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“DESIGN IMPROVEMENT IN FRONT BUMPER OF A PASSENGER CAR USING IMPACT ANALYSIS”-A REVIEW

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Abstract - Car accidents are happening every day. We must take into account the statistics – ten thousand dead and hundreds of thousands to million wounded each year. These numbers call for the necessity to improve the safety of automobiles during accidents. Automotive bumper system is one of the key systems in passenger cars which helps to protect the vehicle during impacts. The following paper deals with the design improvements in the front bumper of passenger cars in India, using impact analysis. The modification will be made considering size, shape and material.

Keywords - bumper, impact.

I. INTRODUCTION

Car accidents are happening every day. Most drivers are convinced that they can avoid such troublesome situations. Nevertheless, we must take into account the statistics – ten thousand dead and hundreds of thousands to million wounded each year. These numbers call for the necessity to improve the safety of automobiles during accidents. Automotive 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. Under the International safety regulations originally developed as European standards and now adopted by most countries outside North America, a car's safety systems must still function normally after a straight-on pendulum or moving-barrier impact of 4 km/h (2.5 mph) to the front and the rear, and to the front and rear corners of 2.5 km/h (1.6 mph) at 45.5 cm (18 in) above the ground with the vehicle loaded or unloaded. In North America (FMSS: Federal Motor Vehicle Safety Standards) and Canada (CMVSS: Canadian Motor Vehicle Safety Standards), it should be meet 4KMPH pendulum and barrier impacts.

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.

II. LITERATURE REVIEW

Hosseinzadeh RM and et.al^[1] in their paper says that 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.

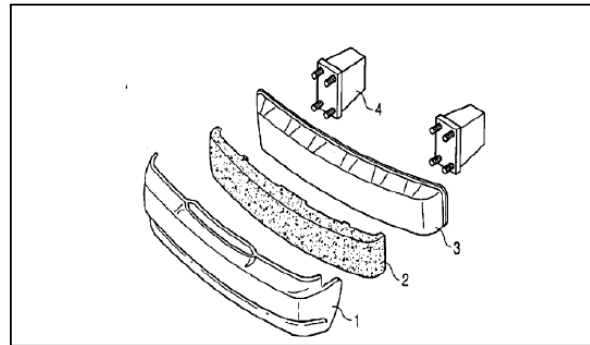
In this paper, Marzbanrad JM et.al^[2] discussed the most important parameters including material ,thickness, shape and impact condition are studied for design and analysis of an automotive front bumper beam to improve the crashworthiness design in low-velocity impact. The simulation of original bumper under condition impact is according to the low-speed standard of automotives 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 behavior. 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 behavior is examined.

Different countries have different performance standards for bumpers. Under the International safety regulations originally developed as European standards and now adopted by most countries outside North America, a car's safety systems must still function normally after a straight-on pendulum or moving-barrier impact of 4 km/h (2.5 mph) to the front and the rear, and to the front and rear corners of 2.5 km/h (1.6 mph) at 45.5 cm (18 in) above the ground with the vehicle loaded or unloaded. In North America (FMSS: Federal Motor Vehicle Safety Standards) and Canada (CMVSS: Canadian Motor Vehicle Safety Standards), it should be meet 4KMPH pendulum and barrier impacts.^[3]

Mohapatra S^[4] 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.

A bumper is a car shield made of steel, aluminum, rubber, or plastic that is mounted on the front and rear of a passenger car. When a low speed collision occurs, the bumper system absorbs the shock to prevent or reduce damage to the car. Some bumpers use energy absorbers or brackets and others are made with a foam cushioning material. The car bumper is designed to prevent or reduce physical damage to the front and rear ends of passenger motor vehicles. Generally, a bumper is attached to either end of a vehicle to absorb impact in a collision, thereby protecting passenger. As shown in Fig. 1, a conventional bumper system comprises a bumper cover 1 defining an outer appearance of the bumper system, an energy absorber 2 formed of an elastic material such a polypropylene foam body or an urethane foam body to absorb energy, an impact beam for supporting the energy absorber 2, and a stay 4 for connecting the impact beam 3 to a vehicle body.^[5]



Andersson R et.al^[6] disclosed is a bumper system including a bumper cover, an energy absorber formed of a synthetic resin material through a foam molding process, an impact beam for supporting the energy absorber, the impact beam being formed of a glass mat thermoplastic ssand 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.

Butler M et.al^[7] focuses that to increase crash performance in automotive vehicles it is necessary to use new techniques and materials. Components linked to crash safety should transmit or absorb energy. The energy absorbing capability of a specific component is a combination of geometry and material properties. For these components the chosen material should have high yield strength and relatively high elongation to fracture. These demands have led to increasing interest in the use of high strength stainless steels.

Carley ME et.al^[8] the objective of this study is to design efficient epoxy structural foam reinforcements to improve the energy absorption of front and rear automotive bumper beams. Three bumper structural performance criteria were studied.

Evans D and Morgan T^[9] 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^[10] 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^[11] 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. To prevent a premature bending collapse, the new longitudinal members consist of two functional components: an inside square crushing column for a normal stable axial force level and a stiff outside sliding supporting structure that gives the necessary extra bending resistance. An integrated cable system transmits the force to the other longitudinal member. With this novel design concept, a vehicle has similar energy absorption in the front structure for the entire range of collision situations (full, offset, oblique).

Zonghua Zhang, Shutian Liu, Zhiliang Tang^[12] discusses that material selection for automotive closures is influenced by different factors such as cost, weight and structural performance. Among closures, the automotive bonnet must fulfill the requirements of pedestrian safety which is evaluated by child and adult headform impactors. The mechanisms of injury are complex, therefore; the Head Injury Criterion (HIC) which shows a measure of the likelihood of head injury arising from an impact is developed. HIC includes the effects of head acceleration and the duration of the acceleration. In this paper a new finite element model has been developed which is capable to simulate head impact phenomenon between headform impactors and composite bonnet. Then the behavior of three identical bonnets made of steel, aluminum and composite have been investigated by the developed model.

In this paper, O. G. Lademo et.al^[13] discusses about a rib-reinforced thin-walled hollow tube-like beam (named as rib-reinforced beam) is presented for potential application in vehicle bumper. Through numerical simulation of the bending behavior under impact loads, the rib-reinforced beam is compared with thin-walled hollow tube-like beams filled with

and without foam materials (empty beam and foam-filled beam) in crashworthiness. The effects of the shape of the reinforced rib are investigated and the shape optimization design is performed for increasing energy absorption and reducing the initial peak force. A multi-objective crashworthiness optimization formulation including maximum energy absorption, maximum specific energy absorption and minimum initial peak force is constructed based on the ideal point method (IPM). The optimum configuration of the reinforced rib is given with a normalized cubic spline function. Numerical example results show that, compared with the empty and foam-filled beams with same weights, the optimized rib-reinforced beam has higher energy absorption performance and lower initial crash force. It is found that for the rib-reinforced beam little rumple is formed around the compressed indentation, which helps to retard the collapse of the side wall and means more energy absorption.

Nitin S. Gokhale, Sanjay S. Deshpande, Dr. Anand N. Thite^[14] Manufacturing of a bumper system from aluminum extrusions often involves series of forming operations performed in the soft W-temper condition, and then artificially age-hardening of the components to the material's peak hardness T6 condition. It is probable that proper finite element (FE) modeling of the crash performance of the resulting systems must rely upon a geometry obtained from an FE model following the process route, i.e., including simulation of all major forming operations. The forming operations also result in an inhomogeneous evolution of some internal variables (among others the effective plastic strain) within the shaped components. Results from tensile tests reveal that plastic straining in W-temper leads to a significant change of the T6 work-hardening curves. In addition, the tests show that the plastic pre-deformation causes a reduction of the elongation of the T6 specimens. In the present work, these process effects have been included in a user- defined elastoplastic constitutive model in LS-DYNA incorporating a state-of-the-art anisotropic yield criterion, the associated flow rule and a non-linear isotropic work hardening rule as well as some ductile fracture criteria.

III. SUMMARY OF LITERATURE REVIEW

Sr. No.	Author	Year	Title	Journal	Findings
1.	Evans D and Morgan T	1999	Engineering Thermoplastic Energy for Bumpers	SAE Paper	In this paper new and innovative Expanded Polypropylene (EPP) foam technologies and techniques are discussed.

Sr. No.	Author	Year	Title	Journal	Findings
2.	Witteman WJ	2000	Improved Vehicle Crashworthiness Design by Control of the Energy Absorption for Different Collision Situations	Doctoral dissertation, Eindhoven University of Technology	This paper addresses an alternative to the bumper energy absorber systems
3.	Andersson R, Schedin E, Magnusson C, Ocklund J	2002	The Applicability of Stainless Steel for Crash Absorbing Components	SAE Technical Paper	The impact beam being formed of a glass mat thermoplastic and having a "C"-shaped section, and a stay for connecting the impact beam to a vehicle body.
4.	Butler M, Wycech J, Parfitt J, and Tan E	2002	Using Terocore Brand Structural Foam to Improve Bumper Beam Design	SAE Technical Paper	In this work energy absorbing capability of a specific component is a combination of geometry and material properties is discussed.
5.	Carley ME, Sharma AK, Mallela V	2004	Advancements in expanded polypropylene foam energy management for bumper systems	SAE Technical Paper	Design efficient epoxy structural foam reinforcements to improve the energy absorption of front and rear automotive bumper beams.
6.	Hosseinzadeh RM, Shokrieh M, and Lessard LB	2005	Parametric study of automotive composite bumper beams subjected to low-velocity impacts	Journal of Composite Struct	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
7.	Mohapatra S	2005	Rapid Design Solutions for Automotive Bumper Energy Absorbers using Morphing Technique	Altair CAE users Conference 2005, Bangalore, India	Impact Analysis of a car shield made of steel, aluminum, rubber, or plastic of a passenger car at low collision speed.
8.	O. G. Lademo, T. Berstad, M. Eriksson, T. Tryland, T. Furuc, O. S. Hopperstad, M. Langseth,	2008	A model for process-based crash simulation	Norwegian University of Science and Technology Trondheim, Norway	Discussed a rib-reinforced thin-walled hollow tube-like beam (named as rib-reinforced beam) is presented for potential application in vehicle bumper.
9.	Zonghua Zhang, Shutian Liu, Zhiliang Tang	2009	“Design optimization of cross-sectional configuration of rib-reinforced thin-walled beam”	Dalian University of Technology, Dalian, China.	Discusses that material selection for automotive closures is influenced by different factors such as cost, weight and structural performance
10.	Marzbanrad JM, Alijanpour M, and Kiasat MS	2009	Design and analysis of automotive bumper beam in low speed frontal crashesh	Thin Walled Struct	Discusses the important parameter 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.
11.	Masoumi A, Mohammad Hassan Shojaeefard,	2011	Comparison of steel, aluminum and composite bonnet in terms of pedestrian	College of Engineering, University of Tehran,	Describes the design of a new frontal vehicle structure that directs the asymmetric crash load of an offset collision as an axial

Sr. No.	Author	Year	Title	Journal	Findings
	Amir Najibi		head impact	Tehran, Iran	load to the second unloaded longitudinal member

IV. FINDINGS OF LITERATURE REVIEW

The above mentioned literature can be summarized in the following way:-

- a. There are few studies reporting about the work done related to improvement in the design of front bumper of passenger car.
- b. The applicability of these studies for passenger cars (India) is not validated
- c. Present studies have not identified the effect of shape, size and or material
- d. The safety of the passenger needs to be increased.

The literature does not address the impact analysis of the passenger cars considering the shape, material and size for the Indian cars.

V. STATEMENT OF THE PROBLEM

Design Improvement in Front Bumper of a Passenger Car using Impact Analysis

VI. SCOPE OF THE WORK

The study will focus on existing design performance, advantage and limitations. Based on observations design improvements will be made in terms of shape, size and or material based on design modification objectives. Modified front bumper design will be tested using FEM software for impact loads as per international standards.

VII.OBJECTIVE OF THE WORK

The aim of this work is to study front bumper of one of the existing passenger car in Indian market and suggest design Improvement in front bumper of a passenger car using Impact Analysis

VIII. CONCLUSION

From the above literature it can be concluded that the 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 the passengers and new size and shape can also be considered to replace the existing one.

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