STATIC AND MODAL ANALYSIS OF CAR BUMPER

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Abstract –
Bumper plays an imperative part in keeping the effective energy from being transferred to a vehicle and travelers. Sparing the effect energy in the bumper to be discharged in the environment decreases the harms of the vehicles. The main objective of this paper is to outline a bumper with least weight by utilizing the Glass Material Thermoplastic (GMT) materials. This bumper either ingests the effect energy with its distortion or exchanges it opposite to the effect direction. To achieve this point, an instrument is intended to change over around 80% of the kinetic effect energy to the spring potential energy and discharge it in an environment in the low effect speed as indicated as American standard. Likewise, since the residual kinetic energy will be damped with the minute versatile disfigurement of the bumper components, the passengers won't detect any effect. It ought to be noticed that in this paper, modeling, and result analysis are shown in Pro-E and ANSYS programming respectively.

Keywords - Car bumper, Pro-E and ANSYS programming

1.1 INTRODUCTION

Present days, Substitution of polymeric based composite material in car parts was effectively actualized in the journey for fuel and weight reduction. Among the parts in the car business substituted by polymeric based composite materials are the bumper bar, bumper sash, spoiler, associating bar, pedal box framework, and entryway inward board. The bumper framework comprises of three fundamental parts, to be specific bumper pillar, belt and energy safe bumper. One of the choices to decrease energy utilization is weight diminishment. Nonetheless, the architect ought to know that to diminish the weight; the wellbeing of the auto traveler must not be yielded. Another creation in innovation material was presented with polymeric based composite materials, which offer high particular solidness, low weight, erosion free, and capacity to deliver complex shapes, high particular quality, and high effect energy ingestion.

The car body is one of the basic subsystems of a vehicle, and it does different capacities. It should hold the parts of the vehicle together and serve to channel commotion and vibration. Moreover, it ought to have the capacity to ensure its tenants when mishaps happen. To do this, the car body originator ought to make a structure with critical levels of quality, solidness, and energy retention.

Fig 1: Car Bumper
1.2 DESIGN OF BUMPER FOR VEHICLE SAFETY

As the limitations, the fatality rate increments drastically in fast effects. Keeping in mind that, an effective lightweight vehicle and essentially enhance the crash execution of current vehicles, innovative advancement is at yet required. On the off chance that the car body could expand its front end amid or just before a crash, the system of retaining the crash energy would be very surprising from that of the passive structure. During a frontal crash, the front side part is required to overlap dynamically, in order to retain more energy and to guarantee enough traveler space. To do as such, different cross segments and shapes have been explored for the front rail of the car body to boost crashworthiness and weight productivity; their outline included strengthening the cross-segment.

![Fig 2: Automotive bumper system component](image)

Today, what is fascinating related of this examination is currently an imaginative inflatable bumper idea, called the "I-bumper," is created in this exploration for enhanced crashworthiness and wellbeing of military and business vehicles. The created I-bumper has a few dynamic basic parts, including a transforming component, a versatile bumper, two unstable airbags, and a transforming grid structure with a locking instrument that gives wanted inflexibility and energy ingestion ability amid a crash. Another imaginative enhancing crashworthiness is the use of tubes loaded with a granular material to assimilate energy amid of a crash.

1.3 MATERIAL PROPERTIES

1. High Strength to weight ratio
2. Rigidity
3. Corrosion resistance
4. Electrical Conductivity
5. Fatigue Resistance
6. Good tensile strength but Brittle
7. Fire Resistance/Not flammable
8. High Thermal Conductivity in some forms
9. Low coefficient of thermal expansion
10. Biologically inert
11. Self-Lubricating
12. Excellent EMI (Electromagnetic Interference) Shielding Property
13. Relatively Expensive

1.4 OBJECTIVES AND SCOPES

a) To break down the mechanical properties on front part (belt) of auto bumper:
   i. To examine on mechanical properties concentrate on stretch examination
   ii. To displaying the genuine measurement of the vehicle bumper into the UG software and examine by utilizing FEA programming (Analysis).
   iii. To research polymer composite material bumper (Proton Pesona) in view of their geometry and different parameters that impact the similarity of vehicle bumper.

b) To assess failures component of the car bumper:
   i. To think about the load dispersion on the bumper possibly it is consistently conveys to all the part amid the analysis.
To anticipate the basic point.
Their UI (user interface) toward interactive windows frameworks.

2 MODELING

![Modelling of bumper](image)

3 STRUCTURAL ANALYSIS

Steps followed in ANSYS workbench

3.1 Importing the Model

In this step the PRO-E model is imported into ANSYS workbench as follows:

![Imported Geometry](image)

In utility menu record alternative and select import outside geometry and open document and tap on produce. To go into recreation module tap on venture tab and tap on new reenactment.

![Defining material properties](image)
3.2 Defining Element Type
To characterize kind of component for the examination, picked the fundamental menu, select sort of contacts and after that tap on work right snap embed strategy
Technique - Tetrahedrons
Calculation - Patch Conforming
Component Midside Nodes – Kept

![Fig 6: Defining element type](image)

3.3 Meshing the model
To play out the cross section of the model these means are to be taken after:
Picked the principle menu tap on work right snap embed measuring and afterward select geometry enter component size and after that tap on create work.

![Fig 7: Meshing model](image)

3.4 Applying Boundary conditions and Loads
To apply the limiting conditions on the model these means are to be taken after:
Picked the primary menu, tap on new investigation tab select static, tap on face and after that select face of the geometry-right snap embed settled. Pick the principle menu, select face and tap on face of geometry-right snap – embed – drive

![Fig 8: Fixed supports](image)  ![Fig 9: Force application](image)
Table 1 Aluminum A390 alloy Properties

<table>
<thead>
<tr>
<th>Properties</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (x1000 kg/m³)</td>
<td>2.6 – 2.8</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>0.33</td>
</tr>
<tr>
<td>Elastic Modulus (GPa)</td>
<td>70-80</td>
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<tr>
<td>Tensile Strength (MPa)</td>
<td>180</td>
</tr>
<tr>
<td>Yield Strength (MPa)</td>
<td>180</td>
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<tr>
<td>Elongation (%)</td>
<td>&lt;1.0</td>
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</tbody>
</table>

Static Structural Analysis

Deformations at different frequency for Aluminum A390 are as follows:

Fig 10: Equivalent stress
Fig 11: Total Deformation
Fig 12: Mode 1 (75.837 Hz)
Fig 13: Mode 2 (91.862 Hz)
Fig 14: Mode 3 (108.98 Hz)
Fig 15: Mode 4 (137.4 Hz)
Fig 16: Mode 5 (151.48 Hz)

Fig 17: Mode 6 (164.8 Hz)

Table 2 Carbon Fiber Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Young’s Modulus</td>
<td>$3.88 \times 10^5$ Mpa</td>
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<tr>
<td>Poisson’s Ratio</td>
<td>0.358</td>
</tr>
<tr>
<td>Density</td>
<td>$1.6 \times 10^{-6}$ kg/m$^3$</td>
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<tr>
<td>Thermal Expansion</td>
<td>0.11/°C</td>
</tr>
</tbody>
</table>

Static structural analysis

Fig 18: Equivalent stress

Fig 19: Total Deformation

Deformations at different frequency for Carbon Fiber are as follows

Fig 20: Mode 1 (234.07 Hz)

Fig 21: Mode 2 (282.89 Hz)
Mild steel properties
Mild steel contains:
- Carbon: 0.16 to 0.18 % (maximum 0.25% is allowable)
- Manganese: 0.70 to 0.90 %
- Silicon maximum: 0.40%
- Sulfur maximum: 0.04%
- Phosphorous maximum: 0.04%
- Mildest grade of carbon steel or mild steel contains a very low amount of carbon: 0.05 to 0.26%

Table 3 Mild Steel Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<tbody>
<tr>
<td>Young's Modulus</td>
<td>210 Mpa</td>
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<tr>
<td>Poisson's Ratio</td>
<td>0.303</td>
</tr>
<tr>
<td>Density</td>
<td>7860 kg/m³</td>
</tr>
<tr>
<td>Thermal Expansion</td>
<td>$2.3 \times 10^{-0.051}/°C$</td>
</tr>
</tbody>
</table>
Static structural analysis

Deformations at different frequency for mild steel are as follows:

Fig 26: Equivalent stress

Fig 27: Total Deformation

Fig 28: Mode 1 (7.727e-005 Hz)

Fig 29: Mode 2 (9.3778e-005 Hz)

Fig 30: Mode 3 (1.11e-004 Hz)

Fig 31: Mode 4 (1.4022e-004 Hz)

Fig 32: Mode 5 (1.543e-004 Hz)

Fig 33: Mode 6 (1.677e-004 Hz)
DYNAMIC ANALYSIS
Material: Carbon Fiber

<table>
<thead>
<tr>
<th>Statistics</th>
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<tbody>
<tr>
<td>Nodes</td>
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<tr>
<td>Elements</td>
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</tbody>
</table>

Fig34: Geometry

Fig35: Messing part

Fig36: Directional Deformation - z Hitting Wall With 60 Km/Hr

Fig37: Total Deformation With 60 Km/Hr

Fig38: Equivalent stress With 60 Km/Hr

Fig39: Directional Deformation - z Hitting Wall With 80 Km/Hr

Fig40: Total Deformation with 80 Km/Hr

Fig41: Equivalent stress With 80 Km/Hr
RESULTS AND DISCUSSION

Table 4 Results

<table>
<thead>
<tr>
<th>Mode</th>
<th>Aluminum A390 alloy</th>
<th></th>
<th>Carbon Fiber</th>
<th></th>
<th>Mild steel</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency (Hz)</td>
<td>Total deformation (mm)</td>
<td>Frequency (Hz)</td>
<td>Total deformation (mm)</td>
<td>Frequency (Hz)</td>
<td>Total deformation (mm)</td>
</tr>
<tr>
<td>Mode 1</td>
<td>75.837</td>
<td>30.615</td>
<td>234.07</td>
<td>40.113</td>
<td>7.727e-005</td>
<td>1.8239</td>
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<tr>
<td>Mode 2</td>
<td>91.862</td>
<td>42.472</td>
<td>282.89</td>
<td>55.88</td>
<td>9.377e-005</td>
<td>2.2532</td>
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<tr>
<td>Mode 3</td>
<td>108.98</td>
<td>38.605</td>
<td>336.24</td>
<td>50.825</td>
<td>1.111e-004</td>
<td>2.2914</td>
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<tr>
<td>Mode 4</td>
<td>137.4</td>
<td>56.419</td>
<td>423.4</td>
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<td>3.5666</td>
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<td>Mode 5</td>
<td>151.48</td>
<td>41.4</td>
<td>467.54</td>
<td>54.907</td>
<td>1.543e-004</td>
<td>2.4422</td>
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<tr>
<td>Mode 6</td>
<td>164.8</td>
<td>62.671</td>
<td>509.35</td>
<td>81.85</td>
<td>1.677e-004</td>
<td>3.7452</td>
</tr>
</tbody>
</table>

Equivalent stress and Total Deformation

Table 5 Equivalent stress and Total Deformation

<table>
<thead>
<tr>
<th>Materials</th>
<th>Equivalent stress (MPa)</th>
<th>Total Deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum A390 alloy</td>
<td>51.719</td>
<td>1.2881</td>
</tr>
<tr>
<td>Carbon Fiber</td>
<td>51.566</td>
<td>0.23427</td>
</tr>
<tr>
<td>Mild steel</td>
<td>51.82</td>
<td>0.43751</td>
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</tbody>
</table>

Dynamic analysis results:

<table>
<thead>
<tr>
<th>Material</th>
<th>Directional deformation - Z(mm)</th>
<th>Total Deformation (mm)</th>
<th>Equivalent Stress (Mpa)</th>
<th>Material</th>
<th>Directional deformation</th>
<th>Total deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Fiber</td>
<td>60kmph</td>
<td>80kmph</td>
<td>60kmph</td>
<td>80 kmph</td>
<td>60kmph</td>
<td>80kmph</td>
</tr>
<tr>
<td></td>
<td>47.832</td>
<td>61.11</td>
<td>49.087</td>
<td>61.525</td>
<td>10.956</td>
<td>14.067</td>
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</table>

CONCLUSION

As we seen the above results, the total deformation and equivalent stresses are minimum in carbon fiber material. So, the material used for bumper as we preferred is carbon fiber.

References