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Impact Analysis of A Car Bumper Using Carbon Fiber Reinforced PEI And S2 Glass/Epoxy Materials By Solid Works Software

Ayyappa Swamy GV #1, P Satish Reddy #2, Matta Manoj #3, P.Bhaskar #4
ME Department, Prasiddha College of Engg and Technology, Anathavaram
[1]swamy16@rocketmail.com, [2] satish2436@gmail.com, [3] mattamanoj13@gmail.com, [4] smilybobbys@gmail.com

Abstract- Bumper is an important part which is used as protection for passengers from front and rear collision. The intend of this study was to investigate the structure and material employed for car bumper in one of the car manufacturer. In this study, 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.

The simulation of a bumper is characterized by impact modeling using Pro/Engineer, impact analysis is done by COSMOS according to the speed that is 13.3 m sec^{-1} (48 km h^{-1}) given in order to analyze the results. This speed is according to regulations of Federal Motor Vehicle Safety Standards, FMVSS 208- Occupant Crash Protection whereby the purpose and scope of this standard specifies requirements to afford impact protection for passengers.

Keywords-Bumper, Simulation, COSMOS, FMVSS 208

I. INTRODUCTION

An automobile's bumper is the front-most or rear-most part, ostensibly 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 impacts, but are increasingly being designed to mitigate injury to pedestrians struck by cars.

In 1971, the U.S. National Highway Traffic Safety Administration (NHTSA) issued the country's first regulation applicable to passenger car bumpers. **Federal Motor Vehicle Safety Standard No. 215 (FMVSS 215)**, "Exterior Protection," took effect on 1 September 1972 — when most automakers would begin producing their model year 1973 vehicles. The standard prohibited functional damage to specified safety-related components such as headlamps and fuel system components when the vehicle is subjected to barrier crash tests at 5 miles per hour (8 km/h) for front and 2.5 miles per hour (4 km/h) for rear bumper systems.

The standards were further beefed up for the 1974 model year passenger cars with standardized height front and rear bumpers that could take angle impacts at 5 mile-per-hour (8 km/h) with no damage to the car's lights, safety equipment, and engine. In 1990, IIHS conducted four crash tests on three different-year examples of the Plymouth Horizon. The results illustrated the effect of the changes to the U.S. bumper regulations (repair costs quoted in 1990 United States dollars).

In early 2009, Canada's regulation shifted to harmonize with U.S. Federal standards and international ECE regulations. Consumer groups are upset with the change, but Canadian regulators assert that the 4 km/h (2.5 mph) test speed is used worldwide and is more compatible with improved pedestrian protection in vehicle-pedestrian crashes.

II TYPES OF BUMPERS

- Plastic bumper- Most modern cars use a reinforced thermoplastic bumper, as they are cheap to manufacture, easy to fit and absorb more energy during a crash.

- Body kit bumper- Modified cars often now have a full body kit rather than just a front and rear bumper. These kits act as a skirt around the entire body of the car and improve performance by reducing the amount of air flowing underneath the car and so reducing drag.
- Carbon fiber bumper- Carbon fiber body work is normally the thing of super-cars, but many car companies, and specialist modifiers, are starting to use it for replacement body part on everyday cars.
- Steel bumper- Originally plated steel was used for the entire body of a car, including the bumper. This material worked well, as it was very strong in a crash, but it was very heavy and dented performance. As car engine design has improved, steel bumpers have pretty much disappeared for anything except classic cars. Replacing one involves a lot of searching for scrap cars or having one specially made.

III MATERIALS USED IN BUMPER

At one time, most car bumpers were made of steel. Then, most were made of chrome or a chrome-plated material. Today, car bumpers can be made from anything from chrome-plated material to a variety of different rubber materials or plastics. This makes detailing car bumpers somewhat more complicated, as bumpers made from different materials require very different detailing treatments.

Detailing a chrome-plated bumper requires a bit of patience and a light sanding touch, but it is certainly something that even the most casual car owner can accomplish in a day or less. The primary enemy of chrome-plated bumpers is oxidation (rust). The longer you allow rust spots to remain on your bumper, the more difficult the detailing process is going to be.

Bumpers on most new cars are color-coordinated plastic "wrappers," molded sleekly around the front and back ends of the vehicles. They may please the eye, but whether these bumpers protect the vehicle they surround from damage in low-speed impacts is another matter. According to the National Institute for Highway Safety, how well the car is protected depends largely on what's underneath the plastic. Bumper systems usually include a reinforcement bar plus energy-absorbing material, such as polypropylene foam. Better bumpers often have hydraulic shock absorbers instead of, or in addition to, the foam.

Today's plastic auto bumpers and fascia systems are aesthetically pleasing, while offering advantages to both designers and drivers. The majority of modern plastic car bumper system fascias are made of thermoplastic olefins (TPOs), polycarbonates, polyesters, polypropylene, polyurethanes, polyamides, or blends of these with, for instance, glass fibers, for strength and structural rigidity. The use of plastic in auto bumpers and fascias gives designers a tremendous amount of freedom when it comes to styling a prototype vehicle, or improving an existing model. Plastic bumpers contain reinforcements that allow them to be as impact-resistant as metals while being less expensive to replace than their metal equivalents. Plastic car bumpers generally expand at the same rate as metal bumpers under normal driving temperatures and do not usually require special fixtures to keep them in place.

IV DESIGN AND MODELING-Actual Car Bumper

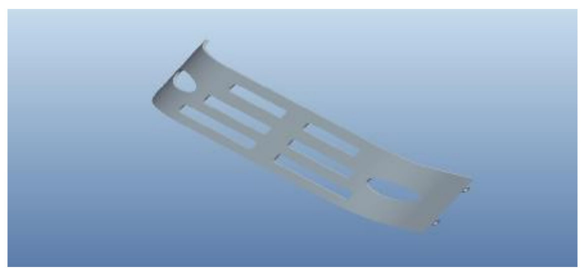

Fig-1: Model of a Car Bumper

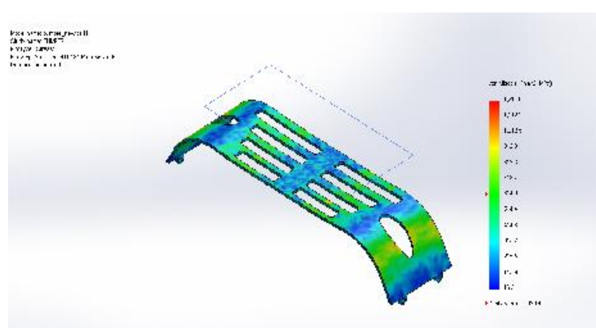

Fig-2: Stresses for actual Bumper-Alloy Steel at Speed 48km/hr

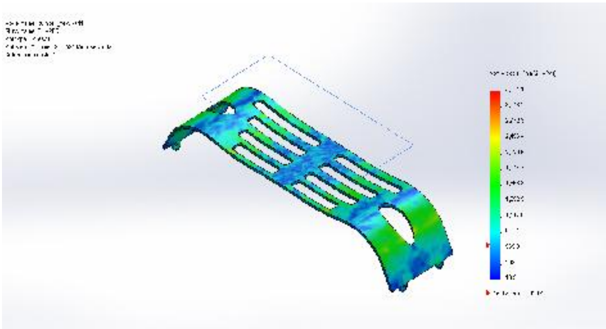

Fig-3: Stresses for actual Bumper-Alloy Steel at Speed 120 km/hr

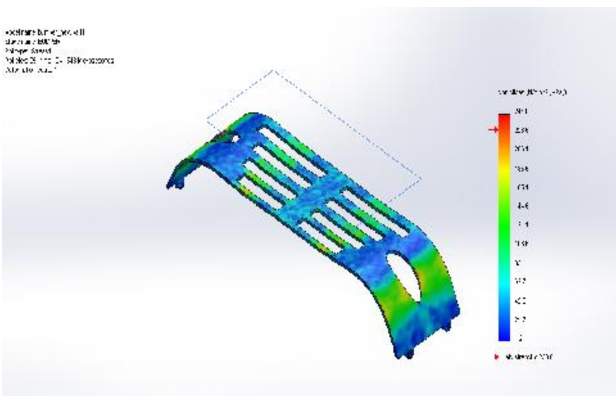

Fig-4: Stress for actual bumper-Carbon Fiber Reinforced PEI at speed 48 km/hr

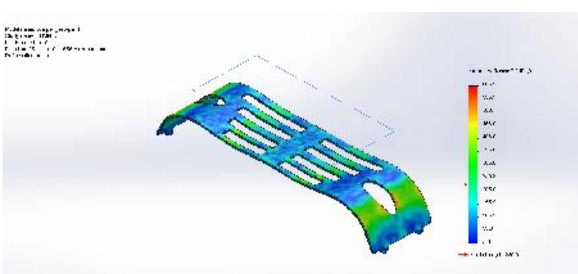

Fig-5: Stress for actual bumper-Carbon Fiber Reinforced PEI at speed 120 Km/hr

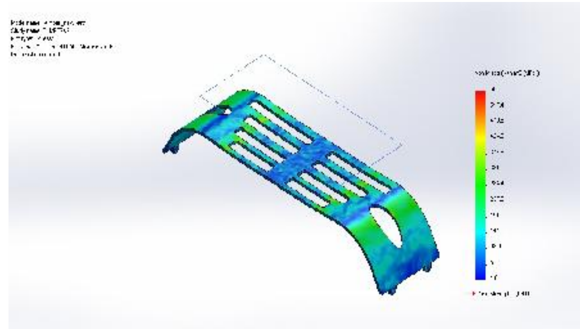

Fig-6: Stress for actual bumper-S2glass/Epoxy at speed 48Km/hr

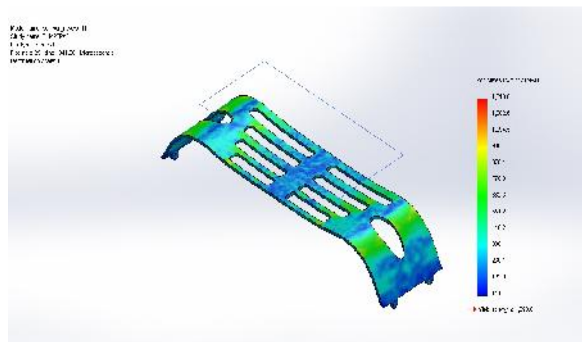

Fig-7: Stress for actual bumper-S2glass/Epoxy at speed 120 Km/hr

V DESIGN AND MODELING- Modified Bumper

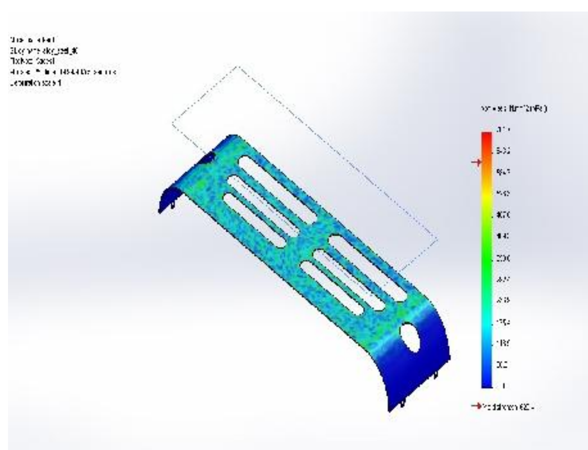

Fig-8: Stress for modified bumper-alloy steel at speed 48Km/hr

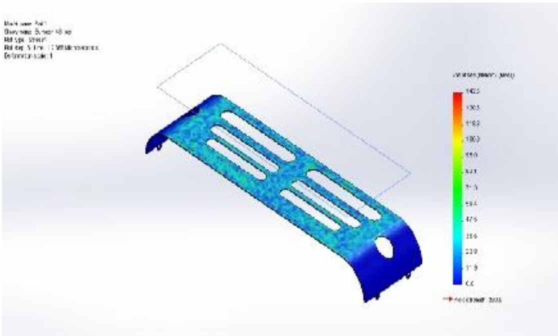

Fig-9: Stress for modified bumper-Carbon fiber reinforced PEI at speed 48km/hr

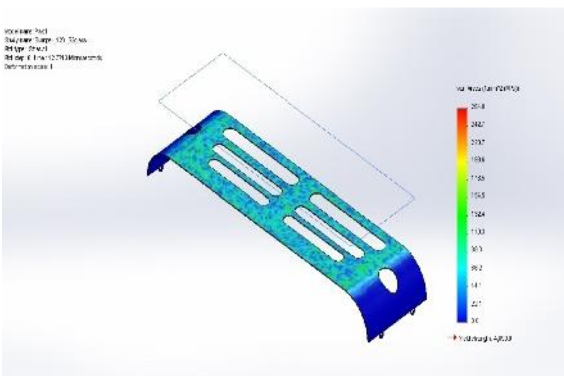

Fig-10: Stress for modified bumper-S2glass/Epoxy at speed 48km/hr

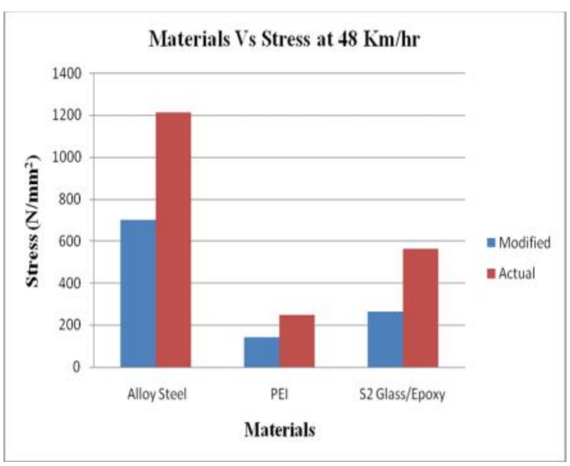

Fig-11: Stress comparison at speed 48 km/hr

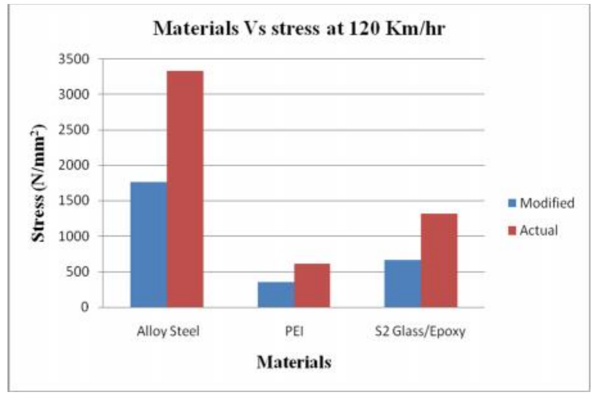

Fig-12: Stress comparison at speed 120 km/hr

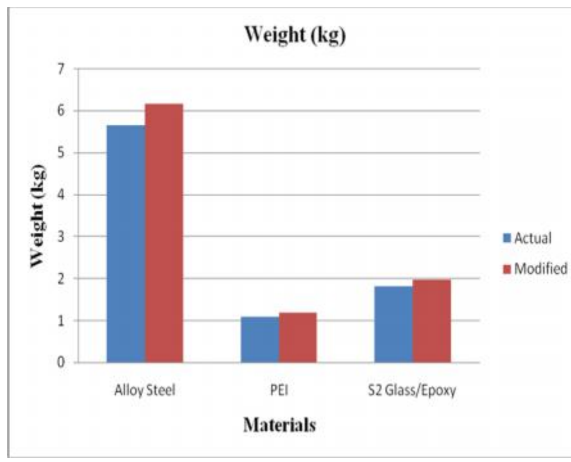

Fig-13: Weight Comparison

VI CONCLUSION

1. In our thesis, actual model of a car bumper is designed and a modified model to the actual is also designed.

2. Impact analysis is done on the car bumper for different speeds of 48Km/hr and 120Km/hr. The analysis is done on the car bumper for different materials Alloy Steel, S2 Glass/Epoxy and Carbon Fiber Reinforced PEI.

3. Present used material for car bumper is steel. By using steel the weight of the car bumper is more but by using composites the weight of the bumper is reduced since densities are very less compared with steel. By using S2 Glass/Epoxy, the weight is almost reduced by 4Kgs and by using carbon Fiber Reinforced PEI it is almost reduced by 5Kgs.

4. By observing the analysis results for both the designs, the analyzed stress and displacement values are more for the actual model than the modified model. So it can be concluded that modifying the original design is better.

5. By observing the analysis results, the analyzed stress values when steel and PEI are used are safe when impacted at a speed of 48km/hr, but the stress values for those materials when impacted at a speed of 120km/hr is not safe since their analyzed stress values are more than their respective yield stress values. So using Steel and Carbon Fiber-Reinforced PEI at a speed of 120km/hr is not better.

6. But the analyzed stress values when S2 Glass/Epoxy is used impacted at both the speeds is safe since the stress values are less than its yield stress value. So we can conclude that using S2 Glass/Epoxy is better.

VII SCOPE OF FUTURE RESEARCH

By this thesis, it is proved analytically that using composites is better for bumper than steel due to the reduction in weight and also stresses. But more experiments have to done for feasible using of composites considering cost and other conditions.

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