Investigation on Mechanical Behaviour of Hybrid Composite Bumper Using Sisal Fibre

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Abstract – In this exploration work, the wellbeing of automobiles and travellers the bumper is considered, which is one of the fundamental key structures of car part which is manufactured with the mixture composite material picked. The material chosen for the guard is sisal, E-glass which are filaments and PLA (Poly Lactic Acid), which is the pitch to give quality to the fibre. The primary goal is to test the effect quality of the material in the wake of knowing the ductile properties of the example made by the material that is picked determined previously. The elastic properties of the materials can be controlled by UTM (Universal Testing Machine) and dead weight tests can be directed for finding the effect quality tentatively. The guard made of sisal/E-glass fortified PLA contrasted and the consequences of E-glass/epoxy. At last the model of guard made by utilizing Pro-E and broke down utilizing ANSYS, at that point contrasted and test estimations of effect quality.

Index Terms – Bumper, Hybrid Composites, impact Test, Analysis.

1. INTRODUCTION

The Bumper is a security framework that is utilized to assimilate more vitality into crash and keeps affect vitality from being exchanged to car and travelers. The bumper beam is one of the fundamental parts of cars as it is the structure for retaining the vitality of crashes. Generally the guard is made of materials like steel, aluminum, elastic, or plastic that is mounted on the front and back of a vehicle. In the current scenario the weight is bumper high, however in the present the weight lessening is the principle center of car industry. This can be accomplished by presenting preferred material over that of steel which is composite material. In any case, many explores made on composite materials and demonstrated that the lessening of weight is conceivable and great effect engrossing properties than that of steel and different materials.

Car manufacturers incorporate numerous safety systems and features for their vehicles to reduce the damage to the vehicle and also to passengers. Anon [4] has developed structural composite bumper for medium, heavy-duty truck and bus using a hybrid glass fibre, which is lighter than its steel equivalent. Sapuan et al (2005) has presented the development of polymeric –based composite automotive bumper using the conceptual design approach. The selection of material is the main focus of the bumper beam in the product development activities, Hambali.A et al(2010) shown that glass fibre epoxy is the most optimum decision using analytical hierarchy.

(3) Bumper should also withstand 5 mph crash into a parked vehicle.

(4) Placement of the bumper is 16 to 20 inches above the road surface.

The bumper system is generally recognized as being composed of four basic components of bumper fascia, energy absorber, bumper beam and bumper stay, as depicted in Fig.1.

One of the most important components of bumper system is the bumper beam. It plays an important role of absorbing the bulk of energy and provides protection to the rest of the vehicle.

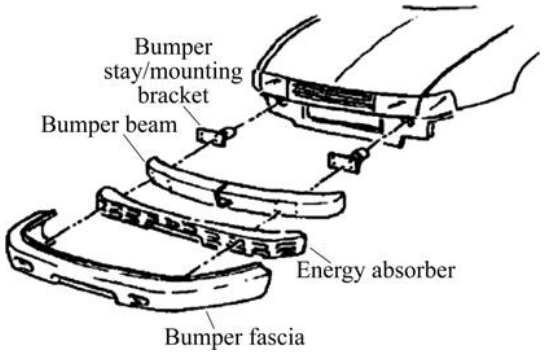

Fig.1 Diagram of bumper systems

The bumper requires the material that should absorb more energy while collision, good rust resistance, high strength, light in weight, easy to manufacture in large quantity, low cost.

A .The composite bumper

The composite material is defined as the combination of two or more materials to form unique properties of the material. The

advantages of composite material are it has less weight than that of steel, corrosion resistance, high impact strength, absorbs more collision energy so it is preferred for the bumper manufacturing.

Properties of composites are strongly influenced by the properties of their constituent materials, their type, their distribution and the interaction between them. Like conventional materials, composites are not homogeneous and isotropic. Composites are generally completely elastic up to failure exhibit no yield point or a region of plasticity.

In recent days, various materials like composites are experimented in almost all parts of the automobiles and it has also ventured into bumper. The most common advanced composites are polymer matrix composites(PMCs) consisting of a polymer such as epoxy, polyester, urethane, etc., reinforced by thin diameter fibres such as graphite, aramids, boron, glass, etc. Such type of PMC that is flexible and good resistance to heavy loads are used nowadays in automobile manufacturing industry.

Advantages of glass fibre

- Low density
- Corrosion resistance
- Impact resistance
- Molten glass easily drawn into high-strength fibres
- Readily available/easy to fabricate

Advantages of epoxy resin

- Good compatibility with Glass fibre
- High strength
- Low viscosity and low flow rates, which allow good wetting of fibres and misalignment of fibres during processing
- Low shrink rates which reduce the tendency of gaining large shear stresses of the bond between epoxy and its reinforcement.

One of the most advantageous reasons for considering such composite material is

- Reduced weight.
- Absorb more collision energy
- Excellent corrosion resistance,
- High impact strength,
- Material properties of composite bumper allow rapid response to induced or release stress.

2. MATERIALS AND METHODOLOGY

The materials for fabricating bumper are listed below along with the properties of each fibre and matrix which is hybrid composite. The methodology used for fabricating the bumper is hand lay-up process

A. The hybrid composite material

The advanced composite material and that have more than one reinforcing phase and single matrix phase or single reinforcing phase with multiple matrix phases is called hybrid composites. The properties of a hybrid composite mainly depend upon the fibre content, length of individual fibres, orientation, extent of intermingling of fibres, fibre to matrix bonding and arrangement of both the fibres. The hybrid composite that is chosen for the fabrication of bumper is sisal/E-glass fibre reinforced PLA (poly lactic acid) which is Biofibre-Synthetic Fibre Composite. Hybrid biocomposites can be designed by the combination of a synthetic fibre and natural fibre (biofibre) in a matrix and a combination of two natural fibre / biofibre in a matrix. Hybridization with glass fibre provides a method to improve the mechanical properties of natural fibre composites.

The properties of material prove the reason of choosing such a material for the application of bumper. The main requirement of bumper is to withstand the impact load and prevent the physical damage to the front or rear ends of passenger motor vehicles in low speed collision.

Fig.2 Sisal Plant

Fig.3 Sisal fibre

Advantage of sisal fibre

- Good impact absorbing properties,
- Acid and alkali resistance,
- Ability to stretch,
- Resistance to deterioration to salt water.

Advantages of glass fibre

- High strength,
- Impact resistance,
- Corrosion resistance, and
- Easy to manufacture.

In this selection of hybrid fibres both the properties of fibres include the resistance of impact load, so it is proven that it satisfies the need of bumper to have good impact absorbing properties.PLA, the resin or matrix which is the strength provider for the fibres is linear thermoplastic polyester produced from renewable resources such as corn starch (in U.S), tapioca roots, chips or starch (mostly in Asia), or sugarcanes. One of the additional benefits of large commercial production of lactic acid for PLA is the increased availability and reduced cost of lactic acid.

B. Fabrication of hybrid composite bumper

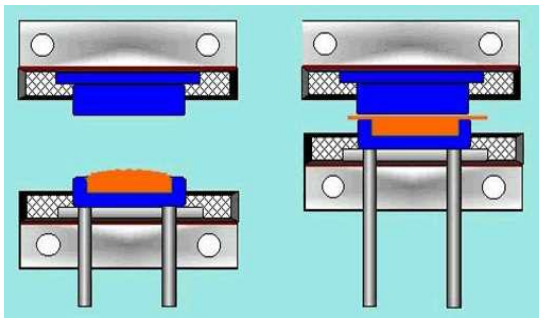

Fig.4 Compression Molding Process

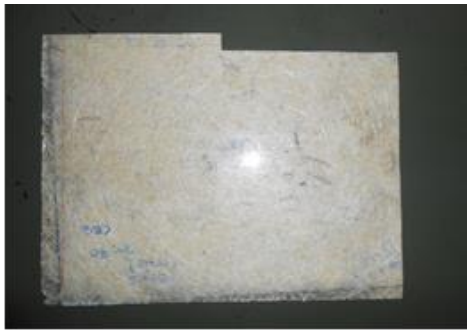

Fig.5 Specimen Piece of Hybrid Composites

There are various methods to fabricate the composites. They are had lay-up process, pultrusion process, filament winding process, resin transfer molding, sheet molding compound, reaction injection molding. Here we use the compression molding process for the fabrication of hybrid composites.

The compression molding process shown in Fig 4

- With the dies apart, the prepared polymer 'dough' is placed into the cavity.
- With the die closed, the article is formed and the small amount of flashing on each side will be removed later.
- When the die is closed, heat and pressure is maintained until the condensation polymerization process is completed.

The hot compression moulding process is used to form components from phenolic, urea and melamine thermosetting polymers, as well as alkyd resins.

3. ALKALI TREATMENT FOR SISAL FIBRE

Before the compression molding process the natural fibre must be treated with NaOH to strengthen sisal fibre. The dewaxed fibres are immersed in 5 and 10% NaOH solution for 1 h at 300C, then washed thoroughly with deionised water and air dried to get 5 and 10% alkali treated fibres respectively. The alkali treatment shown in Fig 6,7 and 8.

Procedure of Alkali Treatment

- Fibre is dipped in distilled water for 24 hrs and then it is dried in direct sun light.
- Secondly it is dipped in NaoH solution for 24hrs and then it is dried.
- Finally it is placed in oven for 6hrs.
- This treated fibre is then converted into mat i.e., fabric material.

Fig.6 Dried fibre

Fig.7 Fibre dipped in NaoH

Fig.8 Fibre dried in oven for 6Hrs

4. EXPERIMENTAL TEST AND ANALYSIS

The bumper made of E-glass/epoxy is fabricated now and results taken and the analysis carried out with the properties of such composite material in order to compare with the tested results of bumper made of sisal/E-glass reinforced with PLA which is proposed work of the project. Then FEA analysis is carried out now with the properties of E-glass/epoxy made bumper and further work is to analyze the bumper which is made of sisal/E-glass reinforced with PLA with the specific properties of that material.

A. Impact Test

The impact test is for the purpose of knowing the material's ability to resist the impact load and the service life of the material. The impact test designed to give information on how a specimen of a known material will respond to a suddenly applied stress, e.g. shock. A method for determining behavior of material subjected to shock loading in bending, tension, or torsion. The quantity usually measured is the energy absorbed in breaking the specimen in a single blow, as in the Charpy Impact Test, Izod Impact Test, and Tension Impact Test. Impact resistance is one of the most important properties for a part designer to consider, and without question, the most difficult to quantify. The impact resistance of a part is, in many applications, a critical measure of service life. More importantly these days, it involves the perplexing problem of product safety and liability.

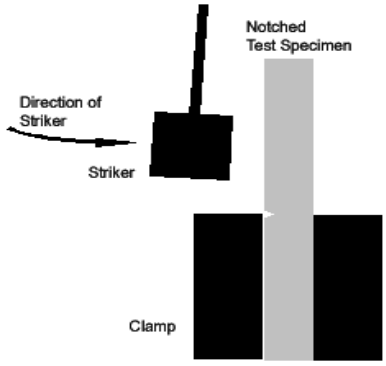

Fig.9 Charpy Impact Test Machine

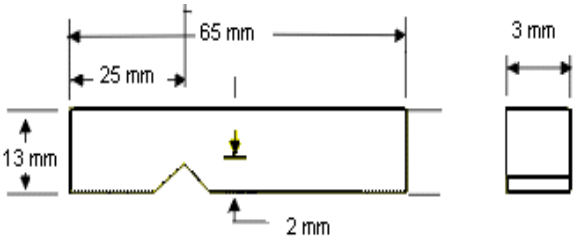

Fig 10.Specimen ASTM standard of Impact Test

The main requirement of bumper is to find the impact strength, thus impact test must be needed, and we use the charpy impact test machine shown in Fig.3. The charpy impact test is known as charpy v-notch test which is standardised high strain rate test. It is widely used in industry, and easy to prepare, conduct the result to obtain quicker and cheaper.

The apparatus consists of pendulum hammer swinging at a notched sample of material. The notch in the sample affects the result of the impact test, thus it is necessary or the notch to be regular dimension and geometry, the size of the sample can also defect the results, since dimension determine whether or not the material is in plane strain, difference can greatly affect conclusions made. The charpy test specimens normally measure 55*10*6mm and have notch machined across one of

the larger faces. The notch dimensions are v-shaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base.

Table 1 Impact test Results

Specimen Piece	Impact Strength(J/mm^2)
1	6.105
2	6.593

B. Tensile Test

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250x25x3)mm. Typical points of interest when testing a material include: ultimate tensile strength (UTS) or peak stress; offset yield strength (OYS) which represents a point just beyond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates into pieces.

Fig 11.UTM machine for tensile testing.

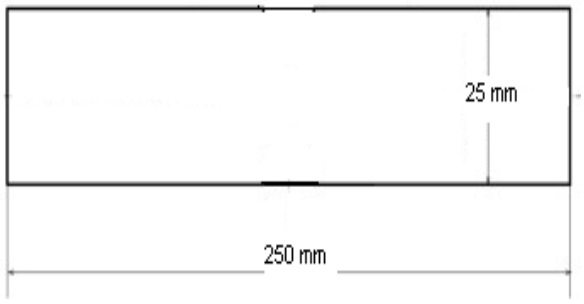

Fig 12.Specimen ASTM standard of Tensile Test

The tensile test is performed in the universal testing machine (UTM) Instron 1195 and results are analyzed to calculate the tensile strength of composite samples. The universal testing machine Instron 1195 is shown in Fig 3.1.

Table.2 Tensile Test Results

SPECIMEN PIECE	TENSILE STRENGTH(N/mm^2)
1	49.987
2	53.55

C. FEA Analysis

The solid model of bumper with given dimension is modeled using the software CATIA V5R16. The 3D model was exported to the IGES format from the modeling software.

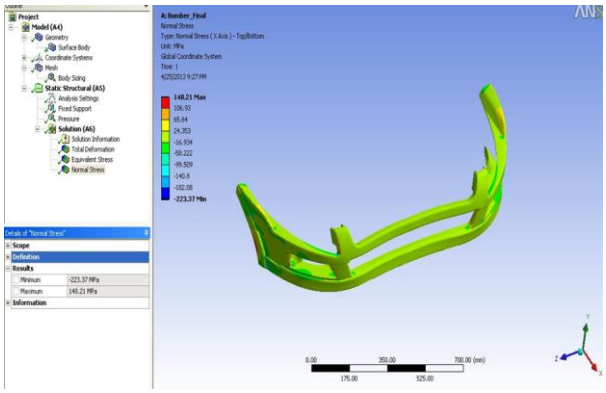

Fig 12.Imported Bumper for Analysis using ANSYS 10.0

The IGES format was imported for the analysis work in the ANSYS 10.0 software.In Pre-processing stage the element type for the steel bumper that is 20 node 186 (solid186) is defined. Material properties for the bumper are given in the material models. Meshing is done using mess tool option and number of divisions is assumed as 10.Then loads are defined at the suitable positions (i.e.) displacement is arrested at the two ends and constant pressure load is applied at front face of the bumper. After defining the loads solution is done using solve option. In general post processor from plot results von messes stress is chosen to display the stress distribution in the bumper. Description for Composite Bumper is shown in the table 3.

Table 3 Description for Composite Bumper

DESCRIPTION	E-glass/epoxy
Element type	Solid 191
Pressure load(N/mm^2)	0.13
Young's modulus(N/mm^2)	78×10^3
Poisson ratio	0.27

The model of bumper is shown in Fig.13 and stress distribution of bumper made of E-glass/epoxy shown in Fig.14

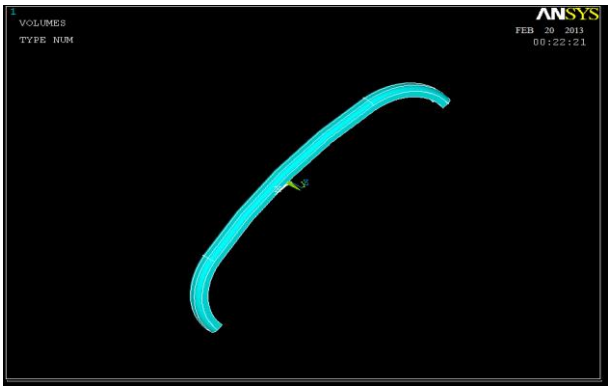

Fig.13 Model of bumper

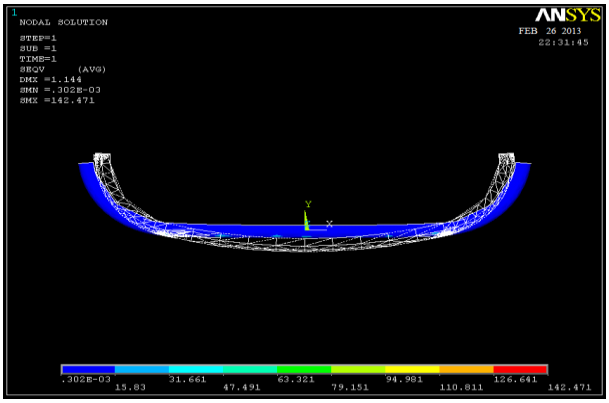

Fig.14 Stress Distribution of Composite Bumper

Maximum stress = 142.471 N/mm^2

Minimum stress = 0.302x 10^{-3} N/mm^2

Ultimate stress for composite = 490MPa (composite hand book)

Factor of safety = ultimate stress/working stress

= 490/142.471

F.O.S = 3.4

Table 4 Comparison of Results for the Bumper

Results	**EGlass/ Epoxy**	**Hybrid Composite**
Max.stress(N/mm^2)	148.21	144.96
Min.stress(N/mm^2)	-223.37	-222.57
Factor of safety	3.34	3.45

5. CONCLUSION

The hybrid composite material that is applied here for the bumper mainly focused on the impact strength. The additionally values found for knowing the properties, is tensile strength. The failure analysis is done here for determining the safer or failure layer which is strength ratio and the maximum load applied on the layer also found using mathematical analysis called first ply failure analysis. Then finally modeling of bumper done by solid works and analysis conducted using ANSYS V12. Thus the following conclusions show the values in detailed:

1. The tensile strength of two specimen made of hybrid composite material, sisal/E-glass/epoxy are 53.55 and 49.987 N/mm^2.
2. The impact strength of two specimen made of hybrid composite material, sisal/E-glass/epoxy are 6.593 and 6.105 J/ mm^2.
3. The first ply failure analysis is carried out and predicted from the strength ratio that the layers are safe. The maximum load applied on the lowest strength ratio is also determined.
4. The modeling of the bumper is created using SOLIDWORKS with required dimensions as we have used the design of SWIFT car bumper.
5. The bumper is analysed using ANSYS V12 to find out the normal stress and factor of safety of bumper made of steel and hybrid composite material and thus compared. Thus, the F.O.S is 3.45 for hybrid composite material and 3.34 for E-glass/epoxy.

In further improvement, the additional properties of hybrid composite material such as flexural, compressive strength and failure analysis are also be carried out considering different cases of laminates to find the strength ratio in order to predict the safe or failure of each ply or layer.

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