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Review paper on Design and Analysis of composite truck bumper using Finite Element Method

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Abstract - *In this paper we are comparing strength to weight ratio of truck bumper made up of mild steel and composite material (glass epoxy) and modeling is done by using software catia, analyzed for linear static analysis and impact stress analysis. Truck bumper made of mild steel of thickness 1.6mm of truck bumper was used and by using bending moment formula, thickness of the composite material was determined and the value is 1.7mm. The Composite bumper designed gives lesser stress compare to mild steel bumper for linear static analysis and composite bumper has lesser weight compared to mild steel. From linear static analysis composite bumper was considered as best design. Impact analysis was done for both the mild steel and composite bumper for the thickness of 1.6mm. From impact analysis results, it was observed that the composite bumper produces less stress compared to mild steel bumper. From the linear static and impact analysis results, composite bumper has good impact behavior. The theoretical calculation of displacement of the mild steel was calculated assuming bumper as fixed beam.*

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

1. INTRODUCTION

Bumpers are the structural component fitted in front and rear end of the vehicles. It helps to protect the vehicle from minor impact. Generally bumpers are made up of metal, it has low strength to weight ratio. Designer has to design the bumper with high strength to weight ratio. Weight reduction of the bumper without sacrificing strength should be done by the designer. This can be done by the series of experiments and analysis process. Using finite element analysis process we can design a best bumper having light weight with high strength to weight ratio.

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.

1.1 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 the grille, hood, exhaust and cooling systems, also protects some components like parking lights, head lamps and taillights in low speed collisions.

1.2 MATERIALS USED FOR BUMPER

Depending on the make, model, and type of truck, there are a variety 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.

1.2.1 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.

1.2.2 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.

1.2.3 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.

1.2.4 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 metal is steel, typically with chrome finish.

1.3 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

1.3.1 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.

1.3.2 AERODYNAMICS

Designer has to design the bumper to less resistance to air, if more is air resistance than power requirement also more to run the vehicle. So designer has to design the bumper with less resistance to air for better performance.

1.3.3 SAFETY

Steel bumpers cause serious injuries to pedestrians when the vehicle hits them. Due to these steel bumpers has been replaced by plastics. Designer should design the bumper with lighter material.

1.3.4 AESTHETICS

Look and appearance is important for bumper it must be attractive to customers. So designer must concentrate on look of the bumper by changing design. Designer must consider curvature effects such as fillets, different shapes of holes on the bumper and many more.

1.3.5 PRODUCTION COST

The cost of the bumper material should be low, without compromising the strength and weight. Many production techniques are there to produce bumpers, such as extrusion or molding process depending upon type of material used. Production cost should be low in order to get good profit. These factors must be considering the designer to produce the bumpers.

1.4 TYPES OF BUMPERS

Generally many types of bumpers are used depend upon vehicle compatibility. Different parameters come into account to design the parameters.

1.4.1 STANDARD BUMPER

These type of bumpers used for most of the vehicles and more for cars.

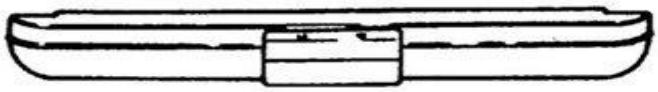

Fig. 1.2 Standard bumper

1.4.2 DEEP DROP BUMPER

It is also known as cowboy bumper; this type of bumper is typically found on older trucks and is usually chrome plated. Deep drop bumpers have a heavy-duty towing capacity and a lower ball height than a step bumper. The drop from the bottom of the frame is usually 10 or 12 inches.

Fig. 1.3 Deep drop bumper

1.4.3 ROLLPAN BUMPER

Roll pan bumpers are typically found on custom compact trucks. The trailer hitches available will sit in the middle, behind the bumper.

Fig. 1.4 Roll pan bumper

1.4.4 STEP BUMPER

This type of bumper is typically found on trucks, vans and SUVs. The small cutout in the center looks like a step. This bumper also has holes for hitch balls and can be used to tow lightweight trailers.

Fig. 1.5 Step bumper

1.4.5 TUBE BUMPER

It has tube like structure in resemblance andthis type of bumper is typically found on jeeps.

Fig. 1.6 Tube bumper

2. LITERATURE REVIEW

Prabhakaran,et al.[1]has explained the design of composite bumper made of glass/epoxy by using existing mild steel bumper. The thickness of the composite bumper is calculated by using bending moment equation and others dimensions for both steel and composite is considered a same. From the above procedure they calculated the thickness of composite bumper. They were taken both the bumpers for analysis using ansys software. They obtained some of results for both the bumpers such as stress, weight and factor of safety. They also conducted the impact test by using charpy test method for both steel and composite materials. They fabricated the composite bumper by using steel bumper as mold. Analysis results are tabulated below.

Shahril, et al.[2] has conducted the stress analysis of bumper bracket by using materials properties such as grey cast iron and high strength low alloy. They used the catia v5 software for modeling and abacus CAE software for analysis. They mainly aimed to reduce to stress, strain and displacement of bumper bracket under loading condition. They compared the results of both the materials in terms of stress, strain, and displacement. From analysis they concluded that high strength low alloy is better than grey cast iron in terms of stress, strain and displacement. Bumper bracket made from High strength and low alloy can withstand more force and pressure than the grey cast iron.

Davoodi, et al.[3] they examined the effect of impact analysis using composite kenaf/glass epoxy bumper beam with ribs and without ribs condition. By using abaqus Ver16R9 low speed impact was simulated. A pendulum with 1000kg and speed 4 km/hr. impacted on bumper beam, it fixed at both the ends. From the impact analysis they conclude that ribbed bumper beam yields lesser deflection compared to unribbed condition. Ribbed bumper beam has more weight than unribbed condition.

Saeed AbuAlyazeedAlbatlan[4] focused on improvement of impact resistance of bumper, for that they are using three types cross section of bumpers. By adding extra one layer as filler material to bumper such as honey comb cardboard cell and cardboard sheets. After the adding filler material to bumper, they made the bumpers to impact test by using impact device.

After the impact tests they concluded that bumpers with filler materials shows the good impact behavior. The device used for impact as shown in below

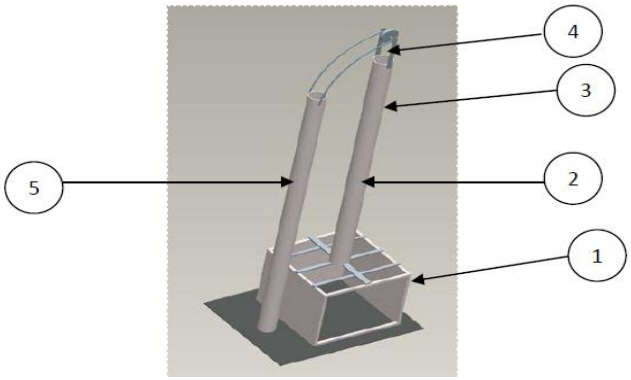

Fig. 2.1 Impact device

1-base box

2-hollow shaft

3-drop weight with wire

4-pulley

5-fixed arm

Kleisner, et al.[5] conducted the safety tests according to research council for automobile repairs (RCAR) and European methodologies. RCAR is an international organization that works towards by improving damage ability, safety and security by low speed offset car crash test. By using different materials and bumper profiles are used for crash test. PAM crash software is used for numerical analysis. Numerical results are validated with experimental results.

Mohan srikanth, et al.[6] conducted the impact analysis for bumper by using steel, carbon fiber reinforced poly ether amide and glass epoxy material properties for car bumper for different impact velocities of 48km/hr. and 120km/hr. after conducting impact analysis for these material finally they conclude that epoxy glass has better impact behavior.

Nithin S. Motgi, et al.[7] conducted the modeling of car bumper and the impact analysis of bumper by using material properties of aluminium and composite with the velocity of 4Km/hr. They were also done the displacement analysis for both the materials. Calculation of internal energy for both the materials also carried out. By analyzing stress pattern they concluded that composite material bumper has good impact behavior.

3. CONCLUSIONS

In this paper revived for both mild steel and composite material bumper was selected to carry out linear static and impact 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.
- In impact analysis, the maximum stress developed by composite was5.921×10^2MPa and mild steel was 1.337×10^3MPa. Stress For composite bumper was less than mild steel bumper.
- 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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