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# Effects of Preload, Speed and Eccentricity Ratio of Rotor on the Thermohydrodynamic Performance of Two Lobe Journal Bearings

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**ABSTRACT:** Due to the growing use of oil journal bearings, as an effective support for the rotating parts of industrial machines, analysis of their performance is of importance. The shear stresses and the frictional forces, proportional to the speed of the lubricant layers in different points of the bearing clearance space, causes variation in the temperature of the lubricant, journal and bearing shell. However the bearing design parameters also have effects on the lubricant temperature. So, in the present work, the effects of design parameters such as the journal speed and the preload factor of the noncircular lobe journal bearing on the temperature variations which result in variation of the pressure distribution of the lubricant as well as changes in the load carrying capacity and attitude angle of the noncircular two lobe journal bearings are investigated. Then the bearing performance parameters are calculated using the final thermal pressure distribution of lubricant. Comparing the performance of two lobe bearings, with the thermal effects and without them, shows that the lubricant viscosity and the pressure distribution in the bearings decreases by increasing the rotational velocity of the journal. Also the results indicate that the effects of lubricant temperature changes on the bearing performance decreases by increasing the amount of the bearing preload.

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## 1- Introduction

Performance of journal bearings is affected by several parameters. Design parameters, type of lubricant, shape of bearing and operating conditions are some of the important affecting factors which have influence on bearing performance.

From literature review, it is seen that though there are studies regarding the effects of temperature variation on the performance of circular and also non-circular elliptical bearings, however about the performance of two lobe non-circular bearings, considering temperature variation effects as well as the effect of design parameter preload, no investigation has yet been carried out. So in the present work effects of the above factors on the performance of noncircular two lobe bearings are studied using GDQ method which is a more efficient numerical method compared to other methods.

## 2- Lobe Bearings

A noncircular lobe bearing is an assembly of two or more partial arc bearings referred to as the lobes. Analysis of noncircular bearings involves the solution of the governing equations separately for each individual lobe of bearings, treating each lobe as an independent partial bearing. obtaining the overall performance of a lobe bearing requires that the characteristics parameters be computed lobe-wise and then added together.

## 3- Governing Equations

### 3- 1- Reynolds equation

With the usual lubrication assumptions for incompressible fluid flow, the Reynolds equation for pressure distribution in a noncircular hydrodynamic bearings is [1]:

$$\frac{\partial}{\partial x}\left(\frac{h^3}{\mu}\frac{\partial P}{\partial x}\right)+\frac{\partial}{\partial z}\left(\frac{h^3}{\mu}\frac{\partial P}{\partial z}\right)=6U\frac{\partial h}{\partial x} \tag{1}$$

The expression for film thickness in i[th] lobe of the noncircular journal bearings is [2]:

$$h_i=c\left(\frac{1}{\delta}-X_j\cos\theta-Y_j\sin\theta+\left(\frac{1}{\delta}-1\right)\cos\left(\theta-\theta_o^i\right)\right) \tag{2}$$

$$i=1,2$$

where $X_j$, $Y_j$ are the journal center coordinates. $\delta$ is the preload in the bearing, the ratio between minor and conventional radial clearance.

### 3- 2- Energy equation

The energy equation for steady-state, incompressible fluid is given [3]:

$$\rho c_p\left(u\frac{\partial T}{\partial x}+w\frac{\partial T}{\partial z}\right)=\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right)+\mu\left(\left(\frac{\partial u}{\partial y}\right)^2+\left(\frac{\partial w}{\partial y}\right)^2\right) \tag{3}$$

where $\rho$ is density, $c_p$ specific heat and $T$ is the fluid temperature. $u$ and $w$ are the components of velocity of the fluid lubricant along $x$ and $z$ axes, respectively.

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### 3- 3- Heat transfer equation

The temperature in bearing shell is determined by using the Laplace equation as given below[4]:

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}=0 \tag{4}$$

### 3- 4- GDQ method

In the present work GDQ method has been used as a simple, efficient and high order numerical technique for the solution of the Reynolds equation to determine the pressure distribution as well as the solution of energy and heat transfer equations in the fluid lubricant and the bearing shell. Details of the application of this technique are as in reference [5].

## 4- Analysis

In the present study in order to apply the GDQ method. in the first step the Reynolds equation is solved and the isothermal pressure in bearing is obtained. The new viscosity of the lubricant is calculated. Using present pressure and viscosity values in energy and heat transfer equations, the new temperature of the lubricant is derived Having new thermal characteristics of the lubricant, again the process of calculating pressure, viscosity and temperature of lubrication are repeated till the stable below given conditions are fulfilled:

$$\frac{\sum\left(\left(P_{i,j}\right)_{n-1}-\left(P_{i,j}\right)_n\right)^2}{\sum\left(\left(P_{i,j}\right)_n\right)^2}\le 10^{-6} \tag{5-a}$$

$$\frac{\sum\left(\left(T_{i,j}\right)_{n-1}-\left(T_{i,j}\right)_n\right)^2}{\sum\left(\left(T_{i,j}\right)_n\right)^2}\le 10^{-6} \tag{5-b}$$

$$i=1,2,\dots N_x \quad j=1,2,\dots N_y$$

## 5- Results and Discussion

In order to verify the accuracy of the developed computer programs, the output for the load carrying capacity of circular bearings from the present study, has been compared with the result of reference [6] in Fig. 1. It is seen that the results are close.

Fig. 2 and 3 show the variations of the lubricant temperature and viscosity as a function of eccentricity ratio, respectively, for different preload values.

Fig. 2 shows that by increasing the eccentricity ratio and preload values, the temperature in the lubricant also increases,whereas the results of Fig. 3 shows that in the case of viscosity, its value decreases as eccentricity and preload values are increased.

## 6- Conclusions

It is observed from the results of the present study that increasing the preload factor can increases the temperature of the lubricant. An increase of the preload factor also affects the viscosity of the lubricant. Its increase causes a decrease in viscosity. Both the above effects are unfavorable as the rise in temperature of the lubricant as well as the decrease in its viscosity can reduce the load carrying capacity of bearings.

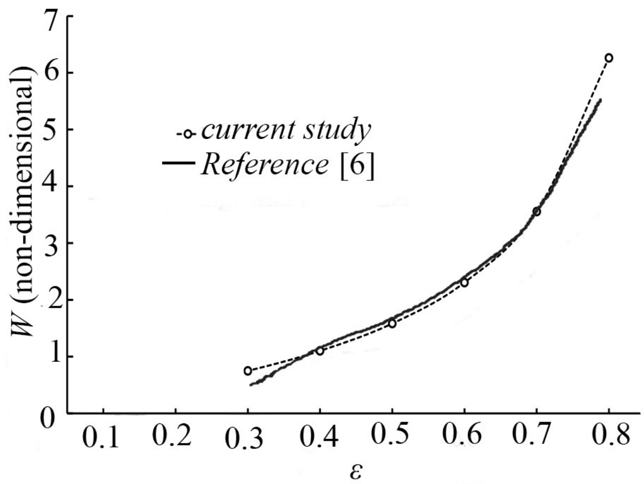


**Figure 1. Variation of load carrying capacity as a function of eccentricity ratio of journal in the bearing space**

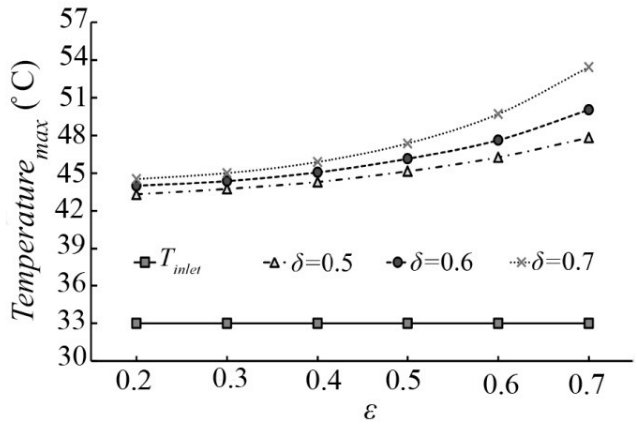


**Figure 2. Variation of maximum lubricant film temperature as a function of eccentricity ratio at different values of preload factor , $\omega$=5000rpm**

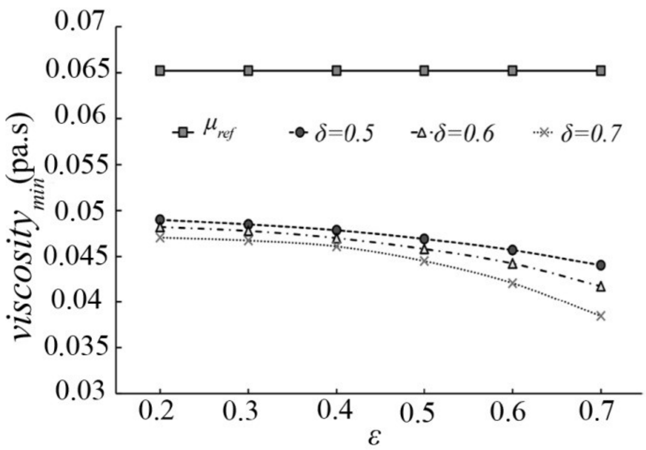


**Figure 3. Variation of minimum lubricant viscosity as a function of eccentricity ratio at different values of preload factor, $\omega$=5000rpm**

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