WEIGHT OPTIMISATION OF COMPOSITE BUMPER BEAM IN COMPACT ELECTRIC CARS

Ms. Shital Potdar[1], Prof. N. Vivekanandan[2].

[1] ME Student, Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Pune
[2] Professor, Dept. of Mechanical Engineering, Pimpri Chinchwad College of Engineering, Pune

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Abstract – *A Front Bumper beam is an important automotive component to protect passengers from injury and damage produced by severe collision. Composite materials can be used in Bumper beam to increase the structural performance and providing light weight solutions. Initially we considered 3 shapes of bumper beam i.e., D shape, B shape and C shape. Static Structural analysis was performed on these 3 shapes. The results are analyzed from the aspect of Equivalent stress and Total deformation. Then it is observed that C shape bumper beam gives better best result than other shapes. So, we used C shape bumper for further process. For designing of bumper beam 2 different composite materials are used i.e., jute fiber and synthetic glass fiber. Static structural analysis performed for both the composites. After FEA results, Optimized composite beams manufactured using hand lay-up method. Experimental validation of optimized composite beam was done on Universal Testing Machine by three-point bending test.*

Key Words: Bumper Beam, Composite Material, Structural Analysis.

1. INTRODUCTION

In recent years the auto industries are principally concentrating on electrical cars development. however electrical automotives conjointly needed external body to protect passengers from car accident. And conjointly want BIW systems for assemblies [2]. The Bumper is most vital element and highlighted part in safety. The bumper is generally manufactured from steel.

A bumper may be a structurally connected or integrated with the front and rear ends of a motorized vehicle, to soak up the impact in a minor collision, ideally minimizing the repair prices. the aim of getting a bumper on your automotive is incredibly specific. many of us suppose that its purpose is to stop or reduce injury severity in a very crash [3]. In fact, bumpers don't seem to be thought of safety options supposed to shield occupants in the slightest degree. The aim of bumper is to scale back or forestall physical harm to the front and rear of vehicles in low-speed crashes. The bumpers are designed to shield the hood, trunk, grill, fuel, exhaust and cooling system.

A bumper is typically manufactured from steel, Aluminum, etc. It absorbs shocks from automotive accidents. The standard says it needs protection within the region sixteen to twenty inches higher than the paved surface.

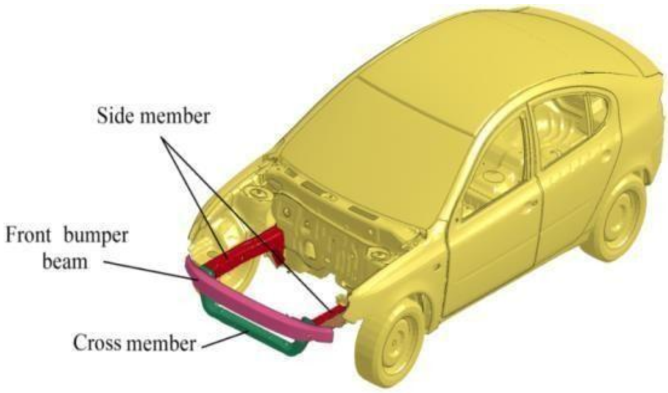


Fig. Front Bumper Beam

As electrical cars are chiefly specialized in the efficiency of the battery and driving range. So, scale back the burden of the automobile is best plan to extend the potency of the electron volt. So, to beat this designated Al and stuff are designated to develop machine bumper. however, focus is on conjointly strength of the bumper. Develop differing kinds of form of bumper to extend the effectiveness of the most purpose of bumper.

There are differing kinds of stuff on the market in market and chiefly classified as natural stuff and artificial composite materials [1]. These constituent materials have notably dissimilar chemical or physical properties and are incorporated to form a cloth with properties in contrast to the individual parts. Inside the finished structure, the individual parts stay separate and distinct, characteristic composites from mixtures and solid solutions. Fiber- reinforced chemical compounds embrace carbon fiber bolstered polymer and glass-reinforced plastic. If classified by matrix then there are thermoplastic composites, short fiber thermoplastics, long fiber thermoplastics or long fiber- reinforced thermoplastics.

2. LITERATURE SURVEY

The paper [1] proposes Carbon fiber composites have demonstrated to have the option to perform incredibly well on account of a crash and are being used to produce committed energy-retaining parts, both in the engine sport world and in developments of aeronautic design. While in metallic designs the energy assimilation is achieved by plastic deformity, in composite ones it depends on the material diffuse crack. The plan of composite parts ought to give steady, standard and controlled dispersal of dynamic energy to keep the deceleration level as least as could be expected. That is possible solely after nitty gritty insightful, exploratory and numerical examination of the primary crashworthiness. In request to guarantee the driver's security if there should arise an occurrence of high-speed crashes, extraordinary effect structures are intended to retain the racecar's motor energy and cutoff the deceleration following up on the human body. In current auto turn of events, to improve their crashworthiness and increment solidness to weight proportion, composite material is presented with the extent of streamlining of car body parts.

The paper [2] proposes Application of normal fiber composites will increment in various regions caused by environmental, technical and financial benefits. In any case, their low mechanical properties have restricted their particular application in car primary segments. Hybridizations with different fortifications or matrices can improve mechanical properties of regular fiber composite. Also, mathematical optimizations have a critical part in primary strength improvement. This investigation zeroed in on choosing the best geometrical guard pillar idea to fulfill the security boundaries of the characterized item plan specification.

The paper [3] proposes Taylor and Francis bends over backward to guarantee the exactness of all the data (the "Content") contained in the distributions on our foundation. Be that as it may, Taylor and Francis, our representatives, and our licensors make no representations or guarantees at all regarding the accuracy, completeness, or appropriateness for any reason for the Content. Any assessments and perspectives stated in this distribution are the viewpoints and perspectives on the creators, and are not the perspectives on or supported by Taylor and Francis. The exactness of the Content not be depended upon and should be autonomously checked with essential wellsprings of data. Taylor and Francis will not be responsible for any misfortunes, activities, claims, procedures, requests, costs, costs, harms, and different liabilities what severer howsoever caused emerging straightforwardly or by implication regarding, in relation to or emerging out of the utilization of the Content. To diminish fuel utilization and outflows and to help improve vehicle's presentation, it is important to make vehicles lighter.

The paper [4] proposes the crashworthiness and lightweight necessities in auto industry, composite material shave been acquiring progressively more consideration for their high explicit strength, high specific stiffness and high energy retention capacity. Guard framework is one of the fundamental designs which secure cars from the front and back crashes. It's anything but a powerful method to foster the guard framework utilizing composite materials to meet the accident security and lightweight requests at the same time. Notwithstanding, the application of composite material additionally brings incredible difficulties into the enhancement configuration measure, for example, complex non-direct material conduct, multi working conditions and enormous measure of plan factors. In this paper, a construction plan and enhancement strategy are proposed for a business front guard system made via carbon fiber woven composite.

The Paper [5] proposes automotive guard pillar is a significant part to shield traveler and vehicle from injury and damage actuated by serious breakdown. Late examinations showed that froth filled designs have significant advantages in light weight and high energy assimilation. In this paper, a novel guard shaft filled with functionally evaluated froth (FGF) is considered here to investigate its crashworthiness. To approve the FGF bumper shaft model, the tests at both segment and full vehicle levels are conducted. Parametric study shows that inclination outstanding boundary m that controls the variety of froth density has critical impact on guard bar's crashworthiness; and the crashworthiness of FGF-filled bumper beam is discovered far superior to that of uniform froth (UF) filled and empty guard bar. A FGF-filled guard bar framework was concentrated in this paper, aimed to improve the energy absorption under sway. A numerical FGF-filled guard bar model was worked with unequivocal finite element code LS- DYNA. Parametric examination was directed to explore the impacts of FGF-filled guard shaft boundaries on crashworthiness in correlation with the UF-filled guard beams. It was tracked down that the FGF-filled guard bar permitted absorbing more sway energy than the UF-loaded up with a similar weight. Density angle m, thickness range (qf1 and qf2), and divider thickness effect sly affect EA, SEA, Fmax, and CFE.

3. PROBLEM STATEMENT

1) To study effect of cross-sectional shapes of structures on electric cars bumper beam.

2) Study of Natural and Synthetic composite fibers used for bumper beam application.

4. OBJECTIVES

1) To perform static structural analysis of composite bumper beam in ANSYS Workbench.

2) Manufacturing of optimized composite beam using hand layup Methodology.

3) Study of Natural & Synthetic composite fibers used for bumper beam application.

4) Experimental validation of optimized composite beam with the help of 3 point bending test on UTM Machine.

5. METHODOLOGY

Step_1- Initially research paper is studied to find out research gap for project then necessary parameters are studied in detail. After going through these papers, we learnt about reinforcement of composite material bumper beam in compact electric cars.
Step_2- Research gap is studied to understand new objectivesfor project.
Step_3- After deciding the components, the 3D Model and drafting will be done with the help of CAD software.
Step_4- The static structural analysis of the components will be performed with the help of ANSYS tool post
Step _5- The Experimental Testing will be carried out using UTM.
Step_6- Comparative analysis between the experimental and analysis result.

EXISTING CAD BUMPER BEAM

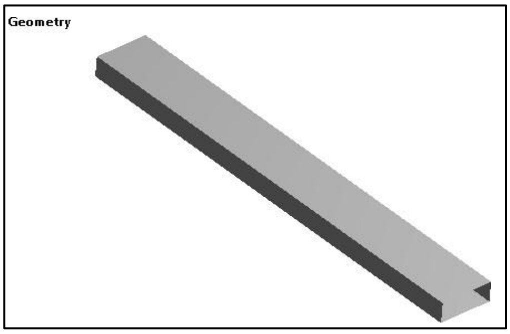


Fig.1 CAD model of D section

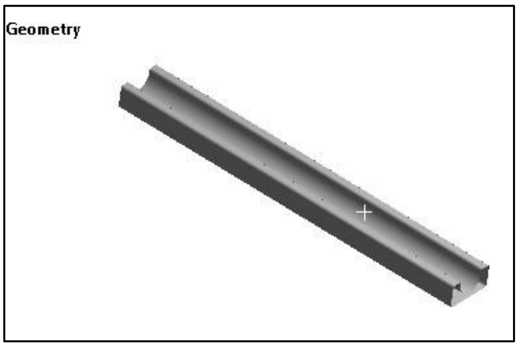


Fig. 2 CAD model of B Section

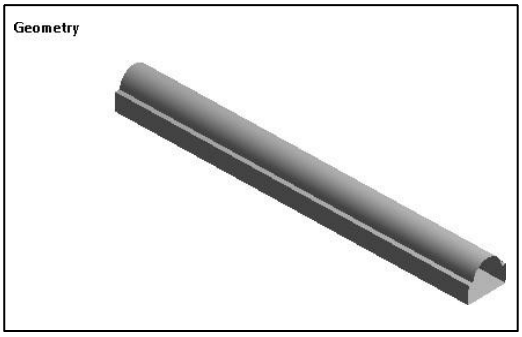
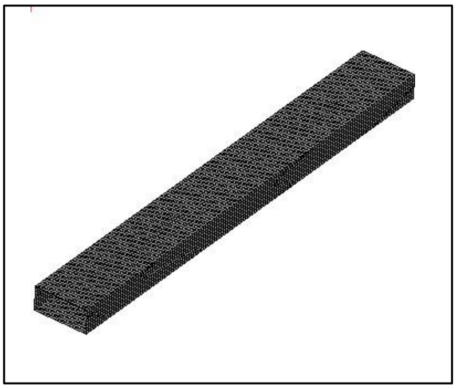


Fig. 3 CAD model of C Section

MESH

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multiphysics solutions.



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Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Type	Element Size
Element Size	2.0 mm
Advanced	
Defeature Size	Default (3.9031e-002 mm)
Size Function	Uniform

Statistics	
Nodes	7853
Elements	7803

Fig. Meshing details

BOUNDRY CONDITION

A boundary condition for the model is that the setting of a well-known value for a displacement or an associated load. For a specific node you'll be able to set either the load or the displacement but not each. The main kinds of loading obtainable in FEA include force, pressure and temperature. These may be applied to points, surfaces, edges, nodes and components or remotely offset from a feature. We apply the 15000 N force on the front bumper as shown in fig. of boundary condition for calculating the maximum deformation and equivalent stress.

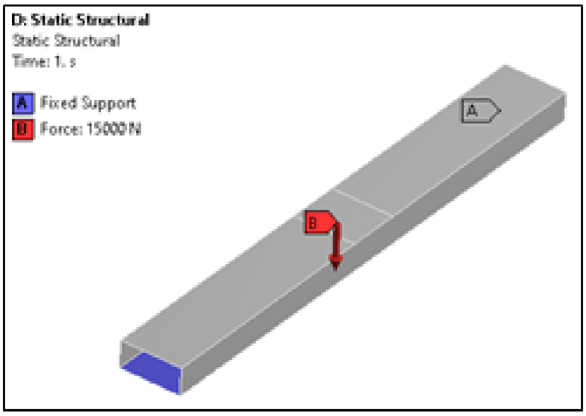


Fig. Boundary condition for bumper beam

RESULTS

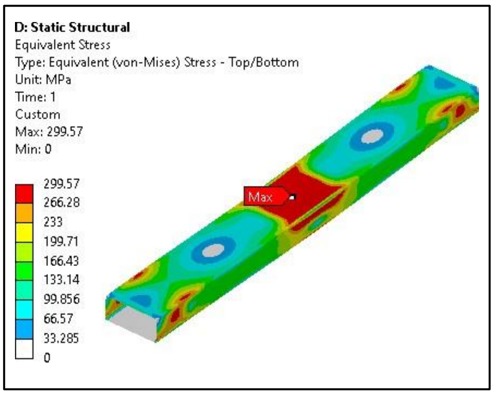


Fig. Equivalent stress

The equivalent stress is 299.57 MPa.

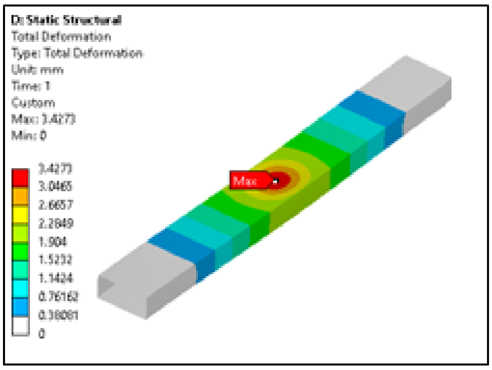
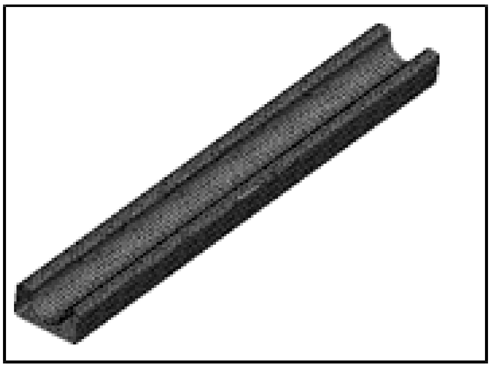


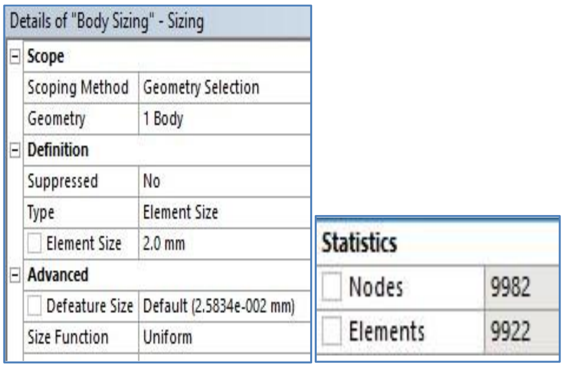
Fig. Total deformation

The maximum deformation is 3.4mm

ANALYSIS OF B SHAPE BUMPER

MESHING





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Definition	
Suppressed	No
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Advanced	
Defeature Size	Default (2.5834e-002 mm)
Size Function	Uniform

Statistics	
Nodes	9982
Elements	9922

Fig. Meshing details Of B Shape Bumper

BOUNDARY CONDITION

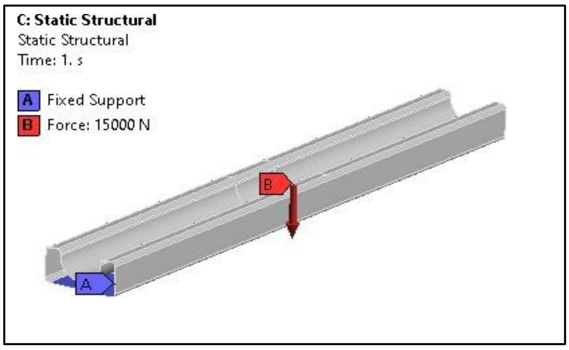


Fig. Boundary condition Of B Shape Bumper

RESULTS

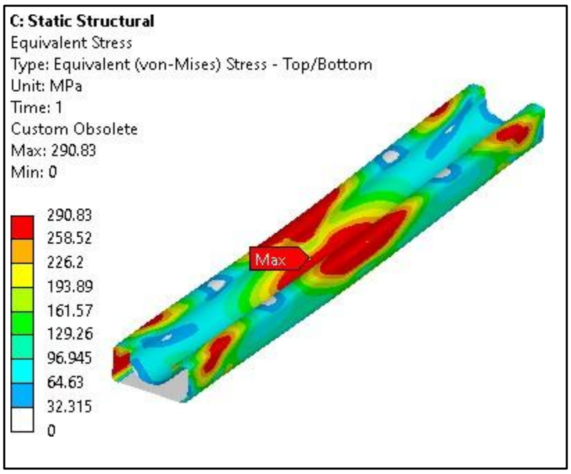


Fig. Equivalent stress Of B Shape Bumper

Maximum Equivalent stress was induced in B Shape Bumper is 290.83 MPa

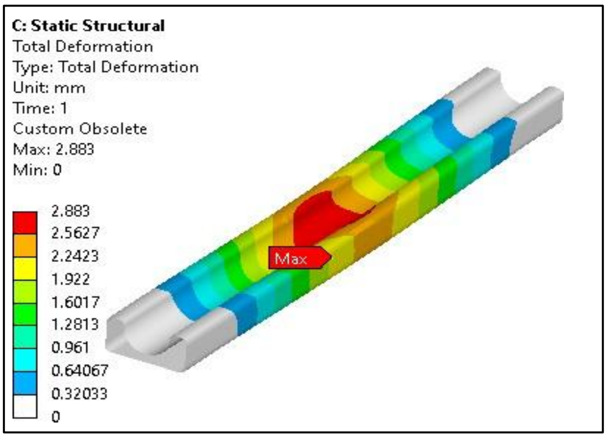
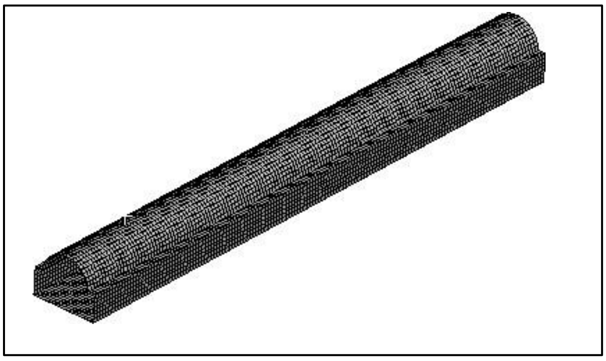


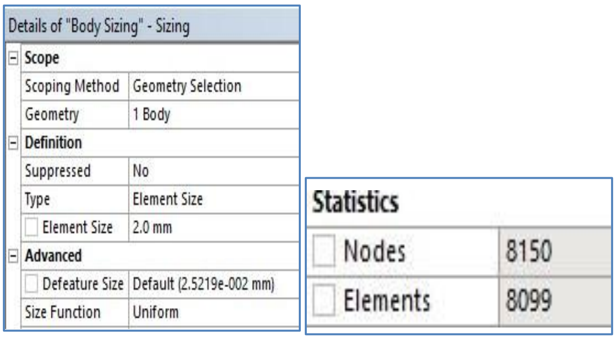
Fig. Total deformation Of B Shape Bumper

Maximum deformation was induced in B Shape Bumper is 2.883 mm

ANALYSIS OF C SHAPE BUMPER

MESHING





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Scoping Method	Geometry Selection
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Definition	
Suppressed	No
Type	Element Size
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Advanced	
Defeature Size	Default (2.5219e-002 mm)
Size Function	Uniform

Statistics	
Nodes	8150
Elements	8099

Fig. Meshing detail Of C Shape Bumper

BOUNDARY CONDITION

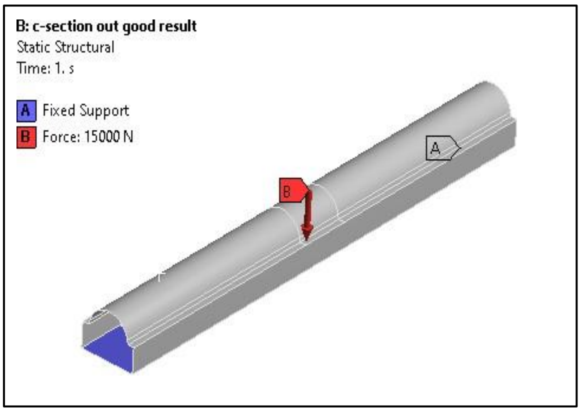

Fig. boundary condition Of C Shape Bumper

RESULTS

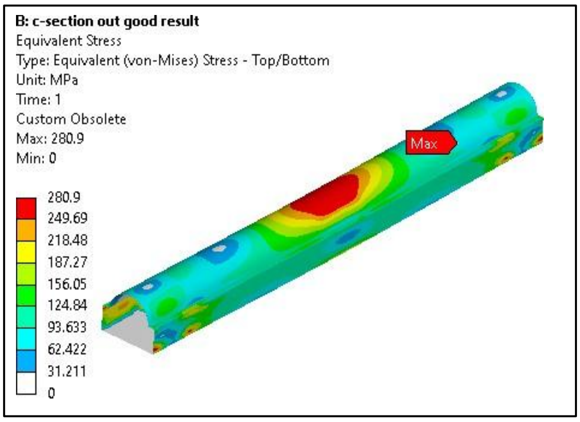

Fig. Equivalent stress of C Shape Bumper

The equivalent stress was induced in C Shape Bumper 280.9 MPa

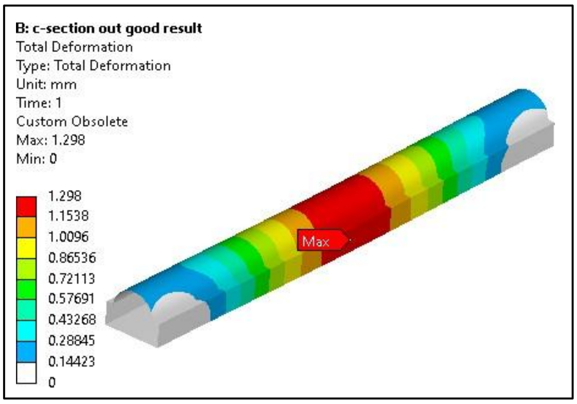

Fig. Total deformation of C Shape Bumper

Maximum deformation was induced in C Shape Bumper is 1.2mm

COMPARISON OF TOTAL DEFORMATION AND EQUIVALENT STRESS WITH DIFFERENT SHAPES

SR. NO.	SHAPE TYPE	TOTAL DEFORMATION	EQUIVALENT STRESS
1	Rectangular bumper	3.4 mm	299.57 MPa
2	B–shape bumper	2.88 mm	290.83 MPa
3	C-shape bumper	1.2 mm	280.9 MPa

We notice that C-shape bumper beam gives better result than other shapes. So, we use C-shape bumper beam for further process.

ANALYSIS OF C SHAPE BUMPER WITH JUTE FIBER

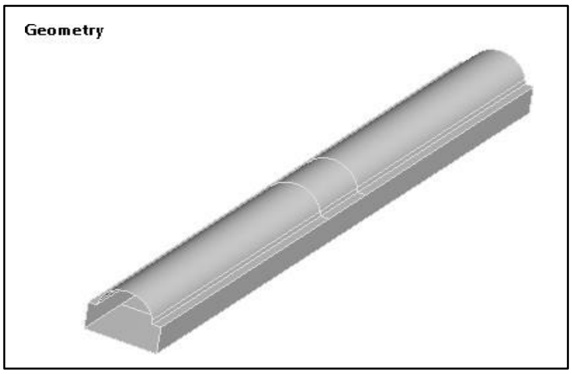

Fig. geometry

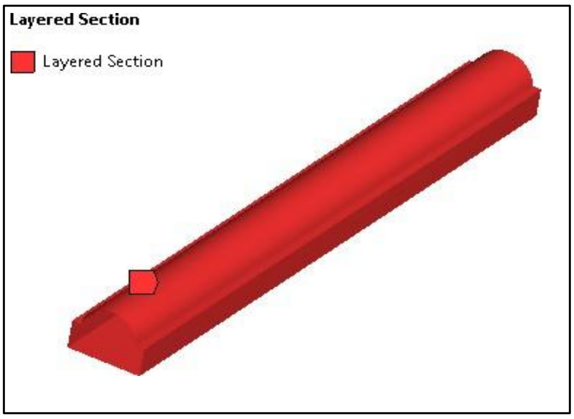

Fig. Layered section

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
3	JUTE	1	0
2	JUTE	1	0
1	Aluminum Alloy NL	3	0
(-Z)			

Fig. Layer arrangement

BOUNDARY CONDITION

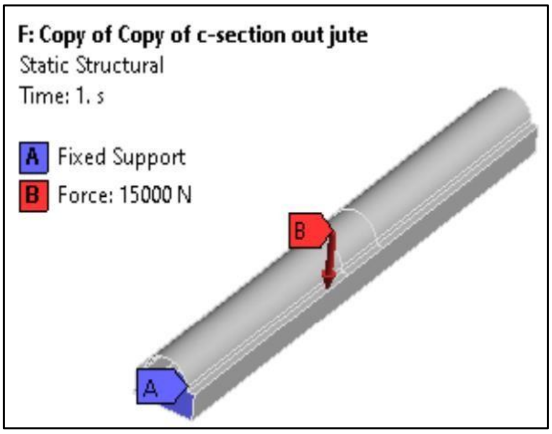

Fig. boundary condition Of C Shape Bumper with Jute Fiber

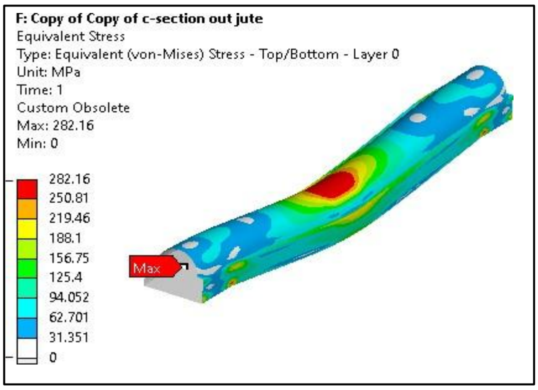

Fig. Equivalent stress Of C Shape Bumper with Jute Fiber

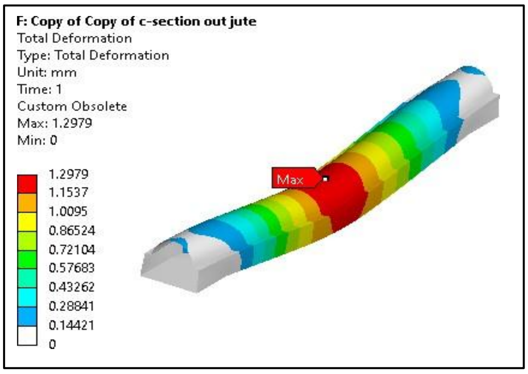

Fig. total deformation Of C Shape Bumper with Jute Fiber

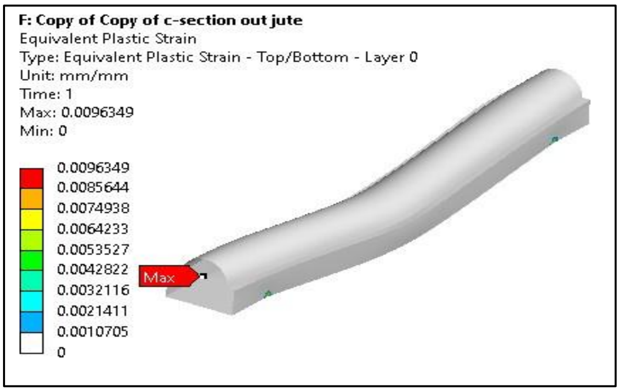

Fig. Equivalent plastic strain Of C Shape Bumper with Jute Fiber

ANALYSIS OF C SHAPE BUMPER WITH EPOXY E-GLASS FIBER

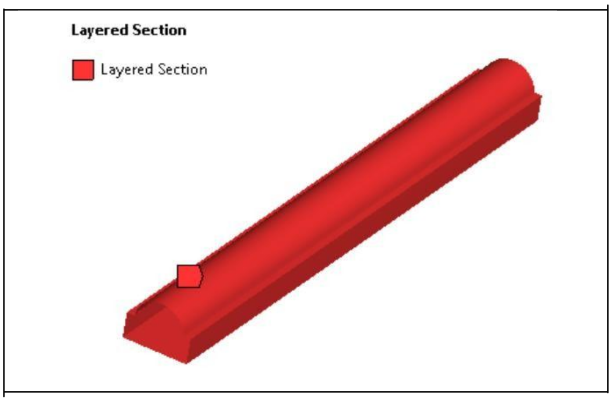

Fig. Layered section

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
3	Epoxy E-Glass UD	1	0
2	Epoxy E-Glass UD	1	0
1	Aluminum Alloy NL	3	0
(-Z)			

Fig. Layer arrangement

BOUNDARY CONDITION

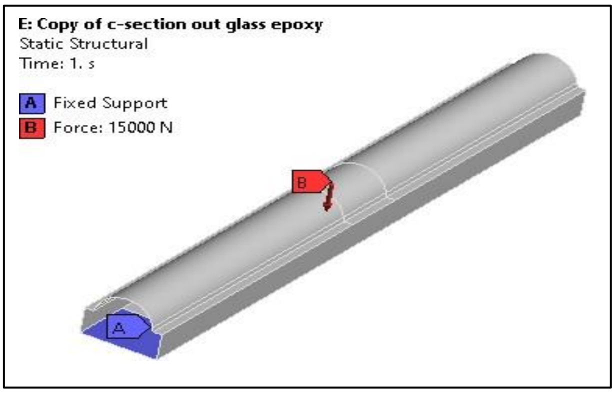

Fig. boundary condition Of C Shape Bumper with Epoxy E glass Fiber

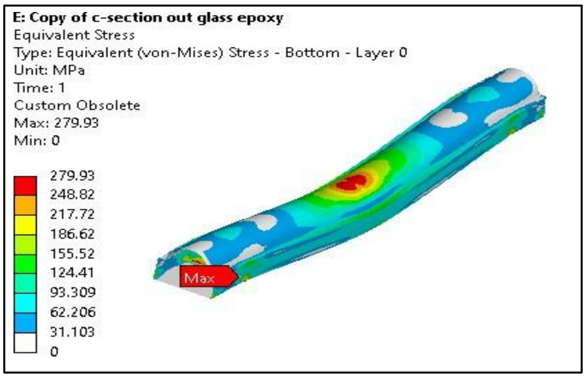

Fig. Equivalent stress Of C Shape Bumper with Epoxy E- Glass Fiber

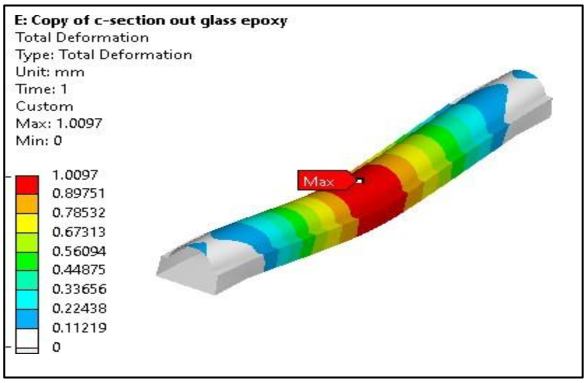

Fig. Total deformation Of C Shape Bumper with Epoxy E- Glass Fiber

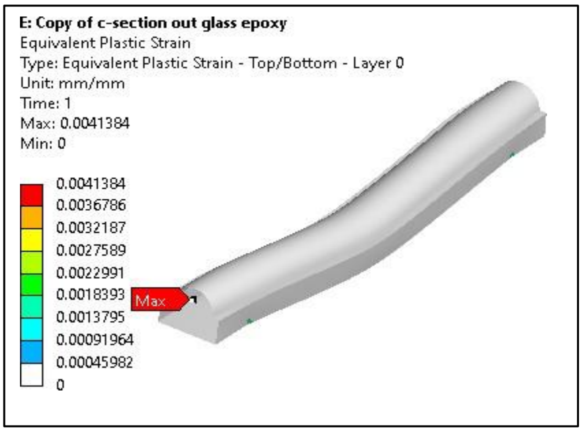

Fig. Equivalent plastic strain Of C Shape Bumper with Epoxy E-Glass Fiber

COMPARISON OF TOTAL DEFORMATION AND EQUIVALENT STRESS WITH NATURAL COMPOSITEAND SYNTHETIC COMPOSITE MATERIAL

SR. NO.	COMPOSITE MATERIAL	TOTAL DEFORMATION	EQUIVALENT STRESS	EQUIVALENT PLASTIC STRAIN
1	JUTE FIBER	1.29 mm	282.16 MPa	0.009
2	GLASS FIBER	1.0097 mm	279.93 MPa	0.004

So, in this analysis we find out that the glass fiber composite material is better than the natural composite material.

MANUFACTURING PROCESS

Fig. Aluminum pipe for manufacturing

Fig. Glass fiber sheet

Glass fiber for hand-layup method

Fig. C-shape model for experimental testing

EXPERIMENTAL VALIDATION:

A Universal Testing Machine (UTM) is used to test both the tensile and compressive strength of materials. Universal Testing Machines are named as such because they can perform many different varieties of tests on an equally diverse range of materials, components, and structures.

Universal Testing Machines can accommodate many kinds of materials, ranging from hard samples, such as metals and concrete, to flexible samples, such as rubber and textiles. This diversity makes the Universal Testing Machine equally applicable to virtually any manufacturing industry.

The UTM is a versatile and valuable piece of testing equipment that can evaluate materials properties such as tensile strength, elasticity, compression, yield strength, elastic and plastic deformation, bend compression, and strain hardening. Different models of Universal Testing Machines have different load capacities, some as low as 5kN and others as high as 2,000kN.

SPECIFICATION OF UTM:

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase , 440 Volts, 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

Fig. manufacturing model

Fig. Experimental testing

Fig. Experimental testing result

1) As per graph shows the 1mm deformation generated on the specimen using UTM testing, and load is applied gradually on the specimen.

2) When the deformation reach near the 1 mm, the load is between the 14 KN to 16 KN as per graph.

3) As per analysis the deformation generated in glass fiber specimen using ANSYS software is 1 mm at the 15000 N load.

RESULT AND DISCUSSION

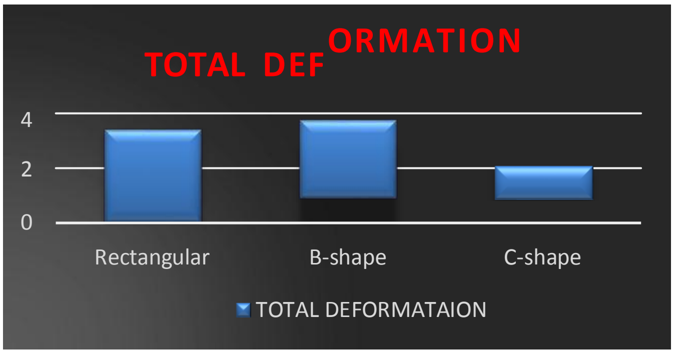

Fig. Total deformation

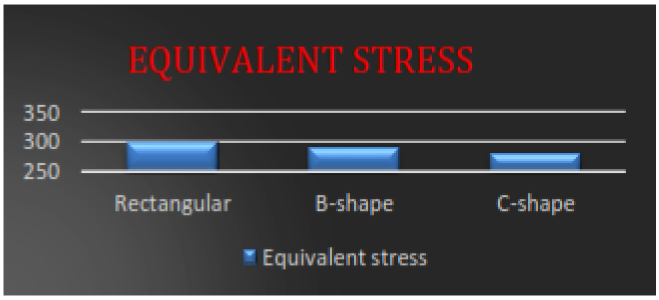

Fig. Equivalent stress

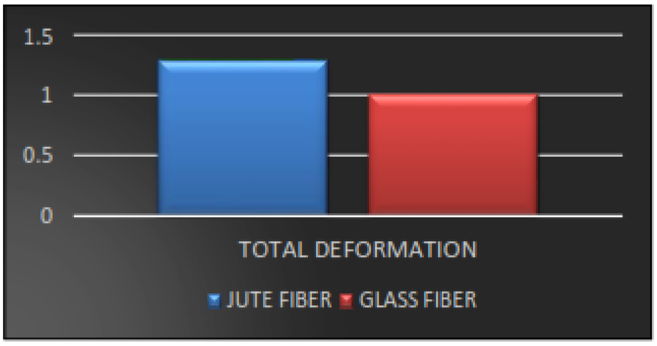

Fig. Total deformation comparison

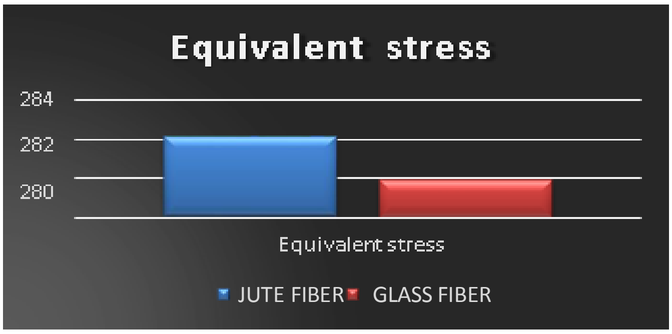

Fig. Equivalent stress comparison

CONCLUSION

1. We have used aluminum material for electric car bumper beam, existing material used in bumper was steel. The density of aluminum as compared to steel Is less, hence the weight optimization of bumper is done.

2. After optimization in bumper weight, we need to check the stresses generated in body and concluded that we have to increase the strength of bumper. so, we tried the different type of shapes to increase the strength of bumper.

3. In this research we considered 3 shapes of bumper namely b-shape, c-shape and d-shape. The Static Structural Analysis of all the 3 shapes is done by using ANSYS software.

4. The total deformation and equivalent stress generated in optimized shape i.e., c-shape is 1.2 mm and 280.9 MPa respectively.

5. After finalizing the shape of bumper, we used composite material i.e., jute as natural composite and glass fiber as synthetic fiber. We used the 2 mm layered for reinforcement of the bumper.

6. Total deformation and equivalent stress of optimized bumper (glass fiber reinforced) is 1.00 mm and 279.93 MPa respectively.

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