Wear properties of nanoclay filled epoxy polymer

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ABSTRACT – Polymeric material is one of the best materials that are being used in many applications. This is owing to their excellent properties such as low density, good mechanical and good chemical resistance. The main objective of this research is to evaluate the effect of nanoclay on wear properties of epoxy polymer and fibre reinforced composites. The main materials used in this study were high temperature epoxy, hardener and nanoclay. While, woven fiberglass was used as fiber reinforcement in advanced fibre reinforced polymer (FRP) composite. The nanocomposites were fabricated using shear mixing system. The testing involved were dry sliding and slurry tests. The results showed that wear properties of pure epoxy system were enhanced when the weight fraction of nanoclay in the system reached up to certain weight percentage. Epoxy system with 3 wt% of nanoclay has higher wear properties when compared to pure, 1 wt% and 5 wt% of nanoclay in epoxy systems.

1. INTRODUCTION

Epoxy resins are advanced adhesive and versatile materials that can react with a variety of substrates. Some of the superiority properties of epoxy resins are excellent corrosion resistance, chemical and heat resistance, good in thermal and mechanical properties, high adhesion strength to various substrate, high electric insulation properties, excellent impact resistance, and low shrinkage during curing process and it can be processed in many conditions [1]. Callister [2] reported that the addition of nanofillers could further improve the properties of polymers. Although the effect of nanofillers on mechanical properties of polymers has extensively been studied by a number of researchers, the information on wear and tribological properties still lack and need to be studied. In previous researches, Lam and Lau [3] reported that the wear properties of nanocomposite were increased with increasing nanoclay content of up to 4wt%. Jawahar and co-workers [4] found the least coefficient of friction and highest wear resistance of nanocomposite with a clay content of 3 wt%. The results from their observation showed that the specific wear rates decreased when organoclay was added into the polymer system. In this project, the effect of nanoclay on wear properties of epoxy polymer and fibre reinforced composites is evaluated.

2. EXPERIMENT SETUP

In this project, Miracast 1517 epoxy supplied by Miracon (M) Sdn. Bhd. was used as resin system and nanoclay I.30E supplied by Sigma-Aldrich (M) Sdn. Bhd. was used as nanofiller. For the sample of pure epoxy resin, Miracast 1517 polymer was cured by Miracast 1517 hardener with ratio of 100:30. Then, the mixture was cured for 24 hours in room temperature. For advance FRP composite in this project, pure epoxy resin was applied on the woven fiberglass and these GFRP samples were produced using a vacuum bagging system. 1 wt.%, 3wt.% and 5 wt.% of nanoclay in epoxy samples were fabricated using high shear mixing process as shown in Figure 1. The mixtures were milled at 60 °C temperature and a speed of 12 m/s.

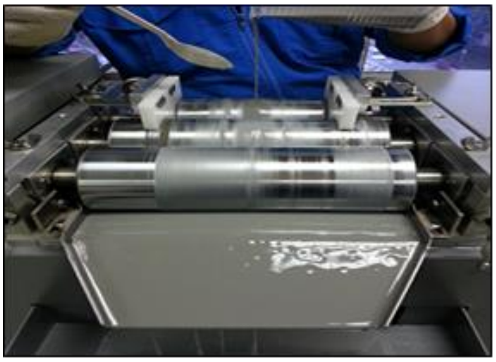

Figure 1 Fabrication of specimen.

Table 1 Operational parameters for dry sliding test.

Parameters	Experimental Conditions
Contact geometry	Cylinder on flat
Type of motion	Unidirectional sliding
Applied load	20 N
Sliding speed	267 rpm
Sliding distance	10000 m at interval 2000 m

Table 2 Operational parameters for slurry test.

Parameters	Experimental Conditions
Type of motion	Unidirectional sliding
Type of sand	Medium size (0.2 mm – 0.63 mm)
Sliding speed	267 rpm
Sliding time	20 hours at interval 4 hours
Sliding distance	10000 m at interval 2000 m

The specimens were tested using Abrasion Resistance Tester and Slurry Erosion Tester to evaluate the mass loss vs. distance of two different systems (a) epoxy polymer with and without nanoclay (b) Glass fibre reinforced polymer (GFRP) composite with and without nanoclay. Table 1 shows the summary of the operational condition for dry sliding test and Table 2 shows the operational parameters for slurry test.

3. RESULTS AND DISCUSSION

Mass loss over distance of the polymer nanocomposite and advanced GFRP nanocomposite were obtained from dry sliding test as shown in Figure 2 (a) and (b).

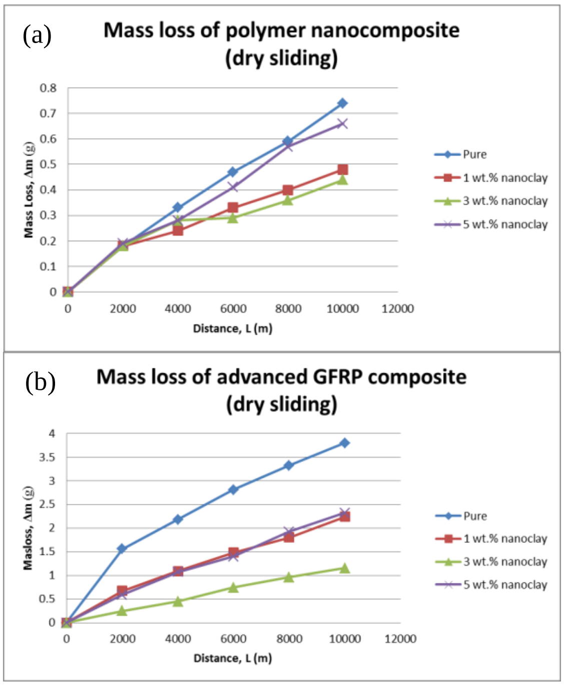

Figure 2 Mass loss vs. distance in dry sliding test of two different systems (a) epoxy polymer with and without nanoclay (b) GFRP composite with and without nanoclay.

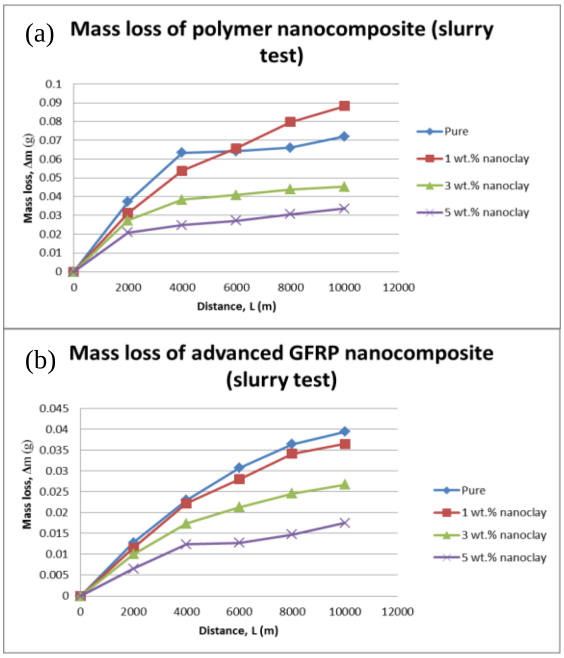

Figure 3 Mass loss vs. distance in slurry test of two different systems (a) epoxy polymer with and without nanoclay (b) GFRP composite with and without nanoclay.

The results showed that, based on the graphs, the mass loss for both nanocomposite and advanced GFRP nanocomposites was increased as the distance travel increased. For polymer nanocomposite, pure polymer system has the highest mass loss after traveled for 10000 m distance which was 0.74 g, whereas the lowest mass loss is at 3 wt.% of nanoclay filled epoxy polymer, which was 0.44 g. Pure GFRP composite recorded the highest mass loss after traveled for 10000 m which was 3.8 g while 1.15 g of mass loss was recorded for 3 wt.% of nanoclay filled GFRP composite which was the lowest mass loss after traveled 10000 m. These results showed that the mass loss of advanced GFRP composite system was higher than polymer nanocomposite due to the presence of high density continuous glass fibre in the polymer system. Figure 3 (a) and (b) show the results of mass loss over distance of the polymer nanocomposite and GFRP composite that were obtained based on slurry test. A similar pattern of results was obtained where the mass loss for both polymer and GFRP composite systems was increased as the distance travel increased.

4. CONCLUSIONS

The mass loss of both polymer and GFRP composite systems were obtained using dry sliding and slurry tests. For dry sliding test, the addition of nanoclay in epoxy polymer up to 3 wt% enhanced wear properties of polymer and GFRP composite. Further addition of nanoclay reduced the wear properties of the system. This may be due to the agglomeration of nanoclay particle in the system at high nanoclay content. For slurry test, the addition of 5 wt% nanoclay into epoxy polymer enhanced wear properties of both polymer and GFRP composite systems.

5. ACKNOWLEDGEMENT

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