Design and Analsis of Car Bumper By Varying Materials and Speeds

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***Abstract*—** one of the main parts in car is Bumper which is used as protection for passengers from front and rear collision. This research was to analyze the structural and material employed for car bumper in one of the car, material, structures, shapes and impact conditions are studied for analysis of the bumper beam in order to improve the crashworthiness during collision. An automobile's bumper is the front-most or rear-most part, designed to allow the car to sustain an impact without damage to the vehicle's safety systems. They are not capable of reducing injury to vehicle occupants in high-speed impacts, but are increasingly being designed to mitigate injury to pedestrians struck by cars.

Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design. Impact analysis is done by COSMOS. This speed is according to regulations of Federal Motor Vehicle Safety Standards, FMVSS 208- Occupant Crash Protection whereby the purpose and scope of this standard specifies requirements to afford impact protection for passengers. In this research, analysis is done for speed according to regulations and also by changing the speeds. Simulation using Finite Element Analysis software, which is COSMOS, was conducted. The material used for bumper is carbon fiber-reinforced poly-ether-imide pei.

Keywords- *Design &Analysis Of Car Bumber,*

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I. INTRODUCTION

Every day Car accidents are happening. Most troublesome situations are occurred to the drivers that they can avoid such. The statistics shows that ten thousand dead and hundreds of thousands to million wounded each year. Hence, improvement in the safety of automobiles is prerequisite to decrease the numbers of accidents. Automotive bumper system is one of the key systems in passenger cars. Bumper systems are designed to prevent or reduce physical damage to the front or rear ends of passenger motor vehicles in collision condition. It protects the hood, trunk, grill, fuel, exhaust and cooling system as well as safety related equipment such as parking lights, headlamps and taillights, etc. A good design of car bumper must provide safety for passengers and should have low weight. Different countries have different performance standards for bumpers. Under

The International safety regulations originally developed as European standards and now adopted by most countries car’s safety systems still function normally after a straight-on pendulum or moving-barrier impact of 4 km/h to the front and the rear, and to the front and rear corners of 2.5 km/h at 45.5 cm above the ground with the vehicle loaded or unloaded.

The function of automotive bumpers has changed considerably over the past 70 years. The later performance is achieved by a combination of careful design, material selection to obtain a particular balance of stiffness, strength and energy absorption. Stiffness and Energy absorption are essential criterion. Stiffness is important because vehicle design consideration limits the packaging space for the bumper design to deform under load and Energy absorption is important because bumper must limit the amount of the impact force transmitted to the surrounding rails and vehicle frame. Automotive bumper plays a very important role in absorbing impact energy (original purpose of safety) and styling stand point/aesthetic purpose. Now a day, automotive industry concentrates on optimization of weight and safety.

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II. LITERATURE

Literatures related to impact are studies by many researchers. It was observed that, major injury due to impact velocity of around 20-30 kmph was affected to the knee ligament. Davoodi et al. [4] proposed conceptual design of fiber reinforced epoxy composite bumper absorber as a pedestrian energy absorber. The energy absorption capacity was sufficient for pedestrian impact and it could possible to use as substitute for the existing materials such as EPP foam for low impact collision.

Mohapatra S [5] discussed that automotive development cycles are getting shorter by the day. With increasing competition in the marketplace, the OEM’s and suppliers main challenge is to come up with time-efficient design solutions. Researchers are trying to improve many of existing designs using novel approaches. Many times there is conflicting performance and cost requirements. This puts additional challenge for Research and Development units to come up with a number of alternative design solutions in less time and cost compared to existing designs. These best solutions are best achieved in a CAE environment using some of the modern CAD and FEM tools. Such tools are capable of effecting quick changes in the design within virtual environment.

Andersson R et.al [6] emphasized that to increase crash performance in automotive vehicles it is necessary to use new techniques and materials. The components that are linked to crash safety should transmit or absorb energy. The energy absorbing capability of a specific component is a combination of geometry and material properties. The chosen material should have high yield strength and relatively high elongation to fracture. These demands lead to increase interest to use of high strength stainless steels.

A Standards for bumper

In most jurisdictions, bumpers are legally required on all vehicles. The height and placement of bumpers may be legally specified as well, to ensure that when vehicles of different heights are in an accident, the smaller vehicle will not slide under the larger vehicle.

India

India is the 10th largest producer of automobiles in the world. The country's attention to vehicle safety requirements has progressed significantly since the year 2000. More than 35 million vehicles are registered in India. In 1989, the Central Motor Vehicle Rules (CMVR) became effective and the rules are greatly enforced today. Under Rule 126 of the CMVR, manufacturers of motor vehicles must allow a separate agency to test prototypes of new vehicle designs for safety requirements. It is necessary for all vehicles in India to have basic safety features, such as seat belts, rear-view mirrors and laminated safety glass for windshields. Also, all vehicles in use must pass a pollution test every six months.

B Types of bumpers

- Plastic bumper
- Boby kit bumper
- Carbon fibre bumper
- Steel bumper

Plastic bumper

Most modern **cars** use a reinforced thermoplastic bumper, as they are cheap to manufacture, easy to fit and absorb more energy during a crash. A majority of car bumpers are custom made for a specific model, so if you are looking to replace a cracked bumper with a similar one, you would have to buy from a specialist dealer. However, many companies now offer alternative designs in thermoplastic, with a range of fittings designed for different models.

Boby Kit Bumper

Modified cars often now have a full body kit rather than just a front and rear bumper. These kits act as a skirt around the entire body of the car and improve performance by reducing the amount of air flowing underneath the car and so reducing drag. Due to each car's specifications, these have to be specially purchased and can be made from thermoplastic, like a standard bumper, or even out of carbon fiber.

Carbon Fiber Bumper

Carbon fiber body work is normally the thing of super-cars, but many car companies, and specialist modifiers, are starting to use it for replacement body part on everyday cars. This is because it is very light and is safe during a crash. It is, however, a lot more expensive than normal thermoplastic.

Steel Bumper

Originally plated steel was used for the entire body of a car, including the bumper. This material worked well, as it was very strong in a crash, but it was very heavy and dented performance. As car engine design has improved, steel bumpers have pretty much disappeared for anything except classic cars. Replacing one involves a lot of searching for scrap cars or having one specially made.

C Materials used in bumper

At one time, most car bumpers were made of steel. Then, most were made of chrome or a chrome-plated material. Today, car bumpers can be made from anything from chrome-plated material to a variety of different rubber materials or plastics. This makes detailing car bumpers somewhat more complicated, as bumpers made from different materials require very different detailing treatments. For the purposes of this article, we will assume that your car bumper is chrome-plated. Detailing a chrome-plated bumper requires a bit of patience and a light sanding touch, but it is certainly something that even the most casual car owner can accomplish in a day or less. The primary enemy of chrome-plated bumpers is oxidation (rust). The longer you allow rust spots to remain on your bumper, the more difficult the detailing process is going to be.

Bumpers on most new cars are color-coordinated plastic "wrappers," molded sleekly around the front and back ends of the vehicles. They may please the eye, but whether these bumpers protect the vehicle they surround from damage in low-speed impacts is another matter.

III. 2DMODELLING OF A CAR BUMPER

From literature review it is clear that automotive bumper has evolved over the years. Although it is evolved ergonomically there is no systematic study which explains design and analysis of front bumpers in the presence of solid mechanics using advanced FEA tools

Pro/ENGINEER is a feature based, parametric solid modeling program. As such, it's use is significantly different from conventional drafting programs. In conventional drafting (either manual or computer assisted), various views of a part are created in an attempt to describe the geometry. Each view incorporates aspects of various features (surfaces, cuts, radii, holes, protrusions) but the features are not individually defined. In feature based modeling, each feature is individually described then integrated into the part. The other significant aspect of conventional drafting is that the part geometry is defined by the drawing. If it is desired to change the size, shape, or location of a feature, the physical lines on the drawing must be changed (in each affected view) then associated dimensions are updated. When using parametric modeling, the features are driven by the dimensions (parameters).

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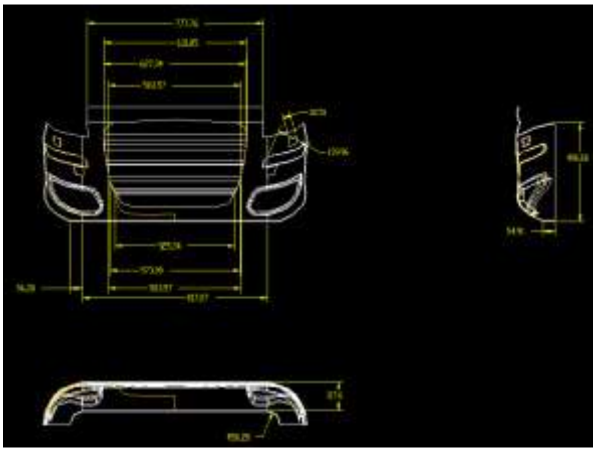


Fig 1. 2D solid modeling of car bumper

IV. 3D SOLID MODELING

Solid modeling in general is useful because the program is often able to calculate the dimensions of the object it is creating. Many sub-types of this exist. Constructive Solid Geometry (CSG) PRO/ENGINEER uses the same basic logic as 2D SKETCHER, that is, it uses prepared solid geometric objects to create an object. However, these types of software often can be adjusted once they are created. Boundary Representation (Brep) solid modeling takes CSG images and links them together. Hybrid systems mix CSG and Brep to achieve desiredcar bumper designs.

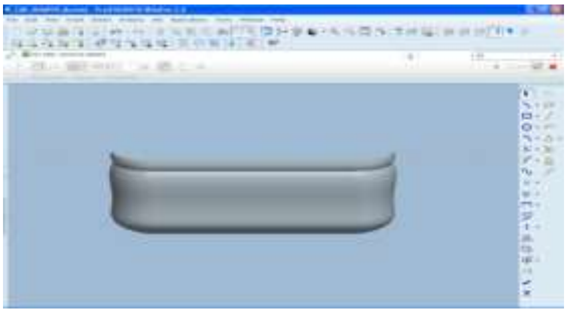


Fig 2. 3D solid model Extracted from 2D

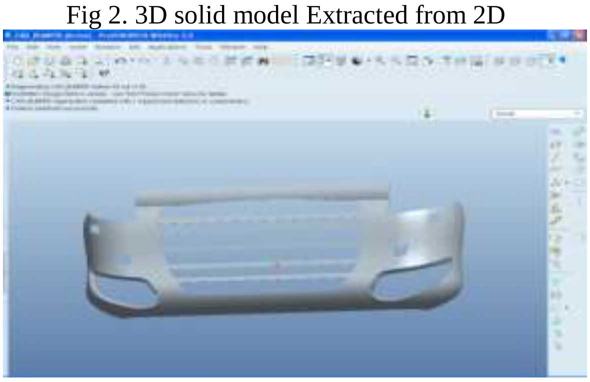


Fig 3. 3D solid model after slotting operation

V. ANALYSIS ON CAR BUMPER BY FEA

- Finite element analysis (FEA) is a fairly recent discipline crossing the boundaries of mathematics, physics, engineering and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. The finite element method is comprised of three major phases: (1) pre-processing, in which the analyst develops a finite element mesh to divide the subject geometry into sub domains for mathematical analysis, and applies material properties and boundary conditions, (2) solution, during which the program derives the governing matrix equations from the model and solves for the primary quantities, and (3) post-processing, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacements and stresses), and derives and examines additional quantities (such as specialized stresses and error indicators).
- Cosmos works is useful software for design analysis in mechanical engineering. That's an introduction for you who would like to learn more about COSMOS Works. COSMOS Works is a design analysis automation application fully integrated with Solid Works.
- This software uses the Finite Element Method (FEM) to simulate the working conditions of your designs and predict their behavior. FEM requires the solution of large systems of equations. Powered by fast solvers, COSMOS Works makes it possible for designers to quickly check the integrity of their designs and search for the optimum solution.
- A Analysis steps
- We complete a study by performing The following steps:
- Create a study defining its analysis type and options. If needed, define parameters of your study. Parameters could be a model dimension, a material property, a force value,or any other entity that you want to investigate its impact on the Design.
- Analysis Background: Linear Static Analysis Linear Material property, Material Models, Linear Elastic Isotropic, Plotting Results, Describes how to generate a result plot and result tools. Listing Results, Overview of the results that can be listed,

- Graphing Results, Shows you how to graph results, Results of Structural Studies, Lists results available from structural studies, Results of Stress Check**.**
- Lists the basics of checking stress results and different criteria used in the checking.

B Properties of car bumper by using different materials

Name	:	Alloy Steel
Model type	:	Linear Elastic Isotropic
Default failure criterion	:	Max von Mises Stress
Yield strength	:	6.20422e+008 N/m^2
Tensile strength	:	7.23826e+008 N/m^2
Elastic modulus	:	2.1e+011 N/m^2
Poisson's ratio	:	0.28
Mass density	:	7700 kg/m^3
Shear modulus	:	7.9e+010 N/m^2
Thermal expansion coefficient	:	1.3e-005 /Kelvin

Name	:	ABS
Model type	:	Linear Elastic Isotropic
Default failure criterion	:	Max von Mises Stress
Tensile strength	:	3e+007 N/m^2
Elastic modulus	:	2e+009 N/m^2
Poisson's ratio	:	0.394
Mass density	:	1020 kg/m^3
Shear modulus:	:	3.189e+008 N/m^2

Name	:	PEI
Model type	:	Linear Elastic Isotropic
Default failure criterion:		Max von Mises Stress
Yield strength	:	2.3e+008 N/m^2
Tensile strength	:	2.41e+008 N/m^2
Elastic modulus	:	3.38e+010 N/m^2
Poisson's ratio	:	0.4
Mass density	:	1480 kg/m^3
Shear modulus	:	3.189e+008 N/m^2

C Generate mesh

At this point COSMOS understands the makeup of the part. Now define how the modeled system should be broken down into finite pieces.

Fig 4.Solid Mesh for COSMOS analysis

D Apply loads

Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions.

The study properties studied under drop test and the mesh type is soild mesh and setup for impact test at velocity 13.3m/sec on plane 1 reference under gravitational pull of 9.81 m/sec and friction coefficient is taken as 0. The solution time after impact is 20 microseconds.
The study results on alloy steel at speed 48 km/hr shows the minimum von mises stress of 2.451e-0.14 N/mm^2 at node 6273 and maximum is 1053.78N/mm^2 at node 14495. Minimum displacement is 0.00131926 at node 9658 and maximum displacement is at node 139.

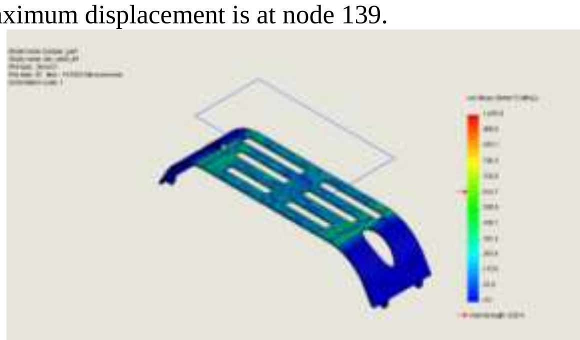


Fig 5. Stress analysis on alloy steel at 48 km/hr

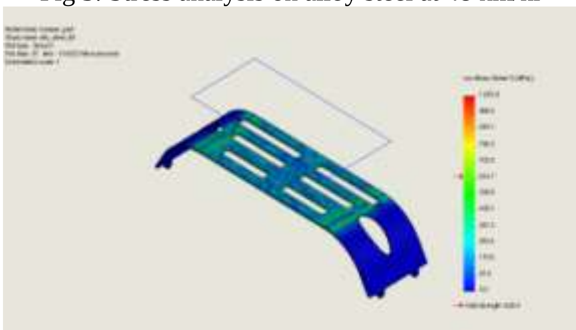


Fig 6.Displacement analysis on alloy steel at 48 Km/hr

Study results on ABS plastic at speed 48 km/hr the von mises stress is minimum at node11391 is 1.79916e-016N/mm^2 and maximum at 307 node is 25.4296 N/mm^2. the minimum displacement is0.0017mm and maximum displacement is 0.29mm.

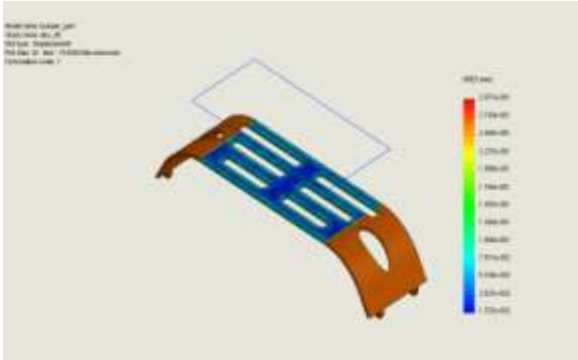


Fig 7.Stress analysis on ABS Plastic at 48 Km/hr

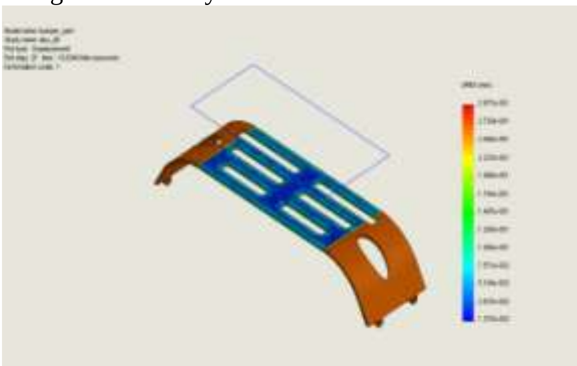


Fig 8.Displacement analysis on ABS Plastic at 48 Km/hr

Study results on PEI at speed 48Km/hr the minimum von mises stress at node15694 is 1.0008e-014 N/mm^2 and maximum 169.485 is at node 14495.the Displacement is minimum at node15102 is 0.0035 mm and maximum is 0.31mm at node 1091.

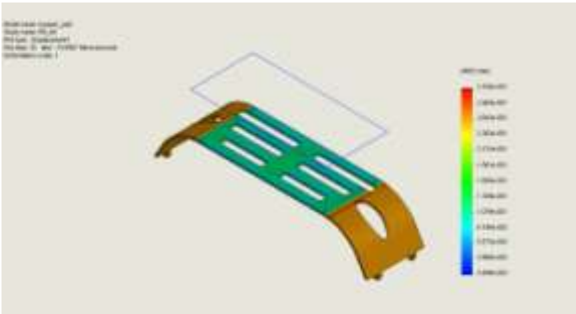


Fig 9.Von mises stress on PEI at 48 km/hr

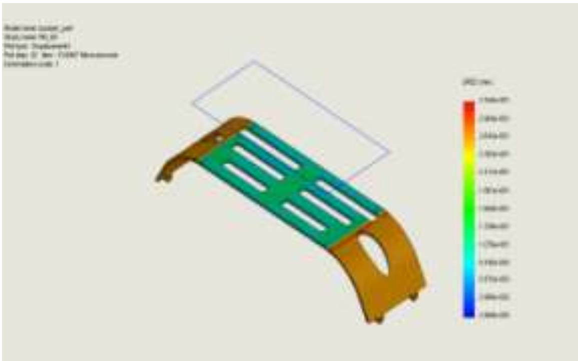


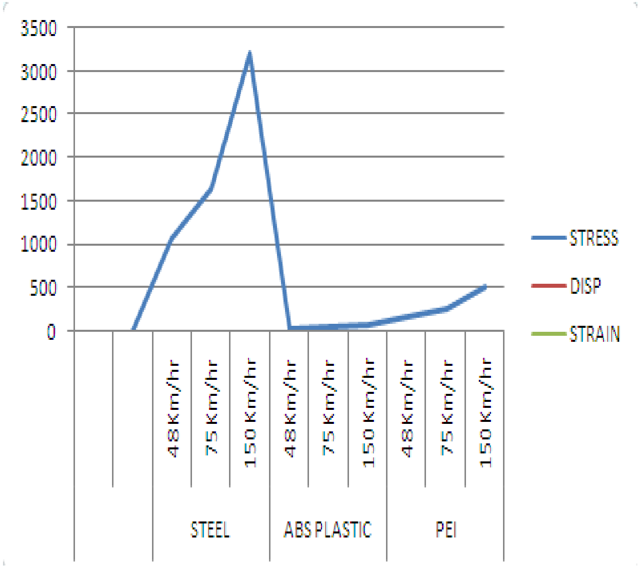
Fig 10. Displacement on PEI at speed 48 Km/hr.

Study results on alloy steel, ABS Plastic and PEI is obtained by varying different speeds these results are obtained by using COSMOS software. There are many ways to present the COSMOS results, we can choose tables, graphs and contour plots.

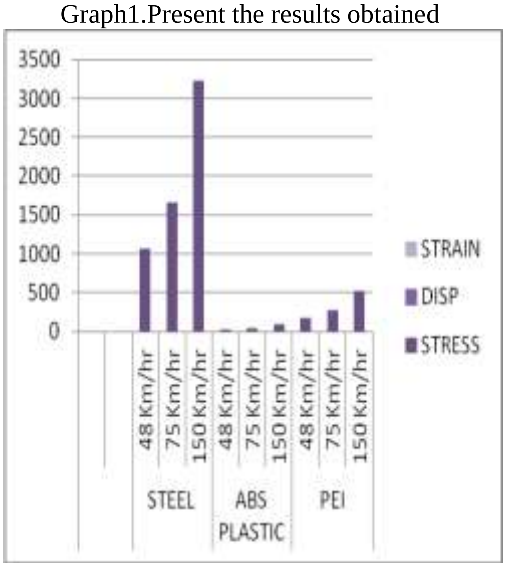
The below shown table represents the results obtained by using the COSMOS software.

MATERIAL	SPEED	STRESS N/mm^2	DISP mm	STRAIN
STEEL	48 Km/hr	1053.78	0.317229	0.002165
	75 Km/hr	1645.34	0.496801	0.0033870
	150 Km/hr	3218.56	0.999592	0.0064334
ABS PLASTIC	48 Km/hr	25.4296	0.297715	0.00865195
	75 Km/hr	39.6692	0.452602	0.0118735
	150 Km/hr	78.9181	0.916127	0.023666
PEI	48 Km/hr	169.485	0.31642	0.0025749
	75 Km/hr	264.538	0.494451	0.0040249
	150 Km/hr	513.819	0.983933	0.0080296

By observing the above results the speeds are 48,75, 150 Km/hr the stress obtained for different materials can be plotted in a graph and stress strain curve can be drawn by observing the graph we can easily conclude which material is good for a car bumper.



Graph1.Present the results obtained



Graph 2.Stress, Displacement results

We can draw bar graph to know the stress value if the stress is maximum displacement is also maximum and we can see steel is having maximum stress at maximum speed thus we can understand for maximum speed there will be more impact on the bumper and steel will have more impact than the other materials. In this Finite element modeling of the bumper testing during frontal collision was performed according to FMVSS and IIHSS standards. Initially the bumper specification was taken from standard passenger car bumper beam and modeled using PRO -E software. Impact analysis is done on the car bumper for different speeds of 48Km/hr, 75Km/hr, 150km/hr.

VI. CONCLUSION

In our project, we have modeled a car bumper using 3D modeling software Pro/Engineer. Impact analysis is done on the car bumper for different speeds of 48Km/hr, 75Km/hr and 150Km/hr. The analysis is done on the car bumper for different materials Steel, ABS Plastic and Carbon Fiber-Reinforced Poly-Ether-Imide PEI.

Present used material for car bumper is steel. We are replacing with ABS Plastic and Carbon fiber - Reinforced Poly-Ether-Imide PEI. The density of ABS Plastic and PEI is less than that of steel, thereby the overall weight of car bumper is reduced.

By observing the impact analysis results, the stress values are less for ABS Plastic and PEI than steel. By comparing the results of ABS Plastic and PEI, the stress values are less for ABS Plastic than PEI.

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