Design and Analysis of Bumper using Carbon Fibre 395

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Abstract - *Bumper is one of the key structural parts, which plays an important role in the frontal crashes of a Vehicle. The most important parameters of an automotive front bumper Such as material, shape and impact condition are to be studied to improve the bumper. The aim of paper is to increase the strength of bumper by using composite material carbon fibre 395. In recent years, security regulation has been very crucial t hat enforces the manufacturer to decrease passenger vehicle w eight. Carbon fiber 395 has low price and excellent strength. The 3D model of bumper is done on Catia V5 software and Explicit Dynamics is done on Ansys 19.2 Software to find out the deformation, Stress and Strain. The main problem of bumper during collision is the wear and tear of bumper at high speed so to increase in the strength and reduce the wear and tear of the 3 bumper for that the new bumper with proper new material is manufactured.*

Key Words: Carbon fiber, Bumper, Ansys, Catia, Strength

1. INTRODUCTION

Bumper is a structure that is attached to or integrated with the front and rear end of the vehicle to absorb small and large impacts and thud minimize repair costs. Rigid metal bumpers appeared on motor vehicles as early as 1904, which was predominantly decorative. The bumper have changed over the years with numerous developments, improvement in material and technology as well as a stronger focus on functionally to protect vehicle components and improve safety. Ideally, bumpers minimize vehicle height difference and protect pedestrians against injury. Regulatory rule measure had been taken to reduce the repair costs of vehicle. Bumper's purpose is to reduce physical damage during slow accidents to the rear and front of vehicle. The bumpers protect the system, grill, fuel, cap, trunk, and exhaust and cooling. A bumper is a shield made of aluminum, steel, and plastic. The attributes of a good bumper system are geometry, stability and energy absorption. Bumpers on colliding vehicles should be geometrically aligned to inter mesh with a slow impact to absorb the impact energy. Bumpers are designed to anticipate or decrease physical damage to traveler vehicles ' front or backsides in collision condition. It secures sub-systems, fuel line, gas flow system out, and cushion or radiator refrigeration. Distinctive countries have similar executions and guards gauges. In the originally generated global security controls as European gauges & now usually adopted by countries. The usefulness of vehicle bumpers has greatly altered over the past seventy years. A mixture of cautious plan, material selection to attain a particular impression of adjusting firmness, quality and ingestion of vitality, is achieved not long after execution.

Tie Wang and Yonggang Li [1] discussed the process of the Design & analysis of Bumper. Also they stated that the bumper and beam analysis is accomplished for the carbon fiber composite material to analyze impactor deformation, absorption of energy, impact strength, weight and acceleration. It has been specified that the weight is reduced to enhanced bumper beam and the impact performance is not weak. Gandla Pradeep [2] discussed the main strength criteria for minimizing bumper costs through the use of composite materials. Meanwhile, the design should be in passenger safety with the low weight. K Suneetha [3] Aim of this paper was to analyze & study the structure & material employed for car bumper. In the most important parameters of the front bumper beam in this paper, i.e. to improve the bumper's crashworthiness, shape, impact, material and condition should be studied. Vysyaraju Neelima [4] the heavy-duty vehicle bumper beam is designed and analyzed using steel materials and the design is modified and improvised using the shape of optimization tool in Ansys. P. Ravinder Reddy [5] this project is for the design of bumper system summarized as a degree of absorption of impact energy in a limited clearance between back face of bumper, body parts of vehicle. This project attempts to show a method using computer simulation which has been broadly adapted in the various design stages of vehicle development. Rajesh. B. Buktar [6] in this paper, the most important parameters of automotive front bumper beam i.e. Shape, impact, material and condition are to be studied to improve crashworthiness of the bumper. Sachin Manojkumar Jain [7] the frontal beam of the automotive bumper plays a major role in the absorption of impact force. In the new car assessment program (NCAP), bumper absorbs 15% of total energy from the crash test.

2. METHODOLOGY

Bumper manufacturing is very costly process and it takes lot of time as we go for conventional methods. So use the technology like CAE during the designing of actual components to detect the problem. This technology saves work, time and cost. During the development of bumper design. First theoretical calculation is carried out for bumper. From this data CAD model is generated using 3D cad software like CATIA. From this 3D parts bumper assembly generated. This assembly imported in Ansys software in igs format, by applying material property and boundary cognitions values and simulation is carried out. From the results of simulation finally deformation, stress, strain are obtained.

3. MODEL GENERATION

The following data is collected from the front bumper of passenger bus. Total length 2.59m, Thickness 0.006m, Total breath 0.1524 m, Profile of Bumper is C type.

The following Geometry model of passenger bus front Bumper has been made of using CATIA V5 software.
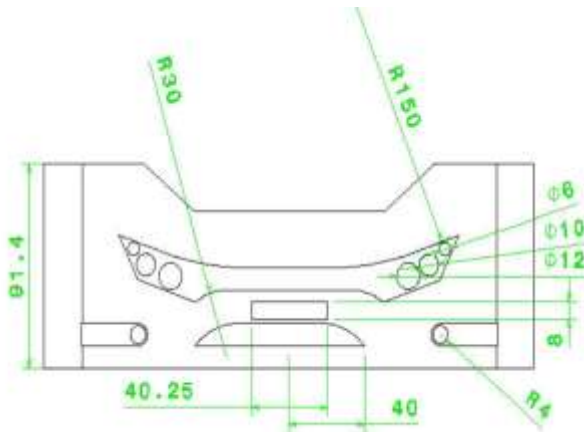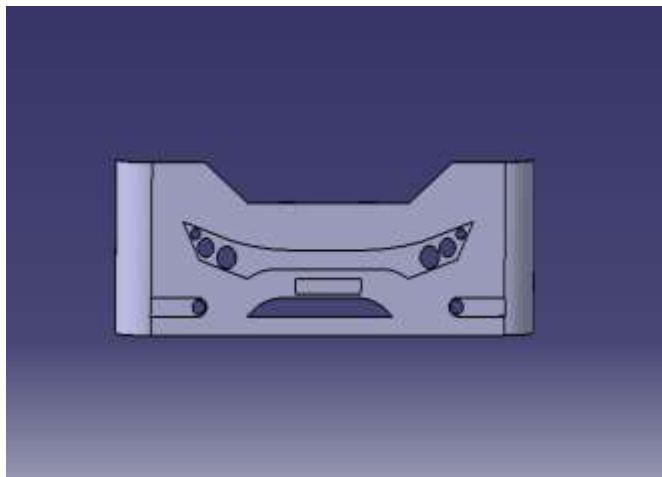

Fig -1: 2-D Diagram of Bumper

Fig -2: Front View Bumper

4. MATERIAL PROPERTIES

Carbon Fibre 395 has high strength and lightweight properties, the benefits of carbon fiber and its composites include: A unique and distinct appearance that's nearly impossible to replicate. Excellent strength to weight ratio, compared to other materials. Material Properties of Carbon fibre 395 is not available in Ansys material library. That's why new material property is created with help of company data. The material properties of carbon fibre 395 is shown in below table.

Table -1: Material Properties of carbon fibre 395

5. FINITE ELEMENT ANALYSIS

File generated in Catia is imported in Ansys software in igs format. Carbon fibre 395 material properties such as density, young's modulus, poisons ratio, bulk modulus, shear modulus, tangent modulus, yield strength, ultimate strength are missing in Ansys material library so it is necessary to create custom material properties for Carbon fibre 395 in material library. Meshing is done using Ansys Mechanical APDL with element size for bumper are 5mm. For this element size node and element counts are 15129 and 34015 respectively. The boundary conditions are applied for analysis. Bumper travels to positive Y axis towards wall with velocity of 108 kmph, displacement is set as 0mm in z direction. The Explicit simulation is carried out for better convergence of the problem for deflection and stresses.
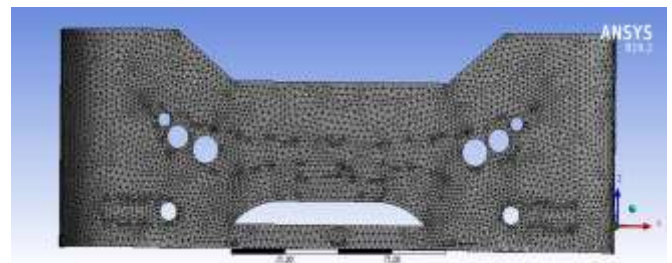

Fig -3: Meshing of CAD model

5.1 Total deformation

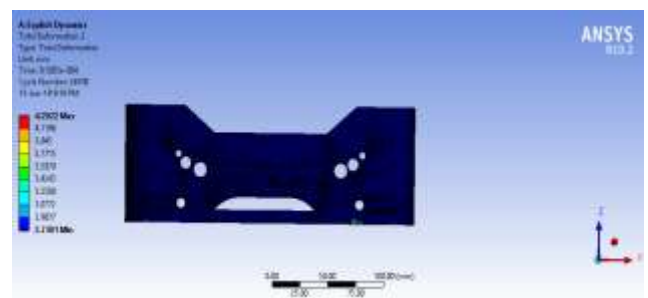Total deformation obtained from analysis is 4.292 mm. This shows the total deformation is within acceptable value.

Fig -4: Deformation of Bumper

5.2 Equivalent Elastic Strain

Equivalent Elastic Strain is 2.0979. This value shows the ratio of change in dimension with original dimension. From the results we can say that bumper is not too thin.
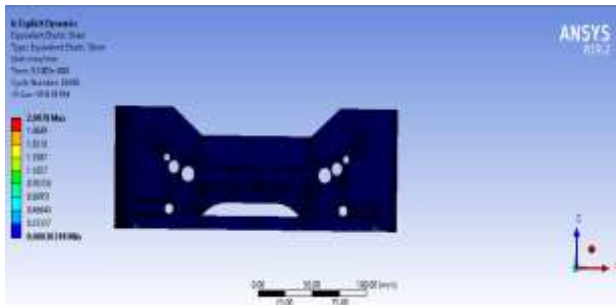

Fig -5: Elastic Strain of Bumper

5.3 Equivalent Elastic Strain

Fig.6 shows equivalent stress generated on component. Maximum stresses occur at the Bumper is 13474 MPa. In this simulation no single tearing evidence found at neck while checking animated simulation video.
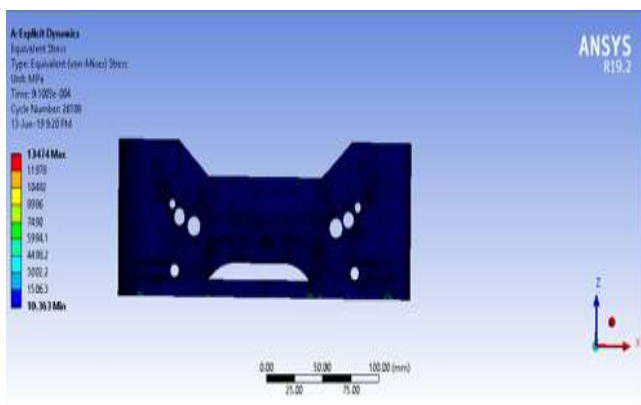

Fig -6: Equivalent Stress of Bumper

6. RESULTS

Below table shows the strain stress and resultant Bumper generated as particular deformation value.

Table -2: Result Table

Total Deformation (mm)	Equivalent Elastic Strain x10^{-3}	Equivalent Stress (MPa)
0.40958	0.0001191	207.021
0.6832	0.0005075	211.7084
0.8190	0.0008007	235.06
1.0921	0.001323	391.89
1.2322	0.002067	611.86
1.3801	0.002067	871.18
1.5359	0.002746	1189.7
1.69	0.0030295	1246.5
1.8328	0.002214	1463.5
1.9486	0.00197	1143.8
2.0819	0.5032	4613.6
2.9439	0.4790	6149.4
3.736	1.9639	10225
4.2415	2.1236	11896
4.2922	2.0979	13474

From this value for better understanding about behavior of stress and strain with respective to deformation graphs are plotted as below.
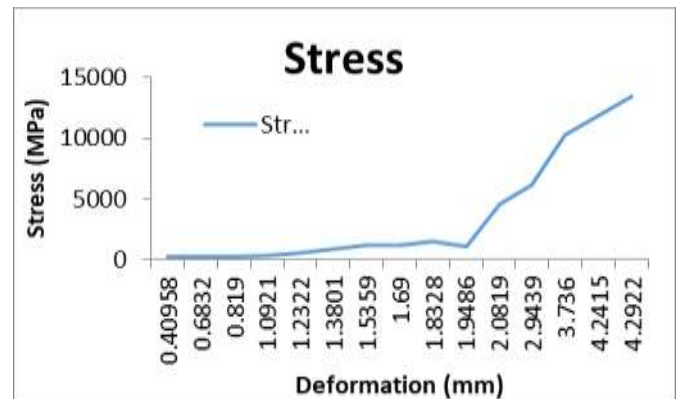

Chart -1: Stress analysis with change in deformation

Above graph shows the relationship between the changes in deformation with change in stress value. As deformation increases stress also increases. The behavior of this graph is non- linear.
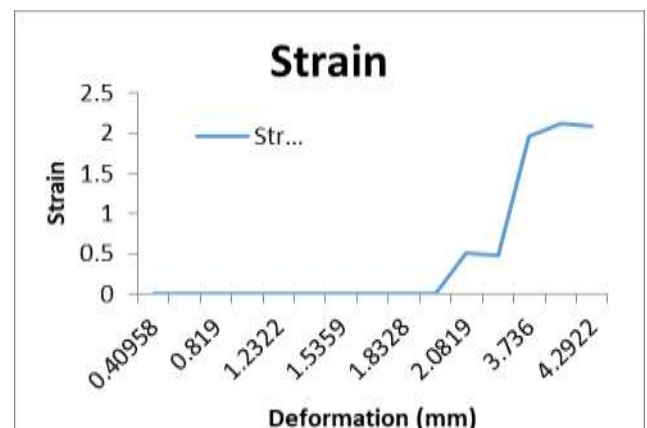

Chart -2: Strain analysis with change in deformation

This graph shows the relationship with change in deformation with change in strain value. As deformation increases strain also increase. The behavior of this graph is non- linear. From the previous research or analysis on vehicle bumper, basically they focus on the design and crashworthiness optimization. However, for this analysis just focusing on the stress analysis on vehicle bumper by applying various loads and materials on the static condition only. In the real situation, there is much point that points that bumper mounting to the car which make it stronger or can absorb more energy during the impact. For the simulation, wall taken as fixed member and the bumper is the moving member. The total bumper part is taken in consideration for test.

7. CONCLUSIONS

From the above results it is clearly indicative that use of composite material is very advantageous than metals, due to following reasons:

Decrease is system weight, improves an automotive's fuel efficiency. Carbon Fiber 395 displacements is less than simple carbon steel, so using carbon fiber makes the system more compact and efficient.

Nowadays, composite materials such as TPO, polypropylene used in bumpers are connected to the fenders because of this the displacement is greater and the ability to handle stress is lower than that of Carbon Fiber 395.

Bumpers produced of Carbon Fiber395 do not need any additional attachments that can be connected straight to the chassis of the vehicle that can enhance their ability. The carbon fiber 395 is therefore the best material for the production of bumper.

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