Design of Shock Absorber for Car Front Bumper

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Abstract

Automotive designs with economy, safety and aesthetics have been a great challenge to design engineers. Automobile bumper subsystem is the front and rear structure of the vehicle that has the purpose of energy absorption during low velocity impact. Bumpers are structural components installed to reduce physical damage to the front and rear ends of a light/ heavy motor vehicle from low-speed collisions. The bumper should support the mechanical components and the body. It must also withstand dynamic loads without undue deflection. This Project deals with the idea of Hydraulic shock absorber using bumper in the front overhang of the four wheeler, which reduces the loss and deformation of the vehicle during the accident. It includes Hydraulic fluids and shock absorber spring as an active component in the Impact reducing system. This Project model built using the CATIA V5 R20 Software.

Keywords: Bumper, Frontal Crash, Shock Absorber, Safety

I. INTRODUCTION

The Car accidents are happening every day. Most drivers are convinced that they can avoid such troublesome situations. However, the statistics shows that ten thousand dead and hundreds of thousands of million wounded each year. Hence, improvement in the safety of automobiles is prerequisite to decrease the numbers of accidents. Automobile bumper is a structural component of an automobile vehicle which contributes to vehicle crashworthiness or occupant protection during front or rear collisions. The bumper system also protects the hood, trunk, fuel, exhaust and cooling system as well as safety related equipment. Bumper beams are usually made of steel, aluminum, plastic, or composite material. Bumper beams are also the backbone of the energy absorbing systems located at both front and rear on automobiles. This energy absorber which looks like a shock absorber, functions as a connecting member between a bumper and front cross member for the purpose of damping load and the shock load during a low speed collision between the motor vehicle and an obstacle. Under the bumper impact situation these energy absorbers are loaded in compression or tension as well as the bumper moves from a designed outer position toward the vehicle body and are operative to absorb the energy of the impact. After impact, these energy absorbers recover at various rates to return associated with bumper assembly toward its original pre-impact position.

Two absorbers are located between the front cross member and the front bumper reinforcement. During a front end impact, the energy absorbers shorten, just like a telescope type shock absorber. Following the impact, if the impact is not beyond the designed limits of the energy absorbers, they return to their original length. This action of forces hydraulic fluid to flow around the metering pin and through the orifices in the end of the piston tube. As the piston tube continues to move the flow of hydraulic fluid into the piston tube pushes the floating piston to the left. This compresses the oil in the piston tube; automotive bumper plays a very important role in absorbing impact energy for original purpose of safety and styling stand point/aesthetic purpose. Now days, automotive industry concentrates on optimization of weight and safety.

II. EXISTING METHODOLOGY

Most modern cars use a reinforced thermoplastic bumper, as they are making cheap to manufacture, easy to fit and absorb less energy during a crash. A majority of car bumpers are custom made for a specific model. However, many companies now offer alternative designs in thermoplastic, with a range of fittings designed for different models.

Steel Bumper Originally plated steel was use 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 bumper have pretty much disappeared for anything except classic cars. Replacing one involves a lot of searching for scrap cars or having one specially made. Improving passenger car damageability and repair ability.

A. Objective

The main objective of this work is to study front bumper in passenger cars in terms of shock absorber.

- To Design the shock Absorber assemblies in between chassis and front part of car bumper shock load withstand.
- Low speed collision focus on control.
- Bumper which will ensure passenger safety, with high strength to weight ratio through the static and having dynamic stability.
The main purpose of Shock Absorber is to absorb shock in case of a collision. Two materials have been used to develop these shock-absorbing capabilities, such as steel, aluminum. The purpose of this project is to design a bumper which is to improve crashworthiness of the bumper beam. Crashworthiness is the ability of the bumper beam to prevent occupant injuries in the event of an accident and this is achieved by minimizing the impact force during the collision.

### III. DESIGN CALCULATION

**A. Spring Calculation**

Mass of the car = 1500kg ;
Low speed = 5 km/hr
Velocity = 1.38m/s

Kinetic Energy = \( \frac{1}{2} mv^2 = \frac{1}{2} \times 1500 \times 1.38^2 \) m = mass; v = Velocity

\[ K.E = 1428.3 \times 10^3 \, \text{N.mm} \]

Strain Energy of spring (E) = \( 2 \times \left( \frac{1}{2} P \delta \right) \), P = load; \( \delta \) = Deflection. (Two shock Absorber)

Deflection we take Approximate = 150mm

\[ = 2 \times \left( \frac{1}{2} \times P \times 150 \right) = 150 \, \text{P} \]

Kinetic Energy = Strain Energy of spring

\[ 1428.3 \times 10^3 = 150 \, \text{P} \]

Load (P) = 9522 N ; \approx 10000 \, \text{N}

Steel wire Ultimate Tensile Strength \((S_u) = 1250 \, \text{N/mm}^2\) (High Tensile cast steel) Data book

Modulus of Rigidity \((G) = 80000 \, \text{N/mm}^2\) \((0.79 \times 10^5-0.85 \times 10^5)\) steel.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Specifications</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Permissible shear stress ((\tau))</td>
<td>625 , \text{N/mm}^2</td>
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<tr>
<td>2</td>
<td>Spring Index (k)</td>
<td>1.252</td>
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<tr>
<td>3</td>
<td>Mean coil Diameter (D)</td>
<td>120 mm</td>
</tr>
<tr>
<td>4</td>
<td>Wire Diameter (d)</td>
<td>20 mm</td>
</tr>
<tr>
<td>5</td>
<td>Total No of coils (N_t)</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Actual Deflection of spring ((\delta))</td>
<td>162 mm</td>
</tr>
<tr>
<td>7</td>
<td>Solid length of spring (L)</td>
<td>300 mm</td>
</tr>
<tr>
<td>8</td>
<td>Pitch coil (P)</td>
<td>35 mm</td>
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<tr>
<td>9</td>
<td>Stiffness (k)</td>
<td>61.72 , \text{N/mm}</td>
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</table>

**B.**

**C. Material properties**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Materials</th>
<th>Density (Kg/m³)</th>
<th>Modulus of Elasticity (N/mm²)</th>
<th>Modulus of Rigidity (N/mm²)</th>
<th>Poisson’s ratio</th>
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<tbody>
<tr>
<td>1</td>
<td>Aluminium</td>
<td>2710</td>
<td>0.675 \times 10^5</td>
<td>0.260 \times 10^5</td>
<td>0.34</td>
</tr>
<tr>
<td>2</td>
<td>steel</td>
<td>7850</td>
<td>2 \times 10^5</td>
<td>0.79 \times 10^5 - 0.89 \times 10^5</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Fig. 3.1: Steel Spring
**D. Hydraulic shock absorber**

Hydraulic shock absorber help to make your protection more efficient, processes faster, soft silent safety and more sustainable. A series of orifices is drilled in the inner cylinder wall at exponential intervals. The reason for the exponential spacing is derived from the equation for kinetic energy: $KE = \frac{1}{2} mv^2$. The cylinder is filled with fluid, and all air is bled from the fluid because air bubbles cut the efficiency of the shock absorbers by causing spongy or erratic action. When a moving load contacts the piston rod, it moves the piston inward, forcing fluid through the orifices in the inner cylinder wall. The fluid is forced through the oil return passages, into the space behind the piston head. As the piston retracts, it closes the orifices behind it, reducing the effective metering area, and maintaining a uniform deceleration force as the load loses its energy. Fluid pressure is constant in a shock absorber, providing constant resistance to the load. Hydraulic shock absorber parts are made in aluminium material like as piston head, piston rod, and cylinder.

<table>
<thead>
<tr>
<th>Table - 3.3 Oil properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade of product</td>
</tr>
<tr>
<td>Kinematic viscosity (100°C) mm²/s</td>
</tr>
<tr>
<td>Kinematic viscosity (40°C) mm²/s</td>
</tr>
<tr>
<td>Viscosity index</td>
</tr>
<tr>
<td>Flash point (COC), °C</td>
</tr>
<tr>
<td>Pour point, °C</td>
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</table>

**Fig. 3.2 Shock Absorber**

**IV. CONSTRUCTION OF DEVICE**

Solid modelling is a set of principles for mathematical and computer modelling of three-dimensional solids and is distinguished from related areas of geometric modelling and computer graphics by its emphasis on physical fidelity. At first the three dimensional drawing of the bumper and shock absorber is assembled in fixed front over hang. From main menu we go to ‘mechanical design’ and then to ‘part design’ and ‘Assembly Design’. Then select the required plane by using the ‘sketch’ option. Then the required lines are drawn. To exit from workbench, use the ‘exit workbench’ command. Use the ‘pad’ option for making these three dimensional drawing into the required one with dimensions. In between them usage of necessary steps like slot, pad and mirror options are also necessary for obtaining the desired model from the ‘mechanical design’ menu option. The various views of the shock absorber bumper are shown here from the different materials used to this shock Absorber model are aluminum, and Mild steel. The different properties which are used in mentioned.

**Fig. 4.1: Assembly of shock absorber**
V. CONCLUSION

Vehicle collisions are occurred in different possible modes. It may be head-on collision, rear end collision, and side collision and roll overs. Of these modes, head-on collision is mostly occurred one and causes severe damage to both vehicle and passengers. We cannot totally avoid these types of vehicle collisions. Instead of preventing these accidents which is not possible, collision effects can be reduced by providing Bumpers in the front side of vehicles. Thus in this project, effects of collision is much reduced by implementing the several units of Hydraulic Shock Absorber with spring in bumper of vehicles. The spring due to designed with stand 5 km/hr and remaining fluid action. Thus the development of smart materials will be an essential task in many fields such as energy, transportation, safety engineering and military technologies.

REFERENCES