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ENERGY ABSORBING BUMPERS AND IT'S COMPARATIVE STUDY

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ABSTRACT

Bumper is one of the most important protective part in vehicles which is present at the front most and rear most of the vehicles. It is designed to protect car bodies from damage in low-speed collisions, absorbing crash energy without significant damage to the bumper itself. Hence the researchers have to be focused on the safety and comfortness of passengers. In this paper we had comparatively studied mechanical properties of the bumper beams such as Carbon Fiber Reinforced Polymer (CFRP), Aluminum Honeycomb sandwich panel, Steel Bumper, metal Foam.

Keywords; Bumper, CFRP, Aluminum honeycomb sandwich panel, Steel bumpers, Metal Foam bumpers, Mechanical properties.

I. INTRODUCTION

The bumper was designed from the early 1900's to protect the vehicles front and rear end of the vehicles after slow speed collision and also ensures pedestrian. In early years bumper was designed for its aesthetics which were not effective during slow speed collision.

Instead of protecting vehicle part bumpers are also designed to have two safety functions:

1. Minimizing the height mismatches between the vehicles.
2. Protecting pedestrians from injury.

The bumper system also protects the hood, trunk, fuel, exhaust and cooling system as well as safety related equipments. Automotive bumper beam is one of the key systems in passenger cars. Generally, bumper beam is placed behind the plastic fascia either in front or rear ends of bumper system mainly to absorb kinetic energy during collision. There are two main components of bumper beam, namely horizontal beam and axial beam or crush box and it is molded in single piece. The use of plastic in auto bumpers and fascias gives designers a tremendous amount of freedom when it comes to styling a prototype vehicles or improving an existing model. As highlighted above, the styling of the bumper has become more important than the structural design of the bumpers. Nevertheless, the standards and regulations governing the design of the bumpers should not be compromised in any circumstances. The first bumper standard issued under the 1996 Act was FMVSS 215 Exterior protection, which called for passenger cars, beginning with model year 1973, to withstand 5 mph front and 2 ½ mph rear impacts against a barrier without damage to certain safety related components and also the impact and test requirements were upgraded for subsequent model years. The final

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rule, issued on April 9, 1971, required to passenger cars, beginning with model year 1973, be in compliance with the standard. Any wrong steps in material selection or neglecting the standards of regulation would badly affects the structural integrity as it would be next to impossible to provide protection neither to the vehicle body nor the occupant during the crash.

II. TYPES OF BUMPERS

a) Carbon Fiber Bumpers:

Carbon fiber reinforced polymer or often carbon fiber is an extremely strong and light fiber-reinforced plastic which contains carbon fibers. Polymers that are usually used for binding are mainly thermoset resins. Epoxy is one of the thermoset resin. Sometimes in some cases other thermoset or thermoplastic polymer is also used. Such polymers are polyester, vinyl ester or nylon. The required strength and rigidity of a carbon fiber reinforced polymer is obtained from reinforcement which is measured by stress and elastic modulus accordingly. Unlike isotropic materials like steel and aluminum, CFRP has directional properties.

Fig (1) Carbon Fiber Reinforced Polymer Bumper

CFRPs demonstrate excellent corrosion resistance; the effect of moisture at wide ranges of temperatures can lead to the degradation of the mechanical properties of CFRP, particularly at the matrix–fiber interface. Carbon Fiber bumper are light weight bumpers as compared to conventional bumpers made of steels. Carbon fiber body work is normally the thing of super-cars, but many a car companies and specialist modifiers, are starting to use it for replacement body parts on everyday cars.

b) Aluminium Honeycomb Sandwich Panel Bumpers:

As from the name we know that it has geometry of a honeycomb which minimizes the amount of material us ed. Due to this it causes to lower its costs and weight. This aluminum honeycomb is produced by the expansion process.

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Fig (2) Aluminum Honeycomb Bumper

This type of construction consists of thin two facing layers separated by a core material. The aluminum honeycomb panel provides light weight, high rigidity and high structural stability.

c) Steel Bumpers:

Steel front bumper are mostly used in off road vehicles which has a coating to influence the corrosion life of the bumper. Steel is often e-coated and then painted or powder-coated. Steel bumpers that are made of bare steel and are then e-coated after the forming process. Some steels are coated with zinc which improves the life of the steel by discouraging or preventing corrosion.

Fig (3) Painted Steel bumper

In past steel bumpers were very thick due to which it increases the weight. Nowadays because of new technology gauge of the steel decreases and its strength increases.

d) Metal Foam Bumpers:

The metal foam has a cellular structure which consists of a solid metal as well as it has a pores which makes it a ultra light material. The aluminum and its alloys has a low density due to which it is used as a metal foam. Bumpers made of metal foam posses high compression strength. Generally there are two types of metal foam open and close type. In automotive industry for making of bumpers mostly closed type is used which provides optimal energy absorption.

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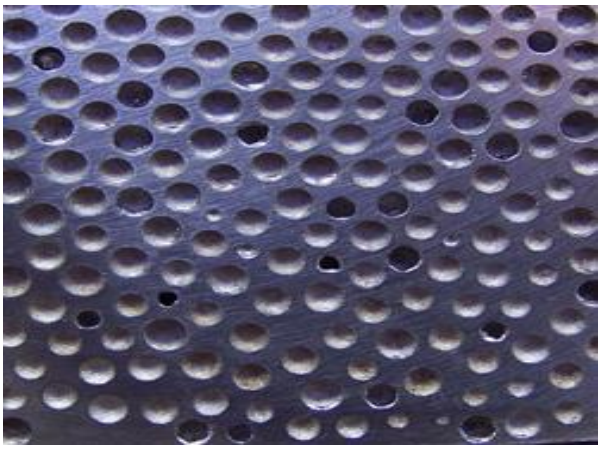

Fig (4) Structure of metal foam

Many automakers make use of aluminum foam crash box which is placed between impact beam and front rail of car. During collision at slow speed of about 15km/hr they deform and absorb all energy. Thus protecting all valuable parts at the front end in addition to the car frame.

III. COMPARATIVE STUDY

The selection of bumper material is very important as it offers safety to the automotive parts and also safety to the pedestrian during slow speed collision. In this paper after studying the properties of different bumpers, we came to know that bumpers made of CFRP are very light in weight as compared to other bumpers. Steel bumpers are the heaviest bumper and thickest bumper as compared to other bumper. Mostly steel bumpers are chrome plated to enhance its aesthetics and also it offers corrosion resistance. Al-honeycomb sandwich are also light weight because of which it saves money on fuels and to get optimum speed much quicker with less efforts. Metal foam bumper are ultralight in weight if 70% - 90% of the volume consists of a void spaces. Carbon fiber bumper is strongest bumper in the market. Truly it is five times more stronger than steel bumper and also it does not catch fire i.e. it is used in many racing cars. Some honeycomb structure also has a cell geometry which is capable of elastic buckling, which gives the honeycomb structure to recover their shape and properties after collision. Al-honeycomb structure if deformed in collision then they have to be changed or repaired. Actually most of the bumpers has to be changed or repaired if possible after its first collision. CFRP is the costliest one because of its long and arduous manufacturing process. The honeycomb structure has strength and absorbs more energy which reduces the chest ‘g’ thereby it insures passenger safety. Foam bumper made by Age-hardening of aluminum shows the improvement of foam with large void sizes but not with small sizes. Mostly steel bumpers are used in heavy vehicles and rest of the bumpers are used in almost all types of vehicles.

IV. FUTURE SCOPE

In automotive industries there is continuous advancement in technologies of improving safety and making light weight of the vehicles. In slow speed collision bumper plays an important role in protecting the vehicle parts from damage either front or from the rear. So it is very important to select the proper bumper for the required vehicles. After comparative study of the types of bumpers every types has its use in some or the other cases.

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Steel bumpers are useful in off road vehicles as it provides built-in winches and hooks for towing. Carbon fiber has a large application as it has great strength to weight ratio. Metal foam are better in compression strength so it has many application. In future due to continuous evolution in safety features in automotive industry the bumper should be built such that it can provide protection to front end parts and also ensures safety to the passengers and also to the pedestrian.

V. CONCLUSION

Here we had concluded that the bumper made of different materials has an application in some or the other type of vehicles.

Steel bumper can be used in off road vehicles as it provides fitting for various accessories.

CFRP bumpers are light in weight and much stronger than steel and are used in hybrid cars.

Al-honeycomb structure has great compression strength and has high energy absorbing capacity.

Metal foam has a light weight and also posses high compression strength.

If they are used in combination of two or three material then can give better results.

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