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Compensated hole-entry hybrid journal bearing by CFV restrictor under micropolar lubricants

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ABSTRACT – The present work investigates the performance of compensated hole-entry hybrid journal bearing by constant flow valve (CFV) restrictor under micropolar lubricants. The Reynolds equation for micropolar lubricants has been solved with finite element technique. Performance of bearing has been evaluated as a function of external load ($\overline{\boldsymbol{W}}_{\boldsymbol{o}}$). The simulated characteristics of bearing under micropolar lubricants have been compared with similar bearing under Newtonian lubricant. The results have been presented for the selected values of micropolar parameters $\boldsymbol{N^2}$ and $\boldsymbol{l_m}$. Simulated results indicate that the bearing under micropolar lubricants exhibits the increased values of characteristics than similar bearing under Newtonian lubricant.

1. INTRODUCTION

The estimation of flow behavior of lubricant plays an important role in order to accurately predict the behavior of bearings. The concept of micropolar fluid theory was given by Eringen [1] which accounts for the internal structures of fluids. This theory of fluids exhibits microrotational effect and microrotational inertia [2]. Several researchers studied the operation of journal bearings under micropolar lubrication [3-5]. Tipei [3] presented the characteristic parameters of short journal bearing under micropolar lubrication. A numerical study by Wang and Zhu [4], deals with finite hydrodynamic bearing operating with micropolar fluids. Later on, Nathi and Sharma [5] analyzed the effect of micropolar lubrication on compensated hole-entry hybrid journal bearing by orifice restrictor. Many studies about the performance of hole-entry journal bearings have been reported [6,7]. Cheng and Rowe [6] proposed a selection model which is concerned with the selection of bearing type and configuration, the fluid feeding device and bearing material. Later on, the performance of hole-entry journal bearing was analyzed by Rowe et al. [7]. This study considers the influence of micropolar lubricants on performance of compensated hole-entry hybrid journal bearing by CFV restrictor.

2. ANALYSIS

The modified Reynolds equation governing the flow of lubricant in hole-entry journal bearing [Fig.1] for micropolar lubrication is expressed as [5]

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

Where, $\overline{\Phi}=1+\frac{12l^2}{\bar{h}^2 l_m^2}-\frac{6N}{\bar{h}l_m}coth\left(\frac{N\bar{h}l_m}{2}\right)$,
$N=\left(\frac{k}{2\mu+k}\right)^{1/2}, l=\left(\frac{\gamma}{4\mu}\right)^{1/2}$

N and l are two parameters which characterize the micropolar lubricant and makes it different from the Newtonian lubricant. When l_m approaches to infinity and N^2 tends to zero, the lubricant behaves like a Newtonian lubricant.

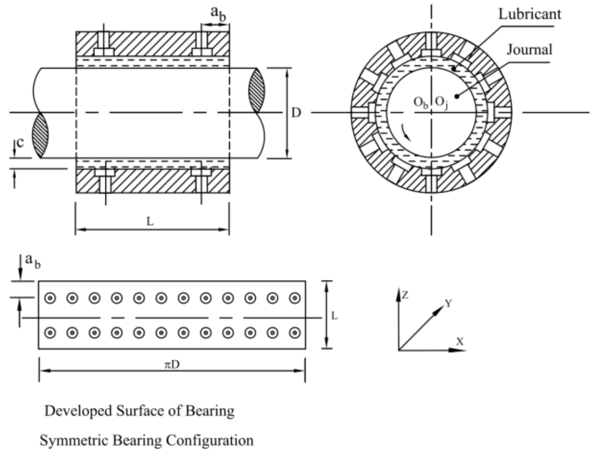

Figure 1 Hole-entry journal bearing.

3. RESULTS AND DISCUSSION

An analytical model is used to determine the performance of hole-entry hybrid journal bearing under micropolar lubricants. A computer program has been developed according analytical model. The bearing characteristics parameters have been presented in terms of minimum fluid film thickness$\left(\bar{h}_{min}\right)$ and stability threshold speed margin ($\bar{\omega}_{th}$). The results have been presented for values of micropolar parameters $N^2 = 0.1-1.0$, $l_m = 5-30$ and Newtonian lubricant. The numerically simulated results have been presented through Figs.2 to 3 for bearing parameters such as Bearing aspect ratio (λ) = 1.0; Land width ratio ($\bar{a}_b$) = 0.25; Speed parameter (Ω) = 1; No. of rows of holes = 2; No. of holes per row = 12; External load ($\overline{W}_o$) = 1.25;

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concentric design pressure ratio (β^*) = 0.5. Fig.2 shows the variation of minimum fluid film thickness $\bar{h}_{min}$ with coupling number N^2. It may be noticed that the value of $\bar{h}_{min}$ increases with decreasing value of characteristic length of micropolar lubricant l_m at constant value of coupling number N^2 when bearing operates with micropolar lubricants than Newtonian lubricant. However, the maximum percentage of increase in the value of $\bar{h}_{min}$ at $N^2 = 0.9$ and $l_m = 5$ is 10.26% as compared to the bearing with Newtonian lubricant. Fig.3 indicates the influence of micropolar parameters N^2 and l_m on the value of stability threshold speed margin $\bar{\omega}_{th}$. It may be observed from Fig.3 that an increase of 85.21%, 39.11%, 25.31% and 17.15% in stability threshold speed is found corresponding to the coupling number $N^2 = 0.9$ for the values of $l_m = 5, 10, 15$ & 20 respectively as compared to the bearing under Newtonian lubricant.

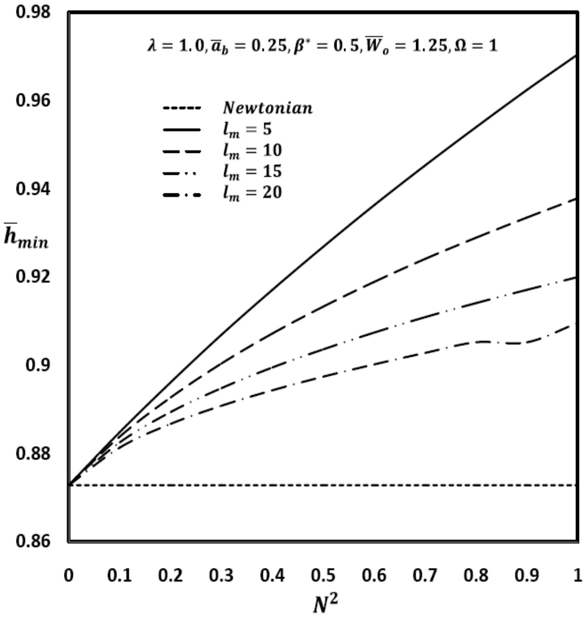

Figure 2 Variation of $\bar{h}_{min}$ with N^2.

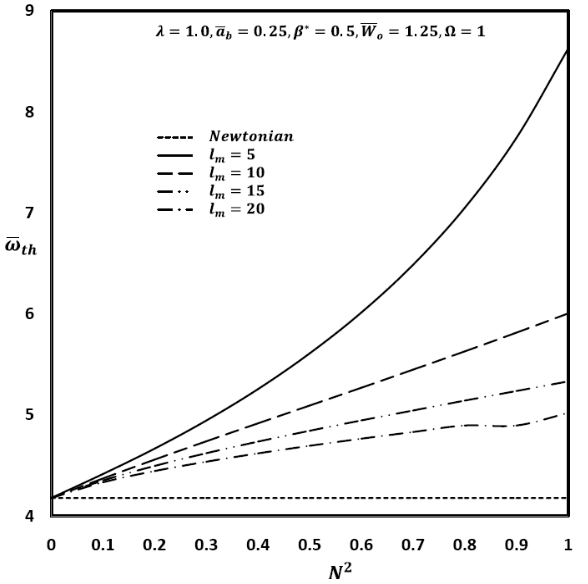

Figure 3 Variation of $\bar{\omega}_{th}$ with N^2.

4. CONCLUSIONS

The following conclusions have been drawn from numerically simulated results in this study:

1. It is observed that the value of minimum fluid film thickness $\bar{h}_{min}$ gets increased due to increased value of coupling number and lower value of characteristics length of micropolar lubricant as compared to the same bearing under Newtonian lubricant.
2. The influence of micropolar parameters on the bearing stiffness and damping coefficients gets improved significantly for bearing under micropolar lubricant than Newtonian lubricant.
3. The stability threshold speed margin $\bar{\omega}_{th}$ is larger for a bearing with micropolar lubricant as compared to corresponding similar bearing with Newtonian lubricant.

5. REFERENCES

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