Environmental friendly manufacturing and support – Issues and challenges

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Environmentally Conscious Manufacturing and Product Support (ECMPS) is an important issue driven by concern for the escalating deterioration of the environment. ECMPS involves integrating environmental thinking into the design of a product, the selection of materials, manufacturing processes, delivery and support to consumers, and end-of-life management of the product after its useful life has ended. Both academia and industry are interested in finding solutions in this newly emerging research area. Related research is on pollution prevention, remanufacturing, disassembly, life cycle of products, after sale support and material recovery. The aim of this study is emphasizing the product design, operation, maintenance and disassembly effects on environment, and how these issues can be considered in manufacturing phase to minimize the negative environmental impact.

Keywords: Environmentally friendly, Manufacturing, Product support, Pollution.

1. Introduction

Environmental consciousness and recycling regulations are putting pressure on both manufacturers and consumers, forcing them to produce, use and dispose of products in a responsible manner. This has led to a need for models, algorithms and software to create new designs and also to address the logistics involved in support and remanufacturing, recycling and disassembly for an ever-increasing number of discarded products [1].

The current focus on environmental manufacturing and logistics is different from the traditional focus on pollution control. Products are now seen as interacting with the environment. Therefore, rather than looking at a product in isolation, manufacturers need to adopting a cradle-to-grave approach and consider the product life cycle support and requirements. For example, how many resources are used to manufacture the product, how much energy is expended, what are the requirements for transportation and distribution, and how much waste is created with their disposal at end of life? The traditional role of the manufacturer has been to design and produce a product meeting specific environmental rules. Today, manufacturers must be product stewards and support them [2].

For environmentally conscious manufacturing to take effect, there must be a shift from the traditional paradigm. Up to now, the focus has been on building reliable, cost-effective quality products. But as manufacturers are starting to focus on methods to support, recover, disassemble, and reuse materials, the management of a product’s life cycle becomes a key issue [3, 4]. Known as product stewardship, this concept represents a systematic effort by manufacturers to reduce the risks to human health and the environment over all segments of a product’s life cycle. Product stewardship assures the following expectations of environmentally conscious manufacturing are met:

- Evaluation of product design, material selection and support for environmentally conscious manufacturing.
- Ease of maintenance and recycling.
- Ease of support and disassembly.
- Effectiveness of waste collection systems.
- Safe disposal of hazardous wastes.
- Environmental impact assessment of manufacturing and maintenance processes.
- Economics of support and recycling.

Billions of tons of materials are discarded in today’s consumer society; most waste ends up in landfills [5]. This seems to be about to change. Consumers are becoming more conscious of their environment and the potential problems arising from its neglect. They have a newfound interest in buying environmentally friendly products which will be taken care while are in use and back by manufacturers at the end of their useful life. This, in turn, creates an incentive for manufacturers to design green products to gain a competitive advantage in the marketplace. Thus, manufacturers are analyzing the product life cycle, seeking to insert an environmental component into the product design and support to produce a product that is both environmentally friendly and low cost [6-7].

2. Environmentally conscious manufacturing

Environmentally conscious manufacturing is concerned with methods for manufacturing a product, going from its conceptual design to its final delivery and ultimately to its disposal or reuse. Its goal is to produce a product with none environmental effects [8-9]. Environmentally conscious manufacturing consists of the following two key issues:

1) Understanding the life cycle of the product and its impact on the environment at each of its life stages;
2) Making better decisions during product design, manufacturing and use so environmental attributes of the product and manufacturing process are kept at a desired level.

In addition, understanding the operation and end-of-life stage of the product is critical as one of the largest impacts on the environment occurs at this stages [5].

3. Design for environment

Products must be designed in a such way that the potential environmental impact throughout the life cycle is minimized [1]. Traditional product development aims at achieving improvements in design with respect to manufacturability, functionality and cost, but product designers are starting to add environmental criteria to the design stage.

Park and Tahara [10] discuss quality, environmental and customer satisfaction related aspects of products through the concept of producer-based eco-efficiency and consumer-based eco-efficiency.

As noted above, it is now generally recognized that products have environmental impacts over the entire of life cycle, from extraction and procurement of raw materials to manufacturing, distribution, use and disposal [11]. Knowledge acquired during life cycle analysis needs to be transferred into the preliminary design of a new product (Fig.1). Fortunately, it is possible to focus on a specific stage of a product's life to minimize the environmental impact in that stage while also considering the entire life of the product. Researchers have analyzed various stages of a product's life and developed techniques to improve design from an environmental viewpoint; this is called design for the environment [12-13]. The goal of environmental design is to reduce the overall environmental damage when manufacturing and using products [14]. The environmental effect of a product can also be reduced by designing the support for product in its entire life through taking each of the following into account: design for assembly, design for reliability, and design for maintenance (minimum requirements for maintenance and repair [5].

Design for disassembly/maintenance considers the ease of disassembling, repair/service of a product [15]. Veerakamolmal and Gupta [16] introduce a design for disassembly index to measure efficiency.

Fig. 1. Environmental consideration in product lifecycle

The index is calculated using a disassembly tree which allows the identification of precedence relationships defining the structural constraints in terms of the order in which components can be retrieved. Kroll and Carver [17] develop a time-based design for disassembly metrics to be used to compare alternative designs of the same product.

4. Material selection

The incorporation of environmental issues into the design and development stages of a product is expressed in various terms: eco-design, design for reliability, design for maintainability, design for the environment, green design, sustainable design, life-cycle design, re-design etc. Although these concepts highlight different aspects of "green", they all aim to minimize damage to the environment/human during a product's life cycle and, at the same time, to maximize the use of resources (Fig. 2). Consequently, they lead to savings in energy and materials, while benefiting the environment.

The selection of materials is affected by such factors as availability and cost, but reliability and environmental issues are increasingly being added to the mix. A number of methodologies and tools have already been suggested by researchers to deal with environmental issues at the design stage. For example, Giudice et al. [18] develop a systematic method to minimize the environmental impact of the selected materials while satisfying functional reliability and performance requirements.

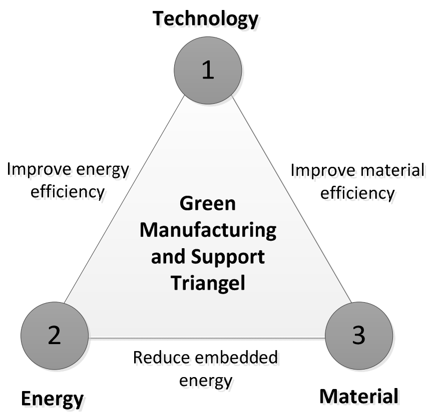

Fig. 2. Green manufacturing and support triangle and its dominant elements

Holloway [19] extends a conventional material selection technique, namely, material selection charts, by integrating environmental concerns. Finally, Tseng et al. [20] perform a green material cost analysis to recommend environmentally friendly materials.

5. Industry examples

The automotive industry leads in research and development activities. For example, Mercedes Benz first started taking scrap cars in 1991; material recovery is part of its environmentally friendly production program. Nowadays MB thinks about the environment through reliable production and after sale support. At Ford and Chrysler, researchers are trying to improve features of their automobiles to ensure both ease of destruction and ease of construction [5]. Environmental friendly operation of products is also their concern, which is fulfilled with design for maintenance and support.

6. Conclusions

According to the discussed issues, the main important points could be summarized as following:

1. Environmental issues are increasing popular among researchers, leading to a significant increase in the number of studies on environmentally conscious design and manufacturing.

2. There is increasing concern about environmental issues in product design and support; systematic frameworks need to be created and offered to designers.
3. Automated disassembly systems are widely studied, as a significant portion of the current disassembly systems is based on manual labor; research is also required into environmentally friendly disassembly.
4. Research on product design focuses on multi criteria techniques which allow the simultaneous consideration of material requirements and economic, consumer and environmental concerns. However, the environmental impact of product manufacturing and support are ignored. We need environmentally conscious design, manufacturing and implementation methodologies that integrate design and processes.
5. With increased environmental awareness in society, product manufacturers must educate their engineers and technicians in environmental aspects of manufacturing to increase their competitive edge. In addition, environmentally conscious manufacturing and support principles should be incorporated into engineering courses at universities.

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