Crash Analysis of Car Cross Member Bumper Beam

G. Yedukondalu
Asst. Professor
K L University
Guntur Dt.-522502, India
yedukondalu@kluniversity.in

Dr. A. Srinath
UGC Research Awardee Professor
Mechanical Engg., K L University
Guntur Dt.-522502, srinath@kluniversity.in

Dr. J. Suresh Kumar
Professor
JNTUH University
Hyderabad-500085, India
jyothula1971@gmail.com

Keywords: Bumper system, Crash analysis, Hyper works

Abstract

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. Damage and protection assessments are the commonly used design criteria in bumper design. For damage assessment, the relative displacements representing stiffness performance are examined and crash test will be done. The purpose of a crash analysis is to see how the car will behave in a frontal or rear collision. In this paper, impacts and collisions involving a car bumper beam model are simulated and analyzed using Hyper works software. The bumper should support the mechanical components and the body. It must also withstand static and dynamic loads without undue deflection or distortion. The given model is tested under frontal collision conditions and the resultant deformation and stresses are determined using hyper works software. The crash analysis simulation and results can be used to assess both the crashworthiness of current bumper and to investigate ways to improve the design. This type of simulation is an integral part of the design cycle and can reduce the need for costly destructive testing program.

Introduction

The automotive industry has always been known to be very competitive as far as its design and material usage are concerned. The automotive industry always faces greater market pressure to develop high quality products more quickly at lower cost, reduce weight in order to improve fuel efficiency and cost. Automotive bumper system was selected as a study of this paper. Automobile bumper is a structural component of an automotive 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 equipments [1]. The bumper system is generally recognized as being comprised of 4 basic components namely bumper fascia, energy absorber, bumper beam and bumper stay as shown in Figure 1 [2, 3]. When it is installed in a structure to be protected from shock, its weight is not a problem but its volume may be. Bumper beams are usually made of steel, aluminum, plastic, or composite material [4]. In contrary, for the shock absorber, low-density foam material is used.

There are several factors that an engineer must consider when selecting a bumper system. Bumper beam was selected, as it plays an important role of absorbing the bulk of energy and providing protection to the rest of the vehicle [5]. Bumper beams are also the backbone of the energy absorbing systems located at both front and rear on automobiles. Thus, it is important to determine the most appropriate design concept and material for the automotive bumper beam at the early stage of product development process.
Design requirements of car cross member bumper beam

Bumper beam is one of the main parts of the bumper system that protects a vehicle from front and rear collisions. Thus, it is important to design and manufacture bumper beam which can contribute to have good impact behavior. The most important consideration in designing bumper system is the ability of the bumper system to absorb enough energy to meet the original equipment manufacturers (OEM's) internal bumper standard [7]. A recent work published in [1] cited that the ability to stay intact at high speed impact, weight, manufacturing process ability, cost, formability and recyclability of materials are the major factors needed to be considered in designing bumper beam during the design phase. The other factors such as strength, shape, impact condition, thickness, cross section and ribbing pattern also need to be considered in designing automotive bumper beam [7-9]. However, bumper beam designs have to satisfy and meet safety standards requirement by local and international regulations.

Design of bumper beam

The automotive frontal bumper dimensions are considered for that of the “TATA Indica” car as shown in Figure.2 and dimensional parameter of the bumper beam as shown in Table.1. Now the model of Indica car cross member bumper beam is created in CAD software as shown in Figure.3
### Table 1: Dimensional parameter of the bumper

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L</td>
<td>Length of bumper</td>
<td>1020mm</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>Width of bumper</td>
<td>80mm</td>
</tr>
<tr>
<td>3</td>
<td>θ</td>
<td>Angle of bumper</td>
<td>26°</td>
</tr>
</tbody>
</table>

**Figure 3: CAD Model of cross member bumper beam**

**Types of Tests for bumper**

The bumper is assessed on three tests; frontal impact, side impact and pedestrian impact. The three tests are mandatory and can bring up to four stars. The fifth star is gained by the fourth test known as pole impact. The ratings are presented in stars, five stars being the maximum score. We tend to demonstrate the behavior of our model in pole impact, the impact which represents the frequent type of road crash. In frontal impact, the car strikes the pole at 30 m/s as shown in Figure 4.

**Figure 4: Car frontal bumper impact to the pole**

**Crash analysis**

The CAD model is imported into Hyper works and meshing is created on model in Hyper mesh as shown in Figure 5. For this analysis, steel has been considered as structural material. A rigid cylindrical pole (wall) created against cross member bumper beam as illustrated in Figure 6 is considered to get impacted with the car bumper.
Results & Discussions

a) Displacement contour plot

During the initial stages of collision the loads are induced slowly on model. Here the maximum value of displacement is found out to be 2.536 E+01. The Figures. 6 & 7 shows the contour displacement plot at initial stages of collision and after collision.
Figure 6: Displacement at initial stages of collision

Figure 7: complete deformation after collision
b) Von-Mises stresses

The Figures 8 & 9 shows the stress at the initial point of collision and after collision. Here the maximum value of stress is found out to be $2.271 \times 10^3$ at node 1673. The Figures 10 & 11 shows how the internal forces varying with collision and the variation of acceleration with collision.

Figure 8: Impact at the time of initial collision (VonMises stresses)

Figure 9: Impact of induced stress after collision
Figure 10: Internal forces during collision

Figure 11: Acceleration during collision
c) *Kinetic Energy*

Surviving a crash is all about kinetic energy. When the body of occupant is moving it has certain amount of kinetic energy. After the crash, when it comes to a complete stop, it will have zero kinetic energy. So, one can say that the kinetic energy decreases in course of time during collision and completely becomes zero after crash as shown in Figure 12.

*Figure 12: showing the drop in Kinetic Energy with time*
Future Plans

The design of the existing bumper should be modified so that there should not be any deformation for low or high speed collisions. Instead of using high carbon steels composite materials should be included in the fabrication of cross member bumper beam to withstand at higher loads.

Conclusions

During the crash analysis test the maximum Von-Mises stress was observed to be 2.271 E+03 for a low speed collision with a velocity of 30 m/s.

Crash testing leads to improvement of the safety systems. These systems again have to be tested for their workability during a crash. Hence crash testing plays a vital role in continuous improvement of the safety systems. Design changes in vehicles and the location of engine block have been the results of evolution of crash testing. Therefore in future, crash testing could suggest many more design changes, which could further minimize the probability of damage during a crash.

ACKNOWLEDGEMENTS

The authors are thankful to Sri Koneru Satyanarayana, President, K L University, Guntur Dt., Andhra Pradesh, India for having the Altair Design Center established at K L University-Guntur District in 2009, which made this work possible.

REFERENCES


