Appraise of Green Design and Manufacturing Paraphernalia and Practices in the Dominion of Uncontaminated Environment

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***Abstract*—Green Design and Manufacturing also known as Environmentally Conscious Design and Manufacturing (ECDM) has become an obligation to the environment and to the society itself, enforced primarily by governmental regulations and customer perspective on environmental issues. This is mainly driven by the escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. ECMPRO involves integrating environmental thinking into new product development including design, material selection, manufacturing processes and delivery of the product to the consumers, plus the end-of-life management of the product after its useful life. This research Survey had invented the clarity, narration of ECDM, benefits of ECDM, Paraphernalia of ECDM, advantages of these Paraphernalia and other aspects also.**

Keyword- ECMPRO- Environmentally Conscious Manufacturing and Product Recovery, DFR- design for recycling, DFE-design for environment, DFD-design for disassembly, EPA-Environmental Protection Agency , EOL- end-of-life , LCA - Environmental Life Cycle Assessment , ECDM- Environmentally Conscious Design and Manufacturing , DOE-Department of Environment , NCPCS-National cleaner production centers , DFS - Design for sustainability , ECM-Environmentally Conscious Manufacturing.

I Introduction

Traditional process design and optimization often pay much attention to the economic profit, such as fixed capital investment, net present value, operation cost, and payback period. The environmental impacts of process design have been given a lower priority, and generally are incorporated into traditional design as end-of-pipe treatment. Over the past decade, as a result of escalating environmental control costs and newly issued environmental regulations, industries are showing increasing interests in minimizing environmental impacts of product or process design and development. [Chunshan Li et al. (2009) [31]]

It has been a tough trade-off decision between economic growth and environmental protection especially in developing countries. Tireless efforts to accelerate economic growth had kept environmental considerations as secondary objectives in policy making in these countries. This indifference towards Environmental protection has led to serious environmental Problems in the developing countries and has threatened their sustainable future. For example, damage caused by pollution in India is estimated to cost $14 billion annually: amounting to close to 4.5% to 6% of GDP (Economic Survey of India, 1998–1999). In response, many developing countries have started enacting and implementing environmental policies in relation to air and water pollution and solid waste disposal to limit the severity of environmental degradation [Shunsuke Managi et al.(2008) [25]]

During the industrial revolution, environmental issues were not addressed when designing and manufacturing products. However, in the last decade or so, Environmentally Conscious Manufacturing and Product Recovery (ECMPRO) has become an obligation to the environment and to the society itself, enforced primarily by governmental regulations and customer perspective on environmental issues. ECM is concerned with developing methods for manufacturing new products from Conceptual design to final delivery and ultimately to the end-of-life (EOL) disposal such that the environmental standards and requirements are satisfied. Product recovery, on the other hand, aims to minimize the amount of waste sent to landfills by recovering materials and parts from old or outdated products by means of recycling and remanufacturing (including reuse of parts and products). Fig. 1 depicts the interactions among the activities that take place in a product life cycle.

ECMPRO is mainly driven by the escalating deterioration of the environment. Today's high-tech society requires thousands of different products which ultimately result in billions of tons of materials discarded, most of which end up in landfills. According to the US Environmental Protection Agency (EPA), in 1990 the amount of waste generated in the USA reached a whopping 196 million ton up from 88 million ton in the 1960s [212]. As a consequence of both fast depletion of the raw materials and an increasing amount of different forms of waste (solid waste, air and water pollution etc.), two

commonly accepted primary objectives have been gaining momentum: (1) create environmentally friendly products,(i.e. green products); and (2) develop techniques for product recovery and waste management.

In order to design a product which is environmentally benign, the life cycle of the product should be well understood .Life cycle analysis (LCA) spans over the development, manufacturing, use and disposal stages of the product (Fig. 1). At each of these stages, environmentally friendly decisions need to be made. These have prompted campaigns such as design for recycling (DFR), design for environment (DFE) and design for disassembly (DFD).

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II REVIEW OF LITERATURE

A. *History of Manufacturing Industries*

In many past situations, the process of product design was strongly oriented to the market needs. The process of design and manufacturing was traditionally been oriented to the better performance of product, low cost, efficiency of production and high profits overall. As a result, the goal of designer was to define appropriate materials, improving projects and its phases and making the use of product safe and better.

So environmental effects were ignored during design stage for new product and process the negative environmental impact of product during its entire life cycle, from initial design to disposal or recycling were neglected. Hazardous wastes were dumped in the most convenient fashion possible. Inefficient energy use resulted in high operating cost. Waste was common in material production, manufacturing and distribution.

B. *The Revolution "Green Manufacturing"*

First, so from the environment perspective, due to public pressure, Government policies, stricter regulations, social organizations, the process of product design is now a day's been focused on impact of product during its service and at the end of service on the environment. Design methodologies and rules have to be chosen as possible to achieve both society needs and preservation of nature

The first environmental revolutions were started in 1970 in United States. Currently Europe seems to have a lead over the United States. Now, a day other countries like Japan, China, and India are focusing more and more on environmental issues. Every government has formed R & D sectors, rules and regulations, different types of act, norms to reduce pollution and other effects on environment.

C. *Benefits of Green Manufacturing*

- Eliminate the cost of the disposal of used product in landfills.
- Conserving natural resources as a consequence of reusing recovered and recycled material in new product.
- Providing cash return as a result of selling the recycled material to other companies.
- Improving yield and quality
- Reducing pollution and toxins

D. *Survey of Management Paraphernalia in Green Manufacturing*

The main aim of these Paraphernalia is to attain situations that can achieve environmental compliance, increase productivity and enhance competitive advantage. Shifting from pollution control to preventing pollution is always better. Companies are realizing that pollution is a symptom of inefficiency and waste is often valuable raw material. The growing cost of waste disposal and remediation make a compelling case design, pollution prevention, and source reduction, waste minimization and cleaner production.

The main management Paraphernalia are:-

- Environmental Engineering
- Pollution Prevention
- Environmentally conscious design and manufacturing / green design and manufacturing
- Environmental Life Cycle Assessment (LCA)
- Clean Productivity
- Industrial Ecology
- Design for Sustainability

E. *What are these Paraphernalia ?*

Environmental Engineering

It is concerned with the managing the fate, transport, and control of contaminants in water supplies and discharges, air emissions and solid waste. In the manufacturing context the focus of environmental engineering efforts is after pollutants have been generated, or at the "end of the pipe."

The U.S. government environmental policy expanded from clean water to clean air to cradle-to-grave solid and hazardous waste management, environmental engineering research helped us better understand how pollutants migrate through soils, groundwater, and the air and developed treatment technologies to minimize their impact on the natural and human environment. Over the past 30 years, treatment and disposal

technologies were conditioned in technology based policies and incorporated into manufacturing processes.

It has been increasingly recognized that technological progress can play a key role in maintaining a high standard of living in the face of these increasingly stringent environmental regulations. However, the extent of the contribution of technological progress depends on how well environmental policies are designed and implemented. Successful environmental policies can contribute to technological innovation and diffusion while poor policy designs can inhibit innovation. [Shunsuke Managi et al. (2008) [25]]

Pollution Prevention

The concept of pollution prevention as an alternative to treatment and disposal was embraced by pioneering corporations (like the 3 M Company) and state-level industry assistance program. In U.S. the approaches are source reduction closed loop or in process recycling, out of process recycling, treatment and disposal.

The pollution prevention Act of 1990 narrowed the range of activities to those that eliminate pollutants all together like

- Equipment
- Technology
- Process
- Procedure modifications
- Formulations or redesign of product
- Substitution of raw materials
- Improvement in management, training, inventory control, material handling.

As practiced in industry pollution prevention usually focuses on elimination of pollution from existing product and process technologies.

Environmental policies in India

To combat the problem of environmental degradation, several environmental policies were initiated by the Government of India from late 1970s. India was the first country to insert an amendment into its own situation allowing the State to protect and improve the environment for safeguarding public health, forests and wild life. The 42nd amendment was adopted in 1976 and went into effect January 3, 1977. The Directive Principles of State Policy (Article 47) requires not only a protectionist stance by the state but also compels the state to seek the improvement of polluted environments.

The Air (Prevention and Control of Pollution) Act was passed in 1981 and the Parliament had passed the Environmental Protection Act in 1986. The responsibility of administering new legislations fell on the central and state pollution control boards. The Department of Environment (DOE) was created in 1980, which was supposed to appraise the environmental aspects of development projects, to monitor air and water quality, to establish an environmental information system, to promote environmental research, and to coordinate activities between federal, state and local governments. The DOE was criticized, however, by environmental groups for its small political and financial base. Environmentalists recognized quickly that the DOE would essentially serve

As an advisory body with few enforcement powers. [Shunsuke Managi et al. (2008) [25]]

Environmentally Conscious Design and Manufacturing (ECDM)

ECDM is intended to develop more environmentally benign products and processes. The application of ECDM involves a particular framework for considering environmental issues, the application of relevant analysis and synthesis methods and a challenge to traditional procedures for design and manufacturing.

1) Green Design

Negative impact of product on environment can be reduced by making changes in design of product. It can be designed for less pollution, recyclability, less wastage during manufacturing, service and at the end of service.

Challenges of green design

a. It is to alter conventional design and manufacturing procedures.

b It requires change in existing procedures

c Change for any existing process is difficult

d Changing design procedures is particularly difficult because designers take many conflicting objectives.

Objectives of green design

The three general goals of green design are

a Reduce or minimize the use of non-renewable resources.

b Manage renewable resources to insure sustainability

c Reduce with the ultimate goals of eliminating toxic and otherwise harmful emissions to the environment including emissions contributing to global warming.

Most common design practices

a Design for recycling

b Design for disassembly

c Design for energy efficiency

d Design for remanufacture

e Design for disposability

f Design for Hazardous material minimization.

Design for Disassembly

Dismantling a product for recycling has cost implications (e.g. the cost of labor required to take apart the different components). Accordingly, components and products have to be designed so that they can be disassembled with ease, thus reducing the cost of disassembly and making recycling economically attractive. This leads us to the concept of design for disassembly (DFD), which involves designing the product for rapid disassembly. E.g. joining two components with an adhesive is an easy way to assemble them but would create problems when trying to disassemble them whether for maintenance or at the end of service life of the product.

Paraphernalia of DFD

a] Material Selection

- Reduce the number of different materials employed especially when dealing with various kinds of plastics. This sometimes results in over designing the properties of some part so that they can use the same material as other parts that require these properties.

Another good approach that is recommended for cutting down the variety of plastics used in a product is to design complex components out of only one kind of plastic that has different properties depending on the molecular weight or degree of polymerization.

- When designing plastic components, try to employ thermoplastic materials rather than thermo sets whenever the functional requirements permit it because these plastics are easy to recycle.
- Use compatible material and avoid secondary finishing operations like painting and coating.
- Factors such as ease and cost of recycling as well as potential markets for recycled material must be considered when selecting materials for a new producer design.

b] Fastening and joining Considerations

Basically there are two methods of disassembling of product for recycling; the selection of one of them depends upon the method of combining components together to form a product.

- The first method is reversed assembly, which involves following the some steps included in the assembly process in reverse order.
- The second approach for disassembly involves crude methods of dismantling with brute force.
- The designer has to decide upon the method of disassembly during the early design phase and to promote that method when preparing design.

Pros and Cons of the different fastening and joining methods from the viewpoint of design for environment.

- Welded parts may or may not be easily recycled.

E.g. Metals are recycled effectively after use but in case of plastics where two dissimilar resins are joined together by stacking, ultrasonic welding and so on, brute force is required to separate the components.

- Screws are undesirable for both assembly and disassembly. Snap are better than screws. If these are not feasible, standard types of screws, sizes and head shape are strongly recommended to facilitate disassembly.
- Adhesives, although they facilitate assembly are undesirable for disassembly.
- Snap-fit latches are ideal for DFA and DFD.

2) Green Manufacturing

The world is becoming more and more aware of the importance of considering the environmental impact of manufacturing. Industries are beginning to view waste not as an unavoidable result of their processes, but as a measure of efficiency. In other words, the most waste a process generates, the less efficient it is considered and greater is the improvements.

Ideas that promote the concept of environmental consciousness.

- Minimize material use and reduce and conserve energy used in manufacturing.
- Understand the side effects of processes and equipment emissions such as paint vapor and abusive molding. This is the first step in preventing pollution as its source.
- Whenever possible, avoid using or generating toxic materials, heavy metals and the like by substituting nonpolluting chemical processes.
- Use R & D and rational analysis to minimize the amount of coolants, lubricants and cutting fluids in the different machining an forming processes Only environmentally safe fluids should be used.
- Whenever a new substance is used in daily production operations, make sure it will not result in a waste that requires off-side disposal.
- Do not allow solvents, catalysts and reagents to cross the boundaries of the plant. They have to be recovered for recycling and to eliminate their toxic or hazardous nature.
- The priorities for waste management should be as follows.
- Waste reduction (highest priority)
- Recycle and recovery
- Treatment

- Disposal
- Try to produce and use environmentally friendly packaging. Minimize the amount and select appropriate materials and always remember that packaging amounts to 40 % of the plastics in landfills.

Waste minimization is a very important issue for cleaner production. Waste management should not be limited just to the issue of disposal as sometimes happens. It is crucial to maximize the utilization of valuable resources through the reuse of products, recycling of materials or recovery of energy in the waste streams. There are numerous regulations in waste management that enforce energy recovery from wastes. Thermal treatment, including incineration, is just one way to use waste for energy recovery. Recycling reduces the need for energy intensive extraction and production of resources.[Laszlo sikos et al.(2009) [32]]

Environmental Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is a technique that addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, recycling and final disposal (i.e. cradle -to-grave). LCA is conducted according to internationally recognized ISO 14040 standards – Environmental Management – Life Cycle Assessment.

There are four phases in an LCA study according to ISO 14044:2006 standard:

• Goal and scope definition – here the intended use of the LCA is defined, system boundaries are set and the functional unit is selected;

• Inventory analysis (LCI) – a database se of all processes within the system boundaries is created. During this step the input and output data for all the processes in the product or service system are collected. These data are related to the functional unit.

• Impact assessment (LCIA) – evaluation of potential environmental impacts associated with the selected inputs (resources and materials) and outputs (emissions and waste). During this step inventory data on inputs and outputs is translated into information about the product system's impacts on the environment, human health, and resources.

• Interpretation of the results – here the results of the LCA are evaluated according to the study's goals. Sensitivity analysis is usually conducted here to qualify results and conclusions. [Anastassia Manuilova et al. (2009) [6]]

Clean Productivity

The United Nation Environment Program [UNEP] Introduced the Concept of Cleaner Production in 1989 and defined in as the continuous application of an integrated preventive environmental up strategy applied to processes, products and services to increase eco- efficiency. It is a broad term that encompasses waste minimization, avoidance, and pollution prevention and resource efficiency.

CP involves applying expert improving technology and above all, Changing attitudes among management of enterprise. In 1994, UNEP and UNIDO jointly coordinated the establishment of National cleaner production centers [NCPCS] in developing countries. By using cleaner production philosophy to tackle pollution and waste problems, the dependence on 'end- of- pipe' solution has been reduced and in some case, eliminated altogether.

Element of cleaner production

1] The precautionary approach:

Potential polluters must prove that a substance or act will do no harm.

2] The preventive approach:

Preventing pollution at the source rather than after it has created.

3] Democratic Control:

Workers, Consumers and Communities all have access to information and are involved in decision making.

4] Integrated and holistic approach:

Addressing all material, energy and water flows of LCA.

Benefits of Cleaner Production-

1] Decreased Waste

2] Recovery of valuable by- Products.

3] Improve environmental performance

4] Increased resource productivity

5] Increased efficiency.

6] Lower energy consumption

7] Overall Reduction in cost

Thus cleaner production can reduce environmental risks and liabilities and lead to greater competitiveness. Companies can improve and gain the confidence of consumers.

Waste management is viewed as part of a generation, collection and disposal system. A systems approach that reveals its relationship to other parts of the system is examined in the light of producing more sustainable practice.[Jeffrey K. Seadon (2010) [30]]

Industrial Ecology:

It provides an integration system approach to managing the environmental effects of using energy, materials, and capital in industrial ecosystem. To optimize resource use (and to minimize waste flows back to environment) managers need a better understanding of the metabolism (use and transformation) of materials and energy in industrial ecosystem, better information about potential based sources and uses and improved mechanism(markets, incentives and regulation structure) that encourage system optimization of material and energy use.

Industrial ecology serves as a general paradigm for improving the environmental performance of industrial processes and the environmental attributes of products.

In 1987 the World Commission on Environment and Development has announced sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs .Industrial ecology is one of the concepts that could assist countries, communities and industrial complexes to become sustainable. Industrial ecology has been proposed by United Nation Environment Program as systems- oriented study of the physical, chemical, and biological interactions and interrelationships both within industrial systems and between industrial and natural ecological systems. Frosch and Gallopoulos suggested a concept of an industrial eco-system, in which the consumption of energy and materials is optimized. Gertler proposed two basic industrial ecological strategies focusing within a company or industry or on a network of different companies and agencies.[Song Hawa Chae et al. (2010) [1]]

Design for sustainability:

The concept of Design for sustainability (DFS) is strongly related to the capacity of promoting production system that can respond to environmental requirement in their products using as fewer natural resources as possible to current patterns.

In these term the designers and decision makers co-ordinate every products, Service and communication that can contribute to clarity the alternatives and technical solutions in order to attend social and cultural innovations. It also considers the life cycle of matters and its impact on human and natural system.

The DFS is aimed to offer efficiency to the design process, focusing on reduction of manpower, choosing the right and eco-friendly source of energy, optimizing and giving more lasting capacity for products and especially designing disassemble facilities.

Important phases of DFS

a Redesign

b Upgrading

c New Consumption Patterns

d Sustainability

III CONCLUSION

This research paper would definitely help the research scholars in perusing their work in the field of green manufacturing, green design, pollution control, LCA, cleaner production, DFE, environmental engineering, pollution prevention, design for sustainability etc. This would also help to common people to understand the revolution of ECDM

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