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Investigation of Wear and Load Carrying Capacity of Polyamide Composites for Gear Application

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Abstract: Plastic gears are widely used in mechanical devices such as photocopier machines, printers, automatic teller machines under oil-less conditions. Plastic gear materials undergo degradation from high temperature caused by accumulated heat which results in severe wear or early fracture. This wear can be reduced by using different composites of polymer material. Generally thermoplastic polymers like acetal polymer and nylon polymer are used for gear applications. The objective of this Dissertation work is to evaluate the influence of test speed and load on the wear behaviour of polyamide 66 reinforced with increasing amount of glass fibers under dry condition .Wear tests of PA66 against EN8 steel disc is carried out on pin on disc arrangement. Tribological test are performed at room temperature. Mechanical properties like tensile test and hardness test are investigated in accordance with ASTM standards. Scanning electron micrographs are used to analyze fracture morphologies. The wear loss of the composites are compared at different loads and sliding velocities.

Keywords: Polyamide (PA66), Plastic Gears.

I. INTRODUCTION

Composite materials provide an opportunity to combine different properties and design materials for applications requiring multiple functionalities. Over the past decades, injection molded thermoplastic composites have been increasingly used for various mechanical and tribological purposes such as seals, gears and bearings. These materials are light in weight and are better alternatives to metallic components.In various applications plastic gear became an alternative to traditional metal gears. For the plastic gears it is required to transmit high power. Plastic gears have been used from low power transmission into more demanding power transmission applications. As designers learned about the behaviour of plastics and their unique characteristics in gearing. There are number of advantage of plastic gears over metal gears. They have lower inertia, less weight and produce less noise while running. Plastic gears do not require lubrication or can be compounded with internal lubricants such as silicon or PTFE. Plastic gears have a less unit cost than metal gears, and can be designed to incorporate other features needed in the assembly. These gears can resist many corrosive environments. Mostly light weight high strength composites are made with glass or carbon fibers and base material which gives excellent mechanical properties. Polymer composites are mostly used in the tribo situations where resistance to abrasive wear is an extremely important criterion. The polyamide gears have a many disadvantages for low power transmission. These gear having low load carrying capacity, poor heat resistance, less running life respectively. Over the past few decades, a considerable number of studies were conducted on the performance of polyamide gears. Plastic gear materials experience degradation from high temperature caused by accumulated heat, which results in severe wear and/or early fracture[7].This research work is to study the changes in mechanical and tribological properties of polyamide 66 with different content of filler of glass fiber and suggest the best material among all the composites having better wear resistance.

II. EXPERIMENTAL SPECIFICATION

A. Material used

For the testing Polyamide (PA66) composite materials were used.This material is in the form of cylindrical rod with dimensions 20mm diameter and 150 mm length. The test specimens (pins) of 10 mm diameter and 30 mm length are cut.

TABLE:I LEVEL OF EXPERIMENTAL PARAMETERS

Parameters	**Unit**	**levels**			
		I	**II**	**III**	**IV**
Material	Type	A: PA66	B: PA66+5%GF	C: PA66+10%GF	D: PA66+15%GF
Speed	RPM	260	380	500	-
Load	Kg	4	6.5	9	-

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B. Friction and sliding wear testing

Connect the power input cable to 230 V, 50 Hz, and 15 Amps supply. Switch ON controller. Allow 5 minutes for normalizing all electrical items. Using dial indicator, clamp disc within 10 µm run out.Thoroughly clean specimens, remove burs from the circumference using a 2000 grit fine silicon carbide abrasive paper. Clean the wear disc thoroughly with petrol. Insert specimen pin inside the hardened jaws and clamp to specimen holder. Set the height of specimen pin above the wear disc using height adjustment block, ensuring the loading arm always horizontal. Tighten clamping screws on jaws to clamp specimen pin firmly. Swivel off the height adjustment block away from loading arm.Set the required wear track diameter according to sliding speed by moving the sliding plate over graduated scale on base plate. Tighten both the clamping screws to ensure assembly is clamped firmly. Wear display: Loosen LVDT lock screw, rotate thumbscrew to bring LVDT plunger visually to mid position, the wear reading display on controller should be as near to zero. Initialize wear display to „0" by pressing „ZERO" push button on controller. Frictional force display: Move loading arm away from frictional force load cell and set frictional force display „0" by pressing relative „ZERO" button on controller. Place required weights on loading pan to apply normal load. Setting disc speed: Set 10 minute time on controller, press test, start push button and rotate. Set by rotating rpm knob on controller till required test speed is displayed. Continually run for the remaining time to observe any fluctuation. Press STOP button. Test duration of 60 minutes is selected. On controller the acquired test parameters like wear, frictional force, speed and temperature are displayed, the same values are displayed on PC screen with graph. The test was carried out by application of different loads (4,6.5,9kg) and rotational speeds (260,360,500 RPM)

Fig1Photograph of Experimental Set up (Tribometer TR-20LE)

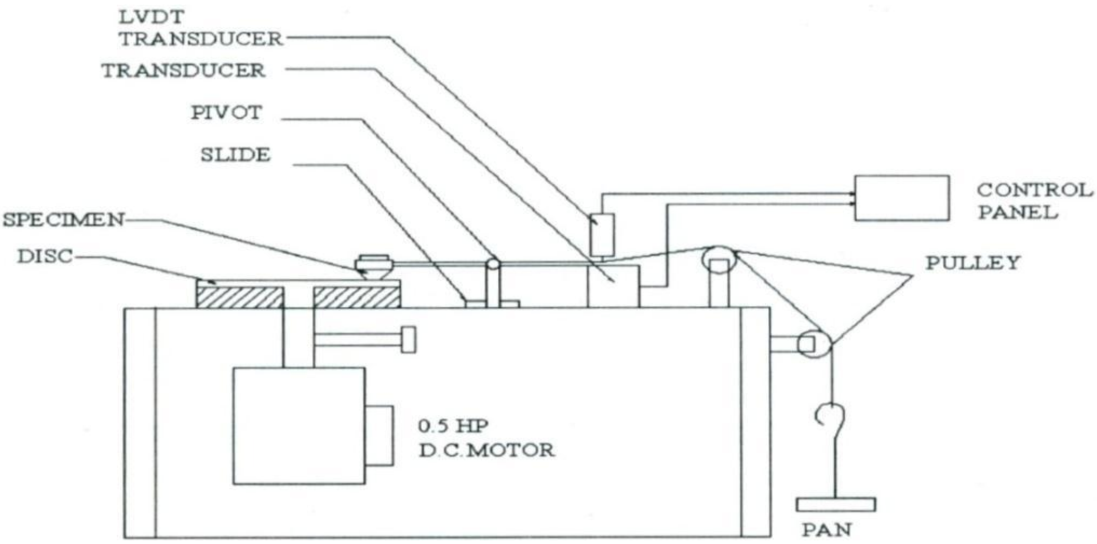

Fig2Experimental Setup of Pin on Disc Tribometer Scanning electronic micrography

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After wear test, the samples were examined using a scanning electron microscope (SIGMA HV model).Before the examinations, a thin gold film was deposited on the wear surface.

III. RESULT AND DISCUSSION

A. Friction and sliding wear results

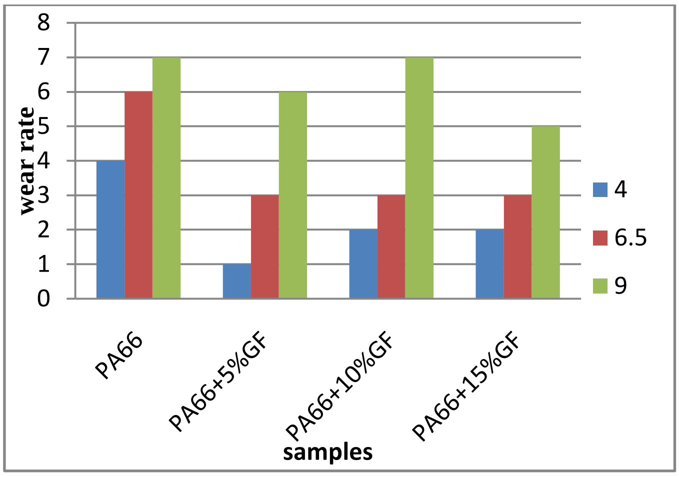

Fig3-wear of a material at a speed of 260 rpm

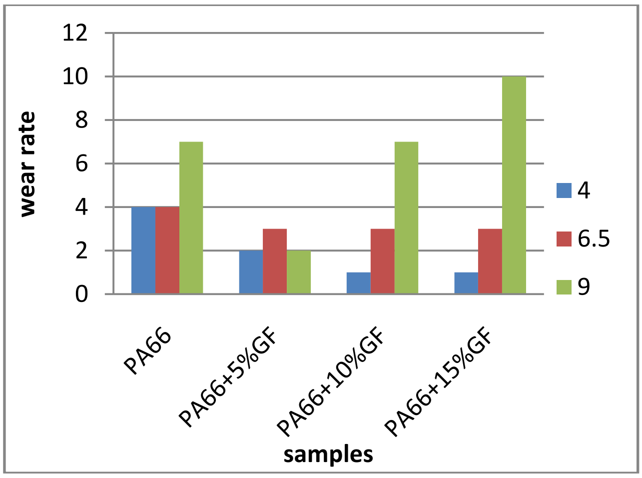

Fig4-wear of a material at a speed of 380 rpm

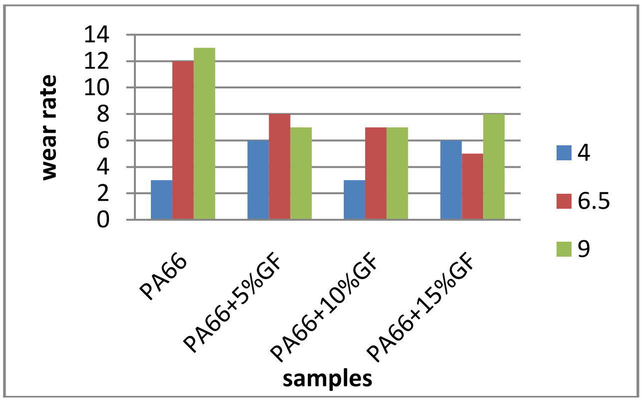

Fig5-wear of a material at a speed of 500 rpm

Fig 3,fig 4,fig 5 shows the wear of material at a load of 4kg,6.5 kg,9 kg.The primary reasons for adding fillers or reinforcing fibers to polymers is to improve their mechanical properties, but the effects on wear rate are not invariably beneficial. Investigated the wear behaviour of particulate filled glass/carbonfabric reinforced epoxy composites. in pure polyamide the wear rate is significantly high. addition of filler material decreases wear rate .In fig 3 at constant speed

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260 RPM as load increases the wear rate increases. The wear of material In abrasive wear situations, depends on the experimental test parameters such as load and abrading distance. The PA66+GF 10% Material shows constant wear rate for all loads and rotational speeds.

B. Worn surface morphology

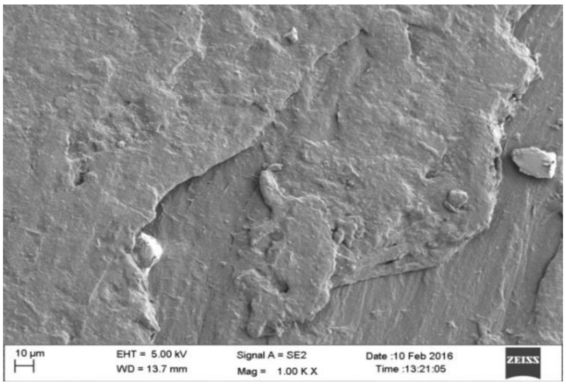

Fig.6SEM Structure of Polyamide (PA66)+5%GF Pin after Testing having a rotational speed 500 RPM and load 9 kg.

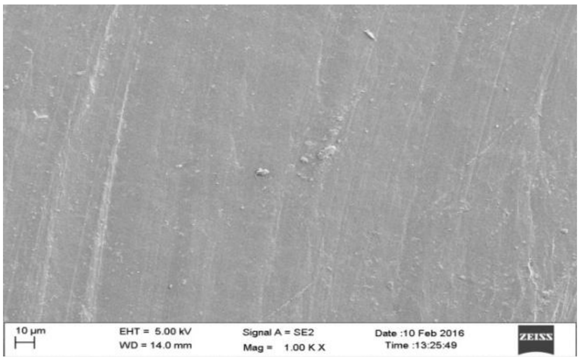

Fig.7SEM Structure of Polyamide (PA66)+10%GF Pin after Testing having a rotational speed 500 RPM and load 9 kg.

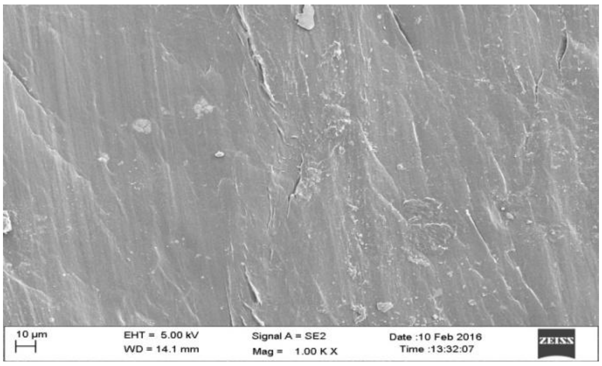

Fig.8SEM Structure of Polyamide (PA66)+15%GF Pin after Testing having a rotational speed 500 RPM and load 9 kg.

Fig.6, Fig.7,Fig.8 shows the images of polyamide composites after testing. The surface which is seen rougher at 1000X magnification before testing seems to be flaky and some portion of material is also dig out.Therefore the wear rate is more 9 kg load and 500 RPM. The images after testing shows more wear of surface shows in PA66 material and the less wear of surface is observed in PA66+15%GF.The transfer film of Polyamide (PA66) & Glass fiber particles is created on the pin surface which interprets that in dry the Glass fiber particles are worn out & they make a transfer film with the Polyamide (PA66) grains. Transfer film formed is good, thick and uniform covered the most of the area of the surface showing the less further wear of composite.

IV. CONCLUSION

From Analytical Calculations, Graphs & SEM Analysis Conclusions Interpreted are as Follows: The coefficient of friction is increases linearly with time and become constant irrespective of change in percentage of glass fiber as a filler material. The coefficient of friction is varies with time is depend on the applied load on the material. As the load increases from 4kg to 9kg at constant rotational speed the C.O.F increases. The wear rate for the material PA66+GF10% is nearly constant for all loads and. At a constant rotational speed wear rate varies with load. As load increases the wear of material increases and then become constant. SEM analysis shows that surface of pure polyamide (PA66) and its composite is rougher before testing. After testing SEM images shows flaky surface because of wear. At same magnification comparison of images shows that wear rate is decrease as percentage of glass fiber increase in pure material.

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