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Mechanical Characterization of Carbon Fiber Reinforced Epoxy Composites with and Without Mo_{s2} Filler

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***Abstract* - A typical composite is a material system composed of two or more constituent elements mixed and bonded on a macroscopic scale. Generally, a composite material is composed of reinforcement embedded in a matrix. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new material exhibits better properties than would each individual constituent element.**

In this paper, an experimental investigation was carried out to study the mechanical characterization of carbon fiber reinforced epoxy composites with and without filler in tensile, hardness and flexural test conditions.

Key Word: Filler, Carbon fiber, MoS2, Tensile strength, modulus, flexural strength and modulus

I INTRODUCTION:

The need for the use of newer material to combat wear situations has resulted in the emergence of polymer based composite materials. Fiber reinforced polymeric composites are the most rapidly growing class of materials due to their good combination of high specific strength and specific modulus. They are widely used for a variety of engineering applications. The importance of tribological properties convinced many researchers to study the friction and wear behavior to improve the wear resistance of polymeric composites. The polymer and their composites find very useful applications in automotive components such as gears, cams, wheels, brakes, clutches, bearings and also in other engineering applications like conveyor aids, chute liners, power, mining, agriculture and other allied field.

The present study involves an experimental investigation was carried out to study the mechanical characterization of carbon fiber reinforced epoxy composites with and without filler in tensile, hardness and flexural test conditions.

II LITERATURE REVIEW:

Fibre reinforced polymeric materials have been widely used due to their superior properties, low density, and manufacturing flexibility. Numerous applications have been allocated for these materials in aerospace and automotive industries such as gears, seals, bearings, cams etc. In order that these components satisfactorily perform under loading conditions, they should have good mechanical, tribological and machining properties. Number of scientists and researchers are carrying out work to develop newer material system and characterize them for their various properties so that they can be selected for specific end use. A brief review of the literature is presented below throwing more light on the above.

B. Suresha et al. [5] carried out a study on three-body abrasive wear behavior of carbon and glass fiber reinforced epoxy composites. From the study, they found that specific wear rate increased with applied load at lower abrading distance and decreased with increased abrading distance. Carbon epoxy composite showed better abrasion resistance as compared with that of glass fiber epoxy composites.

A study on Erosive wear behavior of epoxy based composites at normal incidence was carried out by A.P. Harsha et al. [6]. They found that the bi-directional glass fibre reinforced epoxy composites showed better wear resistance than unidirectional reinforced composites. The erosion behavior of epoxy composites is controlled by the type of fibre and its arrangement. They also reported that the epoxy composites have shown peak erosion rate at 60^0 impingement angle at a velocity of 25m/s.

J. Stabik et al. [7] conducted a study on electrical and tribological properties of gradient epoxy-graphite composites. They concluded that the surface resistivity increased significantly with decreasing content of filler in composite.

J.K. Lancaster et al. [8] conducted a study on the effect of carbon fiber reinforcement on the friction and wear of polymers. They found that the wear rate can be reduced by the addition of a third component, such as graphite or bronze, although only with small sacrifice on the bulk strength. However, they felt that further investigations are required to determine the most effective additives and their proportions to obtain an optimum compromise in strength and wear properties.

A study on solid particle erosion of glass fiber reinforced fly ash filled epoxy resin composites was carried out by V.K. Srivastava et al. [9]. From the experimental investigation, they found that the inclusion of fly ash filler in the GFRP composite decreased the hardness, tensile strength and density. They also reported that GFRP without any filler showed the highest erosion rate. The influence of impingement angle on erosive wear of all composites under consideration exhibited semi ductile wear behavior with maximum wear rate at 60° impingement.

N. Mohan et al. [10] carried out a study for investigating two-body abrasive wear behavior of silicon carbide filled glass

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fabric-epoxy composites. The wear loss of the composites was found increasing with the increase in abrading distances. A significant reduction in wear loss and specific wear rates were noticed after incorporation of SiC filler into GE composite.

B. Suresha et al. [11] carried out a study on Mechanical and tribological properties of glass-epoxy composites with and without graphite particulate filler. Their investigation revealed that the tensile strength and dimensional stability of G-E composite increased with increasing graphite content. The wear loss of the composites decreased with increasing weight fraction of graphite filler and increased with increasing sliding distance. On further investigation using SiC instead of graphite as the filler material in E-glass reinforced thermoset composites [12], they found that tensile strength, flexural strength and hardness of the glass reinforced thermoset composite increased with the inclusion of SiC filler.

Substantial research work has been carried out to investigate the mechanical behavior of carbon fiber reinforced epoxy composite with and without addition of fillers. Though number of fillers has been tried out, the effect of adding MoS_2 filler on the mechanical behavior of fiber reinforced polymeric composites is not much reported. In this context, the present work is carried out with the main objective of characterizing the mechanical characterization of carbon fiber reinforced epoxy composites with and without the addition of MoS_2 filler.

III EXPERIMENTAL METHOD

MATERIALS:

Table 1. Composite selected for study

Material	Matrix	Filler
Carbon –Epoxy (C-E)	40	-
MoS_2 Filled(C-E1)	36	4
MoS_2 Filled(C-E2)	32	8

Specimen Preparation

A hand layup procedure was adopted for making C-E composites. The reinforcement material consists of carbon fibers which are randomly oriented. LY 556 epoxy was used as the resin for the matrix material with HY 951 grade room temperature curing. The layup procedure consisted of placing a glass surface mat to give smooth surface finish to the top and bottom layers of the cured composite. On this, a resin hardener mix prepared for this purpose was smeared. Over this, another layer of fabric was laid down and the resin was spread once again. The process was repeated till all the 8 layers of fabric (arrived at by trial experiments) made ready for the layup, were used up in the stacking arrangement. Use of spacers of about 3mm thickness helped in obtaining laminates of the required thickness following final curing.

IV MECHANICAL TESTING:

After fabrication the specimens were subjected to various mechanical tests as per ASTM standards. The mechanical tests that were carried out are tensile test, flexural test and hardness.

TENSILE TEST:

Test was conducted on the Hounstill’s universal testing machine. This testing machine has constant rate of cross head movement and comprises fixed member, movable member and grips. Fixed grips are rigidly attached to the fixed and movable members of the testing machine. Self aligning grips are attached to the fixed and movable members of the testing machine in such a manner that they will align as soon as any load is applied. Tensile test was conducted according to ASTM D-638. Specimens were prepared as per the ASTM standard and schematic of the same is shown in figure. Universal testing machine is calibrated before use. Specimen plate is enclosed between the grippers, the distance between the grips is 115m. Load is slowly applied at the rate of 5mm/min. At some load the specimen gets fractured. The Load corresponding to deformation is noted down. Then stresses at this load and corresponding deformation were established. Similar procedure is repeated for specimen of 4% and 8% of MoS_2 filler filled composites.

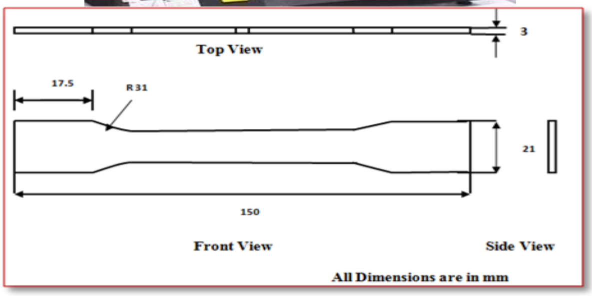

Fig 4.1. Tensile Test Specimen

FLEXURAL TEST:

The test specimens were prepared according to ASTM D790. Most commonly, the specimen lies on a support span and the load is applied at the centre by the loading nose, thus producing three point bending at a specified rate. The parameters for this test are the support span, the speed of loading, and the maximum deflection for the test. The test was carried out at a slow speed and continued till the material has achieved 5% deflection or breaks. The load at fracture is noted. Flexural strength and modulus was established.

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Fig 4.2 Flexural Test Specimen

SHORE-D HARDNESS TEST:

Hardness test was conducted according to ASTM D-2240. For ASTM D2240, the specimen dimension is 50mmX50mmX3mm. The test was carried out with a Durometer as shown in figure. First calibrate the Durometer by using standard check gage. If there is any error, note down the zero correction. Place the specimen on hard, horizontal surface. Hold the Durometer in a vertical position with point of indentor at least 12mm from any edge of the specimen. Apply the presser foot so as to make the indentor contact the specimen as rapidly as possible without shock. Apply just sufficient pressure to obtain contact between the indentor and the specimen. Read the scale within 1 min with the indentor in firm contact with the specimen. If a reading after a time interval is specified, hold the indentor in contact with the specimen without change in position of pressure and read the scale after the period specified. Make three measurements at different positions on the specimen and determine the median value or arithmetic mean. The test was carried out for three carbon fiber epoxy specimens; unfilled and filled with 4 and 8% MoS_2 filler.

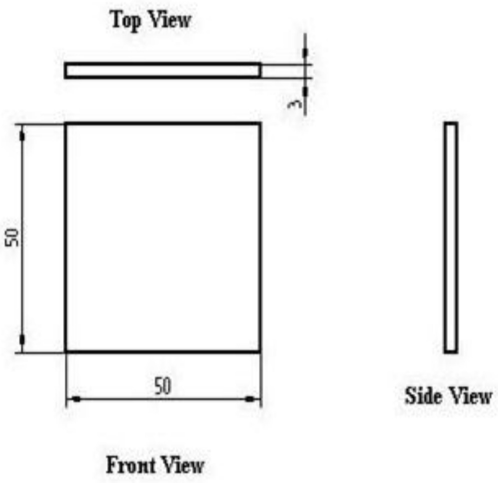

Fig 4.3. Durometer

V RESULT AND DISCUSSION:

TENSILE TEST:

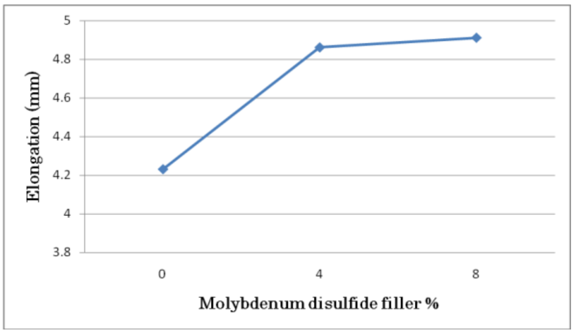

Fig 5.1. Percentage elongation as a function of MoS_2 filler content

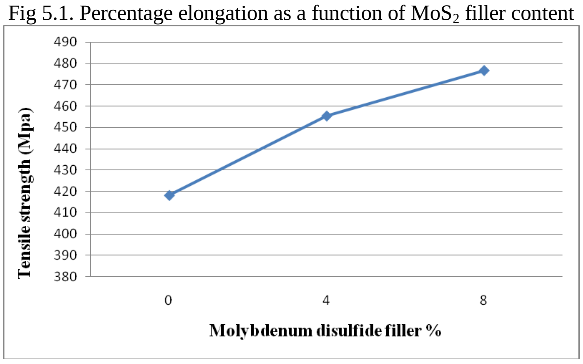

Fig 5.2 Tensile strength as a function of MoS_2 filler content

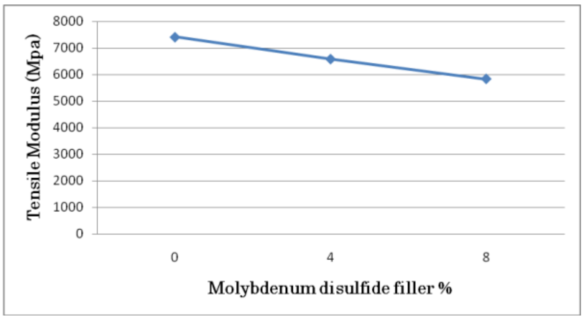

Fig 5.3 Tensile Modulus as a function of MoS_2 filler content

In this study, percentage of elongation, tensile strength and tensile modulus at fracture of unfilled and MoS_2 filled carbon fiber reinforced epoxy composites are plotted as a function of MoS_2 filler and the same is shown in Fig.5.1, 5.2 and 5.3. Fig.5.1 shows the percentage elongation of carbon fiber reinforced epoxy composite with and without MoS_2 filler. It

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is observed that, the carbon fiber reinforced epoxy composites with 8% MoS_2 filler has highest elongation of 4.92mm and carbon fiber reinforced epoxy composite without MoS_2 filler the elongation is 4.27. Fig.5.2 shows a linear increase in the tensile strength as the percentage of MoS_2 increased. The tensile strength of composite without filler and with 4% and 8% of the MoS_2 content has been increased from 418.08 Mpa to 476.72 Mpa. The tensile modulus from fig.5.3 shows that, decrease in modulus as the filler content in the composite is increased. These observations suggest overall improvement in tensile properties with the addition of MoS_2 filler

FLEXURAL TEST:

Fig.5.4 and 5.5 shows the variation of flexural strength and modulus as a function of MoS_2 filler. Carbon fiber reinforced epoxy composite with 8% MoS_2 additives showed the least flexural strength and modulus. Whereas the one with 4% of MoS_2 filler indicated the maximum value suggesting that if flexural properties are important in any application, one should use minimum filler content

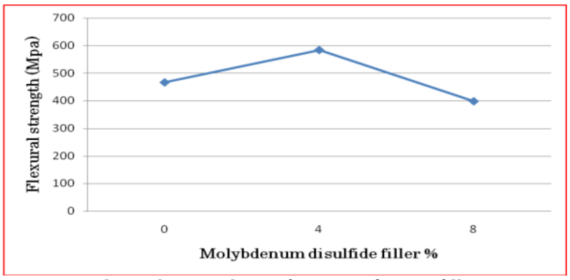

Fig 5.4. Flexural Strength as a function of MoS_2 filler content

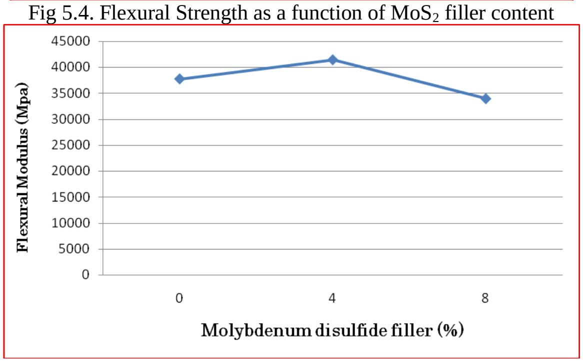

Fig 5.5. Flexural Modulus as a function of MoS_2 filler content

SHORE-D HARDNESS TEST

Shore D Hardness number of carbon fiber reinforced epoxy composites with and without MoS_2 filler were arrived at and average results are plotted as shown in Fig.5.6. Figure shows the linear increase in the hardness as the percentage of MoS_2 content increases, although the magnitude increase in hardness with MoS_2 filler content is not substantial.

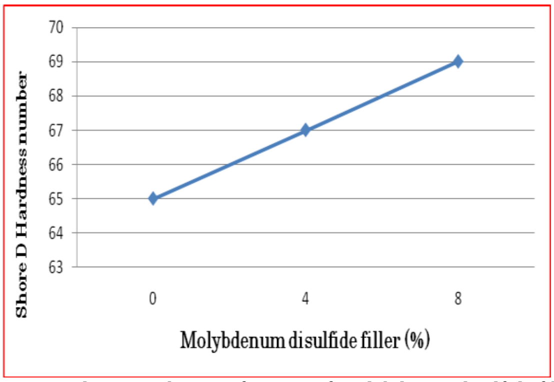

Fig 5.6. Hardness number as a function of Molybdenum disulfide filler content

VI CONCLUSION:

Carbon fiber reinforcement and the addition of fillers to the epoxy matrix generally improved the mechanical properties of the composites. The following conclusions are made:

Carbon fiber reinforced epoxy composite with 8% MoS_2 filler content showed the maximum tensile strength and elongation, whereas maximum flexural strength and modulus was obtained for C-E Composites with 4% MoS_2 filler. An increase in hardness was observed with increased percentage of MoS_2 filler in the composite

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