DESIGN AND ANALYSIS OF AN AUTOMOTIVE BUMPER USED FOR LOW PASSENGER VEHICLE

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Abstract: In this work, a bumper used for low passenger vehicle, Benz car. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction at different speeds (40, 60, 75& 80 km/hr).The materials used for these analyses are Aluminum B390 alloy, Chromium coated mild steel, and Glass Mat Thermoplastic (GMT) materials. 3D modeled by using the software Pro-Engineer and analysis done in COSMOS software. In this thesis, the static and impact analysis to determine the stress, strain and deformation, modal analysis to determine the frequency and deformation for Aluminum B390 alloy, Chromium coated mild steel, Glass Mat Thermoplastic (GMT) materials.

Keywords: car bumper, glass mat thermo plastic material, cosmos software, impact analysis.

I. Introduction to bumper of a car

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.

fig:1 front bumper

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.

Fig: 2 bumper

II. Literature review

INTRODUCTION

The purpose of this review of literature is to provide background information on the issues, methodologies and problems related to the present experimental work and emphasize the relevance of the study. The reviews of the available research reports related to the present study are described in this chapter under the following topics.

- Glass mat thermo plastic material
- Impact Analysis

The work done by Chagantipati Sridevi Bumpers play an important role in preventing the impact energy from being transferred to the automotive and a passenger, saving impact energy on the bumper to be released in the environment reduces the damages of the automotive and passengers. The new design considers on reducing the amount of material use and also eliminating the process involve in manufacture the bumper for example eliminating the grille attachment. The goal of this project is to design a bumper with minimum weight by employing the composite materials (just like glass fibre epoxy materials). This bumper either absorbs deformation or transfers it perpendicular to the impact direction. To reach this aim, a mechanism is designed to

convert above 80% of kinetic impact energy is to the spring potential energy. In addition, since the residual kinetic energy will be damped with infinitesimal elastic deformation of the bumper elements, the passengers will not sense any impact, it should be noted in this project modeling, solving and results are analysis are done in ANSYS software respectively. The suitable material that can be used as the bumper in terms of economical but still maintaining the toughness is Carbon Fiber composite which is not expensive compare to the best material from the analysis Aluminum alloy, Mild steel(chromium Coated).

The objectives of this project are:
(a) To design a composite car bumper by using CATIA.
(b) To perform an impact analysis of composite car bumper by using Ansys
(c) To propose a suitable composite material for the car bumper.

III. Problem description and methodology

The impact direction at different speeds (40, 60, 75& 80 km/hr).The materials used for these analyses are Aluminum B390 alloy, Chromium coated mild steel, and Glass Mat Thermoplastic (GMT) materials. 3D modeled by using the software Pro-Engineer and analysis done in COSMOS software.

Material	Car speed(km/hr)
Aluminum B390 alloy	40 60 75 80
Mild steel	
Glass mat thermoplastic	

IV. INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixilated) environments.

INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

INTRODUCTION TO FEA

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

INTRODUCTION TO COSMOS

COSMOS Works uses the Finite Element Method (FEM). FEM is a numerical technique for analyzing engineering designs. FEM is accepted as the standard analysis method due to its generality and suitability for computer implementation. FEM divides the model into many small pieces of simple shapes called elements effectively replacing a complex problem by many simple problems that need to be solved simultaneously.

V. BUMPER LOAD CALCULATIONS

Mass of the car (Benz) =1750 kg

Average mass of 5 persons =350 kg

Total mass =1750+350=2100kg

Assume this car is hitting at another identical one and it will stop in 0.1 seconds.

Deceleration of the car = (u-v)/t

Force acted during collision = m×a

V=final velocity of the car in m/s

U=initial velocity of car in m/s

T=time after which vehicle stopped in seconds.

Pressure acted on the bumper =F/A

SPEED (km/hr)	**Velocity(m/s)**	**Pressure (n/mm^2)**
40	11.11	0.389
60	16.66	0.5845
75	20.83	0.7308
80	22.22	0.7795

VI. MODELING AND ANALYSIS

Fig 3: Car bumper 3d model

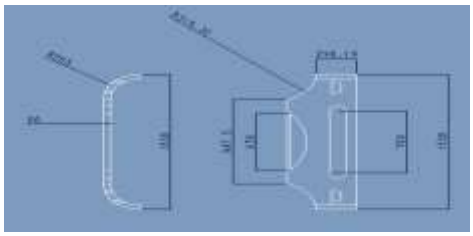


Fig 4: Car bumper 2d model

STATIC ANALYSIS OF CAR BUMPER

USED MATERIAL ALUMINUM B390 ALLOY, MILD STEEL AND GLASS MAT THERMO PLASTIC

Material	Aluminum B390 alloy	Mild steel	Glass mat thermoplastic
Density	2710kg/m^3	7800kg/m^3	4900g/m^2
Young's modulus	81.3GPa	210GPa	69GPa
Poisson's ratio	0.33	0.3	0.39

SPEED OF THE CAR- 40, 60, 75&80km/hr

Fig: 5Imported model

Fig: 6 Meshed model

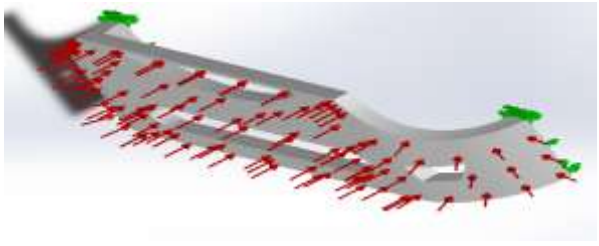


fig: 7 Boundary conditions

Material – aluminum B390 alloy

Speed – 40km/hr

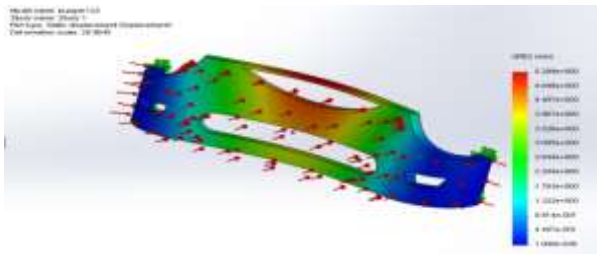


Fig: 8 Deformation

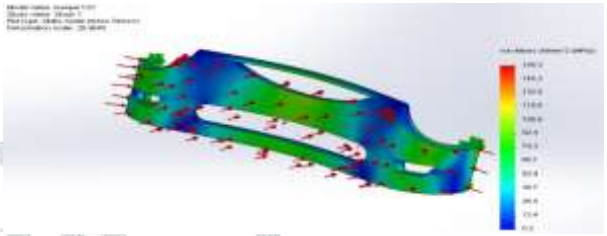


Fig: 9 Stress

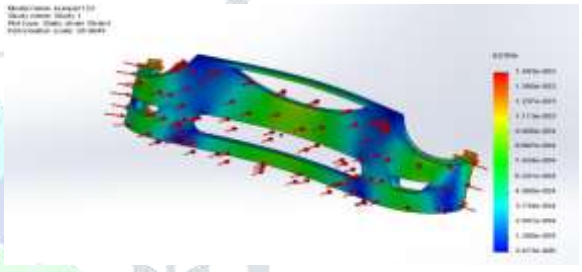


Fig: 10 Strain

MODAL ANALYSIS OF THE CAR BUMPER

Material- aluminum B390 alloy

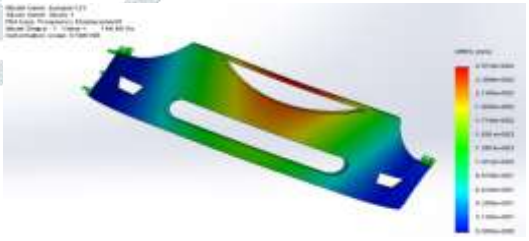


Fig 11Deformation1

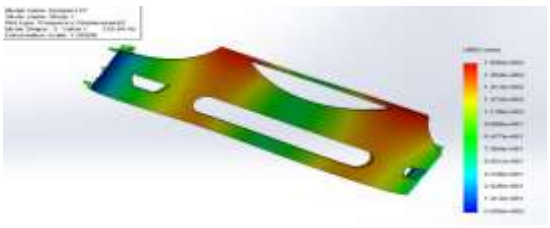


Fig 12 Deformation 2

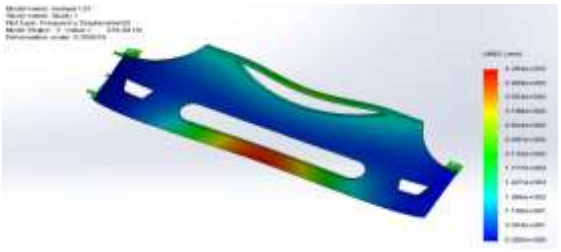


Fig 13 Deformation 3

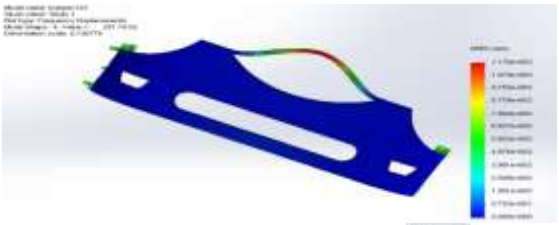


Fig 14 Deformation 4

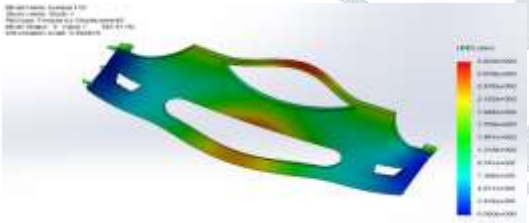


Fig 15 Deformation 5

IMPACT ANALYSIS OF CAR BUMPER

Material – aluminum B390 alloy

Speed – 40km/hr

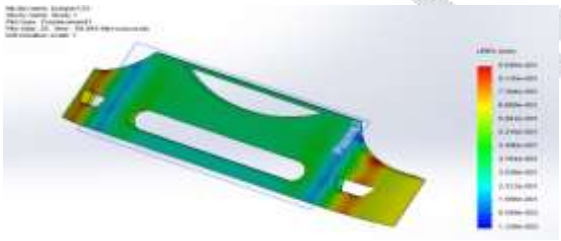


Fig 16 Deformation

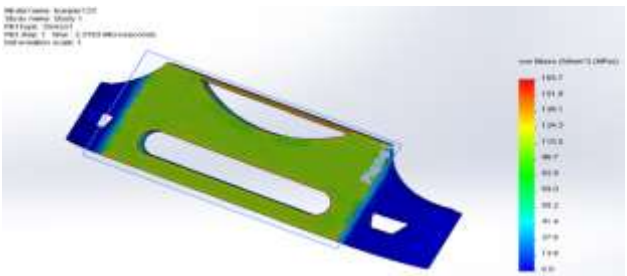


Fig 17 Stress

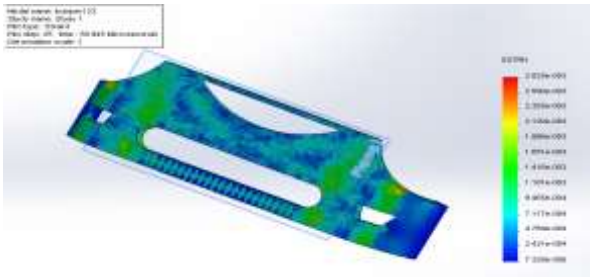


Fig 18 Strain

RESULT & DISCUSSIONS

STATIC ANALYSIS RESULT TABLE

Material	Car speed(km/hr)	Deformation(mm)	Stress (MPa)	Strain
Aluminum B390 alloy	40	5.289e+000	158.3	1.483e-003
	60	7.949e+000	238.0	2.230e-003
	75	9.925e+000	297.1	2.784e-003
	80	1.047e+001	313.4	2.936e-003
Mild steel	40	4.812e-004	154.8	4.812e-004
	60	8.477e-004	236.6	8.477e-004
	75	1.058e-003	295.4	1.058e-003
	80	1.116e-003	311.6	1.116e-003
Glass mat thermoplastic	40	7.177e+001	142.8	1.462e-002
	60	7.44e+001	176.1	1.787e-002
	75	1.518e+002	251.8	2.660e-002
	80	1.933e+002	290.5	3.094e-003

MODAL ANALYSIS RESULT TABLE

Material	Mode shapes	Deformation (mm)	Frequency (Hz)
Aluminum B390 alloy	Mode1	2.574e+002	146.66
	Mode2	1.695e+002	216.84
	Mode3	4.264e+002	234.09
	Mode4	1.170e+003	251.79
	Mode5	2.922e+002	393.41
Mild steel	Mode1	1.513e+002	138.72
	Mode2	9.890e+001	204.81
	Mode3	2.511e+002	222.61
	Mode4	6.890e+002	238.25
	Mode5	1.682e+002	373.87
Glass mat thermo plastic	Mode1	4.216e+002	69.923
	Mode2	2.826e+002	103.78
	Mode3	6.963e+002	110.38
	Mode4	1.912e+003	139.98
	Mode5	4.987e+002	185.74

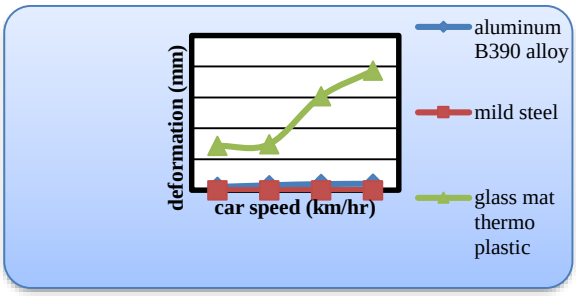
IMPACT ANALYSIS RESULT TABLE

Material	Car speed(km/hr)	Deformation(mm)	Stress (MPa)	Strain
Aluminum B390 alloy	40	8.846e-001	165.7	2.825e-003
	60	1.326e+000	248.6	4.236e-003
	75	1.657e+000	310.8	5.293e-003
	80	1.768e+000	331.6	5.644e-003
Mild steel	40	8.827e-001	436.6	2.789e-003
	60	1.323e+000	654.9	4.17e-003
	75	1.654e+000	818.9	5.211e-003
	80	1.764e+000	873.6	5.557e-003
Glass mat thermoplastic	40	8.886e-001	18.0	4.461e-003
	60	1.333e+000	27.1	6.690e-003
	75	1.670e+000	33.9	8.371e-003
	80	1.782e+000	36.1	8.933e-003

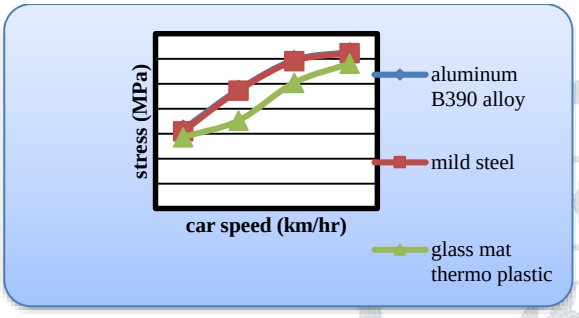
GRAPHS

STATIC ANALYSIS GRAPHS

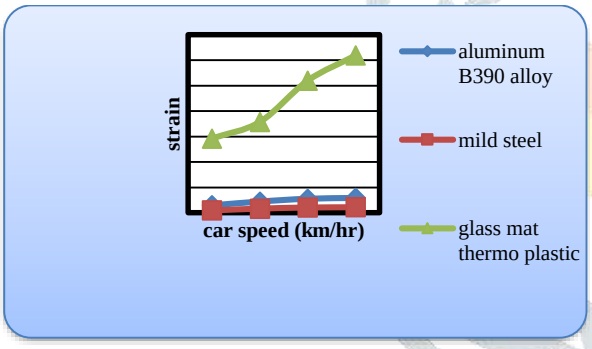
DEFORMATION PLOT



STRESS PLOT

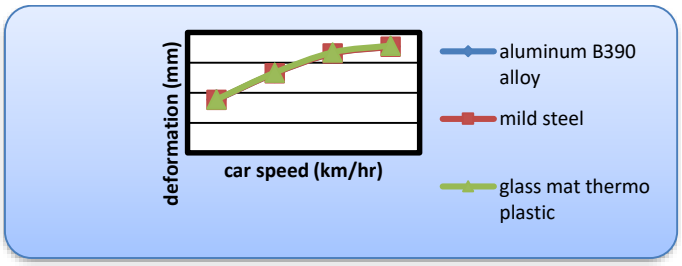


STRAIN PLOT

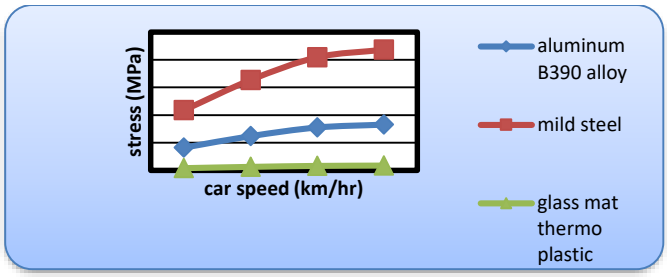


IMPACT ANALYSIS GRAPHS

DEFORMATION GRAPH



STRESS PLOT



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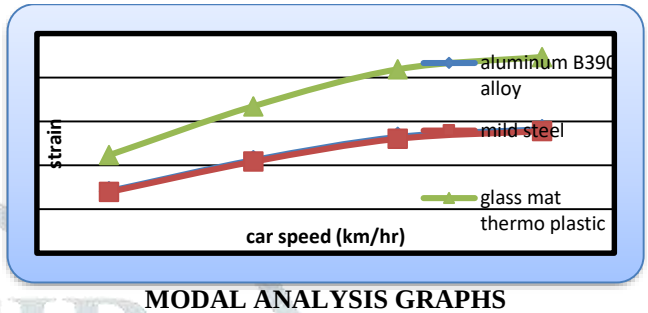
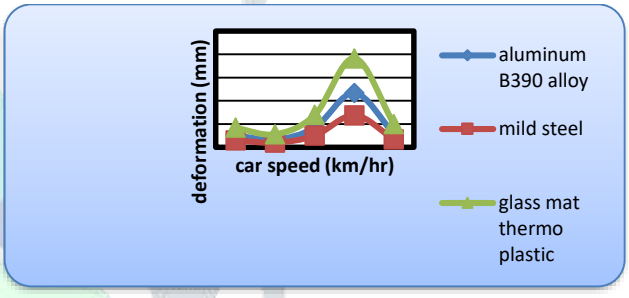
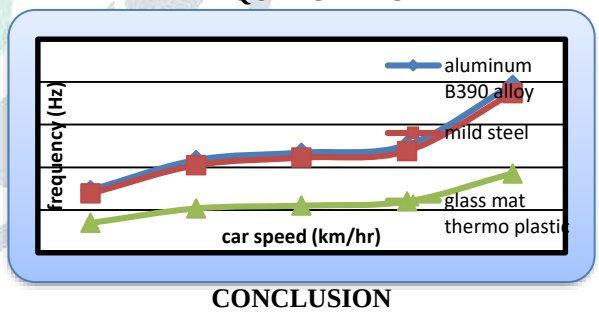


MODAL ANALYSIS GRAPHS

DEFORMATION PLOT



FREQUENCY PLOT



CONCLUSION

In this work, a bumper used for low passenger vehicle, Benz car. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction at different speeds (40, 60, 75& 80 km/hr). The materials used for these analyses are Aluminum B390 alloy, Chromium coated mild steel, carbon composite and Advanced Glass Mat Thermoplastic (AGMT) materials. By observing the static analysis, the deformation and stresses increases by increasing the car speed and high deformation & low stress for glass mat thermoplastic material when compare the mild steel and aluminum alloy B390.By observing the modal analysis the deformation value low for glass mat thermoplastic material than mild steel and aluminum alloy B390.By observing the model analysis, the deformation and stresses increases by increasing the car speed and high deformation & low frequency developed in

glass mat thermoplastic material when compare the mild steel and aluminum alloy B390.From all these analysis glass mat thermo plastic material is better for car bumper.

REFERENCES

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