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Tribological Investigation of Polyamide (PA66) Composites with and without Effect of Surface Texturing

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Abstract: Significant improvement in load capacity, wear resistance, friction coefficient etc. of tribological mechanical components can be obtained by forming regular micro-surface structure in the form of micro-dimples on their surfaces. In the present investigation the effect of surface texturing on tribological properties of Polyamide (PA66) composite materials considering elliptical shape texture pattern with varying orientations so as to observe the comparative friction and wear behavior of Polyamide (PA66) composites with & without surface texturing on mating surface at dry & wet lubrication by using a pin-on-disc Tribometer. The results shows that the coefficient of friction varies considerably with surface texture patterns, some texture patterns shows a higher load carrying capacity & due to that negative coefficient of friction was observed. Scanning Electron Micrographs shows that wear of some textured surfaces was reduced compared with the non textured surface at both the lubricating conditions. The circumferentially oriented pattern shows better results as compared to radially oriented pattern.

Keywords: Dimples; Surface Texturing; Tribometer.

I. INTRODUCTION

Surface texturing as a method for enhancing the tribological properties of surfaces for many years. Adding a controlled texture to one of two faces in relative motion can have many positive effects, such as reduction of friction and wear also increase in load carrying capacity (adding texture to both faces tends to increase friction and cause other negative effects).

Early studies recognized the potential of micro asperities to provide hydrodynamic lift during film lubrication[1,2,3], while later research indicated that small-scale texturing could also provide lubricant reservoirs in poorly lubricated conditions and trap wear particles in boundary and dry lubrication.

A further use of micro textured surfaces may be found in the use of partial texturing – a textured region can take the place of macro-geometry such as steps or inclined planes meant to provide hydrodynamic lift [4].

All of these effects may decrease friction and wear between two sliding surfaces, but some experimental results also show a negative effect from surface texturing.

In some cases texturing is not optimized for a given case, in others there is no optimal case any kind of texturing may be worse than a smooth surface. Research and analysis presented to date demonstrates both the potential to improve tribological properties via surface texturing, and the need to understand the materials, lubricants, and running conditions before a surface texture is applied.

Micro-topography consists of micron-scale surface features, either negative (cut into the “flat” surface) or positive (protruding). Early textures were limited to grooves and troughs, while new techniques have allowed complex patterns of different shapes, including circular, Elliptical, triangular, and other geometric shapes, to be used.

Asperity shape, area, depth, area ratio (the ratio of asperity to flat area), density and orientation can all impact the effectiveness of a given texture.

II. EXPERIMENTAL METHODOLOGY

Experimental set up of a pin-on-disc Tribometer (TR-20LE) was used for the readings of a wear and frictional force.

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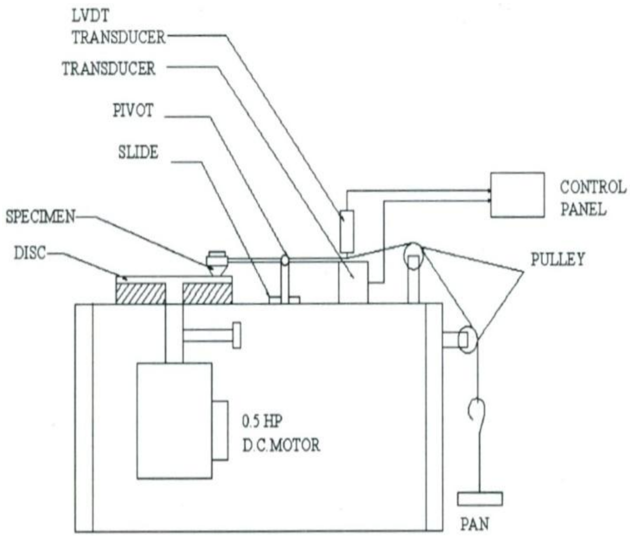


Fig.1 Experimental setup of Pin on Disc Tribometer

The TR-20LE pin on disc wear testing is advanced regarding the simplicity and convenience of operation, ease of specimen clamping and accuracy of measurements, both of wear and frictional force along with lubrication and environmental facility. The machine is designed to apply loads up to 20 Kg and is intended both for dry and lubricated test conditions. It facilitates study of friction and wear characteristics in sliding contacts under desired test conditions within machine specifications. Sliding occurs between the stationary pin and a rotating disc. Normal load, rotational speed and wear track diameter can be varied to suit the test conditions. Tangential frictional force and wear are monitored with electronic sensors and recorded on PC. These parameters are available as a function of load and speed.

III. PREPARATION OF SPECIMEN

Polyamide (PA66) composites material is in the form of cylindrical rod with dimensions 20 mm diameter and 150 mm length. The test specimens (pins) of 10 mm diameter and 30 mm length are cut. The disc of material AISI SS 304 stainless steel plate of the surface roughness Ra for counter surface i.e. for disc is 0.20 µm. The surface texture patterns were made on the AISI SS 304 plate by the Lasers. The details of texturing on AISI SS 304 disc are as below:

Table. 1 Details of texturing on AISI SS 304 disc [5]

No	Dimple major axis (µm)	Dimple minor axis (µm)	Dim. depth (µm)	Dim. density (%)	Dimple Orientation
E1	732	366	50	10, 20, 40	Radially
E2	732	366	50	10, 20, 40	Circumfe-rentially

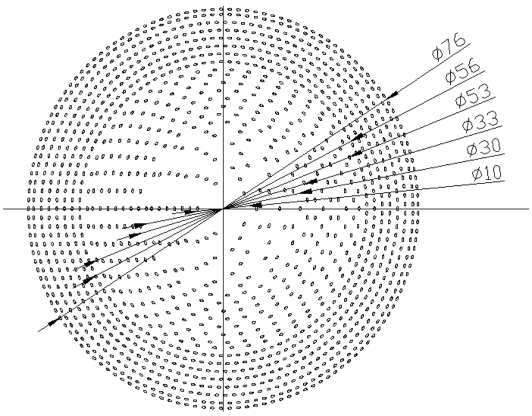


Fig. 2 Drawing of Dimples Distribution at 10 %, 20% & 40% Dimple Density for Circumferential Orientation

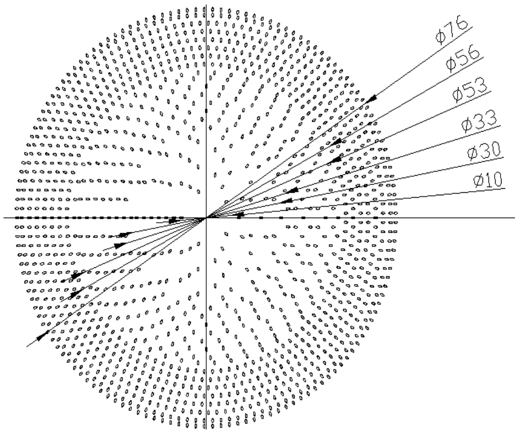


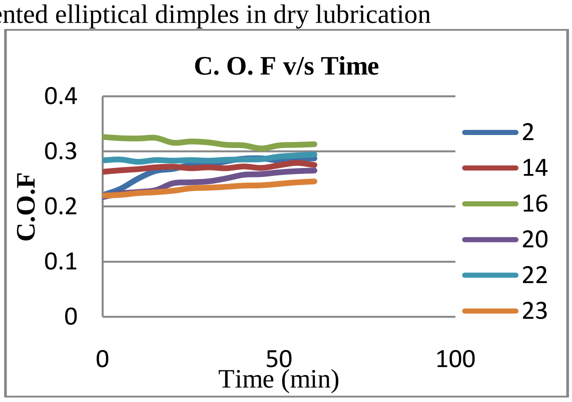
Fig. 3 Drawing of Dimples Distribution at 10 %, 20% & 40% Dimple Density for Radial Orientation

Experimental Parameters:
Sliding Velocity:- 0.12 m/s
Time:- 60 min
Load:- 18.85 Kg
Lubricant:- IPOL 3 Oil

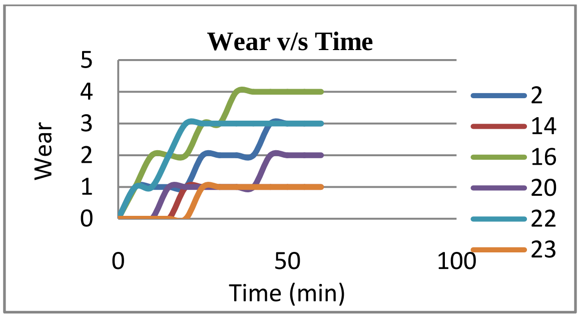
Experimentation
Experimental data of slide wear and coefficient of friction of Pure Polyamide (PA66), Polyamide (PA66) + 5% Glass Fibres, Polyamide (PA66) + 10% Glass Fibres composite test pins against the tracks of densities 10%, 20%, 40% for Circumferential and Radial orientation of surface texturing pattern made on the AISI SS 304 stainless steel disc with time is tabulated for sliding velocity of 0.12 m/s and normal load of 18.85 Kg under dry & wet lubricating condition using a pin-on-disc Tribometer (TR-20LE) at NTP. Using these tables, for each track of surface texturing pattern, graphs of variation of wear in micrometer with time and variation of coefficient of friction with time are plotted.

IV. RESULTS

A) Effect of Orientation:-
a. Effect of circumferentially oriented elliptical dimples in dry lubrication



Graph 1 COF v/s Time plot at Circumferential orientation for Dry lubrication



Graph 2 Wear v/s Time plot at Circumferential orientation for Dry lubrication

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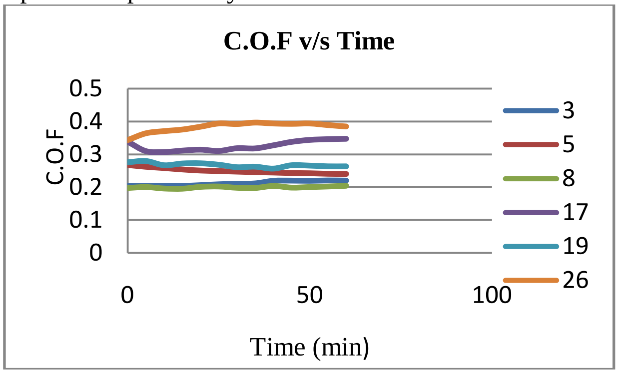
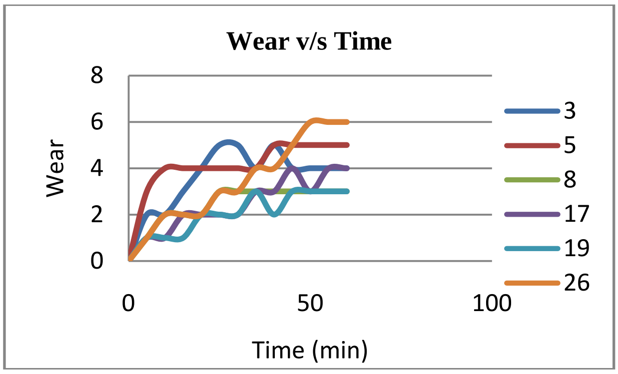
b. Effect of Radially oriented elliptical dimples in dry lubrication

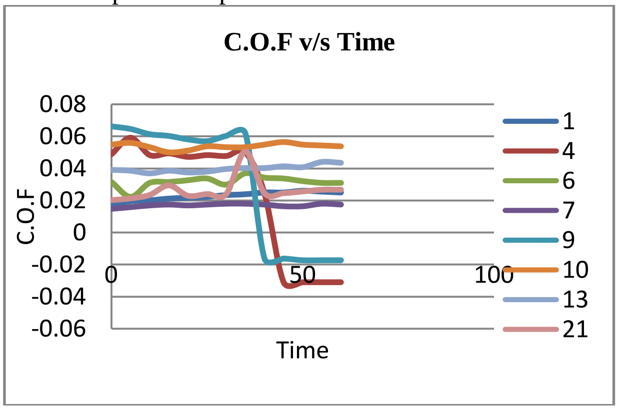


Graph 3 COF v/s Time plot at Radial orientation for Dry lubrication

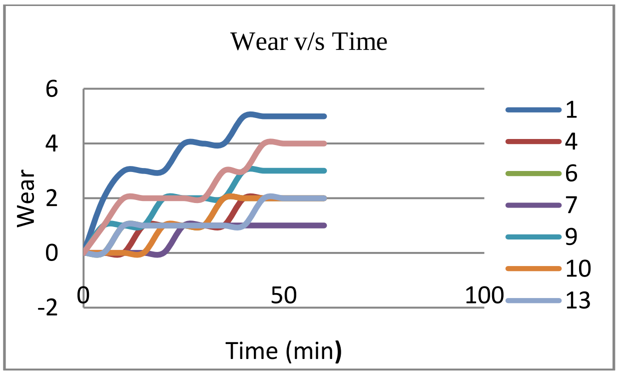


Graph 4 Wear v/s Time plot at Radial orientation for Dry lubrication

c. Effect of circumferentially oriented elliptical dimples in Wet lubrication



Graph 5 COF v/s Time plot at Circumferential orientation for Wet lubrication



Graph 6 Wear v/s Time plot at Circumferential orientation for Wet lubrication

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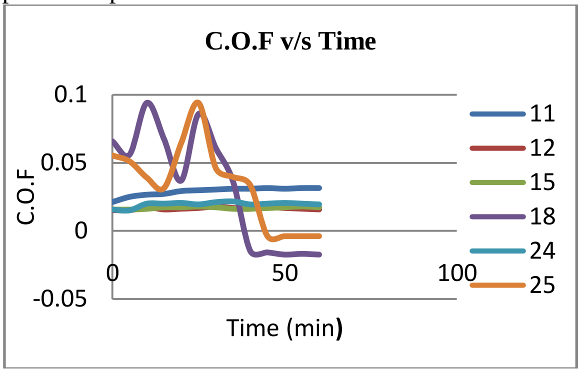
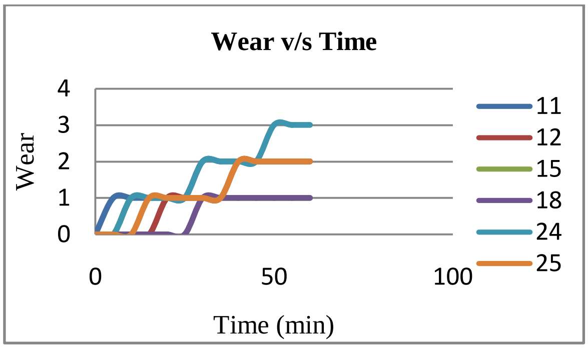
d. Effect of Radially oriented elliptical dimples in Wet lubrication



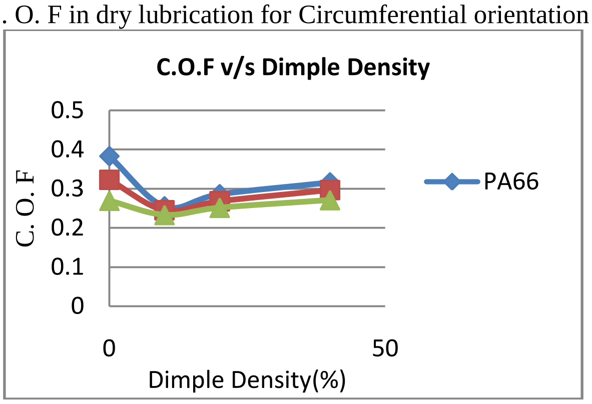
Graph 7 C.O.F v/s Time plot at Radial orientation for Wet lubrication



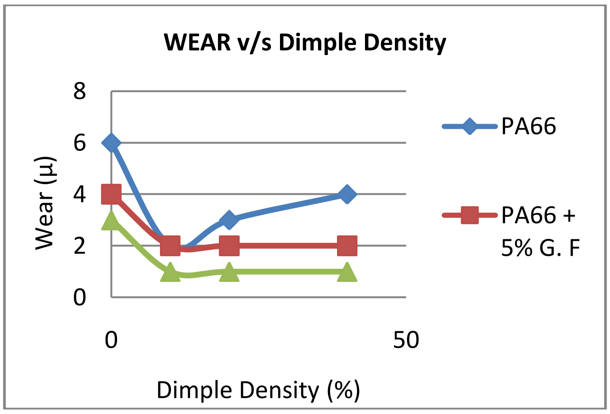
Graph 8 Wear v/s Time plot at Radial orientation for Wet lubrication

B) Effect of Dimple Density:-

a) Effect of Dimple density on C. O. F in dry lubrication for Circumferential orientation



Graph 9 Dimple density vs C. O. F



Graph 10 Dimple density vs Wear

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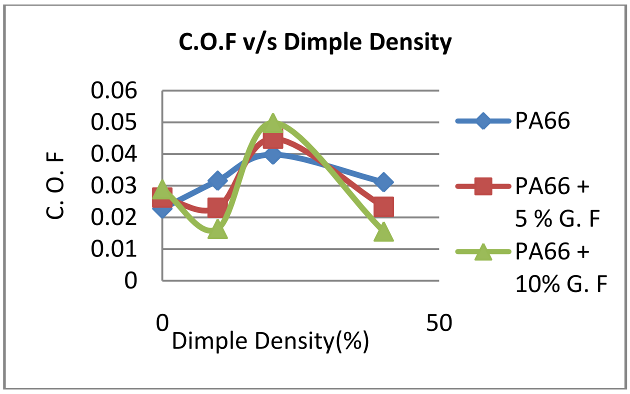
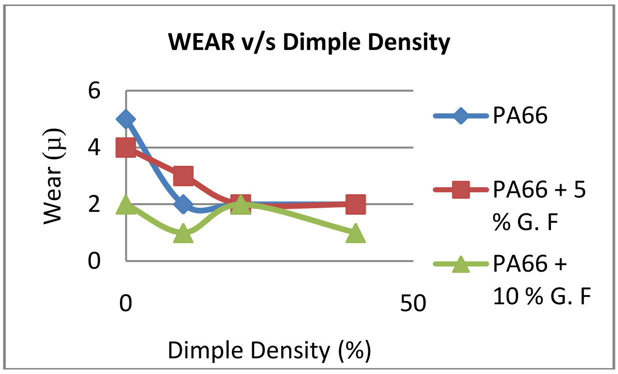
b) Effect of Dimple density on C. O. F in Wet lubrication for Circumferential orientation



Graph 11 Dimple density vs C.O.F



Graph 12 Dimple density vs Wear

V. DISCUSSION

From the above results it can be shown that circumferentially oriented pattern shows low C.O.F & Wear as compared to radially oriented pattern. At high dimple density in wet lubrication, texturing pattern shows negative C.O.F that shows high load carrying capacity. From tested material, PA66 + 10% G. F material is better than other two materials from C.O.F & wear point of view. The 10% dimple density track shows low wear & C.O.F as compared to other two track.

VI. SEM ANALYSIS

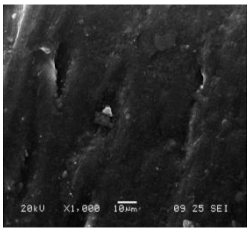


Fig . 4 SEM image of PA66 before test

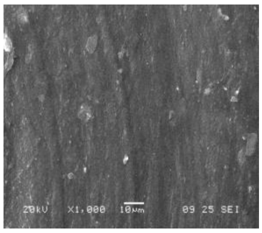


Fig . 5 SEM image of PA66 + 10% G.F before test

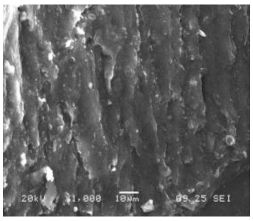


Fig. 6 SEM image of PA66 + 10% G. F in dry lubrication at non textured surface

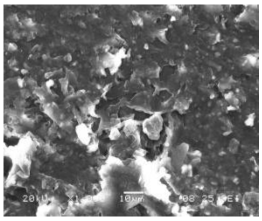


Fig. 7 SEM image of PA66 + 10% G. F in Wet lubrication at non textured Surface

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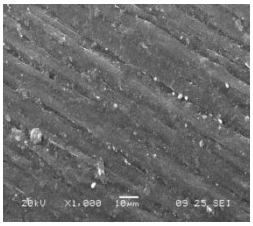

Fig. 8 SEM image of PA66 + 10% G. F in Dry lubrication at 10 % density at circumferential orientation

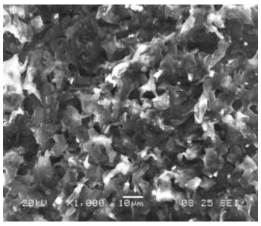

Fig. 9 SEM image of PA66 + 10% G. F in Wet lubrication at 10 % density at circumferential orientation

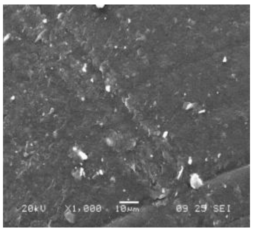

Fig. 10 SEM image of PA66 + 10% G. F in Dry lubrication at 40 % density at circumfer. orientation

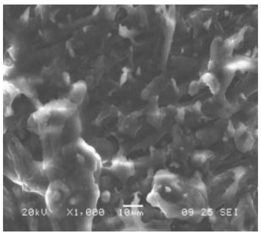

Fig. 11 SEM image of PA66 + 10% G. F in Wet lubrication at 40 % density at circumferential orientation

VII. CONCLUSIONS

- C. O. F of Textured pattern is low compared with non textured pattern. It also increases with density of the dimples.
- SEM images shows that the wear of textured surface is low compared with non textured surface in both dry & wet lubrication conditions.
- Load carrying capacity of textured surface is increased in higher dimple density track due to that it shows negative C. O. F in wet lubrication.
- Polyamide 66 + 10% G. F material has low C. O. F & wear as compared to other two materials.
- The circumferential orientation is better than radial orientation as a C. O. F & wear point of view
- It improves the mechanical efficiency & bearing life.

REFERENCES

[1]. Hamilton D. B., Walowit J. A., and Allen C. M., "A Theory of Lubrication by Microasperities", ASME J. Basic Eng., vol.88, pp. 177-185, (1995).
[2]. Anno J. N., Walowit J. A and Allen C. M, "Microasperity Lubrication", ASME Journal of Lubrication Technology, vol. 90, pp. 351-355, (1968).
[3]. Anno J. N, Walowit J. A, and Allen C. M,"Load Support and leakage from Microasperity-Lubricated Face Seals", ASME Journal of Lubrication Technology, vol. 91, pp.726-731, (1969).
[4]. Tonder K., "Inlet Roughness Tribodevices: Dynamic Coefficients and Leakage", Tribology International, vol.34, pp. 847-852, (2001).
[5]. Y. Qiu, M. M. Khonsari "Experimetal investigation of tribological performance of laser textured stainless steel rings" Tribology International 44 pp.635-644, (2011).
[6]. Chenbo Ma, Hua Zhu "An optimum design model for textured surface with elliptical-shape dimples under hydrodynamic lubrication" Tribology International 44 pp.987-995, (2011) .
[7]. I. Etsion "Improving tribological performance of mechanical components by laser surface texturing" Tribology Letters, Vol. 17, No. 4 November 2004.
[8]. Andriy Kovalchenko, Oyelayo Ajayi, Ali Erdemir, George Fenske "Friction and wear behavior of laser textured surface under lubricated initial point contact" Wear 271 pp.1719-1725, (2011).
[9]. Chenbo Ma , Hua Zhu "An optimum design model for textured surface with elliptical-shape dimples under hydrodynamic lubrication" Tribology International 44) pp. 987-995 (2011).
[10]. L. Chang, Z. Zhang, H. Zhang, A. K. Schlarb " On the sliding wear of nanoparticles filled polyamide 66 composites" composites science and Technology 66 pp. 3188-3198, (2006).
[11]. K.Y. Tsang, D. L. DuQuesnay, P. J. Bates "Fatigue properties of vibration-welded nylon 6 and nylon 66 reinforced with glass fibres" Composites: Part B 39 pp. 396-404, (2008).