COLLISION ANALYSIS OF AN AUTOMOBILE BUMPER USING FEA

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Abstract- Fuel efficiency is the biggest design parameter of all heavy transport vehicles.Weight reduction is now the main issue in automobile industries. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The weight of the vehicle is going on increasing due to additional luxurious and safety features. The most effective method is to reduce the weight of the vehicle, but this cannot be done at the expense of safety. Safety here is for both the occupants of the vehicle and the pedestrians.

To reduce the impact, the body of the vehicle has to absorb most of the energy. Most vehicles use steel as the preferred material for bumpers. While this is efficient for impact resistance, it is heavy. In order to overcome this problem we propose to use steel with composites. Composites are one of the strongest as well as lightest structural materials available now. Composites can be used in conjunction with steel sheets to form very strong and light bumpers.In this thesis, we intend to come up with the optimum replacement of existing steel bumper with steel composite sandwich panels consisting of definite structure that will not only reduce the weight but also help reduce the impact in case of accidents.

Index Terms*- Creo parametric 2.0, composite sandwich panels, design optimization, weight reduction.*

I. Introduction

In automobiles, a bumper is usually a metal bar or beam, attached the vehicle's front-most and rear-most ends, designed to absorb impact in a collision. Regulations for automobile bumpers have been implemented to allow the car to sustain a low-speed impact without damage to the vehicle's safety systems.

The main function of a bumper is to protect the car's body in a slight collision, typically at parking speed. The bumper structure on modern automobiles generally consists of a plastic cover over a reinforcement bar made of steel, aluminium, fiberglass composite, or plastic.

In most jurisdictions, bumpers are legally required on all vehicles. The height and placement of bumpers may be legally specified as well, to ensure that when vehicles of different heights are in an accident, the smaller vehicle will not slide under the larger vehicle. Although a vehicle's bumper systems should be designed to absorb the energy of low-speed collisions and help protect the car's safety and other expensive components located nearby, most bumpers are designed to meet only the minimum regulatory standards.

Bumpers are not capable of reducing injury to vehicle occupants in high-speed impacts, but are increasingly being designed to mitigate injury to pedestrians struck by cars, such as through the use of bumper covers made of flexible materials.In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturer in the present scenario. The introduction of composite materials has made it possible to reduce the weight of the bumper without any reduction on load carrying capacity and stiffness. So, composite materials are now used in automobile industries to take place of metal parts.Since the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel. Composite materials offers opportunity for substantial weight saving.

II. PROBLEM IDENTIFICATION

The bumper is designed to have optimal mechanical properties which improve the pedestrian protection and low-speed collision as well. The bumper essentially consists of a cover, an absorber, arranged beneath to the cover and mounting elements to connect a cover and absorber to the vehicle body.The optimal mechanical properties to improve the pedestrian protection and low speed collision are achieved using general principals of stiffness, in which the stiffness of the lower portion of the bumper in its mounted position is increased relative to the upper portion of the bumper. By making the lower portion of the bumper which is directed forwardly into the direction of the driving stiffer, the impact force in case of collision with a pedestrian is concentrated at the lower portion of the bumper.

Bumpers in the earlier years were made of steels or heavy metals. Nowadays, bumpers are made of rubber, plastics and other light painted and resilient materials. Some bumpers now features crumple zones which allows the material to flex upon collision in order to absorb the impact and returns to its original shape.The majorities of modern cars are made of thermoplastic olefins (TPOs), polycarbonates, polyester, polypropylenes, polyamides, or blend of these with, for instance glass fiber for strength and structural rigidity. Other than that, there is also a rubber bumper or elastomeric bumper can be made from either natural or synthetic rubber.

Bumper systems usually include a reinforcement bar plus energy-absorbing material, such as polypropylene foam. Better bumpers often have hydraulic shock absorbers instead of, or in addition to, the foam. The most widely used energy absorber construction is made from expanded polypropylene foam (EPP).

Honeycomb energy-absorber, which are made from ethylene vinyl acetate (EVA) copolymer, are also still used on some other cars.The replacement of metal in bumper to reduce the weight of the vehicle, reduce cost and improve petrol consumption has follow several stages mostly directed at the bumper fascia and improving polypropylene, polyurethane, thermoplastics, elastomers, PC/ABS and PC/PBT blends. Bumpers fascia's are hardly 3 mm thick and the key physical properties are for flexibility and shock resistance.

MODELING OF BUMPER

The modeling of the Bumper is done in Creo Parametric 2.0.

Introduction to Creo Parametric:

Creo Parametric is a computer graphics system for modeling various mechanical designs and for performing related design and manufacturing operations. The system uses a 3D solid modeling system as the core, and applies the feature-based, parametric modeling method. In short, Creo Parametric is a feature-based, parametric solid modeling system with many extended design and manufacturing applications.

Creo Parametric is the first commercial CAD system entirely based upon the feature-based design and parametric modeling philosophy. Today many software producers have recognized the advantage of this approach and started to shift their product onto this platform.

The model is as shown in the figure 1 as shown below:

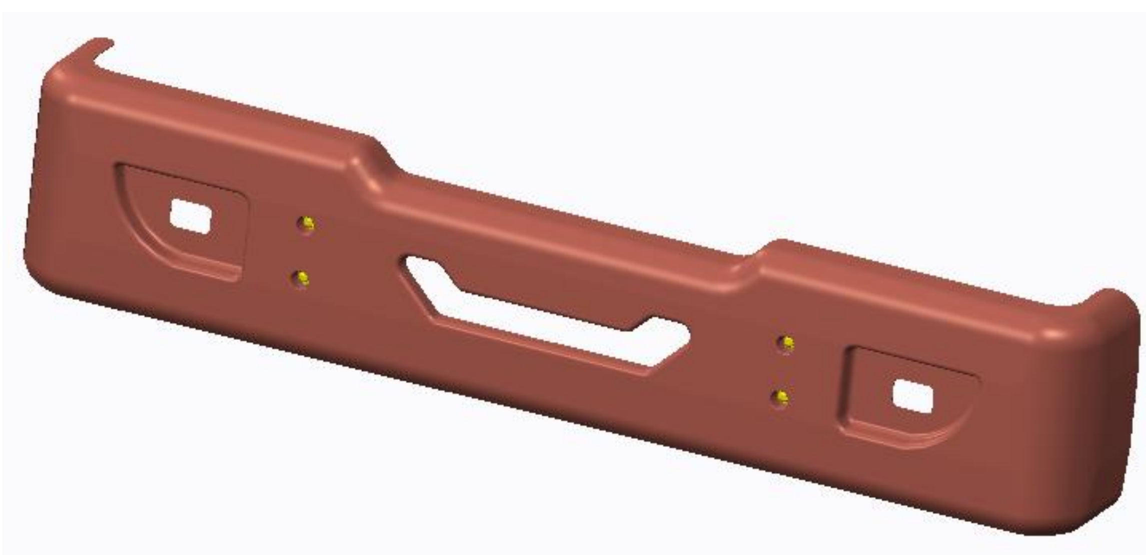

Fig 1. BUMPER MODEL

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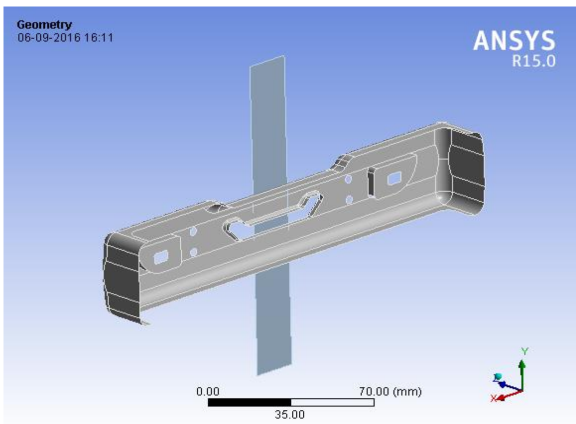
Creo Parametric was designed to begin where the design engineer begins with features and design criteria. Creo Parametric's cascading menus flow in an intuitive manner, providing logical choices and pre-selecting most common options, in addition to short menu descriptions and full on-line help. This makes it simple to learn and utilize even for the most casual user. Expert users employ Creo Parametric's "map keys" to combine frequently used commands along with customized menus to exponentially increase their speed in use. Because Creo Parametric provides the ability to sketch directly on the solid model, feature placement is simple and accurate.

III. ANALYSIS OF BUMPER

The analysis of the BUMPER is done in Ansys 15.0 and the analysis reports are as shown below.

The geometry and the mesh model in Ansys are as shown in the Fig.3 and Fig. 4 below respectively.



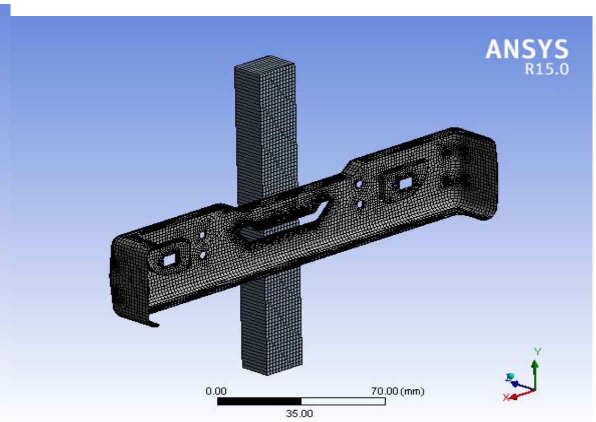
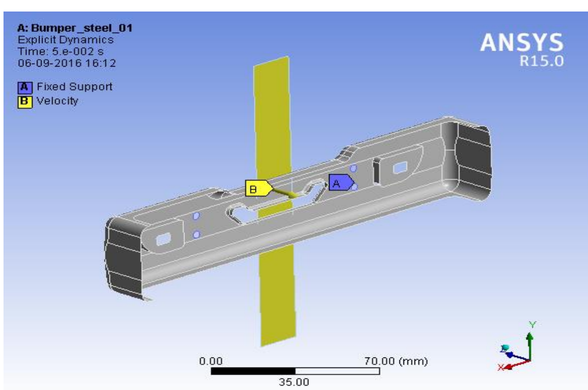


Fig. 3 Geometry of the BUMPER **Fig.4 Mesh of the BUMPER**

The analysis is carried out for the steel material, sandwich composite panel material and the steel composite honey comb panel material for the Bumper.

Analysis of BUMPER:

The Boundary Conditions are as shown in the Fig. 5. The base material is Steel. The deformation report for the steel Bumper are are as shown in the Fig. 6.



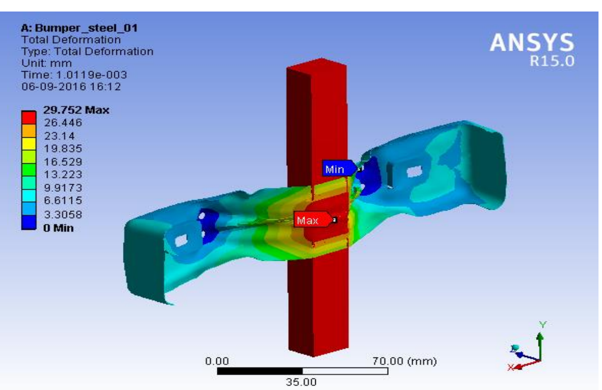


Fig.5Boundary Conditions **Fig. 6 Deformation of the BUMPER**

The Geometry of composite sandwich panels are as shown in the Fig. 7. The boundary conditions are as shown in the Fig. 8. The deformation report for the composite sandwich panel Bumper are are as shown in the Fig. 9.

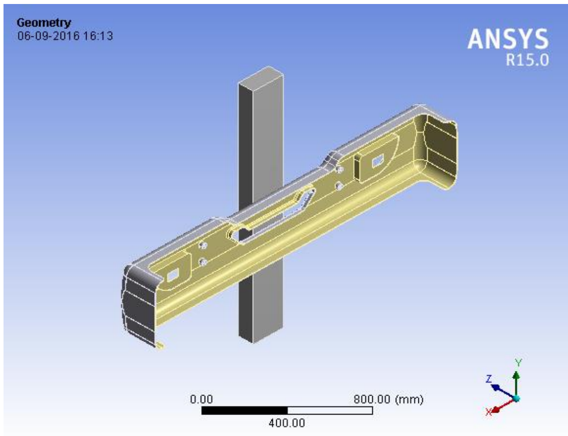


Fig. 7Geometry of composite sandwich panels

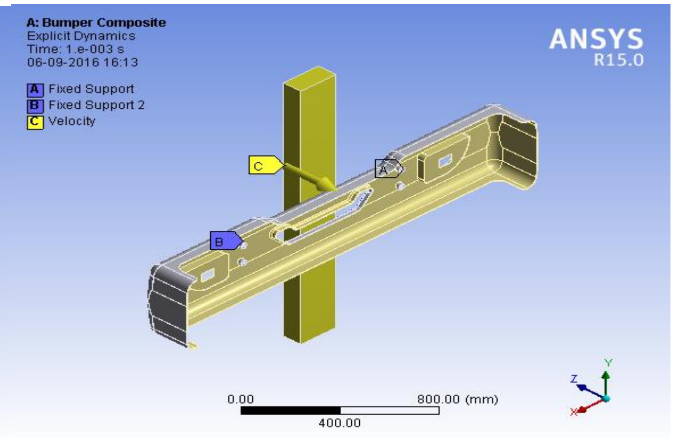


Fig.8Boundary conditions of composite sandwich panels

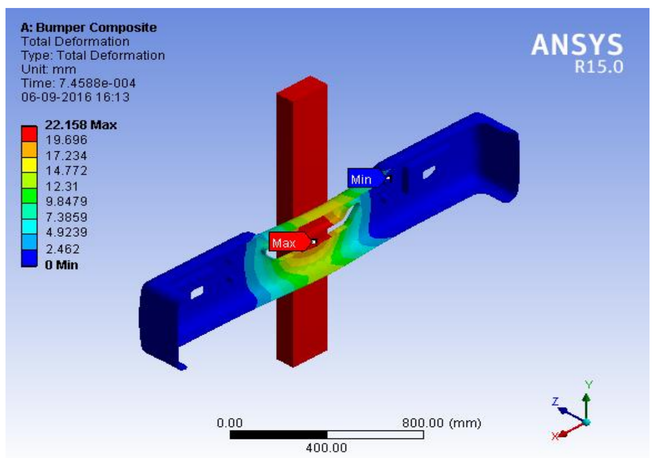


Fig.8Deformation of composite sandwich panels

Also the analysis is carried out for the steel composite honey comb panel material for the Bumper. The deformation reports are tabulted respectively with comparison.

The Glass Epoxy properties are as shown in the Fig. 11

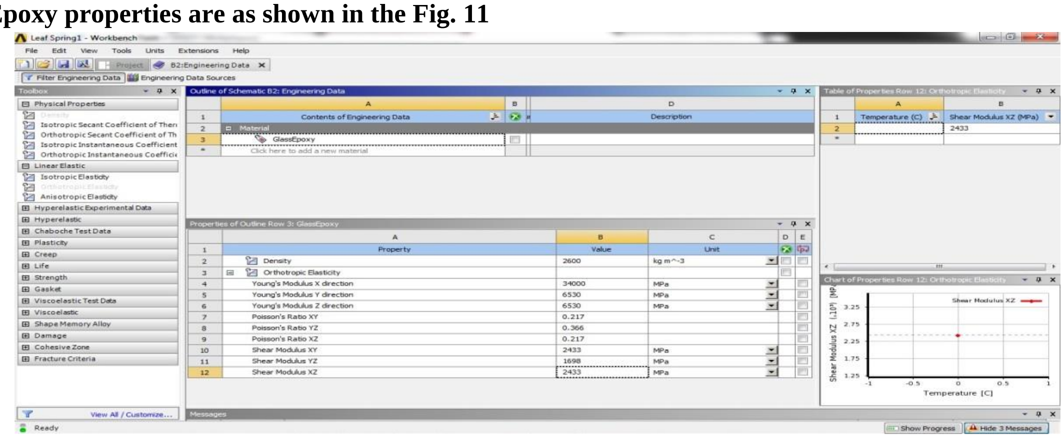


Fig. 11 Glass Epoxy material properties

IV. RESULTS AND DISCUSSION

The analysis of Steel Bumperand the composite Bumper is done. The analysis is carried out in Ansys 15.0. The results for the bumper for various considerations are as shown below:

S. No	**Case**	**Deformation (mm)**
1	Steel	29.752
2	Hybrid (Steel Composite)	22.158
3	Hybrid definite structure	10.910

V. CONCLUSION

Hence the crash analysis of the bumper is done and we observe a change of 25.62% less deformation in the case of a Composite bumper which is observed to be a positive change when taken into existence. Also, we observe a change of 48% less deformation in the case of a Honey comb- Hybrid structure bumper which is observed to be a positive change when taken into existence.We can fabricate the Composite Bumper using Hand Lay-up technique. In Hand lay-up, liquid resin is applied to the mold and then fiber glass is placed on the top. A roller is used to impregnate the fiber with resin. Another resin and reinforcement layer is applied until a suitable thickness builds up. It is very flexible process that allows the user to optimize the part by placing different types of fabric and mat materials. Because the reinforcement is placed manually, it is also called the hand lay-up process. Though this process requires little capital, it is labor intensive.

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