ANALYSIS ON BUMPER DURING COLLISION

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ABSTRACT
Bumper is one of the main parts which are used as protection for passengers from front and rear collision. Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. So it become an important part of a vehicle as a safety and performance point of view. In this paper, a domestic A-class car bumper is being studied. CAE model was established by using crash analysis (HyperMesh) software, and the finite element method is assigned to solve the calculation of the model. In this work, the simulation of a bumper is characterized by impact modeling using CAE and the impact analysis is done through HyperMesh which has a speed that is 15.27 m sec-1 (55 km h-1) given in order to analyze the results.

KEYWORDS: *Automotive engineering bumper, CAE model, HyperMesh pre-treatment, Finite Element Analysis.*

I. INTRODUCTION

A commercial front bumper beam was chosen in this study for meshing and impact test. With the introduction of automobile safety legislation, crash- worthiness and safety should be considered as preconditions in light-weighting design of bumper beam. The automobile bumper weight can be reduced by the use of composite and high- strength metallic sheet of a thinner thickness material. When the bumper is impacted by a stiff object, such kind may happen in a parking accident or in the legislative low speed impact pendulum test, then the bumper fascia alone may not be there to withstand the impact without considering the forces acting on it. Thus there were four main strategic parameters being studied during the test. Firstly, the material, i.e., how the type of material can affect the impact specifications and what kind of materials can be used as replacement in order to lower part weights. The effect of module of elasticity, yield strength and Poisson's ratio on impact behavior of bumper beam was under investigation in this section. Secondly, the thickness, i.e., how the bumpers beam thickness can affect the impact specifications. Thirdly, the shape, i.e., how even small changes and modifications can result in easier manufacturing processes and lessening material volume without lowering the impact strength.

II. BACKGROUND OF STUDY

The automobile industry has been improved significantly since 1953 by emerging the composite materials. Since it is proved that the composite materials can achieve the desirable properties such as low weight, high fatigue strength, easy forming and high strength, they are suitable for material replacing. But these composites have undesirable properties also like, relatively long time processing, expensive raw materials and low surface finish quality. Though its light weight is the major reason for the increasing application of the composite materials in the automobile industry. In the mass production of vehicles, the light weight of components results in a significant reduction of the fuel consumption and consequently the reduction of the CO2 and other emissions. Since the experimental tests, particularly at full-scale, are very costly and require highly specialized test facilities and also the model being evaluated inevitability and suffer large amount of damages. Thus utilizing the crash simulations seems to be crucial.

FUNCTIONS

A bumper is usually designed for providing a shielding effect and providing the safety from the collision. Bumper is generally made up of steel, aluminum rubber or plastic which is mounted on the rear and front of a vehicle. The main function of the bumper is to absorb the amount of energy and shocks and to reduce the damage which will affect the car. Some bumper use energy absorbers or brackets and others made with foam cushioning material. Bumpers are also designed to prevent or reduce the physical damage and to protect the hood, trunk, grille, fuel tank, exhaust and radiator besides the engine and rear part. Bumpers are intended to prevent injury to occupants in the passenger cars. They are also designed so that the cars can collide without much danger to the drivers. Each vehicle consists of a large rubber bumper all around it, which prolongs the impact and diffuses the force of collision.

III. LITERATURE REVIEW

Today's plastic auto bumpers and fascia systems are aesthetically pleasing, which gives several of advantages to both designers and drivers. The majority of modern plastic car bumper system fascias are made up of thermoplastic olefins (TPOs), polycarbonates, polyesters, polypropylene, polyurethanes, polyamides, or blends of these with, for instance, glass fibers, for strength and structural rigidity. As bumper beams are one of the main structures of passenger cars that protect them from front as well as rear collisions. In this work, a commercial front bumper beam made of Fibre-Reinforced Plastic (FRP) is studied and characterized by impact modeling using HyperMesh.

Three main design factors for this structure: Shape, Material and Impact condition are studied and the results are compared with modified design using steel as a material. Finally the aforementioned factors are characterized by proposing a high strength bumper instead of the current FRP. In this paper, we discussed the most important parameters including material, thickness, shape and impact condition are studied for design and analysis of an automotive front bumper beam to improve the crashworthiness design in medium-velocity impact. The simulation of bumper is taken under economy-speed and the impact condition is studied. In this research, a front bumper beam made of two materials: steel and Fibre-Reinforced Plastic (FRP) is studied by impact to determine the displacement, impact due force, stress distribution over the surface and energy-absorption behavior. These characteristics are compared to each other to find the best choice of material, shape and thickness. So by these results a modified FRP bumper is taken that can minimize the bumper beam displacement, impact force and also maximizes the stress distribution over the surface. In addition, the effect of passengers in the impact behavior is examined. Different countries have different performance standards for bumpers. Many times there are conflicting performances and cost requirements, which put an additional effort to the R&D units to come up with a number of alternative design solutions in less time. Some of the modern CAD and FEM tools are capable of effecting quick changes in the design within virtual environment.

3.1. Parameter Considered

During the car collision, a large amount of energy is dissipated by body deformation. But the collision is totally depending upon the members which are loaded axially or by bending or by the combination of both. Axially loaded members will normally dissipate some part of the energy during the front collision. It is observed that some amount of energy will collapse by folding and bending the plate elements composing the component. Thus small variations in the geometry, properties of the material and the loading conditions will change the result.

Today engineers are focusing on the robust behavior of the energy dissipating structure. So they decide the geometry, loading and the boundary conditions and variation in the material properties. Thus the automotive industry now emphasizing on the Finite Element Analysis to reduce the lead time.

3.2. Fibre Reinforced PlasticTitle

Fiber reinforced polymer is also known as Fiber-reinforced plastic or simply FRP. It is a composite material which is made up of a polymer matrix reinforced with fibers. The fibers are generally made of glass, carbon, or aramid. There are some other fibers such as paper or wood or asbestos have been

sometimes used. The polymer is usually an epoxy, vinylester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

They are the composites which are used in advanced engineering such as aircrafts, helicopters and space crafts. Now it became into existence to boats, ships, automobiles, sports goods, civil infrastructure such as bridges and buildings. Due to this it includes development in high performance resin systems and new style of reinforcement, such as carbon nanotubes and nanoparticles.

FRP Material possesses superior mechanical properties such as:

- Strength
- Impact Resistance
- Ability to carry loads
- Flexibility
- Stiffness

3.3. Failure Loads

Structural Failure can occur in FRP materials due to following reasons:

1. Tensile forces stretch the matrix more than the fibres, causing the material to shear at the interface between matrix and fibres.
2. Tensile forces near the end of the fibres exceed the tolerances of the matrix, separating the fibres from the matrix.
3. Tensile forces can also exceed the tolerances of the fibres causing the fibres themselves to fracture leading to material failure.

3.4. FRP Applications

Fibre-reinforced plastics are best suited for designs which gives in weight reduction, precise engineering, finite tolerances and which are easy in production. They are cheaper, faster and much easier to manufacture than cast aluminum or steel artifact.

IV. HYPERMESH SOFTWARE

HyperMesh is product of design and development of Altair Engineering. It is a software which is based on CAE Models as these CAD models were imported through this software and further the Meshing process occurs. The meshing of a model plays a very important role in analysis of an object. Through this analysis various amount of forces, stresses and displacement can be calculated. As there are numerous of software which provides quite appreciable analysis of these objects. But the basic purpose to choose this software for analyzing is that it gives quite understandable results as well as it is famous for crash analysis. In today's world crash analysis is now getting very much importance for safety and security of the passengers as well as for the vehicles.

Altair Hyper Mesh is a high-performance finite element pre-processor to prepare even the largest models, starting from import of CAD geometry to exporting an analysis run for various disciplines. In the year 1990, HyperMesh was released by Altair and in the year 1994, Altair receives Industry Week's "Technology of the Year" award for OptiStruct.

Hyper Mesh enables engineers to receive high quality meshes with maximum accuracy in the shortest possible time. A complete set of geometry editing tools helps to efficiently prepare CAD models for the meshing process. Meshing algorithms for shell and solid elements provide full level of control, or can be used in automatic mode. Altair's Batch Meshing technology meshes hundreds of files precisely in the background to match user-defined standards. Hyper Mesh offers the biggest variety of solid meshing capabilities in the market, including domain specific methods such as SPH, NVH or CFD meshing.

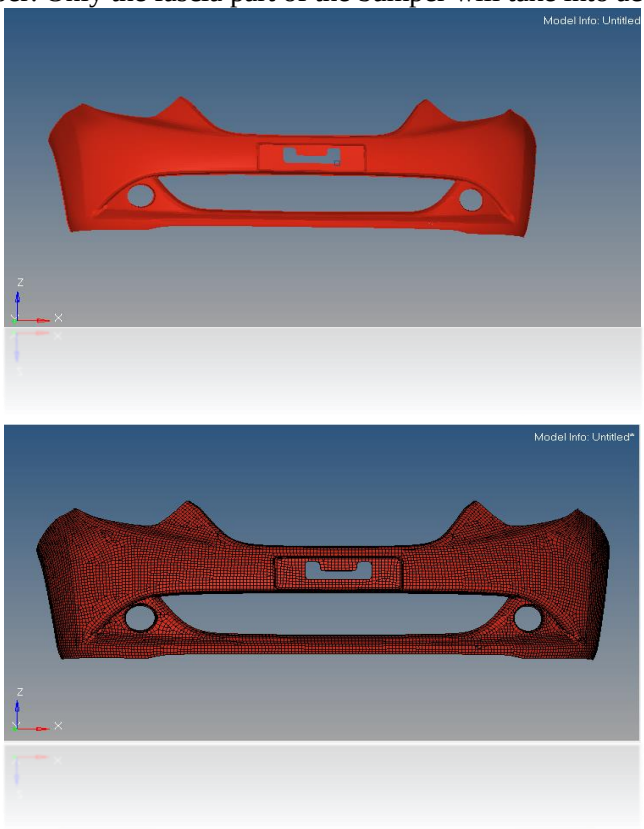
With a focus on engineering productivity, HyperMesh is the user-preferred environment for:

- Solid Geometry Modeling
- Surface Geometry Modeling
- Shell Meshing
- Batch Meshing

- Automatic Mid-Surface Generation
- Model Morphing
- Solid Mesh Generation

V. PROBLEM STATEMENT

From the previous research or analysis on car bumper, basically they focus on the design and crashworthiness optimization. However, for this analysis we are focusing on the stress analysis on car bumper by applying the point load on the static condition only as at some particular points during crash, the portion which is slightly outwards will first comes in contact due to the collision. In the real situation, there are many points onto which the bumper is mounted on the car which makes it stronger or it can absorb more energy due to the impact. For the simulation, we are taking both the ends as fixed points of the bumper. Only the fascia part of the bumper will take into account.



Above figure is a commercial bumper which is fully auto-meshed in HyperMesh and material is FRP.

VI. OBJECTIVES OF THE WORK

The main aim of this work is to study front bumper of one of the existing passenger cars in Indian market and suggest design improvement in front bumper of a passenger car in terms of material selection using Impact Analysis.

1. To analyze the mechanical properties on front part (fascia) of car bumper by comparative speed impact analysis.
2. To analyze the mechanical properties which focuses on stress analysis.
3. To meshing the actual dimensions of the car bumper into the HyperMesh software and analyze by using impact loading.
4. To investigate Optimum and effective material bumper based on their geometry and other parameters that influence the compatibility of car bumper with Finite Element Analysis.

VII. RESULTS AND ANALYSIS

Necessary Conditions for Analysis

- Kinetic Energy should be zero.
- Summation of all the Forces should be zero. All forces should be in equilibrium.

7.1. Results on FRP Material

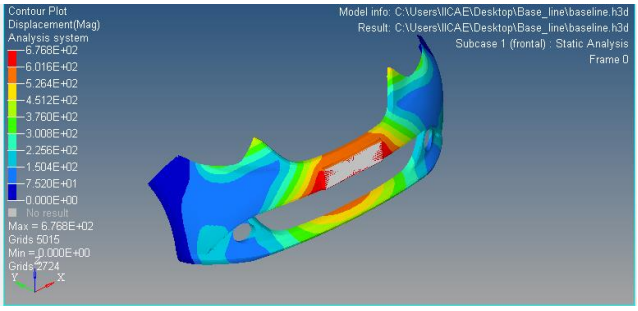


Figure shows the Maximum Displacement before Collision

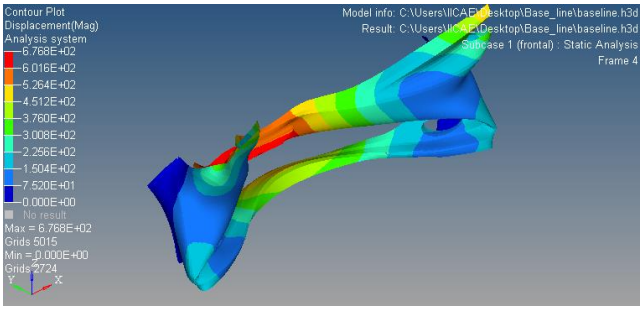


Figure shows the Maximum Displacement after Collision

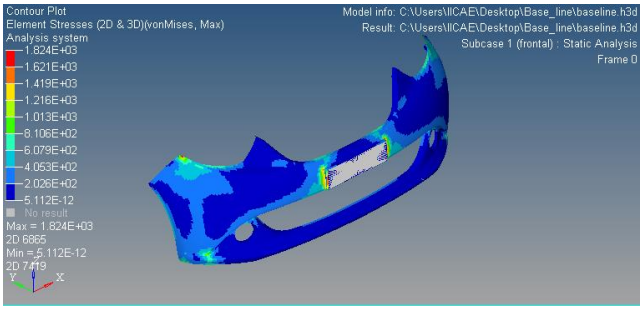


Figure shows the Maximum amount of Stresses before Collision

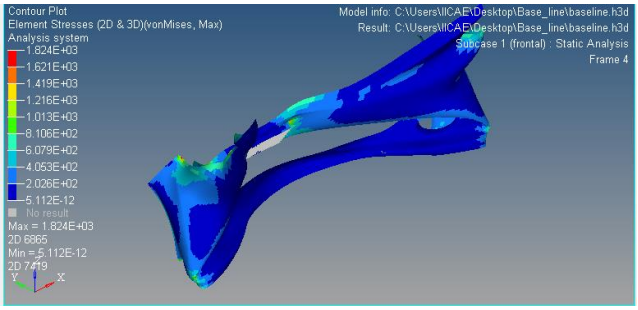


Figure shows the Maximum amount of Stresses in 2D and 3D after Collision

7.2. Results on FRP Material with Steel Plate

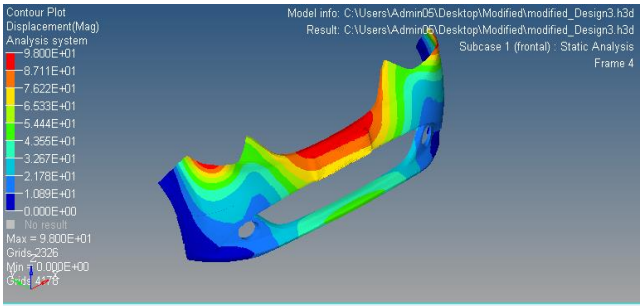


Figure shows the amount of Displacement on a Modified Design

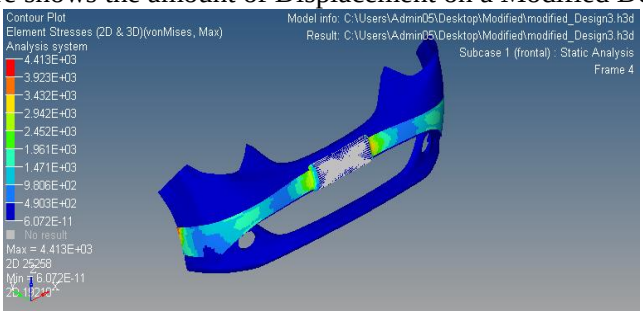


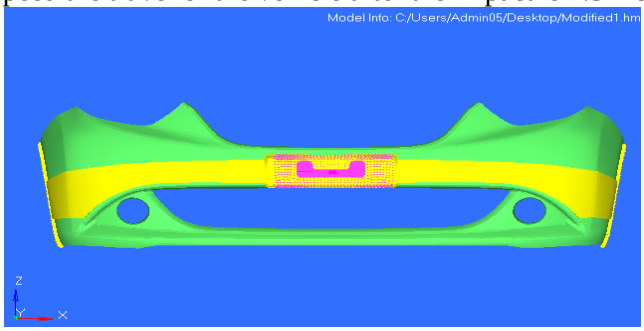
Figure shows the amount of Stresses in 2D and 3D on a Modified Design

7.3. Mathematical Results

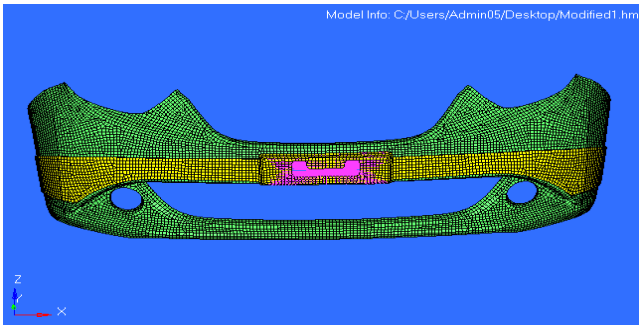
These mathematical results were calculated through calculations. As these results are for frontal crash force to measure the maximum travel of the vehicle after the impact.
The vehicle is designed for the maximum speed of 55 kmph and the total weight of the vehicle (including the driver) is estimated to be ‘m’ kg
Thus the kinetic energy is equals to the work done. So

$$Wnet = Force * Displacement$$

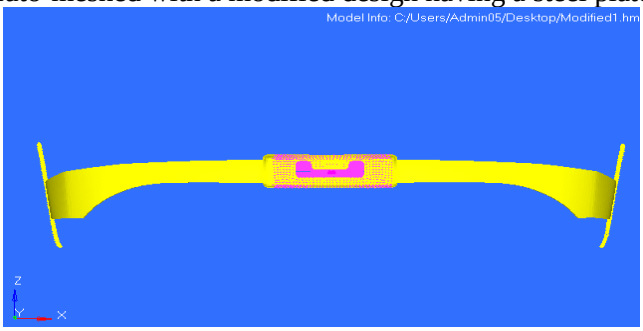
It is considered for the analysis that the vehicle comes to net 0.1 sec after the impact. So for speed of 55 kmph (15.27m/sec) speed the travel of the vehicle after the impact is 1.5278 m.



Above figure is a FRP Material with steel plate. The FRP material is in green colour whereas steel plate is shown in yellow colour.



Above figure is a fully auto-meshed with a modified design having a steel plate.



Above figure is a steel plate which made to absorb more amount of energy and stresses so that the vibrations which are transmitting should be less.

7.4. Finite Element Calculation Parameters

Table 1

Fibre	Fibre Diameter (um)	Density (g/cm^3)	Tensile Strength (N/mm^2)	E-Modulus (N/mm^2)
Polyamid	10-40	1.14	840	2800

Other than these parameters one of the important parameter is also considered which is Poisson's Ratio and it is taken as 0.400

VIII. CONCLUSION

After all calculations related to this Research and Project we have measured that the amount of Displacement is quite very large with only FRP (Fibre Reinforced Plastic) Material and the Stresses on 2D and 3D which were produced after the Collision is very less. But when we modify our design from only FRP Material to FRP Material with Steel plate, as there is steel plate which was placed during the manufacturing of a Bumper, absorbs more amount of energy. So due to this modification the amount of Displacement is greatly reduced and the amount of Stresses are increased and uniformly distributed over the surface such that it absorbs a large amount of energy which will prevent it from transmitting it to the occupants, passengers and to the engine room.

IX. FUTURE WORK

If we design the Bumper with steel plate it gives more safety as amount of stresses are increased so better absorption of energy. During the manufacturing of this design of Bumper a very little amount of weight is increased. Else its performance is quite better than the normal bumper which was made up of FRP Material. According to this little amount of shocks and vibrations are transmitted to occupants than alone FRP Material. Even it gives good positive results and at a speed of about 55kmph it gives less amount of displacement.

We can save a large amount of cost which occurs during Collision. As many of you may think that it may increase the weight of the Bumper than the previous one. If we reduce the weight then it becomes possible to reduce the consumption of fuel. Thus by saving the specific fuel consumption we save our environment.

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AUTHORS

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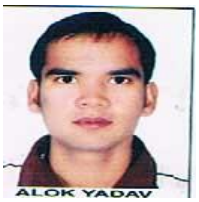

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