FABRICATION OF ALUMINIUM REINFORCED SUGARCANE BAGASSE COMPOSITES AND EVALUATION OF ITS MECHANICAL PROPERTIES

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Abstract - *The mechanical properties of Fibre Metal Laminate (FML) composite that is used in aircraft structure. In this paper the Aluminum sheet in GLARE material is replaced with Aluminum wire mesh to reduce the de lamination effect. The intensive experimental analyses of these materials are focused on the assessment of their mechanical properties. Practical test specimens were prepared by Hand layup technique. Then it is going test the mechanical properties in the form of tensile, compression, impact and hardness.*

Key Words: Aluminum wire mesh, sugarcane biogasse, Epoxy Composites

1. INTRODUCTION

Fiber Metal Laminates (FMLs) are hybrid composite consisting of alternative thin layer of meal plies and fibre reinforced epoxy. The fiber/metal composite technology combines the advantages of metallic materials and fibre reinforced matrix systems. The most widely used metal in fiber metal laminates is aluminium. Aluminium foils and meshes have extremely light in weight, have low density, high strength, excellent corrosion resistance and also cheap. Fiber metal laminates take advantages of metal and fiber-reinforced composites, providing superior mechanical properties to the conventional one. A relatively newer range of composites even employ natural fibers as reinforcements. The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative as man-made fibers used for the manufacturing of composites.

From the previous investigation studies it is revealed that Glass Fiber Reinforced Plastics and Fiber Metal Laminates are the best alternatives in terms of lower cost and superior mechanical properties. According to1, GLARE (Glass Laminate Aluminium Reinforced Epoxy composites) are the most successful and popularly used type of fiber metal laminates. Wang2 experimented natural coconut fibres composites to find the tensile strength, fineness, weight distribution. Comparing to coconut coir fiber, the human hair reinforced glass fibre has comparatively higher ultimate stress. Moreover, other properties are also found enhanced comparing to coconut coir reinforced glass fibre. Ion Dinca, Adriana Stefan and Ana Stan3 mention about the higher behavior of carbon fibre aluminum laminates compared to aluminum-fibre glass laminates. According to4, natural fibers are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. In5 carried out experiments using tensile and flexural (three-point bending) tests of natural fibers reinforced with composite materials (Musaceae/epoxy). The fracture toughness and fracture mode of Banana Fiber and GFARP were individually studied by6. Samples of several Jute-Bagasse-Epoxy & Jute-Lantana camera-Epoxy hybrids were manufactured and their properties studied by7. In8 studied the properties of bio-composites reinforced with natural fibers. In9 highlighted the influence of eco-friendly coconut coir and human hair inclusion on the mechanical properties of hybrid glass fiber reinforced composites.

In10 have experimented and have found that fatigue behavior in composites presented a decrease in fatigue life when greater tension was applied. In11 studied the mechanical behavior of Polypropylene and Human Hair Fibres and Polypropylene Reinforced polymeric composites and found that composite with 3 to 5 wt% of bio fibre shows higher flexural strength, flexural modulus and Izod impact strength than non-reinforced polymer. They also find that the tensile and flexural properties decrease when the fibre loading percentage increases. It has been noticed by12 that by adding of a small wt. percentage of Banana Fiber in GFREC enhances its properties to a great extent. The Hybridization of Banana Fiber and Glass Fiber not only improves the mechanical properties of FRP composite but also reduces its cost and makes it an eco-friendly composite. To put further emphasis on the influence of banana fibers as reinforcements, In13 have stated in their research work that polymer banana reinforced natural composites are the best natural composites among the various combinations of other natural fibers in polymer matrix composites. In14 have experiment and found that the hardness is decreasing with the increase in fibre length up to 20 mm. In15 studied the impact behaviour of FML with aluminium as reinforcement. Usage of natural fibers as reinforcements also improve the mechanical properties of glass fiber reinforced composites. In16 there was slight increase in the thickness of the reinforcement materials. There was non-uniform

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distribution of reinforcement in material, Microstructure revealed fibre cracks which were oriented in line to the crack growth on the skin material. No other defects were observed. In17 Speed, feed rate and tool angle have significant influence on the entrance and exit damages but tool diameter does not have any influence. Similarly, the squares of all input factors have a dominant influence on the damages. Optimization has been done by setting the objective as minimizing the output responses.

However, no research has been done so far on the inclusion of both aluminium and banana fibers as reinforcements into GFARP hybrid composites. The present paper thus reports the influence of aluminium and banana fibers as reinforcements in hybrid glass fiber reinforced plastic composites. Aluminium is employed as reinforcement in GFARP both as foils and wire meshes, along with banana fiber-strands. The two types of composites: GFARP and SBARP (Aluminium- sugarcane bagasse composite) are fabricated through hand-layup process and are subjected to a variety of mechanical tests in order to determine their mechanical properties and compare them.

2. SPECIMEN PREPARATION

The specimens are prepared by a method called compression moulding as seen in Figures 1, SBARP (aluminium wire mesh as reinforcements). All the specimens have a thickness of 4 mm. The sugarcane bagasse and aluminium wire mesh in the form of strands. Wire mesh has a thickness of 0.5 mm.

The SBARP hybrid composite has a total of 2 layers, comprising of aluminium wire mesh and sugarcane bagasse in particulate fiber layers. The aluminium foils/ wire mesh and banana fibers are used alternatively. The pure GFARP specimen, on the other hand, has 7 layers of just glass woven roving. The binding agent was used as a combination of epoxy resin-type LY556 and hardener-type HY951 in the ratio 10:1. While preparing SBARP with aluminium wire mesh, circular notches are punched in the foil to enhance bonding between the immediately adjacent layers as seen in Figure 3. After fabrication, the specimens are cut according to ASTM standards for further mechanical testing as follows.

Fig 1. Initial materials

Fig 2. Compression machine process

Fig -3 Final fabricated SBARP (with aluminium wire - mesh).

3. Mechanical Testing

After the specimens are cut in accordance to ASTM standards, (Table 1) they are subjected to mechanical tests.

Table -1: ASTM standards for specimen cutting

SL NO	TEST	SPECIMEN DIMENSION (l x b) in mm
1	Tensile	175 x 25 (ASTM D3039)
2	Flexural	125 x 25 (ASTM D790)
3	Impact test	60 x 60 (ASTM D3029)
4	Hardness	55 x 25

3.1 Flexural Test

A total of 6 Specimens are prepared for the test. These specimens have been separated into three different groups, each consisting two specimens (Figure 4). The first two specimens are normal GPRP, the second group is SBARP. The 3-point bending test fixtures were then fitted in the UTM machine. The specimens were then loaded turn by turn, so that a span length of 100 mm was maintained for each specimen. The feed rate was set as 1 mm/sec. For each specimen, the bending test was done while the data was interpolated simultaneously in the 'Horizon' software. 'Force' and 'Position' were the two primary data variables collected as output, using which, Load vs. Deflection curves were plotted. The data was collected, the values of flexural stress and strain were estimated and the graphs were plotted

Figure 4. Flexural testing of the specimen.

3.2 Tensile Test

A total of 4 Specimens are prepared for the test. These specimens have been separated into two different groups, each consisting two specimens as follows (Figure 5). The specimens is SBARP with notched aluminium wire mesh reinforcement,

The tensile test fixtures were then fitted in the UTM machine. The specimens were then loaded turn by turn, such that a span length of 100 mm was maintained for each specimen. The feed rate was set as 2 mm/sec. For each specimen, the tensile test was done while the data was interpolated simultaneously in the 'Horizon' software. 'Force' and 'Position' were the two primary data variables collected as output, using which, Load vs. Deflection curves were plotted (Figure 6)

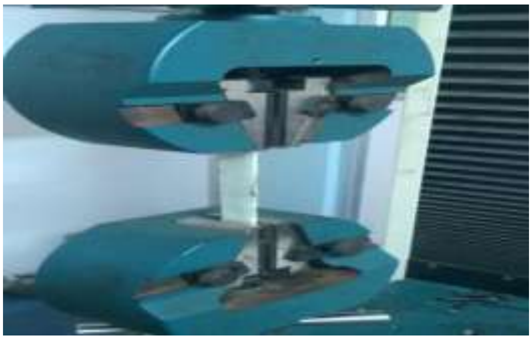

Figure 5. Tensile testing of the specimen.

3.3 Impact Test

A total of 4 Specimens are prepared for the test. These specimens have been separated into three different groups, each consisting two specimens as follows (Figure 7). The first two specimens are normal GPRP, the second group is SBARP (Al Wire Mesh). Factories Plus - Drop Impact Tester was used for this purpose. The specimen size was fixed as 60 x 60 mm, and the drop speed was set as 3 m/s for all the specimen. Peak force', 'Impact Energy', 'Total Deformation' were some of the variables collected as output, using which graphs were plotted (Figure 8).

Figure 6. Impact testing of the specimen

3.4 Hardness Test

The hardness of both the specimens – GFARP and the hybrid were estimated using Brinell hardness tester (Figure 9) with a ball-indenter diameter of 10 mm. A load of 2000 kg was applied to the specimen to be tested. Each specimen was indented twice, the diameters measured, hardness values (BHN number) estimated for each, and a mean value arrived at.

Thus, a total of four mechanical tests were performed according to ASTM standards and the respective mechanical properties determined.

Figure 7. Hardness testing of the specimen

3.5Results and Discussion

The mechanical properties were determined from the values of the various variables obtained as a result of the tests that were conducted. The data was interpolated to plot graphs and perform comparative studies

Flexural Test

The 'Load ' vs. 'Displacement' graph was plotted from the 'Force' and 'Position' values obtained as outputs of the flexural test (Figure 8).

The three types of graphs were plotted together as follows: The values obtained were tabulated to do a comparative flexural study (Table 2).

Table 2. flexural test result

SL NO	SAMPLE ID	ULTIMATE LOAD (KN)
1	SBARP	803.11

It has been observed from the graphs of the GABGRP hybrid that there is a resistance to load even after the breakage of the first layer of glass fibred. The reinforcements, especially aluminium, being ductile in nature, thus resist the fracture to some extent. Also the usage of wire mesh as reinforcement exponentially increases the capacity of the hybrid composite to withstand a larger load. It was also observed that the replacement of Al foils by Al wire mesh negated the de-lamination effect observed otherwise. It was observed that de-lamination in the case of GABGRP with Al foil reinforcement occurs due to improper bonding between the smooth surface of the foil and its adjacent glass fiber layer Figure 10.

Figure 9. SBARP (Al mesh) hybrid after flexural test (no de-lamination observed)

Tensile Test

The 'Load ' vs. 'Displacement' graph was plotted from the 'Force' and 'Position' values obtained as outputs of the flexural test (figure 8). The three types of graphs were plotted together and a comparative tensile study is done (Table 3).

It is inferred that due to the presence of notches in the aluminium foil, the load-withstanding capacity of the foil reinforced SBARP hybrid increases (Figure 10). This is due to greater bonding between the adjacent layers of the notched foil. And by replacing the foils with wire meshes, the load-withstanding capacity of the hybrid increases drastically. Here too, it is observed that the wire mesh inclusion in the SBARP hybrid composite prevents de-lamination of the specimen unlike the case of GAGRP-Al foil hybrid, where a considerable amount of de-lamination is observed.

Table 3. tensile test result

SL NO	SAMPLE ID	ULTIMATE LOAD (KN)
1	SBARP	18234

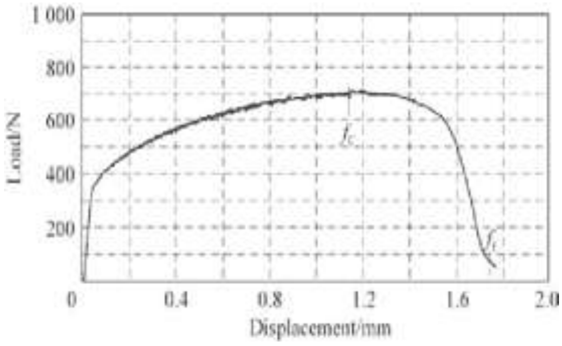

Figure 10. Load vs. displacement graphs for tensile test.

Impact Test

The impact energies (in Joules) of the hybrids and the standard GFARP were plotted It is inferred that presence of Al wire mesh and banana fibers in the hybrid composite increases its impact energy and hence its toughness Table 4.

Table 4. impact energy chart

SL NO	SAMPLE ID	IMPACT ENERGY (J)
1	SBARP	5.73

Hardness Test

Using the values of the diameter of indentation in each specimen after hardness testing, the respective RH numbers were found out Thus, it is inferred that the inclusion of Aluminium and SUGARCANE BAGASSE makes the composite less hard. Being less hard, the hybrid composites are less brittle and more ductile (Table 5).

Table 5. Hardness test result

SL NO	AVERAGE DIA (in mm)	BHN DIA (in mm)
1	7.2	34.26

4. CONCLUSION

From the investigation conducted on sugarcane bagasse-Aluminium Wire Mesh Composites, it has been observed that: The SBARP (with Al wire mesh) composite has the highest flexural strength. Also, with the other two composite types. It has higher toughness value than the standard GFARP. SBARP (with Al wire mesh) also exhibits a lower hardness value, which shows that it is less brittle. Thus, it is inferred that the inclusion of Sugarcane bagasse fibers and aluminium wire mesh as reinforcements in composites influences its mechanical properties, contributing towards a higher flexibility, ductility, impact and tensile properties.

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