Experimental of Oil Film Thickness in a Ball Bearing

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Abstract: The design is to test the oil film thickness of the ball bearing on the special bearing test device. Based on the principle of capacitance measurement, a corrected oil film thickness formula considering the non-Newtonian shear-thinning and thermal is introduced into the prediction of oil film in ball bearings. And then the film thickness distribution and the corresponding capacitance are calculated in a ball bearing under different rotating speeds and external loads. The results show that the oil film thicknesses between the ball and inner or outer raceways are growing gradually with the increment of rotating speeds, but there is no obvious variation when increasing the radial loads. By comparing the calculated capacitance and measured results, it can be concluded that the calculated results by use of the corrected film thickness formula are much closer to the test findings than the classical computed values according to Hamrock-Dowson.

1. Background and Purpose

The lubrication state of the rolling bearing not only affects the local stress on the contact surface, but also leads to the change of the material resistance and failure mechanism of the contact surface. The lubrication state has a great influence on the performance and life of rolling bearings, it is one of the important ways to improve the performance and life of the bearing by improving the lubrication state effectively. Therefore, the dynamic analysis of rolling bearing oil film is of great significance to improve the performance and life of rolling bearing. At present, the theoretical research on the oil film of rolling bearing has a certain foundation, but the relative test of the bearing performance in mechanical equipment is relatively less. In order to further lay the technical foundation for the design, manufacture and application of rolling bearings, and accumulate the test data for the evaluation of rolling bearing life, the design scheme is based on the capacitance method to measure the oil film thickness of rolling bearings.

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2. Concept and Idea

The rolling bearing tester is cantilever structure, which is composed of motor, coupling, rotating shaft, supporting unit, measured bearing, loading unit, Slip ring distributor, lubrication system, etc. The overall structure is shown in Fig.1. The drive system mainly provides the power for the spindle system, and realizes the stepless adjustable function of the spindle system in different speed range. The bearing tester is driven by a servo motor, which drives the bearing to rotate by connecting the diaphragm coupling with the shaft to realize the speed control of the bearing. The supporting unit provides the support of the rotating shaft, which is composed of a supporting bearing block, a supporting bearing, etc. The loading device is composed of loading bolt and force sensor. The inner ring signal transmission is realized under the condition of high speed rotation of the inner ring of the main bearing.

3. Design and Functions

When the bearing oil film thickness is measured by the capacitance method, the bearing is fixed in the nylon

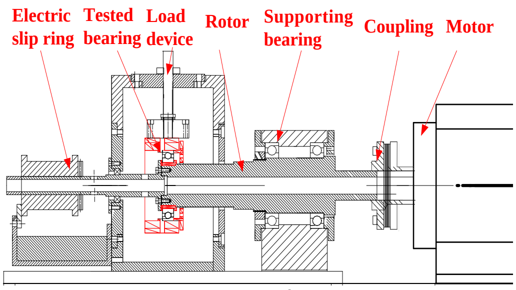

Fig.1 Sketch of test rig

insulation bearing block, and the inner ring of the bearing is also insulated with nylon material, as shown in Fig.2 and Fig.3. In the lubrication state, the inner and outer rings of the bearing form a capacitor with Elastohydrodynamic lubrication film as the medium. The capacitance value between inner ring and outer ring is measured by bridge tester. Under the condition of known dielectric constant of lubricating oil film, the capacitance value of oil film is inversely proportional to oil film thickness. Therefore, the oil film thickness can be calculated by measuring the oil film capacitance value. At the same time, numerical calculation is used to calibrate the relationship between the capacitance value and the oil film thickness, and then the parameters of the oil film thickness of the bearing are obtained.

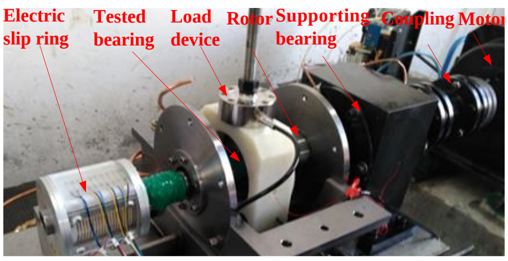

Fig.2 Test rig for bearing capacitance measurement.

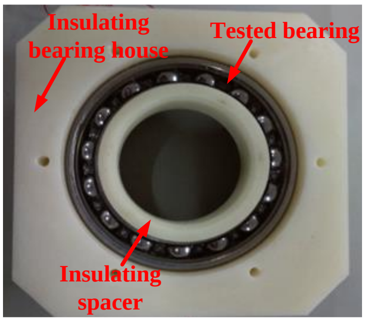

Fig.3 Test rig for bearing capacitance measurement.

The innovation of the design lies in the extraction and transmission of the signal when the bearing inner ring rotates. As shown in Fig.4, the bearing inner ring signal line is connected to the bridge tester through the slip ring distributor, and the outer ring signal line is directly connected to the bridge tester, and the balance of the bridge is achieved by adjusting the size of the variable capacitor. It is known that the variable capacitance value C_0 is approximately equal to the capacitance value C_x to be measured, and then the thickness of the bearing oil film is calculated according to the C_x value.

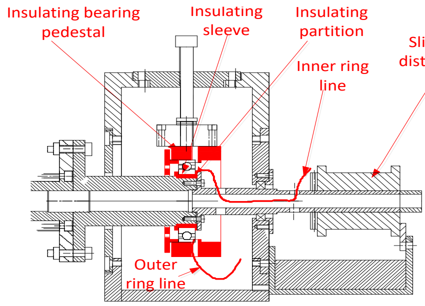

Fig.4 Signal transmission schematic diagram of inner and outer rings.

4. Problems and Future Work

The capacitance method used in this experiment is an effective method for measuring the thickness of Elastohydrodynamic oil film. However, the experimental results show that the thickness of Elastohydrodynamic oil film may be disturbed by temperature, assembly accuracy and other related factors. Therefore, the measured results are not accurate enough:

(1) The measured oil film thickness is the average thickness, which cannot reflect the true value of any part. Moreover, when the film thickness is less than 0.5um, electric breakdown will occur.

(2) When the bearing is in partial film lubrication state, the capacitance method may not be able to read.

(3) This method fails when the metal micro peak contacts, and the distributed capacitance is often difficult to estimate accurately, which affects the accuracy of calibration and test results.

The method requires that the lubricant should be non-polar, In order to make the measurement result more accurate, Interference caused by distributed capacitance of conductor and surrounding environment should be avoided.