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Development of Composites for Designing Bumpers: A Review

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Abstract - *The energy absorption characteristics of bumpers should be good enough to absorb impact energy without causing any damage to internal parts. The current research studies the various analysis conducted on front bumper using numerical and experimental techniques to determine the effect of various composite materials, high-strength sheet moulding compounds and reinforced rib on improving energy absorption characteristics of bumper. From the linear static and impact analysis results, composite bumper has good impact behavior. The theoretical calculation ofdisplacement of the mild steel was calculated assuming bumper as fixed beam.*

***Key Words*: truck bumper, mild steel, glass epoxy, staticanalysis, impact analysis, fixed beam, etc**

1. INTRODUCTION

Generally bumpers are made by metal, so weight of the bumper increases and decreases the efficiency of the vehicle. So designers should design the bumpers with low weight to high strength ratio. So replacement of metal should be carried out by series of experiment and analysis work. Now a day's the plastic materials are used to manufacture the bumpers, because of its low weight to strength ratio and should be economical. So the designer has faced lot of problems to reduce the weight of the bumpers without sacrificing the strength. Based on strength and weight designer has to design the automobile bumper. Weight reduction is the main aim to design the bumper but strength should not be reduced due to these several materials selected to make bumpers and experiment and analysis work is carried out by many people to get good bumpers.

PURPOSE OF BUMPERS

It helps to prevent the vehicle from physical damage by front and rear ends from smaller collisions. When low speed occurs, the bumper absorbs the shock and avoids the damage to the vehicle. A bumper are designed to protect thegrille, hood, exhaust and cooling systems, also protects some components like parking lights, head lamps and taillights inlow speed collisions.

MATERIALS USED FOR BUMPER

Depending on the make, model, and type of truck, there are avariety of options with regard to bumper material. Unless a sturdier bumper is required, it is best to purchase a replacement bumper composed of the same material as the previous, factory issued bumper. Replacement bumpers are made of polyresin (a type of plastic), fiberglass, carbon fiber, or metal. The sections below discuss each material further.

POLYRESIN

Polyresin is a plastic used by most of the automotive industries, now a day most of the vehicles components by made by polyresin plastic. It has good impact behavior and rust resistant. If any crack in polyresin bumper then it is difficult to repair the bumper. Painting should be done over polyresin bumper.

FIBERGLASS

Most aftermarket parts manufacturers make fiberglass bumpers. Fiberglass is lightweight, strong, and unlike polyresin, is easily repairable. It may also be sanded before painting. It has less flexibility compared to polyresin.

CARBON FIBER

A carbon fiber bumper is very lightweight and durable. It is also heat resistant, and can be painted or left unpainted, depending on the preference of the truck owner. Carbon fiber bumpers can be repaired, but should be painted afterwards to seal the repair part on bumper. Carbon fiber bumpers are usually more costly than other types and most of the bumpers now manufactured using carbon fiber. Carbon fiber has more advantages than other materials.

METAL

Originally the only material used for vehicle bumpers, the metal bumper is very strong and durable, but very heavy. The added weight adds drag and lowers fuel efficiency. Metal bumpers are recommended for off-road or work use, rather than for everyday driving. The most common bumper metalis steel, typically with chrome finish.

Parameters Required for Designing Bumper

The good design criteria for bumpers are:

a. Strength to weight ratio
b. Aerodynamics
c. Safety
d. Aesthetics
e. Production cost

Strength to weight ratio

The strength to weight ratio should be high in order to get good bumper design. If both strength and weight is more than the bumper weight is increases it will affects performance of the vehicle, so designer look for less weight and more strength.

2. LITERATURE REVIEW

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 modelling 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 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. 3, 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] Figure 3: Conventional bumper system 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 thermoplastics and 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.

3. CONCLUSIONS

In this paper revived for both mild steel and composite material bumper was selected to carry out linear static andimpact analysis to find out the best one. According to series of analysis composite bumper was found better than mild steel bumper, Reasons are explained below.

- In linear static analysis, the maximum stress developed by composite bumper was144.5 MPa and for mild steel maximum stress developed was384.5 MPa. So composite bumper develops less stress for same loading condition.
- The mild steel bumper weighs about 5.396 Kg where the weight of composite was 1.397Kg. Composite is 74.11% less weight than steel bumper. It helps to improve the efficiency of vehicle.
- So from above analysis results we can conclude that composite bumper is better than mild steel bumper.
- The maximum displacement of mild steel bumper by finite element analysis was 1.197mm and maximum displacement of mild steel of mild steel by theoretical method is 1.35mm.
- The theoretical validation of displacement of mild steel bumper was done.

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