UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Manufacturing Process Selection for Automotive Bumper Fascia Using Analytical Hierarchy Process

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) (Hons.)

by

INTAN LIYANA BT. ISMAIL

B050810132

891222-14-5750

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APPROVAL

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

………………………………

(Project Supervisor)

ABSTRACT

This project describes an approach, based on the analytical hierarchy process (AHP) that assists decision makers or manufacturing engineers determining the most appropriate manufacturing process that to be employed in manufacturing of automotive bumper fascia at the early stage of product development process. Manufacturing process selectionproblem has also been treated as a multicriteria decisionmaking due to various factors affecting the selectionprocess must be considered. One of the concurrentengineering tools that can be implemented to assistmanufacturing engineers determining the most optimummanufacturing process is analytical hierarchy process(AHP).There are5 types of processes under consideration are injection moulding (IM), vacuum thermoforming, reaction injection moulding (RIM), compression moulding (CM), and blow moulding (BM). The analysis ranks the 5 types of processes for suitability of use in manufacturing automotive bumper fascia based on 6 main selection factors and 12 subfactors. Determining the right manufacturing process wasperformed based on AHP concept through the 9 steps. The results indicated that the vacuum forming was the most appropriate manufacturing process because it has the highest value (23.99%) among the other manufacturing processes. This result is supported by MindDecider result where the vacuum forming.

ABSTRAK

Projek ini menerangkan pendekatan, berdasarkan proses hierarki analisis (AHP) yang membantu pembuat keputusan atau jurutera pembuatan yang menentukan proses pembuatan yang paling sesuai untuk diambil bekerja dalam sektor perkilangan bumper fasia pada peringkat awal proses pembangunan produk. Masalah dalam pemilihan proses pembuatan juga telah dianggap sebagai keputusan untuk kepelbagaian kriteria disebabkan pelbagai faktor yang mempengaruhi proses pemilihan mesti dipertimbangkan. Salah satu alat kejuruteraan serentak yang boleh dilaksanakan bagi membantu jurutera pengeluaran yang menentukan proses pengeluaran yang paling optimum adalah proses analisis hierarki (AHP). Terdapat 5 jenis proses yang sedang dipertimbangkan iaitu *injection moulding (IM)*, *vacuum thermoforming*, *reactioninjection moulding (RIM)*, *compression moulding(CM)*, dan *blow moulding (BM)*.5 jenis proses dipilih untuk mencari yang paling sesuai digunakan dalam pembuatan bumper fasia yang berasaskan pada 6 pemilihan faktor-faktor utama dan 12 subfactors. Untuk menentukan proses pembuatan yang betul ianya dilakukan berdasarkan konsep AHP melalui 9 langkah. Keputusan menunjukkan bahawa proses *vacuum forming* adalah proses yang paling sesuai berbanding yang lain kerana ia mempunyai peratus yang paling tinggi (23.99%). Keputusan ini disokong oleh perisian *MindDecider*.

DEDICATION

To my beloved parents, siblings and my special ones.

ACKNOWLEDGEMENT

Apart from the efforts of me, the success of any project depends largely on the encouragement and guidelines of many others. I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this project. I would like to show my greatest appreciation to Engnr. Dr. Hambali b. Arep @ Ariff. I can't say thank you enough for his tremendous support and help. Without his encouragement and guidance this project would not have materialized. Finally, an honorable mention goes to our families and friends for their understandings and supports in completing this project**.**

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AHP	-	Analytical Hierarchy Process
AV	-	Availability of Equipment and Labour
BM	-	Blow Moulding
CD	-	Complexity of the Design
CM	-	Compression Moulding
CS	-	Cost Consideration
EC	-	Equipment Cost
EM	-	Ease of Maintenance
ERP	-	Enterprise Requirement Planning
GD	-	Geometry of the Design
IM	-	Injection Moulding
LC	-	Labour Cost
MS Word	-	Microsoft Word
MT	-	Material
PC	-	Production Characteristics
PQ	-	Production Quantity
PSM	-	Projek Sarjana Muda
PT	-	Processing Time
RIM	-	Reaction Injection Moulding
RP	-	Rate of Production
R&D	-	Research and Development
SH	-	Shape of the Design
SWOT	-	Strength, weakness, opportunity, threat
SZ	-	Size
TC	-	Tool Cost
TPO	-	Thermoplastic Polefin

TS	-	Tolerance and Surface
USA	-	United States of America
VF	-	Vacuum Forming
WG	-	Weight
WT	-	Wall Thickness
°	-	Celsius
XML	-	Extensible Markup Language

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Ashby (1999)developed a useful systematic approach which consists offour main steps namely translating, screening, rankingand supporting information for determining suitablemanufacturing process for a product. Manufacturing process selectionproblem has also been treated as a multicriteria decisionmaking due to various factors affecting the selectionprocess must be considered. One of the concurrentengineering tools that can be implemented to assistmanufacturing engineers determining the most optimummanufacturing process is analytical hierarchy process(AHP). However, the application of AHP in the field ofmanufacturing process selection is less addressed in theliterature. Currently there is no paper in the literature thatdiscusses the use of AHP process in determining themost suitable manufacturing process for automotive bumper fascia.In this project, a method that will be used in considering the selection of manufacturing process is called Analytical Hierarchy Process (AHP). The AHP method is a one of the early decision making in the concurrent engineering. According to Giachetti (1998), an importantaspect of concurrent engineering is the earlyconsideration of manufacturing process in the productdevelopment process to achieve a reduction in productdevelopment time, production costs, and quality defects. The AHP method was used to assists decision makers ormanufacturing engineers determining the mostappropriate manufacturing process to be employed inmanufacturing of automotive bumper fascia at the early stage of development process. There are5 types of processes under consideration are injection moulding (IM), compression moulding (CM), reaction injection moulding (RIM), vacuum forming (VF), and blow moulding (BM). The analysis ranks the 5 types of processes forsuitability of use in manufacturing automotive bumper fascia based on 6 main selection factors and 12 subfactors.Determining the right manufacturing process wasperformed based on AHP concept through the nine steps. There is no studied the application of AHP relatedto manufacturing process selection in product developmentprocess. Thus, the main focus of this project is to explore thepotential use of AHP in assisting manufacturing engineers toevaluate and determine the most appropriate manufacturing process for producing automotive bumper fascia atthe early stage of product development process.

1.2 Problem Statement

Bumper fascia is known as the bumper cover for a car. As a cover it must have an aesthetic element and few criteria to be implemented on the bumper fascia. When the criteria has determined, the manufacturing process shall be choose for the ability in manufacturing based on the criteria. The production of a product is commonly relates with the manufacturing processes. Each of manufacturing processes has its own capability, advantage and disadvantages. The processes also will affect the life cycle of the bumper. It is important to choose the right manufacturing process for bumper fascia to minimise cost and make sure that all variables that needed for bumper fascia capable to manufacture by the process. Among all, there is no research that comparing each manufacturing processes in bumper fascia and no results in choosing the best and suitable manufacturing process. To avoid choosing a wrong process there are many decision tool making can be used for choosing the right process. As being stated in the introduction, the AHP is one of the decision making tool. It is a useful method in order to choose the specific idea among the candidates. The selection of processes for automotive bumper fascia has never been done by using the AHP method.

1.3 Objective

In this project, the main objective is to determine the best manufacturing process for automotive bumper fascia production. The specific objectives are as follows:

(a) To identify the factor influence the selection process for manufacture automotive bumper fascia
(b) To verify the results using MindDecider software

1.4 Scopes of Project

The scopes of this project are:

(a) Introduction of AHP, the automotive bumper fascia, and the conceptual design concept
(b) The criteria selection of bumper fascia.
(c) The manual steps of the AHP method.
(d) The analysis of AHP method for the bumper fascia selection.
(e) The MindDecider software utilization for decision making and use to compare the results of AHP.

CHAPTER 2

LITERATURE REVIEW

2.1 Automotive Bumper

According to Helps (2001a), the main function of a bumper is to protect the car's body in a collision. There is some difference between American and European practice in assessing performance. In North America, impact requirements for the bumper beam tend to be stringent, but damage to the fascia is not considered in meeting the requirements. Designers usually meet these specifications by making the beam stiff and having the fascia fill a purely decorative role. In Europe, impact requirements are generally less stringent but fascia damage indicates failure of the test. Therefore, the fascia plays a more structural role and material selection is more critical. However, North American car makers are showing signs of moving in the direction of European practice, especially on vehicles in which bumper system are taking on a more active energy management role. The initial move away from metal to plastic front and rear bumper on cars and related vehicles came in the USA, where bumper design is now a key styling feature. European manufacturers have followed suit.

Plastics bumper have almost wholly superseded metal bumpers because of the cosmetic design freedom they offer. However, a price has to be paid. There is substantial body of opinion expressing the view that bumper have ceased to provide the protection necessary at parking speeds, and that furthermore, as they have become integrated into the design of the car, replacement of a bumper has become almost as expensive as replacing the parts that would have been damaged if the bumper had not been there.

2.1.1 Bumper Systems and Components

Based on Figure 2.1, the front bumper systems are consisting of fascia, energy absorber and reinforcing bumper beam. For assembling, the energy absorber is positioned between fascia and reinforcing bumper beam. The fascia envelopes energy absorber and reinforcing bumper beam in the assembled form. Means are desirable provided to fixedly attach the energy absorber to the bumper beam such as bolts and nuts. Fascia is maybe formed from a thermoplastic material which, preferably, has a finished surface and may be amenable to finishing utilizing conventional vehicle painting and/or coating techniques. As stated, generally, the fascia will envelop both the energy absorber and reinforcing bumper beam such that neither of thecomponentsis visible once they are attached to the vehicle. The fascia may be attached to the bumper beam or other part of the vehicle.

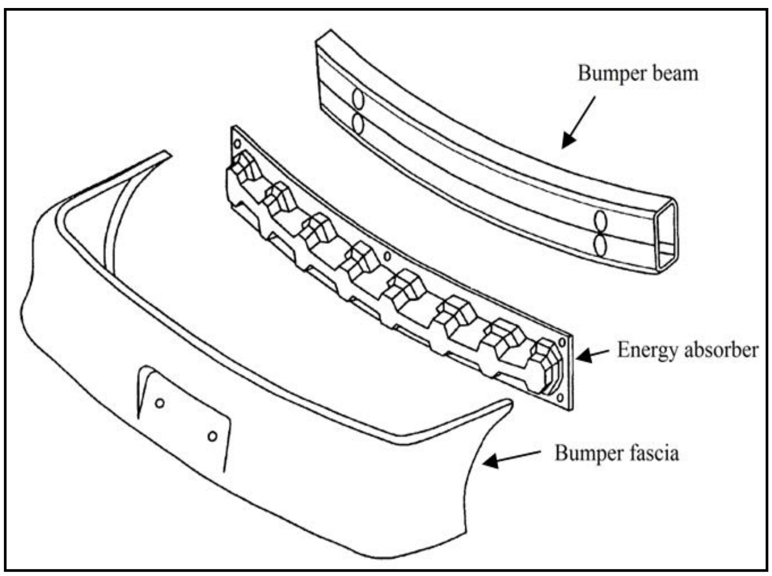

Figure 2.1: Automotive bumper system components (Shuler et al., 2005)

2.1.2 Bumper Fascia

Bumper fascia for each car is normally different in design and material.

2.1.2.1 Design of Bumper Fascia

An automobile bumper fascia is a component, which contributes to vehicle crashworthiness during frontor rear collisions. According to Suddin et al. (2004), to reduce air resistance when the car is moving, the bumper fascia has a ″C″ profile as the aerodynamic design for the fascia. The thickness of the bumper fascia is based on the idealthickness of the fascia of most passenger cars.The bumper fascia was determined with a smoothouter surface. By using the bolts and nuts, the bumper fascia needs to mount to the bumper bracket. Figure 2.2 shows the bumper fascia for Viva’s car model.

Figure 2.2: Viva’s bumper fascia

2.1.2.2 Material of Bumper Fascia

Based on the Helps (2001b) research, the TPO’s have a dominant position (90%) in the European bumper market, where PP/EDPM is extensively used by VW, BMW, Mercedes-Benz, Audi, Ford, Opel and Porsche. High impacts TPOs are used, often with mineral reinforcement to impact higher stiffness. Bumper fascias are considered to be a market where reactor-made TPOs are likely to have a promising future. An ultra-thin wall grade of reactor made TPO is being used in the bumper fascia of Ford’s 2000 Sable model, offering more stiffness and toughness. This is the first instance of the commercial use of reactor-made TPOs in an ultra-thin wall, directly paintable bumper fascia for a high volume vehicle. Compared with the compounded TPO it replaces, the reactor-made TPO has lower weight, reduced cost, improved base colour and better paint adhesion.

2.2 Manufacturing Processes of Bumper Fascia

There are five candidates of manufacturing processes for bumper fascia. The candidates are injection moulding (IM), compression moulding (CM), reaction injection moulding (RIM), vacuum forming (VF), and blow moulding (BM).

2.2.1 Injection Moulding (IM)

This process is a high-volume production process used primarily with thermoplastics materials, but it can also be used with thermosets. It is an important process for the plastic industry. Injection moulding is a process that forces a measured amount of liquid plastic into a heated die cavity. Thermoplastics materials than have been heated and softened are forced into the mold cavity by the injection moulding plunger. After the part cools, the mold opens and is ejected or removed. Injection moulding is a high-speed production process that can produce large quantities of small parts (DuVall, 1996a).

2.2.2 Compression Moulding (CM)

Compression moulding can be used to process both thermoplastics and thermosets, although its use with the latter material but it is not all common. This is because, with the thermoplastics, the mould would need to be alternatively heated, to shape the materials, and cooled top permit ejection from the mould cross linking materials, on the other hand, may be ejected at the high mould temperature. The major advantages of compression moulding are that it is a simple process with a little waste and particularly suitable for material that cross-link during processing. By the nature of process there are no parts where prematurely cured material can get trapped and cause prolonged down-time. Basically the system consists of matched male and female dies which are heated to temperatures between $125^{\circ}-200^{\circ}$C. A pre-weighed charge of the material to be moulded is placed between the two mould halves and these are then closed. Under the heat and pressure, the polymeric material plasticises, flows to the shape of the mould and become cured (Swift and Booker, 2003a).

2.2.3 Reaction Injection Moulding (RIM)

Reaction injection moulding (RIM) is a high production process used with thermoset plastics. The process involves combining two or more reactive liquids by aggressive mixing in a high-pressure mixing head just before they enter the mould. Once the liquids are in the mold, they quickly polymerize to form the completed part. One of the greatest advantages of the RIM process is the design flexibility that it permits. The use of low-viscosity liquids permits easy filling of mould, and makes it much simpler to produce complex parts (DuVall, 1996b).

2.2.4 Vacuum Forming (VF)

Thermoforming processes all involve forcing a heat-softened sheet of material into or over a mold, then allowing it to cool and assume the mould shape. The mould shape for this complex thermoformed part is cooled internally to speed production. In vacuum forming, the plastic sheet is clamped and heated. A vacuum is then applied beneath the sheet, causing the atmospheric pressure to draw the sheet down against the cavity of the mold. When the plastic touch the wall of the moulds, it cools. Vacuum forming is the most widely used of the thermoforming processes. It can be used effectively even for fairly large product such as bumper fascia (DuVall, 1996c).

2.2.5 Blow Moulding (BM)

Blow moulding offers the advantage of manufacturing moulded parts economically, in unlimited quantities, with little or virtually no finishing required. It is principally mass production method. The surfaces of the moulding are as smooth and bright, or as grained and engraved, as the surfaces of the mould cavity in which they were processed. The biggest application area is for all types of bottles, but products range from small phials to large tank and bumper fascia is possible (Swift and Booker, 2003b).

2.3 Total Design

Pugh (1991) has described the total design methodology as a ‘partial design’. According to Torres (2001a), the total design objective is to achieve integration of the technological as well as nontechnological subject’s material with the goal of creating successful products and processes. From the Pugh (1991) explanation, total design requires the input from people of many disciplines, both engineering and non-engineering, in a mix that is almost unique to the product under consideration. It is a systematic activity necessary, from the identification of the market/user need, to the selling of the successful product to satisfy the need that encompasses product, process, people and organization.

2.3.1 Product Design Core

As stated by Torres (2001b), total design may be constructed as having a central core of activities, all of which are imperative for any design, irrespective of the domain. It can be called as a product design core and consist of core as shown in Figure 2.3.

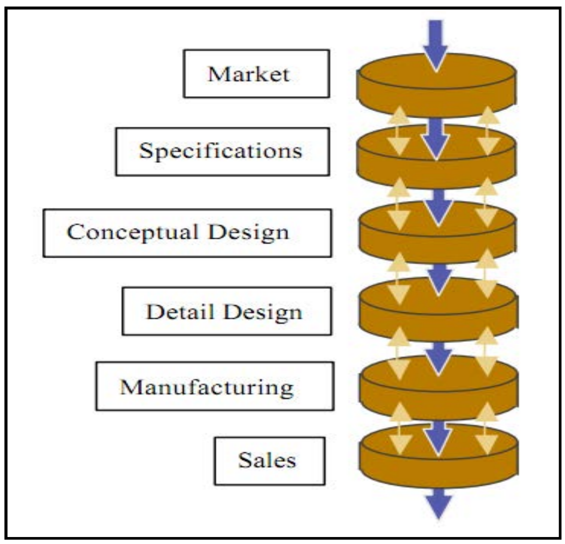

Figure 2.3: Product Design Core (Torres, 2001c)

2.3.1.1 Conceptual design

As stated by Tan (2004), conceptual design represents the sum of all of the subsystems and of the component parts which go to make up the whole system, or equally a subsystem or the components of the design specifications. The conceptual phase of the design core is primarily concerned with the generation of solutions to meet the design