J. Indian Inst. Sci., 64 (B), Nov. 1983, Pp. 317–319

Short Communication

The effect of linear inertia on the squeeze film between parallel annular plates

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Received on April 11, 1983 ; Revised on August 13, 1983.

Abstract

The effects of linear inertia on the action of the squeeze film between two parallel annular plates, when the upper plate moved normal to itself and approached the lower plate with uniform velocity, were theoretically investigated using the method of regular purturbation Expressions for pressure, load capacity and squeeze time were obtained. For the same annular plates, pressure, load capacity and squeeze time were found to increase with the linear inertia.

Key words : Linear inertia, squeeze film, load capacity, squeeze time, annular plates, lubrication.

1. Introduction

Archibald[1] analysed the behaviour of the squeeze films between various bearing configurations with parallel surfaces. However, effects of linear inertia were neglected by him. Bhat *et al*[2] stressed the importance of considering the linear inertia effect. In this paper we study the effects of linear inertia on the squeeze film between parallel annular plates using the regular perturbation method.

2. Analysis

The bearing configuration consists of two parallel annular plates, each with inside radius a and outside radius b. The upper plate moves normal to itself and approaches the fixed lower plate with uniform velocity $\dot{h} = dh/dt$, h being the film thickness at time t. With the notations[2] the governing equations are :

$$E\left(U\frac{\partial U}{\partial R} + V\frac{\partial U}{\partial Z}\right) = -\frac{dP}{dR} + \frac{\partial^2 U}{\partial Z^2} \text{ and } \frac{1}{R}\frac{\partial}{\partial R}(RU) + \frac{\partial V}{\partial Z} = 0. \tag{1}$$

The boundary conditions are :

$$U(R,0) = U(R,1) = V(R,0) = P\left(\frac{a}{h}\right) = P\left(\frac{b}{h}\right) = 0,\ V(R,1) = -1. \tag{2}$$

3. Solution by the regular perturbation method

Solving[2] the equations (1), the dimensionless pressure

$$P^* = -3(r^{*2} - 1 + 2D\ln r^*) + \frac{27E}{70}\left[-(r^{*2} - 1) - \left(\frac{1}{r^{*2}} - 1\right)\frac{D^2}{2} + \left\{(k^2 - 1) + \frac{D^2}{2}\left(\frac{1}{k^2} - 1\right)\right\}\frac{\ln r^*}{\ln k}\right], \tag{3}$$

where $D = \frac{1}{2}\frac{1 - k^2}{\ln k}$, $k = \frac{a}{b}$, $r^* = \frac{r}{b}$ and E is the inertia parameter.

The dimensionless load capacity is

$$W^* = \frac{3}{4}[1 - k^4 + 2D(1 - k^2)] + \frac{27E}{280}\left[1 - k^4 + 3D(1 - k^2) - D^3\left(\frac{1 - k^2}{k^2}\right)\right]. \tag{4}$$

The dimensionless squeeze time $\bar{t}$ is the same as in Bhat *et al*[2], $\bar{e}$ being the corresponding inertia parameter.

4. Results and discussion

The results for circular plates are obtained by making $a \to 0$ in equations (3) and (4) to yield

$$P^* = 3(1 - r^{*2})\left(1 + \frac{9E}{70}\right) \text{ and } W^* = \frac{3}{4}\left(1 + \frac{9E}{70}\right).$$

The effects of k and E or $\bar{e}$ on W^* and $\bar{t}$ are displayed in Tables I and II. Both W^* and $\bar{t}$ increase with $1/k$ and E or $\bar{e}$.

Table I

Values of W^* for various values of k and E

k \ E	0·0	0·0001	0·01	0·1
1/2	0·09449	0·09450	0·09532	0·10281
1/3	0·20134	0·20134	0·20176	0·20557
1/4	0·27157	0·27158	0·27218	0·27760
1/100	0·58717	0·58730	0·60016	0·71704

Table II

Values of $\bar{t}$ for various values of k and $\bar{e}$. $\bar{h}_2 = 0\cdot02$

k \ $\bar{e}$	0·0	0·0001	0·01	0·1
1/2	1·1339	1·1339	1·1380	1·1688
1/3	2·4161	2·4161	2·4171	2·4258
1/4	3·2589	3·2589	3·2600	3·2692
1/100	7·0461	7·0462	7·0565	7·1422

References

1. ARCHIBALD, F. R. — Load capacity and time relations for squeeze films, *Trans. ASME* Ser. D, 1956, 78, 231–245.

2. BHAT, M. V., GUPTA, J. L. AND VORA, K. H. — The effect of linear inertia on the squeeze film action between a curved circular plate and a flat plate, *J. Indian Inst. Sci.*, 1983, 64 (B), 17–24.