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STUDY OF MECHANICAL AND TRIBOLOGICAL PROPERTIES OF HYBRID COMPOSITE MATERIAL E-GLASS/EPOXY WITH CARBON POWDER

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ABSTRACT
Composite materials play important role in many industrial applications. Researchers are working on fabrication of new composite materials to enhance the applicability of these materials. Chopped strand mat glass fibre reinforced polymer composites is widely used in many industrial applications particularly in the automotive industry due to advantages such as low weight, ease of processing, price and noise suppression., The objective of the present work is to analyse mechanical and wear behaviour of chopped strand mat E-glass fiber, reinforced in epoxy matrix with carbon powder as filler. Three different types of composites are fabricated using 10% carbon, 20%carbon and 30% carbon with epoxy resin and hardener. The epoxy resin and hardener are mixed in 10:1 weight ratio.. The present work shows that incorporation of carbon filler into E-glass fiber epoxy reinforced composites modifies the hardness compressive and wear properties of the composites when compared with unfilled E-glass epoxy composite.

Keywords: *Composite, FRP, E-Glass Fibre, hardness, D-shore,wear test.*

I. INTRODUCTION
Fiber reinforced polymer composites are widely used for the production of complex shape materials because of their favourable properties like, low coefficient of thermal expansion, high tensile and compressive strength, and good fatigue resistance. The applications of composite applications are aircraft fabrication, wind power plant, boats, ships etc. Among the composites, Chopped strand mat E-glass/ epoxy composite has shown better growth for marine application due to their high strength and moisture resistance than any other composites in making boat hulls, fiber glass boat. The other material Epoxy is widely used in industrial applications in relation to adhesives, coatings, and aerospace structures.
Very limited work has been done on mechanical behaviour of chopped strand mat E-glass fiber reinforced epoxy composite of varying fiber wt% and carbon powder as a filler material. Therefore, the aim of this work is to fabricate the chopped strand mat E-glass / epoxy carbon powder composite of varying wt% using hand layup technique and to study the mechanical and tribological properties of the composites by conducting different tests.

II. MATERIAL

1. E Glass Fibre
The glass fiber most commonly used is known as E-glass, a glass fiber having useful balance of mechanical, chemical, and electrical properties at very moderate cost. Typical strength and stiffness levels for the individual filaments area about 3450 MPa tensile strength and 75.8 GPa Young's modulus. For specialized applications, such as thermal barriers, antenna windows etc. Glass fiber is the best known reinforcement in high performance composite applications due to its appealing combination of good properties and low cost.

2. Epoxy Resin
Epoxy Resins are thermosetting resins, which cure by internally generated heat. Epoxy systems consist of two parts, resin and hardener. When mixed together, the resin and hardener activate, causing a chemical reaction, which cures (hardens) the material. Epoxy resins generally have greater bonding and physical strength than do polyester resins.

3. Activated Charcoal
Activated carbon, also called activated charcoal, activated coal, carbo activatus or an "AC filter", is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions.

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Activated is sometimes substituted with active. Due to its high degree of micro porosity, just one gram of activated carbon has a surface area in excess of 500 m^2, as determined by gas adsorption.

III. EXPERIMENTAL PROCEDURE

Table 1:Composition of the specimen

Composites	Compositions
Plain	Epoxy (65wt %) + glass fiber (25wt %)+ Hardener (10wt %)
Carbon 10wt%	Epoxy (55wt %)+ glass fiber (25wt%)+ Hardener(10wt%)+carbon powder(10wt%)
Carbon 20wt%	Epoxy (45wt %)+ glass fiber (25wt%)+ Hardner(10wt%)+carbon powder(20wt%)
Carbon 30wt%	Epoxy (35wt %)+ glass fiber (25wt%)+ Hardner(10wt%)+carbon powder(10wt%)

Working Methodology

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, wax is pasted on the mould surface to avoid the sticking of polymer to the surface. Required amount of E-glass fiber and epoxy is taken three times the weight of e-glass. E-glass in the form of chopped strand mats are cut as per the mould size and placed at the surface of mould after pasting wax. Then the general purpose resin (epoxy) is mixed thoroughly with a hardener hy951 of amount 10% of epoxy (curing agent) and poured onto the surface of mat already placed in the mould. The polymer is uniformly spread with the help of brush and quenched with the brush. Since there is chance of formation of air cavities it is important to quench properly. Second layer of mat is then placed on the polymer surface and again quenched on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After completing this much work, wax is pasted on the inner surface of the top mould plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature, mould is opened after six to seven hours and the developed composite part is taken out and further processed.

Figure 1: Shows Hand layup Method

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IV. TESTING PROCEDURES

Mechanical And Tribological Tests

Hardness test

The test was conducted using Durometer. The test specimen is prepared according to ASTM D2240 standard.

The term Durometer is often used to refer to the measurement as well as the instrument itself. Durometer is typically used as a measure of hardness in polymers and rubbers. There are several scales of Durometer, used for materials with different properties. The two most common scales, using slightly different measurement systems, are the ASTM D2240 type A and type D scales.

Figure 2:Durometer used for Hardness test

Compression Test

A compression test is a method for determining the behaviour of materials under a compressive load. Compression tests are conducted by loading the test specimen between two plates, and then applying a force to the specimen by moving the crossheads together. During the test, the specimen is compressed, and deformation versus the applied load is recorded. The compression test is used to determine elastic limit, proportional limit, yield point, yield strength, and (for some materials) compressive strength.

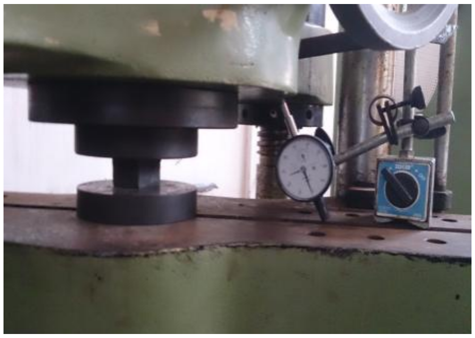


Figure 3: Universal Testing Machine

Wear Test

Wear test is carried out to predict the wear performance and to investigate the wear mechanism.

Two specific reasons are as follows

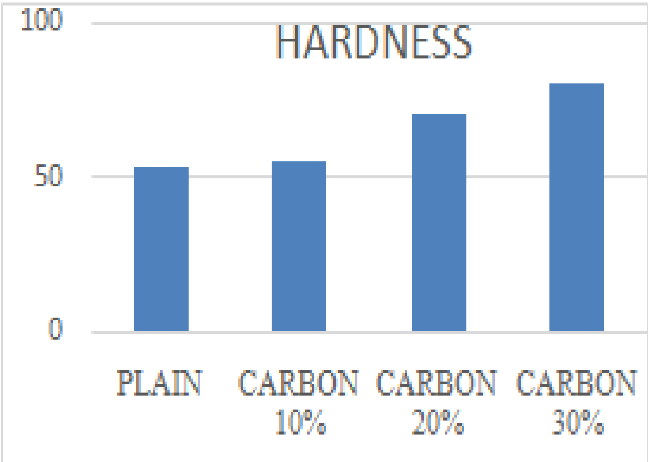
From a material point of view, the test is performed to evaluate the wear property of a material so as to determine whether the material is adequate for a specific wear application.

From a surface engineering point of view, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions (processing parameters) on the wear performance, so that optimised surface treatment conditions can be realised.

Figure 2:Wear Testing Equipment

V. RESULTS & DISCUSSION

The measured hardness values of all the four composites are presented in Graph 1.It can be seen that the hardness value of chopped stand mat glass fibre reinforced epoxy composites is increasing gradually with the filler material (carbon) content. With the increase in carbon content from 0wt% to 30wt% the hardness is found to have increased from about 53shored to 81 shore d.An average of three readings was taken for each specimen.



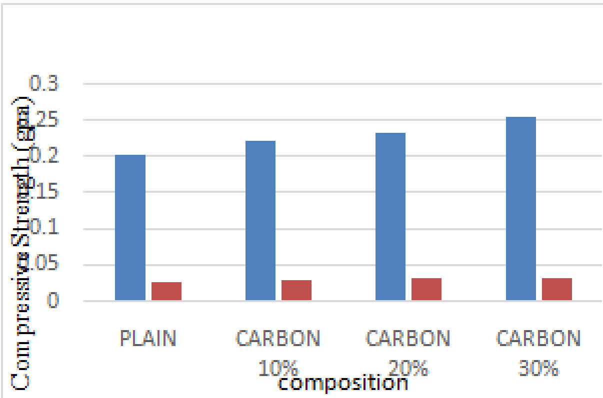
Graph 1:Hardness Vs composition

The hardness of composite increased with increase of carbon filler loading. From Figure 6.1 it can be seen that the carbon filler greatly increased the hardness of carbon, which can be attributed to the higher hardness and more uniform dispersion of carbon filler. The higher hardness is exhibited by the 30 wt% carbon filled composite compared to other micro composites. The graph shows that for a 30 wt% increase in carbon content there is 45% increase in hardness. The increase in carbon content results in an increase in brittleness of the composite. Hence this results in an increase in hardness value of the composite.

Compression Test

Figure 3: Specimen after Compression

It is a material property which is maximum force per unit area before failure occurs. The compression test was carried out using a universal testing machine of capacity 4 tons. The test specimen is prepared according to ASTM D 695standard. In the present investigation the compression of specimen across and along the fibre is carried out.



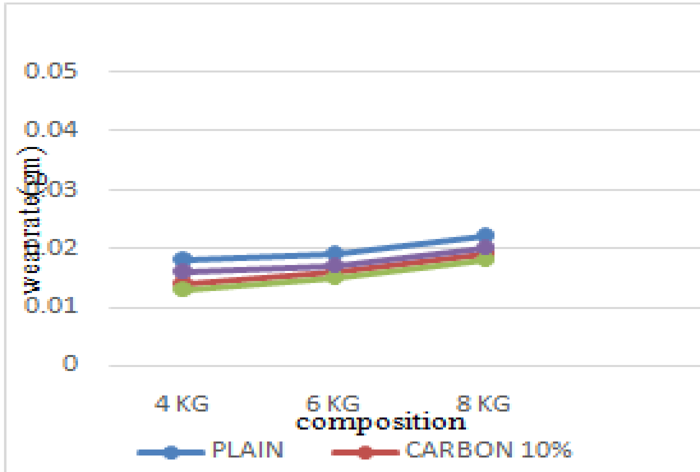
Graph 2: Compressive strength Vs. Composition

Results of compression test are shown in graph 2 Compression tests were carried out for four different specimens. Remarkable differences can be seen in the values of compressive strength. It can be noticed that for the plain E-glass/Epoxy material the compressive strength value across the fiber is 0.2333 and along the fiber is 0.0277. With the addition of carbon as filler material it is seen that the compressive strength values are increasing. A maximum is seen at 30% carbon filled material. For 30% carbon filled material the compressive strength across the fiber is 0.25667 and along the fiber is 0.03333. Also we can see that the compressive strength across the fiber is too high comparing to along the fiber. Compressive strength increases with increase in filler material because of increased grain content and strong bonding of fibres. Result of some simulation showed that the increase in the strength of the material is very sharp when filler volume is high.

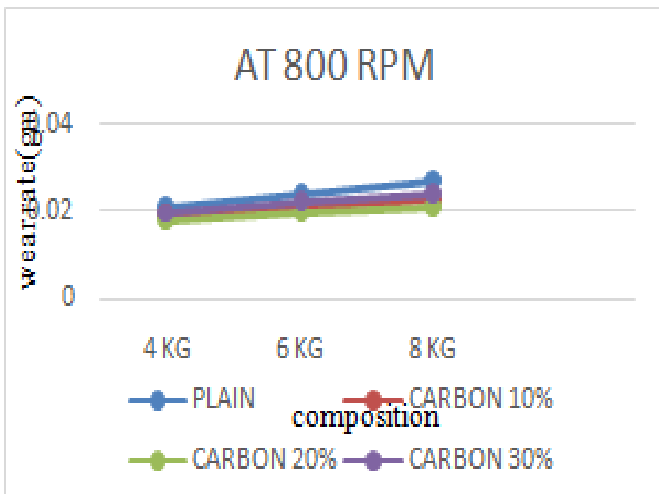
Wear Test

The wear test is carried out using the ducom pin on disc apparatus. The test specimen was prepared according to ASTM G76 standard.The weight loss was measured at 400,800,1200 rpm by applying normal loads of 4 kg, 6kg and 8 kg under sliding distance of 157.079mm.(sliding distance = π*d, where d is the track diameter which is 50 mm).The weight loss of each specimen was measured by taking the weight difference of the sample before and after each test.

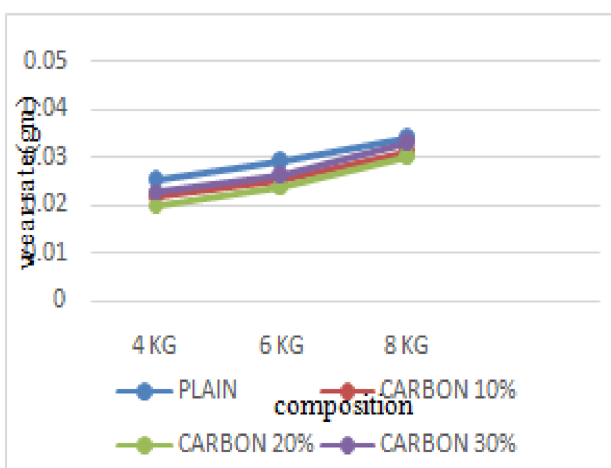
Wear loss = initial weight – final weight



Graph 3.1: Wear loss at 400rpm



Graph 3.2: Wear loss at 800rpm



Graph 3.3: Wear loss at 1200rpm

The experimental results reveal that weight loss for all samples increases with increase in applied normal load as we can see in the above graph. The composite which is filled with 20wt% exhibits less wear loss compared to other composites. The reason for improved wear resistance may be attributed to the type, surface treatment and filler loading. Carbon particles are dispersed uniformly in composite and hence, the fibres are less exposed to the abrasive medium resulted in the lower wear volume loss as compared to unfilled composites. And while comparing all the 4 variants we can see plain E-glass/Epoxy composite have more wear loss. The higher wear loss in plain E-glass/Epoxy composite may be due to lower matrix ductility and poorer fiber–matrix adhesion. In the present work, during wear, in the initial stage of wear, wear occurs at soft outer layer of the composite (matrix) due to the lower hardness. Once the matrix layer was removed, the harder phase of the composite (fibers) was exposed to the rubbing area, which acted as a protector, leading to a reduction in the removal of material.

VI. CONCLUSION

In this study, an experimental investigation has been conducted to evaluate the mechanical properties and wear behaviour of glass-fiber reinforced epoxy matrix filled with different proportions of carbon powder. The following main conclusions can be drawn from this study.

- The successful fabrication of a chopped glass fiber reinforced epoxy composites with different amount of filler material has been done by simple hand lay-up technique.

- The present work shows that incorporation of carbon filler into Eglass fiber epoxy reinforced composites modifies the hardness compressive and wear properties of the composites.

- Compared with unfilled eglass epoxy composite, the hardness of carbon filled eglass epoxy improves obviously, also the compressive strength across the fiber has a good improvement and along the fiber there is a slight increment.

- The composite which is filled with 20wt% exhibits less wear loss compared to other composites. The reason for improved wear resistance may be attributed to the type, surface treatment and filler loading.The specific wear rate increases with load and speed. The higher percentage (30 wt%) of carbon content in eglass epoxy composite results to higher compressive strength, hardness and 20wt% carbon content has better wear resistance.

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REFERENCES

1) *Dr.P.K.Palani, M.Nanda Kumar, "Analysis Of Mechanical Properties Of Chopped Strand Mat E-Glass Fiber Epoxy Resin Nanoclay Composites", The International Journal Of Engineering And Science (Ijes) ||Volume||2 ||Issue|| 2 ||Pages|| 185-189 ||2013|| Issn: 2319 – 1813 ISBN: 2319 – 1805*
2) *Bijesh, "study of mechanical behaviour of chopped strand mat and epoxy composites", (may2010)*
3) *Daniel I. M and Ishai O, "Engineering mechanics of composite materials", Oxford University Press; 22(4), 1994, pp. 1342-1361.*
4) *Dahl J. S, Smith G. L and Houston D. Q, "The influence of fiber tow size on the performance of chopped carbon fiber reinforced composites", In: materials and processing technologies for revolutionary applications, 37th ISTC conference proceedings. Seattle, Washington: 100, 2005, pp. 695-701.*
5) *Jacob G. C, Starbuck J. M, Fellers J. F, Simunovic S and Boeman R. G, "Fracture toughness in random-chopped fiber-reinforced composites and their strain rate dependence", Journal of Applied Polymer Science, 100, 2006, pp. 695-701.*
6) *Jacob G. C, Starbuck J. M, Fellers J. F, Simunovic S and Beoman R. G, "Crashworthiness of various random chopped carbon fiber reinforced epoxy composite materials and their strain rate dependence", Journal of Applied Polymer Science , 101, 2006, pp. 1477-1486.*
7) *Harris B, "Fatigue and Accumulation of Damage in Reinforced Plastics", Composites, 8, 1977, 214-220.*

8) *Stinchcomb W. W and Reifsnider K. L, "Fatigue Damage Mechanisms in Composite Materials: A Review", Fatigue Mechanisms, ASTM STP 675, American Society for Testing and Materials, 1979, pp. 762-787.*
9) *Agarwal B. D and Broutman L. J, "Analysis and Performance of Fiber Composites", New York: John Wiley and Sons, 1980.*
10) *Konur O and Matthews F. L, "Effect of the Properties of the Constituents on the Fatigue Performance of Composites: a Review", Composites, 20(4), 1989, pp. 317-328.*
11) *Beyerlein I. J, Zhu Y. T and Mahesh S, "On the influence of fiber shape in boneshaped short-fiber composites", Composite science and technology, 61, 2001, pp. 1341-1357.*