# DESIGN AND IMPACT ANALYSIS OF CAR FRONT BUMPER

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**Abstract:** Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. In this work, a bumper used for light motor vehicle is used for our analysis purpose. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction at different speeds ( 40, 60, 90 and 100 km/hr). The materials used for these analyses are Aluminum B390 alloy, Mild Steel and Glass Mat Thermoplastic (GMT) materials. Static & impact analysis is to determine the deformation and stress of the car bumper. Modal analysis is to determine the natural frequency and deformation for mode shapes.

INTRODUCTION:

The bumper beam is the main structure for absorbing the energy during collision therefore suitable impact strength is the main expectation for such a structure. The analysis is done by considering the previous experiments carried out by the researchers in the field of selection of material in the automotive bumper impact analysis. Researchers focus mainly on the mechanical properties of the materials used for the bumper design. Composites have the ability to perform extremely well in the case of a crash. They are being used in the manufacturing of different dedicated energy absorbing components in the automobile world. For identifying the best material, various analyses like static analysis, impact or crash analysis, dynamic and modal analysis are required.

**TYPES OF BUMPERS**

- Plastic Bumper
- Boby Kit Bumper
- Carbon Fibre Bumper
- Steel Bumper

**PLASTIC BUMPER:**Most modern cars use a reinforced thermoplastic bumper, as they are cheap to manufacture, easy to fit and absorb more energy during a crash. A majority of car bumpers are custom made for a specific model, so if you are looking to replace a cracked bumper with a similar one, you would have to buy from a specialist dealer. However, many companies now offer alternative designs in thermoplastic, with a range of fittings designed for different models.

**BOBY KIT BUMPER**:Modified cars often now have a full body kit rather than just a front and rear bumper. These kits act as a skirt around the entire body of the car and improve performance by reducing the amount of air flowing underneath the car and so reducing drag. Due to each car's specifications, these have to be specially purchased and can be made from thermoplastic, like a standard bumper, or even out of carbon fiber.

**CARBON FIBRE BUMPER:** Carbon fiber body work is normally the thing of super-cars, but many car companies, and specialist modifiers, are starting to use it for replacement body part on everyday cars. This is because it is very light and is safe during a crash. It is, however, a lot more expensive than normal thermoplastic.

**STEEL BUMPER**: Originally plated steel was used for the entire body of a car, including the bumper. This material worked well, as it was very strong in a crash, but it was very heavy and dented performance. As car engine design has improved, steel bumpers have pretty much disappeared for anything except classic cars. Replacing one involves a lot of searching for scrap cars or having one specially made.

TODAYS PROBLEM

1. The main problems that we are facing now a days w.r.t. bumpers are they are not following the basic standards which are given to them and at least minimum thickness should be maintained for reducing the passenger injuries and by the same increasing the pedestrian safety.

2. While we are using the materials which are not recyclable then the waste produced from the damaged bumpers are going on increasingly effecting the environment and thus causing global warming.

3.Now a day's customers are not seeing for the cost but focusing on safety so we can give the bumper material which ensures the passenger safety so that they will not invest more money on protecting guards which may cost them extra money in terms of fixing and mileage problems.

REVIEW OF LITERARTURE

Javad et al.[1] studied the most important parameters including material, thickness, shape and impact condition for design and analysis of an automotive front bumper beam to improve the crashworthiness design in low-velocity impact.

The composite materials like GMT and SMC are used and studied to find best impact behavior. The maximum stress of the bumper must be below the yield stress.

From the above mentioned benefits, advantages like ease of manufacturing due to simple shape without ribs , economical aspects like utilizing low cost composite materials and at the same time standards should be maintained and reducing weight w.r.t. others can be achieved.

BUMPER DIMENSIONS

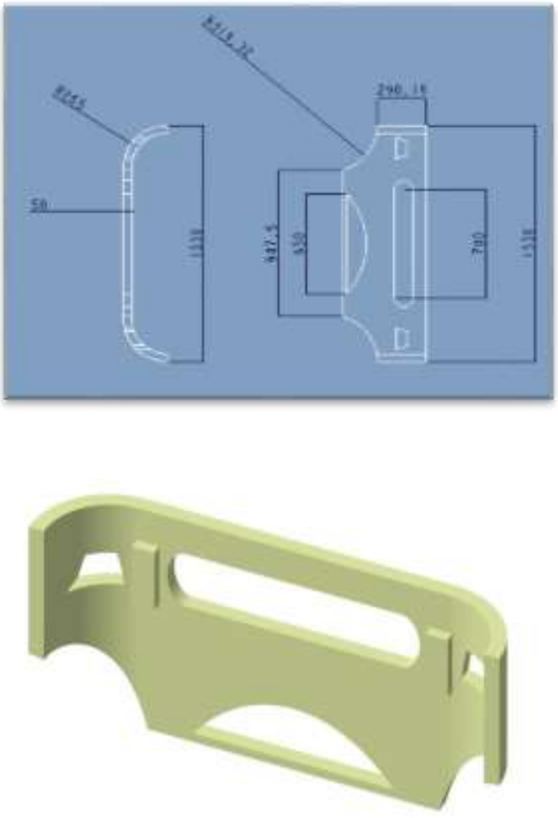

Figure 1 : Designing of car bumper using CATIA designing software

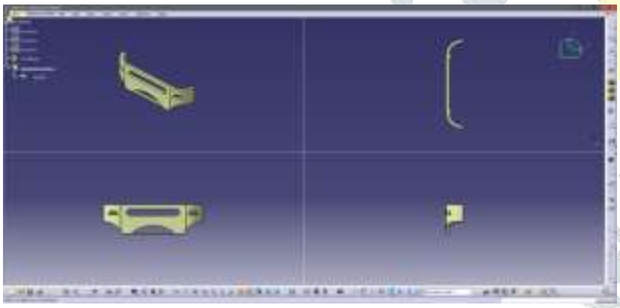

Figure 2 : Different views of the Bumper

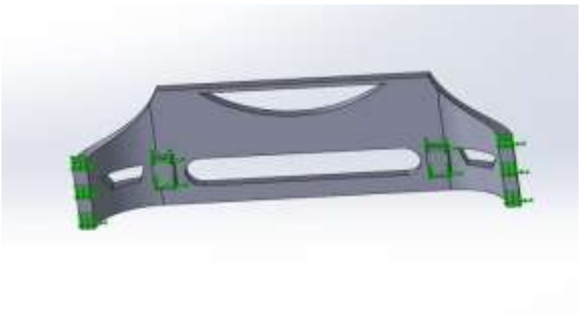

Figure 3 : Boundary Conditions Fixed supports

Figure 4 : Meshing Of Car-Bumper

Mesh Information

| | |
|---|---|
| Mesh Type | Solid Mesh |
| Mesher Used | Standard Mesh |
| Jacobean points | 4 Points |
| Element Size | 15.4467mm |
| Tolerance | 0.772334mm |
| Total NODES | 85047 |
| Total ELEMENTS | 53604 |
| Maximum Aspect Ratio | 3.9551 |
| Percentage of Elements with aspect ratio < 3 | 99.9 |

Table 1 : Loads applied

| Speed (Km/Hr) | Velocity ( m/s ) |
|---|---|
| 40 | 11.11 |
| 60 | 16.66 |
| 90 | 25.00 |
| 100 | 27.78 |

Table 2 : Material properties

| Materials | Young's Modulus (GPa) | Poisson's Ratio ( U ) | Density ($kg/m^3$) | Yield Stress (MPa) |
|---|---|---|---|---|
| Aluminium B390 alloy | 70 | 0.33 | 2710 | 250 |
| Mild Steel | 210 | 0.3 | 7850 | 370 |
| Glass Mat Thermoplastic | 12 | 0.41 | 1280 | 230 |

IMPACT ANALYSIS OF BUMPER

MATERIAL GLASS MAT THERMOPLASTIC IMPACT DEFORMATION

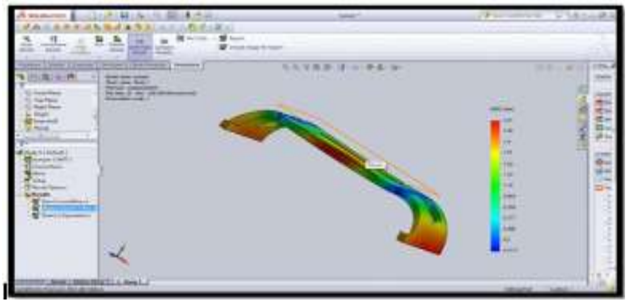

FIG: 5 MAXIMUM DEFORMATION @40KMPH

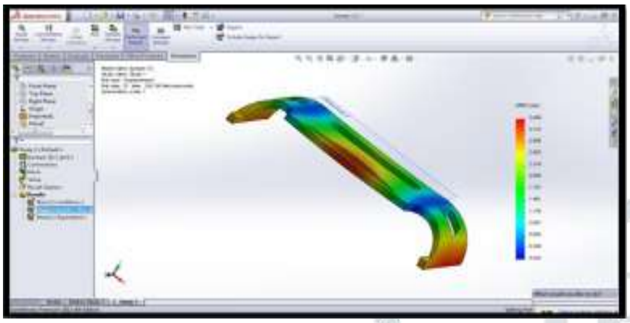

FIG: 6 MAXIMUM DEFORMATION @60KMPH

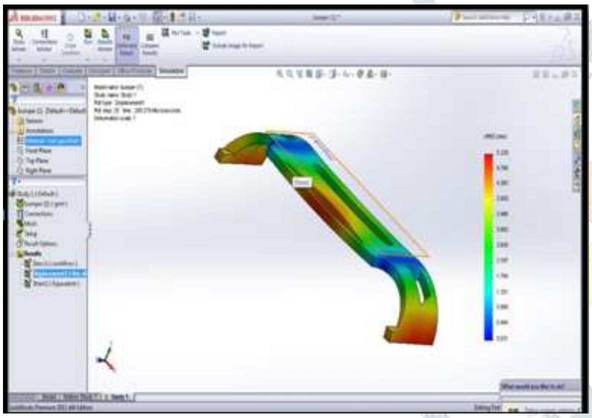

FIG: 7 MAXIMUM DEFORMATION @90KMPH

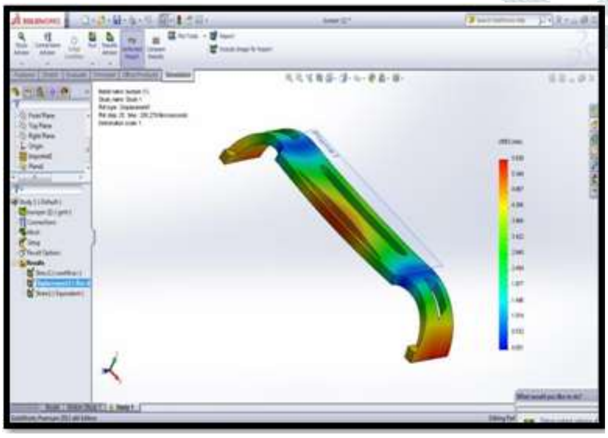

FIG: 8 MAXIMUM DEFORMATION @100 KMPH

IMPACT ANALYSIS OF BUMPER MATERIAL GLASS MAT THERMOPLASTIC- IMPACT STRESS

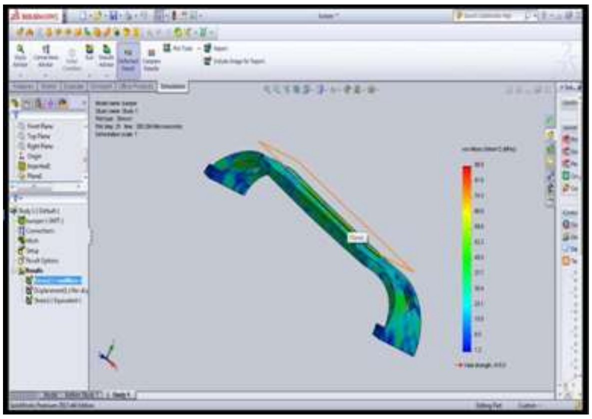

FIG: 9 MAXIMUM STRESS @40KMPH

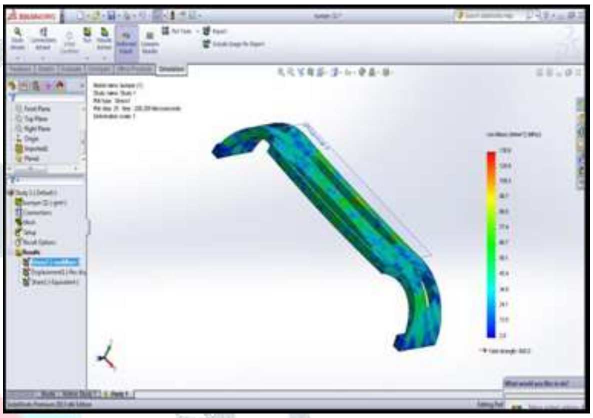

FIG:10 MAXIMUM STRESS @60KMPH

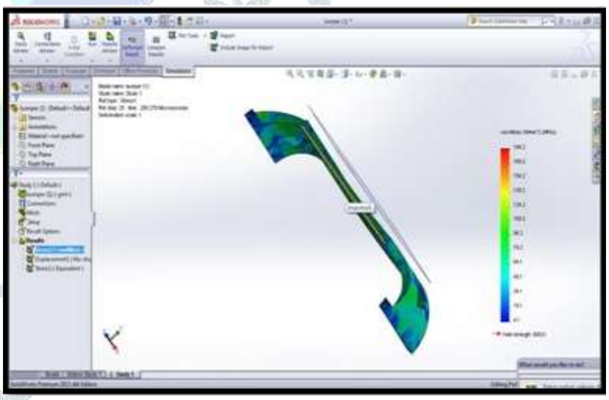

FIG: 11 MAXIMUM STRESS @90KMPH

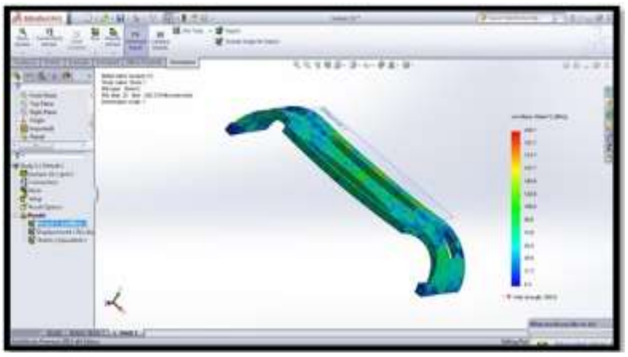

FIG: 12 MAXIMUM STRESS @100KMPH

Table: 6 Impact analysis deformations

| Speed (km/hr) | Aluminum B390 Alloy (mm) | Mild steel (mm) | Glass mat thermoplastic (mm) |
|---|---|---|---|
| 40 | 2.74 | 2.82 | 2.27 |
| 60 | 4.09 | 4.23 | 3.46 |
| 90 | 6.15 | 6.36 | 5.229 |
| 100 | 6.84 | 7.08 | 5.830 |

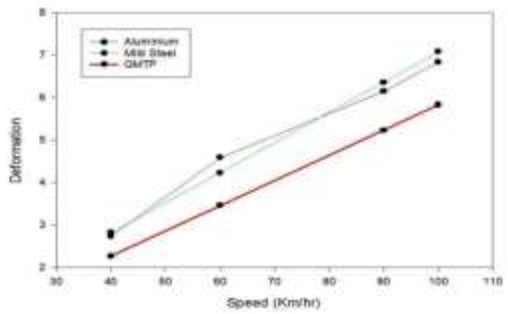


Figure 25: Impact analysis deformation plot

Table: 7 Impact analysis stress

| Speed (Km/hr.) | Aluminum B390 Alloy (MPa) | Mild steel (MPa) | Glass Mat Thermoplastic (MPa) |
|---|---|---|---|
| 40 | 513.6 | 1275.7 | 88.9 |
| 60 | 778.7 | 1847.3 | 130.7 |
| 90 | 1226.3 | 2785.3 | 184.2 |
| 100 | 1345.6 | 3080.5 | 208.7 |

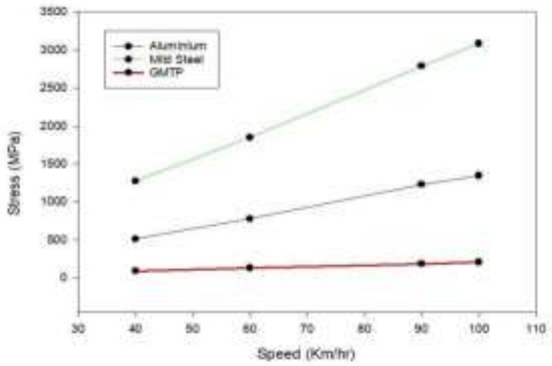


Figure 26: Impact analysis stress plot

Table:8 Impact analysis strain

| Speed (km/hr) | Aluminum B390 Alloy | Mild steel | Glass mat thermoplastic |
|---|---|---|---|
| 40 | 0.00396 | 0.0039 | 0.00507 |
| 60 | 0.00645 | 0.00557 | 0.00746 |
| 90 | 0.00996 | 0.00859 | 0.011 |
| 100 | 0.0109 | 0.0096 | 0.012 |

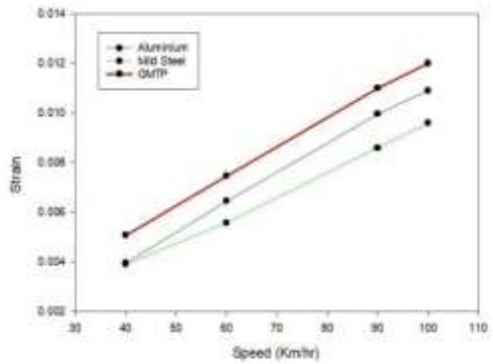


Figure 27: Impact analysis strain plot

Table:13 Impact Analysis

| Material | Car speed (km/hr.) | Deformation(mm) | Stress (MPa) | Strain |
|---|---|---|---|---|
| Aluminum B390 Alloy | 40 | 2.74 | 513.6 | 0.00396 |
| | 60 | 4.59 | 778.7 | 0.00645 |
| | 90 | 6.15 | 1226.3 | 0.00996 |
| | 100 | 6.84 | 1345.6 | 0.0109 |
| Mild Steel | 40 | 2.82 | 1275.7 | 0.0039 |
| | 60 | 4.23 | 1847.3 | 0.00557 |
| | 90 | 6.36 | 2785.3 | 0.00859 |
| | 100 | 7.08 | 3080.5 | 0.0096 |
| Glass Mat Thermoplastic | 40 | 2.27 | 88.9 | 0.00507 |
| | 60 | 3.46 | 130.6 | 0.00746 |
| | 90 | 5.229 | 184.2 | 0.011 |
| | 100 | 5.830 | 208.7 | 0.012 |

**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, 90& 100 km/hr). The materials used for these analyses are Aluminum B390 alloy, Chromium coated mild steel and Glass Mat Thermoplastic (GMT) materials.

By observing the static analysis, the deformation and stresses increases by increasing the car speed. Stress values are less for glass mat thermoplastic material when compare the mild steel and aluminum alloy B390.

So it can conclude the glass mat thermo plastic material is better for car bumper.

**FUTURE WORK**: In the future work a cost analysis can be done. More materials, composites and alloys can be used as raw-materials in the manufacturing of bumper in the near future. Further analysis on environmental impact can be done using the Life Cycle Assessment software and carbon calculator tools. An experimental analysis can be proposed after fabricating the model with these materials for the validation of the result. With the role of safety, fuel efficiency and emission gas regulations are being more important in recent years that enforce the manufacturer to reduce the weight of passenger cars. With the use of GMT materials it is achieved.

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