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CFD Analysis of The Effect of Constant and Varying Depth Dimples Textured Surface on The Performance of Hydrodynamic Journal Bearing

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Abstract - In this study, we use computational fluid dynamics (CFD) to examine the impact of surface texturing on the performance of journal bearings. Particularly, we evaluate the influence of dimples of varying depth on the lubricant film thickness and frictional losses in journal bearings. We used the ANSYS Fluent program to simulate a journal bearing with a 50 mm diameter. By maintaining their width constant at 4mm, we changed the depth of the dimples on the bearing surface. In the area of the bearing where the lubricant film thickness is the minimum, the dimples were inserted. The dimple depths that we employed ranged from 0.25mm to 2.5mm. As a result of the thicker lubrication coating caused by the application of dimples on the bearing surface, frictional losses are reduced, according to our findings. Overall, our work shows how surface texturing can enhance journal bearing performance and offers guidance on how to create textured surfaces that are best for journal bearings. Our findings imply that using dimples of a specific depth in the bearing's minimum film thickness zone might significantly boost performance, with possible uses in a variety of industrial contexts.

***Key Words*:** Journal Bearing, CFD, ANSYS, Lubricant.

1.INTRODUCTION

A Journal bearing is one of the most crucial components required to sustain rotating shafts in heavy machinery. It is subjected to abrasion from the shaft and must support heavy weights. Thus, it requires extensive lubrication to lessen wear and friction. The hydrodynamic journal bearing is one of the most affordable and effective machine components, used to support the rotating shaft. It doesn't require any external mechanisms to maintain lubrication pressure along the shaft's periphery. In a hydrodynamic journal bearing, the viscosity of the lubricant is crucial. Due to viscosity, the lubricant becomes sticky to the shaft's and the bearing's surface.

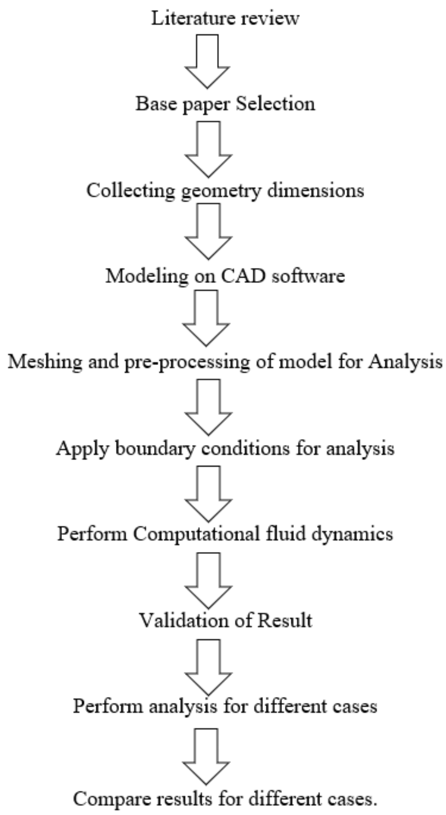
Viscosity is strongly influenced by temperature; viscosity lowers as temperature rises and vice versa. The lubricant is drawn to the area of sliding contact between the surfaces of the shaft and bearing as the journal starts to rotate. In essence, the journal serves as a lubricant pump. As the journal rotates more quickly, a wedge action arises between the journal and the bearing, lifting the journal and separating it from the bearing surfaces.

In this situation, the lubricant's viscosity is crucial because if it is too low, the wedge won't form at all, and if it is too high, the friction will quickly cause the bearing to overheat. Tribology is the study of wear, lubrication, and friction between two interacting surfaces that are moving relative to one another. It includes a broad spectrum of disciplines, such as mechanical engineering, materials science, chemistry, physics, and biology. When it comes to journal bearings, tribology is a key factor in determining the effectiveness and longevity of the bearing. The resistance to relative movement is known as friction, loss of material due to this movement is known as wear, and the use of a fluid to lower friction and wear is known as lubrication.

Friction is the usually unconnected resistance to movement between two touching solid bodies. Friction is also known as the resistance to motion. The materials, geometries, and surface characteristics of the substances in contact, as well as the operational circumstances and prerequisites, all influence how significant this resistance is. Reduced friction is necessary to improve the efficiency of a component or process. It is possible to reduce friction by using a lubricant. Friction always rises with load and surface roughness.

2. METHODOLOGY

Selection of the project involves deep and keen study of research papers. For this project, a thorough study of research papers has been done based on journal bearing, dimples, and dimple depth.



It is often important to refer back (or forward) to specific sections. Such references are made by indicating the section number, for example, “In Sec. 2 we showed…” or “Section 2.1 contained a description….” If the word Section, Reference, Equation, or Figure starts a sentence, it is spelled out. When occurring in the middle of a sentence, these words are abbreviated Sec., Ref., Eq., and Fi Modeling is carried out using the ANSYS workbench platform in our case. We drew a circle with circumferential clearance and another circle inside it to model the journal bearing. The inner circle will serve as a shaft wall, while the outer circumferential circle will serve as an internal wall of the bearing. We have drawn dimples within a span of 48o, starting at 122o from maximum film thickness. The width of dimples was taken of a constant length. The volume we got between the circles is considered a lubricating oil film. The inner circle's center is positioned eccentrically concerning the bearing.

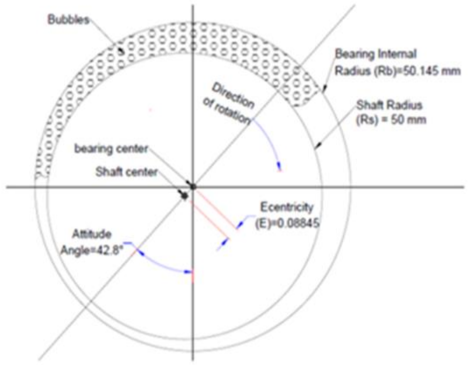


Fig -1. CAD Modeling of Journal bearing

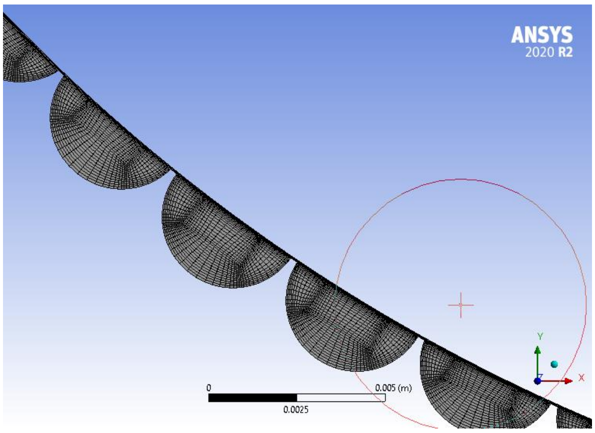


Fig -2. Meshing Strategy

3. RESULT AND DISCUSSION

For the first experiment, we kept the width of the dimples constant as well as the depth of the dimples have been also kept constant as a result, the above pressure contour shows us that the pressure drops and it is less than it is in the previous case i.e., when journal bearing has been taken without any dimples introduced on its surface.

The maximum pressure is shown in the area where the flow of oil is getting to upstream as it is a region where there is minimum clearance between the shaft and the bearing surface and the pressure is minimum where the clearance is maximum. The maximum pressure showing is 2.200 e+05 pascal.

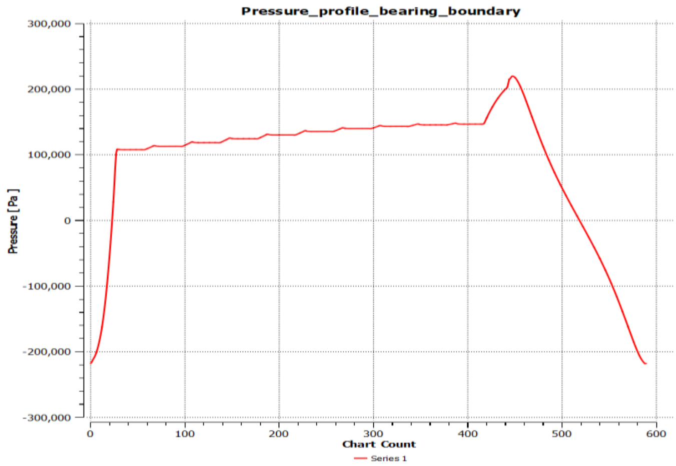


Fig -3. Pressure variation chart for Case 1

Table – 1. Comparison of Change in Load Carrying Capacity, Frictional force, and coefficient of friction for the 8 different cases

	Load (%)	Friction(%)	f(%)
Configuration 1	-24.138	-0.031	31.624
Configuration 2	-18.759	0.575	23.932
Configuration 3	-18.103	0.805	23.077
Configuration 4	-25.38	1.812	35.897
Configuration 5	-24.414	1.967	35.043
Configuration 6	-24.483	2.241	35.043
Configuration 7	-26.38	8.305	47
Configuration 8	-25.897	2.9	38.462

The results of the trials are displayed in the above table along with a comparison to our reference model. And the above table makes it abundantly clear that the configurations we chose for our dimples resulted in a loss of load carrying capacity but an increase in the frictional force acting on the shaft, and when we took into account both of these factors, we obtained a noticeably higher percentage of increase in the bearing's coefficient of friction. As we all know, if there is a high coefficient of friction between two surfaces, it indicates that there is a strong resistance to relative motion between those surfaces. This means that the surfaces in touch will experience more wear and tear over time, which will eventually cause damage.

Table – 2. Comparison of Change in Load Carrying Capacity, Frictional force, and coefficient of friction for the 10 different cases

	Load(%)	Friction(%)	f(%)
Configuration 1	-11.034	4.384	17.094
Configuration 2	-7.931	-1.789	6.838
Configuration 3	-9.621	-5.231	5.128
Configuration 4	-9.276	-7.182	1.71
Configuration 5	-9.103	-8.446	0.855
Configuration 6	-8.172	-9.778	-1.709
Configuration 7	-8.172	-10.262	-2.564
Configuration 8	-8.99	-10.088	-1.709
Configuration 9	-8.207	-10.958	-3.42
Configuration 10	-8.207	-11.263	-3.42

As can be seen in the above table 4.2 , when we compare all of the experiment's percentage-wise to our base model, we discovered that as we increased the depth of the dimples, the load carrying capacity, the frictional force of the bearing, and the coefficient of friction all decreased. As seen in the above table, trials with dimple depths of 1.5 mm and higher have produced positive outcomes.

When comparing all the data, dimples with a depth of 2.25 mm have produced the greatest results among all configurations due to their second-lowest percentage loss in terms of load bearing capacity, second-lowest frictional force, and lowest drop in coefficient of friction.

4. CONCLUSIONS

Load carrying capacity of textured bearing with dimples of varying depth and constant depth is analysed in terms of its coefficient of friction. The following have been observed: -

- The maximum pressure is reduced to great extent as the result of that the load carrying capacity gets reduced from 18 % to 26 %, but the co-efficient of friction increases from 23 % to 47 % in comparison to bearing without dimples
- Hence bearing configurations with varying dimple depths is not successful.
- Dimples on bearing surfaces affect the load carrying capacity. When the dimples with the ratio of d/hmin> 1 is provided in the maximum pressure region at high eccentricity ratio is showing more reduction in percentage of co-efficient of friction and less reduction in load carrying capacity.
- By analysis we observed that there is reduction in co-efficient of friction begins from the dimple depth 1.5 mm, and the maximum reduction observed with the dimple depth of 2.25 mm.
- It is observed that the pressure almost remains constant in the dimple region but the maximum pressure is shifted to the 4th quadrant i.e. just right side of the dimple region.
- Contours shows us that the pressure rises from maximum film thickness region to the dimple region
- Stiff fall of pressure is observed from maximum pressure location to just below the cavitation zone.
- In cavitation zone the pressure almost remains constant.
- By the above results it can be conclude that if we provide dimples of optimum shape and size in the minimum film thickness area for the journal with high eccentricity ratio, it can improves the performance of the hydrodynamic journal bearing.
- Although, we have to compromise with the pressure but the frictional force is reducing more, due to which the co-efficient of friction is also reducing which can increase the bearing life.

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