

STRESS ANALYSIS ON FRONT CAR BUMPER

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive.

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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**Dedicated to my beloved parents, family, and
friends..**

**Thank you for all your support, ideas, and
cooperation..**

All of you always in my heart forever..

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First of all, I would like to express my grateful to ALLAH s.w.t. for the blessing given to me to complete my project.

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ABSTRACT

The project focuses on the stress analysis of a car frontal protection system (bumper) simulations. To achieve that, we go to basic concepts of improving the safety on the car by do analysis the car bumper. It is important to know their mechanical properties, how their failure mechanism during the impact. This analysis was carrying out by using commercial Finite Elements software (ALGOR) to evaluate the behavior of bumper system. Another additional innovative for improving crashworthiness is the use of material to produces the part to absorb energy during the process of a crash. Research concentrates on polymer composite material. It is considering their function, geometry, and other parameters that influence the compatibility of the bumper. In future research, this bumper will face the static test and analyses do on their load distributions by applying the variation of load and locations. Result will be compare for the centre and side load. How the load applied effect the stress distrubution. After that a related study was carried out to know bumper properties during the impact.

ABSTRAK

Projek ini menumpukan pada analisis simulasi tegasan sebuah kereta terhadap sistem perlindungan hadapan (bamper). Untuk mencapai matlamat itu, tumpuan diberikan kepada konsep asas memperbaiki ciri keselamatan sebuah kereta dengan menjalankan analisis terhadap bamper kereta. Adalah sangat penting mengetahui sifat mekanikal bahan tersebut, macam mana mekanisme kehancuran semasa perlanggaran. Analisis ini dijalankan menggunakan software yang digunakan ramai dalam industri iaitu ALGOR. Selain pengubahsuaian tambahan untuk mengurangkan tekanan adalah menggunakan bahan yang menyerap tenaga semasa perlanggaran. Penyelidikan ini tertumpu terhadap polymer composite. Ia termasuk fungsi, geometry dan sebab-sebab lain yang mempengaruhi ketahanan sebuah bamper. Perbandingan keputusan akan dibuat untuk beban tengah dengan beban tepi. Bagaimana beban mempengaruhi taburan tekanan. Pembelajaran seterusnya dijalankan untuk mengetahui ciri-ciri bamper semasa perlanggaran. Seterusnya bamper akan mengalami ujian statik sama ada beban tersebar kesemua bahagian dengan meletakkan variasi beban dan lokasi yang berbeza.

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LIST OF SYMBOL**No. of Symbol**

- | | |
|------------------|---------------------------|
| 1. N | Newton |
| 2. % | Percent |
| 3. K | Kelvin |
| 4. σ | Stress |
| 5. I | Section Moment of Inertia |
| 6. S | Section Modulus |
| 7. ε | Error |

LIST OF ABBREVIATIONS

<i>EPP</i>	Expanded Polypropylene
<i>FEA</i>	Finite Element Analysis
<i>DOE</i>	Design of Experiment
<i>DOF</i>	Degree of Freedom
<i>CFRP</i>	Carbon-fibre reinforced polymer composites
<i>FYP</i>	Final Year Project

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Nowadays, in development of technology especially in engineering field make among the engineers more creative and competitive in designing or creating new product. They must be precise and showing careful attentions on what they produce. Here, we concentrate on automotive industry. The greatest demand facing the automotive industry has been to provide safer vehicles with high fuel efficiency at minimum cost. Current automotive vehicle structures have one fundamental handicap, a short crumple zone for crash energy absorption

One of the options to reduce energy consumption is weight reduction. However, the designer should be aware that in order to reduce the weight, the safety of the car passenger must not be sacrificed. A new invention in technology material was introduced with polymeric based composite materials, which offer high specific stiffness, low weight, corrosion free, and ability to produce complex shapes, high specific strength, and high impact energy absorption [1].

Substitution of polymeric based composite material in car components was successfully implemented in the quest for fuel and weight reduction. Among the components in the automotive industry substituted by polymeric based composite materials are the bumper beam, bumper fascia, spoiler, connecting rod, pedal box system, and door inner panel. The bumper system consists of three main components, namely bumper beam, fascia and energy absorber.

The automotive body is one of the critical subsystems of an automobile, and it carries out multiple functions. It should hold the parts of the vehicle together and serve to filter noise and vibration. Additionally, it should be able to protect its occupants when accidents happen. To do this, the automotive body designer should create a structure with significant levels of strength, stiffness, and energy absorption [2, 3].



Figure 1: Based composite material bumper Proton Pesona (source: mudah.com)

1.2 BUMPER DESIGN FOR VEHICLE SAFETY

Because of these limitations, the fatality rate increases dramatically in high speed impacts. In order to design a successful lightweight vehicle and significantly improve the crash performance of current cars, technological development is still needed. If the automotive body could extend its front end during or right before a crash, the mechanism of absorbing the crash energy would be totally different from that of the passive structure.

During a frontal crash, the front side member is expected to fold progressively, so as to absorb more energy and to ensure enough passenger space. To do so, various cross sections and shapes have been investigated for the front rail of the automotive body to maximize crashworthiness and weight efficiency; their design included reinforcing the cross-section.

For several decades, bumper design has focused on material and structure. Andersson et al. (2002) [5] investigated the applicability of stainless steel for crash-absorbing bumpers to increase crash performance in automotive vehicles. Butler (2002) [6] studied the design of efficient epoxy structural foam reinforcements to increase the energy absorbed in front and rear automotive bumper beams. Carley (2004) [7] introduced Expanded Polypropylene (EPP) foam technologies and techniques for bumper systems. Cheon et al. (1995) [8] developed a new composite bumper that has two pads at each end of the bumper. Evans and Morgan (1999) [9] studied thermoplastic energy absorbers for bumpers.

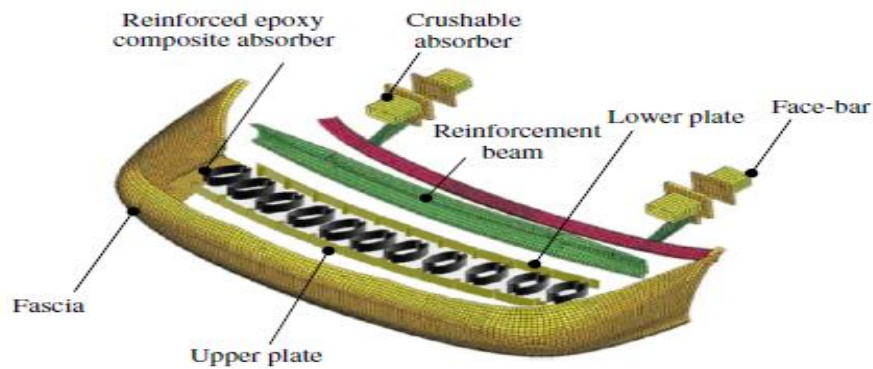


Figure 2: Automotive bumper system component (source: Neopolen, 2006) [20]

Today, what is interesting related of this research is now an innovative inflatable bumper concept, called the “I-bumper,” is developed in this research for improved crashworthiness and safety of military and commercial vehicles. The developed I-bumper has several active structural components, including a morphing mechanism, a movable bumper, two explosive airbags, and a morphing lattice structure with a locking mechanism that provides desired rigidity and energy absorption capability during a collision [4]. Another additional innovative means for improving crashworthiness is the use of tubes filled with a granular material to absorb energy during the process of a crash.

1.3 MATERIAL PROPERTIES

The common use of the term stress analysis includes any kind of structural analysis. In the field of thermoplastics design, there is a growing awareness of the importance of stress analysis. In many years, plastics have been used for applications in load-bearing structural components in the automotive, aerospace, sporting, and construction industries. Hence, design engineers are

increasingly concerned about stress-related problems, typically with the strength, stiffness and life expectancy of their products [10]. About many years ago, these problems were primarily associated with the metallic components. Stress analysis has always been interdisciplinary, because an effective analysis needs to bring together a thorough knowledge of the operating characteristic of the product, material behavior, structural behavior and solid mechanics. Structural plastics design is a field that is evolving in the same manner as did the aero-space and nuclear power industries. That is, a sequence of products innovations, and better methods of design and analysis continuously reinforce each other and lead to the optimum design of the product. Stress analysis is a vital activity in this process.

From the point of view of stress analysis, are the thermoplastics very different from metals? The answer is yes and no. Yes, because a few types of behaviors of thermoplastic materials call for advanced techniques of analysis, because such behaviors are encountered only in special applications of metals.

No, because several calculations and test procedures for characterizing the mechanical properties of thermoplastics are very similar to those of metals. Thus such stress analysis is also similar. Material properties of plastics such as elastic modulus, yield point, tensile strength and fracture toughness are understood, measured and used in a manner similar to those for metals. Many structural plastics design may be performed using the familiar strength of material approach. Likewise detailed stress analyses of plastic components are performed assuming linear elastic behavior [11].

1.4 PROBLEM STATEMENT

From the previous research or analysis on car bumper, basically they focus on the design and crashworthiness optimization. However, for this analysis just focusing on the stress analysis on car bumper by applying various loads on the static condition only. In the real situation, there is much point that bumper mounting to the car which make it stronger or can absorb more energy during the impact. For the simulation, just take fixed point both end of the bumper. Only the fascia part of the bumper will take into account.

1.5 OBJECTIVES AND SCOPES

- a) To analyze the mechanical properties on front part (fascia) of car bumper:
 - i. To analyze on mechanical properties focus on stress analysis
 - ii. To modeling the actual dimension of the car bumper into the SolidWork software and analyze by using FE software (ALGOR).
 - iii. To investigate polymer composite material bumper (Proton Pesona) based on their geometry and other parameters that influence the compatibility of car bumper.

- b) To evaluate failure mechanism of the car bumper:
 - i. To study the load distribution on the bumper either it is uniformly distributes to all the part during the analysis.
 - ii. To predict the critical point.

CHAPTER 2

LITERATURE REVIEW

2.1 PARAMETER CONSIDERED

Basically in car collisions, most of energy is dissipated by body deformation. But the things is depending on the type of collision, members are loaded axially and by bending or a combination all of that. Axially loaded members will normally dissipate a substantial part of the energy during a front collision. Some energy may be observed for such members, which normally collapse by folding and bending of the plate elements composing the component. Small variation in geometry, material properties as well as boundary and loading conditions can produce this scatter in the result. We will analysis how this parameter can effect and to reduce energy dissipation and thus to prevent more damage during the collision [5].

Engineers today emphasize robust behavior of the energy-dissipating structure. So they must very wall in decide the variation in the material, geometry, loading and boundary conditions. Hence, the automotive industry uses finite element analysis in order to reduce the lead time to develop a new product and cost.

Research from the American Iron and Steel Institute on bumper compatibility stated that the difference in heights and weights between these two types of vehicles (and indeed average-sized cars and trucks) creates an advantage for the heavier and/or taller vehicle when in a collision. A bumper is designed to absorb the energy of a low speed impact with another vehicle, while an incompatible structure such as a headlight, or even a hood in some cases, is not. When a bumper strikes an object that is not designed for impact, the bumper will sustain less damage and inflict much more damage on the soft item. Bumpers need to hit each other squarely to serve their purpose [12].

2.2 FUNCTION

A bumper is a shield made any of material like steel, aluminum, rubber or plastic that is mounted on the front and rear of passenger car. The function is when a low speed collision occurs, the bumper system absorbs the shock to prevent or reduce damage to the car. Some bumper use energy absorbers or brackets and others made with foam cushioning material. The car bumper is design to prevent or reduce physical damage to the front car. It is also design to protect the hood, trunk, grille, fuel, exhaust and cooling system besides the engine. It is not safety feature intended to prevent or mitigate injury to occupants in the passenger cars.

Bumper car rides are designed so that the cars can collide without much danger to the riders. Each car has a large rubber bumper all around it, which prolongs the impact and diffuses the force of the collision. The bumper cars run on electricity, carried by a pole on the back of the car that leads up to a wire grid in the ride's ceiling. This grid carries the electricity that runs the car. Electrical energy carried to the cars from the grid is converted to kinetic energy, some of which is converted to heat [13].



Figure 3: Actual function of car bumper (source: Cheon S.S, 1995) [8]

2.3 GEOMETRY

Bumpers are structural components installed to reduce physical damage to the front and rear ends of a passenger motor vehicle from low-speed collisions. Damage and protection assessments are the commonly used design criteria in bumper design. For damage assessment, the relative displacements representing stiffness performance are defined and examined. At the protodesign stage for a new car, finite element (FE) analysis is often utilized to predict the stiffness of a bumper.

However, conventional bumper analysis through FEM outputs a constant stiffness even though the stiffness has some distribution due to uncertainties. The uncertainties are assumed to be the tolerances of thicknesses. Under this uncertain condition, the displacements representing stiffness are calculated by approximate statistics and by worst-case analysis. Then, a robust design is determined by design of experiments (DOE) using the orthogonal array strategy to find the design having a minimum weight of bumper within the stiffness constraints.

Steel can be used to effectively absorb impacts, but when the impact structures are set at different heights and the bumpers do not hit each other squarely, then the bumpers of each vehicle are not going to behave optimally. The height disparity can cause unnecessary damage to the lower vehicle and, more importantly, the occupants of the lower vehicle. Having considered all of these facts, the Alliance of Automobile Manufacturers has voluntarily agreed to alleviate Vehicle Incompatibility all together by 2009.

All vehicles made by BMW Group, DaimlerChrysler Corporation, Ford Motor Company, General Motors, Honda, Hyundai, Isuzu, Kia, Mazda, Mitsubishi, Nissan, Subaru, Suzuki, Toyota and Volkswagen will be compatible (they will also have a variety of other safety features per this agreement). But what is compatible? The AAM defines compatibility as having the majority of the Primary Energy Absorbing Structure within sixteen to twenty inches of the ground [14].

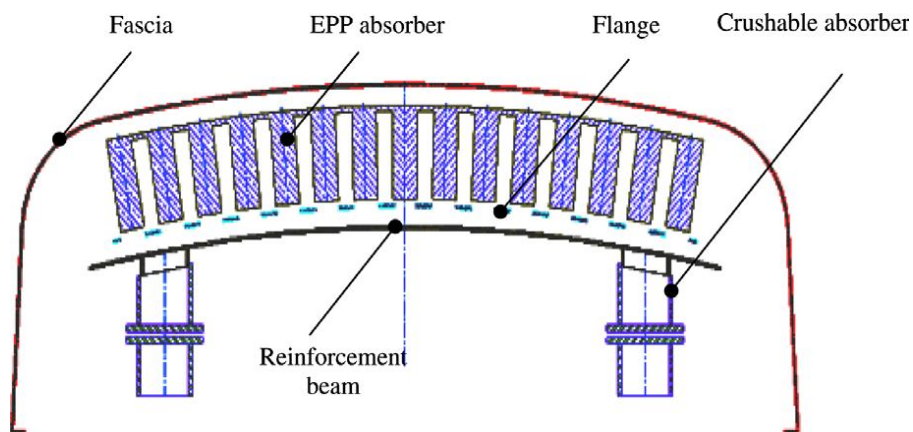


Figure 4: Cross section of the bumper system technology (source: Neopolen, 2006) [20]