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MODELING AND FEA ANALYSIS ON CAR BUMPER AT VARYING MATERIALS AND SPEEDS

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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 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-E 5.1 according to the speedsThis research, the three types of material was selected that are relevant to be applied to the front bumper beam. The materials consist of alloy steel, Poly either imide (PEI), S2Glassepoxy. These materials were studied by impact modeling to determine the stress on bumper, kinetic energy, potential energy and strain energy. The selected materials are compared to each other to find the best material with highest material strength and structure. Simulation using Finite Element Analysis software of COSMOS, which is PRO-E, was conducted. The results showed that a modified S2Glassepoxy bumper can reduce the impact of collision with higher performance and was suggested to replace Alloy Steel and PEI. The duration taken for S2Glossepoxy to deflect the impact was the shortest compared to Alloy Steel and PEI the findings also showed that Alloy Steel cannot totally absorb the energy and reduce the impact of collision.

INTRODUCTION

Bumper is one of the most important parts in passenger cars for which the material and structure should be considered in order to reduce the impact of collision. Since suitable impact strength is the main expectation for such a structure, the variables that directly give impact characteristics and wished for easily achievable modifications resulting from impact modeling on A good design of car bumper must provide safety for passengers and should have low weight. Beside the role of safety, fuel efficiency and emission gas regulations are being more important which encourage manufacturer to reduce the weight of passenger cars.

In this project, a front bumper beam made of three materials that are expanded poly either imides (PEI), Alloy Steel and high-strength S2Glossepoxy is studied by crash simulation analysis to determine the stress, kinetic energy, potential energy and strain energy. The main characteristics are compared between all the materials to find best material and structure. The results show that a modified S2Glossepoxy bumper beam can minimize and reduce the impact of bumper collision. Commercial bumpers, Have studied that accidental always occur in front side. By using reinforced polymer and composites type of bumper, the bumper impact of collision can be reduced by replicating the similar as possible to reality in to COSMOS and meshed in order to get a simulation results. The energy absorption capability of the composite materials offers a unique combination of reduced weight and improves crashworthiness of the vehicle structures.

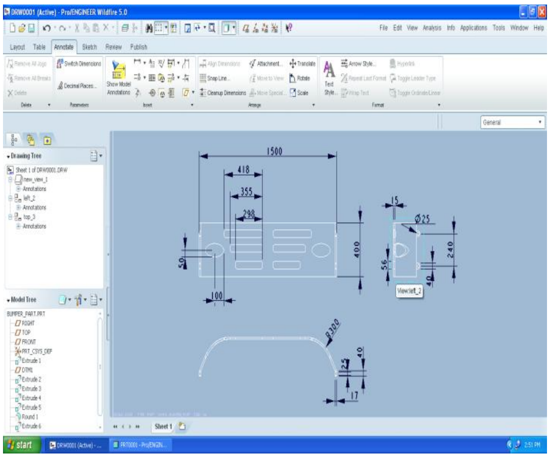
Many researchers have studied the four main variables during crash simulation and analysis. The first variable studied is the material. It has been exposed in this research as a substitution in order to lower part weights and define whether the material can affect the impact of collision or not. In this section, the effect of modulus of elasticity on impact behavior of bumper beam. was investigated. Thickness is the second variable that has been studied in order to relate between bumper and thickness that can affect the impact of collision. Next, the bumper is essential for being economical by utilizing low-cost composite materials besides achieving reduced weight compared to the metallic bumpers. Lastly, the bumper should achieve improved collision compared to the current material.

MATERIALS AND METHODS

The sample of car bumper was given by one of the car HUNDHI in HYDERABAD to be studied by of research. The research started in September 2009 and finished on April 2010. The study was carried out in to the WIN WILL technology Lab where the sample and computer facilities were located. Reverse engineering was carried out to design the part using CAD software. The impact assessment of car bumper was analyzed numerically using FEA software that is COSMOS. The model being used was the same for all analysis. The input variable is material which is thermo set polymer or engineering polymer. The materials being assessed were expanded poly either imides (PEI), Alloy Steel and high-strength S2 Gloss epoxy. The requested field output and history output are Von Misses stress, kinetic energy, frictional dissipation, internal energy, strain energy and total energy. The highest stress value resulting from impact was obtained from Von Misses stress and compared with yield stress of the respected material. From this comparison, I can conclude whether or not the material fails during the collision sustained by bumper. From the result, I would suggest the most optimum solution which satisfied impact condition.

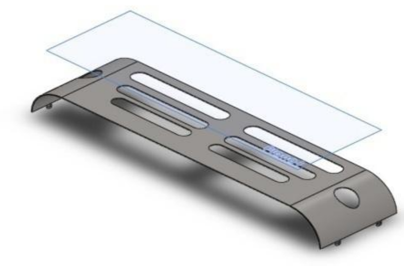
DIFFERENT TYPES OF CAR BUMPERS

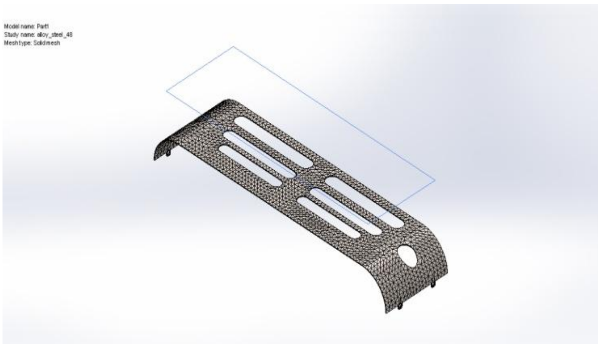
2D DRAWINGS OF CAR BUMPER



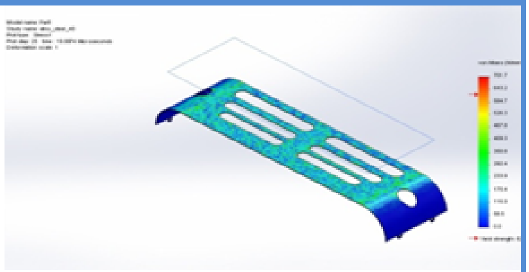
MODEL OF CAR BUMPER

ANALYSIS OF CAR BUMPER FOR ALLOY STEEL
SPEED – 48Km/hr AND 120Km/hr



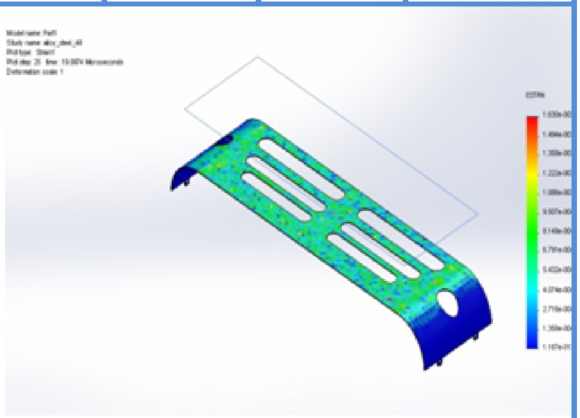


Name	Type	Min	Max
Stress1	VON: von Mises Stress	5.36915e-008 N/mm^2 (MPa) Node: 3939	701.669 N/mm^2 (MPa) Node: 16395



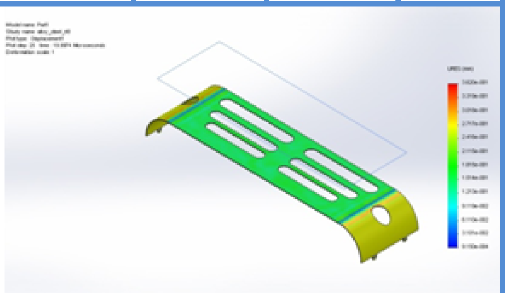
Part1-alloy_steel_48-Stress-Stress1

	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.18729e-013 Element: 383	0.00162972 Element: 1440



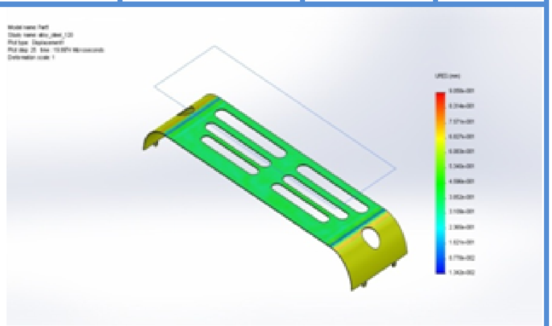
Part1-alloy_steel_48-Strain-Strain1

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.000915034 mm Node: 12427	0.362002 mm Node: 536



Part1-alloy_steel_48-Displacement-displacement

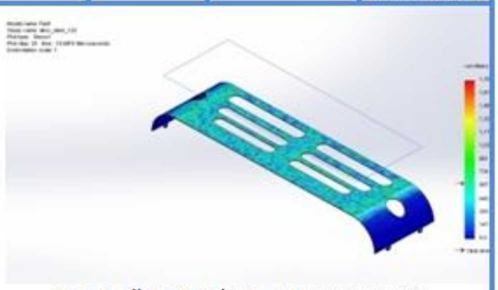
Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.0134152 mm Node: 15743	0.905786 mm Node: 536



Part1-alloy_steel_120-Displacement-Displacement1

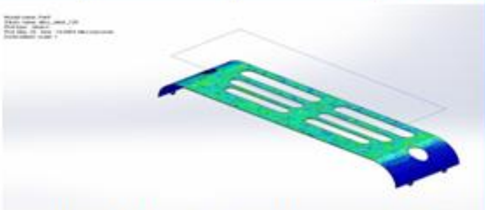
Impact test on bumper by taking the material CARBON REINFORCED PEI test speeds are –48Km/hr and 120km/hr

Name	Type	Min	Max
Stress1	VON: von Mises Stress	1.34092e-007 N/mm^2 (MPa) Node: 3939	1763.44 N/mm^2 (MPa) Node: 16395



Part1-alloy_steel_120-Stress-Stress1

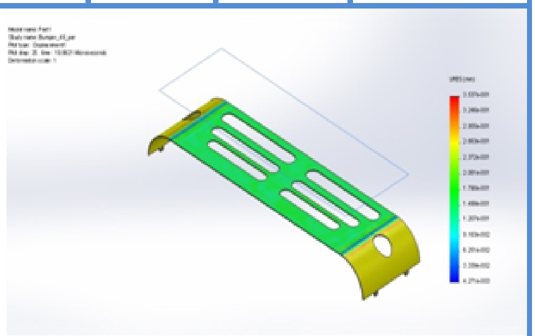
Name	Type	Min	Max
Strain	ESTRN: Equivalent Strain	2.97674e-013 Element: 383	0.004088 77 Element: 1440



Part1-alloy_steel_120-Strain-Strain1

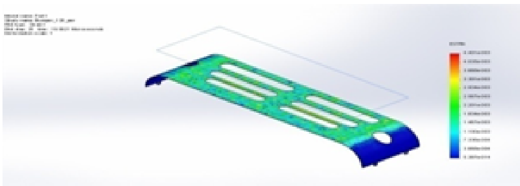
Model Reference	Properties	
	Name:	PEI
	Model type:	Linear Elastic Isotropic
	Default failure criterion:	Max von Mises Stress
	Yield strength:	2.3e+008 N/m^2
	Elastic modulus:	3.1e+010 N/m^2
	Poisson's ratio:	0.3
	Mass density:	1480 kg/m^3
	Shear modulus:	3.189e+008 N/m^2

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.00427119 mm Node: 15763	0.353701 mm Node: 52



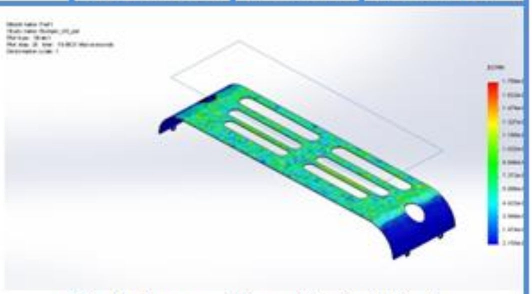
Part1-Bumper_48_per-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	5.38712e-014 Element: 127	0.00440135 Element: 4747



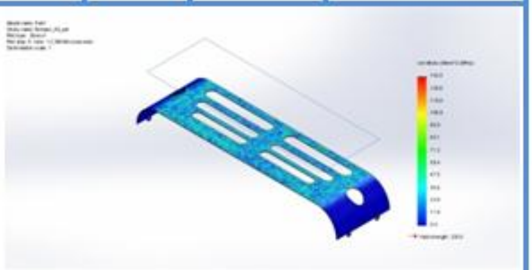
Part1-Bumper_120_per-Strain-Strain1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	2.1547e-014 Element: 127	0.00176926 Element: 4747



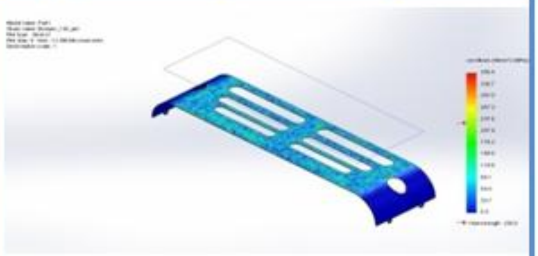
Part1-Bumper_48_per-Strain-Strain1

Name	Type	Min	Max
Stress	VON: von Mises Stress	6.46447e-014 MPa Node: 3932	142.523 MPa Node: 12301



Part1-Bumper_48_per-Stress-Stress1

Name	Type	Min	Max
Stress 1	VON: von Mises Stress	1.48744e-013 MPa Node: 3932	356.365 MPa Node: 12301

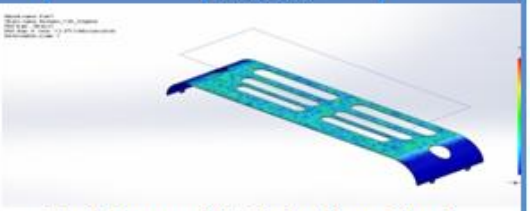


Part1-Bumper_120_per-Stress-Stress1

S2 gloss epoxy Material Properties and impact test speeds 48km/hr, 128km/hr

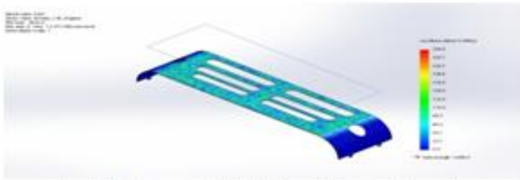
Model Reference	Properties	
	Name:	S2Glass
	Model type:	Linear Elastic Isotropic
	Default failure criterion:	Max von Mises Stress
	Yield strength:	4.89e+009 N/m
	Elastic modulus:	8.69e+010 N/m
	Poisson's ratio:	0.23
	Mass density:	2460 kg/m^3
	Shear modulus:	3.189e+008 N/

Name	Type	Min	Max
Stress1	VON: von Mises Stress	4.85392e-012 (MPa) Node: 2762	264.793 (MPa) Node: 6845



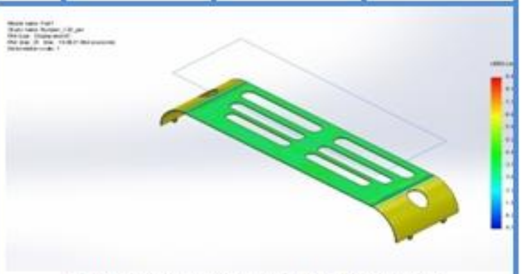
Part1-Bumper_120_S2glass-Stress-Stress1

Name	Type	Min	Max
Stress1	VON: von Mises Stress	4.85392e-012 (MPa) Node: 2762	264.793 (MPa) Node: 6845



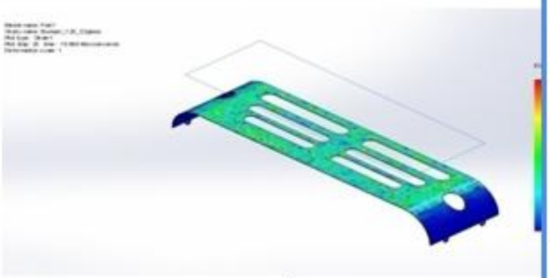
Part1-Bumper_48_S2glass-Stress-Stress1

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.00973094 mm Node: 15763	0.884905 mm Node: 52



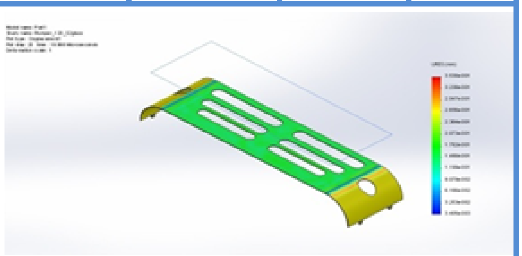
Part1-Bumper_120_per-Displacement-Displacement1

Name	Type	Min	Max
Strain	ESTRN: Equivalent Strain	1.16789e-012 Element: 381	0.00144383mm Element: 6612



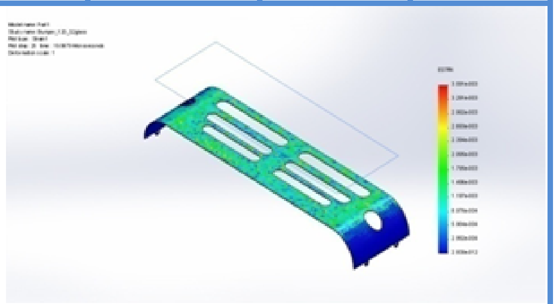
Part1-Bumper_48_S2glass-Strain-Strain1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.00340486 mm Node: 12428	0.352953 mm Node: 536



Part1-Bumper_48_S2glass-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	2.92956e-012 Element: 381	0.00359058 Element: 6612



Part1-Bumper_120_S2glass-Strain-Strain1

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.0146949 mm Node: 15762	0.883082 mm Node: 536

Part1-Bumper_120_S2glass-Displacement-Displacement1

REVIEW OF RESULTS

Material name	Bumper speed	STRESS N/mm^2	DISP mm	STRAIN
STEEL	**48 Km/hr**	701.669	0.362002	0.00162972
	120 Km/hr	1763.44	0.905786	0.00408877
PEI	**48 Km/hr**	142.523	0.353701	0.00176926
	120 Km/hr	356.365	0.884905	0.00440135
S2GLASS EPOXY	**48 Km/hr**	264.793	0.352953	0.00144383
	120 Km/hr	661.332	0.883082	0.00359058

RESULTS AND DISCUSSION

KINETICENERGY

Kinetic energy is the energy of motion whether it is vertical or horizontal. Kinetic energy is absorbed by the bumper plastic deformation and the other energy is dissipated by other forms of deformation. If collision continues, the end of the car bumper will still bend continuously. From the Figure the maximum value of collision force incurred at the beginning and decrease slowly until it turns to zero energy. At the end, the whole structure become unstable and a large displacement incurred due to the bending of the end part. So, at this time the collision force decrease rapidly. Kinetic energy graph of SGE results showed that deformation will occur to the bumper during the collision. Results of kinetic energy for ASE also showed the same result. This is because both materials have the lowest value of Young Modulus compared to PEI. For ASE study results for the bumper showed major plastic deformation because it needs a long period in order to reduce the impact of collision. Next, the physical properties of the material will change according to the arrangement of atoms and molecules after the impact of collisions. So I would choose either SGE or PEI material as substitution for car bumper material. Linear momentum is conserved and since the impact phenomena always with losing energy, kinetic energy is not conserved. The section of kinetic energy system converts to strain energy due to elastic and plastic deformations that occur in bumper.

INTERNALENERGY

Internal energy is the total kinetic and strain energy associated with the motions and relative positions of the molecules of an object. An increase in internal energy results in a rise in temperature or a change in phase. The internal energy also can be obtained if the value of Von Mises Stress is more than or equal to yield stress. This means that the material failed and does not satisfy to be my option. This also shows that the material is ductile and spongy. When collision occurs, the atom in the bumper will vibrate and move to the wall in the bumper. The movement of the atom will produce work done and heat and then transfer to internal energy. The **physical properties** of the bumper also change because it deflects and deforms during the collision. SGE exhibit the best option because it can absorb the energy in a short time and exhibit minor deformation compare to ASE and PEI. Figure shows an internal energy of ASE has a long impulse time during impact. Next one represents an internal energy of PEI. It was also has longer impulse time. In conclusion, SGE gave more benefit in order to improve bumper based on this material selection. It is found that the findings for this work were aligned with studies conducted by many researchers. Based on the tested material, SGE was found as the best material to be used for car bumper. This is supported with findings from where they concluded that SGE in the best material for bumper beam compared to another seven materials. Many other researchers agreed to use SGE as the best material to replace ASE.

CONCLUSIONS

Bumper as the main component in reducing the impact of collision from front view was characterized by COSMOS so as to get the best material and also to strengthen the structure. A commercial fiber glass (composite) model made of S2Glossepoxy and PEI was selected and the standard variables were investigated such as material, structure and impact condition. Besides steel also were assigned to the model and showed inappropriate characteristics such as structural failure and weight increase. Expanded Poly either imides (PEI) as the first selection material was studied or the result showed that this material cannot totally absorb energy and reduce the impact of collision. However, PEI was selected by several car manufacturers because of low cost and easier manufacturing part. High strength SGE composite was proposed to replace STEEL and PEI because it offers better performance in energy absorption and reduce the impact of collision. The structure of SGE showed very good impact compared to other structure which is low in energy absorption and less impact of collision. The time taken for S2Glossepoxy to deflect the impact also shorter compared to other materials which take more than 0.5 seconds. This can cause passenger injury and bad accident. Finally I verify new material for car bumper by simulation software and to reduce the impact of collision that are involved in front bumper are accomplished. So, the authors can conclude that S2Glossepoxy is the best material for bumper in reducing the impact of collision. However I strongly believes rigorous investigation should be carried out to monitor the consistency and benefit of the proposed structure

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