Comparative Study of Mechanical Properties of Hybrid Composites Prepared Using Glass Fiber, Sugarcane Bagasse and Human hair

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Abstract— The main aim of this research work is to prepare hybrid composites and to compare them on the basis of mechanical properties namely Tensile, flexural, and Impact. For preparation of composites, hand lay-up method is used. Unsaturated polyester (UP) resin is principal binding material (50wt %) while Cobalt naphthenate is used as an accelerator (0.5wt %) and Methyl ethyl ketone peroxide (MEKP) is used as a hardener (1wt %). 400 gsm chopped strand mat of E-glass fiber is primary reinforcement material while sugarcane bagasse and human hair fiber waste are used as additive fiber in glass fiber reinforced plastic (GFRP) for preparing hybrid composite. An exothermic reaction occurs in which energy released is more than the energy supplied, this extra energy in the form of heat is due to formation of new bonds by cross-linking. Post curing, prepared composites are evaluated on various platforms viz. tensile test, flexural test and Impact test.

Key words: Glass fiber, UP resin, human hair, sugarcane bagasse, mechanical properties, Myler film

I. INTRODUCTION

A composite material is a material that consists of two or more constituents which are not soluble in each other. One constituent is known as reinforcement material and the other is known as matrix material [1]. When composite material is made up of two or more reinforcement materials it is known as hybrid composite [2]. On the basis of matrix, composites are classified into three types- Metal Matrix Composite (MMC), Ceramic Matrix Composite (CMC) and Polymer Matrix Composite (PMC). Among these three types of composites PMC is very popular due to its simple manufacturing principle and easy production of complicated shapes. Fiber Reinforced Plastic (FRP) which is a PMC is a thermosetting material. In FRP one phase is known as polymer matrix phase while the other phase is known as reinforcement phase. Epoxy, Vinyl ester and Polyester are commonly used polymer matrix material while carbon fiber, aramid fiber and glass fiber are commonly used reinforcement material.

II. MATERIALS AND METHOD

A. Materials:

Chopped strand mat of E-glass fiber of 400 gsm, unsaturated polyester resin, MEKP, Cobalt naphthenate, Myler film, Human Hair, Sugarcane Baggasse. Glass fiber, Resin, Hardener, Accelerator and Myler film are purchased directly from market and sugarcane bagasse and human hair are collected from local sources.

B. Designation of composites:

Refer table 1

C. Sheet preparation of GFRP:

Layer based hand lay-up method used for sheet preparation of glass fiber reinforced plastic (GFRP). Unsaturated polyester resin mixed with cobalt naphthenate 0.5wt% used as an accelerator which increases the reaction rate of process. After mixing accelerator with the resin, 1wt% MEKP is mixed into it as hardener, which is used for curing purpose. Liquid resin is applied with the help of brush on the fiber mat placed on the Myler film. Myler film plays two important roles; it behaves as a mould as well as provides better surface finish. Resin passes through the mat. After applying resin on one layer the subsequent layers are placed in the same way. Then the sheet is pressed by hand roller so that the matrix binds the fiber completely. Another Myler film is placed on the top so as to get better curing results and surface finish.

III. EXPERIMENTAL SETUP

A. Tensile test:

Universal testing machine (UTM) INSTRON 3382 with tensile test fixture and self aligning grips is used for holding test specimen in machine shown in fig.1. Machine is operated at 50 mm/min constant speed during the test. It is fitted with extensometer and load cell to record the test extension and load accurately. ASTM D638 [5] is a standard test method for the tensile test of plastics. Tensile strength is the most important property of materials, it measures the ability of materials to withstand the force that tends to pull it apart and determines to what extent the material stretches before breaking.

Test condition -
Temperature -18◦ C
Humidity - 50 %
Speed - 50 mm/min

Sr.No.	Composite	Composition
1	C	UP resin (50wt %) + glass fiber (50wt %)
2	C1	UP resin (50wt %) + glass fiber (48wt %) +sugarcane bagasse (2wt %)
3	C2	UP resin (50wt %) + glass fiber (46wt %) + human hair (4wt %)
4	C3	UP resin (50wt %) + glass fiber (44wt %) + human hair (4wt %) + sugarcane bagasse (2wt %)

Table 1: Designation of composites

Fig. 1: UTM with tensile test fixture

B. *Flexural test:*

Universal testing machine (UTM) having flexural test fixture such as specimen support and loading nose is used as shown in fig.2. Machine shall be fitted with a load cell and internal extensometer for recording the load and deflection of specimen at any point accurately. Machine is operated at 2.37 mm/min speed. The surface of specimen support and loading nose should have a surface radius of approximately 3.2 mm. ASTM D790 [6] is the standard test method for reinforced plastic materials.

Test condition-
Temperature -18 ◦ C
Humidity – 50 %
Speed - 2.37 mm/min

C. *Impact (Izod) test:*

Pendulum type of impact meter (shown in fig.3) consisting of long rigid arm with striking head at the end is employed. The shape and design of Izod and Charpy impact heads are different to each other. Necessary mass is attached with pendulum Vices are used for clamping and positioning of Izod and charpy specimen. Vice for Izod impact is like cantilever beam and in case of charpy test is simply supported beam. Impact meter is fitted with a device to indicate impact energy. A notch cutter is fitted with cutting tool for notching the specimen. The Vernier calipers can be employed for measuring the width and thickness of specimen. Notch is cut using notch cutter (shown in fig.4) at the striking face of specimen. The angle of notch is 450 ± 10 with a radius of 0.25 mm. The depth of notch is generally 2.54 mm. The purpose of introducing the notch is to concentrate the stress and increase the straining rate at the root of notch. A notch concentrates the stress in a small region during impact. Smaller the radius of curvature at base greater is the stress concentration. ASTM D256 [7] is the standard test method for impact test of plastic materials

Fig. 2: UTM with flexural test fixture

Impact strength of material determines the toughness of material. Impact resistance is one of the important mechanical properties, which describe the resistance to high speed loading. Higher the impact energy, higher is the toughness of a material and vice versa. The area under stress-strain curve obtained in tensile test is directly proportional to the toughness of material. Impact strength of material is used for research and development purpose and also for inspection and quality control of materials. This test is also used for determination of the notch sensitivity of material.

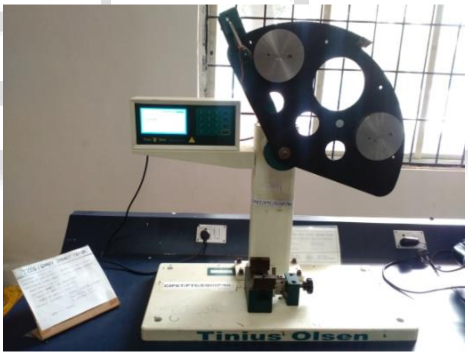

Fig. 3: Impact testing machine

Fig. 4: Notch cutter

IV. RESULT AND DISCUSSION

A. *Tensile Test:*

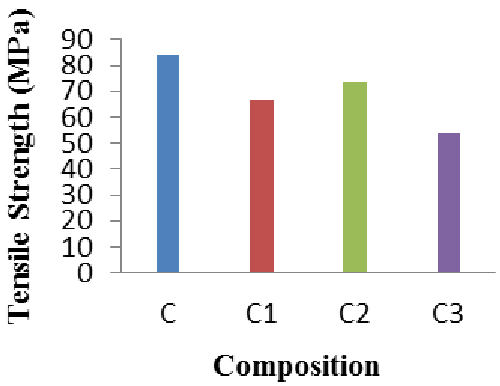

Fig. 5: Comparison of Tensile strength

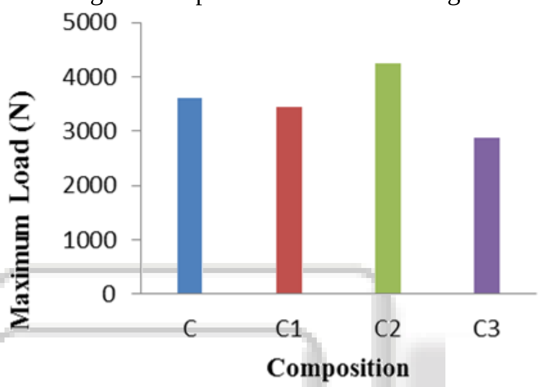

Fig. 6: Comparison of Load at Break (maximum load)

Fig.5 shows the comparison of tensile strength of composites. Y-axis represents tensile strength while composition is represented on X-axis. Tensile strength of all composites is represented by taking mean of tensile strength of all the 5 samples. Fig.6 shows comparison of maximum breaking load of composites, Y-axis represents maximum load while composition is represented on X-axis. Maximum load of all composites is represented by taking mean of maximum load of all the 5 samples.

Results obtained from the tensile test show that the tensile strength of composite decreases when hair fiber is used as an additive fiber and when sugarcane bagasse is used as an additive fiber, the tensile strength turns out to be even lesser. Base composite C shows the highest tensile strength among all the composites. But in case of maximum load at break, composite C2 shows the highest 'maximum load'. It is followed by composite C and C1. Both C and C1 composites show approximately equal maximum load. Composite C3 shows the lowest load at break among all the composites. It signifies that the tensile strength of the material decreases when additive fibers are mixed with GFRP.

B. *Flexural Test:*

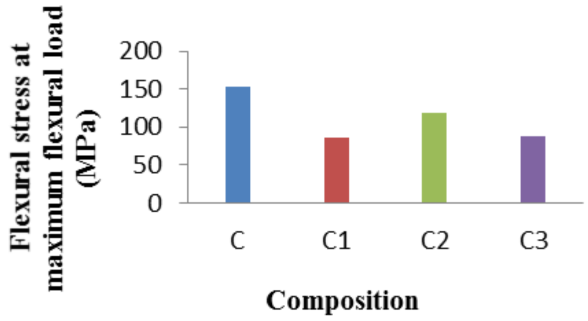

Fig. 7: Comparison of flexural stresses

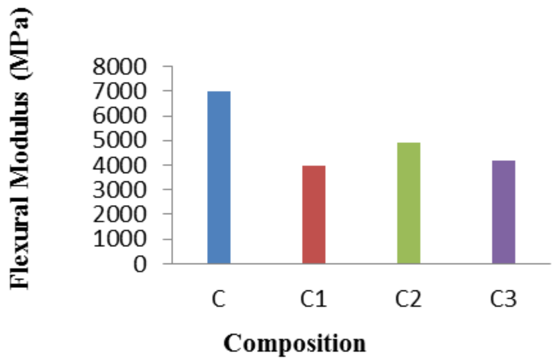

Fig. 8: Comparison of flexural modulus

Fig.7 shows the comparison of flexural stresses of composites at maximum flexural load. Y-axis represents flexural stress while composition is represented on X-axis. Flexural stress of all composites is represented by taking mean of flexural stress of all 5 samples. Fig.8 shows the comparison composites on the basis of flexural modulus. Y-axis represents flexural modulus while composition represented on X-axis. Flexural modulus of all composites is represented by taking mean of flexural modulus of all 5 samples.

Results obtained from three point bending or flexural test show that flexural stress of composites decreases on mixing both hair fiber and sugarcane bagasse. But it decreases more when sugarcane bagasse is mixed with GFRP. Flexural modulus also follows same pattern. It also decreases very much on comparing with base composite C. Composite C shows highest flexural stress as well as flexural modulus and composite C3 shows lowest flexural stress as well as flexural modulus among all composites. It signifies that bending strength of material decreases when additive fibers are mixed with GFRP.

C. *Impact test:*

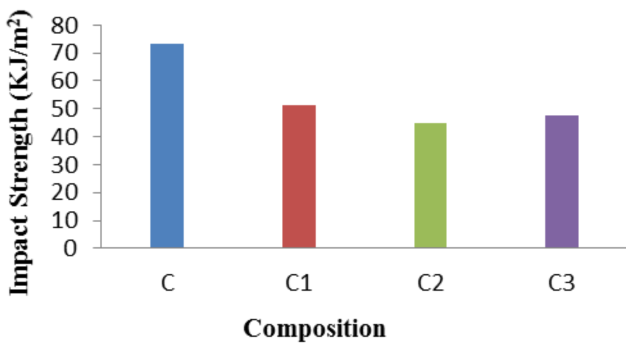

Fig. 9: Comparison of impact strength

Fig.9 shows the comparison composites on the basis of impact strength. Y-axis represents impact strength while composition represented on X-axis. Impact strength of all composites is represented by taking mean of impact strength of all 5 samples.

Results obtained from impact test show that impact strength of composites decreases in comparison to base composite C. Impact strength decreases more when hair fiber is mixed in comparison to sugarcane bagasse. It signifies that the toughness of the material decreases when these fibers are mixed with GFRP. Among all, Composite C shows the highest impact strength and composite C3 shows the lowest.

V. Conclusion

It is concluded that mechanical properties of hybrid composites 'C1', 'C2' and 'C3' do not posses strength as high as base composite 'C'. Results obtained from the tensile test show that the tensile strength of composite decreases when hair fiber is used as an additive fiber and when sugarcane bagasse is used as an additive fiber, the tensile strength turns out to be even lesser. Fig. 6 shows that maximum load (at break) of composite 'C3' is the highest among all the composites; it is due to random orientation of hair fiber. In case of sugarcane bagasse fiber, untreated bagasse fiber is used so that it is not bind well with the resin. Hence composite 'C2' and 'C3' shows less strength than 'C1'. Three point bending or flexural test shows flexural stress of composites decreases on mixing both hair fiber and sugarcane bagasse. But it decreases more when sugarcane bagasse is mixed with GFRP. Flexural modulus also follows same pattern. It also decreases very much on comparing with base composite C. Impact test results show that impact strength of 'C1', 'C2', 'C3' decreases on comparing with composite 'C' it signifies that toughness of the material decreases.

VI. Future Scopes

Though mechanical properties of the composites namely 'C1', 'C2' and 'C3' are less than that of base composite 'C' but the usage of bagasse and hair fibers should be increased because reinforcing material is a waste material. These waste materials create problem to the environment because hair is a non bio-degradable material which is not well managed or utilized. The waste materials can be utilized for many of the beneficial uses in a cost effective manner and by using them their threat to environment can also be curtailed. The promotion of usage of these materials may result in a better and a healthier environment and also a cost effective technique for production of many essential goods.

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