Effect of orientation of pocket on the performance of geometrically irregular hybrid journal bearing

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ABSTRACT – The present work examines the influence of geometric irregularities of journal along with the influence of orientation of pockets on the capillary compensated 4 pocket bearing system analytically. The effect of barrel, bellmouth and circumferential undulated type irregularities of journal on the performance of bearing system was analyzed. Two type of bearing configurations were considered to evaluate the influence of pocket's orientation. The Reynolds equation was solved by using finite element method. The numerically simulated results indicated that the effect of geometrically irregularities of journal affect the bearing performance significantly, however, the effect is dissimilar to the different orientation of pockets.

1. INTRODUCTION

Modern manufacturing technologies have the capability to manufacture the machine components more accurately. Even though, it is rarely possible to manufacture the component without error. Likewise, error may be exist in the manufacturing of journal and bearing. As the oil film thickness in a journal bearing system is of the order of micron, it become important to consider the geometric error in journal and bearing. Error in journal exhibit the dynamic condition whereas bearing exhibit the static condition as journal is rotating and the bearing is static. That is why to consider the error in journal is more important than the error in bearing. The most common types of error in journal are barrel shape, bellmouth shape and circumferential undulated shape as shown in Fig.1. A number of researcher have focused their attention to evaluate the influence of these geometric errors on hydrodynamic journal bearing, porous bearing and hydrostatic bearing [1-4]. These studies indicated that the performance of journal bearing system generally gets deteriorated due to these geometric errors.

During the design of a multirecess hydrostatic journal bearing, the designer have the flexibility to orient the pockets over the circumference of the bearing. In general, the bearing designers use two orientation of pockets. In orientation I, the load line acts through centers of the pockets whereas in orientation II the load line bisects the land between two pockets. Very few researchers [5-7] studied the effect of pocket orientation on the performance of journal bearings.

The available literature in the area of hydrostatic journal bearing system reveals that no study dealing with the influence of geometric error of journal with different orientation of pockets on the performance of bearing system has been carried out. Therefore, the present study examines the influence of geometric irregularities of journal with different orientation of pockets on the performance of hydrostatic journal bearing system.

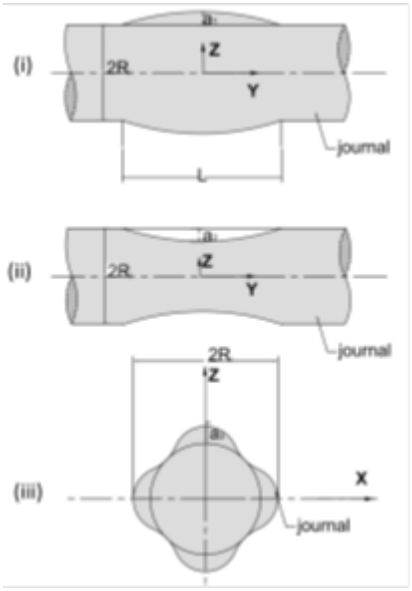

Figure 1 Different geometric irregularities of journal (i) Barrel, (ii) Bellmouth, (iii) Undulations.

2. ANALYSIS

The Reynolds equation governing the flow of lubricant in a finite length journal bearing is expressed in non-dimensional form as [5]:

$$\frac{\partial}{\partial\alpha}\left[\frac{\bar{h}^3}{12\bar{\mu}}\frac{\partial\bar{p}}{\partial\alpha}\right]+\frac{\partial}{\partial\beta}\left[\frac{\bar{h}^3}{12\bar{\mu}}\frac{\partial\bar{p}}{\partial\beta}\right]=\frac{\Omega}{2}\frac{\partial\bar{h}}{\partial\alpha}+\frac{\partial\bar{h}}{\partial\bar{t}} \qquad (1)$$

The fluid film thickness in a journal bearing for the different forms of geometric imperfections can be expressed as:

$$\bar{h}=1-\bar{X}_j\cos\alpha-\bar{Z}_j\sin\alpha+\bar{h}_{ir} \qquad (2)$$

i. $\bar{h}_{ir} = -\bar{a}_1.\sin\left(\frac{\pi\beta}{2\lambda}\right)$, for barrel shaped journal,

ii. $\bar{h}_{ir} = \bar{a}_2.\sin\left(\frac{\pi\beta}{2\lambda}\right)$, for bellmouth shaped journal,

iii. $\bar{h}_{ir} = 0.5.\bar{a}_3.\sin(n\alpha + \xi)$, for undulated journal.

3. RESULTS AND DISCUSSION

The Reynolds equation (1) is solved by using Galerkin's technique of finite element method along with restrictor flow equation incorporating the usual boundary conditions. The performance characteristics of bearing system have been computed for the judiciously selected bearing geometric and operating parameters and discussed as follows.

It may be observed from Fig. 2 that for a specified value of $\overline{W}_0$, the value of $\bar{h}_{\min}$ gets decreased for each type of geometric imperfections vis-à-vis ideal journal bearing for both bearing configurations. However, bearing orientation 1 provides higher value of $\bar{h}_{\min}$ for ideal and bellmouth shaped journal than orientation 2. For barrel shaped and undulated journal, orientation 2 exhibit the higher value of $\bar{h}_{\min}$. Thus for ideal and bellmouth shaped journal, the use of bearing orientation 1 is recommended from the viewpoint of $\bar{h}_{\min}$ and for barrel and undulated journal, Orientation 2 should be used.

Fig. 3 depicts that barrel and undulation type errors result in an increase in the value of $\bar{S}_{zz}$ vis-à-vis ideal journal while bellmouth error causes an opposite effect. Orientation 1 of pocket results in higher value of $\bar{S}_{zz}$ than orientation 2 of pocket.

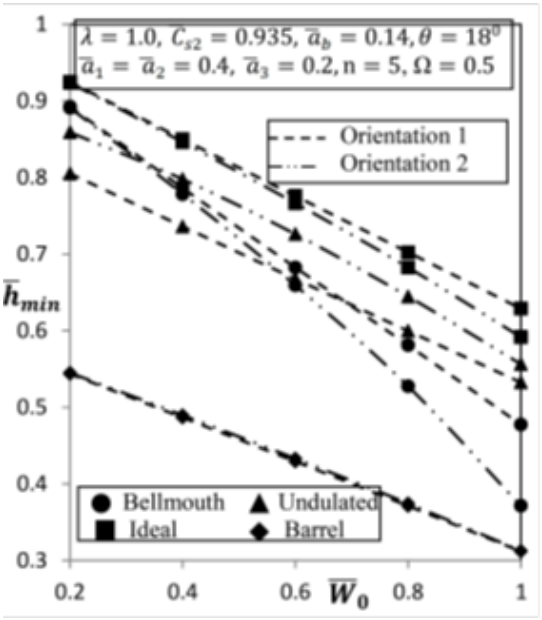

Figure 2 Variation of $\bar{h}_{\min}$ with $\overline{W}_0$.

4. CONCLUSIONS

On the basis of numerically simulated results presented in this study, the following conclusions may be drawn:

(a) The different form of geometric imperfections significantly results in a significant reduction in the value of $\bar{h}_{\min}$ for both orientation of pockets.

(b) The value of direct stiffness coefficient $\bar{S}_{zz}$ gets significantly affected due to the different geometric imperfection of journal as well as the orientations of pockets.

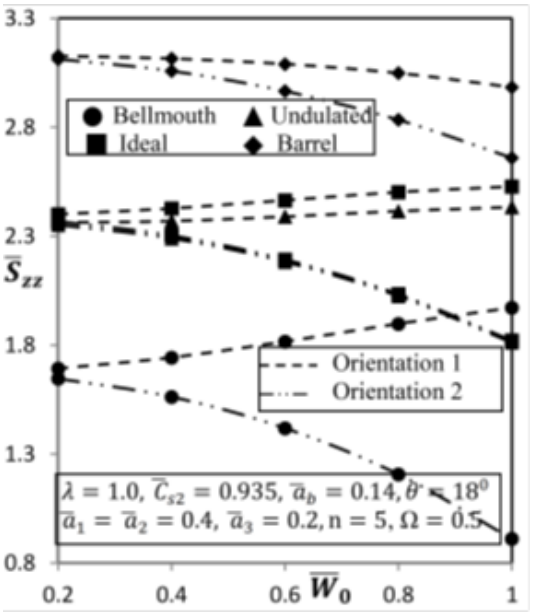

Figure 3 Variation of $\bar{S}_{zz}$ with $\bar{W}_0$.

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