FRICTION AND WEAR BEHAVIOUR OF POLYMER MATRIX COMPOSITES – A REVIEW

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Abstract - Present days polymer composites are most generally used composites due to their high strength to weight ratio, low cost and simple fabrication process. This kind of the composite showing an excellent strength to wear resistance. In this review presents the friction & wear behaviour of the polymer composites and used the various test apparatus. Result reveals that polymer composites filled by various filler material such as SiC, WC, SiO2 and Graphite particles etc. Effect of this fillers it improves the properties of PMC like flexural strength, shear strength and wear resistance etc.

Keywords – Polymer composite, Filler, Friction and Wear.

1. INTRODUCTION

Composites are thus made by combining two distinct engineering materials in most cases one is called matrix that is continuous and surrounds the other phase – dispersed phase. The properties of composites are a function of the properties of the constituent phases, their relative amounts, and size-and-shape of dispersed phase. They consist of mainly three different types. Among them polymer matrix composite (PMC) and metal matrix composite (MMC) are the commonly used in large scale. Fibers place an important role in the field of industries, automobile, military applications. Over the past years, polymer composites are made and most commonly used for structural applications in the aerospace, automotive, and chemical industries, and in providing replacements to traditional metallic materials.

1.1 Fiber

Polymer composites are mixtures of polymers with inorganic or organic additives having certain geometries (fibers, f-lakes, spheres, particulates). Thus, they consist of two or more constituents & two or more phases. The additives may be continuous, e.g. long fibers or ribbons. This type of composite is used in the highest diversity of composite applications due to its advantages such as low density, good thermal, ease of manufacture, and low cost. The properties of polymer matrix composites are generally determined by three constitutive basics such as the types of reinforcements (particles and fibres), the type of polymer, and the interface between them. Polymers are allocated into two categories such as thermoplastics and thermosets. Thermoplastic are in common, ductile and tougher than thermoset materials. They are reversible and can be redesigned by present of heat and pressure. Thermoplastic molecules do not cross-link and so they are flexible and reformable. The most general resin materials utilized in thermoset composites are epoxy, polyester, phenolic, vinyl ester, and polyimides.

1.2 Filler

Depending on the sort of filler forms the addition strength to the mechanical properties and tribological properties of the polymer composite materials. In this fillers SiC, WC, SiO2 and Graphite particles etc are used as reinforcement it will increase the properties like tensile strength, young's modulus, flexural strength and wear resistance.

2. LITERATURE SURVEY

B. Suresha et al [1] compared carbon-epoxy (C-E) composite with that of glass-epoxy (G-E) composites for tribological properties using a pin-on-disc set up. The experiment are conducted under different sliding and loading conditions by subjecting C-E samples sliding against a hard steel disc (62 HRC). This paper presents the friction and wear behavior of C-E and G-E composites run for a constant sliding distance, where in the C-E composites show lower friction and lower slide wear loss compared to G-E composites irrespective of the load or speed employed.

Nak–Ho Sung et al [2] investigate the friction and wear behavior of composites varying fiber orientations with respect to the sliding direction. Both wear and friction coefficients of graphite fiber-epoxy composites were minimum when the orientation of the fibers was normal to the sliding surface. When the largest fraction of fibers was oriented normal to the sliding surface, glass fiber-Moss-PTFE composites wear was minimum. In Kevlar-epoxy composites the wear rate was minimum but the friction coefficient was the highest, when the fibers were oriented normal to the surface and the sliding direction.
Kishore et al [3] studied the slide wear characteristics of a glass–epoxy (G–E) composite, filled with either rubber or oxide particles using a block –on – roller test configuration. At three different loads of 42, 140 and 190, mass loss was determined as a function of sliding distance for sliding velocity between 0.5 and 1.5 m/s. Study showed that oxide

bearing G–E materials resist wear better at low loads compared to rubber bearing ones, the situation reverses at higher loads. The oxides being hard and refractory are effective as wear resistant medium at low loads. The work shows depending on the wear regime a selective filler material will work best as there is a change in the wear pattern observed between the two fillers.

S. Basavarajappa et al [4] investigated the tribological behaviour of glass epoxy polymer composites with SiC and Graphite particles as secondary fillers under dry sliding conditions using a pin-on-disc wear rig. The study showed that the inclusion of SiC and Graphite as filler materials in glass epoxy composites will increase the wear resistance of the composite greatly. Experiments approach by taguchi method enabled used to analyze the wear behavior of the composites with filler material, load, sliding distance and sliding speed.

N.V. Klaas et al [5] carried out the wear tests under ambient temperatures with no lubricant as well as in distilled water at an average sliding velocity of 0.2 m/s and contact pressures of 2.6–6.4 MPa. The forms of glass fibres, glass beads and glass flakes, each with a content of 25% weight were used and hollow and solid glass beads were used in this study. The glass bead filled PTFE revealed comparatively thicker films and greater wear rates than other forms of glass filled grades. The glass fibres and solid glass beads showed the lowest wear whilst hollow beads showed the highest under both low and high pressures due to crumbling and crushing of the beads during the sliding process. The glass flake filled PTFE revealed moderately high but steady wear results up to 4.5 MPa above which the wear rate improved dramatically.

N.S. El-Tayeb et al [6] presents an experimental study of friction and wear properties of a unidirectional oriented E-glass fiber reinforced epoxy (EGFRE) composite. For different sliding surface conditions. Friction and wear experiments were conducted using a pin-on-ring technique. Determined the friction coefficient and wear rate at various normal loads and sliding velocities. The friction and wear behavior of the E-GFRE composite increase in either load or speed decreases the friction changes with the surface conditions which dominate the wear process. Microscopic observations of the worn surfaces allowed detecting the involved different wear mechanisms.

S. Basavarajappa et al [7] examined the comparative performance of glass–epoxy composite with influence of graphite filler under varying applied load, sliding distance and sliding velocity by using a pin-on-disc set up. In a glass–epoxy composite higher weight loss was recorded by the increased applied load situation. Addition of Graphite in glass–epoxy composite exhibit lower weight loss, whose value drops further when the content of the graphite in the composite is increased. SEM analysis has been made to identify the phenomenon of wear as a function of applied load, sliding distance and sliding velocity.

Mainak Sen et al [8] carried out experiment on woven E-glass fiber reinforced polymer (GFRP) composite prepared through vacuum assisted resin transfer molding process to investigate its tribological performance. Friction and wear tests are carried out using block-on-roller arrangement under dry sliding conditions. Wear and friction revealed a tendency to increase with increase in time, load and sliding velocity, but at higher load and sliding velocity. Investigated friction and wear properties of glass fiber reinforced composite are greatly influenced by laminate orientations with respect to sliding direction.

T. Madhusudhan al [9] study was carried out on Silicon Carbide (SiC) filled, different combination of hybrid composites to determine the two body abrasive wear behavior. Fabricated Glass –Sisal-Epoxy, Glass-Jute-Epoxy and Glass-Rubber-Epoxy composites with different weight percentage of silicon carbide filler was subjected to two body abrasive wear test by using pin-on-disc equipment. The effect of filler content on the 0, 5, and 10wt% was revealed for 20N load for different sliding distance 25m, 50m, 75m, and 100m. The results revealed unfilled polymer composites displays higher wear loss when compared to composites filled with SiC filler.

M. Ivosevic et al [10] studied the thermal sprayed coating based on polyimide matrix filler to improve the erosion and oxidation resistance of PMC with varying volume fractions of WC-Co. Coated and uncoated samples are investigated by four independent variable coating system, angle of incident of erodent, erosion temperature and erosion time. The result indicated that coating system was comparatively insensitive to the angle of erodent by erosion volume data, incident from 20 to 90 degree and temperature increases from 20’C to 250’C.

A.P. Harsha et al [11] studied the erosive wear resistance of unidirectional glass and carbon fiber epoxy composite and bidirectional E-Glass fabric reinforcement epoxy composites at normal incidences. The study showed the bi-directional Glass fiber reinforced epoxy composite showed better wear resistance than unidirectional reinforced composites. The erosive behavior of epoxy composites is controlled by type of fiber and its arrangements. The steady-State erosion rate of epoxy ant its composites increased with increase in impact velocity from 25 to 60 m/sec.

N. Mohan et al [12] investigated and analyzed the effect of incorporation of tungsten carbide (WC) powders on erosive wear behaviour in glass fabric-epoxy (G-E) composites. Specimens were fabricated by using the vacuum-assisted resin infusion (VARI) technique. Compared to unfilled G-E composites the WC filled G-E composite exhibited a lower erosion rate. Under consideration exhibits brittle erosive wear, the influence of impingement angle on erosive wear of all composites behavior with maximum erosion rate at 900 impingement angle. The worn surface features of unfilled and filled G-E composites were examined using scanning electron microscopy (SEM)

T. Madhusudhan al [13] investigated the two-body abrasive wear test with different loads and abrading distances by using a pin on a disk set up. Studied the surface hardness strength of SiC filled hybrid composites and result showed that the wear volume increased with increasing abrading distance and the specific wear rate decreased with increasing abrading distance and load for SiC particle filled Hybrid composites. The least wear rate was the found for the material with 10%SiC G-R-E with load of 40N speed 300rpm and abrading distance of 75m.

I. Crivelli Visconti et al [14] studied the wear behaviour of composite materials, sliding under dry conditions against smooth steel counter face. The three different systems of matrix was reinforced to glass woven fabric (epoxy resin filled with powders of tungsten carbide, epoxy resin filled with powders of silica, epoxy resin). Laminates were fabricated by hand lay-up method. The sliding test was conducted by using a pin on disc set up on the specimen. The investigation show that composite with the matrix filled with WC powder presented the highest value of wear resistance in more severe wear conditions. . The different wear behavior of composite material has been analyzed by SEM-micrographic.

B.R. Raju et al [15] conducted experiment on three-body abrasive wear behaviour of glass-fiber reinforced epoxy matrix filled with different proportions of very fine SiO2 particles. Specimens of G-E (0, 5, 7.5 and 10 wt %) of SiO2 filler were tested under different loads and abrading distances. The result show that maximum wear volume and specific wear rate in unfilled G-E composites and decreasing wear rate by increasing SiO2 filler for G-E composites. The study of wear volume, specific wear rate and examination of the worn surface morphological features by scanning electron microscopy (SEM) were investigated.

3. CONCLUSION

The following are the key observations that emerge from this review.

1. Friction and wear characteristics of fabric reinforced epoxy composite systems be influenced by on the kind of fabric material.
2. The slide wear behaviors of C-E samples are greatly superior compared to G-E composites due to the existence of carbon fibers, which act as a self-lubricating material.
3. In graphite fiber-epoxy composites, both wear and friction coefficients were minimum when the orientation of the fibers was normal to the sliding surface. In Kevlar-epoxy composites, the wear rate was also minimum but the friction coefficient was the highest, when the fibers were oriented normal to the surface and the sliding direction.
4. The investigation reveals that whereas oxide bearing G–E materials resist wear better at low loads compared to rubber bearing ones, the situation reverses at higher loads.
5. The incorporation of the SiCp particles in the polymer matrix as a secondary reinforcement increases the wear resistance of the material.
6. Addition of Graphite in glass–epoxy composite exhibit lower weight loss, whose value drops further when the content of the graphite in the composite is increased.
7. Formation of transfer lubricating film on the counter surface results in reduced friction and wear.
8. The polymer composite with the matrix filled with tungsten carbide powders showed the highest value of wear resistance in more severe wear conditions.

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