Advanced Science and Technology Letters
Vol.31 (ACN 2013), pp.71-74
http://dx.doi.org/10.14257/astl.2013.31.17

Impact of Large Size Hydrostatic Guide-way Oil Cavity Depth on the Oil film Flow Pattern

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Abstract. Based on computational fluid dynamics, friction lubrication theory and hydrostatic technology, the research on large size hydrostatic Guide-way that many heavy-duty vertical CNC lathes widely use, established simulation control equation of hydrostatic guide-way's interstitial fluid, adopted finite volume method, defined lubricating oil properties, set boundary conditions such as constant flow inlet, outlet pressure, wall and so on, made iterative computations, got hydrostatic thrust bearing's interstitial fluid velocity field and discussed influence rules of cavity depth on the large size hydrostatic Guide-way's interstitial oil-film velocity distribution. The results of numerical calculation really reflect hydrostatic bearing's internal fluid flow state, and the simulation results provide theoretical basis for the design of practical engineering hydrostatic bearing.

Keywords: heavy-duty vertical lathe, hydrostatic guide-way, finite volume method, interstitial fluid

1 Introduction

Heavy-duty hydrostatic Guide-way plays an important role in the spindle component of lathe, whose property directly affects the machining precision of lathe. The hydrostatic Guide-way utilizes pressure oil-film between rail and rotary table to float bearing spindle and support load. Hydrostatic Guide-way divides into many pads Guide-way and many chambers Guide-way according to whether oil cavity has return chutes or not. The Guide-way which has lateral return chutes between oil cavities is called many pads Guide-way, and which has not a lateral return chute is called many chambers Guide-way. The object of study in this article is many pads Guide-way.

At present many scholars do a certain degree of researches on the oil-film lubrication performance. Singh, Udaya P. took hydrostatic thrust bearing as the research object and built Newton fluid lubricant and non-Newton fluid lubricant, that is the fluid model of lubricating oil mixed into viscosity index improvers or viscosity thickener [1].In 2012,Ram, Nathi did a numerical study on micro lubrication problem of hybrid radial bearing. Through reynolds-equation reveals the flows of micro-polar

ISSN: 2287-1233 ASTL

lubricating oil of bearing clearance space, he analyzed lubricating oil micro-polar parameters and the relationship between revolving speed and bearing performance via finite element method and appropriate boundary conditions [2].

2 Fluid Model of Hydrostatic Guide-way

This essay discusses the constant flux oil supply system of hydrostatic thrust bearing. The feature of it is that every oil pocket of the bearing connects one oil pump of the same flow and the pump sends the transverse flowing lube directly to the oil pocket, forming a pressural lubricant film, buoyantly lifting the main shaft and supporting external load. The working principle is shown in figure 1.

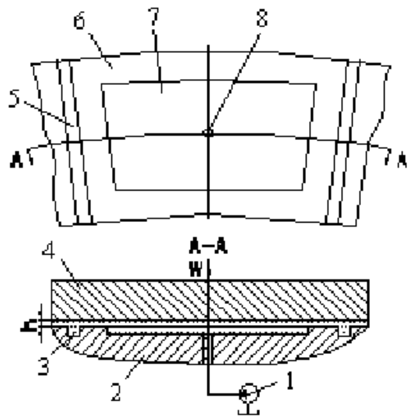


Fig. 1 Constant flux oil supply system of hydrostatic thrust bearing 1-pump, 2-guide rail, 3-Interstitial fluid, 4-rotary table, 5-return chute, 6-land, 7-oil pocket, 8-fuel feed hole, w-external load, h-oil film thickness

3 Fluid Model of Hydrostatic Guide-way clearance

This paper research object that the Interstitial Fluid of hydrostatic guide is cannot compress, and calculation result showed that the Renault coefficient is Re < 2300. Because the interior flow of guide is laminar fluid, bring through continuity equation and momentum conservation equation using laminar model.

Continuity equation

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho u) = 0 \qquad (1)$$

The flow is steady state, so the density ρ is not variety with time, $\frac{\partial \rho}{\partial t} = 0$, previous formula can white as:

$$\frac{\partial \rho}{\partial t} + div(\rho u) = 0 \qquad (2)$$

Also can white as:

$$\frac{\partial \rho}{\partial t} + div(\rho u) = \frac{\partial (\rho u)}{\partial x} + \frac{\partial (\rho v)}{\partial y} + \frac{\partial (\rho w)}{\partial z} = 0 \qquad (3)$$

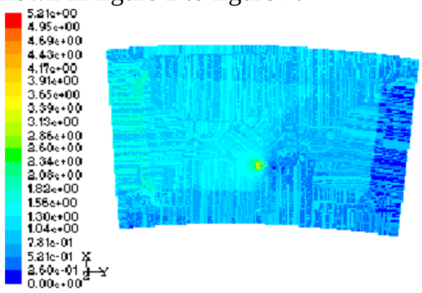
In formula ρ is density, t is time, ∂ is dispersion, u. v. w is the heft of velocity vector u in axle x, y, z directional.

Momentum conservation equation:

$$\frac{\partial (\rho u)}{\partial t} + div(\rho u_r u) = div(\mu\, grad\, u) - \nabla p + F \qquad (4)$$

4 Computed Results and Analysis

To study the influence of the depth of fuel cavity to the velocity field of the hydrostatic guide-way interstitial fluid, simulate the velocity field of interstitial fluid of sectored oil pocket and hydrostatic thrust bearing, with different depth of fuel cavity including 0.25mm, 0.5mm, 1mm, 2mm, 4mm. 6mm, 8mm, 10mm and16mm,. As shown in figure 2 to figure 7.



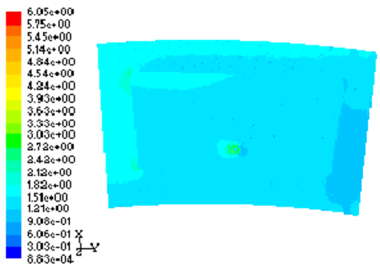
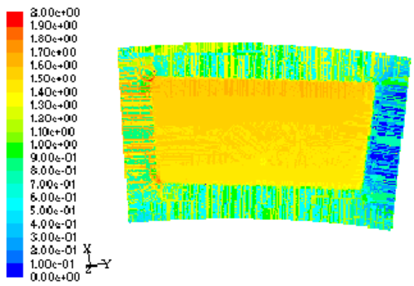


Fig. 2. Velocity field of 0.5mm deep cavity **Fig. 3.** Velocity vector of 0.5mm deep cavity



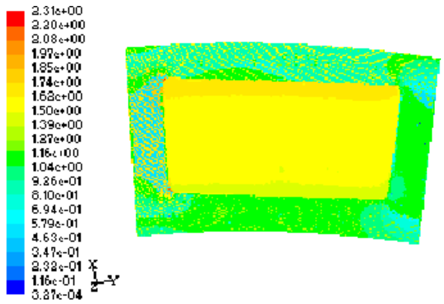


Fig. 4. Velocity field of 8mm deep cavity **Fig. 5.** Velocity vector of 8mm deep cavity

According to the computed result, we can obtain the influence curve of the oil cavity depth on the maximum velocity when the rotation rates are 6r/min.

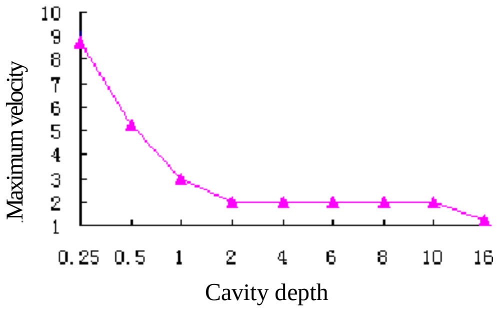


Fig.6. Influence curve of the oil on the maximum velocity

Figure 6 illustrates that the Maximum speed of the fluid of the large size hydrostatic guide-way clearance increases with the oil cavity depth gradually then decreases then remains unchanged.

5 Conclusion

Finite volume method is adopted for hydrostatic guide-way interstitial fluid to carry on numerical simulation, and the internal flow distribution is obtained. The speed of sealing side from high to low is the lift side, the radial-out side, the inside radial side, the right side.

When the oil cavity area is equivalent, we can conclude that by comparing the calculation results of different oil cavity depth, the changing rule of velocity on rail of radical is the same, they all increase gradually from the inside to the outside, as the oil cavity depth increasing the homogeneity of the velocity distribution descending. While the oil cavity depth is the same, the Interstitial fluid flow velocity increasing as the rotation speed increasing.

The numerical simulation result does not appear divergence phenomena, indicates that the equation using finite volume method is stable. At the same time, the flow distribution of interstitial fluid on hydrostatic guide accord with the practical, testify that the research method is credible.

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