Study on the Influence of Surface Texture on the Dynamic Performance of Sliding Bearing

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Abstract. Rotor bearing system is an important part of mechanical equipment. The vibration of equipment caused by rotor system has become a more important problem in engineering. In this paper, the texture technology of the inner surface of the bearing is studied to explore the influence of the surface texture on the vibration reduction characteristics of the bearing. The results show that reasonable texture parameters and texture distribution can reduce the friction of the bearing and increase the end discharge. There is an optimal texture density and texture region. In this paper, a bearing test platform is set up to test and study the tiles with different surface texture. The test results show that the amplitude of the axis orbit of the sliding bearing with texture is significantly reduced, the principal stiffness and cross stiffness of the textured bearing are larger than those without texture, the damping is slightly larger under high speed and light load than that without texture, and the texture has obvious damping effect on the bearing shell.

1. Introduction
Rotor bearing system is an important part of mechanical equipment, which is widely used in ship, aerospace, vehicle and other engineering fields. Surface texture is a kind of lattice with a certain shape or pit formed on the surface of components, which can be used to improve lubrication and wear performance. At present, many scholars have studied the surface texture of bearings. In reference [1], the shape and distribution of the common surface texture on the bearing are introduced, and the theoretical model of sliding bearing with texture is summarized. In reference [2], the axisymmetric fan-shaped straight groove texture is optimized on the surface of the thrust sliding bearing, which improves the hydrodynamic lubrication performance of the bearing. In reference [3], a rotor with surface texture is designed, and the effect of surface texture on rotor vibration is studied. The results show that reasonable surface texture design can effectively improve the stability of rotor system. In reference [4], the influence of texture radius, number, depth and distribution position on bearing capacity, friction force and friction coefficient of sliding bearing is studied. In reference [5], the surface lubrication characteristics of sliding bearing under three textures are studied. The influence of texture on friction and end discharge is analyzed by simulation. In reference [6], a test-bed for dynamic characteristics of thrust bearing is set up. Through experimental research, the conclusion that the surface texture can increase the stiffness coefficient of tilting pad thrust bearing is obtained.

In this paper, the influence of the surface texture on the static and dynamic characteristics of the bearing is studied through the combination of theory and experiment, which can provide theoretical basis and technical means for the vibration reduction design of the rotor bearing system.
2. Influence of axial texture distribution on static characteristics of sliding bearing

2.1. Main theoretical analysis model

The Reynolds equation used for the calculation is as follows.

\[
\frac{\partial}{\partial x} \left( \frac{h^3 \frac{\partial p}{\partial x}}{\mu} \right) + \frac{\partial}{\partial z} \left( \frac{h^3 \frac{\partial p}{\partial z}}{\mu} \right) = 6U \frac{\partial h}{\partial x}
\]  

(1)

The surface geometry model of sliding bearing with texture and the texture structure are shown in Fig. 1. Combined with the texture distribution, the oil film thickness distribution of texture can be obtained. Each convex part represents a texture pit, as shown in Fig. 2. As shown in Fig. 3, the bearing disturbance pressure, oil film thickness and pressure distribution can be calculated by the model. After getting four disturbing pressures and their distribution, we can get eight dynamic coefficients of sliding bearings.

2.2. Influence of axial distribution of texture on static characteristics of bearing

The eccentricity calculated in this section is 0.1, texture depth HP = 0.25, bearing pad radius r = 9mm, bearing width b = 50mm.
Figure 4: Oil film pressure and thickness under different axial texture distribution

Figure 4 shows the oil film pressure and oil film thickness under different texture proportion distribution under the condition of spherical texture on the surface of sliding bearing. From left to right, there are complete texture, front half texture and back half texture. It can be seen that increasing the distribution of texture can slightly increase the central pressure, but the influence of texture on the pressure distribution is not obvious. The influence of the axial distribution of the texture on the oil film pressure is that the complete texture is larger than the partial texture, and the back half texture is larger than the front half texture.

2.3. Influence of circumferential distribution of texture on static characteristics of bearing

In this section, the axial distribution and circumferential distribution of the texture are combined for analysis, and the basic parameters are kept unchanged, only the distribution position of the texture on the bearing pad is changed. In the calculation, the proportion of axial texture is 10% - 100%, and the distribution of circumferential texture is divided into six cases: complete texture (A), 0% - 25% region (B), 25% - 50% region (C), 50% - 75% region (D), 75% - 100% region (E) and no texture (F).

Figure 5: Influence of texture distribution on end discharge
It can be seen from Fig. 6 and Fig. 7 that when the texture is arranged in area D and the complete texture, the friction force is greatly reduced. This is because area D is the main bearing area of sliding bearing. When the texture is distributed nearby, the friction force of bearing can be effectively reduced. But at the same time, the end discharge increases in these two cases, especially when the axial distribution ratio is large, which shows that this area will promote the generation of end discharge. Through the analysis, we can know that there are the best texture density and texture region.

3. Experimental study on the influence of surface texture on the dynamic performance of sliding bearing

3.1. Introduction of test equipment

In order to facilitate the processing, the square pit is selected as the surface texture of the sliding bearing. The specific parameters and the distribution on the inner surface of the bearing are shown in Fig. 7 and Fig. 8.
Figure 9 shows the rotor-bearing test platform used for the test in this paper. On this test platform, the test of axis orbit, bearing stiffness, bearing damping, vibration acceleration and other parameters can be carried out.

3.2. Comparison results of axis orbit
The following figure shows the axis orbit at different speeds under a fixed load of 1000N. It can be seen that the amplitude of the axis orbit increases with the increase of rotating speed, and the amplitude of the axis orbit of the bearing with texture obviously decreases. At 2400 rpm, the axis orbit is close to the circle, which indicates that there are many cross stiffness and damping, and there is a large oil film reaction force.

![Graphs showing effect of screw precision grade on screw pump vibration](image)

Figure 10: Effect of screw precision grade on screw pump vibration

3.3. Comparison results of dynamic characteristics
Fig. 11 and Fig. 12 show the change curve of bearing stiffness and damping respectively. Through the analysis and comparison, it can be seen that the principal stiffness and cross stiffness of the bearing with texture are larger than that of the bearing without texture, and its damping will be slightly larger than that of the bearing without texture at high speed and light load.

![Graphs showing change curve of bearing stiffness and cross stiffness](image)

Figure 11: Change curve of bearing stiffness with texture
Fig. 12: Change curve of bearing damping with texture

Fig. 13 is the vibration acceleration curve of bearing block and bearing shell. It can be seen that the vibration acceleration of the bearing block basically does not change with the change of static load, and the texture has obvious damping effect on the bearing shell, but not on the bearing block.

4. Introduction

In this paper, the sliding bearing with texture is taken as the research object. Through theoretical and experimental analysis, the following conclusions are drawn:

(1) The theoretical results show that reasonable texture parameters and distribution can reduce friction and increase end discharge. There are the best texture density and texture region.

(2) The test results show that the amplitude of the axis locus of the bearing with texture is obviously reduced. When the rotating speed is below 2400rpm, the main stiffness and cross stiffness of the bearing with texture are larger than those of the bearing without texture, and the damping of the bearing with texture is slightly larger than that of the bearing without texture at high speed and light load, and the texture has obvious damping effect on the bearing shell.

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