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CHANGING THE RADIAL CLEARANCE IN BEARING ASSEMBLIES DEPENDING ON THE SIZE AND NUMBER OF ABRASIVE PARTICLES

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Abstract. Radial wear in bearing assemblies depends on the wear rate of bearing elements, and reducing their wear is one of the important engineering problems that does not lose its relevance over time and has various scientific approaches and directions. According to studies on the effect of changes in the size and amount of abrasive particles participating in the wear process on the wear rate of rolling bearing elements, abrasive particles, i.e. mechanical impurities, penetrate the working surfaces of the bearing and cause abrasive wear of the material. With an increase in the number of particles, the wear process accelerates, since more particles scratch and damage the working surfaces. At the same time, the size of the particles also affects the bearing elements. Small particles penetrate deeper into the bearing surfaces and cause microwear, while large particles cause surface scratches and cracks. As a result, the abrasive wear of the bearing elements leads to an increase in the radial clearance in the bearing.

Keywords: bearing, wear, abrasive particle, radial clearance, strength, hardness, ball, inner (outer) ring.

INTRODUCTION

The size and quantity of abrasive particles entering the conical gap formed between the rolling elements of the bearing and participating in the wear process significantly affect the wear process. In this case, the regularity of the change in radial wear in the bearing can be explained as follows. An increase in the size of the abrasive particle entering the wedge-shaped gap leads to an increase in the deformation volume of the friction surfaces, which in turn leads to an increase in the volume of deformed metal and, as a result, to an increase in radial wear, according to the molecular-mechanical theory of friction and wear.

According to the molecular-mechanical theory of friction and wear, wear occurs as a result of the re-deformation of the friction surfaces of machine parts operating in an abrasive environment [1, 2, 3, 4, 5]. The wear rate depends on the amount, size, strength of the abrasive particle in the oil, the mechanical properties of the friction surface material (hardness, coefficient of relative elongation), and the geometric, kinematic and dynamic parameters of the contact surfaces.

The wear of rolling bearing elements occurs as follows. An abrasive particle, considered to be spherical, enters the wedge-shaped gap of the friction surfaces and begins to move towards the contact

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surface under the influence of the friction force, while the amount of compressive normal load acting on the abrasive particle increases, and depending on the increase in this load, the depth of immersion in the friction surface also increases. When the abrasive particle penetrates the friction surface to a certain depth, a further increase in the normal load leads to fragmentation of the abrasive particle. I.V. Kragelsky noted that the refraction of an abrasive particle in a wedge-shaped gap can occur up to 7 times [1, 4, 6, 7].

Thus, the normal force acting on the friction surfaces, together with the movement of the abrasive particle on the friction surfaces before it is fragmented in a wedge-shaped gap, deforms them first elastically and then plastically. According to the molecular-mechanical theory of friction [2, 5, 6], the abrasion of the friction surface by abrasive particles repeatedly deforms the deformed surface, resulting in the formation of wear products. From this point of view, since the number of cycles of separation of wear products in the elastic deformation zone is much larger than that of plastic deformation, we do not take into account the wear caused by elastic deformation.

It is known that the deformation of the friction surface by an abrasive particle depends on the probability of its settling on the friction surface, and its values depend on the hardness of the friction surface material.

RESEARCH METHODS

The deflection of the elements of the rolling bearing (inner and outer rings and balls) affects the change in the radial clearance in the bearing units. Therefore, the change in the radial clearance in the bearing units can be estimated from the deflection rate of the bearing elements. As a result of the theoretical studies, the expressions for calculating the deflection rate of the bearing elements are as follows:

for the raceway of the inner (outer) ring

$$\gamma_{in,ou} = \frac{1{,}836\sigma_a{}^2 G d_{av} \varepsilon_k{}^{1/2} n n_b (i_{1,2} \pm 1) \cdot \left[1 + \left[(\exp(\beta_i \cdot 0{,}9995)^{3,5})^6 - 1\right]\right]}{(n_{nl(in,ou)} H (H + H_b) i_{1,2})}, \qquad (1)$$

for the surface of the ball

$$\gamma_b = \frac{1{,}836\sigma_a{}^2 G d_{av} \varepsilon_k{}^{1/2} n (i_1 + i_2)\left[1 + \left[(\exp(\beta_i \cdot 0{,}9995)^{3,5})^6\right]\right]}{(H_b (H + H_b) n_{nl(b)})}. \qquad (2)$$

The dependence of the deflection rate of the inner and outer rings of the rolling bearing and the ball on the size and amount of abrasive particles is determined based on expressions (1) and (2). The influence of the inner and outer rings of the rolling bearing and the deflection rate of the ball on the change of the radial clearance of the bearing is determined by the following expression:

$$\delta_r = \delta_0 + 2 \cdot t1 \cdot (\gamma_{1i} + \gamma_{2i} + 2 \cdot \gamma_{3i}), \qquad (3)$$

where, δ_0 - the initial radial clearance of the bearing, $\delta_0 = 34 \cdot 10^{-6}$ m for bearing No. 313; $t1$ - the number of rotations of the inner ring of the bearing, min^{-1}; $\gamma_{1i}, \gamma_{2i}, \gamma_{3i}$ - speed of deflection of the inner and outer rings of the bearing and the ball.

The graphs of the change of the radial clearance according to the change in the size and quantity of the abrasive particle using the expression (3) are presented in figures 1-2:

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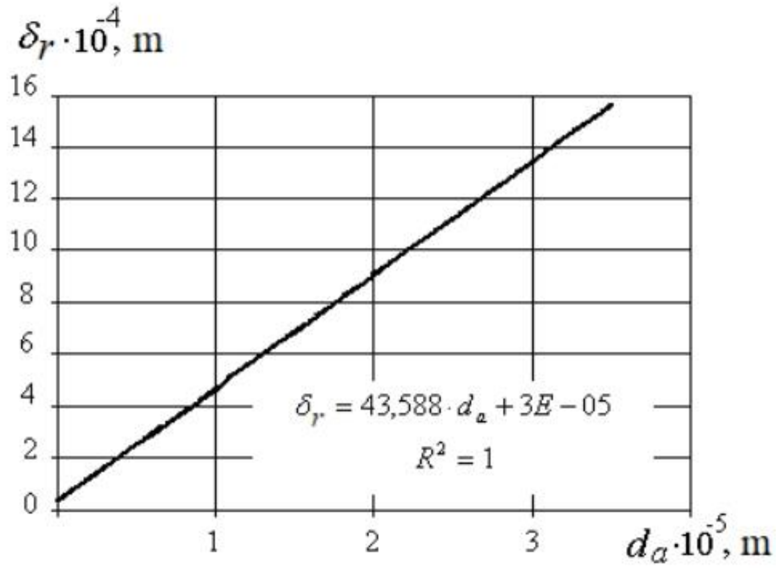
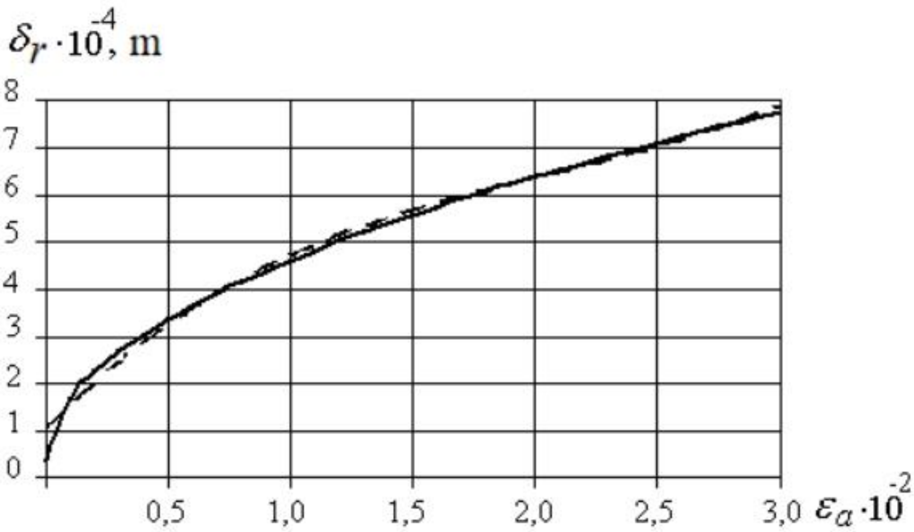


— - research results graph; – – - graph of the law of change

Figure 1. Variation of radial clearance with change in abrasive particle size



$$\delta_r = 32{,}764 \cdot \varepsilon_a^3 - 2{,}0175 \cdot \varepsilon_a^2 + 0{,}0541 \cdot \varepsilon_a + 1E-04$$

$$R^2 = 0{,}9928$$

— - research results graph; – – - graph of the law of change

Figure 2. Variation of radial clearance with change in abrasive particle size

CONCLUSIONS

1. According to analytical expressions for calculating the wear rate of rolling bearing elements, with an increase in the number and size of abrasive particles, the wear rate of bearing elements increases, which leads to a change in the radial clearance in the bearing units, i.e., exceeding the permissible radial clearance will lead to failure of the bearing unit.
2. In order to reduce the ingress of abrasive particles from the external environment into the bearing unit, it is necessary to ensure its tightness at the required level.

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3. It is necessary to monitor the maintenance of bearing units within the periods specified in the regulatory technical documentation.

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