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Fabrication of Micro-Textures on Conical Shape Hydrodynamic Journal Bearing

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Abstract— Hydrodynamic journal bearings are used for various applications in industries. These bearings are used to reduce the coefficient of friction and increase the load carrying capacity. For this, there is need to develop modified configurations of journal bearing to improve performance of bearing for high speed applications. The hydrodynamic bearings are of cylindrical or conical shape out of which the conical journal bearing is a good alternative. The micro irregularities on the surface of bearing are able to develop sufficient fluid film pressure and hence load carrying capacity. In this paper, an attempt has been made for fabrication of the micro textures (i.e. grooves) on the inner surface of the bearing using chemical machining process. The grooves are made on 90-degree portion on inner surface of the bearing. The radium paper is used as a maskant. The required grooves are made on radium paper and it is fixed on the bearing at the appropriate position. Ferric Chloride is used as etchant. The grooves are generated by chemical etching process. Further, the surface roughness is measured at the groove location. From the study, it is concluded that the micro textures on the inner surface of the bearings can be manufactured using chemical machining.

Index Terms: Conical hydrodynamic bearing, Micro-texturing, fabrication, chemical machining, radium paper.

1 Introduction

Hydrodynamic lubrication principle of hydrodynamic lubrication mechanism that is essential to the efficient functioning of the hydrodynamic journal bearings, which are used for various applications. The behavior of the contact is governed by the bulk physical properties of the lubricant, notably viscosity, and the frictional characteristics arise purely from the shearing of the viscous lubricant. Therefore, it becomes important to study the rheological properties of lubricants under various operating conditions such as temperature, pressure and shear rate. It is also important to understand tribology under various operating conditions and operating geometric arrangements. Bearing qualification is very much important before its use in the practical applications. However, in practice all standard journal bearings are tested for its dimensional accuracy and alignments during assembly, due to its simple construction. If the bearing is with complex geometry, it is difficult to measure dimensional accuracy and its need to study functional characteristics. Indirect way of measuring the bearing parameters are frictional coefficient and heat generation.

The performance of hydrodynamic journal bearing lubrication was analyzed by Hamilton et al. [1] and suggested that micro irregularities on the surface were able to develop sufficient fluid film pressure and hence load carrying capacity. The effect of cylindrical texture shape location on the performance characteristics of the hydrodynamic journal bearing was reported by Tala et al. [2]. Shinde et al. [3], [4], [5], [6], [7] have reported the work related to performance analysis of journal bearing, its optimization, use of micro texturing, etc. The fabrication of micro texturing on the inner surface of the bearing is also a crucial task. The micro

texturing includes grooves, dimples or any other micro geometry on the inner surface. The micro texturing can be accomplished by different non-conventional machining processes. Photochemical machining and chemical machining are one of the most suitable candidates for fabrication of these microfeatures on hydrodynamic bearing. Different researchers have reported the parametric study for photochemical machining for different materials like copper, brass, german silver and use of photochemical machining for fabrication of microchannels[8],[9],[10],[11],[12],[13]. In this paper, the fabrication of micro textures on the conical hydrodynamic bearing using chemical machining is reported.

2. MATERIAL AND METHOD:

The methodology for the work is presented in Figure 1. The material used for conical shape hydrodynamic bearing is stainless steel 410.

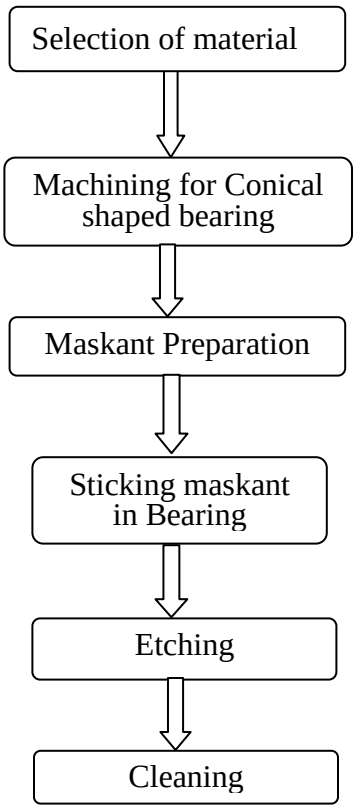
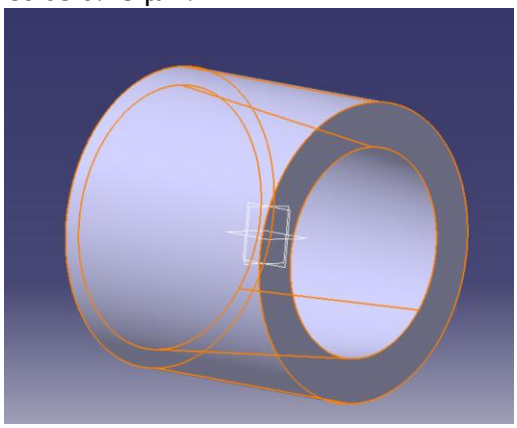


Figure 1: Methodology

Machining: The conical shaped hydrodynamic bearing is machined into required shape using turning operation for the stainless steel 410 material. The CAD drawing of the conical shaped hydrodynamic bearing is presented in Figure 2(a). The surface roughness of the fabricated bearing is checked using Mitutoyo Surface Roughness Tester as demonstrated in Figure 2(b). The average surface roughness is observed as 0.78 µm.



(a)

(b)

Figure 2: (a) CATIA Image of conical shaped hydrodynamic bearing, (b) surface roughness measurement

Maskant Preparation and application on the bearing: The maskant is prepared using radium paper. It is insolvable in the etchants like cupric chloride or ferric chloride. The radium maskant is prepared into required grooved texturing by using CO_2 laser cutting machine. The AutoCAD drawing of grooved texturing is shown in Figure 3.

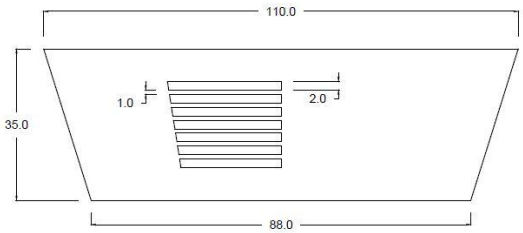


Figure 3: AutoCAD Drawing of Grooved Texturing

Figure 4: CO_2 Laser Cutting machine

Figure 5: Grooved texturing on Radium Paper

Figure 6: Radium maskant applied on the inner side of the bearing

The CO_2 Laser cutting machine set-up is presented in Figure 4 and the prepared Radium with grooved texturing is shown in Figure 5. The prepared radium maskant is further stuck at the required position on the inner side of the bearing as depicted in Figure 6.

Etching Process:

The ferric chloride is used as etchant. The bearing is wrapped with radium paper so that etching will be only for the selected for grooved texturing area (as shown in Figure 7). The etching set up with temperature control arrangement is demonstrated in Figure 8.

Figure 7: Bearing wrapped by radium-ready for etching

Figure 8: Etching set up

In this process material is removed from that area which is exposed to $FeCl_3$ solution. The etching tome is kept as 15 minutes while the etching temperature is

55°C. After this etching process, the cleaning of bearing is done by using acetone solution.

3. RESULTS AND DISCUSSION:

The fabricated grooves using chemical etching process is shown in Figure 9.

Figure 9: Bearing with grooved texturing

Figure 10: Surface roughness measurement for grooved texturing

The surface roughness is measured for the grooved texturing at all six locations using Mitutoyo Surface roughness tester (refer Figure 10). The average surface roughness is observed to be 1.11 µm.

4. CONCLUSION

The microfeatures are fabricated on the inner surface of the conical shape journal bearing using a chemical etching process. The grooved micro texturing is first prepared on the radium maskant and further fabricated inside the hydrodynamic bearing etching process in which ferric chloride is used as etchant. The fabricated grooved micro texturing is observed to be in good agreement with the desired features as the drawing. The surface roughness is also measured and noted to be 1.11 µm.

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