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Investigation of Wear & Friction Characteristics of Laminated Polymer Matrix Composite at Different Temperature - A Review

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ABSTRACT

The use of polymer matrix composites is in boom in many structural, industrial, automotive, and engineering applications. Polymer matrix composites have been turned out the most hopeful material which can replace the conventional materials, metals, and woods. Owing to this the demand for analyzing the tribological behavior of FRPCs is amplified. In the current article an inclusive literature survey on the tribological behavior of FRPCs in terms of friction and wear properties of composite materials is explored. The paper reviews the effects of different operating parameters and material parameters on wear rate and frictional behavior of FRPCs. The analysis reveals that operating parameters like sliding velocity, sliding distance, load, temperature and material parameters like a fiber volume fraction, orientation of fibers , fiber length, filler content, and effect of surface treatment have a significant effect on the tribological behavior of composite material. The wear rate of FRPCs is controlled by adding the proper amount of filler content and fiber orientation.

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I. INTRODUCTION

Polymers and their composites form a very important class of tribo-engineering materials and are invariably used in many mechanical components, such as gears, cams, wheels, impellers, brakes, seals, bearings, bushes, bearing cages etc., where adhesive wear performance in non-lubricated condition is a key parameter for the material selection

Many polymer and polymer based composites are widely used for sliding couples against metals, polymers and other materials. However, where the contact is there, there is problem of friction and wear. The friction between polymers can be attributed to two main mechanism, deformation and adhesion. In this case, the deformation mechanism involves complete dissipation of energy in the contact area while the adhesion component is responsible for the friction of polymer and is a result of breaking of weak bonding forces between polymers and is a result of breaking of weak bonding forces between polymer and chains in the bulk of the material. In fact, triibologists often classify thermoplastic polymeric materials into three distinct groups according to their friction and wear behavior. Numerous nano particle used as oil additives have been investigated in recent years. Results show that they deposit on the rubbing surface and improve the tribological properties of the base oil, displaying good friction and wear reduction.Results showed that wear rates and friction stability were affected by the relative amounts of solid lubricants in the friction composites. There are very good effect of using graphite content wear rates were decreased significantly. The field of tribology deals with design, friction, wear and lubricating surfaces, in relative motion .

In most of these cases the materials are subjected to stringent conditions of loads, speeds, temperatures and hazardous environment.

II. LITERATURE REVIEW

[1].Yousong Sunet.al the authors in this paper have discussed Carbon fabric reinforced composites have drawn much attention currently. Special carbon fabric reinforced composites were fabricated with surface layers modified by carbon/PTFE hybrid fabrics. The tribological properties of these composite s under heavy loads were evaluated. There results showed that tribological properties of the composite were improved with increasing the PTFE content. The friction coefficient, volume wear and temperature rise of the composite with 6yarns of PTFE were reduced by 40%, 91% and 64% respectively in comparison with the composite without PTFE. After testing, PTFE could be observed over the entire wear groove surface, including the bottom.

[2] Xinrui Zhang et.al the authors in this paper have discussed Carbon fabric/phenolic composites modified with potassium titanate whisker (PTW) were prepared by a dip-coating and hot-press molding technique, and the tribological properties of the resulting composites were investigated systematically using a ring-on-block arrangement under different sliding conditions. Experimental results showed that the optimal PTW significantly decreased the wear-rate. The worn surfaces of the composites and the transfer film formed on the counterpart steel ring were examined by scanning electron microscopy (SEM) to reveal the wear mechanisms .It is observed that the wear-rate increased with increasing applied load and sliding speeds.

[3] Li Wenbin et.al the authors in this paper have discussed Carbon fabric/phenolic composites with different weave filaments counts were prepared by dip-coating and hot-press techniques, and then their mechanical and wet tribological properties were investigated based on the analysis of the three-dimensional surface profiles and the pore structures. Results show that the mechanical properties (elastic modulus, flexural modulus, tensile modulus, flexural strength and tensile strength) of the 3K carbon fabric/phenolic composites (Composite A) are better than thatof the 12K carbon fabric/phenolic composites (Composite B). The wear rate of Composite B is 39% greater than that of Composite A and the wear features of worn surfaces demonstrate the excellent wear resistance for Composite A. Based on the observation of worn surface, the wear mechanisms are presented.

[4] Hiral H Parikh et.al In the current article an inclusive literature survey on the tribological behavior of FRPCs in terms of friction and wear properties of composite materials is explored. The paper reviews the effects of different operating parameters and material parameters on wear rate and frictional behavior of FRPCs. The analysis reveals that operating parameters like sliding velocity, sliding distance, load, temperature and material parameters like a fiber volume fraction, orientation of fibers, fiber length, filler content, and effect of surface treatment have a significant effect on the tribological behavior of composite material..

[5] Seyyed vahid Mortazavianet.al This literature review presents a broad review of the many factors influencing cyclic deformation, fatigue behavior, and damage development inSFRPCs. These include micro structural related effects as well as effects related to loading condition and their service environment. Micro structural related effects include those related to fiber length, content and orientation, surface treatment, and failure mechanisms. Cyclic deformation and softening, viscous characteristics, and dissipative response used to characterize and model their fatigue damage behavior and accumulation are discussed.

[6] JieFei et.al the authors in this paper have discussed the Four kinds of paper-based friction materials reinforced with carbon fibers of 100 , 400 ,600 and 800 µm were prepared by paper-making processes .Experimental results showed that the friction materials became porous with fiber length increasing. The friction torque curves were flat except the sample with 100 µm fibers. The wear rate of the sample with 100 µm fibers was only 1.40_10_5 mm 3/J. Tiny debris and fine scratches form edinthe worn surface were there as on for excellent wear resistance of friction pairs with100 µm fibers. The friction pairs with 400,600 and 800 µm fibers showed typically abrasive wear and fatigue wear.

[7] Ning Liu et.al the authors in this paper have discussed the laminate composite of ultra high molecular weight polyethylene (UHMWPE)/high strength glass fabric (S-glass fabric)/phenolic resin was prepared, in which UHMWPE micro particles were etched by chromic acid and S-glass fabrics were treated by silane coupling agent. The inter laminar shear strength(ILSS) and tribological properties of the composite in water environment were investigated, in comparison with those of the composite without any treatments on fillers and the composite with single treatment on UHMWPE. Results showed that the composite with the combined treatment exhibited the best interfacial bond, accordingly showing remarkably enhanced water repellency,

[8] N. Mohan1 This literature review presents a broad review of the introduction of ceramics such (Sic, Al2O3, Tic, etc.) as within the matrix notably increases the friction coefficient and reduces the wear loss. In this work an attempt was made to evaluate the mechanical properties and tribological behavior of glass fabric reinforced- epoxy (G-E) composites and silicon carbide filled glass fabric reinforced-epoxy (Sic-G-E) composites. The fabricated wear specimens were tested by using pin-on-disk test rig at various temperatures. The wear loss in both the composites increases with increase in temperature/applied load and under the same conditions the specific wear rate increases..

[9] Qihua Wang et .al This literature review presents a broad review of the carbon fabric composites filled with several Nano particles were prepared by dip-coating and hot press molding technique. The friction and wear behavior of the resulting composites were studied systematically using a block-on-ring arrangement. Experimental results showed that the optimal content of nano particles as fillers

contributed to improve the tribological properties of the carbon fabric composites.

[10] A. Shalwan et.al the authors in this paper have discussed the mechanical and tribological performance of the epoxy composites based on graphite filler and/or date palm fibers are comprehensively discussed. The influence of the date palm fiber and/or graphite filler on the microstructure of the materials, tensile fracture samples, and worn surface of tribological samples are examined using scanning electron microscopy. The addition of the graphite is highly recommended for the natural fiber / polymer Composites which can assist to reduce the friction which in turn enhances the wear characteristics of the polymer composites;.

[11] B. Shivamurthyet.al the authors in this paper have discussed the Multi-layered laminates of bi-directionally woven E-glass fabric/epoxy with different loading of graphite particles were made by hand layup followed by compression molding. Tensile and flexural behaviors, impact strength, hardness and density of these laminates were determined. Wear behaviors of these composites were investigated by a pin-on-disc wear test apparatus. Specific wear rates of these composites strongly depend on their filler content and applied normal loads
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,[12]Dongya Zhang et.al the authors in this paper have discussed the laminated composites reinforced with the strong and weak layers were fabricated by lamination bonding process in compliance with bionic multilayer structures. The strong layers were silicon steel sheets and the weak layers were polymer matrix filled with MoS2 and graphite. The experimental results showed that the laminated composites have excellent load bearing capacity. Moreover, the laminated composites exhibit remarkable low friction and high wear resistance,

[13] Pramendra Kumar Bajpai et.al The present study explores the possibilities of reinforcing thermoplastic bio-polymer with locally available inexpensive plant fibers for developing a new tribo-material. Three different types of natural fibers (nettle, grewiaoptiva and sisal) were incorporated into PLA polymer to develop laminated composites using a hot compression technique. TGA analysis was carried out to investigate the thermal stability of developed composites. The experimental results indicate that incorporation of natural fiber mats into PLA matrix significantly improves the wear behavior of neat polymer. There was 10–44% reduction in friction coefficient and more than 70% reduction in specific wear rate of developed composites as compared to neat PLA.

[14] Gai Zhao et.al In the present work friction and wear of polyamides reinforced by carbon, glass and aramid fibers were studied and comparatively evaluated under dry sliding against sandpaper and steel rig as well as under three-body abrasive conditions. The worn surfaces of the composites were examined by scanning electron microscopy to reveal mechanisms of materials damage. The best performance under tests conditions was shown by inorganic fibers reinforced composites due to the effective sharing of the load between surfaces in contact.

[15] JianingZhanget.alIn this work, the effects o f nanoparticles on the tribological performances of epoxy-based composites were systematically investigated on a ball-on-plate apparatus in dry sliding conditions with a hardened steel ball .A series of nano silica/epoxy nano composites were fabricated ,using nanoparticles prepared by a specials ol–gel technique,welldispersedupto20wt%. .It was found that the continuous transfer film on the steel ball could be formed only with relatively high nano particle contents, ≥10wt%,which may play a key role in determining the wear performance of nano composites in steady wear stage

[16] R. Petrucci et.al This work concerns the production by vacuum infusion and the comparison of the properties of different hybrid composite laminates, based on basalt fiber composites as the inner core, and using also glass, flax and hemp fiber laminates to produce symmetrical configurations, all of them with a 21–23% fiber volume, in an epoxy resin. The laminates have been subjected to tensile, three-point flexural and inter laminar shear strength tests and their fracture surfaces have been characterized by scanning g electron microscopy. The mechanical performance of all the hybrid laminates appears superior to pure hemp and flax fibre reinforced laminates and inferior to basalt fiber laminates.

[17] Songbo Xu et.al the authors in this paper have discussed the Carbon nano fibers (CNFs) with silane coatings were added into high density polyethylene (HDPE) to improve the tribological properties of the nano composite material. The nano composites were fabricated with various weight percentages of carbon nano fibers. The wear and friction tests were performed on a pin-on-disc tribometer under phosphate buffered saline lubricated condition. Compared with the neat HDPE, the friction coefficients of the nano composites were reduced in all samples, yet only a couple of nano composite samples showed lower wear rates.

[18] JieFeiet.al the authors in this paper have discussed the Four kind s of carbon fabric reinforced phenolic resin composites were fabricated by the impregnation technique in the present study. And the effect of phenolic resin on friction and wear performance of the composites was investigated. Experimental results showed that the friction torque curves of the samples wear every flat during the mixed asperity contact phase of the engagement except the sample with 30wt%resincontent.The dynamic friction coefficient (md) decreased with the increase of resin content ,but the friction coefficient ratio increased.

[19] H.Unalet.al the authors in this paper have discussed the friction and wear performance of pure polyamide-6(PA-6),5wt%,15wt% graphite filled polyamide-6 and 4 wt% wax filled polyamide-6(PA-6þ4% wax) sliding against stainless steel under dry sliding conditions were studied using a pin-on-disc tribometer .The in fluencies of filler type, content, applied load and sliding speed on tribological properties were investigated.. The result showed that ,the friction coefficient for PA6 and P A6 composites increases with the increasing load and sliding speed values while wax filled composite showed insensitivity to the change in load values.

[20] Siddharthaet.al the authors in this paper have discussed the Investigations on mechanical and wear characteristics

of TiO2 reinforced homogeneous epoxy composites and its functionally graded composite materials developed for tribological applications are presented. The effect of various Operational variables, material parameters and their interactive influences on specific wear behavior of these composites has been studied systematically. A series of test are conducted on a pin-on-disc machine with three sliding velocities epoxy–TiO2 epoxy graded composites exhibited lowest specific wear rate TiO2 particle additions on epoxy graded composites have a dramatic effect on the flexural strength, tensile modulus and impact strength in comparison to homogeneous composites

[21] S.R.Chauhan et.al the authors in this paper have discussed the effect of fiber loading on mechanical properties, friction and sliding wear behaviour of vinyl ester composites under dry and water lubricated conditions under variation of normal applied loads and sliding speeds. Friction and wear experiments were carried out at ambient conditions on a Pin on disc machine arrangement. From the study it has been found that higher fiber content though improves some of the mechanical properties but also affect adversely some of the properties. The friction and wear properties of vinyl ester are improved by the addition of glass fiber as reinforced. The coefficient of friction increases with increase in applied normal load and sliding speed under dry sliding condition and decreases with increase in the applied normal load under water lubricated condition,

[22] S.R. Chauhanet.al the authors in this paper have discussed tribological performance of pure vinylester (V), glass fiber reinforced (GFR), SiC filled glass fiber reinforced vinylester composite under dry and water lubricated sliding conditions. Friction and wear tests were carried out with configuration of a pin on a rotating disc under ambient conditions The results showed that the coefficient of friction decreases with the increase in applied normal load values both under dry and water lubricated conditions.

[23] B. SURESHA et.al the authors in this paper have discussed Friction and dry sliding wear behavior of unidirectional (UD) oriented carbon-epoxy (C-E) composites has been studied using block-on-roller test set up. The dry sliding wear experiments were conducted for the following C-E composites namely parallel and anti-parallel surfaces with respect to the sliding direction. The coefficient of friction and wear of the composites for two different loads and various sliding velocities have been determined. It was observed that the wear loss increases linearly with increase in sliding velocity/loads.

[24] B. SURESHA et.al the authors in this paper have discussed about Polymer materials when reinforced with high modulus fibers yield higher strength, higher stiffness, better toughness, and good dimensional stability. Fiber reinforcements are effective in reducing wear in adhesive situations in addition to increasing the strength and stiffness In this particular investigation, carbon-epoxy (C-E) composite is compared with that of glass-epoxy (G-E) composites for tribological properties using a pin-on-disc set up.. This article highlights the friction and wear behavior of these 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.

[25] N.S.M. El-Tayeb et.al the authors in this paper have discussed Friction and wear properties of polyester composite reinforced with laminated glass fibres are experimentally examined in three different orientations, namely, cross-laminar CL, and inter-laminar (normal, NL and parallel, PL) The rubbing experiments of the composite specimens are carried out against abrasive paper (silicon carbide, P600) under various sliding speed and loading conditions. Experimental results show that PL orientation gives the highest value of friction coefficients followed by NL and CL. Microscopic investigations of the worn surfaces are conducted to identify the operating wear mechanism

III.CONCLUSION

After studying the above research paper we have concluded that tribological characterization of various fiber polymers has been carried out by many researchers. The main factors that affect the friction and wear properties are either operating parameters or material parameters. In the operating parameters most influenced parameters are load, sliding distance, sliding velocity, and ambient temperature while the material parameters are fiber length, fiber orientation, and fiber volume fraction. Along with this chemical and physical treatment, types of fillers and manufacturing techniques play an important role in friction and wear properties.

Most of all the research on composites have been carried out without finding the effect of high temperature and lubrication, different fiber orientation in laminated composites but in actual application temperature, lubrication , different fiber orientation in laminated composites might be involved so the experiments can be explored to find out the effect of temperature, lubrication , different fiber orientation in laminated composites on the wear rate.

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