

DESIGN AND ANALYSIS COMPOSITE CAR BUMPER USING CAD AND CAE

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## ABSTRACT

The front-end of car bumper or known as fascia car bumper is a cover for the car frame. This fascia bumper really important in automotive manufacturing industry based on the safety, aesthetical pleasant and protection for the car's chasis. One of the inevitable consequences of the use of automobiles is that from time to time accidents will cause damage to a vehicle's body. Over the years, many new materials have been introduced to the car body. This report presents the findings on the design and analysis on the types of composite materials that can be sustained under maximum impact using Abaqus CAE software. There are three types of composite materials of fascia car bumper which will be introduced in this study. They are ThermoPlastic Olefin (TPO), Polyphenylene Oxide (PP0) and Carbon Fiber Reinforced. These three types of composite materials widely used in automotive industry. TPO is a polymer-based composite. Hence, TPO can consider as the best material for bumper fascia. Based on the mixture of TPO, it's consisting of some fraction of PP (polypropylene), PE (polyethylene), BCPP (block copolymer polypropylene), rubber, and reinforcing filler. The result of the study shows that the best material to replace the existing material for Proton Wira's bumper is Carbon Fiber Reinforced. This is due to the highest value of stress which is  $1.112 \times 10^9$  Pa.

## ABSTRAK

Bahagian depan bumper kereta atau dikenali sebagai fasia bumper kereta adalah bahagian untuk meliputi bahagian hadapan bingkai kereta. Penyerap fasia ini sangat penting dalam industri pengeluaran automotif berdasarkan pada keselamatan, nilai estetika dan perlindungan untuk chasis kereta. Salah satu sebab yang tidak dapat dielakkan ketika penggunaan kereta adalah kerosakkan dan kehilangan badan kenderaan. Sejak bertahun-tahun, bahan-bahan baru banyak telah diperkenalkan untuk badan kereta. Di dalam laporan ini, memaparkan kajian tentang rekabentuk dan analisis bumper kereta komposit yang mampu menampung impak maksimum dengan menggunakan perisian *Abaqus CAE*. Terdapat tiga jenis bahan komposit bumper kereta yang akan diperkenalkan dalam kajian ini. Bahan – bahan ini ialah *ThermoPlastic Olefin (TPO)*, *Oksida Polyphenylene (PP0)* dan *Carbon Fibre Reinforced*. Tiga jenis bahan komposit ini digunakan secara meluas di dalam industri automotif. TPO adalah komposit yang berdasarkan bahan polymer. Oleh itu, TPO merupakan bahan komposit yang terbaik dalam pembuatan bumper kereta berdasarkan pada campuran bahan TPO yang mengandungi PP (*polypropylene*), PE (*polyethylene*), BCPP (*block copolymer polypropylene*), *rubber*, dan *reinforcing filler*. Daripada hasil kajian, bahan komposit yang terbaik untuk menggantikan TPO adalah *Carbon Fiber Reinforced*. Ini adalah berdasarkan dari hasil analisis yang menunjukkan ia mempunyai nilai tegasan yang tertinggi iaitu  $1.112 \times 10^9$  Pa.

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**ABBREVIATIONS**

TPO	=	Thermoplastic Olefins
PP	=	Polypropylene
PE	=	Polyethylene
BCPP	=	Block Copolymer Polypropylene
MOS	=	Metal Oxy Sulfate
EPR	=	Ethylene-Propylene Rubber
EPDM	=	EP-Diene rubber
EO	=	Ethylene-Octene
EB	=	Ethylene-Butadiene
SEBS	=	Styrene-Ethylene-Butadiene-Styrene
TPR	=	ThermoPlastic Rubber
UV	=	Ultraviolet

PPO	=	Polyphenylene Oxide
CFRP	=	Carbon Fiber Reinforced Plastic
GFRP	=	Graphite Fiber Reinforced Plastic
APME	=	The Association of Plastics Manufacturers in Europe
CATI	=	<i>Conception Assistée Tridimensionnelle Interactive</i>
CAD	=	Computer Aided Design
CAE	=	Computer Aided Engineering
CAM	=	Computer Aided Manufacturing
FMS	=	CATIA FEM Surface 2
KJ	=	kilo Joule
ISO	=	International Organization for Standardization
ASTM	=	American Society for Testing and Materials

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

One of the inevitable consequences of the use of automobiles is that from time to time accidents will cause damage to a vehicle's body. Over the years, many new materials have been introduced to the car body. Composite car bumper also implied the same problem which the material will be discussed further in this project.

A car bumper is a front part of the car that covers the car's chassis. The cover of the car bumper called fascia. An automobile's bumper is the front-most or rear-most part, ostensibly designed to allow the car to sustain an impact without damage to the vehicle's frame or safety systems, but it will not withstand damage to high speed impacts. While bumpers were originally constructed of heavy steel and held clear from the bodywork, they have evolved into light-weight structures of thermo-plastic or painted light metal, leaving them susceptible to damage from even light contact.

As known, steel has been the dominant material for vehicles bodies. However, the front of car bumper that known as fascia is made by thermoplastic which the light composite that suit for the commercial front bumper (Ramin Hosseinzadeh et. al. 2004). The bumper fascia's function is to protect and cover the bumper beam that connected to the car's frame. Even it could prevent a small damage for the car, the front bumper important as an aesthetical value. Polymer-based composite are the best materials for

bumper fascia which are aesthetically pleasant, lighter weight and offer many more substantial advantages (S.M Sapuan et al 2,004).

## **1.2 Objectives**

The objectives of this project are:

- (a) To design a composite car bumper by using CAD CATIA or AutoCad.
- (b) To perform an impact analysis of composite car bumper by using CAE Abaqus Software.
- (c) To propose a suitable composite material for the car bumper.

## **1.3 Scope of the research.**

This project has been confined to five relatively simple aspects which they are:

- (a) Literature study on composite car bumper (the fascia bumper)
- (b) Implementing knowledge of CAD software (CATIA) in design.
- (c) Learning and exploring in a way to use CAE software (Abaqus).
- (d) Perform an impact analysis of bumper material by using CAE software.
- (e) Purposing a suitable composite material for commercial front bumper.

#### **1.4 Problem Statement**

Car bumper is very important in keep the passenger safe and also to keep car's frame from damage when impact occurs. Most of the deaths that were caused by car accident are heading the newspaper nowadays. The reason should be come from the car body's quality and the material that has been used to made it. In most cases, the front car usually is badly damage when an accident occurs. So that, the bumper playing a big role to prevent more critical damage of the car. Thus, research is going to be done on one of the element which is the composite of car bumper. Nowadays, people faced that the front car bumper easily broken even in a small crash. This problem based on the material that has been used to make this bumper. The types of material play a big role to influence the front car bumper condition after crashing. In term of high strength and lightweight, aluminium alloy is preferable; however because of expensive price of aluminium alloy, car's manufactures ignore this type of material. In short, this study discussed material type that best suit to be a composite car bumper in order to fulfill the aspect of strength, lightweight, and impact absorption.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.0 Introduction

Based on the previous research, S.M Sapuan et. al. (2004), stated that a conceptual design had been approached towards the development of composite car bumper system. The composite material of the front car bumper stated to determine the suitable composite car bumper. The evaluation of conceptual design for bumper fascia is carried out using weighted objective method and highest utility value is appeared to be the best design concept for the generation.

The composite car bumper depends on the car manufactured based on its model. The most common composite that has been used in manufactured this front bumper is Polymer-based composites, ThermoPlastic Olifen, and Carbon Fibre Reinforced for the custom design. Thus, a research is going to be done on composite material to replace the existing composite and also the design of the fascia bumper.

The design parameters such as the aesthetical value, aerodynamic and the body shape were determined in this research. It was found that the design of the fascia car bumper will be influenced the efficiency of the car bumper. For example for the aesthetical value of the bumper will be attracted customer to buy the bumper and make the car in a high level rated. The design of aerodynamic should be considered because its will affected the flow of velocities of the car.

Other than that, Ramin Hosseinzadeh et. al. (2004), study on parametric research of automotive composite bumper beams subjected to low-velocity impacts found that fuel efficiency and emission gas regulations are the main causes for reducing the weight of passengers' cars by using composite structures. So that could determine that the design and the composite will probably the best combination to produce an effective bumper.

## **2.1 Car Bumper**

The car bumper is designed to prevent or reduce physical damage to the front and rear ends of passenger motor vehicles in low-speed collisions. Automobile bumpers are not typically designed to be structural components that would significantly contribute to vehicle crashworthiness or occupant protection during front or rear collisions. It is not a safety feature intended to prevent or mitigate injury severity to occupants in the passenger cars. Bumpers are designed to protect the hood, trunk, grille, fuel, exhaust and cooling system as well as safety related equipment such as parking lights, headlamps and taillights in low speed collisions.

Car bumper is one of the most important parts in car body. Bumper is the front-most part. In USA front bumper was called Fascia Bumper. However in British English Fascia is its instrument panel and dashboard area - what lies in front of the driver and front-seat passenger. It is used primarily in enthusiast and specialist circles (Car Bumper – [www.nhtsa.dot.gov](http://www.nhtsa.dot.gov)).



**Figure 2.1** Example of bumper fascia, highlighted in red.  
(Source: [http://en.wikipedia.org/wiki/Bumper\\_\(automobile\)](http://en.wikipedia.org/wiki/Bumper_(automobile))))

Figure 2.1 shows the example of car bumper of BMW model. A bumper highlighted in red.

Fascia area is possibly the most critical in defining a car's identifiable look, and is also the easiest to restyle when a car's styling needs to be refreshed. Again, this word is mostly being used by the auto trade and automotive journalist. The term fascia is also used to describe the rear of the vehicle. The total of the front and rear fascias can make up a fourth of the exterior of the vehicle. Furthermore, the fascia is used to describe the single panel that conceals the bumper, front or rear, and ties the bumper element visually with the sides of the vehicle - often including an inlet for cooling.

There are several types of fascia bumper in a market nowadays especially in our country's market. What makes it different are their design, type of composite material and its cost. Thus, the types of composite material will be discussed with further in this project ([http://en.wikipedia.org/wiki/Bumper\\_\(automobile\)](http://en.wikipedia.org/wiki/Bumper_(automobile))).