IMPACT ANALYSIS AND MATERIAL OPTIMIZATION OF A FRONT BUMPER IN A HEAVY VEHICLE

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Abstract- *The fuel efficiency and emission gas regulation of passenger cars are two important issues in these days. The best way to increase the fuel efficiency without sacrificing safety is to employ fiber reinforced composite materials in the cars. Bumper is the one of the part having more weight. Fuel efficiency is the biggest design parameter of all heavy transport vehicles. 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. An automobile's bumper is the front-most or rear-most part, designed to allow the car to sustain an impact without damage to the vehicle's safety systems. They are not capable of reducing injury to vehicle occupants in high-speed impact. In this paper,*

Review of the most important variables like material, structures, shapes and impact conditions are studied for analysis of the bumper beam in order to improve the crashworthiness during collision. More emphasis is given on selection of bumper material. Automotive industry is a very huge ground and research is still evolving. From this safety and comfortless of passenger car is very important. Hence the researchers have to be focused on safety and comfortless. In tune with this improvement in the design of a bumper is very important. This will increase the performance of the bumper; improve absorbing capacity during impact load and increase the protection of the front car component.

Keywords: **Bumper, Impact, bumper, CAD, FEA, impact loading, Analysis composites, steel composite sandwich, honey comb structures.**

1. 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. 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. 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.

2. Literature review

Hosseinzadeh RM and et.al[1] in their paper saysthat bumper beams are one of the main structures of passenger cars that protect them from front and rear collisions. In this paper, a commercial front bumper beam made of glass mat thermoplastic (GMT) is studied and characterized by impact modeling using LS-DYNA ANSYS 5.7 according to the E.C.E. United Nations Agreement [United Nations Agreement, Uniform Provisions concerning the Approval of Vehicles with regards to their Front and Rear Protective Devices (Bumpers, etc.), E.C.E., 1994]. Three main design factors for this structure: shape, material and impact conditions are studied and the results are compared with conventional metals like steel and aluminum. Finally the aforementioned factors are characterized by proposing a high strength SMC bumper instead of the current GMT.

Marzbanrad JM et.al[2] 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 low-velocity impact. The simulation of original bumper under condition impact is according to the low-speed standard of automotive stated in E.C.E. United Nations Agreement Regulationno.42, 1994. 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 behaviour. The mentioned characteristics are compared to each other to find best choice of material, shape and thickness .The results show that a modified SMC bumper beam can minimize the bumper beam deflection, impact force and stress distribution and also maximize the elastic strain energy. In addition, the effect of passengers in the impact behaviour is examined.

MohapatraS[3] discusses that automotive development cycles are getting shorter by the day. With increasing competition in the marketplace, the OEM's and suppliers main challenge is to come up with time-efficient design solutions. Researchers are trying to improve many of existing designs using novel approaches. Many times there is conflicting performance and cost requirements, this puts additional challenge with R&D units to come up with a number of alternative design solutions in less time and cost compared to existing designs. These best solutions are best achieved in a CAE environment using some of the modern CAD and FEM tools. Such tools are capable of effecting quick changes in the design within virtual environment.

Andersson R et.al [4] disclosed is a bumper system including a bumper cover, an energy absorber formed of a synthetic resin material through a foam moulding process, an impact beam for supporting the energy absorber, the impact beam being formed of a glass mat thermo plastic sand having a "C"-shaped section, and a stay for connecting the impact beam to a vehicle body. Tips are formed on front upper and lower portions of the impact beam, and a web portion is formed on the impact beam between the tips. Tip insertion grooves in which the tips are inserted are formed on an inner surface of the energy absorber, and a pressure receiving surface corresponding to the web portion is formed on the inner surface of the energy absorber.

Evans D and Morgan T [5] as vehicle manufacturers continue to become more aggressive with the styling of new vehicles, bumper system technologies will be required to find new solutions that fit into the reduced package spaces while continuing to meet the vehicle performance and cost requirements. The purpose of this paper is to introduce new and innovative Expanded Polypropylene (EPP) foam technologies and techniques.

Witteman WJ [6] automotive styling trends point to reduced bumper overhang, greater sweeps, and reduced overall package space for the bumper system. This paper will review the industry trends associated with bumper energy absorbers and explore the potential fit of this new prototype energy absorber design as an alternative to EPP foam. Also included is a review of the simulated performance of the prototype ETP energy absorber and a comparison of its actual test results for 8 km / h FMVSS Part 581 impact series to the performance of EPP foam packaged in the same environment.

Masoumi A et.al [7] in their thesis describes the design of a new frontal vehicle structure that directs the asymmetric crash load of an offset collision as an axial load to the second unloaded longitudinal member. Only by using both longitudinal members and through a progressive folding pattern, enough energy can be absorbed in the front structure to prevent a deformation of the passenger compartment.

3. MODELLING AND ANALYSIS:

From literature review it is clear that automotive bumper has evolved over the years. Although it is evolved ergonomically there is no systematic study which explains design and analysis of front bumpers in the presence of solid mechanics using advanced FEA tools.

3.1 Modeling:

Pro-E is now recreated as CREO which is software, is used to model the EOT Crane Girder. EOT Crane is designed in CREO software. This section discusses CREO modelling approach followed in the various parts/components and assembly of front bumper. Modelling of front bumper and its component is carried out using CREO software. Keeping objectives in mind, existing bumper systems of different passenger cars have been studied. Moreover, evolution of bumper system is also studied. There is trade off between weight and Performance. Initially, most of the cars used metallic bumper systems with or without energy absorbing materials like rubber, foam, etc. This kind of design increases weight and number of parts in assembly.

Recently, there is emphasis on use of composite materials like G-epoxy. This has reduced weight further and it is observed that composite materials are also capable to absorb energy along with a simplified geometry. Hence, present research includes study of following configurations of fascia and presents different designs in terms of reducing weight and increasing the performance.

3.2 Material Properties:

The material properties of the A514 high strength steel are taken for composites material properties of the carbon epoxy are taken.

3.3 Modeling Of Bumper For A Heavy Weight Vehicle:

Material: High strength low alloy steel plate

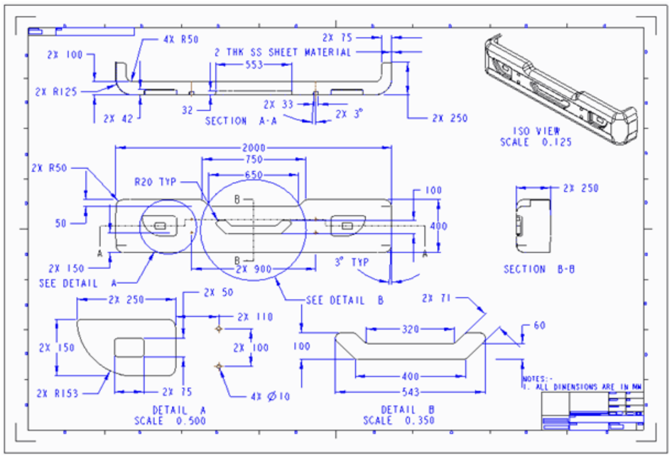


Fig 1: Created 3D Model of bumper in CREO.

Fig 2: Assembly of girder

Part Name: Clamp

Material: Stainless steel sheet material

Bumper with honey comb assembly:

Fig 3: Assembly of bumper with honey comb

4. The Finite Element Analysis (FEA)

ANSYS 18.0 is used to run the analysis. The previously created IGS file is imported on ANSYS file geometry. Solid mesh is used to divide the geometric body in to small strips (Finite elements). Fixed boundary conditions are applied at the supports of frame.

4.1 Analysis of Steel bumper:

Geometric model: The geometric model for the Steel bumper is as shown below

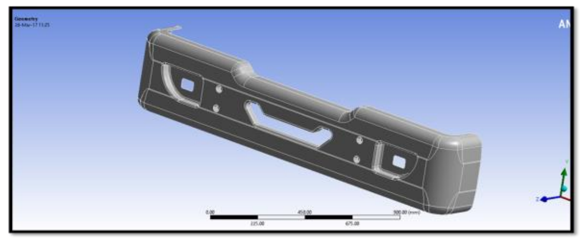


Fig 4: Geometric model of steel bumper

Meshed Model: The meshed model for the Steel bumper is as shown below

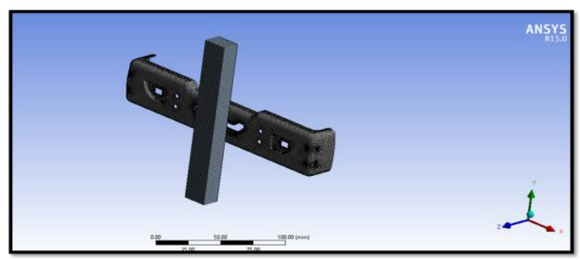


Fig 5: Meshed model of steel bumper

Boundary Conditions:

The boundary conditions for the Steel bumper are as shown below .The velocity 27, 778mm/s.

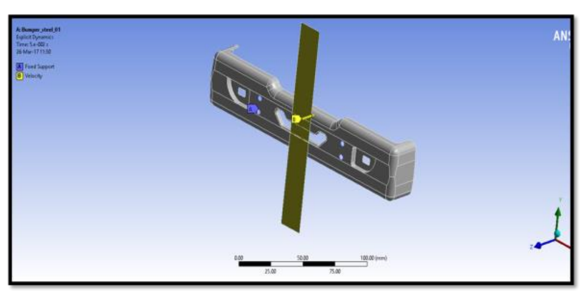


Fig 6: Boundary Conditions of the Steel bumper

Deformation: The Deformation for the Steel bumper shown below

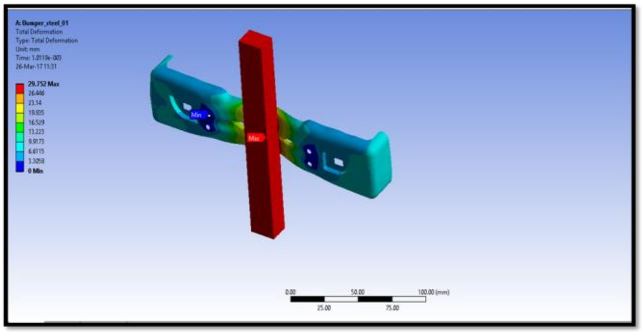


Fig 7: Deformation of the Steel bumper

4.2 Analysis of Composite bumper:

Geometric model: The geometric model for the Composite bumper is as shown below

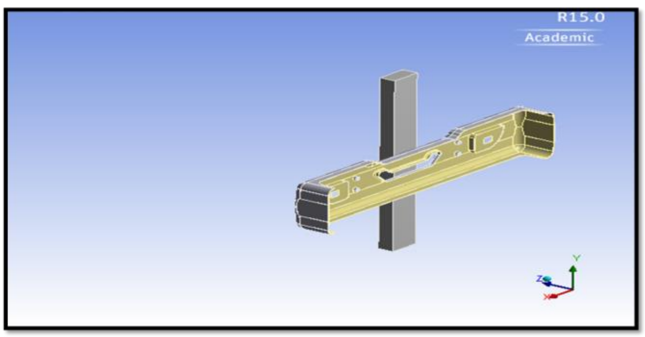


Fig 8: Deformation of the Steel bumper

Composite Layer in the model:

The composite layer in the model for the Composite bumper is as shown below

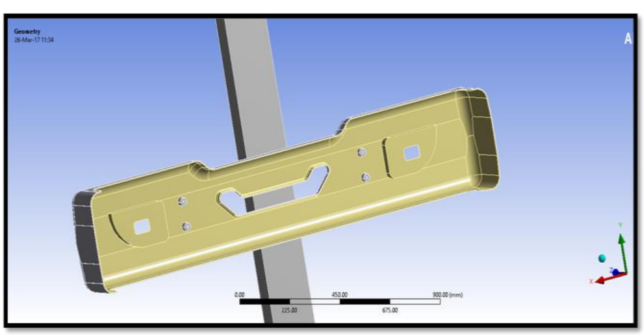


Fig 9: Geometry of the Composite bumper

Meshed Model:

The meshed model for the Composite bumper is as shown below

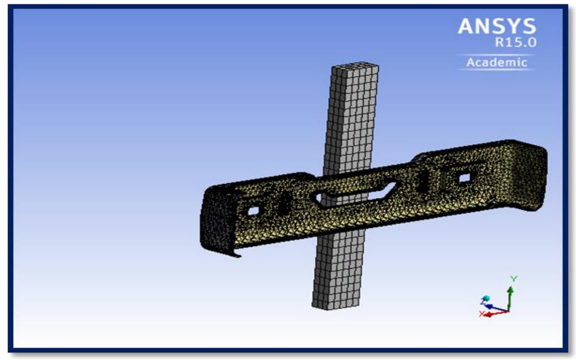


Fig 9: Meshed model of the Composite bumper

Boundary Conditions:

The boundary conditions for the Composite bumper are as shown below. The velocity 27, 778mm/s.

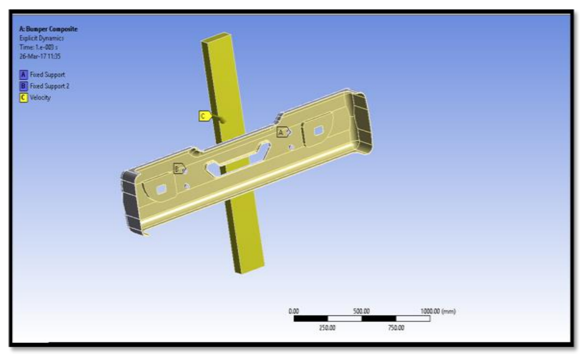


Fig 10: Boundary Conditions of the Composite bumper

Deformation: The Deformation for the Composite bumper is as shown below deformation 22.158 mm

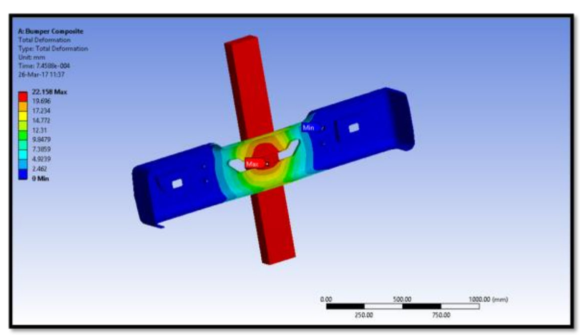


Fig 11: Deformation of the Composite bumper

4.3Analysis of honey comb-hybridbumper:

Geometric model: The geometric model for the honey comb-hybrid bumper is as shown below

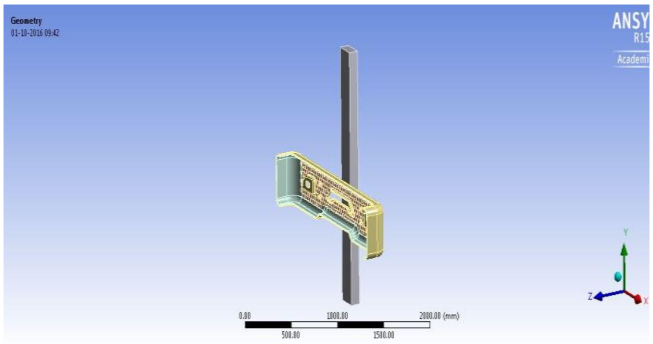


Fig 12: Geometry of the honey comb-hybrid bumper

Meshed Model: The meshed model for the honey comb-hybrid bumper is as shown below

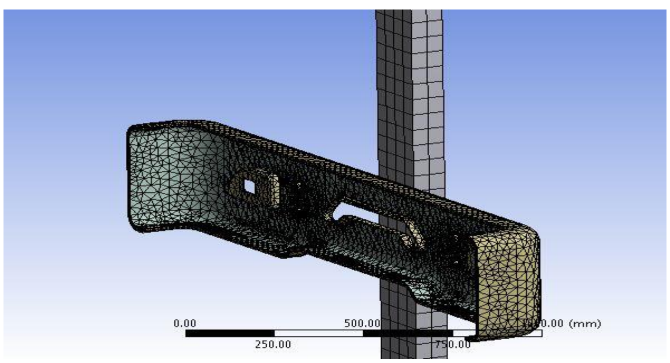


Fig 13: Meshed model of the honey comb-hybrid bumper

Velocity: The velocity for the honey comb-hybrid bumper are as shown below

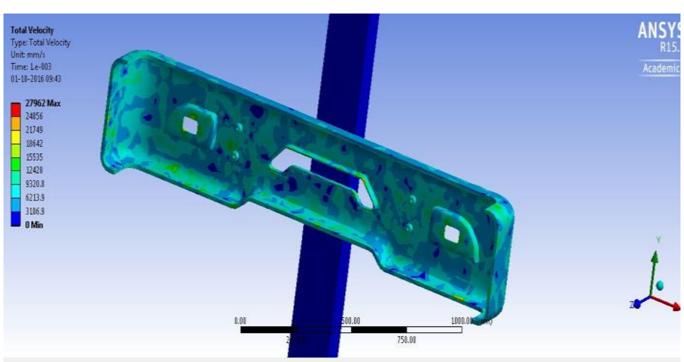


Fig 14: Velocity of the honey comb-hybrid bumper

Deformation: The Deformation for the honey comb-hybrid bumper is as shown below

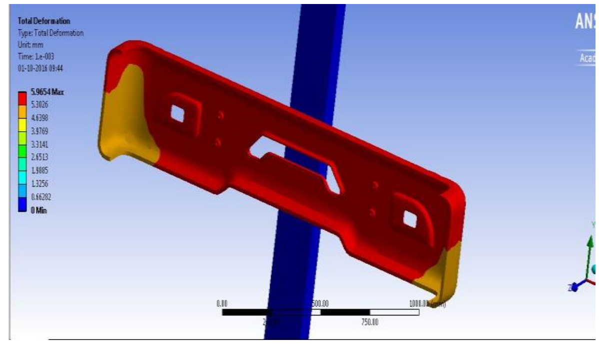


Fig 15: Deformation of the honey comb-hybrid bumper

Directional Deformation:

Directional Deformation for the honey comb-hybrid bumper is as shown below

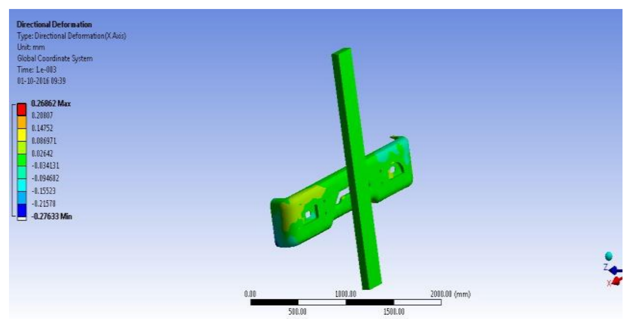
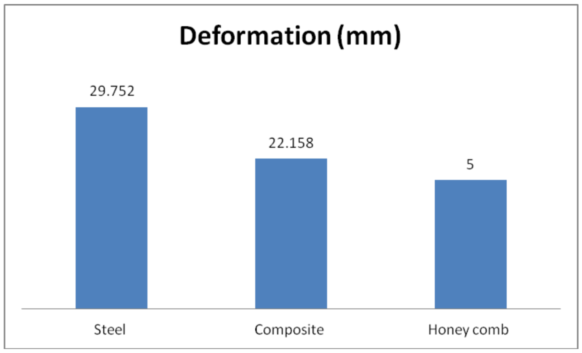


Fig16: Directional Deformation of the honey comb-hybrid bumper

6 .Results and Discussion:

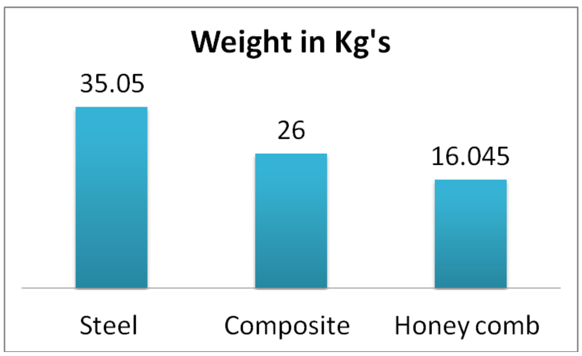
SL. NO	TYPE	DEFORMATION(MM)	WEIGHT
1	Steel	29.752	35.09
2	composite	22.158	26
3	Honey Comb	5	16.045

Table 1: Analysis results



Graph 1: Deformation calculation results

The above table shows the Deformation at different materials. Here maximum Deformation for the material is 29.752 at Steel.



Graph 2: Weight calculation results

Hence the impact analysis of the bumper is done and we observe a change of 25.5% less deformation in the case of a Composite bumper which is observed to be a positive change when taken into existence. Also we can observe that taking weight into consideration there is positive change for honey comb sandwich panel as it is reducing and Deformation wise there is a considerable change.

7. Future Scope of work:

We can fabricate the Composite Bumper using Hand Lay-up technique:

In Hand lay-up, liquid resin is applied to the mould 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 labour intensive.

8. Conclusion:

From the above discussion, it can be concluded that the bumper is an important member of an automobile from the safety point of view. Thus analysis of bumper will help to increase the safety considered to replace the existing materials like steel, composite material and honey comb. 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 heavy vehicle bumper design based on comparative results of the materials.

This work will be milestone in Automotive industry as per as vital issue of passenger safety is Concerned.

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