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EVALUATING THE INFLUENCE OF FIBER ORIENTATION AND FILLER CONTENT ON TENSILE, HARDNESS, AND IMPACT STRENGTH OF HYBRID LAMINATED COMPOSITES.

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Abstract:-

The paper describes some aspects concerning the effect of the Hematite ore (Fe_2O_3) filler and fiber orientation on some mechanical characteristics of hybrid composites. Hybrid composite were fabricated with ± 45^o and ±90^o oriented reinforcement as E glass fiber with Hematite ore (Fe_2O_3) filler material and Polyester resin matrix. The filler content was varied as 6wt%,8 wt% and 10 wt%. The laminates were prepared by hand layup technique, cured at ambient temperature, laminates are peeled according to ASTM standards and the experiments were conducted to determine tensile strength, impact strength and hardness. The result showed that Hematite filled composite better than unfilled composite. The ±90^o oriented composite exhibits better result compared to ±45^o oriented composite. The 6wt% hematite filled glass/polyester has shown excellent to the other studied composite both in ± 45^o and ±90^o oriented composite.

Keywords: Composites; Impact Strength; FRPC; Hematite ore.

1. Introduction

Fiber reinforced polymer composites (FRPCs) have generated wide interest in various engineering fields because of the with different physical/chemical properties at the macroscopic or microscopic scale. The basic idea of the composite is to optimize material properties of the composite. Fibers are the principal load-carrying constituents while the surrounding matrix helps to keep them in desired location and orientation and also act as a load transfer medium between them [1]. The effective properties of the fiber reinforced composites strongly depend upon the geometrical arrangement of the fibers within the matrix [2]. This arrangement is characterized by the volume fraction, the fiber aspect ratio, fiber spacing parameters and orientation angles of fibers. Thermoplastic composites reinforced with long fibers, short fibers and mat (fabric) of natural and synthetic fibers like hemp, jute banana, glass, carbon, Kevlar etc are used in a variety of applications such as aerospace elements, automotive parts, marine structures, structural members and anti vibration applications due to their combined properties of resilience, creep resistance, high strength to weight and stiffness to weight ratios, corrosion resistance and good damping properties.

The fiber reinforcement provides non-isotropic in–plane strength but produces weak interlaminar resin-rich regions, where under loading extensive damage is generated, especially between plies of different orientation.

Fiber –reinforced composites show strong anisotropic mechanical behavior due to their fiber orientations. These orientations cause a variety of failure mechanisms, which are more complex under multi-axial loading conditions. Therefore, continuous effort has been made to make quasi-isotropic composite materials with controlling parameters, such as the orientation adjacent plies, stacking sequence and the properties of the constituents [3]. K.M.Kaleemulla et.al [4] focused the study on influence of fiber orientation and fiber content of epoxy resin components on mechanical properties. The main aim of the present investigation was to study the influence of fiber orientation on mechanical properties and also the influence on varying weight percentage of filler material in the composites.

2. Material details

E-glass fabric (300 GSM) of plain weave construction, procured from High tech suppliers of polymers, Bangalore, was used for the study Orthophthalic polyester resin matrix with methyl ethyl ketone peroxide catalyst and cobalt octet accelerator were used. The filler were Hematite is one of the most common minerals. The sandstone is most red and brown in color because of hematite presence. Non-crystalline forms of Hematite may be transformations of the mineral Limonite that lost water, possibly due to heat chemical formula Fe_2O_3. The filler used was hematite passed through 75-150 μm. In this work there are two types of composite is being prepared.

3. Specimen preparation and test details

A hand lay-up method is used to prepare the glass-GP composites with filler. To prepare glass GP with hematite filler composites, filler is mixed with a known amount of GP resin. The laminate was cured at ambient conditions for a period of about 24 hours. The laminate so prepared has a 300mm X 300mm X 3mm.

The composites are fabricated and cured as reported by Suresha et al [11] and basavarajappa et al. [12]. The cured materials are cut to yield test specimens in accordance of ASTM standards. Tensile test has been carried out according to ASTM D 3039, Impact test has been conducted ASTM E23 and Hardness has been measured in terms of B.H.N. value accordance of ASTM E10.

In this present work the three variables are varied.

1) Orientation of fiber material (90^o,45^o)
2) Volume fraction of filler material.
3) Matrix volume.

Totally the eight laminates are prepared by varying above variables and designated as (A,B,C,D) for 90^o and (A1,B1,C1,D1) for 45^o.

Table1:- shows the proportionate constitutes of the laminates.

composites ±90^o	**Composites± 45^o**	**% of filler**	**Matrix volume %**		**Reinforcement volume %**	
A	A1	0	polyester	50	Glass fiber	50
B	B1	6	polyester	44	Glass fiber	50
C	C1	8	polyester	42	Glass fiber	50
D	D1	10	polyester	40	Glass fiber	50

3.1 Ultimate tensile strength

Tensile test was performed in accordance with ASTM D3039 as shown in figure 1, under displacement with resolution of the piston movement of 0.01mm .Test specimen were well filed to attain overall length and gauge length of 250 and 140mm respectively and an appropriate cross sectional area of 25×3 mm^2 and aluminum tabs with dimensions of 55×25×2 mm with 45deg filing is done at the one end is glued as shown in Fig1

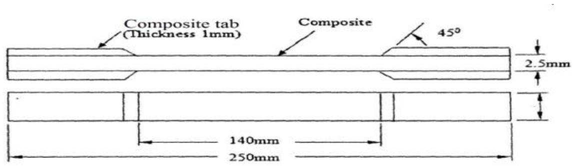

Figure 1 Tensile Test ASTM standard

3.2 Hardness test

Hardness is closely related to strength. It is the capability of a material to withstand scratching, abrasion, indentation, or penetration. It is directly proportional to tensile strength and is measured on special hardness testing machines by measuring the resistance of the material against penetration of an indenter of special shape and material under a given load. The different scales of hardness are Brinell hardness, Rockwell hardness, Vicker's hardness, etc. The test conducted on Brinell hardness machine, as per the ASTM standards the specimen prepared as per ASTM E10. A load of 100 kg was applied on the specimen for 30 sec using 1.6 mm diameter ball indenter and the indentation diameter was measured by using a microscope. The hardness was measured at three different locations of the specimen and the average value was calculated. The indentation was measured and hardness was calculated using equation (1).

$$BHN = \frac{2P}{\pi D[D - \sqrt{(D^2 - d^2)}]} \quad \text{-------- (1)}$$

Where

P= Applied load in (Kgf); D= Diameter of the indenter (mm); d= Diameter of indentation (mm).

3.3 Impact strength

Ability of the cracked (notched) material to resist the impact loading is the measure of its impact strength. It is the ratio of the energy absorbed by the specimen to cross-sectional area under the crack tip. Impact tests are designed to measure the resistance to failure of a material to a suddenly applied load. The test measures the impact energy, or the energy absorbed prior to fracture. The common methods used for measuring impact energy are

- Charpy Test
- Izod Test

Impact energy is a measure of the work done to fracture a test specimen.

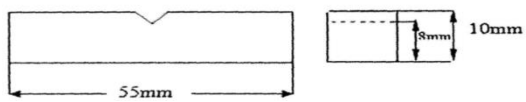

Figure 2 Impact Test ASTM standard

When the striker hits the specimen, the specimen will absorb energy until the specimen yields. At this point, the specimen will begin to undergo plastic deformation at the notch. The test specimen continues to absorb energy and work hardens at the plastic zone at the notch. When the specimen can absorb no more energy, fracture occurs. Figure 2 shows Charpy test specimens normally measure according to ASTM E23 i.e., 55x10x10mm and have a notch machined across one of the larger faces. The notches may be V-notch – A V-shaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base. Impact strength was calculated by using equation (2).

$$Impact\ strength = \frac{EI}{A} \quad (joules/mm^2)\text{---------}(2)$$

Where EI= Impact energy in joules recorded on the scale.

A= Area of the specimen in mm^2.

4. Result and discussion

In all, eight different types of Hybrid laminates were fabricated, four of the Hybrid was ± 45^o oriented composites and other four was ±90^o oriented composites. Among four one laminate was fabricated without filler and rest other with varying filler. Various characterization tests were conducted and their results are depicted in table 2 and are discussed in the following sections.

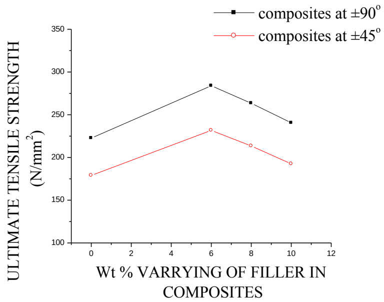

Figure 3
Comparative graph of Tensile Strength

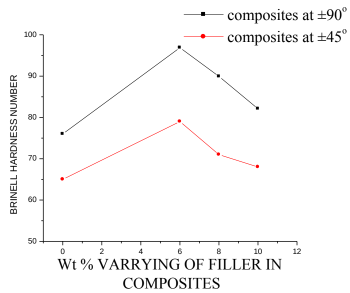

Figure 4
Comparative graph of Hardness No

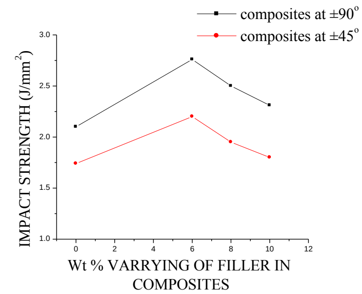

Figure 5
Comparative graph of Impact Strength

Table:- 2 Experimental Values

Sl.No	% of filler	±90° composites Mechanical properties			±45° composites Mechanical properties		
		Uts (N/mm²)	BHN	IS (J/mm2)	Uts (N/mm2)	BHN	IS (J/mm2)
01	0	222.66	76	2.10	178.96	65	1.74
02	6	283.84	96	2.76	231.71	79	2.20
03	8	263.45	89	2.50	213.4	71	1.95
04	10	240.561	82	2.31	192.45	68	1.80

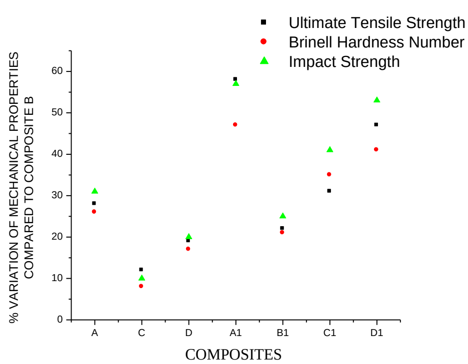

Figure 6 Comparative graph of Mechanical Strength with composite B

4.1 Tensile Strength

The values of eight different composites under consideration are shown in figure 3. The composite developed with ±90° oriented E-glass fiber reinforced and 6wt% of Fe_2O_3 filled and polyester resin matrix shows more Tensile strength compared to other composites. Hence when the composite B is compared with other composite A,C,D,A1,B1,C1,D1, the strength of composite B is increased by 28%,12%,19%,58%,22%,31%,47% respectively as shown in figure6.

4.2 Brinell hardness number

The values of eight different composites under consideration are shown in figure 4. The composite developed with ±90^o oriented E-glass fiber reinforced and 6wt% of Fe_2O_3 filled and polyester resin matrix shows more Hardness Number compared to other composites. Hence when the composite B is compared with other composite A,C,D,A1,B1,C1,D1, the hardness of composite B is increased by 26%,8%,17%,47%,21%,35%,41% respectively figure 6.

4.3 Impact strength

The values of eight different composites under consideration are shown in figure 5. The composite developed with ±90^o oriented E-glass fiber reinforced and 6wt% of Fe_2O_3 filled and polyester resin matrix shows more Impact Strength compared to other composites. Hence when the composite B is compared with other composite A,C,D,A1,B1,C1,D1, the strength of composite B is increased by 31%,10%,20%,57%,25%,41%,53%,respectively figure 6.

5. Conclusion

In the present research endeavor, various characterization tests were conducted over GFR-polyester-Hematite ore filled Hybrid composites. In general, the addition of fillers leads to cost and weight reduction of the regular glass fiber reinforced composites. The effect of the addition of natural filler has been studied and it is concluded that, the Tensile Strength, Hardness, Impact Strength of the composite B is better compared to other composites and at the 6wt% of filler content in both the orientations exhibits the good mechanical characterization.

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