# Experimental Study on Micro-Textured Thrust Pad Bearing

Syed Ismail, Veeraraju V, Sarangi M

**Abstract**

To provide a stable hydrodynamic pressure on a parallel thrust bearing, one of the viable method is providing the surface textures on one of the bearing surface. The work is carried out experimentally to study the effect of positive square shaped textures on the performance characteristics like film thickness and frictional torque of thrust bearing by varying load and speed. The result shows that at low loads, film thickness decreases as speed increases however at high loads, film thickness increases as speed increases. Frictional torque increases as both speed and load increases. By providing textures on the thrust pad bearing, the load carrying capacity increases and frictional torque decreases than that of the plain thrust pad bearing.

**Keywords:** Lubrication, Surface texture, Thrust pad

## 1 Introduction

In most of the mechanical components, certain amount of energy is wasted in friction. By some methods, energy wasted in friction can be reduced because conserving the energy is the paramount importance owing to ever growing demand of energy. One of the viable method is providing the surface textures on one of the sliding surface. The idea of an additional pressure build-up due to surface texturing began around 1965 when a solution for generating a self-sustaining film between parallel surfaces was proposed for mechanical seals. Osman *et al.* [1] carried out experimental study to assess the performance characteristics of hydrostatic thrust bearings. The results demonstrated that the bearing recess size and location have a great influence on the performance of the hydrostatic thrust bearing. Etsion *et al*. [2] analytically and experimentally investigates the textured pore surface and the results showed that a laser textured mechanical face seal was efficient in reducing the friction torque compared to an un-textured seal having same face pressure. Marian *et al.* [3] theoretically and experimentally investigates the effect of partial texturing square dimples on the load carrying capacity of the thrust pad bearing. Haiwu Yu *et al*. [4] numerically analyzed the effect of shape and orientation of the negative surface textures on the hydrodynamic performance characteristics of the contacting

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surfaces. The results indicated that the shape and orientation has positive impact on the performance parameters. Siripuram and Stephens [5] numerically studied various types of deterministic positive and negative textures on the surface. The results indicated that the friction coefficient is insensitive to asperity/cavity shape but quite sensitive to the size of the cross-section. Brizmer et al., [6] numerically finds the optimum area density of the dimples for maximum load support on the parallel thrust pad bearings by analyzing the full and partial width textured surfaces. Etsion et al., [7] experimentally analyze the theoretical model explained by Brizmer et al., [6] and the results showed good correlation with the available theoretical results. In the present work, experimental setup of thrust pad bearing is designed and fabricated. The effect of positive textures on the performance characteristics like film thickness, frictional torque by varying load and speed is studied using the setup.

# 2 Experimental Setup

A test-rig is designed and fabricated to analyze the effect of positive surface textures on the thrust pad bearing. The basic construction of the setup includes a breadboard on which the whole set-up is fabricated. The basic construction of whole setup was divided into four different assemblies namely, upper part assembly, middle part assembly, lower part assembly and test specimen.

## 2.1 Upper part assembly

Upper assembly part basically includes three columns (III) which supports the whole assembly. On the top face of the columns, upper disc (II) is bolted and the electric motor (I) is fitted on the upper disc (II) whose shaft is attached to the shaft of runner (IV) by means of a flexible coupling (V). The shaft of runner is supported by a ball bearing that is press fitted to a disc arrangement (VI). The runner (VII) and assembly of the upper part is shown in the Fig. 1.

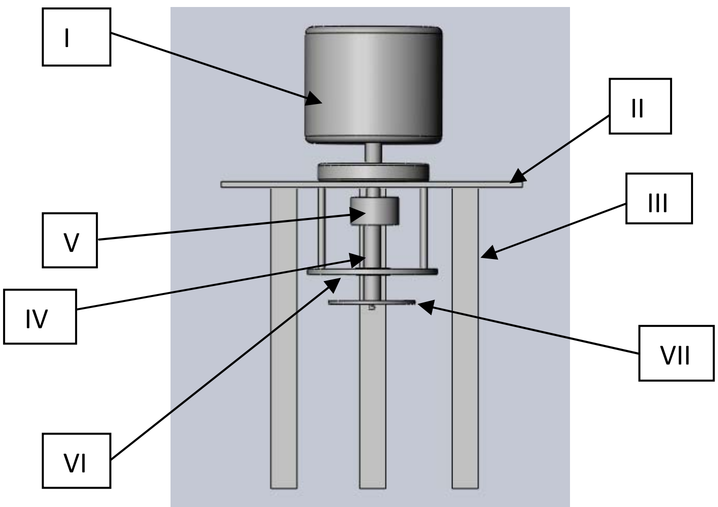


Fig. 1 Upper part assembly

## 2.2 Middle part assembly

Middle assembly part, includes a lower disc (VIII), which is attached to breadboard by means of a three rods (IX). At the centre of lower disc (VIII) a bushing is provided. Bushing is used to support the galvanised iron pipe (X) which is attached to one end of a disc (XI). The disc (IX) is attached to the pad assembly (XIII) by means of thrust ball bearing (XII), which is press fitted to the lower face of pad assembly (XIII) and upper face of disc (XI). The diagram of the middle part assembly is shown in the Fig. 2.

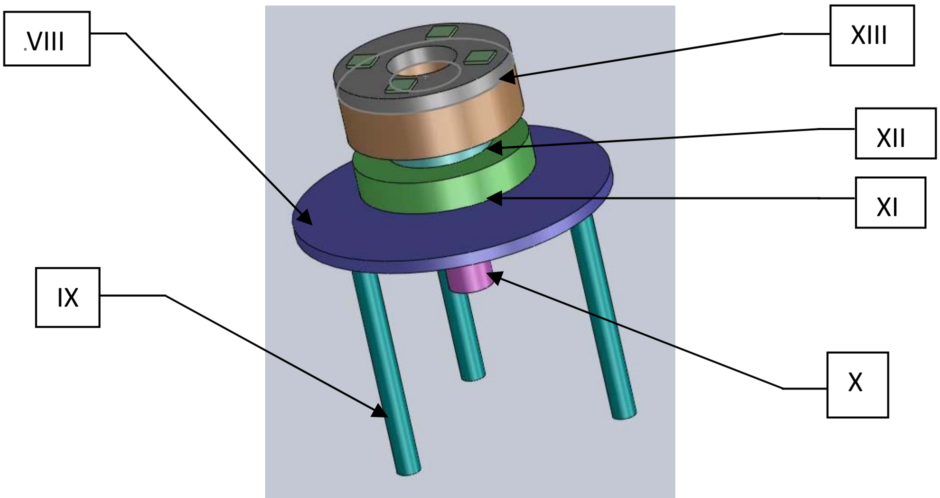


Fig. 2 Middle part assembly

## 2.3 Lower part assembly

Lower part assembly includes a lever (XIV), support (XV) and loading arm (XVI) to support the dead weights. The diagram of the lower part assembly is shown in the Fig. 3.

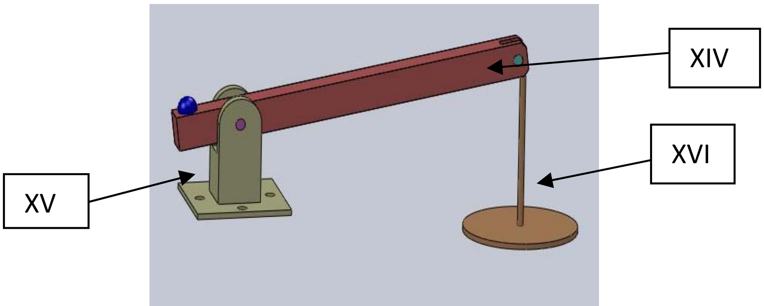


Fig. 3 Lower part assembly

## 2.4 Test specimen

The textures are made of Aluminium foil having an area of 100 $mm^2$ and a thickness 5μm (see Fig. 4) is attached to the pad surface. The textures are attached in an orientation that the flow is towards the edge of the texture.

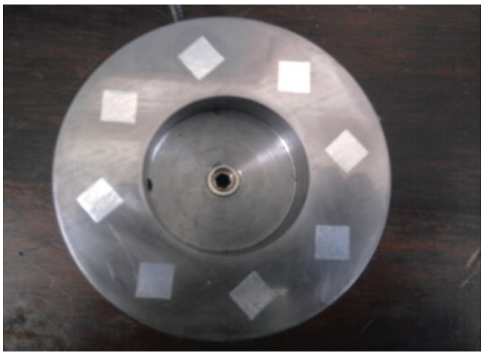

Fig.4 Test specimen

The schematic diagram of whole set-up is shown in the Fig. 5. The power from the electric motor is supplied to the runner through a flexible coupling and the speed is controlled by the speed controller. The load is applied on the loading arm and due to lever mechanism the lever which is attached to the loading arm pushes the thrust pad assembly against the rotating runner. The lubricant is supplied through the centre of the thrust pad bearing by a constant supply pressure.

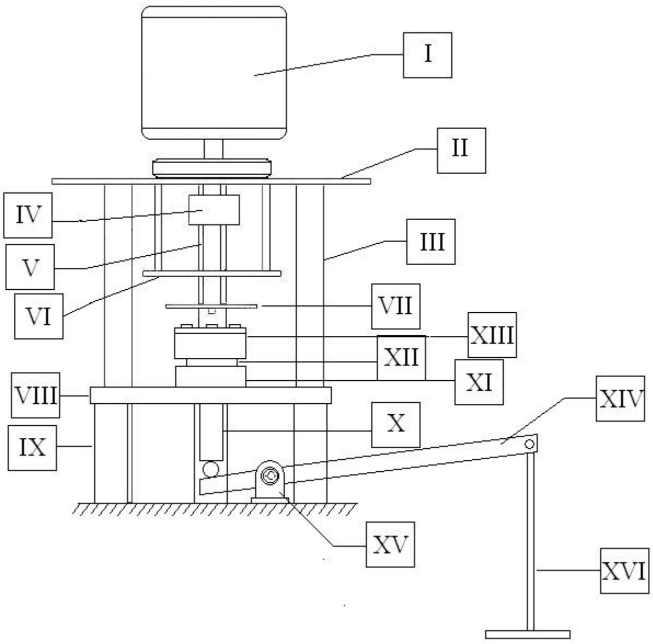


Fig. 5 Schematic diagram of the whole set-up

## 3 Experimental Procedure

The assembly of the experimental setup is shown in the Fig. 6. The test is carried out on the thrust pad bearing which has eight square shaped positive textures with the constant flow system (Supply pressure, $p_s$ = 0.1 bar (gauge)). The inner and outer diameters of the thrust pad are 0.025 and 0.05m respectively. The density and viscosity of the lubricant used in the experiment are 0.863 *kg/l* and 0.9*pa-s* respectively. The height of the surface texture is 5 $\mu$m. The tests are carried out at different speeds ranging from 50RPM to 750RPM and by varying the loads from 8.85N (0.5Kg) to 106N (6Kg). The oil film thickness is calculated using a proximity sensor by measuring the displacement of the lever. The frictional torque is calculated by measuring the frictional force using a strain measurement system which consists of a cantilever beam with two strain gauges on either side. The thrust pad is free to rotate due to the frictional torque experienced from the runner in contact. However, the motion of the thrust pad is arrested by other end of the cantilever beam. Thereby, the frictional torque is measured.

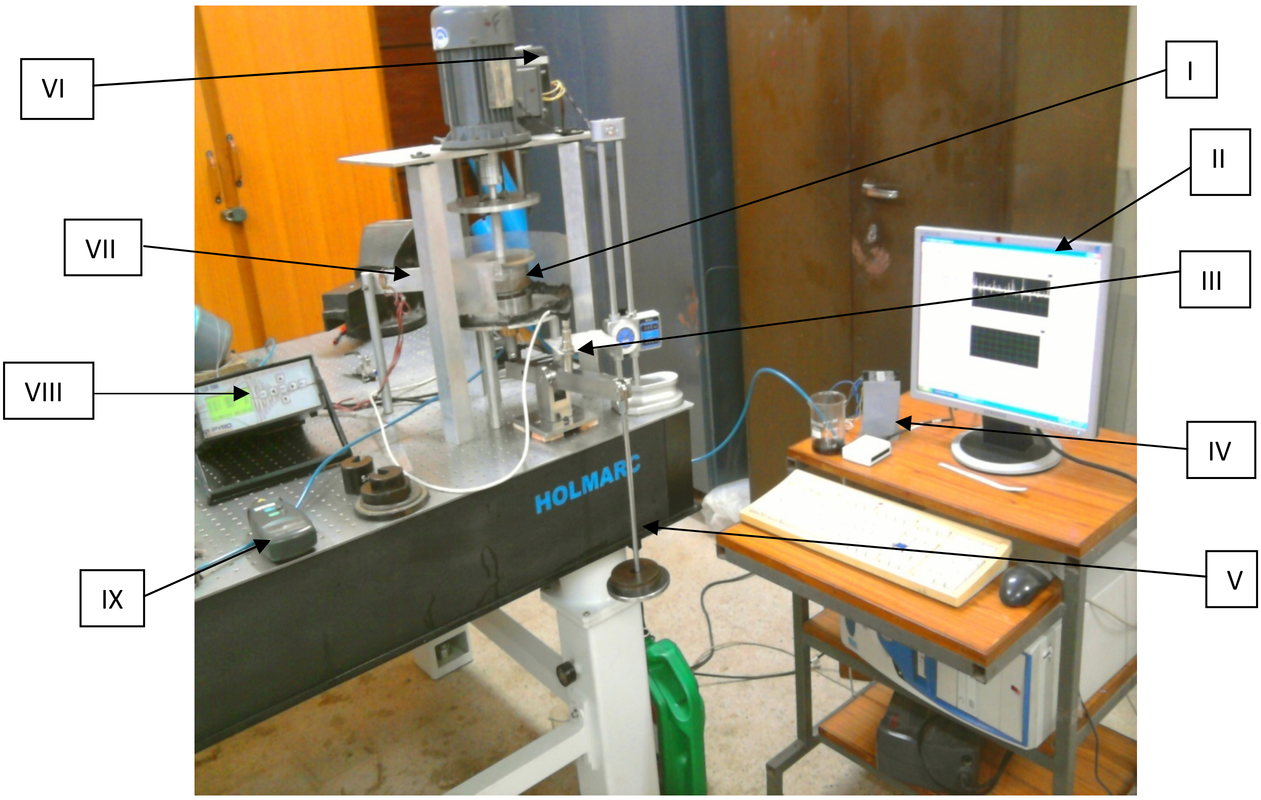


Fig. 6 Schematic diagram of experimental setup

I. Thrust pad II. Monitor III. Proximity probe IV. DAQ card V. Loading arm
VI. Controller VII. Cantilever beam VIII. Strain measuring system (SCAD 500)
IX. Tachometer

# 4 Results and Discussion

The experimental test is carried out to find the effect of positive surface textures on the thrust pad bearing by varying the operational load and speed. The effect of film thickness for different operational loads and speeds are shown in the Figs. 7 and 8. From the Fig.7, it is observed that the film thickness is decreasing as load increases. It is as expected, the increase in load causes pressure to increase, which is obtained by a decrease in film thickness.

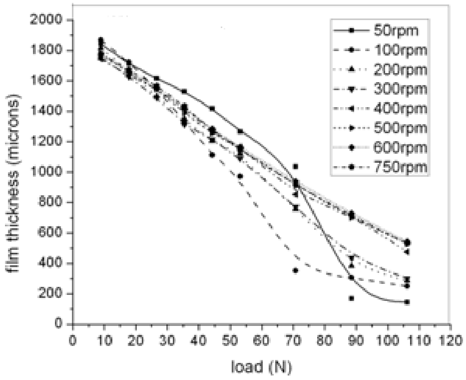


Fig.7 Variation of film thickness with load for different operating speeds

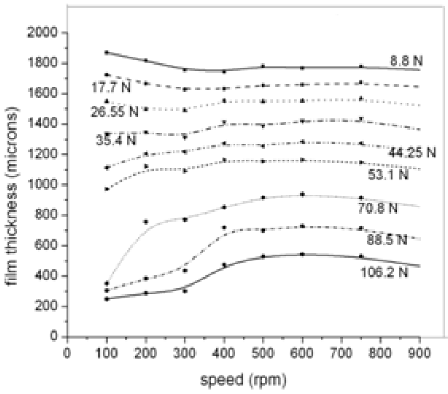


Fig.8 Variation of film thickness with speed for different working loads

Film thickness is decreasing with speed at low loads (see Fig.8). This is because of the cavitation pressure which causes to move the thrust pad towards the runner. But at high loads, the graph following the same trend as generally obtained theoretically i.e., film thickness increases as the speed increases. The effect of frictional torque for different operational speeds and loads are shown in the Figs. 9 and 10.

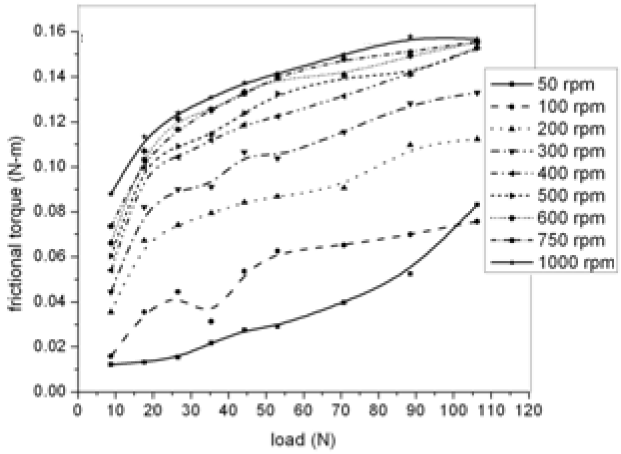


Fig. 9 Variation of frictional torque with the load for different working speeds

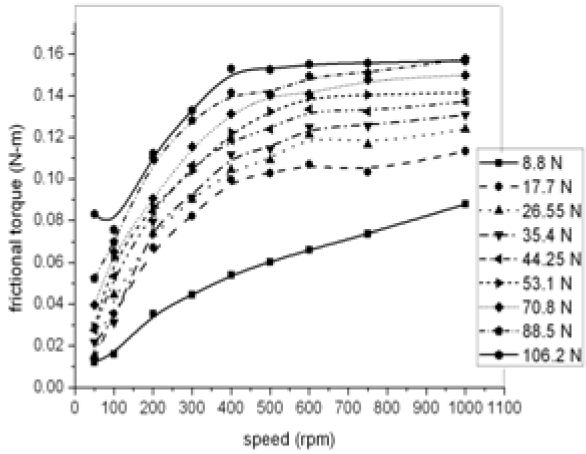


Fig. 10 Variation of frictional torque with speed for different working loads

From the Figs.9 and 10, it is observed that the frictional torque is increasing as load and speed increases. This is because the increase in speed and load causes a more frictional force on the thrust pad which increases the frictional torque. The test is carried out for both textured thrust pad bearing and plain thrust pad bearing; the comparison of film thickness for different conditions is shown in the Fig.11

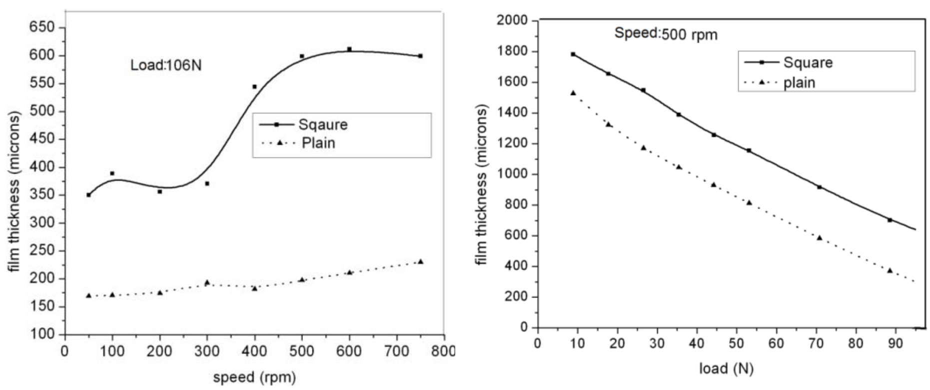


Fig.11 Comparison of film thickness for the plain and textured thrust pad bearings with the speed and load

It is observed from the Fig. 11 that at a particular load of 106N, the film thickness increases as speed increases for a plain and textured pad bearing because speed is directly related to the film thickness. At a particular speed of 500rpm, film thickness decreases as load increases which is obvious that the film thickness should decrease to support a higher load. In both cases the textured pad bearing has higher film thickness than the plain pad bearing. This indicates that the textured surface can carry more load. The frictional torque is increasing as speed and load increases for both textured and plain thrust pad bearings (see Fig.12).

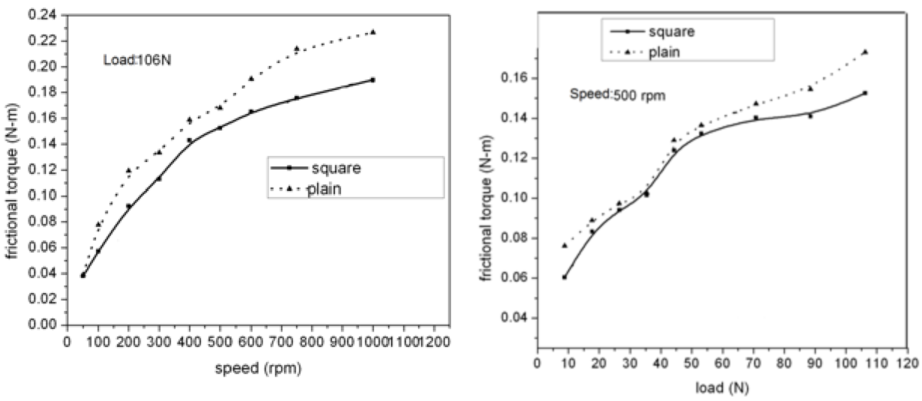


Fig.12 Comparison of frictional torque for the plain and textured thrust pad bearings with the speed and load

The frictional torque developed in the textured thrust pad bearing is less when compared with the plain thrust pad bearing. This indicates that the textured thrust pad bearing gives less power loss due to friction. One of the applications of the thrust pad bearing is mechanical face seal, the desired properties of the face seal is high load carrying capacity, less leakage rate and low frictional torque. The textured thrust pad bearing provides the high load carrying capacity and low frictional torque than the plain thrust pad bearing (see Figs. 11 and 12). This is because a minimum oil reservoir will be maintained by textured thrust pad bearing which gives a low starting frictional torque and due to reduction in film thickness by textures causes a high load carrying capacity than the plain thrust pad bearing which has direct surface contact.

# 5 Conclusion

From the experimental study of thrust pad bearing with square shaped textures considering constant flow system, it can be concluded that for low loads, film thickness decreases as speed increases whereas for high loads film thickness increases. Frictional torque increases as both speed and load increases. Thereby, textured thrust pad bearing gives higher load carrying capacity and lower value of frictional torque than that of plain thrust pad bearing.

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