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Microscip Mechanism in Raceways and Rolling Elements of Roller Bearings

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Abstract

The research refers to the microslip mechanism in the bodies and raceways of roller bearings. It was shown that one of the reasons for rolling friction, occurring in ball tracks characterized by significant curvature of raceways and rolling elements, is the emergence of a microslip between contacting surfaces around the instantaneous rolling axis. The character of friction torque distribution along the contact area of contacting elements was defined.

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Keywords: torque in the bearing; friction torque; microslipping; contact of rolling elements in the bearing.

1. Introduction and problem statement

1.1. Introduction

In the recent years numerous scientific publications have been devoted to modelling friction in rolling element bearings [1-6, etc.]. Most of these papers are devoted to the study of rolling friction occurring between two cylinders, or friction of one cylinder along the rail under the traction load on the rolling element. However, little attention was given to the problem of free rolling friction of elements at great curvature of rolling raceways and rolling elements that has a great importance for rolling contact bearings. This paper gives an insight into the given problem.

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1.2. Problem statement

Let us consider the instantaneous position of two elastic bodies – the spherical element with the diameter d_s and toroidal raceway with the radius r_g and diameter D_g during the rolling procedure. The contacting elements when in the rolling process are under constant external load P, which is directed along the line connecting the centre of the sphere and the initial point of the contact elements. The contact strip between the two contacting elements occurs under the influence of P and is equal to δ_o, which results in a curved contact area having elliptical contour and semiaxes a and b. The semiaxis a is placed in the direction of rolling, whereas the semiaxis b is in the main cross-section of the contact area.

The cross-section of contacting bodies is shown in Fig. 1. The instantaneous axis of relative pivotal point in contact surfaces occurs in the course of rolling. It is placed in the cross-section of the contact zone and crosses it in the points *A* and *B,* where no microslip in the contact surfaces is found.

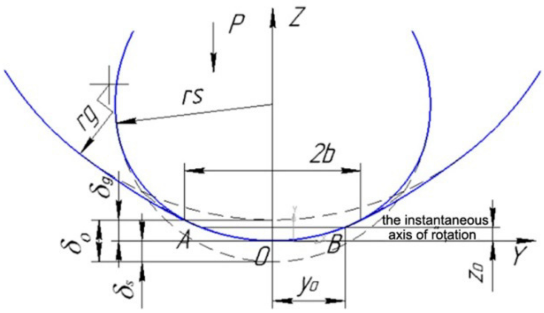

Fig. 1. Scheme of element elastic contact during the rolling process in transverse direction.

Let us design the Cartesian reference system centred around symmetry centre of the contact area. The axis Oz is directed along the normal toward the contact area, the axis Ox in the rolling direction, and the axis Oy – in the transverse direction. Let us set the following restrictions: 1. The coefficient of sliding friction f between contacting surfaces is constant on the whole contact area. 2. The friction forces, acting along the contact area due to significant curvature, considerably exceed the adhesive forces, including the forces caused by elastic hysteresis of body materials. Therefore we do not take into account the impact of these forces. 3. The size of the contact area a is very small compared to the size of the rolling bodies; therefore the curvature of the contact area in the rolling direction can be neglected. 4. The shape of the initial clearance between the bodies in the main sections is described as parabolic:

$$\Delta z(y) = \left(\frac{1}{d_s} - \frac{1}{2r_g} \right) y^2 ,\ \Delta z_x = \left(\frac{1}{d_s} \pm \frac{1}{D_g} \right) \cdot x^2 \tag{1}$$

where “plus” refers to the contact between the rolling elements and the rolling raceway of the inner ring, while “minus” refers to the contact between the rolling element and the rolling raceway of the inner ring..

The error caused by the latter restriction does not exceed 4% at $b \le 0{,}2 d_s$. Let us solve the equation for the cross-section of the contact area. Additionally, let assume that elastic strain at an arbitrary point of the contact area for each contacting body is in inverse proportion to material modulus of elasticity:

$$\frac{\delta_s(y)}{\delta_g(y)} = \frac{E_g \cdot (1-\mu_s^2)}{E_s \cdot (1-\mu_g^2)} = k_E \tag{2}$$