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Ball bearing dynamics at the interference fit on balls

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Abstract

Interference on the rolling elements of bearings is necessary to avoid slippage at high rotation speeds or at low bearing load and exact deviation of control surfaces of the control systems of the aircraft. The aim of this work is to reveal and study the influence ofinterference on the rolling elements of a ball bearing for radial and axial displacements of the bearing rings. In this work was carried out a review of methods and mathematical models for calculating the bearings; performed their analysis based on which a method of calculation of the bearing was selected to conduct our research. The selected methodology takes into account many different parameters and factors, moreover, it was experimentally confirmed with sufficiently high accuracy. The calculation was performed numerically by the method of iterations. The following bearing and parameters were adopted as baseline for the research: bearing № 126126, axial load Fa = 3000 N, radial load Fr = 750...20000 N, interferenceδ = 0...0.03 mm, the shaft speed n = 10000 rpm. Graphs ofinterdependence between the radial and axial displacements of the rings and the magnitude of interference of rolling element were drawn according to the results of the calculations. Analysis of the graphicalinterdependency has shown that increasing interference on the balls decreases the axial and radial displacement of the bearing rings linearly. The results obtained were compared with the results of similar studies of angular contact ball bearings used in machine tool spindles. It should be noted that in these works under interference is understood the provisional value of the axial force acting in the bearings which are installed in the spindle full-length scheme.Since the works are not given data on the magnitude of interference fit on the rolling elements, to compare the results of studies is not possible. It may be noted that interdependence on the displacement of the rings and stiffness coefficients are correlated, which gives an indication of the reliability of the results.It may be noted that interdependence on the displacement of the rings and stiffness coefficients are correlated, which gives an indication of the reliability of the results.

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*Keywords:*Ball bearing; force; interference; deformation; displacement; dynamics

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1. Introduction

Ball bearings are the most common type bearings for supporting axial and radial loads. One of the most important characteristics of bearings is stiffness which determines the magnitude of the relative displacement of the bearing rings. Axial and radial movement of the rings in a rolling bearing are determined primarily by the magnitude of the elastic deformations of parts of the bearing under the action of applied loads. The load distribution on the balls depends on several factors and parameters of the bearing, in particular on the ratio of the magnitudes of axial and radial loads. Improvement of the performance characteristics and technical specifications of machines and mechanisms warrants the need for the use of bearinginterferencefits on the rolling elements; the magnitude of which will change the load distribution on the rolling elements. In this regard, the study of the influence of the magnitude of the interference on the rolling elements on the dynamic characteristics of rolling bearingsisrelevant. The interference on the rolling elements is aimed at: avoiding slippage in the bearings at high speeds or at low load of the bearing.

2. The purpose and objectives of the research

The aim of this work is to reveal and study the influence of the preload on the rolling elements of the ball bearing for radial and axial displacements and how they vary within specified operating conditions. To achieve the goal the following tasks were set: to review the literature, perform analysis of methods of calculation of deformations and displacements in the bearings, and perform the calculation of the bearing when the interference on the rolling elements, and perform an analysis of the calculated results.

3. The state of the question

To perform the assigned tasks, a review of methods and mathematical models of calculations of bearings was performed. Works [1-2] show the calculated interdependences for determination of clearances and interference in roller bearings under various conditions (high speeds, the temperature of the rings, the deformation of the support parts under load, etc.). It was noted that the interference on the rolling elements significantly affects the distribution of load over the rolling elements contact stresses and the durability of bearings. In work [1] the data is provided for the calculation of the bearing value of the interference, which ranged from 0.021 to 0.058 mm. A connection was established between the magnitude of interference on the rollers and the coefficient of slippage in the bearing №1032930 of the support of the rotor of the gas turbine engine in the family PS-90. These models are only applicable to roller bearings. Mathematical models of ball bearings are presented in works [3-5]. However, in these studies no information about the reliability of the calculation resultswere obtained using the proposed models. Therefore, the study of the influence of interference on the ball bearings on the dynamics was performed using the mathematical model described in work [6]. This model takes into account a variety of design, technological and operational factors, and its accuracy was experimentally confirmed in work [7].

4. Calculation of the bearingandinitial data

The essence of the calculation is as follows: first, we determine the load on each ball, whichis chosen from the condition of equilibrium of the balls, and then calculate the value of deformation of the contact by the Hertz theory and the lubricant film thickness according to the hydrodynamic theory of lubrication. Then we determined the value of the relative displacement of the bearing rings in axial and radial directions. The calculation was performed numerically by the method of iterations to achieve the required accuracy of calculations taking into account the compatibility of deformations and displacements.

The initial data was taken: axial load Fa = 3000 N radial load Fr = 750...20000 N, interferenceδ = 0...0.03 mm, shaft speed n = 10000 rpm. The calculation was made for a radial-thrust bearing № 126126, the main geometric dimensions of which are shown in the diagram (figure 1), and the values are given in table 1.