UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

DEVELOPMENT OF SUSTAINABLE MATERIAL SELECTION FOR AUTOMOTIVE BUMPER FASCIA USING ANALYTICAL HIERARCHY PROSES (AHP)

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Master of Manufacturing Engineering (Manufacturing System Engineering)

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DEVELOPMENT OF SUSTAINABLE MATERIAL SELECTION FOR AUTOMOTIVE BUMPER FASCIA USING ANALYTICAL HIERARCHY PROSES (AHP)

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Manufacturing Engineering (Manufacturing System Engineering)

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DECLARATION

I hereby, declared this report entitled "Development of Sustainable Material Selection for Automotive Bumper Fascia Using Analytical Hierarchy Process (AHP)" is the results of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

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Date : 17 June 2013

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Master of Manufacturing (Manufacturing System Engineering). The member of supervisory committee is as follow:

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ABSTRAK

Pemilihan bahan yang mampan adalah sangat penting untuk proses perkembangan produk baru. Oleh itu, keputusan yang tepat dalam pemilihan bahan yang sesuai adalah perlu bagi menyokong keperluan pembangunan yang mampan. Objektif utama kajian ini adalah untuk mencadangkan rangka kerja pemilihan bahan mampan bagi fascia bumper automotif menggunakan proses hierarki analisis (AHP). Kaedah AHP membantu untuk melakukan proses membuat keputusan untuk merumuskan semua kepentingan setiap kriteria ke satu nilai diutamakan. Pelbagai faktor dan sub-faktor yang mempengaruhi proses pemilihan dipertimbangkan. Untuk menunjukkan rangka kerja pemilihan bahan mampan yang dicadangkan, enam jenis bahan dipertimbangkan Hasilnya didapati bahawa ia dapat membuktikan polyamides, PA6 dengan 30% GFR adalah bahan yang paling sesuai untuk fascia bumper automotif kerana ia mempunyai peratusan tertinggi nilai keutamaan pada 19% berbanding dengan bahan lain. Keputusan akhir bahan yang diperolehi dengan melakukan 4 senario analisis sensitiviti dan analisis menunjukkan bahawa ia telah terbukti iaitu PA6 dengan 30% GFR adalah keputusan yang paling optimum.

ABSTRACT

Selection of sustainable material is very essential for the development process of a new product. Therefore, the right decision on selection of the appropriate material is necessary in order to support sustainable development requirements. The main objective this study is to propose a sustainable material selection framework for automotive bumper fascia using analytical hierarchy process (AHP). AHP method helps to perform decision-making process to summarize all the importance of each criterion into one prioritized value. Various factors and sub-factors that influence the selection process were considered. To demonstrate the proposed sustainable material selection framework, six different types of materials were considered. The results revealed that Polyamides, PA6 with 30% GFR is the most appropriate sustainable material for automotive bumper fascia because it has the highest percentage of priority value of 19% compared to the other material. The final judgement of the material is gained by performing 4 scenarios of the sensitivity analysis and the analysis showed that it is proven that PA6 with 30% GFR is the most optimum decision.

DEDICATION

I would like to dedicate this report to my beloved wife and sons, Karmila, Haikal, Harraz and Hafiy and all my friends in order to encourage and helps me in completing this report.

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LIST OF ABBREVIATIONS

ABS	-	Acrylonitrile butadiene styrene
AHP	-	Analytical Hierarchy Process
ANC	-	Average of Normalized Column
ANN	-	Artificial Neural Network
ANSYS	-	Analysis System
APME	-	Association of Plastics Manufacturers in Europe
ASA	-	Acrylonitrile Styrenen Acrylic Ester Copolymer
CAD	-	Computer Aided Design
CBU	-	Completely Built-up Units
CS	-	Cost
CTE	-	Coefficient Thermal Expansion
D	-	Density
DEA	-	Development analysis
DSS	-	Decision Support Software
EAB	-	Elongation at Break
ELECTRE II		ELimination Et Choix Traduisant la REalite
ELVs	-	End-of-Life Vehicles
ER	-	Electric Resistivity
EPR	-	Ethylene propylene rubber
FM	-	Flexural Modulus
FS	-	Flexural Strength
FEA	-	Finite Element Analysis
FOS	-	Factor of Safety

FRP - Fiber-Reinforced Plastics

GF - Glass Fiber

HIPS - High Impact Polystyrene

MA-AHP Morphological Analysis and Analytical Hierarchy Process

MCDM Multi-Criteria Decision Making

MFR - Melt Flow Rate

Mpa - Mega Pascal

MOS - Metal Oxy Sulfate

MP - Mechanical Properties

MS - Microsoft

MT - Mold Temperature

PA - Polyamide

PALF - Pineapple Leaf Fiber

PBT - Polybutylene Terephthalate

PC - Polycarbonate

PCA ......Principal Component Analysis

PDS - Product Design Specifications

PET - Polyethylene Terephthalate

PP - Polypropylene

PPE - Polyphenylene Ethe

PROMETHEE Preference Ranking Organisational Method for Enrichment Evaluation

PU - Polyurethane

PVC - Polyvinyl Chloride

RI - Random Index

R&D - Research And Development

RIM - Reaction Injection Molding

RMC - Raw Material Cost

SAN - Styrene Acrylonitrile Copolymer

SMC	-	Sheet Moulding Compound
TBL	-	Triple Bottom Line
TPU	-	Thermoplastic Polyurethane
US	-	United States
UV	-	Ultra Violet
WA	-	Water Absorption
YS	-	Yield Stress

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Generally this chapter discusses the sustainable material selection by using the Analytical Hierarchy Process (AHP) which includes the background, problem statement, objectives and scope of project.

1.1 Background of Project

Sustainability culture is one of the key factors in enhancing success in design or even in manufacturing on the whole. The increased of awareness towards the importance of sustainability concepts is driven by the demand from the customers for sustainable products and also the expansion of regulations by the government. Sustainability concepts can categorized into economy, environmental and also social perspectives. On the other hand, sustainable concepts in the manufacturing field can be categorized by material, product design and also the manufacturing process. Selection on sustainable concept is essential for contemporary manufacturing organizations. There are various selection methods in the selection process. The Multi-Criteria Decision Making (MCDM) adopts the Analytical Hierarchy Process (AHP) in order to determine and evaluate the material which fulfils the sustainable material selection requirements.

Analytical Hierarchy Process (AHP) is a systematic approach which assists single or group decision makers in problem solving process. The AHP is made up by three processes namely the hierarchy construction, priority analysis and consistency verification. Firstly, the decision makers need to disintegrate complex multiple criteria decision problems into its components part whereby every possible attributes are arranged into multiple hierarchical levels. Subsequently, these clusters will be compared along the same level in a pairwise manner based on their own experience and knowledge (Ho, 2008).

The application of AHP was illustrated in determining the sustainable material selection for automotive bumper fascia. Studies on different types of material were carried out and the sensitivity analysis was performed to test the stability of the priority ranking. Consequently, the study presented the method of selecting sustainable material by considering environmental requirements during selection process by using the analytical hierarchy process.

1.2 Problem Statement

At present, engineers encounter great challenges in determining the sustainable material selection which concurrently fulfils the environmental requirement during the development process. Determining the best sustainable material on product design is a crucial task since there are many factors to be taken into consideration. Inaccurate decision on sustainable material selection during the product development process may lead to redesigning or remanufacturing process of the product. Thus, the AHP is one of the techniques which can be employed in assisting the engineers in their product development process.

Automotive bumper fascia was selected as a case study of this research. Automotive bumper fascia is one of basic structural component of an automotive bumper system which contributes to vehicle crashworthiness or occupant protection during front or rear collisions. Other basic components namely energy absorber, bumper beam and bumper stay (Yim et al., 2005 and Lee and Bang, 2006). From all four basic components, the bumper fascia is already a largely mature application for plastic on automotive industry. Thus, it is important to determine the most appropriate sustainable material for the automotive bumper fascia at the early stage of product development process. So far, there is no researchers have used Analytical Hierarchy Process (AHP) to develop the sustainable material selection for automotive bumper fascia.

1.3 Objectives

The goal of this study is to propose a new sustainable material selection framework for automotive bumper fascia and the specific objectives of this study are as follows:

i. To identify sustainable material factors that influences the selection process.

ii. To determine the possible solution on sustainable material selection for automotive bumper fascia using the proposed framework.

iii. To study the effects of different factors on deciding the best decision option by conducting the sensitivity analysis.

1.4 Scope of project

The scope of study on different types of material for automotive bumper fascia will include:

i. The study on product development process related to sustainable requirements

ii. Performing sensitivity analysis using expert choice software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In order to produce products with low environmental impact, a few principles need to be considered during the product development stage with special regards to material selection, design, product in use, recycling criteria, cultural aspects and many others. The purpose of decision analysis is not to replace judgement, but to help organise it and to provide better understanding of the system. The multi-criteria decision-making process may help the manufacturers systematically develop appropriate and profitable material for their sustainable products.

2.2 Sustainable Manufacturing

The keys of measuring sustainability for five established cement industries mentioned by creating the list of criteria associated with the particular industry and using the proposed list of criteria and the sustainability reports. The harmful effects of CO2 emissions and it are partly related to the performance indicators given in the report that have been presented by Isaksson and Steimle (2009).

Szekely and Knirsch (2005) discussed about the methods and tools employed in various manufacturing organisations such as sustainability indices, performance indicators to measure sustainability performance where else economic, environmental and social as the metrics involved in the achievement of sustainability to improve the measurement of