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FABRICATION AND EVALUATION OF MECHANICAL PROPERTIES OF FE_2O_3 PARTICULATE FILLED HYBRID COMPOSITES

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Abstract: -

The researchers are quite concentrating at the hybrid materials. this is mainly due to their applicable benefits have they offer low density, low cost,etc., an experimental investigation was conducted to study the effect of hematite ore and volume fraction on Tensile Strength, Hardness, Impact Strength of Hybrid composite. General Purpose resin or Orthophthalic resin, E-Glass fiber, and Hematite ore are the constitute of hybrid composite. Specimen was cut from the fabricated laminate according to the ASTM standard for different experiments for tensile test, hardness test, and impact test. The laminates are prepared by varying the volume fraction (6%, 8%, 10 %,). The results shown that the incorporation of hematite ore has a strong influence on the properties.

Keywords: - *GFRP, Mechanical Properties, Orthophthalic polyester resin hematite ore filler.*

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 loadcarrying 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.

Literature survey indicate that very limited work has been done on mechanical behaviour of bidirectional mat E-glass fiber reinforced GP composite of varying filler wt%. Therefore,the aim of this work is to fabricate the bidirectional mat E-glass / GP hematite filled composite of varying wt% using hand lay up technique and to study the mechanical properties of the composites. Various other different methods of fabricating the polymer matrix composites are wet lay up (hand lay up), resin transfer molding, filament winding and compression molding. Among the techniques mentioned above, Hand lay up technique is used in this study since, it is effective, economic, good surface finish and easy fabrication.

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. Table 1 show the constitutes of Hematite ore. The filler used was hematite passed through 75150 µm.

Table: -1

Sl.No	Contents	Hematite Ore
01	FE %	40.18
02	Sio2	20.98
03	AL2O3	14.21

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.Table 2 show the details of the propionates used in the Hybrid composites.The composites are fabricated and cured as reported by Suresha et al [9] and basavarajappa et al. [10]. 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.

Table: -2

composites	% of filler	Matrix volume %		Reinforcement volume %	
A	0	Orthophthalic polyester resin	50	Glass fiber	50
B	6	Orthophthalic polyester resin	44	Glass fiber	50
C	8	Orthophthalic polyester resin	42	Glass fiber	50
D	10	Orthophthalic polyester resin	40	Glass fiber	50

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 Figure1.

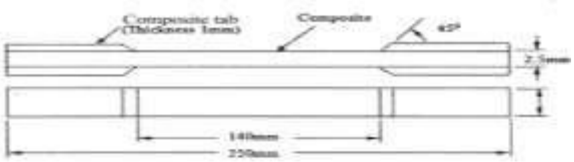


Figure: - 1 Tensile Test ASTM standard

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).

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

Where

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

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 Vshaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base. Impact strength was calculated by using equation (2).

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

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

A= Area of the specimen in mm^2.

Result and discussion:-

Results obtained from this experimental work are presented in Table 3 and figures3, 4, 5. The properties of the constituent's materials, such as type, quality, fiber distribution, orientation, void content and filler particles distribution are influenced on mechanical properties of hybrid composites. The vital properties such as nature of the interfacial bonds and the mechanisms of load transfer at the interphase. Table:-3 Experimental Values of Hybrid composites.

Sl.No	% of filler	Hematite Ore Mechanical properties		
		Uts (N/mm2)	BHN	IS (J/mm^2)
01	***0***	***222.66***	***76***	***2.17***
02	***6***	***249.17***	***85***	***2.42***
03	***8***	***232.19***	***80***	***2.23***
04	***10***	***228.06***	***78***	***2.19***

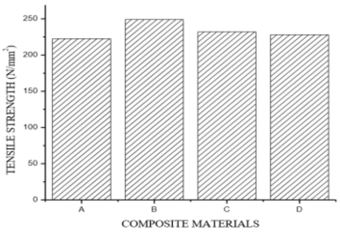


Figure 3
Comparission of Tensile Strength of varying volume fraction

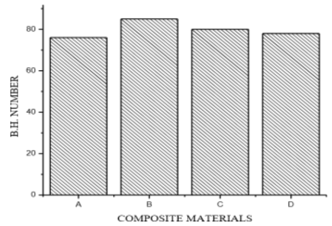
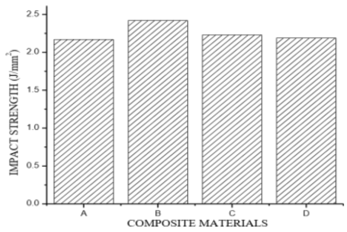


Figure 4
Comparission of Hardness of varying volume fraction



Figures 5
Comparission of Impact strength of varying volume fraction

From the above table3 and figure 3, the composite material shows high tensile strength when compared with the unfilled composite material. It is found that the composite filled by (6% filler) of Hematite ore of 40% iron content exhibit high tensile strength (249.17 N/mm2) compared with the rest. This may be due to better particle dispersion and strong polymer/filler interface adhesion for effective stress transfer. The tensile strength decreases with further increased in the filler content this is due to more filler material distribution in the composite. Hardness is closely related to strength. It is the ability of a material to resist 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; the figure 3 shows the comparison with unfilled glass GP composite and filled glass GP composite. The hardness is increased by increasing the hard reinforcement weight percentages in the composites.From the above table3 and figure5, It is observed that the impact strength decreases with increasing in the filler content and the Grade when compared with the unfilled filler material. By adding Hematite ore as a filler material in hybrid composite makes a material harder and brittle which in turns the reduction in impact strength. The impact strength decreases with high loading of fillers has less ability to absorb impact energy this is because the filler disturbs in the matrix continuity and each filler is a site of stress concentration, which can act as a micro crack initiator and reduces the adhesion and energy absorption capacity of composite. At the (6% filler) of Hematite ore of 40% iron content exhibit high impact strength (2.42 J/mm^2).

Conclusion:-

Based on the test results obtained from the Tensile test, Hardness test, Impact test carried out on the hybrid composite materials, the following conclusion were made.

1) From the obtained results, it was observed that composite filled 5% filler material by volume ratio in both Grade A and B ore's exhibited the better ultimate strength, but the maximum ultimate strength is in Grade B filled composite i.e., 275.027 N/mm^2 compared to other composite. Further increase in the filler percentage decrease in the ultimate strength.
2) The results obtained from the hardness test, the resistance of indentation is gradually increase with increase in the filler percentage in the composite in both Grade A and B but the maximum is in Grade B ore filled composite. When compared to other composites.
3) The experimental results of impact test shows that as the percentage of filler addition increases the impact strength reduces. Grade A ore exhibits the better impact strength compared to Grade B ore

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