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Wear Behaviour of Carbon/Glass Fiber Vinylester Sic Nanocomposites

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Abstract—*The Nano materials must provide unique wear properties with low specific weight and high resistance to degradation in order to ensure safety and economic efficiency. The carbon / glass fiber reinforced vinylester /sic nanocomposite was fabricated by hand lay up techniques.The matrix material is taken as the vinylester resin and the reinforcement as the woven roving mat (glass fiber) and carbon fiber. The surface morphology of the carbon/glass fiber vinylester nanocomposite was analyzed by Scanning Electron Microscope (SEM). The enhancement effect of nano Sic was more significant in the vinylester carbon/glass fiber reinforced composite.*
The wear test was conducted by Pin on disk. Parameters used here are sliding distance, sliding velocity, load. The weight loss for each specimen and specific wear rate was calculated.The SEM images clearly show that the particles are uniformly dispersed and obtained intercalation structure.

Keywords: *Carbon fiber, E-glass fiber (WRM), Vinylester, Nano SiC, SEM.*

1. INTRODUCTION

Composite materials have been extensively applied to the areas of aerospace, aircraft, sports, and military industries. Advanced composite materials have progressed from a laboratory curiosity to a production reality. In recent years, polymer has been extensively utilized in structural and tribological components such as cams, brakes, bearings and gears because of their self-lubrication properties, lower friction and better wear resistance [1]. Wear is defined as progressive loss of material, due to relative motion between that surface and contacting substance or substances. The five main types of wear are abrasive, adhesive, fretting, erosion and fatigue wear, which are commonly observed in practical situations. More and more polymer composites are now being used as sliding components, which were formerly composed only of metallic materials[2]. The particle size, amount and the dispersion homogeneity within the matrix strongly influence the nanocomposite performance. One of the distinct advantages of nanocomposites over microcomposites is that the performance improvement is often acquired at relatively low concentration of the nanoclay.Varley et al. [3] studied the effect of three different nano-modifiers consists of organo-modified layered silicate, Vapor Grown Carbon Fibre (VGCF) and a triblock copolymer (SBM) upon key mechanical properties of carbon fibre reinforced laminates. They indicated that the addition of nanoclay could improve the notch sensitivity under compression.

By adding 1% of nanosic, E-glass/vinylester–sicnanocomposites attributed to almost 44%, 24% and 23 % improvement in interlaminar shear strength, flexural strength and fracture toughness in comparison to conventional S2-glass/epoxy composites.

Nanoparticles reinforced glass fiber composites have attracted more and more attentions. Nanoclayhave the ability in reducing friction and improving the wear resistance of polymers. In many commercial applications and in industries, the clay-nanocomposites have been extensively used.

The present paper focuses on the synthesis and characterisation of glass fiber epoxy nanocomposites filled with different Wt% of nanoclay by hand lay-up techniques. Then the prepared nanocomposites are characterised by using XRD and SEM.

2. EXPERIMENTAL PROCEDURE

2.1 Materials and samples preparation

The matrix material was vinylester resin with hardener Methyl ethyl ketone peroxide (MEKP) both provided by Huntsman.The glass fiber used in the form of woven roving Mat (WRM) and carbon fiber were used as a reinforcement material .The nano sic with size of 45- 65 nm was brought from US Research Nanomaterials, Inc.The primary step of the fabrication process involved in dispersion of nano SiC into the vinylester resin. For preparing nano SiC composites, both the resin and filler with desired proportion were carefully mixed using mechanical stirrer for 90 minutes at constant speed before the curing agent was added at a stoichiometric ratio in respect to the vinylester resin. Now the mixture (consisting of vinylester nano filler and curing agent) is applied over the reinforcement material(Woven roving mat and Carbon fiber) which has been cut to a size of (200x200mm). Six layers of mats are used to prepare a sample in that each mat is kept one

over the other by applying prepared mixtureby rolling operation using a roller over a moulding board(Figure.1). By the help of screw driver and hammer the samples are removed from moulding board after curing for 48 hours (Figure.2).

Fig. 1: Fabrication of Nanocomposites

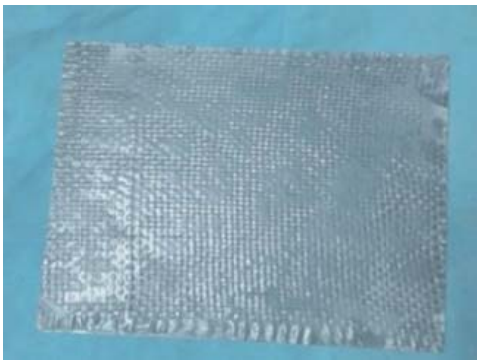

Fig. 2: Finished Sample After Curing

The finished samples are prepared for testing purpose.the sample are cut into different specimen as per the ASTM standards and characterised for SEM XRD and Wear test are made.

3. RESULTS AND DISCUSSION

3.1 X-Ray Diffraction (XRD)

X-ray diffraction experiments were performed to determine the structural characteristics of the nanocomposites and to evaluate the dispersion of nanoSic in vinylester resin. Three distinct morphologies are possible when nanoSic is dispersed into vinylester resin, they are phase separated, intercalated and exfoliated. Among these three morphologies intercalated and exfoliated structures are mostly desirable for improving the performance of the material For nanoSic samples the sharp reflection is noticed that after 3◦ the slopes are gradually decreased and do not show any sharp peak (Fig. 3 a and Fig. 3 b). So the absence of peak reflection in the nanocomposites suggests good intercalation of the Sic particles in the matrix.

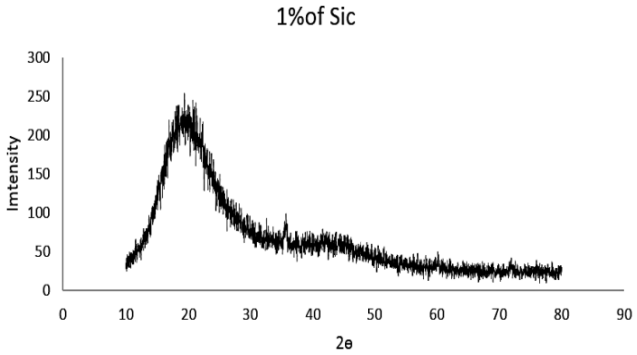

Fig. 3(a): XRD pattern of 1% nanoSic

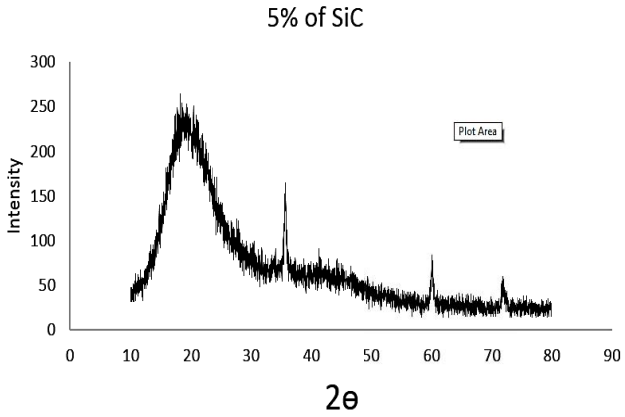

Fig. 3(b): XRD pattern of 5% nanoSic

3.2 Scanning Electron Microscopy(SEM)

Scanning electron microscope (SEM) is a straight forward technique to visualize the dispersion of nanoparticles within matrix and to study the structure of nanocomposites (intercalation/exfoliation). SEM pictures of Vinylester/ nanoSic are displayed (Fig. 4 and Fig. 5). A homogeneous dispersion of nanoparticles is clearly visible. Fig. 4 shows that the dispersion of nanoclay in the matrix is random and uniformly dispersed throughout the matrix. vinylester with 3% nanoclay at lower magnification shows agglomerated structure and the dispersion of the agglomerated particles throughout the matrix(Fig. 5).This agglomerated structure shows that at higher concentration the nanoSic dispersion is difficult in the matrix medium.

In 1% nanoSic specimen, particles are in fewer amounts and hence they are randomly distributed over the vinylester. But in 5 % nanoclay specimen, the concentration becomes high. The randomness becomes less and hence they are clustered together. The nanoSic introduced inside the vinylester act as grid lines of a net like a network chain

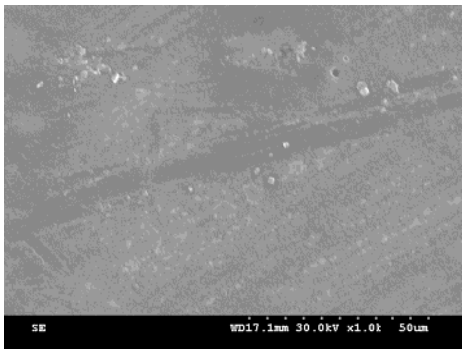

Fig. 4: NanoSic 1 % Distribution

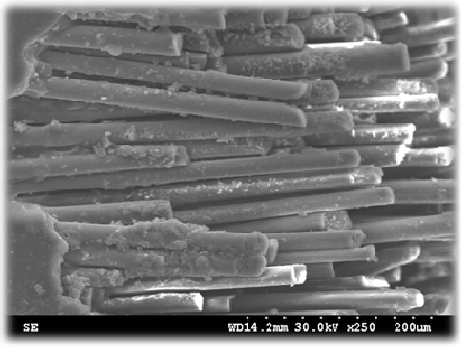

Fig. 5: Nanosic 5 % Distribution

3.3 Worn Surfaces Morphology

The sample was viewed under Scanning Electron Microscope (SEM) after wear test. The worn surfaces are shown in the fig.6 (a) and 6 (b) of the vinylester Nanocomposites. As the nanoSic content was increased, the fracture surface became rougher with much tearing effect .The worm surface of the unfilled Glass –Vinylester composite(Fig) shows both fiber and Matrix breakage and voids formation due to thermal softening of the matrix. In Sic filled Glass-Vinylester matrix well bonds between fiber and matrix and these hard particle are well protects the fiber from worn surface was relatively smooth and less damage to the Matrix was observed and as compared to lower load shows serve damage of both the composites.

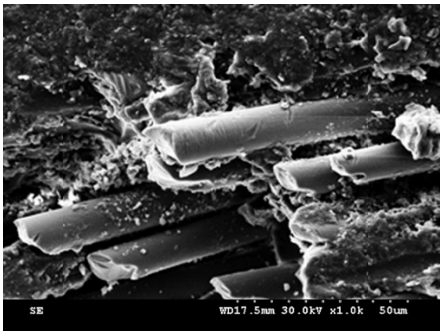

Fig. 6 (a): Worn Surface of 1% Nanosic

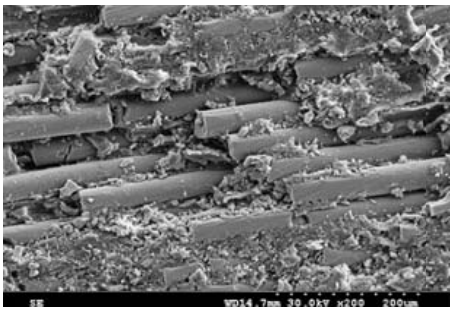

Fig. 6(b): Worn Surface of 5 % Nanosic

3.4 Wear Volume Loss

The wear loss of the composites increase with increase in the applied load and temperature. Due to thermal softening initially both types of composites the vinlyester matrix was detached from the composite surface after certain sliding distance shear deformed polymer matrix containing broken pulverized matrix powder which spreads on the counter surface. This remain there some times as a transfer layer on the steel counter face.in case of unfilled Glass – Vinlyster composites are there broken pulverized glass particles can act as a third body abrasive leading enhances the wear loss. While in case of nano Sic filled Glass –vinylester composite, pulverized debris from the surface of the composite consist of Nano Sic form a layer of transfer film which acts as a effective barrier to prevent the large scale fragmentation of vinylester .This phenomenon is more effective at the lower temperature ,but at higher temperature due to softening effect of the polymer reduces the debris formation and will not create film and failure of surface more on plastic deformation and deep scratches. Hence the wear loss of Glass-vinlyester composite is much higher than those of nano Sic filled Glass-vinylester composite at elevated temperature

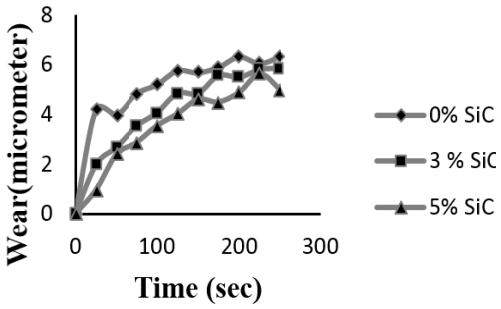

Fig. 7: Worn surfaces of the vinylester Nanocomposites (a) 0% nanoSic and (b) 3% nanoSic (c) 5% nanoSic.

The plot of wear rate as a function of temperature is shown in the Fig. 7 for 0%,3%,5% nanoSic.. The wear rate decrease with increase in the percentage of composition of Nano sic. As compare to the unfilled Glass fibre composite the Nano Sic

filled composite shows low specific wear rate at all condition and which acts as a anti wear additive. The result of present study is matched with several author who have discussed the role of hard powder as effective wear resistant filler in tribological studies

4. CONCLUSION

The nanocomposite were successfully prepared by varying % of 0,1,2,3,4 and 5.Sem image of 1 % of nano SiC shows that the particles are uniformly dispersed and obtained intercalation structure. 5% of nano SiC shows the uniform distribution of fiber over vinylester resin after adding of nanoSiC. The wear volume was less in the composite with 5% SiC filler as compared to that of unfilled glass-vinylester. Higher specific wear resistance (50%) was noticed for SiC-Glass-Vinylester composite than glass-vinylester composite, due to high strength and hardness of SiC filler.The weight loss for 3 and 5% decreases gradually due to the presence of nano sic because of good bonding between the fiber and the polymer.From the sem image after wear test revelaed that the addition of nano Sic carbon/glass fiber with vinylester resin gradually decreasae the fibre fracture, cracking, tearing of matrix etc. the XRD graph were plotted between intensity Vs 2ϴ. From the XRD pattern of 5% nanoSic obtained intercaliated structure due to the presence of more voids and 1% nano SiC shows the exfoliated structure due to absence of peak reveals that the filler material is uniformly disturbed over the vinylester resin.

5. ACKNOWLEDGMENT

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