UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EVALUATION AND SENSITIVITY ANALYSIS FOR SELECTING THE BEST DESIGN OF AUTOMOTIVE FENDER USING ANALYTIC HIERARCHY PROCESS (AHP)

By

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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 supervisor is as follow:

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ABSTRAK

Memandangkan keputusan yang tidak sesuai terhadap konsep reka bentuk di peringkat awal pembangunan sentiasa membawa kepada penglibatan kos yang besar dan akhirnya ke arah memacu komponen pra-matang atau kegagalan produk. Projek ini memberi penekanan kepada keputusan serentak menggunakan Proses Hierarki Analisis (AHP) pada peringkat reka bentuk konseptual untuk membantu pereka dalam membuat keputusan yang betul dalam proses pembangunan produk. Pembangunan fender automotif telah dipilih sebagai kajian kes untuk menggambarkan Proses Analisis Hierarki (AHP) kaedah adalah cara terbaik dalam pemilihan konsep reka bentuk yang terbaik. Selain itu, pilihan Expert Choice akan digunakan untuk penilaian dan analisis sensitiviti konsep reka bentuk. Selain itu, pilihan perisian Expert Choice 11.5 digunakan untuk penilaian dan analisis sensitiviti konsep reka bentuk. Untuk menunjukkan rangka kerja pemilihan konsep reka bentuk yang dicadangkan itu, lima konsep reka bentuk yang berbeza telah dipertimbangkan. Keputusan menunjukkan bahawa Design Concept 5, DC5 dengan peratusan keutamaan tertinggi 28.5% adalah reka bentuk fender automotif terbaik berbanding dengan konsep reka bentuk yang lain. Penilaian terakhir konsep reka bentuk yang diperolehi dengan melakukan 4 senario analisis kepekaan dan analisis menunjukkan bahawa terbukti DC5 adalah reka bentuk yang terbaik untuk fender automotif.

ABSTRACT

Considering inappropriate decisions on design concept at the early stage of development always lead to huge cost involvement and ultimately drive towards premature component or product failure. The project emphasize on simultaneous decision using analytical hierarchy process (AHP) at the conceptual design stage to assist designers in making the right decisions during the development process of products. The development of automotive fender was chosen as a case study to depict Analytical Hierarchy Process (AHP) method is the best way in selection the best design concept. AHP is also used to identify the factors that influence the conceptual design. Besides that, Expert choices software is used for evaluation and sensitivity analysis the design concept. To demonstrate the proposed design concept selection framework, five different design concepts were considered. The results revealed that Design Concept 5, DC5 with highest priority percentage 28.5% is the best automotive fender design compared to other design concepts. The final judgment of the design concept is gained by performing 4 scenarios of the sensitivity analysis and the analysis showed that is proven DC5 is the best design for automotive fender.

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LIST OF ABBREVIATIONS

AHP	- Analytical Hierarchy Process
AR	- Aerodynamic
C	- Cost
CI	- Consistency Index
CR	- Consistency Ratio
CS	- Curve Style
CZ	- Crumple zone
DC	- Design Concept
DEA	- Data Envelopment Analysis
EA	- Energy Absorb
FEA	- Finite Element Analysis
FoS	- Factor of Safety
MCDM	- Multi-Criteria Decision Making
MS	- Microsoft
P	- Performance
PDS	- Product Design Specification
QFD	- Quality Function Deployment
RI	- Random Index
S	- Stiffness
SF	- Safety
St	- Stylist

TOPSIS - Technique for Order of Preference by Similarity to Ideal Solution

TRIZZ - Theory of Inventive Problem Solving

W - Weight

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CHAPTER 1

INTRODUCTION

The design methods generated by academia have potential to ensure efficiency in team design and help to improve the designing products result (Eder, 2008). This chapter describes the general ideas of research studies which involve Analytic Hierarchy Process (AHP) method as the main decision tool that a used for evaluating and analysis the best design of automotive fender. Basically, there are four main sections in this chapter which is the project background, problem statement, the research objective and lastly is the research scope. All main sections will be detailed descriptions.

1.1 Background

There are many parts to assemblies in car manufacture. Car body divided into two sections which is exterior and interior. One of exterior part is fender. Fender was invented by Frederick Simms in 1901. It's designed on purpose to dodge mud, sand and other road spray from being thrown into air by spinning tire. So, the criteria in making automotive fender must be evaluated to produce best conceptual design fender.

The Analytic Hierarchy Process (AHP) method was selected as the decision making tool in order to select the best design of automotive fender. This method was developed by Thomas Saaty in 1970. AHP is a decision making system using a mathematical model. AHP supports in determining priority criteria by evaluating multiple pairwise comparisons of each criterion. Besides that, this method is a framework for making decisions on complex issues to ease and accelerate the decision-making process by solving problems into parts, organize these parts, or variables in a hierarchy, members of the numerical value of the consideration subjective importance of each variable and synthesize these considerations to create a variable that has the highest priority and act to give effect to the results of conditions (Hsiao, 2002). Thus, a research in selecting the best design for automotive fender would be discussed in this report.

1.2 Problem Statement

The best conceptual design automotive fender is important to produce quality product. The conceptual design selection in car body panel requires specification in order to fulfill the customer needs and production line requirement. It's a difficult task to determine the most optimum decisions on conceptual design. It is because many factors much be considerate in selection process. Inaccurate decision of selection design in product may cause redesigned the product.

Automotive fender deliberately designed soft because it is not important car body panel when it comes to collisions. Actually, it is particularly important when it comes to front collision. Strong fender design structure can ensure the safety of the driver and increase the safety features in the car. Besides that, the fender should also be designed with the ability to absorb the shock when the collision occurred. Fender also should be designed to increase the aerodynamic car.

1.3 Objective

The primary objective of this study is to determine the best automotive fender using Analytic Hierarchy Process. The specific objectives are:

a. Identify the factors that influence the conceptual design.
b. To conduct sensitivity analysis for verify the selection process using expert choice.

1.4 Scope of project

This project focuses in development of design process at the conceptual design for automotive fender, determine the most optimum decision on conceptual design by using Analytic Hierarchy Process (AHP), analyze the stress distribution, displacement and factor of safety conceptual design by using Solidwork 2011 and analyze the sensitivity by using Expert Choice.

CHAPTER 2

LITERATURE REVIEW

This chapter provides the preliminary reviews for the research method of fender making approach. The literature review was clarified sustainability associated this research study. The method has been selected as the decision method in an attempt to select the best design of automotive fender is Analytic Hierarchy Process (AHP). Besides that, clear explanations of automotive fender in evaluation and sensitivity criteria analysis for selecting the best design are clearly discussed throughout this chapter.

2.1 History of Automotive Fender

In 1901, Frederick Simms invented the first automotive fender (Heacock, 2014). Automotive fender is designed on purpose to avoid mud, sand and other road spray from being thrown into air by spinning tire. In 1900s, automotive fender designs becoming more than length and width with many curving all the way down to the frame. Figure 2.1 show the example of fender in 1900s.

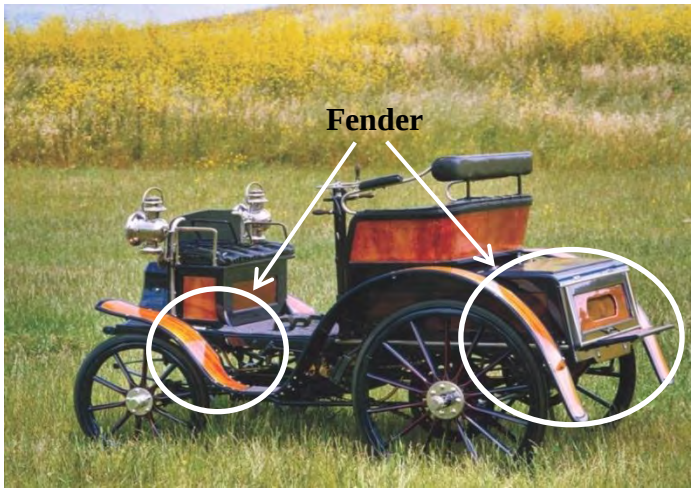

Figure 2.1: example first automotive car fender with long and width design (Heacock, 2014).

After that, the front and rear automotive fender and designed following to frame line. This design became preferred style for more formal cars in early 1900s. By the 1910s just about every car built in America and Europe had some form of fender designed following the body frame.

About in 1920s, American manufacturer had achieved a near equal level of engineering refinement and reliability in their products but the fender, running board and mudguards are separate components and all very much the same in appearance. According to Harley Earl, if the front fender rearward and added a recess at the bottom, the spare tire mount can be added. So, in 1927 Harley Earl brought style sweeping fender lines and side-mount spares spread to the entire Cadillac line. Example of fender designed by Harley Earl depicts in Figure 2.2.

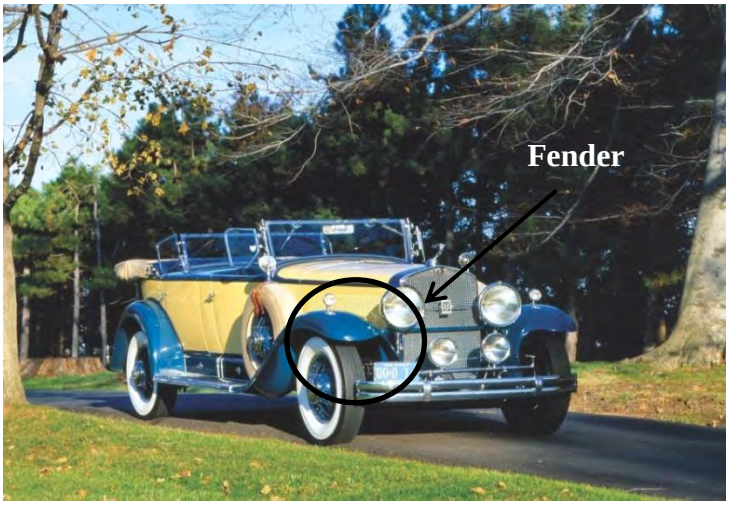

Figure 2.2: Cadillac V8 Phaeton is the first car that designed sweeping fender lines and side-mount spares spread (Heacock, 2014).

About in 1933s, Earl and Cadillac introducing the pontoon fender with the original fender has been redesigned it skirted fender. Pontoon fender is the ultimately the precursor of modern automotive styling. Pontoon fender are designed more width and uninterrupted length of a car. From this design, the developer car can reduce the weight of the car. Figure 2.3 depicts the example of Pontoon fender.

Figure 2.3: Renault Frigate one of example car using pontoon fender after the introduction from Earl and Cadillac (Heacock, 2014).

2.2 Fender Process Development

Usually automotive fender made up from sheet metal. There are four main manufacturing process of automotive fender. Figure 2.4 shows the steps of automotive fender manufacturing process.

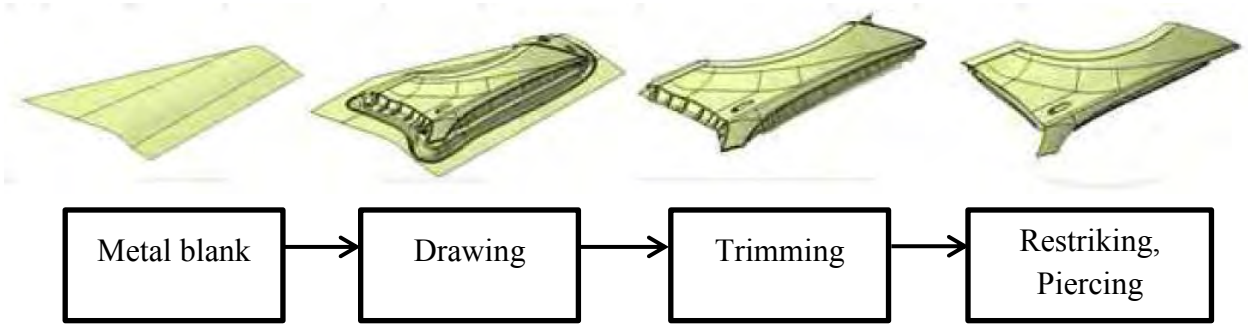

Figure 2.4: Automotive fender manufacturing process (You et al., 2011)

The first operation in automotive fender manufacturing is drawing. The metal blank is drawn without wrinkles or cracks. The second operation is trimming. The sheet metal cut into fitting size and shape with using trimming mold. The most essential factor in this operation is trim cutter and scrap cutter position in a combination that empowers sheet metal scrap to consequently drop and be removed after trimming. In third operation, the sheet metal is formed into a desired shape also known as restriking. This activity refers to folding at any angle and is normally determined by a cam for wide areas. The last operation is piercing. When restriking had done, the position of a hole can move or gap shape can deform during shaping (You et al., 2011).

2.3 Suitable Criteria for Automotive Fender

Just through from design can attract people to buy the product. It proves that the design is the most important process that should be on every product. Design presents your public image and dictates perceptions.

Most modern automotive fenders are designed aerodynamic. Today, automotive fenders are designed to be light, strong and unhurt passenger. The selection for the best design for automotive fender depends on some following factors:

2.3.1 Safety

The scale of deaths due to accidents is increasing every year, it is important to design safety in automotive fender. In order to have safe automotive fender, these are suitable sub-criteria for safety.

i. Energy absorb

Car accidents can bring extreme injuries to the vehicle users. In road cars (passenger cars) for occurrence, side effects are regular and regularly bring about extremely harmful crashes (Fildes et al., 2003; Fildes, 2005). Worldwide mischance insights demonstrate that side effects represent more or less 30% of all impacts and 35% of total fatalities (source: German In Depth Accident Study-GIDAS, National Automotive Sampling System-NASS & BMW mishap database) (Mcneill & Haberl, 2005).

Side impacts likewise require more attention in that there is significantly less crash zone for absorbing energy in the side of the cars compared to the front and rear structures (Strother et al., 1998), and will cause the cars user sit almost within the crash zone with always causes critical injuries (Wang et al., 2005).

Front cars are susceptible to collision during driving. The potential collision more present in high speed driving. In that respect, it is therefore necessary to design the absorb energy automotive fender to reduce the risk of injury to the occupants. So, automotive fender build with absorb energy is good to reduce the high impact collision.

ii. Crumple zone

Crumple zone also known as crush space is a structural feature mainly used in automobiles design. It's designed for purpose to absorb the energy from the impact during car collision. According to a British Motor Insurance repair Research Centre study, mostly vehicle impact occurs 65% were front impacts, 25% rear impacts and 10% side impacts. It depicts that front part automotive have an important role to serve as crumple zone and enable it to absorb energy. This project more focuses on designing crumple zone in automotive fender (Raiciu, 2009).

According to Newton's first law, object that in motion will stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force. In this manner, if a vehicle is traveling at for instance, 70km/h then so is everything and everybody inside the vehicle. If the car is to suddenly stop so residents will continue moving at 70km/h up to something that prevents them. In a collision thing that will stop them is a bit of rigid car. As there is no "give" in the bit of car that hit the stopping time is very short so the force is very large and this can be fatal. By the crumple zone criteria designed in automotive fender, it can help minimize the effect of a collision on the occupants of a vehicle. Decelerations are applied to the passenger compartment will the crumple zone in a car increase the time.