars in Canada and Europe
Curtsey: The Kestrel, from Motive Industry

XII. CONCLUSION

The main objective of the study of recent green manufacturing initiative is to see, what steps are being considered to save globe as for as manufacturing sectors are concern. For sustainability, various manufacturing processes have been discussed through which researchers and technocrats in this field can play very important role by minimizing the manufacturing time, waste reduction, pollution control, optimum utilization of all resources etc. In developed countries like USA, Europe and Canada etc., natural fibers are being extensively used in manufacturing parts of the car which is directly putting the effect on reducing the waste and hence, improving the climate scenario.

In India, there are enormous opportunities in the manufacturing field, particularly, in automotive sector, to do research in the field of use of natural resources like Hemp and Kenaf fibers etc. The research in this new field will generate tremendous job opportunities and greener production.

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