Approach for Green Product Design

Palanivel Subramaniyam, Karthick Srinivasan, and Muni Prabaharan

***Abstract*—In this article an attention to environmental aspects, especially the necessity of recycling usage in the engineering design was paid. From product lifecycle concept, the cycle starts at the design of a product. These Eco-design products are not favorable in the market place as expected even though they sound more environmental friendly and economical. Because, they are focused solely on environmental impact analysis without paying much attention to customer needs and cost considerations. This problem can be avoided by implementing Quality Function Deployment (QFD). This paper presents an approach for the phases to be followed by an organization that incorporates design for recycling (DfR) into product design. It also states that the recycling process of various materials especially for appliance industry. This paper set up a boundary of recycling concept for appliance industry.**

***Index terms*—Recycle, new product design, green supply chain management**

I. Introduction

Recycling is defined as the process of converting a used material into a new product in order to prevent waste of potentially useful materials, including organic recycling but excluding energy recovery. For the purpose of this process, recycling industries also include companies which have activities such as collection, dismantling and sorting as far as they are followed by recycling in the sense of the mentioned directive. When implementing this process into new product development, we can see benefits such as reduce the consumption of fresh raw materials, reduce energy usage, reduce air and water pollution by reducing the need for conventional waste disposal and lower green house gas emissions.

A. Recycled product

It is a product which is manufactured by using recycled material. Industry experts should be agreed that the customer will buy a product which made from recycled material. And make sure that the look, feel and cost of the product should be same as non-recycled based product.

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Serious environmental problems are caused by plastics. It is not intrinsically dangerous, but it takes up a huge amount of space in landfills. For these reasons, wherever it is possible, plastics should be recycled [5].

B. Recyclable product

It is a product which is manufactured to be recycled at the end of their useful life. Mono- materials are used. Toxic and hazardous substances are eliminated.

C. Design for Recycling (DfR)

It integrates the criteria of both recycling and recyclability into the design phases of product. The environmental variable is just another requirement of the product that is added to all the others, such as its cost, its safety, its manufacturability, its use, etc. The application of this variable does not affect the rest of the properties of the product, and price and environmental improvement are combined with the aim of manufacturing products with a reduced environmental impact associated to its entire life cycle and competitive prices.

D. Green Supply Chain Management

Nowadays, manufacturers are facing great challenges with regard to the production of green products due to the emerging issue of hazardous substance management (HSM). In particular, environmental legislation pressures have yielded to increased risk, manufacturing complexity and green components demands ever since the Restriction of Hazardous Substance (RoHS) the directive was passed by the European Union (EU).

Green supply chain management (GSCM) is defined as integrating environment thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers, and end-of-life management of the product after its useful life. According to this definition, GSCM is related to a wide-range of production from product design to recycle or destroy, or from cradle to grave.

From product lifecycle concept, the cycle starts at the designing of product. Green design emphasizes both environmentally conscious design and life cycle assessment/analysis. In designing a product, the designing team can change the raw materials or substances used during the manufacturing to be less toxic, more environmental friendly. Some terminologies are related to design for green such as design for environment or Eco-Design.

E. New product design with respect to environment: ECO-DESIG N

The EuP (energy-using products) directive is the first directive requiring the incorporation of life-cycle-based environmental considerations into the product development process. Several aims of EuP directive have been stated: to ensure the free movement of energy-using products, to improve the overall environmental performance of these products and thereby protect the environment, to contribute to the security of energy supply and to preserve the interests of both industry and consumers. The EuP directive requires manufacturers to integrate eco-design considerations into the product design stage and establish eco-profiles for products via a lifecycle approach.

In the past, several environmental impact analyses and evaluation tools have been developed for Eco-Design products. For example, health hazard scoring (HHS) is an evaluation method for health hazard assessment presented a disassembly planning method for the end-of-life products during the initial design stage. Sustainable process indices based on an operational definition of sustainability, which relies not only on environmental risk, but also includes economic and technical feasibility as well as political compromise. The life cycle of a product refers to the sequence of interrelated steps of a product from the acquisition of raw materials for manufacturing to the disposal of the used product, i.e. its end-of-life. At the end-of-life, the product can be either disposed off, or still in use to extend its life cycle.

To create environmental new product, it is clear enough that regulations, such as European Union's RoHS (Restriction of Hazardous Substances), WEEE (Wastes from Electric and Electronic Equipment), ELV (End-of-Life Vehicle (ELV) Directive), etc., put pressure on firms and tend to make them responsible for the End of Life (EoL) of their products. For instance, WEEE regulation encourages their designers to develop products with recycling in mind. Japan is slightly in advance compared to the EU and the USA, having already started to aggressively pursue the removal of lead from the manufacturing process of electronic component [2]. These regulations insist on the fact that the products have to be designed in order to lower their environmental load, notably through the increase of recycling rate.

F. Eco-design products

Eco-design products are not favorable in the market place as expected even though they sound more environmental friendly and economical. This situation may be due to that they are focused solely on environmental impact analysis without paying much attention to customer needs and cost considerations. In other words, the key issue for a successful Eco-Design product is not only to meet environmental objectives such as resource and energy conservation and environmental burden reduction but also to take into account cost effectiveness, market demand, and multi-functionality requirements. The main environmental concerns in the EEE sector stem from soil and water contamination, resource depletion, energy use and waste. At the production stage, obtaining raw metal for EEE production consumes a large amount of energy, especially the process of extracting resources, which can also lead to degradation of the surrounding environment. When raw metal is shipped to a plant, it goes through a complex, high-energy-consuming process as it is converted into a finished product.

It appears that to develop a risk assessment framework to systematically manage the green components' suppliers is an urgent need for manufacturers. This framework has to minimize the negative environmental impact over the life cycle of EEE by promoting clean technology and green design and also the generation of e-waste. Eco-design of electrical and electronic equipment life cycle management approaches include on improving the recyclability of EEE, maximizing resource recovery from end-of-life EEE management, strategies for extending the life of e-equipment, promoting clean technologies, approaches to promote and encourage eco-design, selecting criteria for eco-design, setting targets for the environmental performance of products and eco-design to address occupational health and safety issues.

II. Problem Statement

The main problem arising from the offshore design centre is "to design green product" for new product development (NPD) activities. However, these Eco-design products are not favorable in the market place as expected even though they sound more environmental friendly and economical. Because, they are focused solely on environmental impact analysis without paying much attention to customer needs and cost considerations.

III. Objectives of This Research Paper

- To describe the phases to be followed by a company that incorporates design for recycling into product design
- To describe the Ecodesign strategy applicable to the various stages of the life cycle of products
- Ecodesign products are not favorable in the market place; this problem can be solved by using Quality Function Deployment (QFD)
- To describe the recycling process for various materials (plastic, metal and electronic items) especially applicable to Appliance products.
- The points need to consider for improving recycling process

IV. Phases to be Followed by a Company That Incorporates Design for Recycling Criteria Into Its Products

A. Commitment

The company management should approve the project. They should inform the company commitment into entire organization.

B. Create

According to the type of company and possibilities, the work team should define. Design, schedule and carry out the diverse stages of the design for recycling process for each product. The need for each purchase and the associated environmental impact should access.

C. Analysis

The team should analyze the aspects like information about the product (functions, components), company resource and capacities, environmental aspects, new material, new technology, market and competitive products.

D. Assessment

The team should assess the overall view of the most significant environmental impacts caused by the product during the different stages of its life cycle.

E. Environmental Improvements

The team should identify the priorities and environmental improvements to be taken into account during the design process.

F. Follow-up

In this phase, they should assess the effect of environmental improvements incorporated. They should find some tools for continuous improvements.

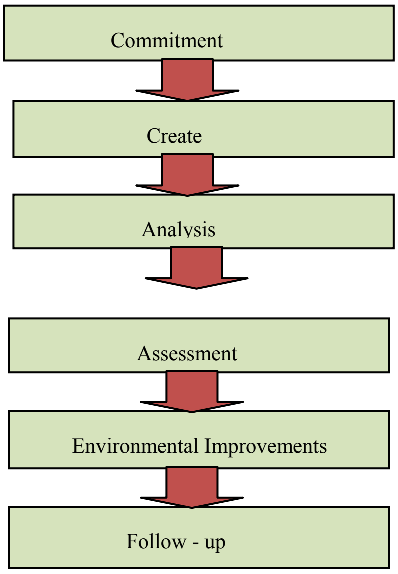


Fig. 1. Different Phases for Recycling

V. Ecodesign Strategy Applicable to the Various Stages of the Life Cycle of Products

Stage 1: Obtaining raw materials

Design for preserving materials and low impact of the materials

Stage 2: Manufacturing

Design for recycling and clean production

Stage 3: Distribution

Design for efficient distribution

Stage 4: Use

Design for efficient use of energy, saving water, pollution prevention and durability

Stage 5: End of life

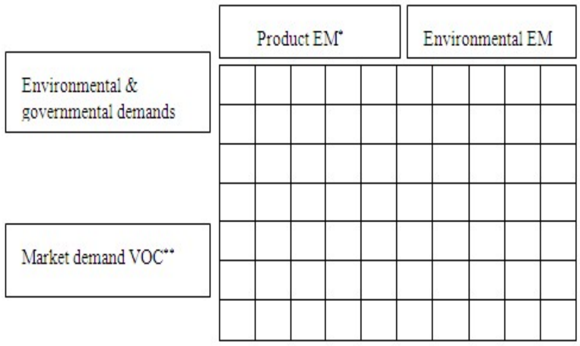
Design for recyclability (use of mono materials, disposal of toxic and hazardous substances, modular manufacturing) [3]

VI. Quality Function Deployment

QFD is a customer-driven product development tool, considered as a structured management approach for efficiently translating customer needs into design requirements and parts deployment, as well as manufacturing plans and controls in order to achieve higher customer satisfaction.

Quality function deployment (QFD) is ‘‘an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production (i.e., marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, sales)’’. The applications of QFD have been expanded to a wide variety of areas, such as design planning, engineering, management, teamwork, timing and costing. QFD is illustrated below.

TABLE 1: Deployment of VOC to EM



VOC – Voice of Customer
EM – Engineering Metrics

Market demand VOC – cheap/quality, operates safely, and operates easily, reliable, aesthetic appearance, etc

Environmental and governmental VOC – reusable, energy efficient, harmless to the living environment, safe disposal, more recyclable material usage, easy to disassemble

Product EM - development time, tooling cost, energy cost, physical lifetime, weight, number of parts, volume, number of types of materials, display

Environmental EM – energy resource, rate of recyclable material, rate of standard components

VII. Improving Recyling Process

We have to develop technologies for improving

1) Ease of dismantling and disassembling
2) Material identification
3) Ease of reuse
4) Ease of recycling

If we will implement the above technologies, then we can see the following benefits

- Lead usage will reduce
- The parts made up of mono materials which is easy to recycle plastic
- The quantity of parts will reduce in order to increase the ease of dismantling
- All plastic parts are labeled for easy recognition
- Recycled plastics are used in order to preserve natural resources

VIII. Role of an Engineer

Engineers have been incorporating recyclable materials in many new product designs for years. More recently a connection has been made between designing for disassembly and designing for recyclability. In both cases, the goal is to ensure that products are designed in a way that is as attractive as possible to recyclers. Making products quick and easy to disassemble helps. Clearly, the specific issues and considerations for any DFR methodology will vary by product type.

IX. Appliance Product Recycling

Appliance products are refrigerators, stoves, dishwashers, microwaves, toasters, food processors, blenders, washing machines, dryers, and other white goods. This following section will focus only about refrigeration.

A. Refrigeration

Once the refrigerator or freezer is in the recycling facility, its components are separated and recycled. In the cases where the most advanced recycling techniques are used, ninety eight percent of the unit is recycled and only two percent goes to the landfill. The large appliance recycling companies, as well as partners of Environmental Protection Agency's Responsible Appliance Disposal Program, capture the chlorofluorocarbons (CFCs), particularly CFC-11, CFC-12, and HCFC-134a, from the refrigerant and the insulating foam, to prevent their release into the atmosphere. These practices help avoid further destruction of the ozone layer and global warming.

B. Refrigeration Recycling Process

Refrigerator contains three types of materials namely plastics, metals and electronic items.

1) Plastic recycling

Step 1: Plastics collection

This is done through roadside collections, special recycling bins and directly from industries that use a lot of plastic.

Step 2: Manual sorting

At this stage nails and stones are removed, and the plastic is sorted into three types: PET, HDPE and 'other'.

Step 3: Chipping

The sorted plastic is cut into small pieces ready to be melted down.

Step 4: Washing

This stage removes contaminants such as paper labels, dirt and remnants of the product originally contained in the plastic.

Step 5: Pelleting

The plastic is then melted down and extruded into small pellets ready for reuse.

2) Sheet metal recycling

Metal recycling is the process of reusing old metal material, mainly aluminum and steel, to make new products. Recycling old metal products uses 95% less energy than manufacturing it from new materials. Aluminum is an ore, which is a mineral, and it usually exists by combining with oxygen. To make an aluminum product an electrical current is run through the metal and separates the oxygen from the aluminum. The aluminum is then melted and shaped into various products. Steel is created in a chemical reaction process located in a hot blast furnace. During this process the iron ore is freed from the oxygen and is then used to make steel. Both of these metal recycling processes consume millions of tons of energy. If we recycle metal products we only have to use 4% of this total energy, which can save our natural resources and reduce our greenhouse gas emissions

3) Electronic items recycling

Most items that recyclers receive are manually dismantled as the first step to separate all of the commodities. Items that cannot be dismantled in an efficient manner are put through a shredding process. Whole e-scrap or dismantled parts can be shredded down to pieces that are less than 2 inches in diameter. They can then be separated through a series of devices all connected via conveyor belts in a process that is 95% automated [6].

X. Benefits of Recycling

- Conserves natural resources such as wood, water and minerals
- Saves energy because less energy is used to manufacture brand new products
- Produces less greenhouse gases because industries burn fewer fossil fuels
- Recycling programs cost less than waste disposal programs
- Recycling centers create jobs
- Prevents the destruction of natural habitats
- Decreases soil erosion associated with mining and logging

XI. Conclusion

This paper integrated environment thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers, and end-of-life management of the product after its useful life. We can overcome the situation which is focused solely on environmental impact analysis without paying much attention to customer needs and cost considerations by implementing QFD. This paper also described that the phases to be followed by a company that incorporates design for recycling into product design. This research study is the boundary for DfR. Future work will focus on each phase of this paper in a detailed manner.

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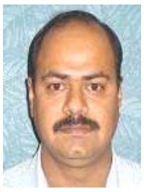

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