DESIGN AND ANALYSIS OF A REAR BUMPER OF AN AUTOMOBILE WITH A HYBRID POLYMER COMPOSITE OF OPEBF/BANANA FIBRES

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ABSTRACT

This research investigated the design and analysis of a rear bumper of an automobile with hybrid polymer composite of OPEBF/Banana fibre. OPEBF/Banana fibre hybrid polymers composite is of low cost, light weight, as well as possess satisfactory mechanical properties. In this research work, hybrid composites have been developed using hand layup technique based on percentage combination of OPEBF/Banana fibre at 10:90, 20:80, 30:70, 40:60, 50:50. 60:40, 70:30. 20:80, 90:10, 95:5. The mechanical properties in the context of compressive strength of 65MPa, flexural strength of 20MPa and impact strength of 3.25Joule was observed and the simulation analysis on the induction of 500N load at factor of safety of 3 were observed to have display a good strength suitable for automobile bumper with the advantages of weight reduction.

Keyword: OPEBF, Banana, Fibre, Hybrid, Polymer, Composite.

1.0 Introduction

According to Prabhakaran *et al*. (2012) The bumper is a safety system used to observe the low speed collision. It is placed in car body. The car bumper is designed to prevent or reduce physical damage to the front and rear ends of passenger motor vehicles in low-speed collision. An automobile's bumper is the front-most or rear-most part, ostensibly designed to allow the cars 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. Front and rear bumpers became standard equipment on all cars in 1925. What were then simple metal beams attached to the front and rear of a car have evolved into complex, engineered components that are integral to the protection of the vehicle in low-speed collisions. 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 can be styled for both aesthetic and functional reasons in many ways without greatly affecting the cost of production. 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. This enables the manufacturer to reuse scrap material in a cost-effective manner. A new recycling program uses painted TPO scrap to produce new bumper fascias through an innovative and major recycling breakthrough process that removes paint from salvage yard plastic. Tests reveal post-industrial recycled TPO performs exactly like virgin material, converting hundreds of thousands of pounds of material destined for landfills into workable grade-A material, and reducing material costs for manufacturers. Bumper beams are one of the important structures in passenger cars. For which we need to have careful design and manufacturing in order to ensure good impact behavior. The new bumper design must be flexible enough to reduce the passenger and occupant injury and stay intact in low-speed impact besides being stiff enough to dissipate the kinetic energy in high speed impact. The bumper beam is the key structure for absorbing the energy of collisions. Since this is energy absorbing structure, suitable impact strength is the main requirement for such a structure, research analyses the parameters that directly affects impact characteristics and proposes easily achievable modifications resulting from impact modeling on commercial bumpers. A passenger car bumper is modeled and tested for the impact. With the introduction of automobile safety legislation, crashworthiness and safety should be considered as preconditions in light-weight design of bumper beam. There were four main strategic parameters being studied in the test modeling in the first step for metallic material. Firstly, the material i.e., how the type of material can affect the impact specifications and what kind of materials can be used as replacement in order to lower part weights. Steel and aluminum structures with a specified thickness that did not fail during the test depicted clearly that they are not suitable as bumper beam structure due to increasing weight. They increased the weight of the structure by nearly 500% and 100% respectively, in comparison with the composite bumper.

2.0 Literature Review

Prabhakaran *et al*. (2012) in their study titled Design and Fabrication of Composite Bumper for Light Passenger Vehicle The fuel efficiency and emission gas regulation of passenger cars are two important issues in these days. The best way to increase the fuel efficiency without sacrificing safety is to employ fiber reinforced composite materials in the cars. Bumper is the one of the part having more weight. In this paper the existing steel bumper is replaced with composite bumper. In this work the design and fabrication of composite bumper made up of glass fiber reinforced polymer is carried out by which weight of the bumper can be reduced. Fabrication of composite bumper is carried out by hand layup process by using E- Glass/ Epoxy bidirectional laminates. Composite bumper is analyzed and Charpy impact tests are carried out. Compared to steel bumper, the composite bumper is found to have 64% higher factor of safety and 80% less in cost. From the fabrication it was found that the weight reduction of 53.8% is achieved using composite material without sacrificing the strength. The incorporation of several different types of fibres into a single matrix has led to the development of hybrid bio-composites. A hybrid composite is a weighed sum of the individual components in which there is a more favorable balance between the inherent advantages and disadvantages. Also, using a hybrid composite that contains two or more types of fibre, the advantages of one type of fibre could complement with what are lacking in the other. As a consequence, a balance in cost and performance can be achieved through proper material design. 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 strength of the hybrid composite is also dependent on the failure strain of individual fibres. Maximum hybrid results are obtained when the fibres are highly strain compatible, Thomas (2002). Observed, that more than one fibre could be developed into a hybrid in a polymer composite and it gives a better product with the advantages of each of the constituents fibres in the matrix (resin), therefore, that product could be ised for a better performing part in a design. Attempt has been made by researchers on natural fibre composites.Yan Li, et.al. (2000) , worked on sisal fibre, hybridizing it with glass fibre,. He reported that Sisal and glass fibres could be added to produce hybrid composites which are better off in properties. Saranya, (2018) studied the characterization and synthesis of nano sisal fiber reinforced composite. In their study, carried out an analysis on the tensile strength of sisal nano-fibre incorporated in a polymer composites with glass fibre reinforced polymer composites and found that the tensile strength of sisal nano fibre reinforced polymer composites have high strength compared to glass fiber reinforced polymer composites. Ravi (2013) worked on the properties of Banana/Sisal Fibre incorporated in poly lactic acid (PLA) hybridized to produced structural parts. Venkata (2008) worked on the kapok/sisal hybrid composites in bid to find the compressive strength, He reported that the addition of small amount of sisal fiber to kapok reinforced polyester matrix improved the compressive strength of the hybrid composites. Likewise, Oreko et al (2018) evaluated the compressive and impact strength of plantain fibre reinforced polyester composite and developed same for automobile fender. Ramesh (2014) evaluated Sisal/Jute/ Glass Fiber reinforced hybrid composites. he found out that the inclusion of sisal and jute fibers with glass fiber reinforced polymer (GFRP) composites gained good impact properties. This research work investigated the design and analysis of a rear bumper of an automobile with a hybrid polymer composite of opebf/banana fibres

2.0 Materials and Method

The materials used are: resin- unsaturated polyester resin (matrix), methyl ethyl ketone peroxide (catalyst), cobalt naphthalene (accelerator). Oil Palm Empty Bunch Fibre OPEBF to Banana fibre . The hand lay-up technique was used. Fibre percentage combination of OPEBF to Banana fibre at 10:90, 20:80, 30:70, 40:60, 50:50. 60:40, 70:30. 20:80, 90:10, 95:5.

Table 1: Samples Designation, Percentage Combination and Plies

S/N	SAMPLE DESIGNATION			PERCENTAGE COMBINATION		NUMBER
	COMPRESSION	FLEXURAL	IMPACT	OPEBF	BANANA	PLIES
1	PC01	PF01	PI01	10	90	4
2	PC2	PF2	PI2	20	80	4
3	PC3	PF3	PI3	30	70	4
4	PC4	PF4	PI4	40	60	4
5	PC5	PF5	PI5	50	50	4
6	PC6	PF6	PI6	60	40	4
7	PC7	PF7	PI7	70	30	4
8	PC8	PF8	PI8	80	20	4
9	PC9	PF9	PI9	90	10	4
10	PC10	PF10	PI10	95	5	4

Figure 1: Samples of the laminates

2.1 Experimental Setup

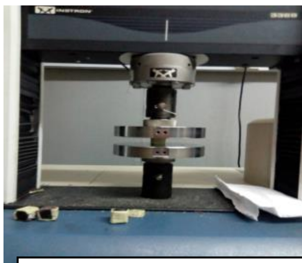

Figure 2. Compressive test on the Universal Testing Machine

Figure 3. Flexural test on the Universal Testing Machine

3.0 Results and Discussions

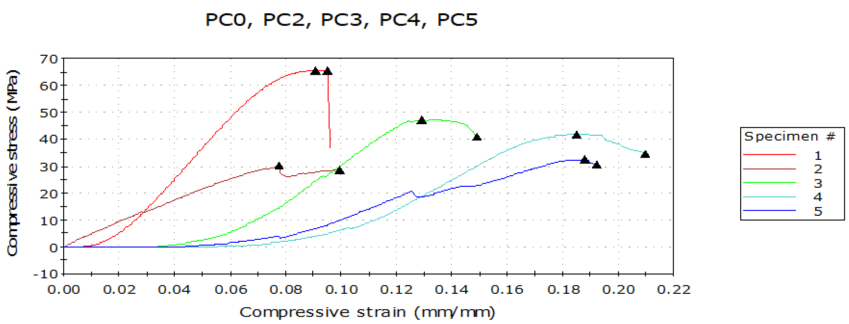

Figure 4. Compressive strength graph for samples PCO to PC5

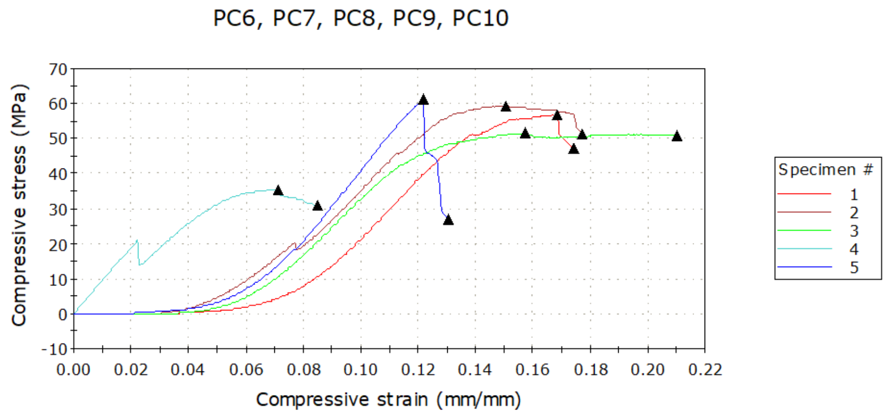

Figure 5. Compressive strength graph for samples PC6 to PC10

The compression test was conducted on all the composite samples according to ASTM C790 in the Instron Universal testing machine. The dimension of each specimen was a cube 20mm X 20mm X 20mm.The compressive property of the unreinforced specimen sample designated PC0 was 65MPa achieved at the anvil height of 18.25mm, compressive strain 0f 0.1mm/mm, at the energy of 33.7J and at a compressive force of 23735N.

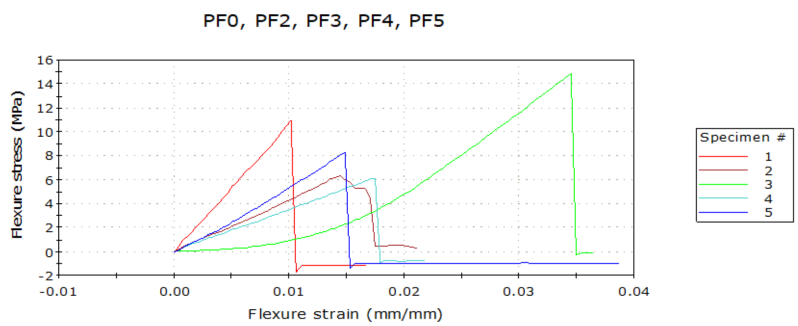

Figure 6. Flexural strength graph for samples PF0 to PF5

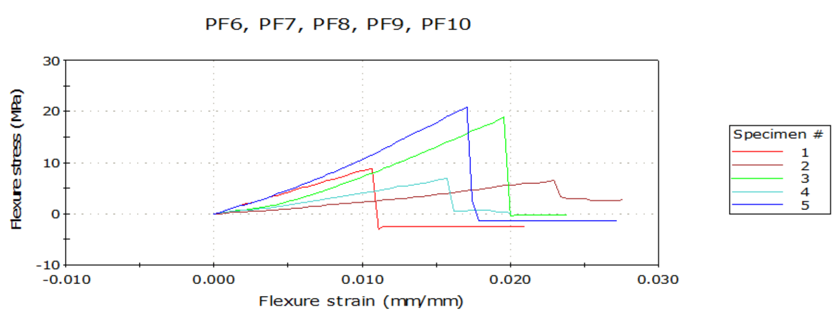

Figure 7. Flexural strength graph for samples PF6 to PF10

The flexural strength of a composite is the maximum tensile stress that it can withstand during bending to reach the breaking point. It is also known as the modulus of rupture. The three-point flexural test was conducted on all the composite samples according to ASTM D790 in the Intron Universal testing machine. The dimension of each specimen was 120mm X 20mm X 5mm. Span length of 100 was maintained. It could be seen that the unreinforced specimen sample designated PF10 demonstrated the highest flexural strength of 20MPa.

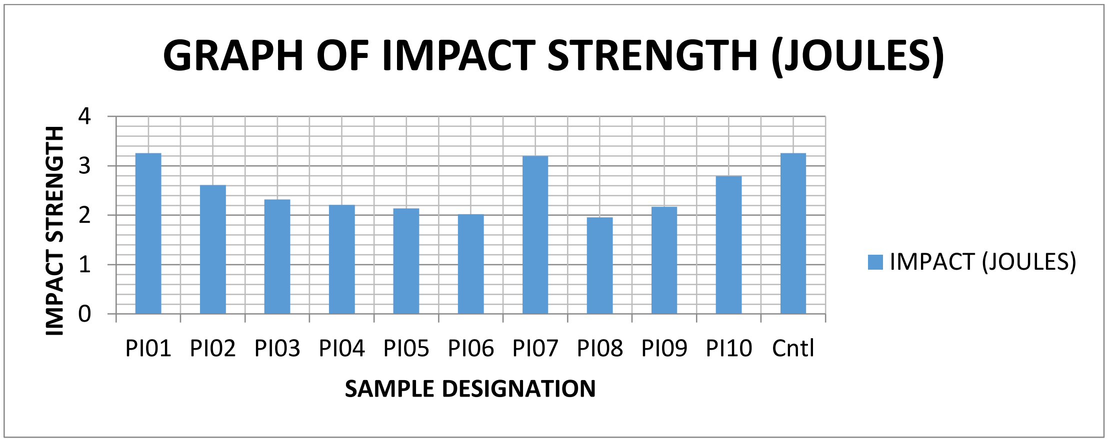

Figure 8. Impact strength graph for samples PI01 to PI10

The impact test was conducted in accordance with ASTM D256 using Izod Charpy Impact testing machine Model: MAT23/1350, S/N:016327. The machine is graduated 1 division= 0.5Joule. The machine has maximum capacity of 50J. The tests were conducted on composite specimen sample of standard un-notched rectangular bar measuring 70mm x 5mm x5mm. prior to samples test, the machine was calibrated. The test samples were grip vertically and the force required to break the rectangular bar was released from the freely swinging pendulum. The value of the angle through which the pendulum swung before the test sample was broken correspond to the value of the energy absorbed in breaking the sample and this was read from the calibrated scale on the machine. The Impact property of the reinforced specimen sample produced with polyester designated P01 was 3.25Joule.

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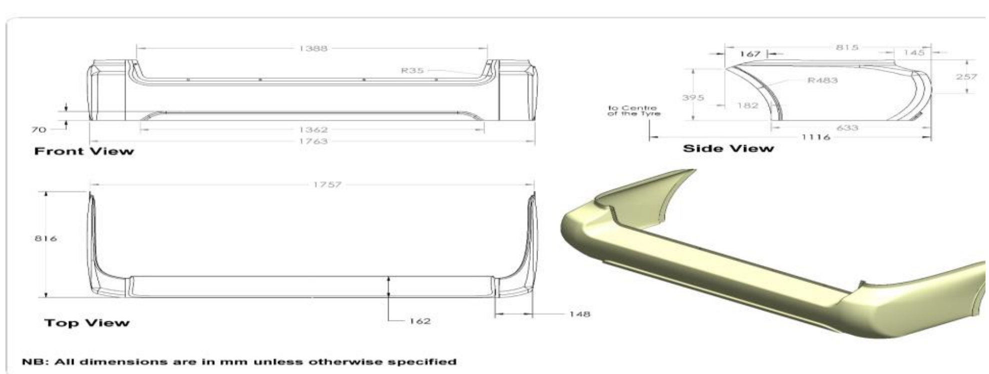

Figure 9. Bumper Design drawings

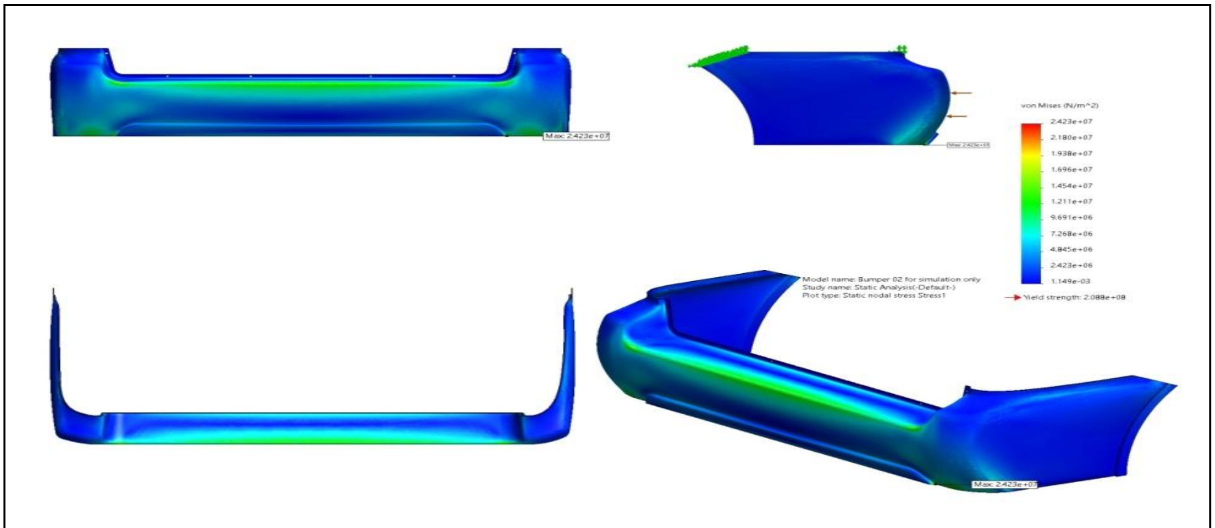

Figure 10. Bumper Simulation

On the simulation, fixtures bounding condition was applied to the top of the bumper and to the cylindrical surfaces of the flanged part of the bumper which indirectly represent the part of the bumper that will be fastened to the vehicle, this constraint the model at those point in the x,y & z axis. And applied load of 50kg (500N) was applied statically at the rear as indicated by the arrow.

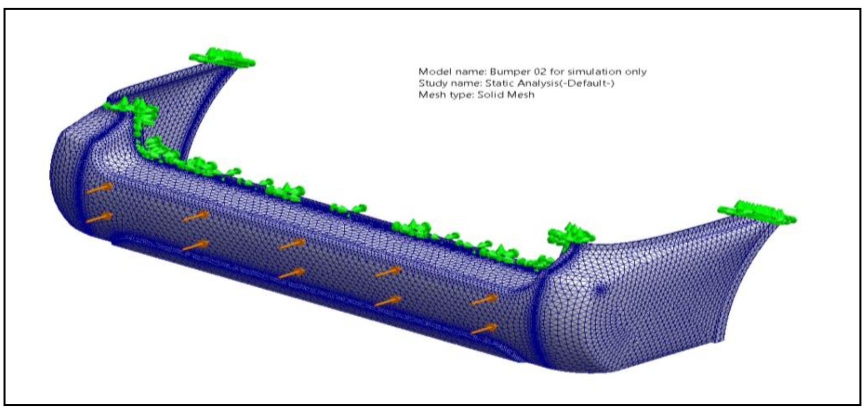

Figure 11. Bumper analysis under fixture and wire mesh

Table 2. Mechanical Properties of Material Selected for the Bumper

Material	S-Glass Fibre	
Properties	Valve	unit
Elastic Modulus	85000	Mpa
Poisson's Ratio	0.23	N/a
Shear Modulus	36000	Mpa
Mass Density	2600	Mpa
Tensile Strength	2050	Mpa
Compressive Strength	5000	Mpa
Yield Strength	208.84	Mpa

Conclusion

This research investigated the design and analysis of a rear bumper of an automobile with hybrid polymer composite of OPEBF/Banana fibre. OPEBF/Banana fibre hybrid polymers composite is of low cost, light weight, as well as possess satisfactory mechanical properties. In this research work, hybrid composites have been developed using hand layup technique based on percentage combination of OPEBF/Banana fibre at 10:90, 20:80, 30:70, 40:60, 50:50. 60:40, 70:30. 20:80, 90:10, 95:5. The mechanical properties in the context of compressive strength of 65MPa, flexural strength of 20MPa and impact strength strength of 3.25Joule was observed and the simulation analysis on the induction of 500N load at factor of safety of 3 were observed to have display a good strength suitable for automobile bumper with the advantages of weight reduction.

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