Research on Oil Film static Characteristics of Three Oil Groove Journal Bearing Based on Fluent

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Abstract

The radial dynamic journal bearing is taken as the object of study , oil film static characteristics of three oil groove journal bearing is analyzed using two phase flow model of Fluent, and the oil film capacity and distribution of cavitation are studied at different eccentricity ratio and viscosities. Results show that the capacity of bearing and pressure of the oil film increase with the increasing of eccentricity ratio.The capacity of bearing and pressure of the oil film increases the improvement of viscosity, but it also contributes to the cavitation phenomenon in the divergence area of oil film, and increases the proportion of cavitation. So Setting reasonable bearing eccentricity and lubricating oil viscosity has important influence on bearing capacity and lubrication performance of bearing.

Keywords

Journal bearing, Fluent,Oil film static characteristics,capacity.

1. Introduction

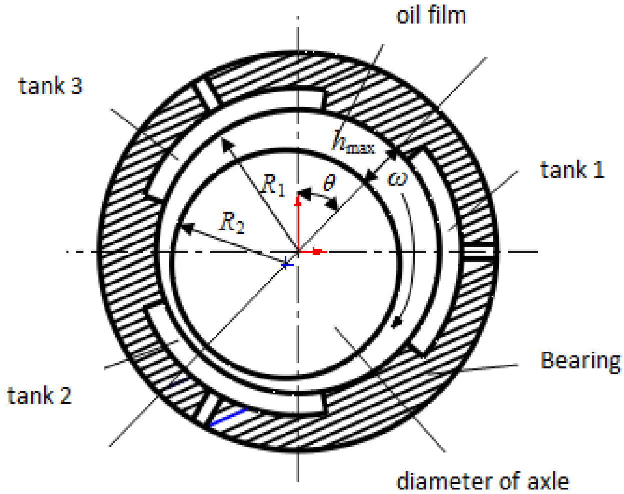
With the working conditions of machinery equipment is becoming more and more high speed, large power and heavy load, because of the good performances such as large carrying capacity, impact resistance, stable operation and high operating accuracy, journal bearing is widely used in the engineering fields such as steam turbine, railway locomotive, high precision lathe and aerospace. In order to make the sliding bearing stable work and prolong the bearing life, not only from the sliding bearing structure on the analysis and improvement, but also from the external factors to analyze the research, especially the static behavior of sliding bearings under different operating conditions.

With the rapid development of computer and fluid mechanics, more and more scholars begin to analyze and study the oil film characteristics of journal bearing by means of CFD software [1-3]. Meng [4] studied the influence of cavitation on the friction performance of bearing by means of CFD software. Cai [5] used Fluent software to study the oil film pressure, bearing capacity, temperature and cavitation volume fraction of journal bearings, he believes that when the lubricant viscosity is considered constant, the oil film temperature and carrying capacity will be overestimated. Liu [6] analyzed the oil film pressure and the oil film thickness of the bearing lubrication system by CFD method. Zhang analyzed the Three Oil Groove Journal Bearing, results show that the structure has good lubrication effect, strong anti-interference ability, and ensures the stability of the mechanical working. Liu [8] studied the pressure field of the hydrodynamic journal bearings by Fluent, and verified the consistency between the simulation results and the literature. Ji[9] have studied the mechanical properties of elliptical bearing by means of Fluent, and think it is more reasonable to analyze the bearing by taking into account the influence of cavitation.

Current studies have found that most scholars often ignore the turbulent condition, with the wide application of high speed journal bearings, it is necessary to consider the characteristics of oil film in turbulent state in order to better study the characteristics of the oil film. In this paper, the Three Oil Groove Journal Bearing are discussed, the static characteristics and the law of change of oil film in journal bearing are studied by using Fluent software considering the cavitation model in turbulent flow.

2. Model establishment and mesh generation

The structural model of a straight groove plain bearing is shown in Figure 1, the three oil grooves are uniformly distributed in the circumferential direction of the bearing. In this paper, the bearing diameter is D=100.1*mm*, the radius of gap c=0.0345 *mm*, bearing width B=110 *mm*, the oil chamber angle α=80°, the depth of the oil chamber h=0.12 *mm*, the oil chamber width L_1=90 *mm*, the oil seal edge width L_2=10 mm, oil viscosity μ=0.002 *Pa.S*, densityρ=890 kg/m^{-3}, eccentricity ™=0.6, speed n=2000 *r/min* , the initial offset angle υ=45°. In order to facilitate analysis, the three oil tanks in the figure are numbered oil tanks 1, 2 and 3 respectively. The oil tank in the positive (right) direction of X is named oil groove 1, and clockwise is oil tank2 and oil tank3.



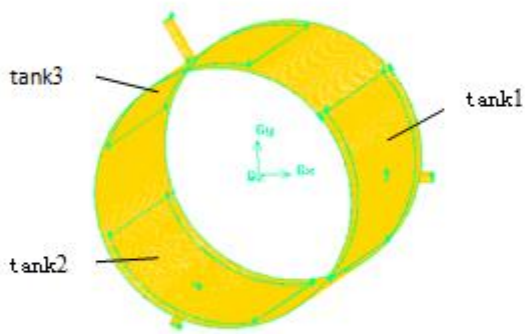


Fig 1 The structural of three straight sleeve bearings Fig 2 Grid model of three straight sleeve bearings

The structural model of the oil film is established by Gambit and divided into grids, as shown in Figure 2. In this paper, the unstructured and unstructured method is used to locate the oil inlet and the oil tank, and the unstructured mesh is divided by the boundary layer, and the rest are divided into regular structured grids, the model not only ensures better mesh quality, but also controls the number of grids, thus effectively reducing the computational effort. Pressure inlet and pressure outlet boundary condition are adopted; the outer wall of the oil film is arranged on a stationary wall, and the inner wall of the oil film is provided with a rotating wall. The two phase flow setting: the prime minister is set up as liquid lubricant, and the second phase is gas. The bearing was calculated by iterative calculation in horizontal direction (X direction) of the bearing capacity and vertical direction (Y direction) of the bearing capacity, so as to meet the conditions of FX/FY[0.004, obtains the final equilibrium position of the deviation angle.

3. Results and analysis

3.1 Influence of eccentricity on static characteristics of oil film

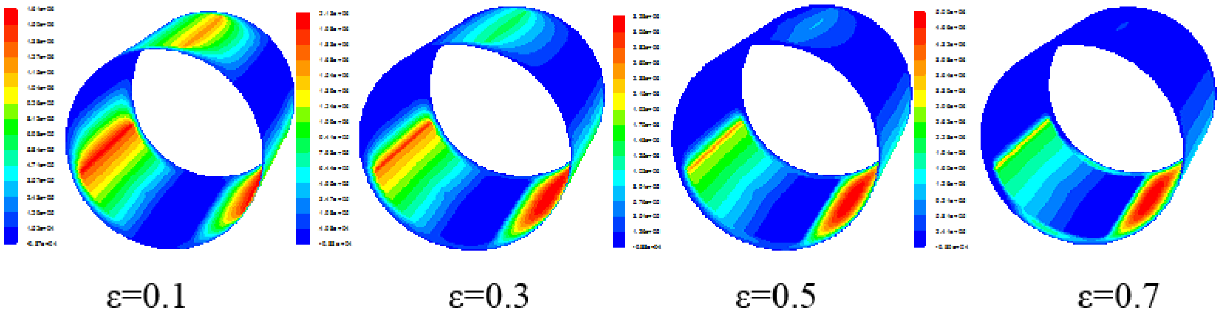


Fig. 3 Oil film pressure cloud with different eccentricity

Figure 3 shows the oil film pressure cloud picture at different eccentricity. As can be seen from Fig. 3, when the bearing is at a small eccentricity, the oil film can clearly display three positive pressure regions in the whole circumferential direction, This is because the eccentricity is lower, the oil film pressure is lower, and the pressure peak value of the three positive pressure zones is smaller, so the pressure cloud picture can show a clear positive pressure zone. With the increase of eccentricity, enhancing the squeezing effect of oil film between the oil film in the region of convergence is the peak pressure increases rapidly, and the oil groove 3 at positive pressure change is small, so the oil film pressure distribution, oil tank 3 the positive pressure region is not obvious. The increase of eccentricity decreases the formation of cavitation in oil tank 1 and oil tank 2, which makes the pressure of oil film increase obviously, but the oil tank 3 is in the oil film divergence region, and the increase of eccentricity results in more cavitation in the 3 grooves and weakens the oil film pressure.

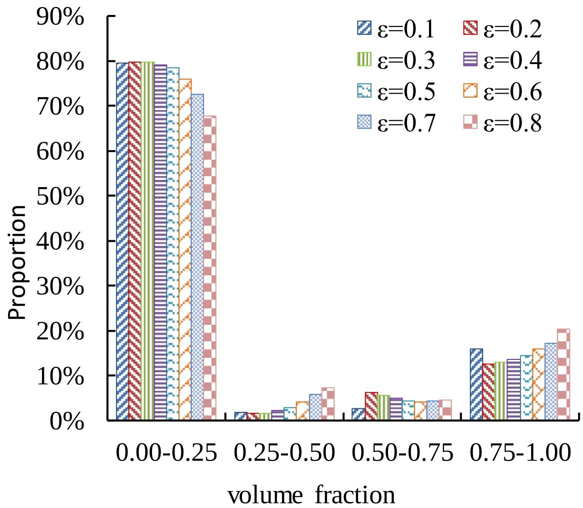


Fig 4 Effect of eccentricity on cavitation volume fraction

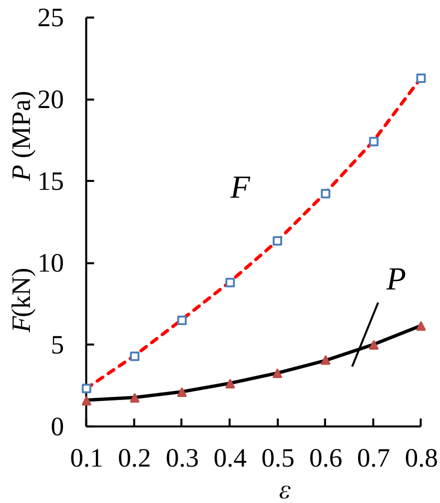
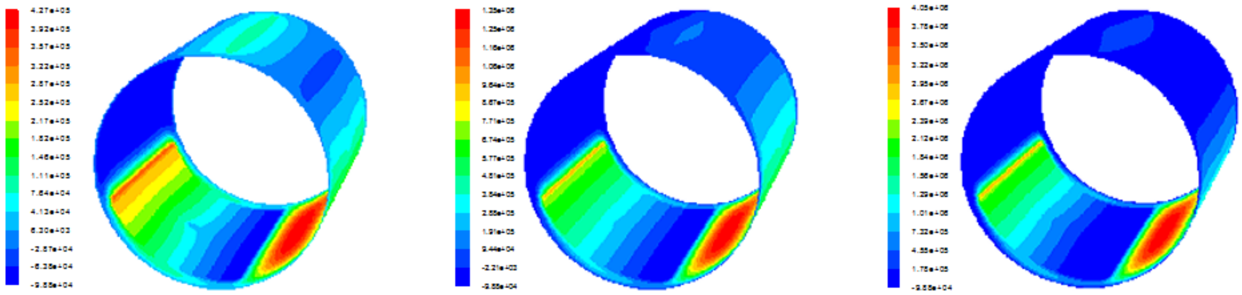


Fig 5 Effect of eccentricity on capacity and oil film pressure

Fig.4 shows the effect of eccentricity on the cavitation volume fraction, Fig.5 shows the effect of eccentricity on the capacity and the oil film pressure. As can be seen from Fig.4, in the small eccentricity, cavitation changes small volume fraction is not obvious, when the eccentricity increases to 0.5, the volume fraction of cavitation cavitation region and the proportion of large volume fraction of cavitation decreases gradually, gradually increase the proportion of the increase of eccentricity, to produce a small volume fraction of cavitation experienced grow together to form a large volume fraction of cavitation, this phenomenon will reduce the effect of lubricating oil film. It can be seen from Fig.5 that the increase of eccentricity increases the peak value of the static pressure and the bearing capacity of the oil film, and the increase of eccentricity increases the bearing capacity obviously.

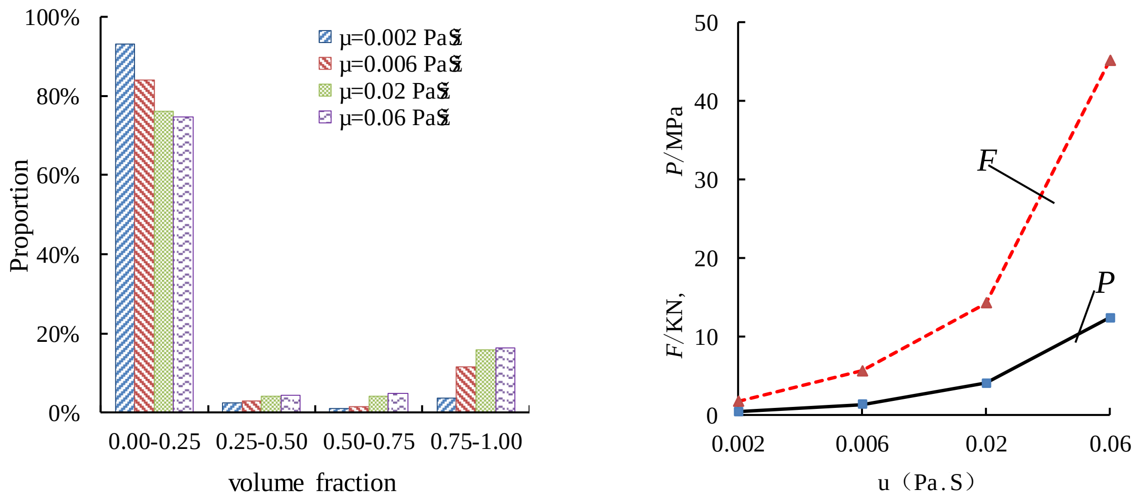
3.2 Influence of viscosity on static characteristics of oil film



μ= 0.002 Pa·S μ= 0.006 Pa·S μ= 0.02 Pa·S

Fig. 6 Oil film pressure cloud at different viscosities

Figure 6 shows the oil film pressure cloud picture at different viscosities. As can be seen from Fig.6, The change of lubricating oil viscosity has a great influence on the change of positive pressure zone of oil film. When the oil viscosity μ=0.002 Pa·S, we can see that the three positive pressure region more obvious distribution of oil film in the circumferential direction. With the increase of lubricating oil viscosity, the positive pressure zone at the oil tank 2 and the oil tank 3 is gradually reduced. As the viscosity increases, the oil film pressure at the 1 oil tanks is much higher than the oil tank 2 and the oil tank 3, so that the oil tank 3 of the positive pressure zone performance of the most obvious. The increase of lubricating oil viscosity makes the oil film pressure at the three oil tanks all increase obviously, because the oil tank 1 is the maximum oil film pressure, oil groove oil film 3 is the minimum peak pressure, which leads to the difference of the oil film pressure distribution on the cloud.



(a) Effect of viscosity on cavitation volume fraction (b) Effect of eccentricity on capacity and oil film

Fig 7 The influence of the lubricating oil viscosity on the oil film characteristics

Fig. 7 (a) is the effect of viscosity on the cavitation fraction of different volume fractions, Fig. 7 (b) is the effect of viscosity on the hydrostatic pressure and the load-carrying capacity of the oil film. From Figure 7 (a) can be seen, for the entire hole area, the volume fraction of the number of holes with high ratio of the volume fraction of the number of holes 0-0.23 and 0.68-1.0 of the whole region accounted for more than 90% of the hole, and the hole cavitation most of the area or on a small scale in the form. With the increase of viscosity, the fraction of cavitation fraction in the cavitation fraction decreases, while the proportion of cavitation in high proportion increases, It shows that the increase of viscosity intensifies the cavitation phenomenon in the divergent region, which makes the high proportion of cavitation increase. It is likely to happen completely cavitation phenomenon, which is very unfavorable to the comprehensive performance of bearings. As can be seen from Figure 7 (b), the static pressure and the bearing capacity of the oil film show an obvious trend of increase with the increase of the viscosity of the lubricating oil. Therefore, in practical application, proper viscosity of lubricant should be chosen.

4. Conclusion

a) With the increase of eccentricity, the enhancement of oil film pressure and bearing capacity is remarkable, and the cavitation area of oil film is obviously affected, so in practical work, the eccentricity can be increased to improve the performance of the sliding bearing.

b) With the increase of lubricating oil viscosity, the bearing capacity is greatly enhanced, but exacerbated the cavitation phenomenon, which increases the area and hole volume, the number of holes in a large volume fraction of cavitation region increase, has certain harm to the bearing work, so in the choice of lubricating viscosity should be reasonable.

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