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ANALYSIS & OPTIMIZATION OF AUTOMOTIVE BUMPER BEAM WITH COMPOSITE MATERIALS USING FEA

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ABSTRACT

The fundamental motivation behind this paper is to enhance the crash worthiness, reduce the weight and improve the cost of the bumper. Designing a heavy vehicle bomber and sequential analysis on how it influences the parameters, for example, shape, thickness and material will help in increment the quality and lessening in weight. This additionally gives a method for utilizing materials that are recyclable and biodegradable which helps in controlling natural contamination. The bumper beam of the heavy vehicle is modelled and analyzed with the steel material and then the design is modified and improvised by using a shape optimization tool in the FEA. In light of the shape enhancement comes about the state of the model is adjusted and replaced with aluminum and composites. shape of the bumper are premeditated for the analysis on an automotive bumper to enhance the properties of the beam particularly to stand against the impact forces of crash, ranging from medium speed to high speed impact collisions. From this work it is recommended that S2 glass epoxy is performing extremely all around contrasted with the current bumper material. The stress is diminished by 45.14% and the deformation is decreased by 55.25%.

Key words: *Bumper, Analysis, Composite material, FEA.*

I. INTRODUCTION

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. 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 fascia's 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.[1]

II. PROBLEM FORMULATION

1. To determine the Deformation and Impact force for various materials used for bumper like Structural Steel, Aluminum alloy, PVC Foam, SAN Foam, Resin Epoxy, Carbon Epoxy and S2 Glass Epoxy by using FEA software.
2. Comparing the result to identify the best suited material for the bumper.
3. To analyze mechanical properties focus on stress analysis.
4. Modeling the car bumper with actual dimension into the solid modeling software and analyze by using FEA software (Analysis).

III. OBJECTIVES

The motivation behind this task is to build up a natural fiber reinforced thermoplastic composite as a bumper material and to explore the mechanical and reusing properties. In the outline and investigation the bumper particulars were taken from the standard vehicle, at that point the displaying of the bumper is finished by the solid modelling software and afterward the effect stacking was connected utilizing FEA programming to break down.

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To analyze the mechanical properties on front part (fascia) of car bumper

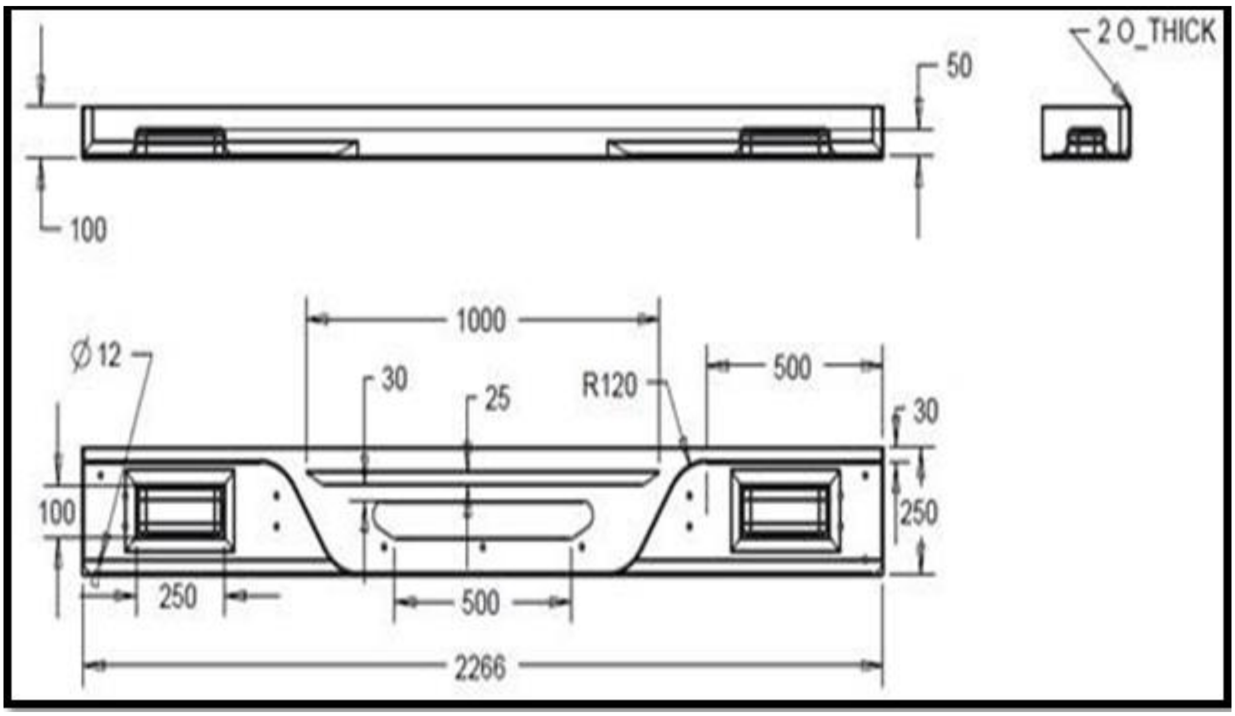
- To analyze on mechanical properties focus on stress analysis
- To modeling the actual dimension of the car bumper into the solid modeling software and analyze by using FEA software (Analysis).
- To investigate polymer composite material bumper based on their geometry and other parameters that influence the compatibility of car bumper.

To evaluate failure mechanism of the car bumper:

- To study the load distribution on the bumper either it is uniformly distributes to all the part during the analysis.

IV. MODELLING AND ANALYSIS

The bumper beam is demonstrated and investigated. The displaying is done in solid modelling software. [2] It is investigated in FEA programming. The parameters which impacts the execution of the bumper is thickness, speed, materials and shape of the object. The thickness of the bumper is 2mm.The heavy vehicle bumper beam is modeled and drawing specification of the Eicher 15.0 bumper is shown in Fig



Bumper beam of Eicher 15.0

V. ANALYSIS & OPTIMIZATION USING DIFFERENT MATERIALS

Mass of the car with bumper =4255 kg
Speed of the car = 2.5kmph
Assume this car is hitting at another identical one and it will stop in 0.1seconds
Force acted during collision = m*a=4255*7 = 29785 N
m= mass of car in kg,
a = acceleration of car in m/s2

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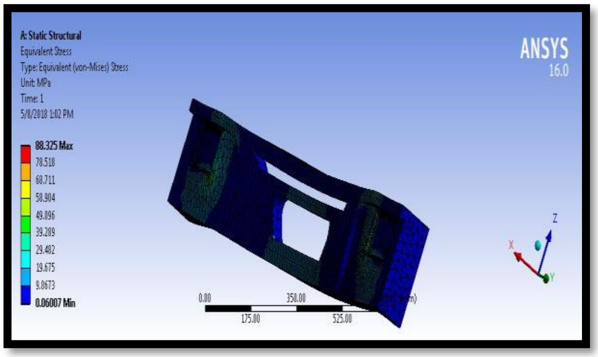
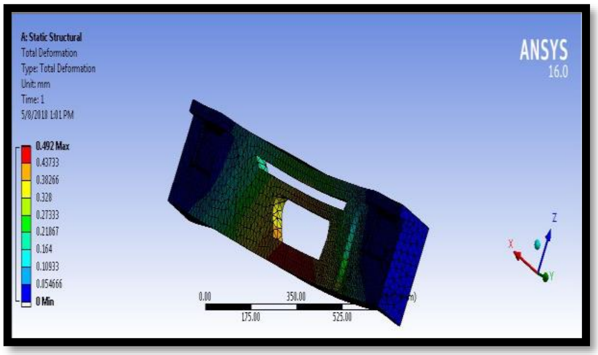
In FEA software we can directly apply this load on the beam as a point load. We are applying the load as point because, when the bumper beam is impacted with impact or the area of concentration is very less. So the load is treated as point load. But for full impact we have to convert this load in to pressure. For the easiness of calculation this force is converted into a pressure which is acted on the front surface of the modeled bumper.[2] By considering the total load is acting on the frontal area of the beam the boundary conditions will change:-

Area of the front face of bumper = 431180 mm2
Pressure acted on the bumper = F / A = 0.07 N/mm2
F= Force acted during collision in Newton's,
A = Area of the front face of bumper in mm2.
Pressure of 0.07Mpa is applied on the bumper beam.

1. Structural Steel

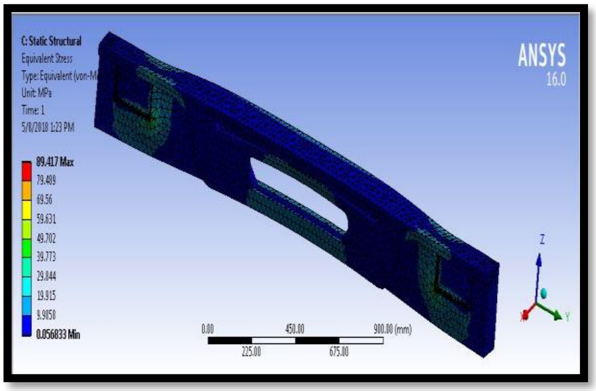


Stress distribution of bumper beam in statics

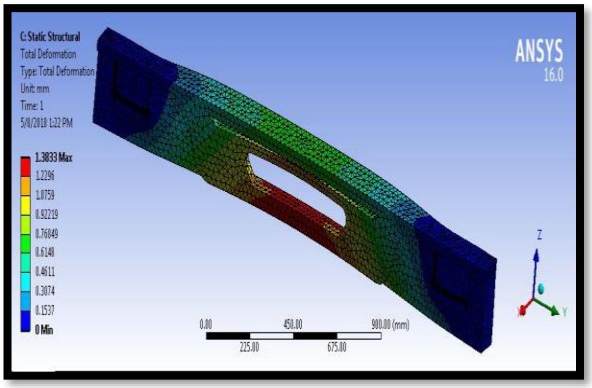


Deformation of bumper in statics

2. Aluminum Alloy Bumper



Stress distribution of bumper beam in static



Deformation of bumper in statics

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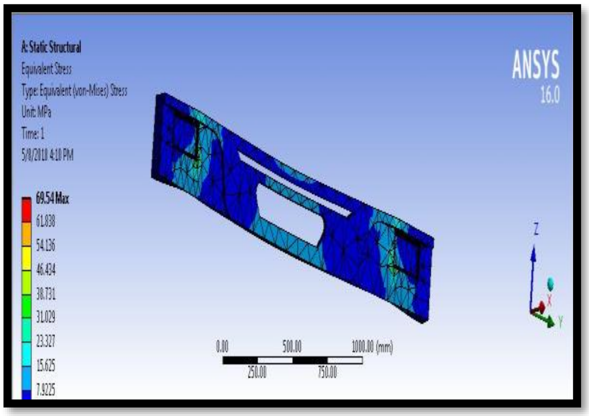
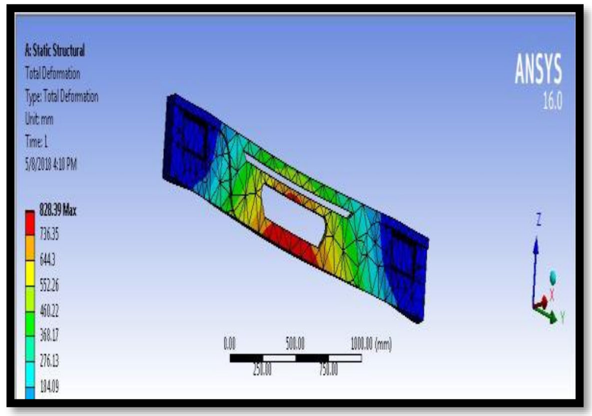
3. PVC Foam Bumper

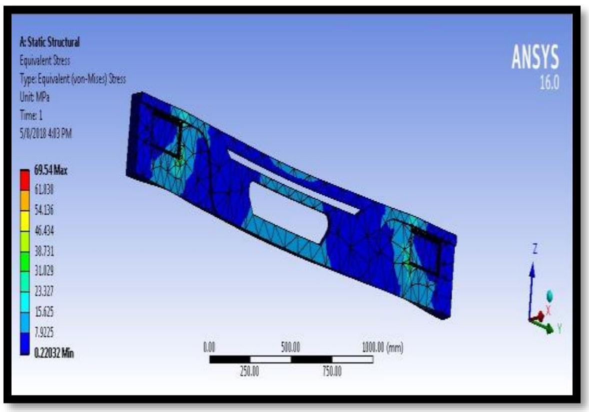


Stress distribution of bumper beam in statics

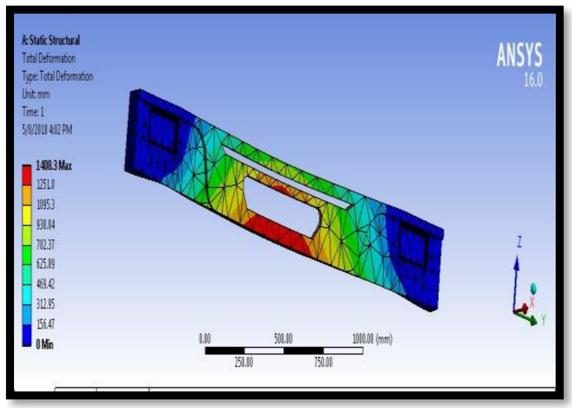


Deformation of bumper in statics

4. SAN Foam Bumper

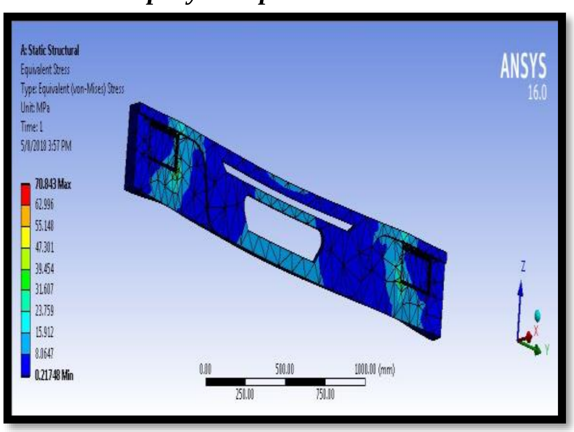


Stress distribution of bumper beam in statics

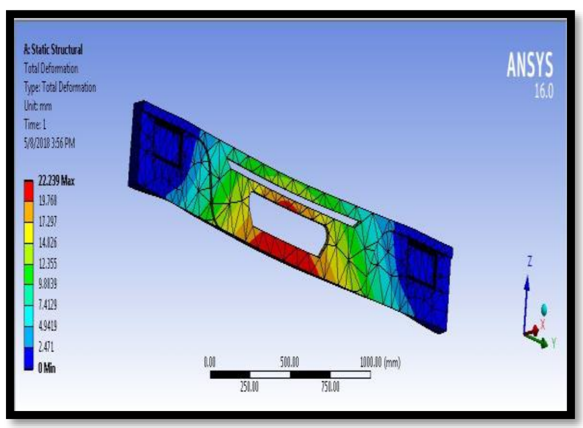


Deformation of bumper in statics

5. Resin Epoxy Bumper



Stress distribution of bumper beam in statics



Deformation of bumper in statics

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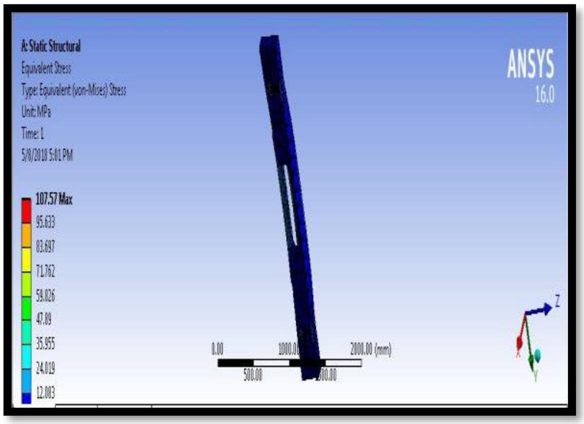
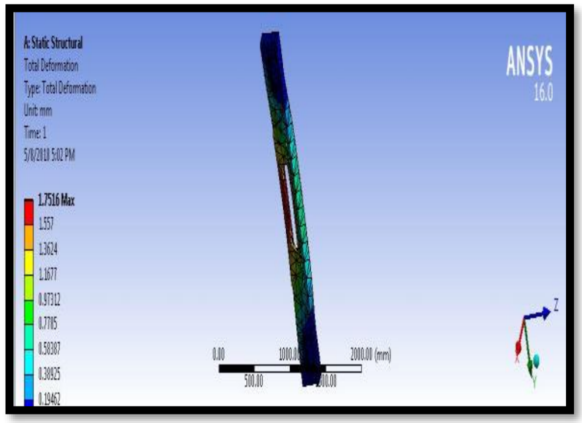
6. *Epoxy Carbon Bumper*

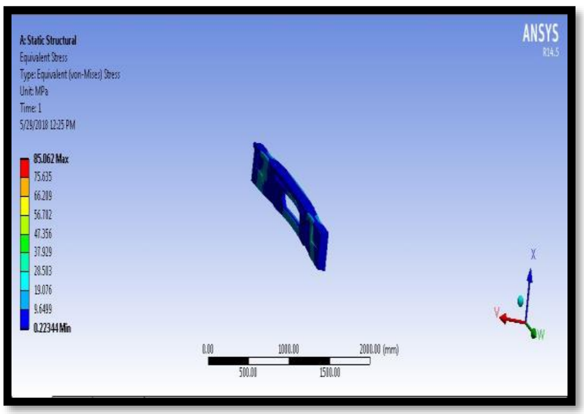


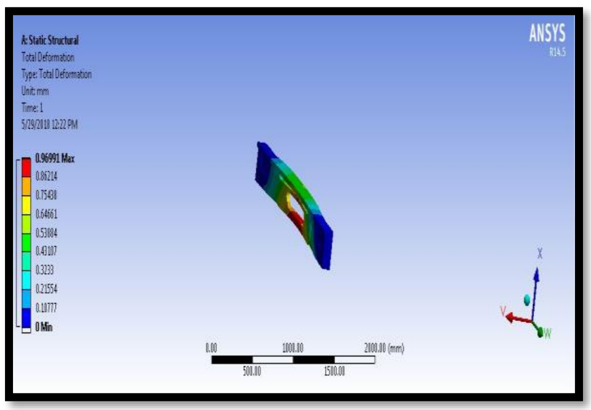


Stress distribution of bumper beam in statics

Deformation of bumper in statics

7. *S2 Glass Epoxy Bumper*





Stress distribution of bumper beam in statics

Deformation of bumper in statics

VI. RESULT & DISCUSSION

The following results are obtained from the impact analysis of Eicher 15.1 bumper using existing & other composite materials.

In this study seven materials were considered based on their properties, they are structural Steel, Aluminum, PVC Foam, SAN Foam, Resin Epoxy, Carbon Epoxy and S2 Glass Epoxy. Analysis of bumper beam with different material under impact load of 2.5 Kmph is done. Structural steel is used in making of existing bumper. From the result stress developed in this bumper is 85.062 Mpa and total deformation is 0.96991 mm, the yield strength of S2 Glass Epoxy 480 Mpa. It is cleared that the bumper beam is withstanding 2.5 Kmph impact and the deformation is also within the range.

Result table

Velocity Kmph	Material	Impact Stress (von misses stress)Mpa	Deformation in mm
2.5	Structural steel	88.325	0.492
2.5	Aluminum	89.417	1.3833
2.5	PVC Foam	69.54	828.39
2.5	SAN Foam	69.54	1408.3
2.5	Resin Epoxy	70.843	22.239
2.5	Epoxy Carbon	107.57	1.7516
2.5	S2 Glass Epoxy	85.062	0.96991

VII. CONCLUSION

In the design of bumper beam the deflection of bumper beam should be below the critical value. According to Indian standard, the bumper beam should not show any yielding when it is impacted at a speed of 2.5 Kmph. Here the material used is steel. The yield stress of the structural steel of grade 55 is 380 N/mm2. The ultimate strength of steel is 480 N/mm2.

The S2 glass epoxy material has shown better stress and deflection result incorporative to structural Steel. In order to achieve highest stability, cost effective and manufacturability of product, the S2 glass epoxy that could replace the Steel based on the strength and deformation criteria. The deformation and stress suitable for bumper is shown by S2 glass epoxy and epoxy carbon. The analysis is done at a speed of 2.5 Kmph.

From the result stress developed in this bumper is 85.062 Mpa and total deformation is 0.96991 mm, the yield strength of S2 Glass Epoxy 180 Mpa. It is cleared that the bumper beam is withstanding 2.5 Kmph impact and the deformation is also within the range.

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