2ND MECHANICAL ENGINEERING POST GRADUATE STUDENT'S CONFERENCE

Effect of Texturing Patterns on Friction and Wear behavior of Glass Fiber filled Polyamide (PA66)

[1]Navale R.A., [2] Aher V.S.

[1]P. G Scholar, Department of Mechanical Engg., A. V. C. O. E, Sangamner;
rutujan63@gmail.com
[2] Asso. Professor, Department of Mechanical Engg., A. V. C. O. E, Sangamner;
vsa_arya@rediffmail.com

***Abstract*: Polyamide (PA66), an engineering thermoplastic polymer is having excellent balance of strength, ductility and heat resistance. However its application has been limited to poor wear and abrasion resistance. The wear resistance can be significantly improved by texturing and addition of some filler materials. Polyamide (PA66) with 10% glass fiber composites produces very thick, uniform and adherent transfer films of both PA66 and glass fiber. Therefore, in the present investigation, the effect of three texturing patterns i.e. elliptical, circular and square with 10% dimple density on the friction and wear behavior of Polyamide (PA66) composites filled with 10% glass fiber particles at varying loads and sliding velocities is studied. The test pins of PA66 composites was examined by rubbing it on stainless steel disc AISI SS 304 with surface texturing under both dry and wet lubrication conditions using wear and friction tester pin-on-disc tribometer (TR-20LE) at NTP. The result and observations of this investigation shows that as load and sliding velocity increases wear loss and friction goes on increasing. Among the three texturing patterns circular texturing pattern shows better result than elliptical and square. The lowest coefficient of friction and wear was examined at wet lubrication condition and using circular textured pattern with dimple density is 10%.**

Index Terms: ***Surface Topography, Dimples, Friction, Tribometer***

I. INTRODUCTION

It is very necessary to reduce the friction and wear between the mating parts of tribological components and it results to the saving an energy, improves durability of component, improving an efficiency and also helps in keeping an environment safe for further engine systems. In such situations Surface texturing of mating parts plays an important role.

It enhances the tribological properties i.e. coefficient of friction, wear loss, lubrication and also improves load carrying capacity. Theory of hydrodynamic lubrication indicates that the microstructures distributed on bearing surface affect the load carrying capacity and lubrication state of the component. The "Surface texturing" i.e. surface topography means making the grooves or cavities on plane surfaces so that it improves tribological properties of mating parts. It improves lubricating property by acting as a oil reservoir so that when oil film breaks down it provides or retains oil for lubrication and also help in entrapping wear particles and works as a abrasion resistance under boundary and dry lubrication [7].

It is reported from one of the best sugar industry, "Sahakarmaharshi Bhausaheb Thorat Sahakari Sakhar Karkhana Ltd., Amrutnagar, Sangamner, Maharashtra", having crushing capacity of 5000 tons per day, that in milling section number of mills are there to extract juice from sugar cane by passing and compressing fiberized sugar cane through slowly rotating (4.5 rpm to 6 rpm) heavy metal mills. The lubrication used for these bearings is hydrostatic lubrication. The thick oil used for this hydrostatic lubrication is IPOL-3 mineral oil. The problems faced in the past & the problems arises during the season for the mill bearings of milling section of this sugar factory are that sometimes the lubricating oil may get mixed with sugar cane juice due to leakage and may change the juice properties slightly. There is need to suggest the self lubricating material for that mill bearing application.

There is a formation of hydrodynamic lift when the textured region can take the place of macro – geometry which is the further use of micro textured surfaces [3]. Even if all such results show better improvement of texturing on friction and wear behavior there is some negative impact of surface texturing. So for the research work there is a need to understand the materials, lubricants and running conditions before going for surface texturing. In early research textures are limited to grooves and troughs but now a days there are

Miss. Navale Rutuja A. is a Student of Design Engineering, Amrutvahini College of Engineering, Sangamner. India.
(Email id : rutujan63@gmail.com)
Mr. Aher Vishnu S. is a Associate Professor in Mechanical Engineering department, Amrutvahini College of Engineering, Sangamner
(Email id: vsa_arya@rediffmail.com)

some new techniques which gives complex nature or shapes of textured patterns such as elliptical, triangular, circular, square and some other geometrical shapes which are having different performance on friction and wear behavior of material. The effectiveness of textured patterns also varies with aspect ratio, area, depth, shape of the textured pattern.

II. EXPERIMENTAL METHODOLOGY

Fig.1 shows the experimental set up of pin-on-disc tribometer (TR-20LE) which was used for readings of wear and frictional force. In experimental work, tests were carried out at the sliding velocities of 0.09 m/s, 0.105 m/s, 0.12 m/s and at the load of 56.81 N, 61.39 N and 65.96 N under both dry and wet lubrication condition.

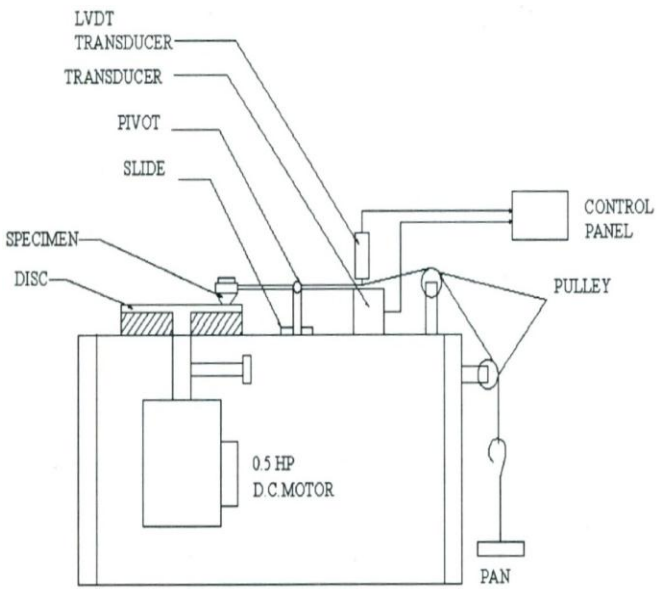

Fig. 1. Experimental setup of Pin on Disc Tribometer

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) filled with 10%[15] glass fiber composites material is in the form of cylindrical rod with dimensions 20 mm diameter and 150 mm length. The test specimens (pins) are made into 6 mm diameter and 30 mm length for the experimentation. 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 three surface texture patterns i.e. elliptical, circular and square were made on the AISI SS 304 plate by the Lasers. The details of three texturing on AISI SS 304 disc are as below:

Table :1 Details of elliptical texturing on AISI SS 304

Sr. No.	Dimple major axis (µm)	Dimple minor axis (µm)	Dimple Depth (µm)	Dimple Density (%)	Dimple Orientation
E1	732	366	50	10	Circumferential

Table :2 Details of Circular texturing on AISI SS 304

Sr. No.	Dimple Diameter (µm)	Dimple Depth (µm)	Dimple Density (%)
C1	100	50	10

Table:3 Details of Square texturing on AISI SS 304

Sr. No.	Dimple Size (µm)	Dimple Depth (µm)	Dimple Density (%)
S1	450 x 450	50	10

There are some running parameters required for experimentation is shown below:

Table: 4 Running parameters for experimentation

Sr.No.	Load (N)	Sliding Velocity (m/s)	Test duration (min)
1	56.81	0.09	60
2	61.39	0.105	60
3	65.96	0.12	60

Lubricant used in wet lubrication condition is IPOL 3 Oil. Following table gives the mechanical properties of PA66 filled with 10% glass fiber.

Table: 5 Mechanical properties of PA66 + 10% G.F.

Sr. No.	Property	Unit	PA66 + 10% G. F
1	Density	Gm/cc	1.980
2	Tensile Strength	Kgf/cm^2	838.67
3	Elongation	%	14.26

4	Compressive Strength	Kgf/cm^2	16089.51
5	Flexural Strength	Kgf/cm^2	281
6	Flexural Modulus	Kgf/cm^2	90328.89
7`	Hardness	Shore	75-77

IV RESULTS AND DISCUSSIONS

1. Variation of wear and coefficient of friction with test duration under dry and wet lubrication condition:

a. Variation of wear with test duration at dry condition:

Following Fig. 2 shows the variation of wear with time. It shows that wear increases with increasing load and sliding velocity. By observing graph run 6 i.e. at load of 65.96 N and sliding velocity of 0.09 m/s of elliptical dimple shape gives minimum wear for dry lubrication condition.

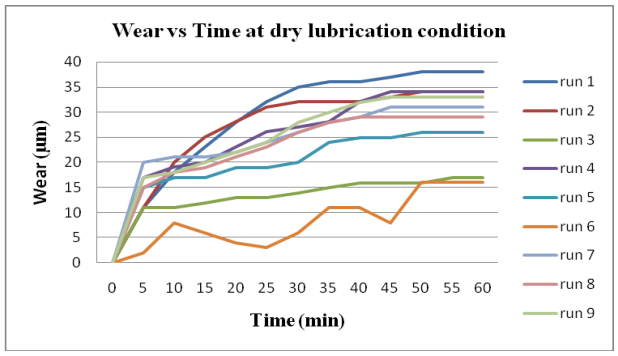

Fig. 2: Wear vs Time at dry lubrication condition

b. Variation of c.o.f with test duration at dry condition :

Fig. 3 shows the variation of C.O.F. with test duration at dry lubrication condition. At the load of 65.96 N and sliding velocity 0.105 m/s of square dimple shape value of C.O.F is minimum i.e. run 9.

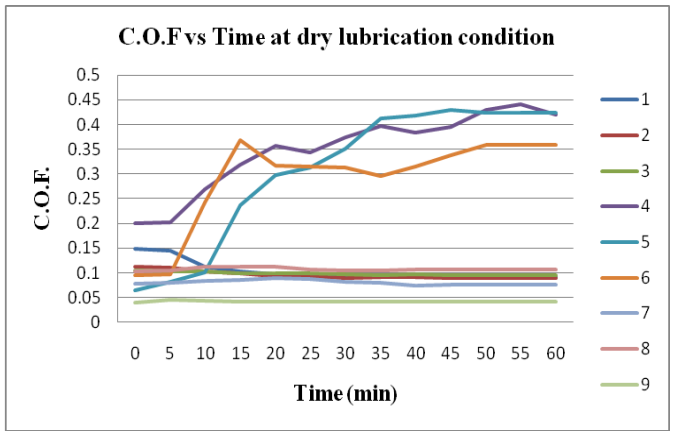

Fig. 3: C.O.F. vs Time at dry lubrication condition

c. Variation of wear with test duration at wet lubrication condition:

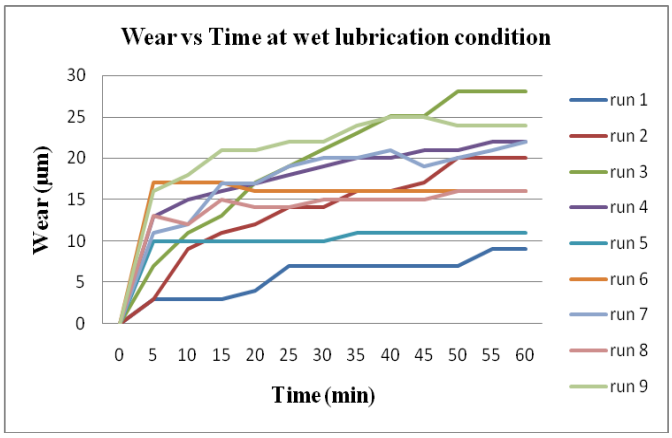

Fig. 4: Wear vs Time at wet lubrication condition

Fig. 4 gives the wear variation of various runs. Wear increases with increasing load and after some time the value of wear keeps constant. Run 1 gives better result for this investigation i.e. Circular dimple shape with 10% dimple density and load of 56.81 N and sliding velocity of 0.09 m/s.

d. Variation of c.o.f with test duration at wet lubrication condition:

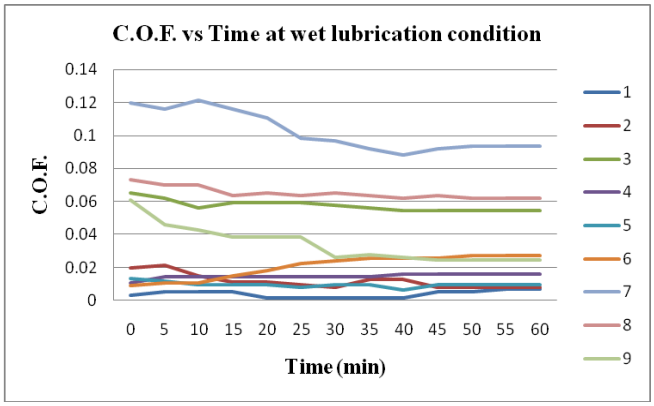

Fig. 5: C.O.F.vs Time at wet lubrication condition

At run 1 C.O.F is minimum compared to other runs. At first C.O.F increases with time after that it will decrease and take constant values.

2. Effect of Load

a. Effect of load on C.O.F under wet lubrication condition

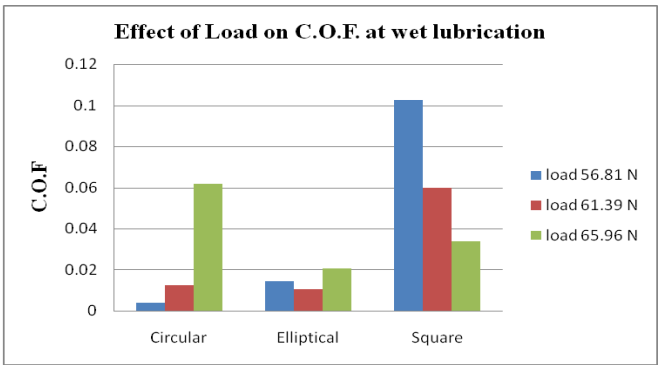

Fig. 6: Effect of load on C.O.F under wet lubrication condition

b. Effect of load on wear under wet lubrication condition

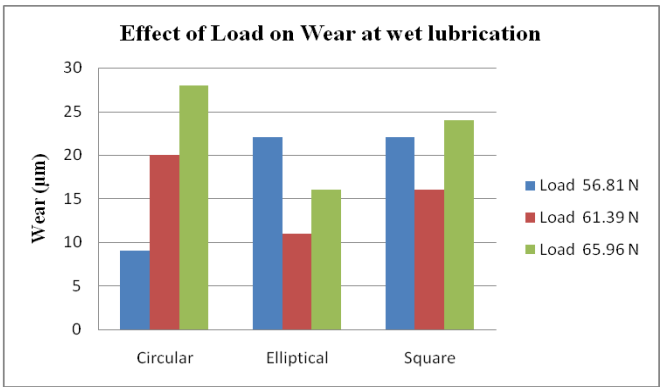

Fig. 7: Effect of load on wear under wet lubrication condition

c. Effect of load on C.O.F under dry lubrication condition

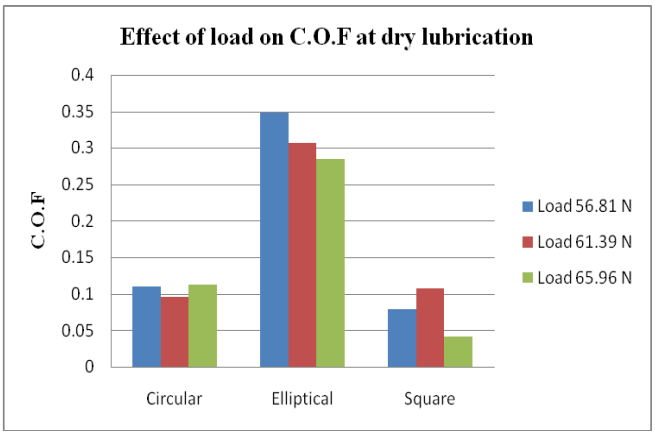

Fig. 8: Effect of load on C.O.F under dry lubrication condition

d. Effect of load on wear under dry lubrication condition

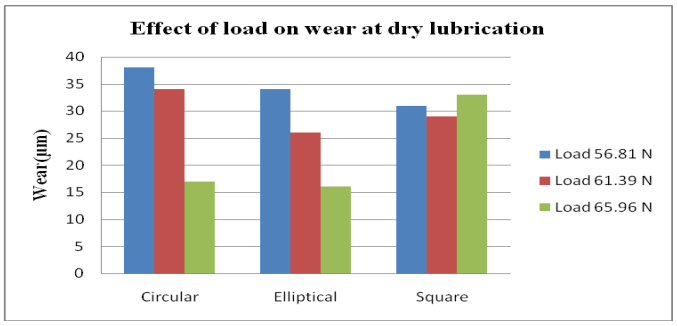

Fig. 9: Effect of load on wear under dry lubrication condition

3. Effect of Sliding Velocity

a. Effect of sliding velocity on C.O.F under wet lubrication condition

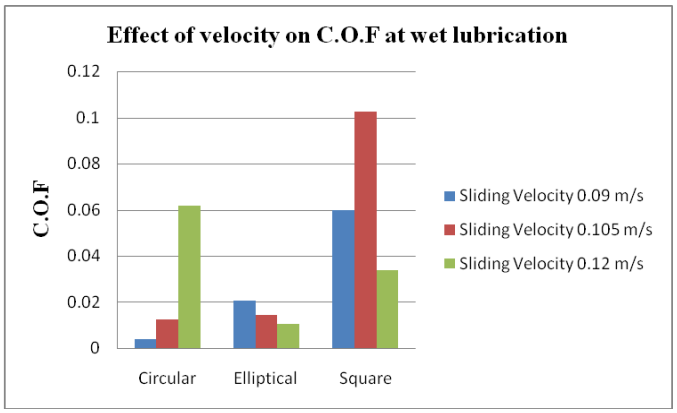

Fig. 10: Effect of sliding velocity on C.O.F. at wet lubrication condition

b. Effect of sliding velocity on wear under wet lubrication condition

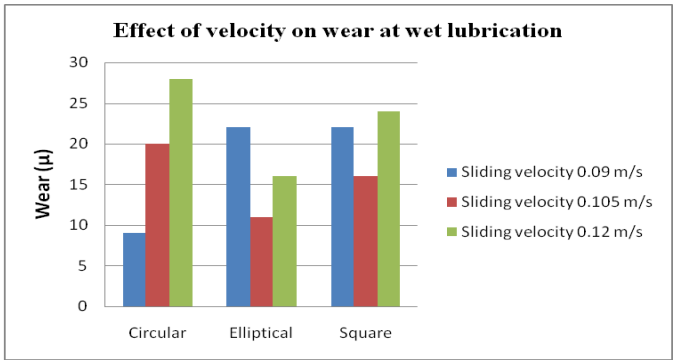

Fig. 11: Effect of sliding velocity on wear at wet lubrication condition

c. Effect of sliding velocity on C.O.F under dry lubrication

condition

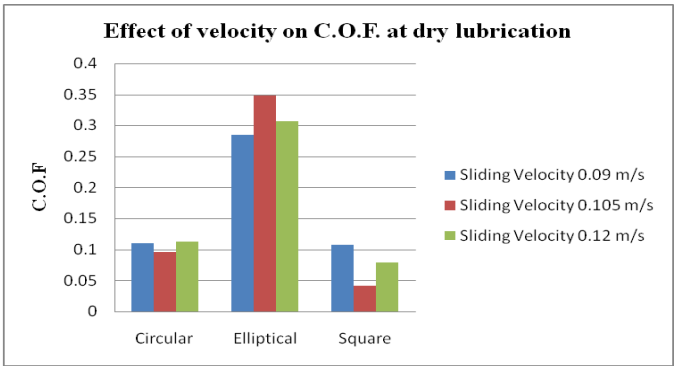

Fig. 12: Effect of sliding velocity on C.O.F at dry 2lubrication condition

d. Effect of sliding velocity on wear under dry lubrication condition

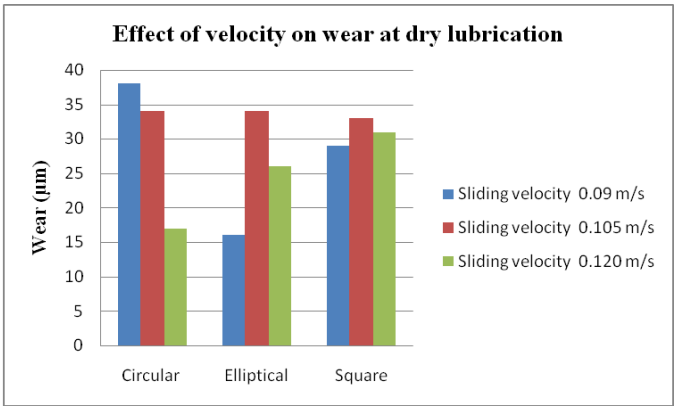

Fig. 13: Effect of sliding velocity on wear at dry lubrication condition

DISCUSSIONS

It is seen from the above results that as load and sliding velocity icreases the coefficient of friction and wear also increased for both dry and wet lubrication condition. From Fig. 2 to 5 at first C.O.F. and wear increase after some time it goes on decreasing and become constant. It is observed from the graphs that coefficient of friction increases with increasing load and sliding velocity. But load is more affective than sliding velocity on coefficient of friction.

It is observed from Fig. 2 to 5 that circular dimple shape shows better performance than elliptical and square. At minimum load i.e. 56.81 N and at minimum velocity i.e. 0.09 m/s and textured pattern is circular the total value of wear is minimum compared to other textured pattern and value of coefficient if friction is also minimum than other textured patterns at wet lubrication condition. Among the wet and dry lubrication at wet lubrication there is a formation of constant thick film of lubricant after some time at minimum load and velocity so that wear value is minimum.

V. CONCLUSIONS

From the above results and discussions the following conclusions can be made about the friction and sliding wear of PA66 filled with 10% glass fiber rubbing against the textured AISI SS 304 stainless steel disc:

- Circular textured pattern shows better performance i.e. gives minimum wear and C.O.F than elliptical and square textured patterns. Hence, for Mill Bearing application Circular textured pattern can be suitable.
- For the selected range of load and sliding velocity, friction and wear value are minimum at low load and low sliding velocity.
- Load carrying capacity of Circular textured surface is maximum than elliptical and square.
- Friction gets more affected by load than sliding velocity i.e. value of c.o.f is increased with increasing load and remains constant after some interval.
- Wet lubrication gives better performance on wear and friction than dry lubrication condition for selected range of load and sliding velocity.

REFERENCES

[1] M. Palabiyik, S. Bahadur "Mechanical and tribological properties of polyamide 6 and high density polyethylene polyblends with and without compatibilizer" Wear 246 (2000) 149–158.

[2] M. Palabiyik, S. Bahadur "Tribological studies of polyamide 6 and high-density polyethylene blends filled with PTFE and copper oxide and reinforced with short glass fibers" Wear 253 (2002) 369–376.

[3] Andriy Kovalchenko, Oyelayo Ajayi, Ali Erdemir, George Fenske, Izhak Etsion "The effect of laser surface texturing on transitions in lubrication regimes during unidirectional sliding contact" Tribology International 38 (2005) 219–225.

[4] Bin-Bin Jia, Tong-Sheng Li, Xu-Jun Liu, Pei-Hong Cong "Tribological behaviors of several polymer–polymer sliding combinations under dry friction and oil-lubricated condition" Wear 262 (2007) 1353–1359.

[5] J. Paulo Davim , Leonardo R. Silva , António Festas , A.M. Abrão "Machinability study on precision turning of PA66 polyamide with and without glass fiber reinforcing" Materials and Design 30 (2009) 228–234.

[6] Kristian Tønder "Dimpled pivoted plane bearings: Modified coefficients" Tribology International 43 (2010) 2303–2307.

[7] WAN Yi, XIONG Dang-sheng, LI Jian-liang "Cooperative effect of surface alloying and laser texturing on tribological

performance of lubricated surfaces" J. Cent. South Univ. Technol. (2010) 17: 906−910.

[8] Andriy Kovalchenko, Oyelayo Ajayi, Ali Erdemir, George Fenske "Friction and wear behavior of laser textured surface under lubricated initial point contact" Wear 271 (2011) 1719–1725.

[9] Fatu Aurelian, Maspeyrot Patrick, Hajjam Mohamed "Wall slip effects in (elasto) hydrodynamic journal bearings" Tribology International 44 (2011) 868–877.

[10] M.H. Cho, Sangil Park "Micro CNC surface texturing on polyoxymethylene (POM) and its tribological performance in lubricated sliding" Tribology International 44 (2011) 859–867.

[11] G. Kalacska , L.Zsidai, R.Keresztes, A.Toth, M.Mohai, J.Sze´pv¨ olgyi"Effect of nitrogen plasma immersion ion implantation of polyamide-6 on its sliding properties against steel surface" Wear 290–291 (2012) 66–73.

[12] Du-Xin Li, Yi-Lan You, Xin Deng, Wen-Juan Li, Ying Xie "Tribological properties of solid lubricants filled glass fiber reinforced polyamide 6 composites" Materials and Design 46 (2013) 809–815.

[13] H. Unal , A.Mimaroglu "Friction and wear performance of polyamide 6 and graphite and wax polyamide 6 composites under dry sliding conditions" Wear 289 (2012) 132–137.

[14] Yusuke Morioka, Yuki Tsuchiya, Masatoshi Shioya "Correlations between the abrasive wear, fatigue, and tensile properties of filler-dispersed polyamide 6" Wear338-339(2015)297–306.

[15] Pendbhaje G. S, Aher V. S, Gadakh S. T, Mishra A. K "Tribological Investigation of Polyamide (PA66) Composites with and without Effect of Surface Texturing" (2015) ISSN (Online) 2393-8021 ISSN (Print) 2394-1588.

Miss. Navale Rutuja A. -M.E. Scholar of Amrutvahini College of Engineering, Sangamner. 422-608 India
I am working in the same institute as a Assistant Professor since one year.

Prof. Vishnu S. Aher received the M.E. degree in Design Engineering from the Pune University and Pursuing Ph.D. degree in Mechanical engineering from the Savitribai Phule Pune university, Pune. Presently working as a associate professor in Department of Mechanical Engineering, Amrutvahini College of Engineering, Sangamner- 422608, Savitribai Phule Pune University, Pune, India and P.G Coordinator of Mechanical Engineering Department. I was published many number of papers in international journals and national journals and guided around 20 number of PG students for their P.G. projects.