International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 3 Issue 10, October – 2019, Pages: 56-62

Low-velocity Impact on Mechanical Behaviors of Laminate Composites with Different type of Glass Fabric in Automobile's Bumper Application

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Abstract**:** *Composite Material is used widely in the automotive industry, Due to its light weight and its good mechanical properties and it reduces the risk level in an event of a collision. The aims of this article are to manufacture composite laminate with different structure (woven glass fabric, non-woven glass fabric) /Epoxy with same thickness for Car's Bumper Application. A dynamic test obtained to determine the amount of absorbed energy by Impact drop weight tests. External and internal damage were evaluated. The results shown that the woven glass fabric composite achieve better properties than the non-woven glass fabric composite for this application.*

Keywords: Car Bumper, Glass Fabric Composite, Impact Test, Absorbed Energy.

1. INTRODUCTION

A composite material is a material made from two or more different materials that, when combined, are stronger than those individual materials by themselves. The bumper is a safety system is used to observe the low speed collision. It is placed in car body [1] .The car bumper is designed to prevent or reduce physical damage to the front and rear ends of passenger motor vehicles in low-speed collisions [2]. Invented by Briton Frederick Simms in 1901 [3], Bumpers were at first just rigid metal bars [4] Firstly by steel, steel bumper systems fall into two categories: beams and face bar [5], and have many advantages such as their relatively high load carrying capacity and high ductility. However, this gives a low strength-to-weight ratio. Car manufacturers have stated that using steel adds to the aesthetic as well as minimizes life cycle costs [6], but Steel Bumpers more expensive and have a heavily weight, that is means more consumption of energy.

The first sports car featuring an aluminum body was unveiled at the Berlin International Motor Show in 1899. Two years later, the first engine with aluminum parts was developed by Carl Benz Following World War II, aluminum had become inexpensive enough to be considered for use in mass- produced vehicles, Aluminum parts can be damaged by impacts with rocks and boulders, Aluminum also gets metal fatigue faster, and it's harder to correct [7].

In present work, the aluminium bumper used in passenger type cars is being replaced by composite materials made up of glass, carbon fibres, etc. and nano-composite materials such as nylon-6 which is a Nano clay-polyamide. The bumper thickness for

Composite bumper, when calculated through bending moment equation and other dimensions for steel, aluminium and composite bumper is considered to be the similar. Comparing the stress, weight and cost saving is therefore objective.

The majority of modern plastic car bumper system fascia is made of Thermo Plastic Olefins polycarbonates, polyesters, polypropylene, polyurethanes, polyamides or blends of these with, for instance, glass fibers, for strength and structural rigidity [8].

In recent days, various materials like composites are experimented in almost all parts of the automobiles and it has also ventured into bumper. Due to reduction in weight, composite materials are preferred over conventional steel bumper. Composite bumper absorbs more collusion energy than steel bumper [9].

Fibre reinforced plastics combine the strength and stiffness of fibrous materials. Materials produced through this means possess very high resistance to corrosion, low density and easy moulding capability. Majority of reinforced plastics produced recently are either polyester resins or glass reinforced epoxy. Glass fibers make good reinforcing agents, due to the relative ease at which high strength can be obtained in using a few microns in diameter [6].

S. Prabhakaran and others fabricated a composite bumper used Glass fiber reinforced epoxy by hand lay-up method, In Hand lay-up, liquid resin is applied to the mould and then fiber glass is placed on the top. A roller is used to impregnate the fiber with resin. Another resin and reinforcement layer is applied until a suitable thickness builds up. It is very flexible process that allows the user to optimize the part by placing different types of fabric and mat materials. Because the reinforcement is placed manually, it is also

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Called the hand lay-up process . Though this process requires little capital, it is labor intensive. And have done studied the energy absorbed by Glass fiber Reinforced Epoxy which showed that is better than steel bumper [1] .

2. Experimental and Materials Fabrication

2.1 Textile Materials

- **Woven fabric**: Glass fabric of glass fiber E , account (31.58Ne), weight density (547 g/m^3) and tensile strength 1(82 Kg).
- **Non-woven fabric**: chopped strands.
- **Thermoset Resin:** epoxy WSR.618 which it is properties shown in table below**.**

Table (1): Epoxy WSR.618 properties

Appearance	Epoxy value (eq/100g)	Epoxy equivalent (g/eq)	Tincture	Softening point(c)	Inorganic chlorine value (eq/100g)	Organic chlorine value (eq/100g)	Viscosity 40℃ (MPas)	Volatile (%)
No obvious mechanical impurities	0.48-0.54	185-196	≤ 2	-	≤ 1*10^-3	≤ 2*10^-2	≤ 2.5	≤ 2

2.2 Fabrication process

Two samples were made, One of them Non-woven fabric/epoxy, and the other plain woven glass fabric/epoxy by opening melding method. In open molding, raw materials (resins and fiber reinforcements) are exposed to air as they cure or harden. Open molding utilizes different processes, including hand lay-up, spray-up, casting, and filament winding.

Hand lay-up is the most common and least expensive open-molding method because it requires the least amount of equipment. Fiber reinforcements are placed by hand in a mold and resin is applied with a brush or roller. This process is used to make both large and small items, this process under room temperature until the matrix is set properly as shown in figure below.

Figure 1: hand lay-up method

After the sample was manufactured, it was encapsulated and connected to the vacuum-bag system to extract air from the sample and mask pores

When vacuum is applied through a valve . On application of the vacuum, the bag conforms to the tooling and places the Prepreg stack under 1 atom pressure, where consolidation and curing can take place in an oven [10].

Figure 2: vacuum bagging method

2.3 Experimental

Preparation of Composite Specimen .

Table 2: Dimensions of test specimen

Unit	**Length(mm)**	**Width(mm)**	**Thickness(mm)**
Impact Test	150	100	3.1

Figure 3: Specimens preparation for impact drop weight

2.3.1 Impact Drop Weight Test

This test method covers the damage resistance of multidirectional polymer matrix composite laminated plates subjected to a drop-weight impact event. The composite material forms are limited to continuous-fiber reinforced polymer-matrix composites, with the range of acceptable test laminates.

And thicknesses . A flat, rectangular composite plate is subjected to an out-of-plane concentrated impact using a drop-weight device with a hemispherical impactor. The potential energy of the drop-weight, as defined by the mass and drop height of the impactor, is specified prior to test. Equipment and procedures are provided for optional measurement of contact force and velocity

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during the impact event. The damage resistance is quantified in terms of the resulting size and type of damage in the specimen. The test method may be used to screen materials for damage resistance, or to inflict damage into a specimen for subsequent damage tolerance testing. When the impacted plate is tested in accordance with Test Method **D 7137/D 7137M** the overall test sequence is commonly referred to as the Compression after Impact (**CAI**) method. The damage resistance properties generated by this test method are highly dependent upon several factors, which include specimen geometry layup, impactor geometry, impactor mass, impact force, impact energy, and boundary conditions Thus results are generally not scalable to other configurations, and are particular to the combination of geometric and physical conditions tested [11].The Specimen dimension is 150*100*3.1 mm.

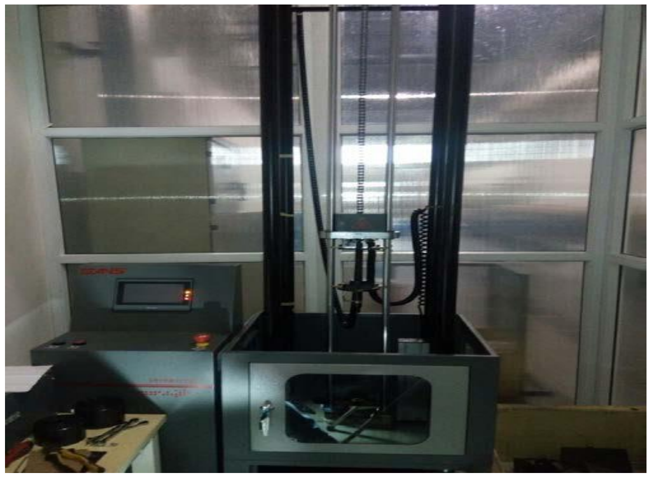

Figure 4: impact testing machine

3. Results and Discussion

3.1 Load Displacement Behavior

The load-displacement plots at different energy levels have been obtained by using the drop weight testing method in order to analyze the impact damage and failure model of the laminate composite with woven and non-woven glass fabric. The failure modes involved in impact damage under varied impact energies of glass composite laminate.

Figure 5 illustrate the load-displacement plots for non-woven glass fabric composite laminate at 10, 20 and 30 J. The impact energy levels are around 4.7 KN. The displacement was found to be increased with an increase in the impact energy levels.

Figure 6 illustrate the load-displacement plots for woven glass fabric composite laminate at 10, 20 and 30 J. The impact energy levels are around 6.9 KN. The displacement was found to be increased with an increase in the impact energy levels.

3.2 Failure Modes

The absorbance energy of the impact test as show in Table 3 which indicates the peak load, displacement at peak load and the absorbed energy for laminate glass fiber composite samples with woven and non-woven at 10, 20 and 30 J, the energy absorption increased with an increase in the impact energy Levels for all the samples. Comparing the failure modes of woven and non-woven glass fabric it can be observed that all samples, At low and medium energy levels, all energy was absorbed by the samples, which mean that the sample does not fail completely, but the woven glass composite show the maximum energy absorbance than the non-woven glass composite due to the orientation fibers, because the interlacing between the warp and weft filament which distributes the absorbed energy in different directions of warp and weft filament.

Figure 7 shows the view of top surface and cross-sectional area of laminate composite with woven glass fabric, the top face laminate suffered damage in the form of matrix crack. The energy was absorbed completely by specimen.

Figure 8 shows the view the cross –sectional area on the top surface of laminate composite with non-woven glass fabric. The damage of this specimen viewed larger than that one of woven fabric specimen due to the randomly orientation of fibers which the absorbed energy didn't distributed in specific directions but based on random fibers trends.

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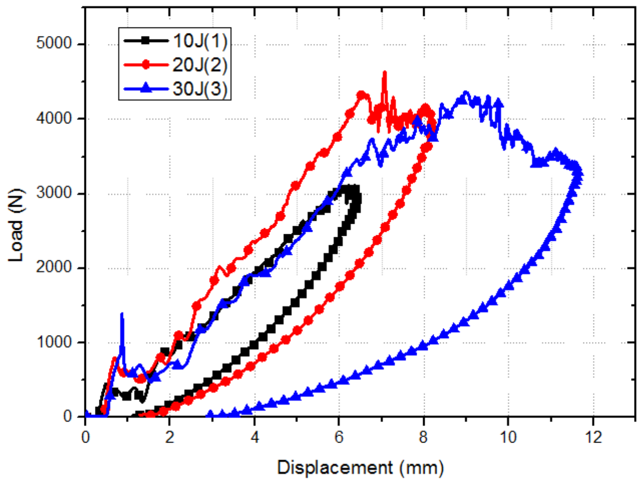

Figure 5: load-displacement curve of non-woven glass composite at 10, 20, and 30J.

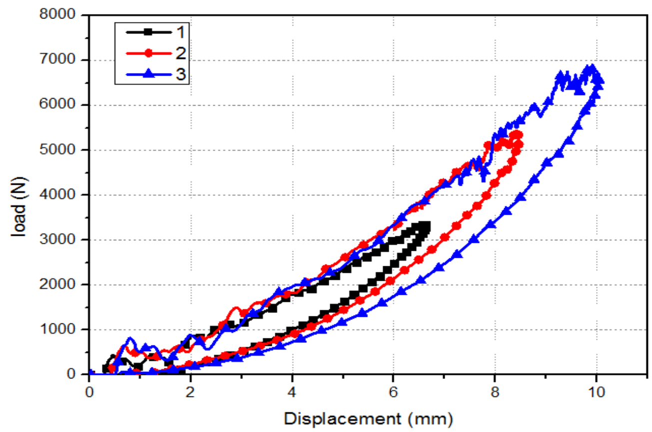

Figure 6: load-displacement curves of woven glass composite at 10, 20 and 30J

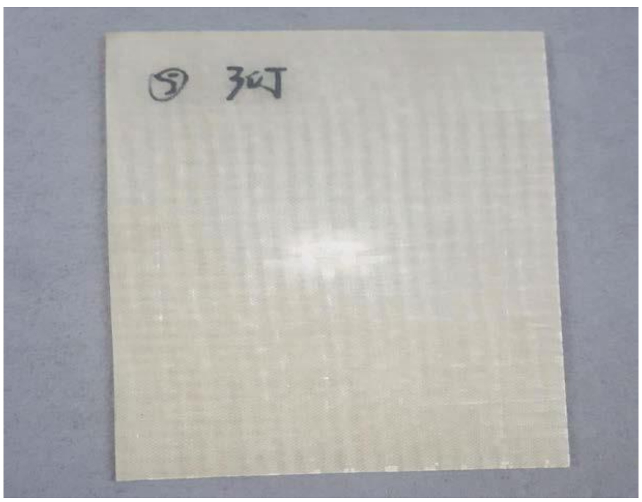

Figure 7: woven composite specimen after the test at 30J

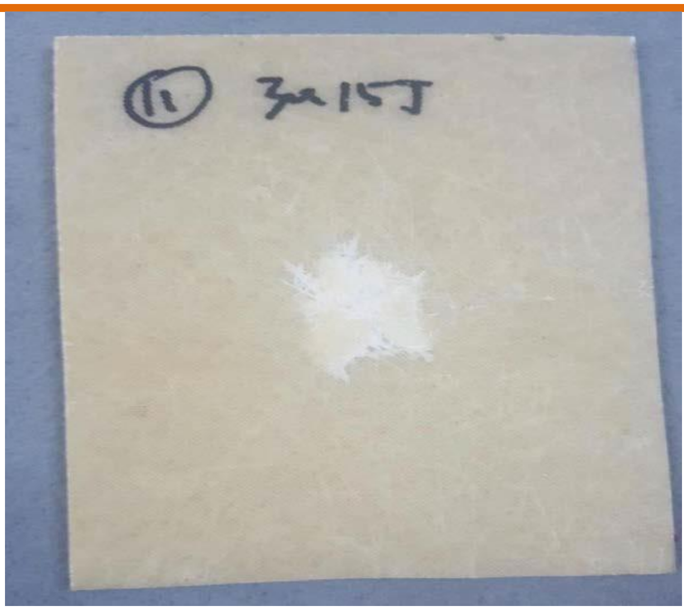

Figure 8: non-woven composite specimen after the test at 30J

Table 3: Results of Impact Test

Sample	Test No	Impact energy (J)	Peak load (KN)	Displacement at peak load (mm)	Absorbed energy (J)
Woven	1	10	3.5	6.95	10
	2	20	5.3	8.9	20
	3	30	6.9	11.2	30
Non-woven	1	10	3.2	6.5	10
	2	20	4.7	8.5	20
	3	30	4.7	11.7	30

4. Conclusion

Produced composite samples using glass fabric (woven and non- woven)/epoxy resin and tested it dynamic test (impact test). Is it suitable to manufacture bumper with better specifications than the previous ones (plastic bumper and steel bumper…etc.). And In the selection of materials, found that the composite materials good characteristics of high tensile and impact resistance, durability, light weight, flexibility, corrosion resistance, and dimensional stability in all surrounding circumstances. Dynamic Impact drop weight test, both of samples absorbed the all energy was exposed, but the woven failure mode at peak load around 6.9KN and non-woven at peak load around 4.7KN due to interlacing the warp and weft filament.

References

[1] P. S, C. K and S. K. M, "Design and Fabrication of Composite Bumper for Light Passenger Vehicle," *International journal of modern Engineering Research (IJMER,* vol. 12, pp. 2552-2556, 2012.

[2] I. G. Helps, *plastics in european cars*.iSmithers Rapra Publishing, 2001, pp. 2000-2008.

[3] D. Hodges, *the guinness book of car facts and feats*. 2008.

[4] "The 1910 Harroun Bumper," *Cycle and Automobile Trade Journal,* vol. 16, p. 142, 2016.

[5] Sindrey and David A, *steel bumper systems for passenger vehicles and light trucks.* fth ed., Vols. 1999-01-1007, SAE Technical Paper, 1999.

[6] D. Ezekwem, "Composite Materials Literature review for Car Bumper," 2016.

[7] "-http://www.ihs.com/".

[8] "https://plastics-car.com/Todays-Automobiles/Auto-Body-Exterior/Bumpers-Fascia-Systems.html".

[9] S. A. Alen John, "A Review on the Composite Materials used for Automotive Bumper in Passenger Vehicles," *International Journal of Engineering and Management Research,* vol. 4, no. 4, 2014.

[10] W. S. Hearle, *high performance fibers*. 2001.

[11] "ASTM D 7137/D 7137M".