DEVELOPMENT OF MULTI-CRITERIA DECISION ANALYSIS METHODOLOGY TO DETERMINE PRODUCT END-OF-LIFE TREATMENT OPTIONS

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I dedicate this thesis report to my beloved parents, brothers and sister for their continuous support and love throughout my work.

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ABSTRACT

There are a number of different End-Of-Life (EOL) scenarios for products at their end of life. The decision of selecting the best EOL option for a particular product, its subassemblies and individual components depends on multiple criteria. The performance of a particular EOL option can be better against one criterion, but might not perform satisfactorily with respect to another. To overcome the problem generated by conflicting criteria, a multi criteria decision analysis (MCDA) technique can be used. In this project MCDA is used to develop a system which aids users to determine the best EOL scenario of products by considering the user preferences and performance of competing EOL options with respect to different criteria.

ABSTRAK

Terdapat beberapa scenario tempoh akhir hayat bagi produk yang berbeza. Keputusan menentukan tempoh akhir hayat yang terbaik untuk produk tertentu, subpemasangan dan komponen individu bergantung kepada kriteria berganda. Menentukan jangka akhir hayat bagi sesuatu produk tertentu terhadap sesuatu kriteria boleh memberikan kesan yang lebih baik, tetapi mungkin tidak bagi kriteria yang lain. Untuk mengatasi masalah yang dihasilkan oleh kriteria bercanggah, teknik *Multi Criteria Decision Analysis (MCDA)* boleh digunakan. Dalam projek ini menggunakan MCDA untuk membangunkan suatu sistem yang boleh membantu pengguna untuk menentukan senario yang terbaik untuk menjangka tempoh akhir hayat produk dengan mempertimbangkan keutamaan pengguna dan prestasi berkenaan dengan pelbagai kriteria yang berbeza.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

The ability to produce environmentally friendly products is becoming a fundamental concern in our society. Demographic growth, combined with an increase in product demand, has led to serious pollution issues. In particular, an extremely large amount of retired products are generated each year and can no longer be controlled. Landfills are now saturated and many of them contain hazardous materials which may damage human health as well as the environment. The choice of an appropriate end-of-life (EOL) destination for discarded products is becoming an important issue for most manufactured products, given the current problems of environmental waste impact and landfill saturation (Remery *et al.*, 2011).

The abandoned waste products present a potential threat to the environment, since substances of this waste stream, for instance fluids and heavy metals, can be leached and released to the soil and water (Mergias *et al.*, 2007). At the product level there is a need to move beyond the traditional 3R concept promoting green technologies (reduce, reuse, recycle) to a more recent 6R concept forming the basis for sustainable manufacturing (reduce, reuse, recover, redesign, remanufacture, recycle), since this

allows for transforming from an open-loop, single life-cycle paradigm to a theoretically closed-loop, multiple life-cycle paradigm (Jayal *et al.*, 2010).

Manufacturers have begun to realize the need for the responsible use and management of resources in the life cycle of a manufactured product, especially the planning for product retirement. This thesis discusses a multi-objective methodology for determining appropriate end-of-life options for manufactured products, set against the often conflicting objectives of minimizing environmental, economic and social impacts, while maximizing surplus (Lee *et al.*, 2001).

In a near future, the original equipment manufacturers (OEMs) in many countries will be financially and organizationally responsible for the take-back of their products when these products reach the end of their useful life (Nagel *et al.*, 1999). This follows the principle of extended producer responsibility according to which producers should be responsible for the entire life cycle of their products and especially for the take-back, the recycling and the final disposal of their products. Hence, the choice of the most appropriate scenario for treating products at their end-of-life should not only be based on economic considerations but should also take into account environmental and social aspects in order to ensure compliance with legislation and the satisfaction of customers (Kiritsis *et al.*, 2003). The problem of selecting an appropriate alternative for treating products at their EOL concerns different types of users such as authorities, recyclers, remanufacturers and not just the OEMs. Different users have their own objectives and priorities and it is possible that a good EOL alternative for one user is not necessarily good for another user (Bufardi *et al.*, 2004).

Therefore a need is felt by users, to have a methodology which can be used universally and be applied on a variety of product types to determine their appropriate EOL option based on the preferences of a specific user.

1.2 Problem Statement

There has been no exclusive methodology which has been developed to determine the End-of-Life options for generic products while also be useful not only for the product designers and OEMs, but other users as well like recycling companies, remanufacturers and government authorities. Further many previously developed methodologies do not consider simultaneous use of the material, environmental, economic and social criteria to determine the product end-of-life (EOL) option.

1.3 Objectives and Scope of Study

The objective of this project is to develop a methodology that will enable users to determine the best suited end-of-life scenario for the product and its components under consideration.

The scopes of the study are:

i. The developed methodology will enable a variety of users, to reach a final decision of product EOL option based on multiple criteria as suited to the users.
ii. Development of an algorithm, based on one of the methods of Multi-Criteria Decision Analysis.
iii. Development of software to enable users to use the methodology with ease.

1.4 Significance of the Work

It is expected that the tools developed will help production firms to design products that will provide optimum end-of-life value during the product retirement phase. Further it will reduce the negative impacts of product disposal on the environment and maximize the social benefits gained from the implementation of the EOL alternatives. The system is to be designed for a variety of users, and for a variety of products, therefore encompassing a much wider product range.

1.5 Thesis Structure

The structure of the thesis consists of brief introduction, literature review of previous work and research conducted, methodology, development of the software, case study, discussion and conclusion. These parts are divided in 6 chapters.

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