Study of Impact on Car Bumper-A Literature Review

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Abstract

India has a high number of deaths due to road accidents. India has the world's sixth-largest car market, but is still the only country among the global top ten car markets without proper new car safety regulation or testing programs. It is estimated that vehicles in India will cost 8-15% more resulting from compliance with these norms. However, harmonizing India's vehicle safety standards with global standards is expected to help automakers export locally produced cars globally. Since 2006, India has been having more road deaths per year than any other nation, with 230,000 dying annually. Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. Saving the impact energy in the bumper to be released in the environment reduces the damages of the automobile and passengers.

Keywords: Car Bumper, Impact

I. INTRODUCTION

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 to million wounded each year. Hence, improvement in the safety of automobiles is prerequisite to decrease the numbers of accidents. Automotive bumper system is one of the key systems in passenger cars.

Bumper system is one of the key systems in passenger Cars. Bumper systems are designed to prevent or reduce physical damage to the front or rear ends of passenger motor vehicles in collision condition. They protect the hood, trunk, grill, fuel, exhaust and cooling system as well as safety related equipment Such as parking lights, headlamps and taillights, etc. A good design of car bumper must provide safety for passengers and should have low weight. Different countries have different performance standards for bumpers. Bumper systems are designed to prevent or reduce physical damage to the front or rear ends of passenger motor vehicles in collision condition.

Automotive bumper plays a very important role in absorbing impact energy (original purpose of safety) and styling standpoint/aesthetic purpose. Now a days, automotive industry Concentrates on optimization of weight and safety.

II. LITERATURE REVIEW

[1] Standard homologation procedures require demonstration of vehicle safety test known as “crash test analysis”. To achieve maximum safety for occupant, also for the pedestrians we need to do crash worthiness of a vehicle, so EuroNCAP has prescribed various standards according to which crash test of vehicle have to perform. Here without considering the whole vehicle for analysis, only a bumper beam system is taken, to minimize the computational work and errors. With the help of LS-DYNA codes nonlinear dynamic contact analysis by using advanced materials has been done effectively.

The program encourages the automotive industry to exceed the Minimum requirements for safety provided by legislation. The vehicles are assessed on three tests; frontal impact, side impact and pedestrian impact.

In frontal impact, the car strikes the offset barrier at 64 km/hr. The foremost important element in frontal impact is the front bumper. The bumper is fixed to the chassis with crash boxes. Indentations in the crash boxes behind the bumper are designed especially to absorb the energy released at the moment of collision. The more energy is used to deform the beams, the less of it remains to deform and damage other elements. The bumper and its crash boxes were built as 3D
Model in CATIA and meshed with finite elements in HYPER MESH.

[2] This paper presents the Finite Element Analysis of the frontal rails of a passenger car. Front rails will connect between Front bumper and Dash Toe pan. They are one of the structural members which will absorb high energies in frontal impact, so

that impact energy won't transmit to driver/passengers. A rigid barrier is modeled to collide with the left frontal rail. The rail is assigned with steel material. After providing the necessary interactions and performing meshing, the whole model is run for dynamic explicit code using ABAQUS 6.11 PR3.

Passenger cars are a major mode of transport in the developed as well as in the developing countries. Therefore the accidents caused due to passenger cars are also significantly on the rise. In all types of crash accidents, about 30 % of the total numbers of accidents are frontal crash case. Therefore, measures to improve passenger vehicle passive safety performance in crash to reduce injury and death of passengers during a crash to the maximum has become an important subject of research.

The frontal rails are an integral part of the crumple zones which form the front energy absorbing area. Front rails will connect between Front bumper and Dash Toe pan. They are one of the structural members which will absorb high energies in frontal impact, so that impact energy won't transmit to passengers / driver .Figure 1 shows the Frontal Rail.

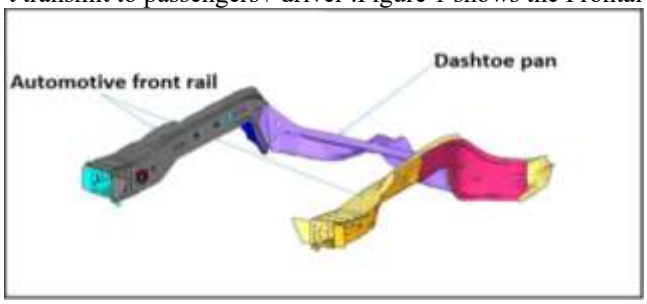

Fig. 1:

The frontal rails are welded with stiffeners inside it. As the name suggests, stiffeners are required to increase the rigidity of the component just to the required level. Figure 2 shows the stiffeners used inside the frontal rails.

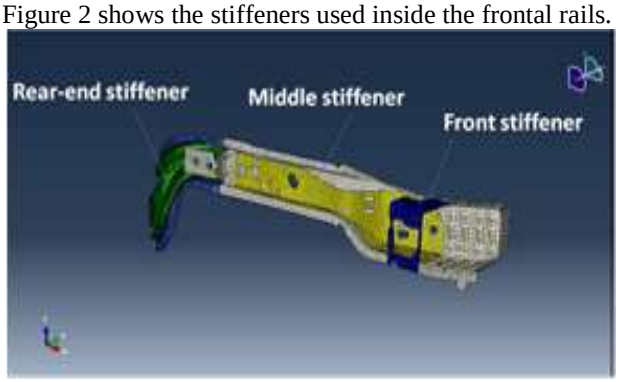

Fig. 2:

[3] In this paper "SIMULATION OF FRONTAL CRASH-TEST" The simulation of vehicle crashes by using computer software's has become an indispensible tool for shortening automobile development time and lowering costs. It also has huge impact on the crashworthiness of an automobile .This work reports on the simulated crash test of an automobile. The objective of this work is to simulate a frontal impact crash of an automobile and validate the results. The aim is also to alter some of the materials of the components with a view to reduce the forces experienced during the crash.

A crash-test is a form of destructive testing usually Performed in order to ensure safe design standards in crashworthiness and crash compatibility for automobiles or related components. To test the cars safety performance under various conditions and during varied types of crashes, vehicle manufacturers crash test their cars from different angles, different sides and with different objects, including other vehicles.

The most common types of crash tests are listed below.

- Front impact test
- Front offset crash test
- Side impact test
- Roll over test

A. Method of Analysis (LS-DYNA)

Crash-testing requires a number of the test vehicle to be destroyed during the course of the tests and is also time consuming and uneconomical. One new recent trend that is gaining vast popularity is computer simulated crash-testing. Here instead of a real vehicle, a FE (Finite Element) model of the vehicle is generated and is used to carry out the different tests that were carried out before using actual vehicles. There are several software packages that are equipped to handle the crash-testing of vehicles, but one of the most popular is from Livermore Software Technology Corporation called LS-DYNA.

With LS-DYNA, automotive companies and their suppliers can test car designs without having to tool or experimentally test a prototype, thus saving time and expense. While the package continues to contain more and more possibilities for the calculation of many complex, real world problems, its origins and core competency lie in highly nonlinear transient dynamic finite element analysis (FEA) using explicit time integration. The application of LS-DYNA covers a wide range of industries.

[4] The goal of this paper is to design a bumper with minimum weight by employing the Glass Material Thermoplastic (GMT) materials. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction.

To reach this aim, a mechanism is designed to convert about 80% of the kinetic impact energy to the spring potential energy and release it to the environment in the low impact velocity according to American standard. In addition, since the residual kinetic energy will be damped with the infinitesimal elastic deformation of the bumper elements, the passengers will not sense any impact. It should be noted that in this paper, modeling, solving and result's analysis are done in CATIA, LS-DYNA and ANSYS V8.0 software respectively.

Nowadays, with the development of the automobile technology, more and more light weighting materials like the Glass Material Thermoplastic (GMT) are applied to the automobile body. . GMT provides a high strength to¬ weight ratio, chemical / corrosion resistance, and excellent impact properties at both low and high temperatures Compared to metals, GMT offers greater design flexibility, lower tooling costs, and opportunities for part consolidation. Compared with thermoset composites, GMT improves productivity with shorter molding cycle time, greater impact resistance, recyclability (melt reprocess ability), and elimination of controlled-storage requirements.

There are three principle types of GMT, including continues glass fiber, chopped glass fiber and unidirectional glass fiber. The use of GMT in high-impact, structural applications in the automotive and transportation industry is well documented.

Over the last few years, some factors have made this Application more interesting for GMT, which are as follows:

1) Increasing demands of the vehicle weight reduction: Reduction in fuel consumption and in addition to, since, the bumper is far from the center of gravity of the vehicle so it's weight is also critical to the inertia and as a result to the vehicle handling.
2) Higher required energy absorption: Achieving energy absorption at bumper mounting points to protect the structures behind it in the vehicle, at low speed crash.
3) Controllable fracture behavior: Part integrity and stabilization function at very high speed crashes. At these rates primarily the deformation behavior is important.

In this research, a typical new front bumper beam on a passenger cars have been designed with GMT composite materials. This bumper absorbs impact energy with its deformation or transfers it perpendicular to the impact direction with the aid of a spring mechanism that is able to convert about 80% of the kinetic energy to the spring potential energy in low speed impacts according to American standard The main design concepts of this bumper are based on aerodynamic forms and frontal configuration of passenger cars. The design of spring system has done with the aid of Genetic algorithm in MATLAB V6. The CATIA data of the bumper structure have imported to LS-DYNA Ansys and analyses have done with nonlinear explicit impact modeling elements.

Main parts of the conventional bumper systems are depicted in Fig. 3

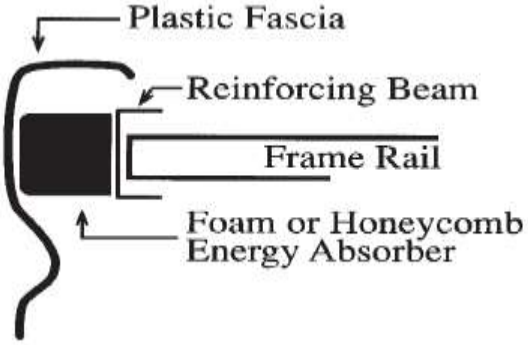

Fig. 3: Configuration of common bumper type.

1) Fascia: bumper fascias must be aerodynamic, light weight and aesthetically pleasing to the consumer. Usually fascias are made of polypropylene, polyurethane or polycarbonate.
2) Energy absorbers: energy absorbers are designed to absorb a portion of the kinetic energy from vehicle collision.
3) Reinforcing beam: this part is a key component of the bumper and helps absorb the kinetic energy and provide protection to the rest of the vehicle.

The main elements of this bumper are as follows (see Fig.3):

1) Front rubber tape: that is composed of polypropylene (PEP) for damping of poor contacts.
2) Fascia: it indicates the aerodynamic form of the bumper and is used as a bearing for spring system retainer.
3) Spring system: it contains 26 vertical springs for converting the kinetic energy to the spring potential energy, In addition to horizontal springs for connecting the fascia to base plate.

4) Conics and base plate: they are main elements of the bumper for energy absorbing in high speed contacts (i.e. reinforcing beam).
5) Connecting plastic parts: two propylene (PEP) parts that connect the bumper base plate to the car. Fig. 4

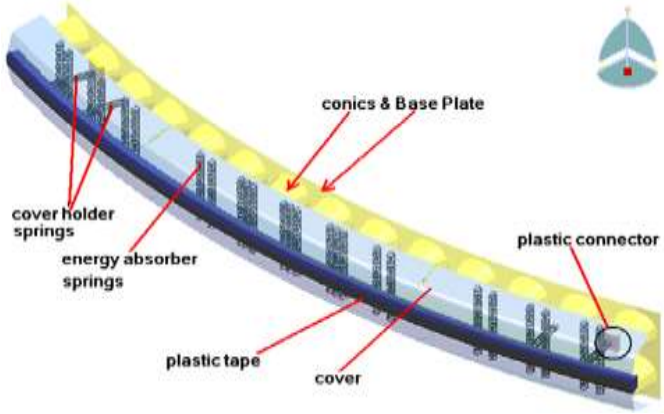

Fig. 4: Schematic configuration of the desired bumper

In the low speed impacts, the cover moves toward the Conics to reaches its top surface and make the spring system to Stretch in vertical direction as a result of cover edges sliding on the conics. The initial dimensions are calculated and selected proportionally then as a result the spring system stretches a totally 6 cm perpendicular to the impact direction.

Explicit method is a fast method for short time problems, complicated contact and impact problems and multiple non linearity's large deformations (Dynamic & quasi static) in LS-DYNA. The CATIA V5 CAD data of the bumper model was imported to LS-DYNA Anys8.0. Then, meshing has created on a 3D model.

The GMT offers more suitable material at lower cost and easier production process in comparison with conventional metals. Also, it can form large and complex parts with appropriate dimensional stability in a short shaping cycling.

[5] In this paper the simulation of a bumper is characterized by impact modeling using Pro/Engineer, impact analysis is done by SOILD WORKS according to the speed that is 13.3 m sec-1 (48 km h-1) given in order to analyze the results. This speed is according to regulations of Federal Motor Vehicle Safety Standards, FMVSS 208- Occupant Crash Protection whereby the purpose and scope of this standard specifies requirements to afford impact protection for passengers. In this research, analysis is done for speed according to regulations and also by changing the speeds. Simulation using Finite Element Analysis software, which is SOILD WORKS, was conducted.

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 fascias 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.

The use of plastic in auto bumpers and fascias gives designers a tremendous amount of freedom when it comes to styling a prototype vehicle, or improving an existing model. Plastic can be styled for both aesthetic and functional reasons in many ways without greatly affecting the cost of production. Plastic bumpers contain reinforcements that allow them to be as impact-resistant as metals while being less expensive to replace than their metal equivalents.

Some of the plastic products used in making auto bumpers and fascias can be recycled. This enables the manufacturer to reuse scrap material in a cost-effective manner. A new recycling program uses painted TPO scrap to produce new bumper fascias through an innovative and major recycling breakthrough process that removes paint from salvage yard plastic.

Pro/E is a software application within the CAD/CAM/CAE category, along with other similar products currently on the market. Pro/Engineer is a parametric, feature-based modeling architecture incorporated into a single database philosophy with advanced rule-based design capabilities. The capabilities of the product can be split into the three main heading of Engineering Design, Analysis and Manufacturing. This data is then documented in a standard 2D production drawing or the 3D drawing standard ASME Y14.41-2003.

Modeling of car bumper is done with help of Pro-e software and dimensions are selected from one of car bumper. As the impact is more for the front portion of bumper only outer dimensions of car bumper has been considered for modeling, Slots provided in middle of car bumper is used for reducing drag effect in car bumper.

Modeling of a car bumper is done using 3D modeling software Pro/E. Impact analysis is done on the car bumper for different speeds of 48Km/hr, 75Km/hr. The analysis is also carried on the car bumper for different materials ABS Plastic and Carbon Fiber-Reinforced Poly-Ether-Imide PEI. At Present the material used for car bumper is steel. Steel is replacing with ABS Plastic and Carbon fiber -Reinforced Poly-Ether-Imide PEI. The density of ABS Plastic and PEI is less than that of steel; thereby the overall weight of car bumper is reduced.

By observing the Impact Analysis results like Stress, Displacement and strain, the stress values are less for ABS Plastic and PEI than steel. By comparing the results of ABS Plastic and PEI, the stress values are less for ABS Plastic than PEI. ABS Plastic is better for utilization comparing PEI.

[6] The designer should be aware that in order to reduce the weight, the safety of the car passenger must not be sacrificed. In development of bumper systems for the automotive industry, iterative Finite Element (FE) simulations are normally used to find a bumper design that meets the requirements of crash performance.

The increasing legal and customer demands on passive safety of automobiles have to be fulfilled under the conditions of shortened development times and cost reductions. Today the design process of a car with regard to its crashworthiness function is driven by a virtual development.

In a case of a collision to the front or rear occurring at low speed, the bumper shall absorb the energy to prevent or reduce damage to the car. Consequently, the purpose of the bumper is not to be a structural component that actively contributes to occupant protection during front or rear collisions but more to protect components like the hood, lights and cooling system of the car.

In bumper system development, iterative finite element (FE) crash simulations are most commonly used to find a candidate design that may meet the requirements stated by the manufacturers, by insurance companies and in legislations. Besides those requirements, considerations of weight and cost for manufacturing are also factors that are regarded. Here we deal with the plastic strain values of components in bumper assembly which are to be kept in permissible limit in both analysis by solver and actual testing.

B. Preprocessing

The model consists of infinite number of points hence it should be discretized to some finite number of divisions on which analysis is to be carried out. So we mesh this model to divide it into finite number of divisions called as nodes and elements. We prefer 2d or shell mesh as the third dimension (thickness) of all the components is very small as compared to other two dimensions.

C. Solution Stage

After preprocessing model is further send for analysis. Here we use LS-DYNA solver for analysis purpose which is an explicit solver.

D. Post Processing

After carrying out analysis results are viewed. Our analysis is of nonlinear type. Here we deal with the effective plastic strain values for the components used in analysis. Our aim is to maintain the plastic strain values of components up to their prescribed tolerance values.

E. Possible Solutions

1) Change in design of components-: we can change the design of components to get the required results. This leads to redesigning the components by addition of ribs or change the geometry thus it increases the cost.
2) Change of material-: We can change the material of the components for proper stress distribution. We can go for some additional composite materials to avoid the design failure.
3) Change in thickness-: we can change the thickness of components to achieve the effective plastic strain values for the respective components. It is cost effective and time consuming way of modification.

The permissible strain values can be achieved by changing the thickness of bumper components. Changing the thickness is one of the cost effective way to get the assembly in safety zone as compared to others such as change in geometry or addition of ribs.

Permissible plastic strain value results show efficient energy absorption, thus making the component assembly safe. Hence running an analysis on explicit solver leads to cost effective way to solve the crash related problems prior to actual production.

Increasing bumper thickness causes a rise in bumper rigidity increasing its strength. Consequently, it results in reduction in strain values.

[7] In this paper types of car bumper are discussed

1) 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.

2) Boby Kit Bumpers

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.

3) Carbon Fiber Bumpers

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.

4) Steel Bumpers

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. Improving passenger car damageability and reparability has been an important RCAR topic since the Council was established in 1972. In some cases, manufacturers have eliminated the bumper beam and replaced them with localized countermeasures, such as crush cans, to manage the test. Such sub-optimized designs are in most cases not robust and often lead to expensive damage in car-to-car crashes. Bumpers should ideally be mounted at slightly different heights front and rear but have sufficient height to maintain engagement over a wide range of circumstances. However, many vehicles do not have bumper reinforcement beams that extend laterally much beyond the frame rails, leaving expensive vehicle components such as headlamps and fenders (wings) unprotected. An international RCAR working group has developed test procedures to assess how well a vehicle's bumper system protects the vehicle from damage in low speed impacts. Damage in these tests closely replicates the damage patterns observed in real world low speed crashes and addresses three components of bumper performance:

1) Geometry – vehicle bumpers need to be positioned at common heights from the ground and extend laterally to the Corners in order to properly engage other vehicles in low speed crashes.
2) Stability – vehicle bumpers need to be tall and wide enough to remain engaged with the bumpers of other vehicles despite vehicle motion due to loading, braking, etc.
3) Energy-absorption – vehicle bumpers should absorb low speed crash energy without damage to other parts of the vehicle.

The majority of modern plastic car bumper system fascia 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.

Three main design factors for this structure: shape, material and impact condition are studied and the results are compared with conventional metals like steel and aluminum.

In this research, a front bumper beam made of three materials: aluminum, glass mat thermoplastic (GMT) and high-strength sheet molding compound(SMC) is studied by impact modeling to determine the deflection, impact force, stress distribution and energy-absorption behavior.

The study will focus on existing design performance, advantage and limitations. Based on Observations design improvements will be made in terms of shape & material based on design Modification objectives. Modified front bumper design will be tested using FEM software for impact loads as per international standards. Side view of a bumper is shown in figure no. 5

Fig. 5: Side view of a bumper

Modern ABS copolymers are being used on an ever increasing scale for the manufacture of many industrial and domestic products. The material is very tough and resilient, has high impact strength, good chemical resistance and is non-toxic and taint free.

The project data can be used for best bumper designs of modern vehicles from material point of view. Impact loading parameters can be evaluated for varying speeds. The project work will be helpful to have optimum material choice for frontal car bumper design based on comparative results of both materials i.e. PEI and ABS plastic.

III. OBJECTIVE

The aim of this work is to study impact on front bumper as it is the important element from safety point of view.

IV. CONCLUSION

From the above literature it can be stated that bumper is an important member of an automobile from the safety point of view. Thus the analysis of bumper will help to increase the safety of passengers and new size, shape and material may also be considered to replace the existing one.

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