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RESEARCH ARTICLE OPEN ACCESS

Design and Analysis of a Car Bumper Using Springs

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Abstract:

Automotive design with economy and safety has been a great challenge to design engineers. The safety of the passengers and vehicle during vehicle crashes can be ensured to a certain limit by using good bumpers. Bumper is an important part of vehicle which acts as one of the safety part of vehicle, now a day's bumper is used in vehicle which directly connected to chassis of vehicle. So that when accidents are happened the force that transfer to other parts of vehicle through linkage There is no mechanism to drop that linkage and to absorb that impact forces. So that the development of a new bumper system by springs. Spring is used to minimize the impact of accidents and it will resists or absorbs impact forces. The new bumper system will be design in CATIA and structural analysis is done by ANSYS. For structural analysis of the bumper materials like Glass mat thermoplastics (GMT), carbon fiber composite and aluminum B390 materials are used.

1. INTRODUCTION:

Automotive design with economy, safety and aesthetics have been a great challenge to design engineers. Augmenting to these factors today environment impact is an upcoming research area. The safety of the passengers during vehicle crashes can be ensured to a certain limit by using good bumpers. In automobiles (passenger) and heavy vehicles bumper is used in front and rear of vehicle as safety purpose. It made in such a way that it takes maximum impact of vehicle and after accident it goes towards chassis. The lot of research is done in this field on material basis. most of the vehicle use bumper which made from steel, light material such as aluminium, and plastic and many more. now a days the bumper that we have seen on vehicle is directly connected to chassis, so there is solid to solid contact between bumper and chassis ,furthermore no space is kept between bonnet and bumper all they make closed (fixed) contact. bumper system that connected to chassis of vehicle with no gap between bonnet and bumper so that after accident impact travel in linkage, and affect to bonnet, engine and finally goes to driver cabin and passenger. But in this paper we proposed new system for bumper in such a way that it will break the linkage of impact which is form by solid to solid contact, by using springs with maintaining the gap between bumper and bonnet.

2.LITERATURE:

B Karthik (2015) "Design and analysis of coil spring shock absorbing bumper to release impact stresses in automobiles". The designed mechanism is used to convert the impact stresses to spring potential energy. Longitudinal Coil Spring Shock Absorbing Bumper the main Components to design are Spring with the stiffness required to manage the impact and the arms that joins shock absorber and the bumper and the small link which pivots between the two arms at both the sidesTo increase the bumper efficiency and passenger safety[1].

Alen john,nidhi (2014)"Modelling and Analysis of an Automotive Bumper Used for a Low Passenger Vehicle". The materials used for these analysis are Aluminium B390 alloy, Chromium coated mild steel and carbon composite. During the impact analysis, the composite shows the highest stress value, lowest deformation and the lowest strain value on compared with above materials. The analysis under the dynamic loading shows this carbon composite has the maximum stress value and it having the highest strength to weight ratio and producing low deformation.[2].

A.R. Mortazavi Moghaddam, M. T. Ahmadian (2011)"Design and Analysis of an Automobile Bumper with the Capacity of Energy Release Using GMT Materials" The design of a bumper with minimum weight by employing the Glass Material Thermoplastic (GMT) materials. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction{[3].

3.MATERIAL SELECTION:

In generally bumpers are manufactured by using conventional materials like mild steel, cast iron and stainless steel etc. To reduce the weight of the bumper composite materials and alloys are used .these are having high strength to weight ratio, stiffness and less corrosive. To analyze the bumper models the materials like carbon fiber composite, glass mat thermoplastic and aluminum B 390 materials are used.

TABLE 1.MATERIAL PROPERTIES

Material	Density(kg/m^3)	Young's modulus (Gpa)	Poisson's ratio
Carbon fiber composite	1600	85	0.15
Aluminium B390	2710	81.3	0.33
Glass mat thermoplastic	1280	12	0.41

4.MODELLING

4.1 INTRODUCTION TO CATIA

CATIA is a one of the worlds leading high-end CAD/CAM/CAE software packages. CATIA (Computer Aided Three dimensional Interactive Application) is a multi-platform PLM/CAD/CAM/CAE commercial software suite developed by Dassault Systems and marketed world-wide by IBM.CATIA is written in the C++ programming language. CATIA provides open development architecture through the use of interfaces, which can be used to customize or develop applications. The application programming interfaces supported Visual Basic and C++ programming languages. Commonly referred to as 3D Product Lifecycle Management (PLM) software suite, CATIA supports multiple stages of product development. The stages range from conceptualization, through design (CAD) and manufacturing (CAM), until analysis (CAE). Each workbench of CATIA V5 refers an each stage of product development for different products. Catia V5 features a parametric solid/surface-based package which uses NURBS as the core surface representation and has several workbenches that provide KBE (Knowledge Based Engineering) support.

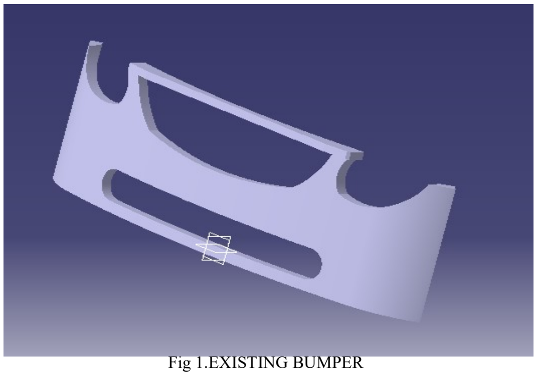

Fig 1.EXISTING BUMPER

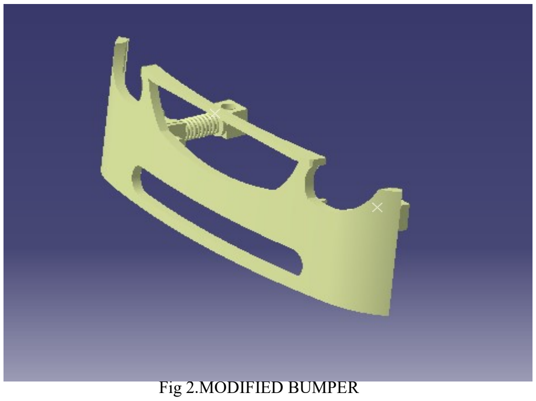

Fig 2.MODIFIED BUMPER

5.PRESSURE CALCULATIONS

Mass of the car =1554kg.
Average mass of 5 persons =350kg.
Total mass=1554+350=1894kg.
Speed of the car=5km/hr, 35km/hr, 60km/hr and 80km/hr.

Convert km/hr into m/s:

Speed at 5km/hr=(5*5)/18=1.38889m/s.
Speed at 35km/hr=(35*5)/18=9.72222 m/s.
Speed at 60km/hr=(60*5)/18=16.6667 m/s.
Speed at 80km/hr=(80*5)/18=22.222 m/s.

Acceleration of car a=(u-v)/2:

At 5km/hr a=(1.38889-0)/0.1=13.8889 m/s^2.
At 35km/hr a=(9.72222 -0)/0.1=97.2222 m/s^2.
At 60km/hr a=(16.6667 -0)/0.1=166.667 m/s^2.
At 80km/hr a=(22.222 -0)/0.1=222.22 m/s^2.

Force calculation F=m*a:

At 5km/hr F=1894*13.8889=26305.5766N.
At 35km/hr F=1894*97.2222=184138.8468N.
At 60km/hr F=1894*166.667 =315667.298N.
At 80km/hr F=1894*222.22 =420888.846N.

PRESSURE (P) =F/A:

Area=504000mm^2.
At 5km/hr σ =26305.5766/0.504=0.05219N/mm^2.
At 35km/hr σ =184138.8468/0.504=0.365 N/mm^2.
At 60km/hr σ =315667.298/0.504=0.62632 N/mm^2.
At 80km/hr σ =420888.846/0.504=0.83509 N/mm^2.

6.ANSYS

6.1 INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

6.2 STRUTURAL ANALYSIS

Structural analysis is probably the most common application of the finite element method as it implies bridges and buildings, naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools. the structural analysis done at different speeds like 5,35,60,80 km/hr and different materials carbon fiber composite, glass mat thermoplastic and Aluminum B390 respectively.

6.2.1.BUMPER WITH OUT SPRINGS:

(i) CARBON FIBER COMPOSITE(5km/hr):

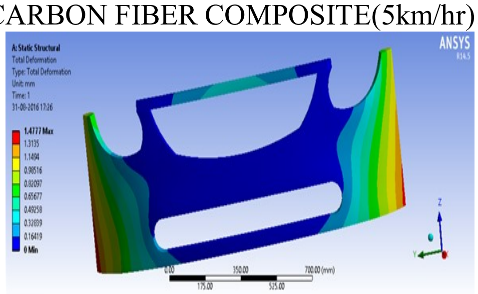

Fig 3.total deformation

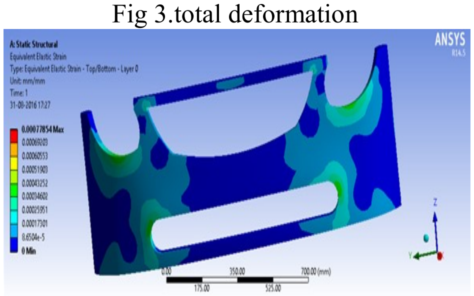

Fig 4.Equivalent elastic strain

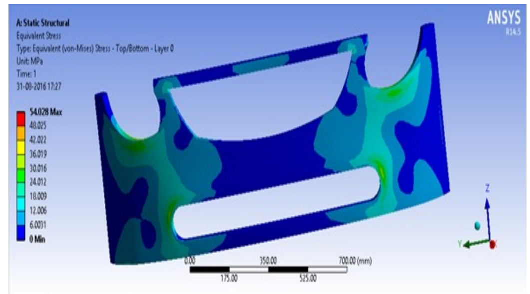

Fig 5.von-mises stress

similarly the structural analysis for bumper without springs for carbon fiber composite, Glass mat thermoplastic and aluminium B 390 materials and speeds like 5,35,60.80km/hr done resectively.The comparison of results will shown in tabular column.

TABLE 2. COMPARISON OF STRUCTURAL ANALYSIS RESULTS BUMPER WITH OUT SPRINGS

MATERIAL	SPEED Km/hr	DEFORMATION (mm)	EQUIVALENT STRESS (Mpa)	EQUIVALENT ELASTIC STRAIN
CARBON FIBER COMPOSITE	5	1.477	54.028	0.00078
	35	10.345	378.22	0.00545
	60	17.734	648.38	0.009343
	80	23.646	864.51	0.0124
GLASS MAT THERMO -PLASTIC	5	9.68	65.018	0.00562
	35	67.77	455	0.039
	60	80.47	621.2	0.53
	80	107.3	828.26	0.070
ALUMINIUM B 390	5	1.478	61	0.000821
	35	10.346	426.95	0.005749
	60	17.736	731.92	0.0098
	80	23.648	975.9	0.01314

6.2.2.BUMPER WITH SPRINGS

(i) CARBON FIBER COMPOSITE (5km/hr)

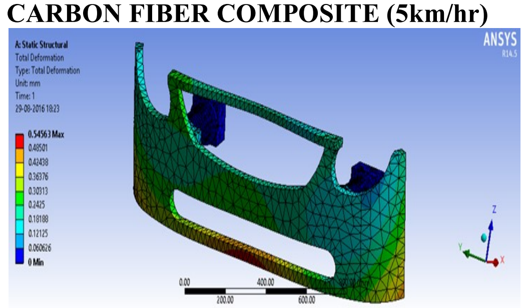

Fig 6.Total deformation

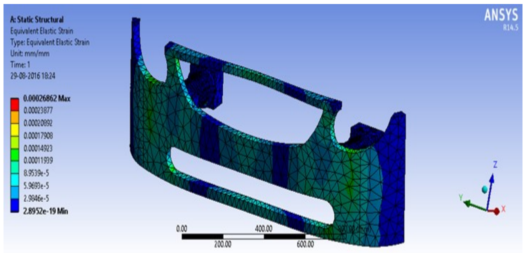

Fig 7.equivalent elastic strain

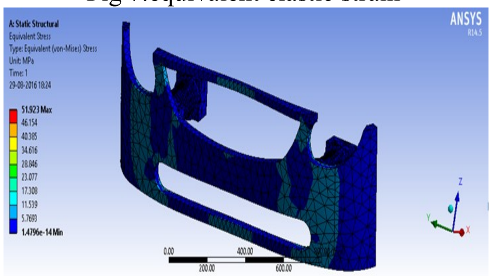

Fig 8.Von-mises stress

similarly the structural analysis for bumper with springs for carbon fiber composite, Glass mat thermoplastic and aluminium B 390 materials and speeds like 5,35,60.80km/hr done resectively.The comparison of results will shown in tabular column.

TABLE 3. COMPARISON OF STRUCTURAL ANALYSIS RESULTS BUMPER WITH SPRINGS

MATERIAL	SPEEDS(km/hr)	DEFORMATION(mm)	EQUIVALENT STRESS (Mpa)	EQUIVALENT ELASTIC STRAIN
CARBON FIBER	5	0.54563	51.923	0.00026862
	35	3.8878	369.97	0.0019
	60	6.7684	644.09	0.003332
	80	8.884	845.41	0.0043736
GLASS MAT THERMO-PLASTIC	5	2.5053	44.544	0.001186
	35	17.846	317.3	0.00846
	60	30.593	543.94	0.1451
	80	40.791	725.56	0.019346
ALUMINIUM B390	5	0.5321	50.9	0.000263
	35	3.7906	363.1	0.0018
	60	6.601	632.31	0.00326
	80	8.6643	829.9	0.0042

6.3 MODAL ANALYSIS

A modal analysis is typically used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed/

6.3.1BUMPER WITH OUT SPRINGS:

CARBON FIBER COMPOSITE

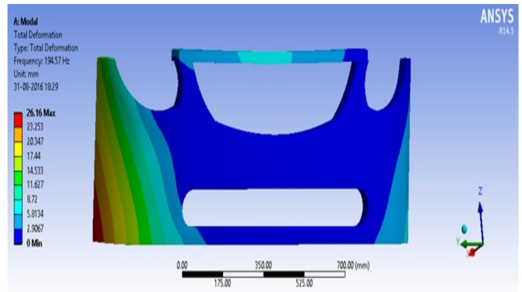

Fig 9.Total deformation at mode 1

GLASS MAT THERMOPLASTIC

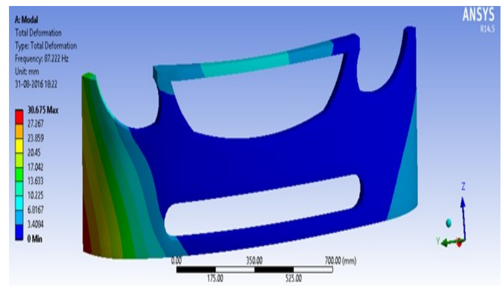

Fig 10. Total deformation at mode 1

ALUMINIUM B 390

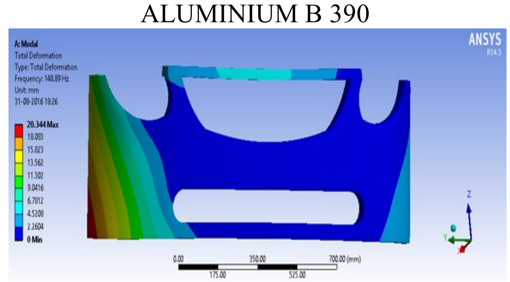

Fig 11. Total deformation at mode 1

Similarly modal analysis for bumper without springs carbon fiber composite, glass mat thermoplastic and aluminum b 390 is done at different modes. the comparison of frequency's and deformations are done.

TABLE 4.COMPARISON OF MODAL ANALYSIS RESULTS BUMPER WITH OUT SPRINGS

MATERIAL	MODES	FREQUENCY (Hz)	DEFORMATION (mm)
CARBON FIBER COMPOSITE	1	194.57	26.61
	2	199.72	26.128
	3	243.96	32.453
	4	256.71	44.843
	5	321.88	23.164
	6	339.31	27.726
GLASS MAT THERMO - PLASTIC	1	87.22	30.67
	2	89.352	30.75
	3	106.24	40.21
	4	110.25	51.38
	5	139.03	27.54
	6	144.91	30.17
ALUMINIUM B390	1	148.89	20.344
	2	152.61	20.38
	3	183.27	25.99
	4	191.32	34.328
	5	239.87	18.137
	6	251.56	20.656

6.3.2 BUMPER WITH SPRINGS:

CARBON FIBER COMPOSITE

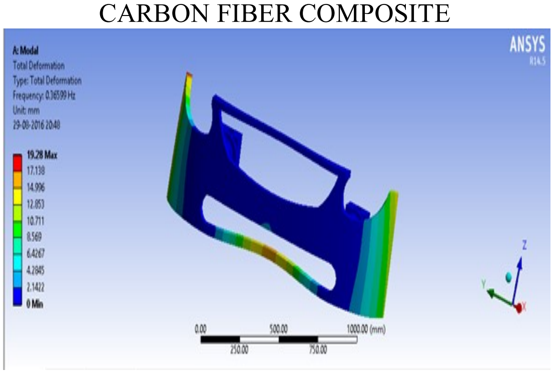

Fig 12.Total deformation at mode 1

GLASS MAT THERMOPLASTIC

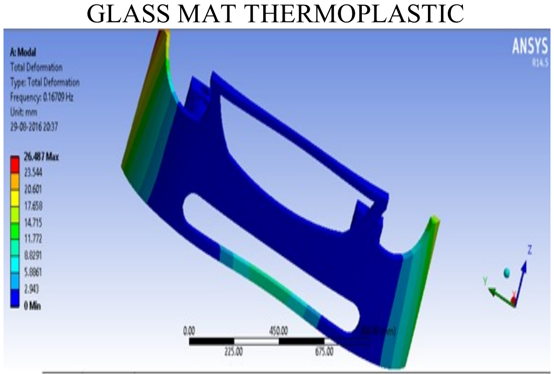

Fig 13. Total deformation at mode 1

ALUMINIUM B 390

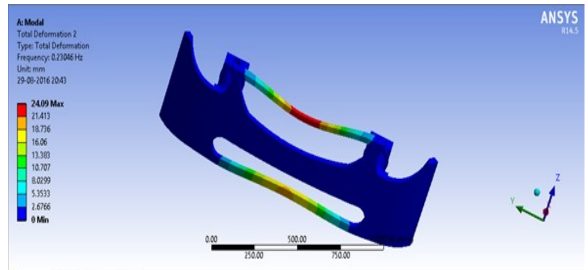

Fig 14. Total deformation at mode 1

Similarly modal analysis for bumper with springs carbon fiber composite, glass mat thermoplastic and aluminum b 390 is done at different modes. the comparison of frequency's and deformations are done.

TABLE 5.COMPARISON OF MODAL ANALYSIS RESULTS BUMPER WITH OUT SPRINGS

MATERIALS	MODES	FREQUENCY (Hz)	DEFORMATION (mm)
CARBON FIBER COMPOSITE	1	0.29633	19.28
	2	0.30904	30.72
	3	0.31979	40.475
	4	0.34736	27.247
	5	0.35496	17.687
	6	0.36599	19.28
GLASS MAT THERMO-PLASTIC	1	0.12769	26.487
	2	0.13292	40.53
	3	0.13608	36.633
	4	0.15082	38.828
	5	0.16087	24.518
	6	0.16709	26.487
ALUMINIUM B 390	1	0.2216	16.8
	2	0.23046	24.09
	3	0.23646	26.44
	4	0.26112	25.146
	5	0.2731	15.452
	6	0.28317	16.8

7.CONCLUSION

The bumper with springs and without springs is designed and analysis is done. The stresses, displacements and frequencies are determined at different speeds 5Km/hr, 35Km/hr, 60Km/hr and 80Km/hr by static and modal analysis. By observing the static analysis results, carbon fiber composite and aluminum B390 material shows high von-mises stress values and low deformation values these two materials are best among the three materials. By observing the modal analysis results, the frequencies are less for glass mat thermoplastic material but the deformations are high for glass mat thermoplastic and carbon fiber composite and aluminium b390 shows the low deformation. All parameters shows high values for existing bumper.

7.FUTURE SCOPE

Dynamic analysis may be applied and the proposed design may applied for all type automobiles.

8.ACKNOWLEDGMENT

The research work dedicated to my parents, staff in mechanical deportment in annamacharya institute of technology and sciences and guide who always motivate and guide me,

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