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Design and Analysis of an Automobile Bumper

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Abstract

The fuel efficiency and emission gas regulation of passenger cars are two important issues in these days. Bumper is the one of the part having more weight present cause. In this paper the existing steel bumper is replaced with light weight with suspension bumper will attached in my project. In this work the design and analysis with fabrication of standard composite material bumper made up of glass fiber reinforced polymer is carried out by which weight of the bumper can be reduced in different cross section of this process. In this project is constructing less weight impact saturation suspension profiles are consumed.

Keywords:
Automobile bumper; cross section; composite material; glass fiber reinforced polymer

1. Introduction

In automobiles, a 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. Recent trends in automotive design worldwide have seen more emphasize towards addressing sustainability issue a part from meeting operational requirements of the component design especially in the early product development stage Among the emerging solutions to meet both objectives is the application of hybrid natural based polymer composites in automotive component development Polymer composites generally encompass two major components which are the fiber which act as the reinforcement and the matrix which holds the fiber together and allow the composites to be produced in various shapes. However, the task of selecting the most appropriate matrix can be very challenging due to the variability of the resin available to be combined with the fibers and various attributes that need to be satisfied simultaneously by the candidate material to suit the intended application. 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 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. The importance of materials selection in the product development process has been well recognized. To develop a systematic method for selecting the best material is not an easy task because the best material is determined by a number of factors that influence the selection process. There are two main reasons why materials selection is required: firstly, to design an existing product for better performance, lower cost, increasing reliability and reduced weight and secondly, to select a material for a new product Materials selection is a main product design consideration because product's overall performance is mainly affected and determined by materials selection process. Strengthen ribs are exploited to improve the structural strength of hybrid kenaf/glass epoxy composite bumper beam in second trial of geometrical improvement in order to improve the performance of utilizing the developed material in structural component's applications. Strengthen ribs increase distortion resistance and structural stiffness with fewer materials in slender wall. It can decrease the bumper beam deflection, elongation and increase impact energy. The previous result showed that the toughened hybrid kenaf/glass fiber epoxy composite cannot fulfill the GMT impact strength. The geometry improvement commenced with bumper concept selection within six criteria with different weight and concluded with double hat profile (DHP) as a best one out of eight concepts. The joints in aircraft and automotive structures lead to regions of stress concentration. Composite materials are relatively brittle and typically offer limited stress relief through localized yielding compared to metals. This, combined with inadequate failure prediction capabilities, can lead to conservatively designed composite bolted joints which amount to severe structural weight penalties. Bonded joints offer higher structural efficiency, but limit accessibility and can increase manufacturing and maintenance costs. Optimizing composite bolted joints using improved modeling tools thus continues to be a priority for airframe manufacturers. Countersunk fasteners are of particular interest for use in skin-structure joints where aerodynamic efficiency is important.

Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. Saving the impact energy in the bumper to be released in the environment reduces the damages of the automobile and passengers. The goal of this paper is to design a bumper with minimum weight by employing the Glass Material Thermoplastic (GMT) materials. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction. To reach this aim, a mechanism is designed to convert about 80% of the kinetic impact energy to the spring potential energy and Release it to the environment in the low impact velocity according to American standard1. In addition, since the residual kinetic energy will be damped with the infinitesimal elastic deformation of the Bumper elements, modeling, solving and result's analysis are done in CATIA, LS-DYNA and ANSYS V8.0 software respectively [1]. 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 help 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. 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 [2].

This paper describes a study of high strength stainless and carbon steels at Volvo Cars Body Components. It demonstrates the difference in formability and crash absorbing capability for a specific component. The austenitic stainless grades and the carbon steel Trip700 undergo a microstructure transformation during plastic deformation. This means that traditional forming limit curves index the formability too low for these types of materials. Instead, a forming limit dome height diagram should be used to index the formability for all type of materials. The crash impact absorbing capabilities was highest for the bumper that was made in high strength stainless steel since that material had the highest yield stress of all materials in this study.

Today's car is a multi-material vehicle. There are several reasons for this. Weight is one key factor. Structural components and body panels are subjected to demands for decreased weight and several lightweight solutions can be found on our streets. Materials are often described by properties such as yield- and tensile strength, elongation to fracture, anisotropy and Young's modulus but shape is not a material property. A sheet metal component is a material made into a certain shape through a forming process. Depending on loading condition, a material-and-shape combination resists the applied load best. Components in a BIW structure should also be able to absorb or transmit impact energy in a crash situation three carbon and two austenitic stainless steels were selected in this study. Two carbon steels had duplex microstructure while the third was a TRIP grade. The stainless steels were cold rolled and delivered from Avesta Polarit. The stainless grades had an austenitic structure with lean composition and one was in fully annealed condition while the other was in temper rolled condition. Both the stainless grades and the TRIP grade of the carbon steels have a meta-stable microstructure, which means that the initial microstructure is able to change during plastic deformation. Uniaxial tensile tests were made to evaluate the mechanical and plastic properties of the materials [3].

Selection of materials, as an area of design research, has been under considerable interest over the years. Materials selection is one of the most important activities in the product development process. Inappropriate decision of materials can cause the product to be reproduced or remanufactured. To avoid this circumstance, one of the useful tools that can be employed in determining the most appropriate material is analytical hierarchy process (AHP) to illustrate the application of AHP; six different types of composite materials were considered. The most appropriate one for suitability of use in manufacturing automotive bumper beam was determined by considering eight main selection factors and 12 sub-factors. The AHP analysis reveals that the glass fibre epoxy is the most appropriate material because it has the highest value (25.7%, mass fraction) compared with other materials. The final material is obtained by performing six different scenarios of the sensitivity analysis. It is proved that glass fibre epoxy is the most optimum decision [4].

This paper presents the effect of finite element analysis (FEA) model improvements to better correlate predictive analyses to pedestrian protection lower leg impact tests. The FEA analysis model prediction is now within 10% of the tested values for tibia deceleration, knee bending angle and knee shear. By using this improved FEA model, new, more efficient energy absorber and vehicle front end design strategies can been developed. A numerical approach to optimizing vehicle front end structures is presented.

The current pedestrian safety assessment procedure consists of several different tests that represent the impact of the leg, upper leg and head. The leg form impact test typically involves the front bumper, radiator grill, hood and headlights. In addition, some vehicle styles incorporate lower fascia structures that can have a significant effect on lower leg impact [5].

The growth of car production governs new environmental regulations "End-of Life Vehicles" (ELV) to enforce car manufacturer to substitute synthetic material to bio based materials. Low mechanical properties of natural fibre composite confine their application in automotive non-structural components. Hybridizations of kenaf with glass fibre along with epoxy PBT toughening did not completely fulfill the required impact property of the developed bio-composite bumper beam to substitute with typical material of the bumper beam glass mat thermoplastic (GMT).Therefore, in the first stage of the geometrical improvement "concept selection" concluded that the double hat profile (DHP) is the most suitable concept out of eight bumper beam concepts when six parameters with different weight are determined. In second trial, the usage of strengthen rib is employed to improve the impact property and performance of the bumper beam for utilization of hybrid kenaf/glass fibre as a car bumper Beam [6]. The joints in aircraft and automotive structures lead to regions of stress concentration. Composite materials are relatively brittle and typically offer limited stress relief through localized yielding compared to metals. This, combined with inadequate failure prediction capabilities, can lead to conservatively designed composite bolted joints which amount to severe structural weight penalties. Bonded joints offer higher structural efficiency, but limit accessibility and can increase manufacturing and maintenance costs.

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Optimizing composite bolted joints using improved modeling tools thus continues to be a priority for airframe manufacturers. Countersunk fasteners are of particular interest for use in skin-structure joints where aerodynamic efficiency is important. Many of these joints are single-lap in nature. Single-lap joints result in significant stress concentrations and lower bearing strengths compared to double-lap joints, while countersunk joints clearly involve a highly complex stress distribution in the laminates. Thus countersunk, single-lap joints are of critical importance to the aircraft industry, but are also the most complex type to analyze. To date, there have been few detailed studies on this type of joint. Finite Element Analysis Finite element method is used to analyze structures by computer simulations and therefore it helps to reduce the time required for prototyping and to avoid numerous test series. The modeling and analysis will be done using Finite element Analysis software [7].

2. Modeling

2.1 Data Collection

The following data's have collected to model the automobile front bumper.

- Effective length: 0.975m
- Total length : 2.055m
- Thickness : 0.002m
- Effective breath: 0.078m
- Total breath : 0.172m
- Profile : C-type profile
- Weight : 5.16kg
- Material : Mild steel (Chromium coated)
- Tensile strength: 460MPa
- Density : 7800 kg/m^3

2.2 Model generation

The following geometry model of automobile bumper has been made by using Solid Works software.

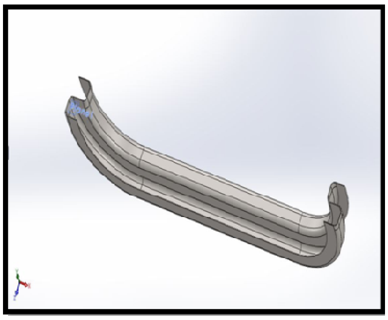

Figure 1 Modeled geometry (S-type profile)

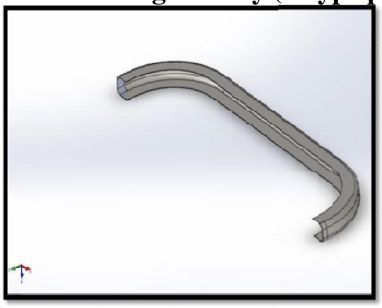

Figure 2 Modeled geometry (C-type profile)

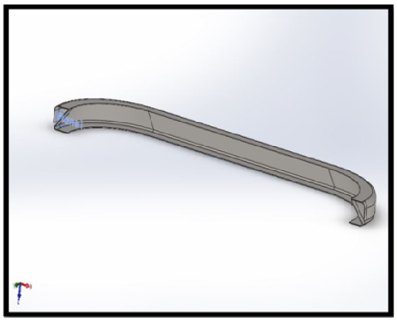

Figure 3 Modeled geometry (Z-type profile)

3. Experimental analysis

The following experimental analysis is carried out to evaluate the impact strength of the design modified automobile bumper by using Charpy and Izod impact tests. Results which is obtained from impact tests are given in the table.1

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Figure 4 'S' Type bumper model

Table 1Impact test results

S.No	Specific Impact Energy (N/mm)	
	Charpy Test	Izod Test
1	170.57	69.80

Figure 5 Schematic arrangement of impact test

4. Numerical analysis and results

The following results have been obtained from the numerical analysis. The total deformation of C-Type profile bumper maximum deformation occurred in the middle portion of the bumper with a value of 4.8283 mm is shown in Figure.6

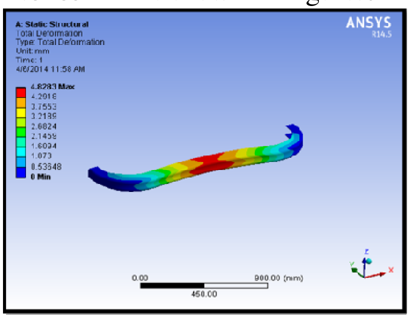

Figure 6 Total deformation of C -type profile

The total deformation of S-Type profile bumper maximum deformation occurred in the middle portion of the bumper with a value of 4.5077mm is shown in figure.7

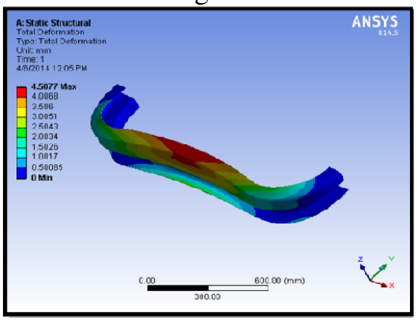

Figure 7 Total deformation of S -type profile

The total deformation of Z-Type profile bumper maximum deformation occurred in the middle portion of the bumper with a value of 25.453 mm shown in figure.8

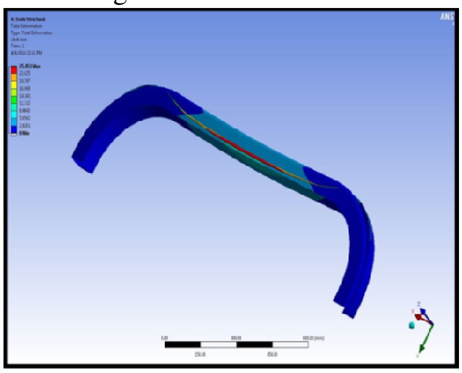

Figure 8 Total deformation of Z -type profile

The total deformation of entire assembly of S-Type profile bumper. Maximum deformation occurred in the middle portion of the bumper with a larger value of 1400.7 mm shown in figure.9

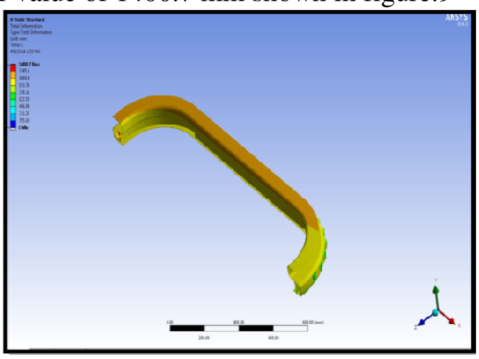

Figure 9 Total deformation of entire S type profile

The Von-Misses stress of entire assembly of S-Type profile bumper. Maximum deformation occurred in the middle portion of the bumper with a magnitude of 5511.6 MPa shown in figure.10.

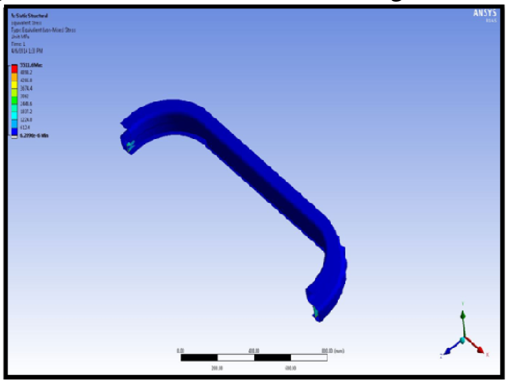

Figure 10 Von-Misses stress

The directional deformation of entire assembly of S-Type profile bumper is shown in the figure.11.Maximum directional deformation occurred in the middle portion of the bumper with a magnitude of 1397.9 mm.

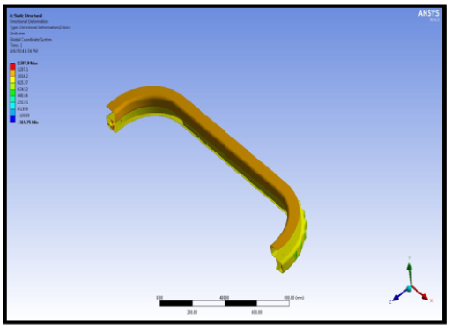

Figure 11 Directional deformation of S-type profile

Figure.12 shows the deformation comparison between the three types of bumper cross section profile. It clearly shows that the bumper cross section with S type profile gives the better deformation among the other three profiles.

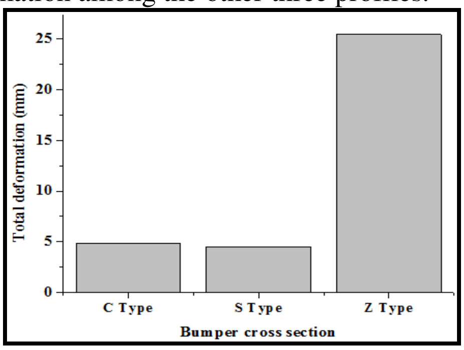

Figure 12 Deformation comparison

5. Summary

The following conclusions have been made from the above numerical analysis. In this analysis automobile bumper with three different cross sections like C type, S type and Z types are taken to do this analysis. Total deformation, directional deformation and Von-Misses stresses of the above three models were examined using ANSYS software. Based on this analysis we have concluded that the automobile bumper with S type cross section offers the minimum deformation of 4.5077 mm.

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