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EFFECT OF WEAR ON THE STATIC PERFORMANCE CHARACTERISTICS OF NON-RECESSED HOLE ENTRY HYDROSTATIC CONICAL JOURNAL BEARING.

TRACK OR CATEGORY
Fluid Film Bearing

Vikas M. Phalle [a]
vmphalle@gmail.com

Sanjay R. Pawar [b]
pawarsanjayrangrao@gmail.com

a. Associate Professor, Dept. of Mechanical Engineering, VJTI, Mumbai 40019, India.
b. Reaserch Scholar, Dept. of Mechanical Engineering, VJTI, Mumbai 40019, India.

INTRODUCTION

Hydrostatic journal bearings have been successfully used in many industrial applications due to their superior characteristics. The drawback of separate radial and thrust bearing and clearance adjustment in cylindrical journal configuration is eliminated by using conical journal bearing. However, one drawback of using these bearing is rubbing and subjecting to wear, which is bound to occur on the bearing surface due to frequent start/stop operation. This paper deals with the numerical study regarding the influence of wear on the performance analysis of non-recessed hole entry hydrostatic conical journal bearing compensated with capillary restrictor. Finite Element Method is used to solve the modified Reynolds equation governing the laminar flow of isoviscous incompressible lubricant in the clearance space of conical journal and bearing. Numerically simulated results indicate that appreciable change in the performance characteristics of hydrostatic conical journal bearing due to wear.

Many researchers have extensively studied the theoretical and experimental behaviour of hydrostatic journal bearing. Raimondi and Boyd [1] and Shaw and Macks [2] were among the first to study the performance characteristics of hydrostatics journal bearing using capillary and orifice restrictor. These performance parameters are obtained by solving algebraic equations derived by considering the continuity of flow for each recess. Pioneer researcher in this area, Rowe [3] analysed the performance characteristics of hole entry journal bearing and reported that hole entry journal bearing configurations are effective for better load support and low energy consumption at zero as well as for high speed as compared to slot entry journal bearing. Tokar and alexandrov [4] are the only researchers known to have investigated the effects of wear on the performance of hydrostatic bearings. However, their paper only discusses the prevention of wear and does not present any results for the effects of wear on the bearing performance. Reddecliff and Vohr [5] testified the wear of about 10 % of radial clearance after 10 starts -stop cycles. Sachhar [6] reported the degradation of performance steadily for wear more than 5 % of the radial clearance and insensitive to the geometrical location of wear. After the experimental work, a geometrical wear model was proposed by Dufrane et al. [7] taking into account the worn region of a steam turbine bearing in 1983. Sharma et.al [8] have analysed the performance characteristics of multi recesses capillary compensated hydrostatics conical journal bearing. And reported reduction in the flow rate corresponding to similar circular hydrostatic bearing. however, they have not considered effect of wear, but this is required for accurate prediction of actual bearing performance during its specified lifespan. So, this work is carried out to bridge the gap in the literature.

ANALYSIS:

The modified Reynolds equation governing the lubricant flow field in the clearance space of journal and bearing for laminar fluid flow is given as [8]

$$\frac{1}{r}\frac{\partial}{\partial r}\left(\frac{r}{12\mu}h^3\frac{\partial p}{\partial r}\right)+\frac{1}{sin^2\gamma}\frac{\partial}{\partial\varphi}\left(\frac{h^3}{12\mu}\frac{1}{r^2}\frac{\partial p}{\partial\varphi}\right)=\frac{\omega_j}{2}\frac{\partial h}{\partial\varphi}+\frac{\partial h}{\partial t} \qquad (1)$$

The fluid film thickness $\bar{h}$ between the bearing and journal surface in non-dimensional form for a conical journal bearing is given as [8]

$$\bar{h}=\left(1-\bar{X}_j\cos\alpha-\bar{Z}_j\sin\alpha\right)\cos\gamma \qquad (2)$$

Dufrane wear model is used to consider worn zone of conical bearing in which the maximum defect value $\partial\bar{h}$ is considered to be 50% of radial clearance of the bearing [7]. This defect value $(\partial\overline{h})$ is added to the calculate film thickness $(\bar{h})$ given by eq. (2)

The fluid flow rate through capillary restrictor is given as [1]

$$\bar{Q}_R=\bar{C}_{s2}(1-\bar{P}_c) \qquad (3)$$

The four noded isoparametric elements are used for discretizing the fluid flow in the clearance space of a hydrostatic journal bearing. Applying Lagrangian interpolation function, the pressure at a nodal point in the element is solved by FEM and incorporating suitable boundary conditions.

RESULT AND DISCUSSION:

As we know, maximum pressure $(\bar{P}_{max})$ generated increases with increase in semi cone angle γ at constant applied load ($\overline{W}_r=1$). The variation of maximum pressure generated ($\bar{P}_{max}$) with wear for various values of semi cone angle γ is represented by fig 1. It is clear from figure that the value of $(\bar{P}_{max})$ decreases with increase in wear depth $(\bar{\delta}_w)$. A reduction of 20%, 15.63%, 13.49%, 11.54%, 9.09% is observed in the value of $(\bar{P}_{max})$ for the semi cone angle $\gamma=5^0$, 10^0, 20^0, 30^0 and 40^0 respectively. However, his percentage reduction in the maximum pressure decreases with increase in the value of semi cone angle.

The influence of wear depth parameter $(\bar{\delta}_w)$ on the bearing fluid flow ($\bar{Q}$) is shown in fig.2 It has been observed that as bearing becomes worn, more radial clearance is available and fluid flow increases due to large leakage flow area and to support same external load, the bearing would require more lubricant. Percentage increase in the flow of order of 13.29, 13.68, 14.73, 16.84, 18.86 is seen for various values of semi cone angle γ= 5^0, 10^0, 20^0, 30^0 and 40^0 respectively. This increase in the flow is increased with increase in the value of semi cone angle. It is also observed that more bearing flow is required for small semi cone angle bearing and less bearing flow is required for large semi cone angle bearing.

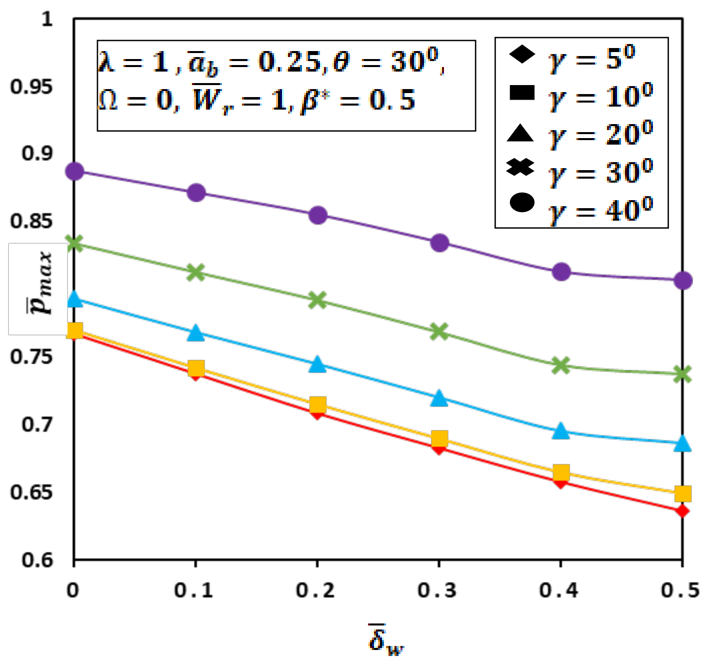

Fig.1 Variation of $\bar{P}_{max}$ with $\bar{\delta}_w$.

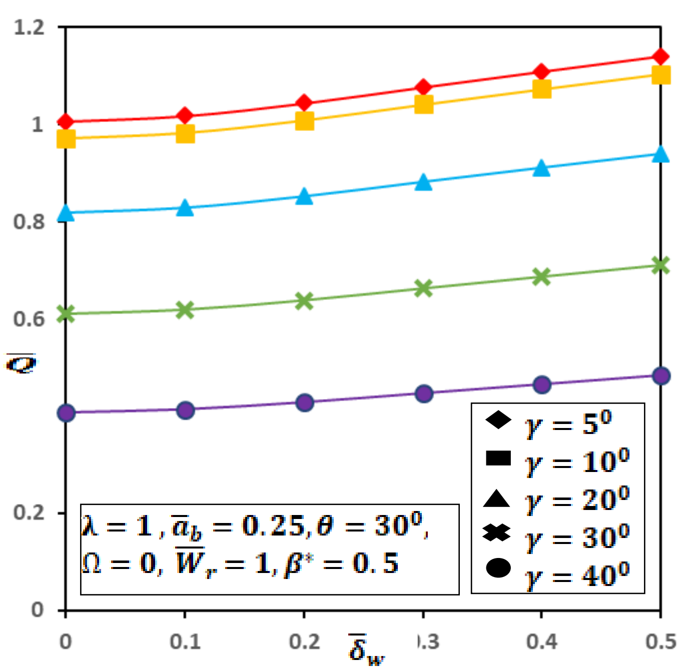

Fig.2 Variation of $\bar{Q}$ with $\bar{\delta}_w$.

CONCLUSION:

Numerically simulated results for capillary compensated hole entry worn hydrostatics conical journal bearing with constant value of unit radial load indicates that

1. The performance of hole entry hydrostatic conical journal bearing is significantly reduced due to wear defect.
2. Maximum pressure generated $\bar{P}_{max}$ reduces with increase in wear depth parameter from $\bar{\delta}_w = 0.0 \text{ to } 0.5$.
3. Bearing flow $\bar{Q}$ increases with wear and decreases with increase in the value of semi cone angle from $\gamma = 5^0$ to 40^0.

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KEYWORDS

Non-recessed, hole entry, wear, conical bearing, capillary restrictor.