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Impact Analysis on Car Bumper by varying speeds using Materials ABS Plastic and Poly Ether Imide by Finite Element Analysis software Solid works

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Abstract: *Bumper is one of the main parts which are used as protection for passengers from front and rear collision. The aim of this study was to analyze and study the structure and material employed for car bumper in one of the car manufacturer. In this study, the most important variables like material, structures, shapes and impact conditions are studied for analysis of the bumper beam in order to improve the crashworthiness during collision. The simulation of a bumper is characterized by impact modeling using Pro/Engineer, impact analysis is done by SOILD WORKS according to the speed that is 13.3 m sec^{-1} (48 km h^{-1}) given in order to analyze the results. 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 SOILD WORKS, was conducted. The material used for bumper is CARBON FIBER-REINFORCED POLY-ETHER-IMIDE PEI and ABS Plastic.*

Keywords: *Pro-E, Solid works, meshing, bumper, stress, displacement, strain*

I. Introduction

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 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. Front and rear bumpers became standard equipment on all cars in 1925. What were then simple metal beams attached to the front and rear of a car have evolved into complex, engineered components that are integral to the protection of the vehicle in low-speed collisions.

Today's plastic auto bumpers and fascia systems are aesthetically pleasing, while offering advantages to both designers and drivers. The majority of modern plastic car bumper system fascias are made of thermoplastic olefins (TPOs), polycarbonates, polyesters, polypropylene, polyurethanes, polyamides, or blends of these with, for instance, glass fibers, for strength and structural rigidity.

The use of plastic in auto bumpers and fascias gives designers a tremendous amount of freedom when it comes to styling a prototype vehicle, or improving an existing model. Plastic can be styled for both aesthetic and functional reasons in many ways without greatly affecting the cost of production. Plastic bumpers contain reinforcements that allow them to be as impact-resistant as metals while being less expensive to replace than their metal equivalents.

Plastic car bumpers generally expand at the same rate as metal bumpers under normal driving temperatures and do not usually require special fixtures to keep them in place. Some of the plastic products used in making auto bumpers and fascias can be recycled. This enables the manufacturer to reuse scrap material in a cost-effective manner. A new recycling program uses painted TPO scrap to produce new bumper fascias through an innovative and major recycling breakthrough process that removes paint from salvage yard plastic. Tests reveal post-industrial recycled TPO performs exactly like virgin material, converting hundreds of thousands of pounds of material destined for landfills into workable grade-A material, and reducing material costs for manufacturers.

Why has bumper effectiveness been reduced in preventing damage in a minor collision? One reason could be that statutory bumper standards were made quite loose. As a result, many of today's bumpers allow cars to be damaged more easily.

II. Design Of Car Bumper By Pro-E Software

Pro/Engineer is a software application within the CAID/CAD/CAM/CAE category, along with other similar products currently on the market. Pro/Engineer is a parametric, feature-based modeling architecture incorporated into a single database philosophy with advanced rule-based design capabilities. The capabilities of the product can be split into the three main heading of Engineering Design, Analysis and Manufacturing. This data is then documented in a standard 2D production drawing or the 3D drawing standard ASME Y14.41-2003.

Modeling of car bumper is done with help of Pro-e software and dimensions are selected from one of car bumper. As the impact is more for the front portion of bumper only outer dimensions of car bumper has been considered for modeling, Slots provided in middle of car bumper is used for reducing drag effect in car bumper.

Figure: 1

Figure: 2

III. Analysis Of Car Bumper With Fea Software Solid Works

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 product development cycle typically includes the following steps: 1 Build your model in the Solid Works CAD system 2 Prototype the design. 3 Test the prototype in the field. 4 Evaluate the results of the field tests. 5 Modify the design based on the field test results. Analysis Steps: You 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 Frequency Analysis Linear zed Buckling Analysis Thermal Analysis Optimization Studies, 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 Thermal Studies. Lists results available from thermal studies, Reports, explains the study report utility. Stress Check. Lists the basics of checking stress results and different criteria used in the checking

MESHING OF CAR BUMPER

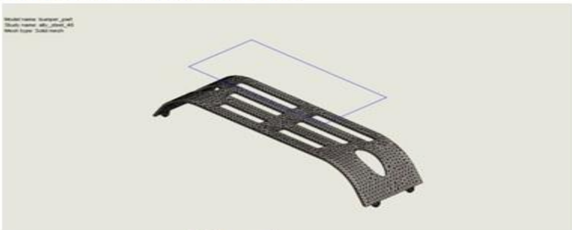


Figure.3

ABS Plastic

Model name: bumper_part Current Configuration: Default	
Solid Bodies	
Treated As	Volumetric Properties
Solid Body	Mass:17.9998 lb Volume:488.464 in^3 Density:0.0368498 lb/in^3 Weight:17.9876 lbf

Table.1

Setup Information

Type	Velocity at impact
Analysis type	Drop Test
Mesh type	Solid Mesh
Velocity Magnitude	13.3 m/sec
Impact Velocity Reference	Plane1
Gravity	9.81 m/s^2
Gravity Reference	Front Plane
Parallel to reference plane	Top Plane
Friction Coefficient	0
Target Stiffness	Rigid target

Table.2

Units

Unit system:	SI (MKS),FPS
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Table.3

Material Properties ABS Plastic

Name : ABS Plastic
Model Type : Linear Elastic Isotropic
Default failure : 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	Type	Min	Max
Stress1	VON: von Mises Stress	1.79916e-016 N/mm^2 (MPa) Node: 11391	25.4296 N/mm^2 (MPa) Node: 307

Bumper_part-abs_48km/hr(13.3 m/sec)-Stress-Stress1

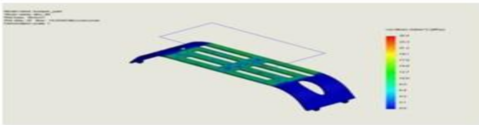


Table.4 & Figure.4

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.00170703 mm Node: 7857	0.2977 mm Node :901

Bumper_part-abs_48km/hr(13.3 m/sec)-Displacement-Displacement1

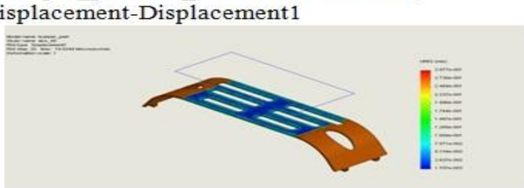


Table.5 & Figure.5

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0 Element: 8041	0.00865195 Element: 545

Bumper_part-abs_48km/hr(13.3 m/sec)-Strain-Strain1

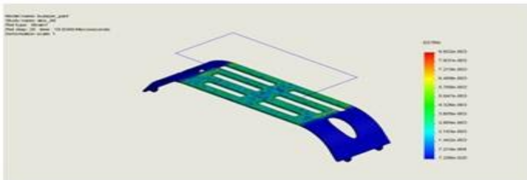
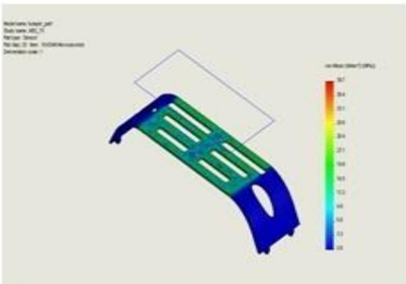


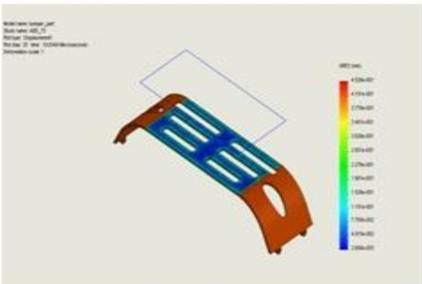
Table.6 & Figure.6

For 75 KM/hr ABS Plastic

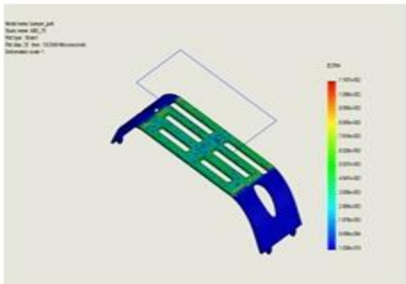
Stress1 MIN 3.60887e-016 N/mm^2 Node: 11712 MAX 39.6692 N/mm^2 Node: 307
Displacement1 MIN 0.00265575 mm Node: 7857 MAX 0.452602 mm Node: 3614
Strain MIN 0 Element: 8041 MAX 0.0118735 Element: 1732



Stress
Figure.7



Displacement
Figure.8



Strain
Figure.9

POLY-ETHER-IMIDE PEI

Model name: bumper_part
Current Configuration: Default

Solid Bodies	
Treated As	Volumetric Properties
Solid Body	Mass:26.1174 lb Volume:488.464 in^3 Density:0.0534684 lb/in^3 Weight:26.0997 lbf

Table.7& Figure.10

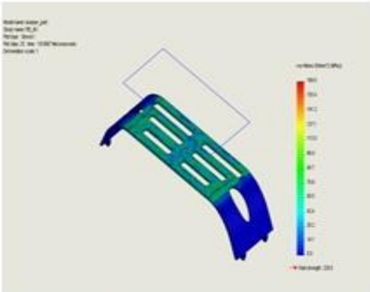
Material Properties PEI

Name : PEI
Model Type : Linear Elastic Isotropic
Default failure : 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

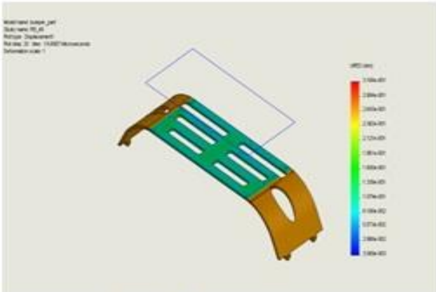
For 48 KM/hr PEI Plastic

Stress1 MIN 1.00086e-014 N/mm^2 Node: 1569 MAX 169.485 N/mm^2 Node: 14495 Displacement1 MIN 0.00358896 mm Node: 15102: MAX 0.31642 mm Node: 1091

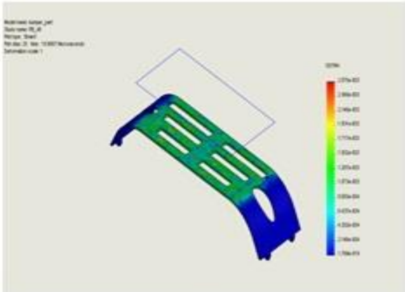
Strain MIN 0 Element: 8041 MAX 0.00257491 Element: 6554



Stress
Figure.11



Displacement
Figure.12



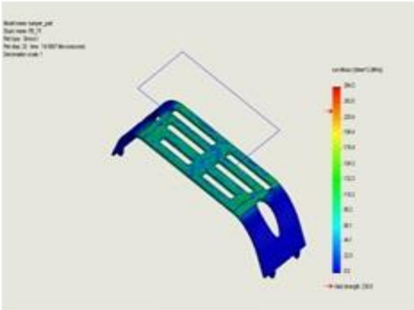
Strain
Figure.13

For 75 KM/hr PEI Plastic

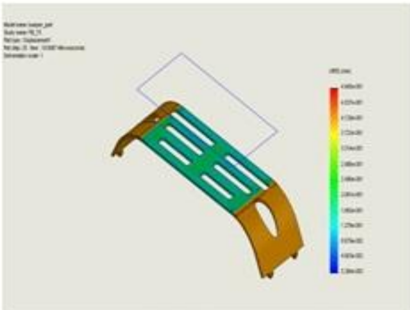
Stress1 MIN 1.11257e-014 N/mm^2 Node: 16808 MAX 264.538 N/mm^2 Node: 14495

Displacement1 MIN 0.00526361 mm Node: 15102 MAX 0.494451 mm Node: 1091

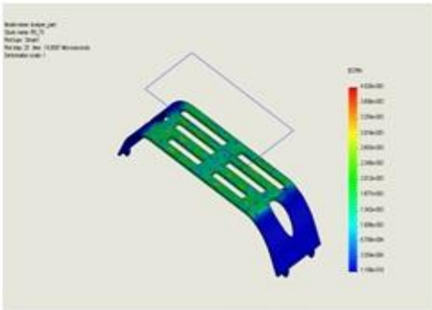
Strain MIN 0 Element: 8041 MAX 0.00402493 Element: 6554



Stress
Figure.14



Displacement
Figure.15



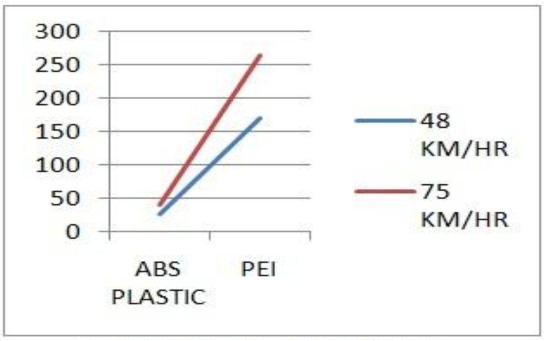
Strain
Figure.16

IV. Results and Discussions

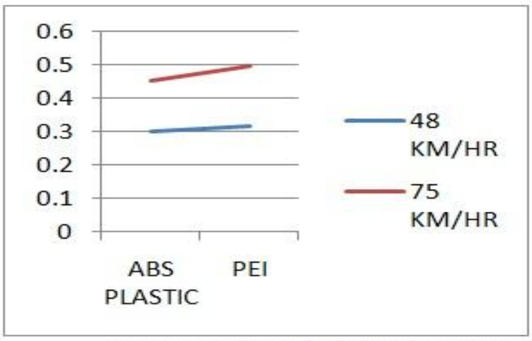
Observing the graphs of stress and Displacement, valves of Abs plastic are less than PEI, The ABS Plastic has good impact resistance when compared to PEI.

		STRESS N/mm^2	DISP mm	STRAIN
ABS PLASTIC	48 Km/hr	25.4296	0.297715	0.00865195
	75 Km/hr	39.6692	0.452602	0.0118735
PEI	48 Km/hr	169.485	0.31642	0.0025749
	75 Km/hr	264.538	0.494451	0.0040249

Table.8



Graph.1 **Materials** Vs Stress



Graph.2 Materials Vs Displacement

V. Conclusion

Modeling of a car bumper is done using 3D modeling software Pro/Engineer. Impact analysis is done on the car bumper for different speeds of 48Km/hr, 75Km/hr. The analysis is also carried on the car bumper for different materials ABS Plastic and Carbon Fiber-Reinforced Poly-Ether-Imide PEI. At Present the material used for car bumper is steel. Steel is 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 like Stress, Displacement and strain , 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. ABS Plastic is better for utilization comparing PEI.

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