ABSTRACT

Polymer and polymer composites are increasingly used in various industrial applications such as aerospace, automotive and chemical industries due to their high strength to weight ratio in comparison to classic materials. Attention of the academia and industry on material properties is largely focused on the mechanics of wear which is causing loss to the industry these days. Many tribological components such as bearings, impellers, cams, driving wheels, bolts, nuts, seals, bushes and gears are used in machinery. Work done in overcoming friction in mechanical components is dissipated as heat and its reduction will lead to an increase in overall efficiency. The energy losses in these tribological components can be reduced drastically by selecting a suitable polymer with different reinforcements and fillers.

An inclusive literature review was carried out to decide the choice of matrix and reinforcement materials. The current work focuses on investigating the use of flyash cenosphere particulates on the tribological characteristics such as friction and wear and mechanical characteristics such as tensile and flexural strength, of carbon fabric reinforced epoxy matrix composites.

The objectives of the current research work are given below

1. To evaluate the mechanical properties such as hardness, tensile and flexural properties of unfilled carbon epoxy (C-E) and silane-treated flyash cenosphere (FAC) filled C-E composites
2. To study the effect of filler on glass transition temperature (T_g) by dynamic mechanical analysis (DMA).

3. To understand the influence of the various parameters such as sliding distance, applied load and sliding velocity on friction and dry sliding wear behaviour of unfilled C-E and silane treated FAC filled C-E composites.
4. To evaluate the influence of the abrading distance, abrasive paper grit size and applied load on two-body abrasive wear behaviour of unfilled C-E and silane treated FAC filled C-E composites.
5. To study the influence of the parameters such as abrading distance and applied load on three-body abrasive wear behaviour of unfilled C-E and silane treated FAC filled C-E composites.

All composite samples were fabricated by hand lay-up technique. The mechanical tests were evaluated using Universal Testing Machine. The tribological tests were conducted using pin-on-disc apparatus and Dry sand/rubber wheel abrasive tester. The surface morphology of the worn surface in different wear experiments were analyzed using scanning electron microscope.

The mechanical properties such as tensile strength, tensile modulus, % elongation, hardness, flexural strength and flexural modulus of the unfilled C-E and silane-treated FAC filled C-E composites were studied. The results revealed that all silane-treated FAC filled C-E composites possessed higher tensile strength (σ) values, but lower values of elongation at break as compared to unfilled C-E composite. This was because addition of FAC treated with silane coupling agent helps in improving the interfacial adhesion between matrix and reinforcement. The viscoelastic properties such as storage modulus, loss modulus and tan delta with the response of the temperature of the unfilled C-E and silane treated FAC filled C-E composites were studied. The storage modulus of FAC

filled composites was increased by the stiffening effect of the FAC, which was particularly significant at higher temperatures.

Friction and dry sliding wear behaviour of unfilled C-E and silane treated FAC filled C-E composites for different applied load, sliding velocity and sliding distance were studied. It was found that wear volume loss of both unfilled C-E and silane-treated FAC filled C-E composites increased with an increase of applied load/sliding velocity. But silane-treated FAC filled C-E composites had a minimum wear volume loss when compared to unfilled C-E composites. During the dry sliding wear when FAC filled C-E composites were in contact with the counter surface of the disc, the FAC particles stuck out from the sample surface. These FAC particles along with the C-E abraded the counter surface and form the transfer layer on the counter surface of the disc, leading to drop in wear volume loss.

Two-body abrasive wear behaviour of unfilled C-E and silane treated FAC filled C-E composites under the parameters of applied load, abrasive particle grit size against the various abrading distances were studied. Wear volume loss of unfilled C–E was higher than those of FAC filled C–E composites and the wear volume loss decreased with the increasing weight percentage of filler. It can be attributed to better inherent mechanical properties and self-lubricating nature of FAC. The specific wear rate is decreased with increasing abrading distance and grit size. The three-body abrasive wear experiments were conducted for unfilled C–E and FAC filled C–E samples as a function of various abrading distances using quartz and silica sand as abrasives. The results showed that irrespective of the sample and load, wear volume loss was found to increase

with increase in abrading distance. This can be explained by the fact that when the abrasive particles got entrapped between the rubber wheel and the composite sample, due to the high stress of the hard abrasive particles, ploughing action took place on the sample surface leading to removal of more matrix material. The lowest wear loss was noticed for composites containing C-E with 6 wt% FAC fillers for both types of abrasive. Specific wear rate data revealed the fact that it tended to decrease with increasing abrading distance. However, the higher filler loaded, that is, 6 wt% FAC filled C-E exhibited the lowest specific wear rate for all abrasives and abrading distances.

The results of the study revealed that improved tribological properties and mechanical properties of carbon fabric reinforced epoxy matrix composites can be obtained by adding silane-treated FAC particulate fillers.