Study on Two Phase Flow Heat Transfer of High Speed Bearings by Injection Lubrication

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Abstract. In this paper, the study of Numerical analysis of bearing lubrication flow field is presented. Through the experiment, due to the centrifugal force, the liquid diffusion of a uniform surface. When \( v=1094\text{mm/s} \), the whole surface has smaller accumulation of fluid film thickness of thicker body, this condition is not conducive to the ball body heat, proper ball rolling speed can in the fluid diffusion into the surface of the ball. Without contact with the stationary samples, the fluid diffusion area. And when the rolling ball contact with the stationary sample, the liquid will be together, the radius is smaller, the fluid gathered more concentrated, which is not conducive to the rolling lubrication and cooling.

Preface

Rolling bearing is a kind of mechanical component widely used in mechanical transmission. High speed ball bearing under the working state, the rolling, the guide plane of the retainer ring and the contact friction loss and bearing internal flow field of fluid viscous dissipation and other reasons will produce a large amount of heat, if the power loss of poor heat cannot be distributed, it will seriously affect the working performance of the bearing. The paper of Pinel et al [1-3] studied the bearing temperature and power loss with the increase of the amount of oil, with increasing the amount of oil bearing, low temperature rise, but at the same time, the greater the friction stir oil, it should choose the proper amount of lubricating oil. Li Bin [4-6] has experimentally investigated the characteristics of two phase flow and heat transfer in the bearing cavity by experiments and simulations. As early as the 60s of the last century, the idea of heat transfer was applied to calculate the temperature of rolling bearings by Harris and Burton [7]. In 1980, Kleckner [8] put forward a large-scale analysis software CYBEANO for cylindrical roller bearings.

Numerical Analysis Model of Internal Flow Field in Bearings

For high speed bearings, the numerical model is shown in figure 1. In this paper, KJYJ6204 deep groove ball bearings are selected as the object of study, and their structural parameters are shown in table 1:

<table>
<thead>
<tr>
<th>Bearing Model</th>
<th>Internal diameter ( D_i ) / mm</th>
<th>External diameter ( D_o ) / mm</th>
<th>Width ( B ) / mm</th>
<th>Scroll diameter ( D_b ) / mm</th>
<th>Scroll number ( Z )</th>
</tr>
</thead>
<tbody>
<tr>
<td>KJYJ6204</td>
<td>20</td>
<td>47</td>
<td>14</td>
<td>9.525</td>
<td>7</td>
</tr>
</tbody>
</table>
The nozzle entrance for mass flow boundary condition at the entrance, the left end bearing flow pressure outlet boundary conditions, pressure as the standard atmospheric pressure, the bearing rotates at high speed, after spraying to lubricating oil bearing and rolling bearing and cage collision will be a part of the oil splash back, therefore also added pressure outlet boundary condition at the right end bearing flow. The rotational boundary conditions and no slip conditions are added to different walls, and the wall area function is adopted in the low Re number region of the near wall region.

**Numerical Results and Analysis of Two Phase Flow in Bearings**

The bearing speed is 8000r/min, the DN value of the ball bearing work reaches $4 \times 10^5$, and the lubrication flow rate is 3L/min. When the injection speed is 10m/s, the temperature distribution in the bearing cavity is shown in figure 2. As can be seen from the diagram, the temperature distribution is not uniform. Up near the nozzle and the rotation direction of the bearing to reduce, which also affected bearing internal flow temperature in the circumferential direction of the uneven distribution of bearing. Oil content of more local temperature is lower, so the temperature distribution of internal flow field of the bearing is not uniform, the temperature in the internal flow field near the nozzle bearing the lowest temperature gradually increased along the direction of rotation, in turn to the other side near the nozzle temperature has dropped.

When the lubricating oil enters the bearing, the interaction between the rolling element and the cage of the bearing will produce oil friction resistance, thus hindering the rolling of the rolling wheel. The more lubricating oil is, the greater the friction resistance is, and the more oil loss is produced. Figure 3 is the bearing internal rolling surface shear force distribution, bearing speed is 8000r/min, lubrication flow is 3L/min. It can be seen from the figure, the rolling body surface shear stress is mainly composed of hindered lubricating oil caused by distribution and the distribution of the oil volume fraction of the shear force, the nozzle, gradually decreases along the direction of rotation bearing, oil volume fraction is where the friction resistance is greater, the greater the shear stress.
Experimental Analysis of Liquid Flow Pattern and Heat Dissipation of Rolling Bearings

In order to better simulation of rolling body and the outer contact when the fluid flow in the ball, the friction mechanism and rolling element and the outer ring of the bearing support and accurate and reliable test. A test design of the experiment, as shown in Figure 4, the rotating sample holder in rotating machinery at different rotational speed. At the same time, the stationary sample in contact with the center of rotating sample symmetry, the whole device is close to the experimental bearing rolling body and the outer contact conditions. The material of using uniform sample is SKD11. The surface roughness is Ra0.8. The hardness is HRC51. The R value of the stationary sample is 0mm, 10.5mm, 12.5mm, 15mm, and the thickness of stationary specimen is 10mm. The black fluid lubrication is used in the test, and the viscosity of it is the viscosity of water. The liquid were rolling dropped from the angles of 90°.

Analysis of Flow Pattern and Heat Dissipation of Liquid Jet with Different Speeds

In v=78.5mm/s, 183mm/s, 1047mm/s, 2094mm/s drops into the same fluid, the results shown in Figure 5, it can be seen from the picture of v=183mm/s compared with v=78.5mm/s, due to the centrifugal force, the liquid diffusion of a uniform surface, when v=1094mm/s, the whole surface has smaller accumulation of fluid film thickness of thicker body, under this condition the ball is not conducive to the body heat, the ball rolling speed is helpful for proper fluid diffusion into the ball surface.

Flow Pattern and Heat Dissipation Analysis with Different Static Samples

At the same speed of v=1047mm/s, respectively, in the absence of contact of stationary sample, and contact arc of stationary sample is R=0mm, 15mm, 12.5mm, 10.5mm when dropping into the same fluid. The results shown in Figure 7, it can be seen from the picture without contact with the
stationary samples, the fluid diffusion area, when the rolling ball contact with the stationary sample, the liquid will be together, and in the center of the largest circle is blocked, when R=15mm, 12.5mm, 10.5mm, the radius is smaller, the fluid gathered more concentrated, which is not conducive to the rolling lubrication and cooling.

![Figure 6. Speed v=1047mm/s flow state of ball fluid under different stationary sample.](image)

a) no contact sample, b) R=0mm, c) R=15mm, d) R=12.5mm, e) R=10.5mm

**Summary**

Through the numerical analysis of rolling bearings, as well as the ball rolling at different rolling speed, different contact specimens of the experiment can be seen:

1. When the oil flow inside the bearing, up near the nozzle and the rotation direction of the bearing to reduce, which also affected bearing internal flow temperature in the circumferential direction of the uneven distribution of bearing.

2. Respectively in v=78.5mm/s, 183mm/s, 1047mm/s, 2094mm/s dropping into the same fluid, the liquid diffusion of a uniform surface, when v=1094mm/s, the whole surface has smaller accumulation of fluid film thickness of thicker body. And when the rolling ball contact with the stationary sample, the liquid will be together, and in the center of the largest circle is blocked, the radius is smaller, the fluid gathered more concentrated, which is not conducive to the rolling lubrication and cooling.

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**References**


