DEVELOPMENT OF A MODEL FOR INTEGRATION OF ASSEMBLY AND DISASSEMBLY IN LIFE CYCLE MANAGEMENT

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ABSTRACT

Regarding the high rate of scrap increase in developed and developing countries, governments and unions are issuing legislations to force companies recycling their products after disposal all over the world. This fact is obvious in vehicle and electrical appliances industry. Currently at the end of life of products recyclers think how to take advantage of product end of life. This problem originates from product design and development process. In order to achieve environmentally conscious products, these two elements have to be considered i.e. assembly and disassembly.

Consequently, new approaches in design such as design for disassembly are introduced. Through these new approaches, companies are able to take benefit of their product end of life value. But still there is some vague area in design for environment especially when designer wants to combine all aspects at the early stage of design.

Tools which are able to consider all design aspects concurrently will decrease total cost in product life cycle and will motivate producers not only to follow legislations, but also get higher benefit of product end of life.

This research expects finding methodologies that can combine assembly and disassembly for a less life cycle cost.

ABSTRAK

Kadar skrap yang semakin tinggi di negara- negara maju dan sedang membangun menyebabkan kerajaan dan kesatuan di seluruh dunia ini megeluarkan perundangan untuk memaksa syarikat syarikat mengkitar semula produk- produk mereka setelah ia dilupuskan. Fakta ini adalah jelas dalam industri kenderaan dan perlengkapan elektrik. Kini di hayat akhir produk, pengitar semula memikirkan bagaimana untuk mengambil kesempatan terhadap produk. Masalah ini berasal dari reka bentuk produk dan proses pembangunan produk. Untuk tujuan mencapai ini, dua unsure hendaklah dipertimbangkan, iaitu pemasangan dan penyahpasangan.

Akibatnya, pendekatan-pendekatan baru dalam reka bentuk seperti reka bentuk untuk pemasangan diperkenalkan. Melalui pendekatan-pendekatan baru ini, syarikat-syarikat boleh memperoleh manfaat daripada nilai hayat akhir produk merek. Tetapi masih terdapat kawasan samar-samar dalam reka bentuk untuk alam sekitar terutama apabila pereka mahu untuk menggabungkan semua aspek di peringkat awal reka bentuk.

Alat-alat yang dapat menimbangkan semua aspek reka bentuk serentak akan merosotkan jumlah kos dalam hayat kitar produk dan akan memotivasi pengeluar-pengeluar bukan sahaja untuk mengikut perundangan, tetapi juga mendapat manfaat yang lebih tinggi hayat akhir produk.

Penyelidikan ini menjangka mencari kaedah-kaedah yang dapat menggabungkan pemasangan dan penyahpasangan untuk megurangkan kos hayat kitaran.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Project

Product design is a critical determinant of a manufacturer's competitiveness. It has been claimed that as much as 80% of the costs of product development, manufacture and use are determined during the initial design stages. The earlier in the product design life cycle, that a design team considers environmental factors, the greater the potential for environmental benefit and cost reduction. The needs in incorporating environmental consciousness into the design for a product or production process lead to the emerging of design for environment (DFE). DFE is the systematic consideration of design performance with respect to environmental, health and safety objectives over the full product and process life cycle. The main environmental implication that a designer seeks to control in a product will dictate what strategy of DFE to pursue. These are Design for Recyclability (DFR), Design for Remanufacturability (DFRM), Design for Reusability (DFRU), Design for Disassembly (DFD), Design for Maintainability and Serviceability (DFMS) and Design for Energy Savings (DFES) in the use phase.

Reuse implies that the component, part or material can be utilized again as it, without modification or upgrade other than cleanup. Remanufacturing involves performing manufacturing operations onto the disposed item so that it can utilize again. Recently, recycling became an emphasis in most industrial countries due to the fact that the quantity of used products being discarded is increasing dramatically. It has been recognized that disassembly of used product is necessary in order to make recycling economically viable in the current state-of-the-art reprocessing technology.

Three objectives that should be considered during design evaluation: maximization of profit (benefit–costs) over a product's life span, maximization of the number of parts reused and minimization of the amount (weight) of landfill waste. Due to their wide spread utilization DFD and DFES have been reported to be the focus of greater research effort (Santochi et al., 2002; Mascle and Balasoiu, 2003; Subramani and Dewhurst, 1991). Some obstacles that made disassembly difficult or today's manufactured products and difficult to gain all the information necessary to plan the disassembly and many consumer products are not designed for ease of disassembly. Two engineering problems associated with DFR are dismantling techniques and recycling costs. The remanufacturing industry faces two issues: (1) components that fail, types of failure and the distributions of times to failure are often unknown and/or present a large variance, and (2) lack of an incentive to customers to buy remanufactured products, as well as perception that they are ‘‘second’’ hand, hence have low quality. Both problems ultimately affect remanufacturing planning. In addition to that, another big issue is the technological barriers to remanufacturing that stem from product differentiation. As for recycling, perhaps the greatest problems that this industry faces are the lack of sufficient collection infrastructure, identification, sorting and compaction of materials, and economic ineffectiveness (Bhander et al., 2003).

1.2 Problem Statement

Disassembly is a process which is applied for reusing abandoned goods and materials; the aim is to protect the environment and to regain the value added to products. In addition, by applying disassembly, future high disposal costs imposed by legislation can be avoided. In order to make the disassembly process economically viable at the current state-of-the-art, a comprehensive disassembly strategy is required. Its main task is to determine the disassembly level and disassembly sequences which provide conditions of the generation of profit while the environmental conditions are maintained. A review of the available theories is presented which are proper for the creation of a disassembly strategy. These theories together with a new mathematical tool result into a comprehensive methodology for the determination of a disassembly strategy. This methodology is illustrated by solving a practical disassembly problem which shows the benefits of its applicability (Penev, 1996).

As at the design problem from manufacturer view it is recognized that the most important items are:

1. Production cost
2. Quick development

The reason why a manufacturer concentrates on these issues is getting high profit. Consequently a manufacturer will go through two main design approaches:

1. Design for Assembly
2. Design for Manufacturing

The aim of these approaches is to design the product in the way that it has less production cost and time; furthermore these approaches concentrate on the cost on early production design.

But, considering design issue from recycler view shows main issues as:

1. Recycling cost
2. End of life value

In these two considerations two other approaches of Design for X are brought into account:

1. Design for Disassembly (DFD)
2. Design for Manufacturing (DFM)

Design for Disassembly and Design for Manufacturing are approaches that consider issues in product end of life.

There are many approaches to do Design for Assembly (DFA), In addition to many researches done on design for disassembly, but still there is a lack of optimizing between these two Designs for X approaches in the way that we can take advantage of both approaches regarding economical and environmental issues.

1.3 Significance of Project

The extremely high and ever-increasing annual disposal rates of solid waste have caused a big problem for environmental protection in the world.

Unlike the first environmental revolution in the1970s, which was aimed at cleaning up hazardous waste from contaminated sites and natural resources and the second revolution is addressing waste reduction.

Most industrialized countries and regions have laws governing recycling which have obvious DFD implications and reflect both a heightened environmental awareness and the practical aspects of waste disposal. For instance, in 2001 Japan calculated that it was soon to run out of space for landfill so government passed a law which added the cost of recycling home appliances to the retail price. Now, over 80 per cent of Japan’s TVs are recycled and another bill passed in the same year made it law for computer manufacturers to take back and recycle obsolete products. Evidence of Japan’s lead in this field is illustrated by companies such as Hitachi and Toshiba who are developing DFD software to help create more sustainable products.

How a product will be recycled is now built into the design process and governs how the product is made.

Vehicles are also responsible for considerable quantities of waste, as 8-10 million cars, trucks and vans are disposed of every year in the USA, in Europe the number is around 14 million and growing as shown in Figure 1.1 and the world figure is about 30 million.

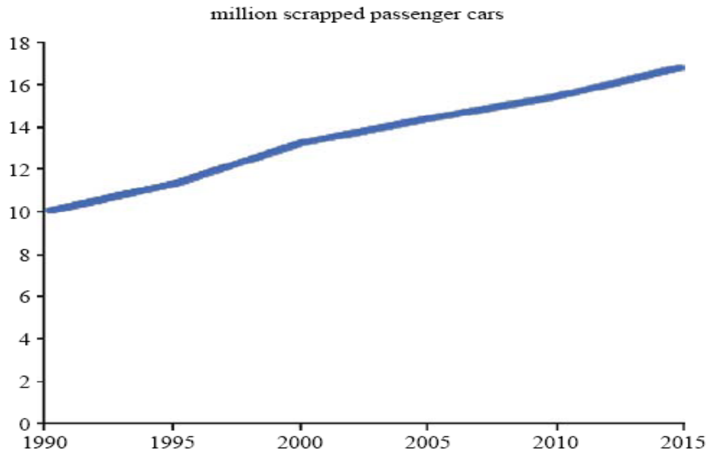

Figure 1.1: Scrapped cars growth in Europe

There are a lot of legislations that force companies and governments to support sustainable product design like Japanese the End of Life Vehicle (ELV) recycling law and Waste Electrical and Electronic Equipment (WEEE) this aims to reduce the quantity of waste from electrical and electronic equipment and increase its reuse, recovery and recycling.

Although there are a lot of different legislations, there are almost ten mutual categories between all of them:

1. Don't use toxic substances
2. Minimize energy and resource consumption in production and transporting
3. Minimize energy and resource consumption in the usage phase, especially for products with most significant to environmental aspects
4. Promote repair and upgrading
5. Promote long life, especially for products with most significant environmental aspects out of usage phase

6. Use structural features and high quality materials to minimize weight not interfering with necessary flexibility, impact strength or functional priorities
7. Use better materials, surface treatments or structural arrangements to protect products for dirt, corrosion and wear
8. Prearrange upgrading, repair and recycling through access ability, labeling, modules, breaking points, manuals
9. Promote upgrading, repair and recycling by using few, simple, recycled, not blended materials and no alloys
10. Use as few joining elements as possible and use screws, adhesives, welding, snap fits, geometric locking etc. according to the life cycle scenario

It is clear that number 4, 6, 8 and 9 are directly related to product early design phase. That is in order to get through environmental regulations; designer should consider these issues in the product design and development process. In fact most of the design issues concentrated on in legislations are related to reuse and repair of product, consequently design for disassembly is brought into account.

Designers need to acknowledge that these products will ultimately fail or become redundant and must be recycled rather than disposed of to landfill. Manufacturers must therefore implement a DFD strategy but despite the activities of the vehicle and computer firms many designers still have little knowledge of the fundamental DFD concepts. This was illustrated well by a recent “Ecodesign” survey of around 100 members of the Industrial Designers Society of America, which showed that information on DFD guidelines was ranked the fourth highest information need (Figure 1.2).

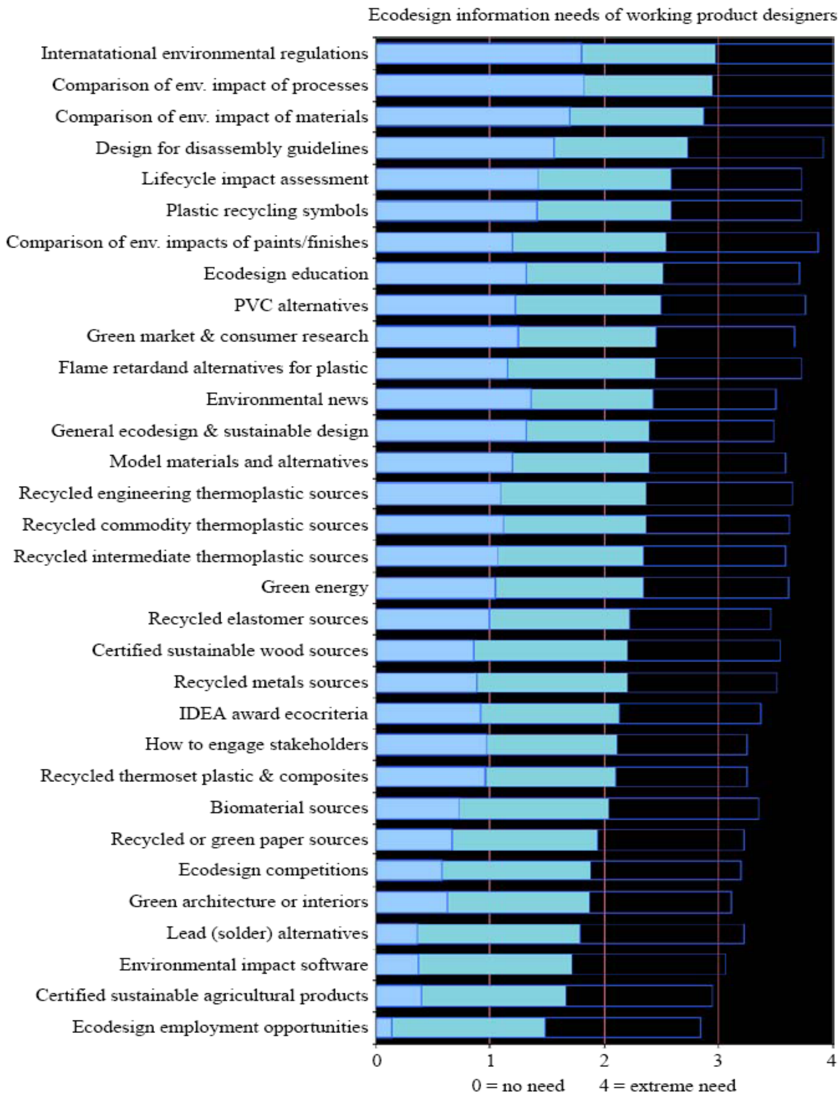

Figure 1.2: Ecodesign information needs of working product designers

Six Rules of Thumb is a quick tool which helps designers focus on environmental improvements either as a brainstorming or to guide product development. It has emerged out of the original three rules of reduce, reuse and recycle which have long been associated with the environment (Tracy Bhama and Vicky Lofthouse, 2002):

1. Re-think: Rethink the product and its functions
2. Re-duce: Reduce the energy and resource consumption in the whole life cycle of product
3. Re-place: Replace hazardous substances with more environmentally sound alternatives

4. Re-cycle: Use those kinds of materials which can be reused or recycled
5. Re-use: Design the product in such a way that the product or parts of it can be reused
6. Repair: Design a product that is easy to repair

1.4 Objectives and Scope of Project

The objective of this project is to develop a model for integration of assembly and disassembly in life cycle management. That is developing a framework or algorithm that can give design guidelines to promote assembly and disassembly designs concurrently.

The scope of this project is divided into two areas:

1. Focus on assembly and disassembly design considerations
2. Validation and verification based on case studies

1.5 Thesis Outline

This thesis consists of seven main chapters that are covering introduction, literature review, research methodology, developing the framework, case study analysis, discussion and conclusion.

First three chapters are covering proposal for the research and next chapters are focusing on proposed method and validating it.

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