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Numerical Simulation of the Effects of Recess Depth on Dynamic Effect of Hydrostatic Thrust Bearing

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Abstract. This work describes a numerical simulation concerning dynamic effect of multi-pad hydrostatic thrust bearing having different recess depth in order to solve the loading capacity of the hydrostatic thrust bearing. Three-dimensional pressure field of gap fluid between the rotation worktable and the base has been computed by using the Finite Volume Method. This study theoretically analyzes the influence of recess depth on dynamic effect of the bearing according to the Computational Fluid Dynamics and lubricating theory, and the simulation results indicate that an improved characteristic will be affected by recess depth easily. Through this method, the optimal loading capacity of such products can be achieved.

Keywords: Recess depth, Dynamic effect, Hydrostatic thrust bearing, Computational Fluid Dynamics (CFD).

1 Introduction

The following reports are important investigations concerning hydrostatic thrust bearings this time. Recently Statish C. Sharma analyzed the capillary compensated four cavities hydrostatic journal bearing with different geometric shapes of recess. It was further reported that influence of recess shape on the performance of capillary compensated circular thrust pad hydrostatic bearing. F. Shen revealed the effect of flow characteristics on the load capacity of oil cavity, the flow of round Rayleigh step cavity in hydrostatic lift was divided into three regions[1]. Christian studied the dynamic effects of hydrostatic bearings. The geometry of the hydrostatic bearing pockets and their restrictors are optimized by using time continuous pressure distribution at the bearing pocket, laminar flow behavior as well as constant velocity of the bearing. The dynamic effects of the flow at high velocities are not considered. L. Guo studied influence of geometric configuration on the characteristics of high speed hybrid bearings[3]. Z.Q. Zhao described pressure of the hybrid bearings based on MATLAB software, the ladder hybrid bearings' static performance was solved with finite element method, oil film bearing pressure field was calculated, and researched the oil film pressure distribution when changing the depth of the ladder of the hybrid

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bearing[4]. C.Y. Zhang studied that influences of different factors on the flow field of center entrance oil cavity were studied[5]. This paper studied that influence of recess depth on the dynamic effect of a constant flow hydrostatic thrust bearing.

2 Working Principle of Hydrostatic Thrust Bearing

The working principle of hydrostatic bearing with quantitative oil supply is shown as Fig. 1[6].

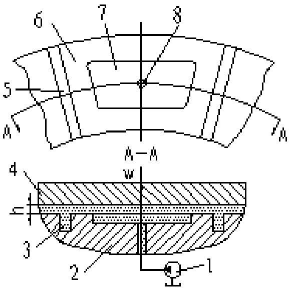

Fig.1. Sketch map of principle of work of quantitative supply static thrust bearing

3 Mathematical Model

Flow problem of fluid between the rotation worktable and base belongs to a laminar flow problem, and its mobility must meet mass conservation equation, momentum conservation equation and energy conservation equation.

3.1 Reynolds Equation

The working principle of Rayleigh step bearing is shown as Fig. 2.

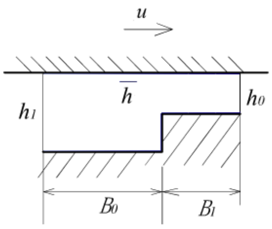

Fig. 2. Working principle of Rayleigh step bearing

In the area B_0 , Reynolds equation is

$$\frac{dp_1}{dx} = 6\eta u \frac{h - h_m}{h^3} \cdot \tag{1}$$

In the area B_1 , Reynolds equation is

$$\frac{dp_2}{dx} = 6\eta u \frac{h - h_m}{h^3} \cdot \quad (2)$$

3.2 Dynamic Pressure Equation

In the area B_0, dynamic pressure equation is

$$p_1 = \frac{6\eta u B_1 \left(h_1 - h_0\right)}{B_0 h_0^3 + B_1 h_1^3} x \cdot \quad (3)$$

In the area B_1, dynamic pressure equation is

$$p_2 = \frac{6\eta u B_0 \left(h_1 - h_0\right)}{B_0 h_0^3 + B_1 h_1^3} x \cdot \quad (4)$$

Where η is viscosity of lubricating oil; h_0, h_1 and h_m are thickness of oil film; B_0 and B_1 are length of step; p is oil film pressure.

3.3 Grid of Oil Film

The grid and the grid quality of the gap oil film are shown as Fig. 3.

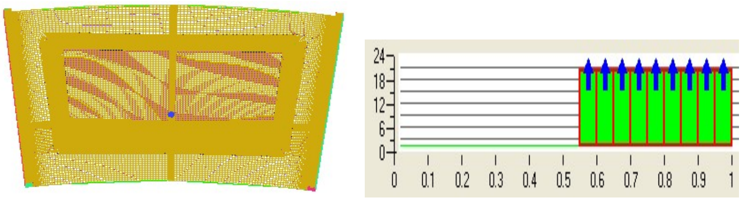

Fig. 3. The grid and the grid quality of the gap oil film

3.4 Boundary Condition

The lubricating oil selects No.46 hydraulic fluid, sets the material properties according to No.46 hydraulic fluid, the viscosity edits the viscosity-temperature function to replace the constant value; The inlet choice the flow capacity entrance, the inlet temperature assumed as 311k, the outlet selects the pressure export; The upper surface of the oil film is the rotating surface, the velocity is the fixed angular speed.

4 Results and Discussions

The three-dimensional dynamic pressure fields are obtained in CFX to be as Fig.4, Fig.5. It is found that as the rotating velocity increases, the dynamic pressure increases. For the same value of rotating velocity, it is noted that the dynamic pressure is decreased with increasing the recess depth.

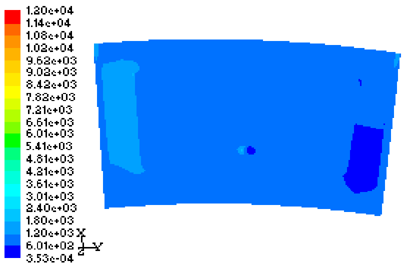

Fig. 4 Dynamic pressure field of 0.5mm depth at 6r/min

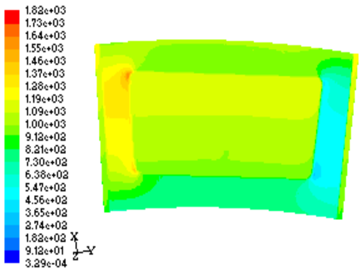

Fig. 5 Dynamic pressure field of 8mm depth at 6r/min

5 Conclusions

Simulation analysis of the three-dimensional dynamic pressure field of multi-pad hydrostatic thrust bearing having sector recess had been achieved through Computational Fluid Dynamics and the Finite Volume Method. The simulation results qualitatively agreed well with the theoretical calculation values. The results showed that oil recess dynamic pressure is affected by rotating velocity and recess depth. It had found that as the rotating velocity increases, the dynamic pressure increases. For the same value of rotating velocity, it was noted that the dynamic pressure was decreased with increasing the recess depth.

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