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Study of Wear Test on Hybrid Material Reinforced Epoxy Based Composites

Mahesh.V.M[1], B.K.Muralidhara[2], Raji George[3], Trisha.K[4]
Asst. Professor, Dept. of Mechanical Engg., M.S.Ramaiah Institute of Technology, Bangalore, Karnataka, India[1]
Professor, Dept. of Mechanical Engg., University Visvesvaraya College of Engineering, Bangalore, Karnataka, India[2]
Professor, Dept. of Mechanical Engg., M.S.Ramaiah Institute of Technology, Bangalore, Karnataka, India[3].
Research student, M.S.Ramaiah Institute of Technology, Bangalore, Karnataka, India[4]

Abstract: In the present work, the hybrid nanomaterial such as Graphene – Multiwalled carbon nanotube reinforced epoxy composites are fabricated with different weight fraction of the reinforcement and are subjected to wear test. The mechanical properties of these composites are investigated and found posses decrease in wear rate, as the increased in weight fraction of the reinforcement there is reducing wear rate compared to the based matrix fabricated using the same process.

Index Terms - Epoxy resin; graphene; hardner; multiwalled carbon nanotube; nanocomposites; wear rate.

1. INTRODUCTION

Graphene and Carbon nano-tubes is the form of carbon, Graphene appears as thin, transparent and one atom thick, multiwalled carbon nanotubes (MWCNT's) is rolled to a tubular shape with multiple layers. MWCNT's are to revolutionize several fields in mechanical and electrical engineering. These are a major component of nanotechnology. Graphene and MWCNT have a wide range of unexplored potential applications in various technological areas, Mechanical strengths such as electrostatic paintings, adhesives, aircraft parts, sports goods, coatings etc., electrical components, etc., Epoxy-based composite materials are used as structural components not only in weight sensitive aerospace industry, but also in the marine, armour, automobile, railways, structural engineering to their excellent high-adhesion, low weight and good chemical/corrosion-resistance. Over the years, many attempts have made to modify epoxy by adding nanomaterial to improve the matrix-dominated composite properties. The addition of nanomaterial improves the Young`s modulus and strength of epoxy.[1] These properties would enable us the specific application for which the specimens can be tailor-made. Applications are of conductive polymers, composites in electronic, automobile products, as sensors, instruments in applications like microscope probe tips, gas leak detectors, electromagnetic shielding sporting goods (tennis racket), as conductive coatings in printed circuit board, as catalysts in petrochemical applications, as textiles, fibers, in lithium ion batteries, lamps, semiconducting materials, advanced ceramics, microwave antennas, medical implants, drug delivery, aerospace etc. The earliest method for the graphene-carbon nanotube production is the electric arc discharge[2][3]. This technique was used already in the early sixties by R. Bacon for the synthesis of graphene-carbon nanotube. The same technique was adapted in 1990 by Kratschmer and Huffman to produce fullerenes in good yields, and later on this method was improved, applied for the synthesis of graphene, multiwalled carbon nanotube (MWCNT) and single walled carbon nanotube (SWCNT). Other methods such as the laser evaporation/ablation and chemical vapour deposition (CVD) were

2. EXPERIMENTAL SECTION

2.1. *Materials*

The polymer matrix consisted of epoxy resin with amine-based hardener and Ethanol was the chosen solvent. Graphene-Multiwalled carbon nanotubes produced by arc discharge were

2.2 Preparation of Graphene-MWCNT/Epoxy Composite.

Graphene-MWCNT was mixed with ethanol and sonicated for 15 minutes in a beaker. The sonication helps disperse the nanoparticles uniformly and reduce lumps, thus countering the Vander wall`s forces set up. This procedure helps us in getting fine grained graphene-MWCNT. The above mixture (graphene-MWCNT & ethanol) is heated on an electric heater to evaporate ethanol in the same beaker. Care must be taken to not heat the graphene-MWCNT above 75`C. MWCNT taken in amounts of 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 1.75% and 2% weight fraction, epoxy resin and hardener were taken in appropriate weight standards (composition), with respect to the mould used. Graphene-MWCNT and epoxy resin were thoroughly mixed for 30 minutes using sonicator. The sonication is carried out in a water bath thereby lowering the undesired heat which polymerizes the epoxy fluid. The sonication helps to disperse the nanoparticles uniformly throughout the epoxy polymer matrix. Hardener was added to the above mixture (Graphene- MWCNT & epoxy resin) 100:1 and stirred for 5 minutes with a stirrer. The mixture is pre-heated in an electric oven up to 45'C after adding the hardener 10:1. The mixture is heated in a controlled environment in an electric oven, then poured into the die and placed in a Petri dish. It is kept in an atmospheric condition for 12 hrs to cure.

3. CHARACTERISATION

3.1 Scanning Electron Microscope (SEM)

The SEM is a microscope that uses electrons instead of light to form an image. The scanning electron microscope has many advantages over conventional microscopes. The SEM has a large depth of field, which allows more of a specimen to be in focus at one time. Because the SEM uses electromagnets rather than lenses, this allows the researcher to have much more control in the degree of magnification. All of these advantages, as well as the actual strikingly clear images, make the scanning electron microscope one of the most useful instruments in research today.

Characterization Process

1) Sectioning

The sample for the microstructure examination is sectioned using a cutting machine with the supply of coolant. Sharp edges, burrs and any intervening deformed material is removed by rough grinding using an abrasive belt grinder.

2) Grinding

Grinding is performed in successive steps using silicon carbide abrasive papers. Emery papers having the grit sizes of 150, 240, 320, 400, 600, 800 and 1000 were used. On each paper the samples were rubbed for 20-30 minutes. Samples were rotated through 90 degrees between successive papers.

3) Mounting

The scanning electron microscope of Epoxy powder taken at (a) lower magnification of 25,000X and (b) higher magnification of 1,00,000X used in the investigation have been presented in figure 1(a) and (b) respectively. From figure 1 (a) it may be observed that particles of epoxy powder have irregular shapes. The particles have different sizes. Further it may be observed that epoxy powder contains small irregularly shaped particles taken at 25,000X magnification. From figure 1 (b) it may be observed that particles of epoxy powder have irregular shapes. The particles have different sizes. Further it may be observed that epoxy powder contains small irregularly shaped particles taken at 1,00,000X magnification.

The scanning electron microscope of 1.0 % (Graphene+ MWCNT) taken at (a) lower magnification of 25,000X and (b) higher magnification of 50,000X used in the investigation have been presented in figure 2(a) and (b) respectively From figure.2 (a) it may be observed that particles of graphene+MWCNT powder have irregular shapes. The particles have different sizes. Further it may be observed that graphene+MWCNT powder contains small irregularly shaped particles taken at 25,000X magnification. The size of a typical large irregularly shaped particle is in the range of 200- 200nm. The size of a typical small irregularly shaped particle is in the range of 20nm- 200nm and is observed that dispersed in the epoxy powder.

From figure 2 (b) it may be observed that particles of 1.0 % (Graphene+ MWCNT) powder have irregular shapes.

The particles have different sizes. Further it may be observed that 1.0 % (Graphene+ MWCNT) powder contains small irregularly shaped particles taken at 50,000X magnification. The size of a typical small irregularly shaped particle is the range of 2nm- 200nm and is observed that dispersed in the epoxy powder.

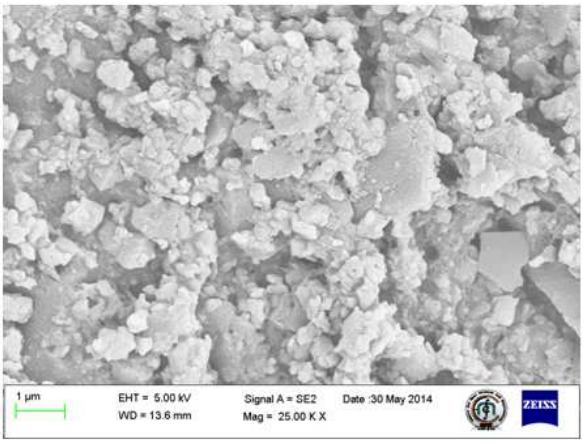


Fig 1a. scanning electron microscope of Epoxy powder taken at (a) lower magnification of 25,000X

Fig 1b. scanning electron microscope of Epoxy powder taken at (a) lower magnification of 1,00,000X

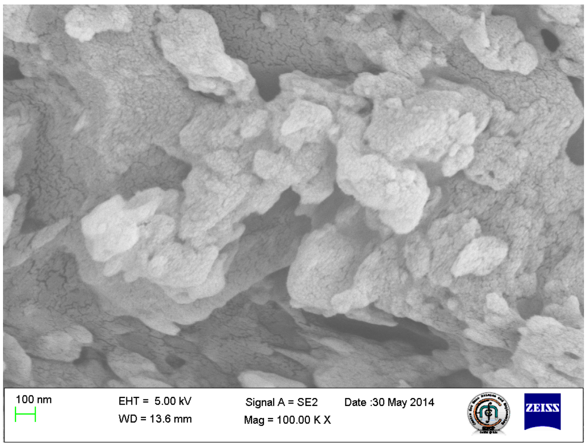


Fig. 2a. scanning electron microscope of 1.0 % (Graphene+ MWCNT) taken at lower magnification of 25,000X

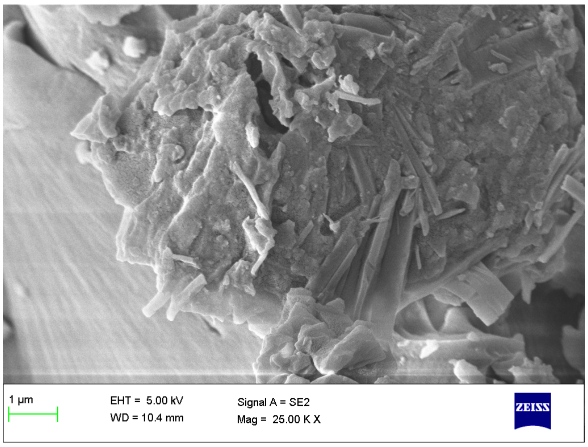
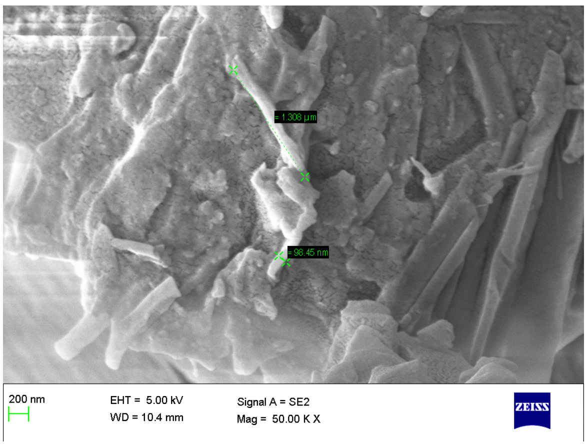


Fig. 2b. scanning electron microscope of 1.0 % (Graphene+ MWCNT) taken at lower magnification of 50,000X



4. RESULTS AND DISCUSSION

4.1 *Wear Test*

Wear can be defined as a process in which interaction of the surfaces or bounding faces of a solid with its working environment results in dimensional loss of the solid, with or without loss of material. In materials science, wear is the erosion of material from a solid surface by the action of one surface with another surface. It is more particularly related to surface interactions and the removal of material from a surface as a result of mechanical action.

A pin-on-disc apparatus was used to perform the wear experiment. The wear track, alloy and the composite specimens are cleaned thoroughly with acetone prior to each test. The pin specimen is pressed against the disc at a specified load usually by means of an arm or lever and attached weights. Other loading methods can also be used, such as hydraulic or pneumatic. Wear results are reported as volume loss in cubic millimetres for the pin and the disc separately.

When two different materials are tested, it is recommended that each material be tested in both the pin and disc positions. The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after the test, or by weighing both specimens before and after the test.

If linear measures of wear are used, the length change or shape change of the pin, and the depth or shape change of the disc wear track (in millimetres) are determined by any suitable metrological technique, such as electronic distance gauging or stylus profiling.

Some of the test parameters in wear test are as follows:

1. Load - Values of the force in Newton's at the wearing contact.

2. Speed - The relative sliding speed between the contacting surfaces in meters per second.

3. Distance - The accumulated sliding distance in meters.

4. Temperature - The temperature of one or both specimens at locations close to the wearing contact.

5. Atmosphere - The atmosphere (laboratory air, relative humidity, argon, lubricant, and so on) surrounds the wearing contact.

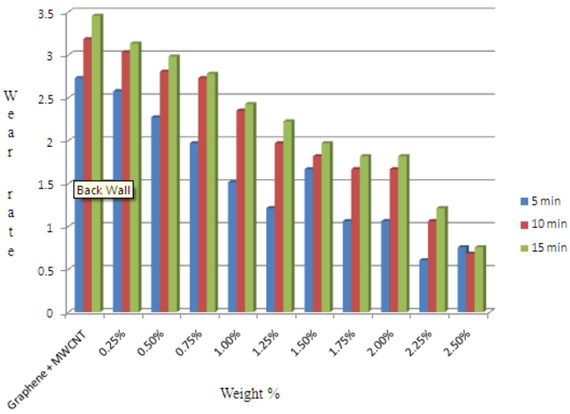
4.2 *Wear Test. (Pin on Disc Test)*

Material : Graphene+MWCNT
Load Applied =10N
Diameter of disc 84 mm
Speed of disc= 500 RPM
Wear time= 5, 10, 15 minutes

Fig. 3.Wear rate of Graphene +MWCNT for different weight fraction and time intervals

From the above figure 3. We can observe that wear rate decreases as the amount of addition of hybrid nanotmaterial.

5. CONCLUSION



The Graphene-MWCNT/epoxy hybrid nanocomposites have been fabricated and the reinforcing effect of graphene-MWCNT been investigated for reducing wear rate in the epoxy resin. It is shown that the blending of graphene- MWCNT a proper content of 0.25 wt.% into the epoxy matrix can simultaneously reduce wear rate. The composite wear test reach the minimum with an improvement of 0.5%, 0.75%, 1.25%, 1.50%, 1.75% and 2.0% for the reducing wear rate for different time proportion respectively. These are explained mainly in terms of the graphene-MWCNT/epoxy interfacial bonding at room temperature and the dispersion of graphene-MWCNT in the epoxy matrix. Consequently, graphene-MWCNT is a promising nano-modifier for reducing the wear rate of epoxy resins.

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