IMPACT TEST SIMULATION WITH DIFFERENT VELOCITY USING FEA FOR BUMPER CAR

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering

(Structure and Material)(Hons.)

By

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DECLARATION

I hereby, declared this report entitled “Impact Test Simulation with Different Velocity Using FEA for Bumper Car” is the results of my own research except as cited in references.

Signature : ……..

Author’s Name : SYED HAFIZ IFWAT BIN WAN KASSIM

Date : ……..

APPROVAL

This report is submitted to the Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering (Structure and Material) (Hons.). The member of the supervisory is as follow:

…….

(MOHD BASRI BIN ALI)

ABSTRAK

Projek ini adalah mengenai simulasi ujian hentaman dengan had laju berbeza dengan menggunakan analisis unsur terhingga untuk bampar kereta. Apabila menjalankan simulasi untuk projek ini, terdapat tiga objektif untuk dicapai. Objektif yang pertama ialah untuk menentukan tenaga yang diserap dengan had laju yang berbeza dan saiz mesh yang berlainan. Objektif yang kedua ialah untuk mengaitkan hubungan antara tenaga yang diserap dengan had laju yang berbeza dan saiz mesh yang berlainan. Objektif yang terakhir untuk dicapai ialah membandingkan keputusan yang diperolehi daripada simulasi dengan kajian yang telah dijalankan sebelum ini. Tambahan pula, pernyataan masalah utama di dalam projek ini ialah untuk mengkaji tenaga yang diserap yang mempunyai kaitan dengan had laju yang berbeza dan saiz mesh yang berlainan untuk meningkatkan prestasi bampar kereta semasa berlakunya perlanggaran sebenar. Bahagian kritikal di dalam projek ini adalah system hentaman dan system bampar. Oleh itu, arah dan lokasi pemasangan untuk kedua – dua bahagian mestilah dilakukan dengan betul untuk mengelakkan daripada memperolehi keputusan yang tidak tepat. Keseluruhan projek ini dilakukan dengan menggunakan perisian Abaqus. Apabila keputusan telah diperolehi, graf daya tindak balas menentang anjakan dan graf tenaga kinetik serta tenaga dalaman menentang masa diplotkan. Setelah selesai memplot graf daya tindak balas menentang anjakan, ruang di bawah graf telah dikira untuk mencari jumlah tenaga yang diserap dengan menggunakan perisian Origin 8.0. Daripada keputusan yang diperolehi, apabila saiz mesh yang digunakan semakin besar, maka nilai daya tindak balas dan tneaga yang diserap akan berkurang Pendekatan teori dan pembandingan dengan kajian yang telah dijalankan juga dilakukan. Ia telah ditunjukkan bahawa keputusan simulasi mempunyai trend garisan graf yang sama seperti kajian yang telah dijalankan sebelum ini. Oleh itu, terbukti bahawa kesemua keputusan berkait rapat antara satu sama lain. Akhirnya, komposit serat karbon, T300/5208 telah dicadangkan sebagai bahan untuk kajian masa depan.

ABSTRACT

This project is about the impact test simulation with different velocity using finite element analysis (FEA) for bumper car. When carrying out the simulation for this project, there are three objectives to be achieved. The first objective is to determine the energy absorbed with different velocity and meshing sizes. Secondly, to correlate the energy absorbed with different velocity and different meshing sizes. Meanwhile, the final objective to be achieved is to compare the simulation results with previous studies. Furthermore, the main problem statement in this project is to study the energy absorption related to different velocities and different meshing sizes to improve the performance of bumper systems during actual collisions. The critical parts involved in this project are the impactor and the bumper system. Hence, the direction and location for each parts during assembly must be correct to avoid obtaining inaccurate results. The entire simulation for impact test is conducted by using the Abaqus software. When results are obtained, graphs of reaction forces against displacement and kinetic energy with internal energy against time are plotted. After plotting the graph for reaction force against time, the area under the graph was calculated in order to obtain the total energy absorbed for the entire simulation by using the software Origin 8.0. Through the results obtained, as the meshing size applied increases, reaction force and energy absorbed decreases. Theoretical approach and comparison with previous studies were also conducted. It was shown that the simulation results have the same graph line trends as the previously conducted studies in terms of reaction force against displacement and energy graphs. Thus, this proves that the results correlates well with each other. Finally, carbon fibre composite, T300/5208 was recommended as a material for future studies as composite materials are gaining more attention in automobiles application.

DEDICATION

To my beloved father,

Wan Kassim Bin Haji Tuanku Taibu,

My beloved mother,

Normardiah Binti Mohd Musa,

My precious sisters,

Sharifah Zalikha Izzati Binti Wan Kassim, Sharifah Athirah Izyan Binti Wan Kassim,

And my dearest brother,

Syed Haziq Iqbal Bin Wan Kassim.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBEREVATIONS

NHTSA	National Highway Traffic Safety Administration
PP	Polypropylene
3D	Three Dimension
ECE	Economic Commission for Europe
OEM	Original Equipment Manufacturer
RCAR	Research Council for Automobile Repair
NCAP	New Car Assessment Program
IIHS	Insurance Institute for Highway Safety
FEA	Finite Element Analysis
CATIA	Computer Aided Three-Dimensional Interactive Application

LIST OF SYMBOLS

W	Work
F	Force
d	Distance
E_k	Kinetic Energy
m	Translational Inertia
v	Velocity
v_i	Initial Velocity
v_f	Final Velocity
$\overline{X}$	Sample Mean or Average
$\sum X_s$	Sum of All The Variables
N	Total Number of Values Being Summed

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The vehicle bumper system, which includes the front and rear parts are designed to have the ability to resist impact during a collision without resulting damage to other components and safety systems that the vehicle owns. However, the existing designs of bumper systems are not capable of fully reducing injury towards the passengers during high speed impact collision. The United States National Highway Traffic Safety Administration (NHTSA) released the first regulation for vehicle bumpers in the year 1971. Federal Motor Vehicle Safety Standard No. 215 (FMVSS 215), "Exterior Protection" standard forbids functional damage towards specified safety related components when the vehicle is put through a barrier crash test at 8 km/h for front bumper systems and 4 km/h for rear bumper systems. Furthermore, the standards were upgraded in the year 1974, which requires the ability to resist damage from impacts at angles with speeds at 8 km/h for vehicles with standardized height of the front and rear bumpers (Ayyappa et al., 2014).

The aim of an automobile bumper subsystem located at the front and rear of a vehicle is energy absorption during low velocity impact. A bumper subsystem basically consists of bumper transverse beam, stays, impact absorbing materials connected to the structural components and a cover. However, among the structural components, the bumper beam is the most important (Beyene et al., 2014). This is due to its ability to absorb the low impact energy by bending resistance. (Wang and Li, 2015).

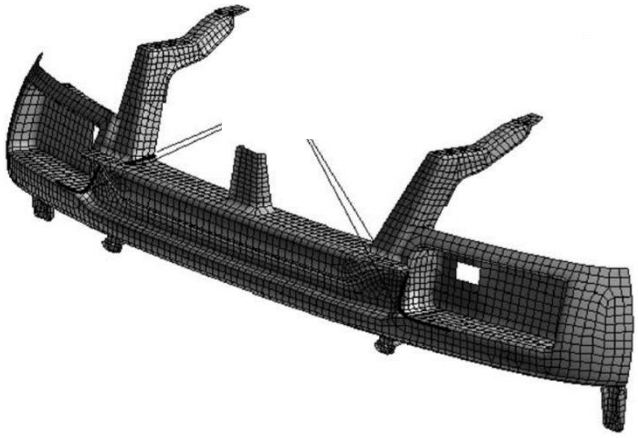

Figure 1.1: Example of a Car Bumper

During a collision, the bumper is the first component to collide with a pedestrian. According to statistics, more than a third of 1.2 million people were killed and 10 million were injured annually in road traffic crashed worldwide are pedestrian (Davoodi et al., 2007). This issue raises awareness for public health, trauma medicine and traffic safety professionals.

According to a study conducted by Richards (2010), speed of a moving vehicle is one of the top contributors towards road traffic accidents. In terms of pedestrian road accidents, the change in velocity of vehicles are closely related with the severity of injury that the pedestrian experience. Based on the datasets acquired, risk for fatalities to occur increases with impact speeds around 48 km/h. Furthermore, when the impact speed increases towards 64 km/h, the probability of pedestrian fatalities to occur increases up to between 3.5 and 5.5 times.

However, light-weight design has obtained more attention from automotive industries due to the need of energy conservation and environmental protection. In order to satisfy the following requirements, the best method taken is material replacement. Other methods such as structural optimization and advanced manufacturing technology is deemed less efficient when compared to material replacement method (Liu et al., 2016).

When integrating light-weight designs and improving the crashworthiness of vehicle safety components, composite materials were implemented during the manufacturing of bumpers. Composite materials possess high specific strength, high specific stiffness and high energy absorption capabilities (Liu et al., 2016). Compared to conventional materials such as steel and aluminium, composite materials showed equal strength and rigidity, reduction of total material used, ease of manufacturing and reduction in production cost (Hosseinzadeh et al., 2004).

Meanwhile, the ability of the bumper system to absorb energy is a crucial factor in determining the level of safety for the passengers. Vehicles with lighter overall weight are preferred by the costumers due to its fuel consumption when compared to heavier vehicles. However, lightweight vehicles cannot provide much safety for the passengers under impact conditions. Therefore, manufacturers are designing vehicles with deformable structures with crumple zones in order to increase the capability to absorb kinetic energy through plastic deformation during a frontal collision incident (Chotika et al., 2011).

1.2 Problem Statement

Bumper beams are both attached to the front and rear end of vehicles plays an important role in absorbing energy. During a crash, bumper beams acts as crash-boxes which receives loads mainly in axial direction. The amount of energy absorbed by the bumper beams determines the damage applied to other parts of the vehicle and risk of injuries to the passengers. Hence, designs of bumper beams are very crucial for improving its effectiveness to absorb energy, which is also known as crashworthiness (Niyazi et al., 2015).

Speed plays an important factor during a crash. When a vehicle is travelling at high speeds crashes, the passenger will undergo a high speed collision which leads to more severe injuries or even death. When two vehicles with the same mass but different speed experiences a crash, the higher speed vehicle will possess a bigger inertia. Hence, require a larger energy absorption capability from the bumper beam in order to protect the passengers (Elvik, 2009).

According to Fang et al. (2005), a crash simulation and assessment of its corresponding parameters are achievable with the help of finite element analysis (FEA). This is due to the programs which were configured specifically for dynamic contact problems. Moreover, crashworthiness characteristics of a vehicle structure can be modified and further optimized by combining simulation tools with non-linear mathematical programming methods. From the previous researches, it is shown that the study of energy absorption related to velocity is important in order to improve the vehicle performance and total manufacturing cost.

Furthermore, when conducting a simulation or analysis, size of meshing (mesh density) used is a critical factor. This is because the size of meshing directly determines the accuracy of the simulation results and the computing time. Generally, models with finer mesh (small element size) provides a higher accuracy in its result but longer computing time, whereas a coarse mesh (large element size) provides less accurate results but a shorter computing time (Shashikant et al., 2015). The study of energy absorption related to different velocities and effect of meshing size is important to improve the current performance of bumper systems during crashes.

1.3 Objectives

This project focuses on impact test simulation with different velocities using finite element analysis (FEA) for car bumper. The objectives of this project are as follows:

i. To determine the energy absorbed with different velocity and meshing size.
ii. To correlate the energy absorbed with different velocity and different meshing size.
iii. To compare the result with previous studies.