Investigation of Mechanical Properties of Silica Powder/Mica Filler Reinforced Epoxy Composite

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Abstract— Fibre reinforced polymer composites are used in a variety of application because of their advantages such as relatively low cost of production, easy to fabricate and superior strength compared to polymer resins. Reinforcement in polymer is either synthetic or natural. Synthetic fibre like glass, carbon etc. has high specific strength but their fields of application are limited due to higher cost of production. Recently there is an increase interest in natural fibre based composites due to the above said advantages. In this connection an investigation is carried out to make better utilization of silica powder for making value added products. The objective of the present research work is to study the physical and mechanical behaviour of silica powder and Mica filler reinforced epoxy based hybrid composites. The effect of reinforcement on mechanical properties like tensile strength, compression, hardness of composites and impact strength are studied.

Key words: Composite, Tension, Compression, Impact, Hardness

I. INTRODUCTION

Modern structural composites, frequently referred to as 'Advanced Composites', are a blend of two or more components, one of which is made up of stiff, long fibers, and the other, a binder or 'matrix' which holds the fibers in place. The fibers are strong and stiff relative to the matrix and are generally orthotropic (having different properties in two different directions). The fiber, for advanced structural composites, is long, with length to diameter ratios of over 100. The fiber's strength and stiffness are usually much greater, perhaps several times more, than the matrix material. The matrix material can by polymeric (e.g. polyester resins, epoxies) metallic, ceramic or carbon. When the fiber and the matrix are joined to form a composite they retain their individual identities and both directly influence the composite's final properties. The resulting composite will generally be composed of layers (laminae) of the fibers and matrix stacked to achieve the desired properties in one or more directions.

Epoxy is used as Matrix materials for various advantages like Adhesion to fibers and to resin, No by-products formed during cure, Low shrinkage during cure, High or low strength and flexibility, Solvent and chemical resistance, Resistance to creep and fatigue, Solid or liquid resins in uncured state, Wide range of curative options, Adjustable curing rate and Good electrical properties. Silica powder and Mica fillers are used as reinforcement for tailoring high defined properties.

II. METHODOLOGY

The investigation of mechanical properties of silica powder / mica filler epoxy composite is carried out by the following steps.

- Specimen Preparation
- Experimental Analysis
- Results and Discussion

III. SPECIMEN PREPARATION

The goals of the composite manufacturing process are to: achieve a consistent product by controlling fiber thickness, fiber volume, fiber directions and minimize voids, reduce internal residual stresses, process in the least costly manner. Silica powders are made of sodium silicate (water glass). They are used in heat protection (including asbestos substitution) and in packing's and compensators. They can be made such that they are substantially free from non-alkali metal compounds. Sodium silicate fibres are used for subsequent production of silica fibres, which is better than producing the latter from a melt containing SiO_2 or by acid-leaching of glass fibres. The silica fibres are useful for producing wet webs, filter linings and reinforcing material. They are used to produce silicic acid fibres by a dry spinning method. These fibres have properties which make them useful in friction-lining materials. The silica powder used for preparing the specimen is shown in figure 1.

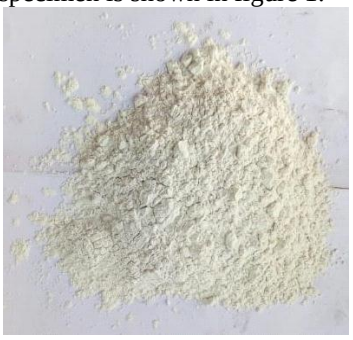

Fig.1: Silica Powder

Mica has the exclusive combination of uniform dielectric steadiness, capacitance stability, enormous dielectric power, high Q factor lower power loss, high electrical resistance and low temperature coefficient. It is highly regarded for its resistances to arc and corona discharge without causing any lasting injury. It is highly fire proof, incombustible, non- flammable, infusible, and also can resist temperatures of up to 1000 degrees Celsius/1832 degrees Fahrenheit. However this depends on the type and variety of Mica used. Mica filler shown in figure 2 is highly tough, having high tensile strength, elastic, and along with being flexible is selected for our investigation. It has immense

compression power and can be machined, die-punched, or handle.

Fig.2: Mica Filler

Epoxy resin density of 1.15-1.20g/cm³, mixed with hardener density of 0.97-0.99g/cm³, is used to prepare the composite material from purchased local source. The matrix epoxy resin used for specimen preparation is shown in figure 3. Methyl ethyl ketone peroxide, also known as 2-butanone peroxide, is strongly oxidizing (caustic) organic peroxide that is commonly used in the manufacture of acrylic resins and as a room temperature hardening and curing agent for preparing hybrid polymeric composites. Accelerators are material which help the decomposition of peroxides and produce free radicals which start the propagation reaction resulting in the gelation and ultimate cure of polyesters. Soaps of Cobalt and certain amines act as accelerators in the homolytic fission of peroxides generating from radicals.

Fig.3. Epoxy matrix

The fabrications of composite slab are prepared by compression moulding technique. The typical moulding machine is shown in figure 4. Silica powder and Mica fillers are used as reinforcement and epoxy resin is used as matrix material. This mix consists of the resin, accelerator, fillers, and additives. The addition of accelerator to resin will not cause any cross linking until catalyst is added. The low temperature curing epoxy resin, catalyst and accelerators are mixed in a ratio of 7.5:1.0:1.5 by weight percentage. A plywood mould having dimension of (310 ×210× 20) mm^3 is used for composite fabrication.

Fig.4. Compression Moulding Machine

The fillers are mixed with epoxy resin by the simple stirring and the mixture is poured into various moulds conforming to the requirements of various testing conditions and characterization standards. The mould should be thoroughly cleaned and free from dirt's before the releasing agent is applied. Then, the mould surface is coated with wax (e.g. mansion polish). After some time the wax has to be removed to have a glassy finish on the mould surface. In certain cases release of the product is difficult with wax alone. So, a layer of poly vinyl alcohol (PVA) is applied. Since, PVA is water soluble material, 15% solution in water is applied with sponge. The brush application will leave the prints of brush lines so, sponge is preferable. After the water evaporates a thin layer of PVA is formed on the mould surface.

The PVA layer must be completely dry before the gel coat is applied perhaps it will create wrinkles called 'elephant skin'. MEK or cellulose acetate, casein, carboxyl-methyl cellulose and methyl cellulose are the other film formers used as releasing agents.

A releasing agent is used for facilitate easy removal of the composite from the mould after curing. If any entrapped air bubbles are there, then they are removed by a sliding roller and the mould is closed for curing at a room temperature for 24 h at a constant load of 25-30kg.

After curing the specimens of suitable dimensions are cut for mechanical test as ASTM standard. The composition and designation of the composites prepared for this study are listed in the below table 1.

Description	Epoxy	Silica Powder	Mica Powder
Specimen 1	70%	15%	15%
Specimen 2	75	15	10
Specimen 3	80	10	10

Table 1. Proportion of Materials for Composite preparation

IV. Experimental ANALYSIS

The experimental analysis of mechanical properties of silica powder / mica filler epoxy composite is carried out by various tests.

1) Tensile Test
2) Compression Test
3) Impact Test
4) Micro Hardness Test

A. Tensile Test

Uniaxial tensile test is known as a basic and universal engineering test to achieve material parameters such as ultimate strength, yield strength, % elongation, % area of reduction and Young's modulus. These important parameters obtained from the standard tensile testing are useful for the selection of engineering materials for any applications required. The tensile testing is carried out by applying longitudinal or axial load at a specific extension rate to a standard tensile specimen with known dimensions (gauge length and cross sectional area perpendicular to the load direction) till failure. The applied tensile load and extension are recorded during the test for the calculation of stress and strain. A range of universal standards provided by Professional societies such as American Society of Testing and Materials (ASTM) provides testing are selected based on preferential uses. This standard contains a variety of test standards suitable for different materials, dimensions and fabrication history. The specimen tested under the given condition is shown in figure 5.

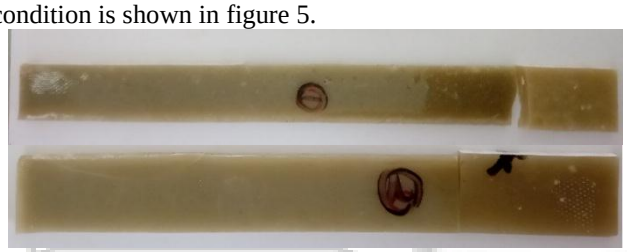

Fig.5. Tensile Test Specimen (After Testing)

B. Compression Test

Compression tests are used to determine how a product or material reacts when it is compressed, squashed, crushed or flattened by measuring fundamental parameters that determine the specimen behaviour under a compressive load. The peak load and compressive strength for the specimen prepared is recorded. The compression test specimen after tested is shown in figure 6

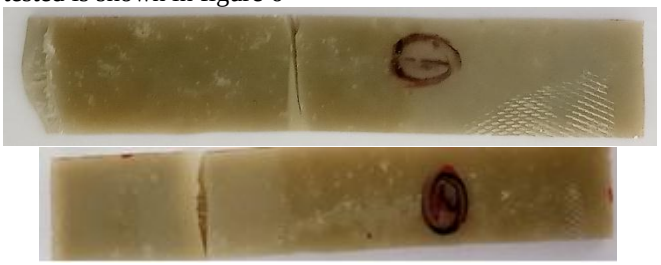

Fig.6. Compression Test Specimen (After Testing)

C. Impact Test

Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force. The test measures the impact energy and the energy absorbed prior to fracture. The tested specimen is shown in figure 7.

Fig.7. Impact Test Specimen

D. Micro Hardness Test

Micro Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. Hardness test is carried out by Vickers Hardness Tester and the tested specimen is shown in figure 8.

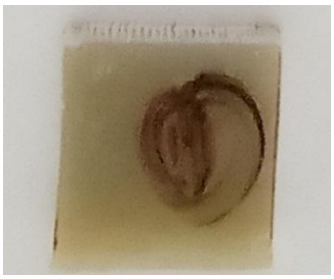

Fig.8. Hardness Test Specimen

V. Results and Discussion

A. Tensile Test

The composite specimens are tested for tensile properties in universal testing machine and obtained tensile strength are shown in Table 2. The value of tensile strength Peak load and % of elongation are recorded.

Findings	CS Area in mm^2	Peak Load in N	% of Elongation	UTS in N/mm^2
Min	100	863.623	1.36	8.633
Max	100	1742.590	2.390	17.423
AvG	100	1312.454	1.753	13.123
Std. Dev.	0.00	439.781	0.556	4.398
Variance	0.00	193407.507	0.310	19.342
Median	100.00	1331.148	1.510	13.312

Table 2. Results of Tensile Test

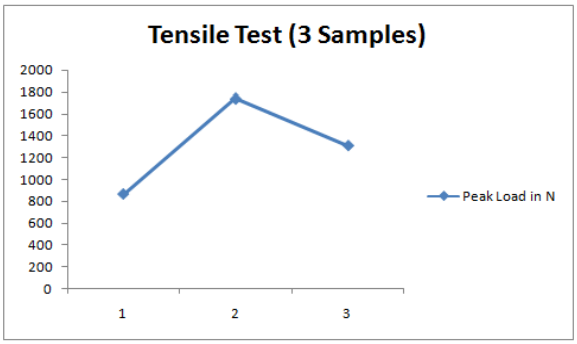

Fig.9. Peak Load in N

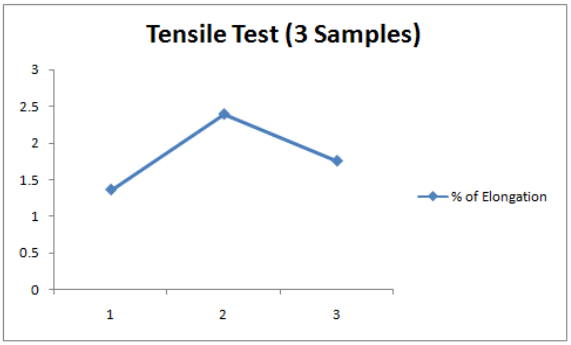

Fig.10. % of Elongation

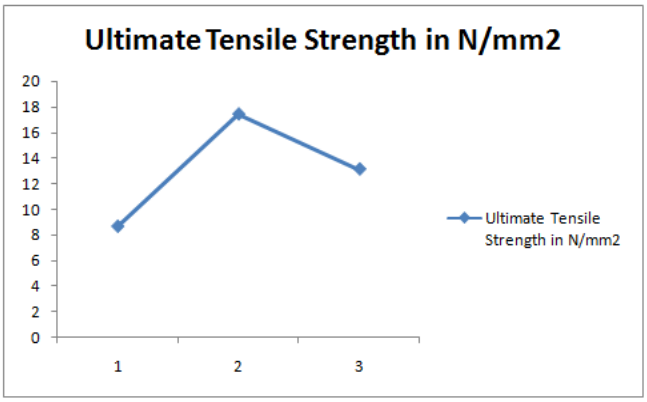

Fig.11. Ultimate Tensile Strength in N/mm^2

B. Compression Test

The compression strength is one of the important factors in NFRPCs and the following table 3 shows the variations in the compression strength of composites. The value of compression test obtained is tabulated.

Findings	CS Area in mm^2	Peak Load in N	Compressive Strength in N/mm^2
Min	100	2258.458	22.583
Max	100	3197.736	31.981
AvG	100	2712.370	27.125
Std. Dev.	0.00	470.428	4.707
Variance	0.00	221302.845	22.154
Median	100.00	2680.916	26.811

Table 3. Results of Compression Test

C. Impact Test

The energy absorbed during the impact test is shown in table 4.

Sample Name	Izod Impact Value in J for given thickness
1	0.10
2	0.25
3	0.05

Table 4. Results of Impact Test

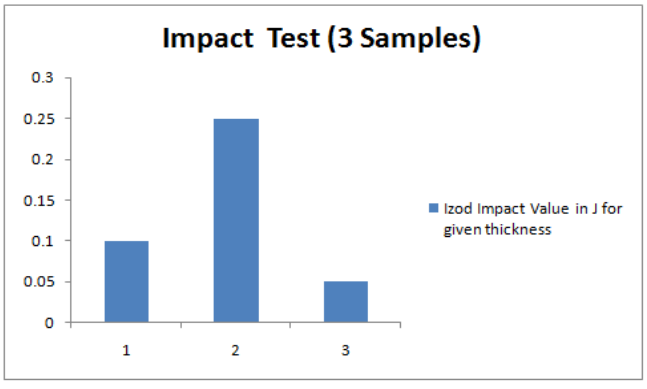

Fig.11. Impact Strength in Joule

D. Micro Hardness Test

The value of hardness obtained is 25.1HV (H). the results tabulated represented the hardness value of the prepared specimen at different points and is tabulated in table 5.

S. No.	Micro hardness (Vickers) HV (H)
1	21.4
2	21.9
3	21.6
4	22.4
5	22.8
6	22.5
7	21.2
8	20.8
9	20.9

Table 5. Results of Hardness Test

VI. Conclusion

The experimental investigation on the mechanical behavior like tensile and compressive strength, impact and micro hardness of silica powder / mica filler with epoxy hybrid composite are made. The maximum tensile strength found on the prepared specimen is 17.423N/mm^2. The maximum compressive strength is 31.981N/mm^2. The maximum impact strength is 0.25J and the maximum hardness recorded is 22.8HV.

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References

[1] Oksman K and Clemons C "Mechanical properties and morphology of impact modified polypropylene–wood flour composites", Journal of Applied Polymer Science, pp. 1503-1513 (1997).
[2] Ismail H, Salmah M and Nasir "Dynamic vulcanization of rubber wood-filled polypropylene/natural rubber blends" Polymer Testing, pp 819-824 (2001).
[3] Bisht N and Gope P C, "Mechanical properties of rice husk flour reinforced epoxy bio- composite" Int Journal of Engineering Research and Applications, Issue 06, pp. 123- 128 (2015).
[4] Begum K and Islam M A, "Natural fiber as a substitute to synthetic fiber in polymer composites: A review", Res. J. Eng. Sci, vol. 3, pp 46-53 (2013).
[5] Yadav S , Gupta G and Bhatnagar R, "A Review on Composition and Properties of Bagasse Fibres", International Journal of Scientific & Engineering Research, vol. 6, Issue 5 pp.143-148 (2015).
[6] N. Natrajan, S. Vijayarangan, I. Rajendran, "Wear behaviour of A356/25SiC$_p$ aluminium matrix composites sliding against automobile friction material", Wear, vol. 261, pp. 812-822 (2006).
[7] Mishra A, "Strength and corrosion testing of jute/ glass-epoxy hybrid composite laminates" Plastic and Polymer Technology, pp. 48-54 (2013).
[8] De Sousa M V, Monteiro S N J and D'Almeida J R M, "Evaluation of pre-treatment, size and molding pressure on flexural mechanical behavior of chopped bagasse polyester composites", Polym. Test, pp. 253–258, (2004).

[9] Palanisamy S Prabakaran J, Gopal S, Kannan K, Ramesh P, "Study The Effect Of Surface Treatment On The Mechanical Behaviour Of Natural Fiber Composites", International Journal of Emerging Technology & Research, vol. 3, Issue 6, pp 27-30 (2016).
[10] P. Paramasivam S. Palanisamy G. Pradeepkumar, "Micro-Structural and Tribological Behavior of AA6063/12sic-5Gr Hybrid Composites", International Journal for Scientific Research & Development, vol. 2, Issue 9, pp 245-247 (2014).
[11] S.Palanisamy J.Prabakaran , K.Kannan , S.Gopal, "Experimental Investigation of Mechanical Properties of Basalt Fiber Reinforced Vinylester Composites", IJSETR, vol. 3, Issue 12, pp 3218-3220 (2014).

