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Radial Bearings with Porous Elements

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Abstract

This paper presents the analytical model of the radial bearing of the finite length with the two-layer porous insert obtained on the basis of the dimensionless equations of movement of a viscous incompressible lubricant in an operating clearance and in porous layers of a bearing sleeve and continuity equations as well. We are analyzing the case when permeability of porous layers on the border of section of a two-layer insert accepts one value. The lubricant moves in a circumferential direction through a bore in a bearing body and the subsequent filtration occurs through insert pores. Permeability anisotropy of porous layers is taken into consideration in radial and circumferential directions.

As a result of the given task, we have obtained the field of speeds and pressure in porous layers and in the lubricant layer. Analytical dependences for components of a vector of supporting force and the friction moment have been found, and we have also defined the loading factor and friction factor. Moreover, in our calculations we have revealed and used the parameter characterizing specificity of lubrication feeding in a circumferential direction. It is proved that the rational mode of operation is reached by a design of a two-layer porous insert given when the resistance factor increases more intensively and from the parameter ψ, and from a relative eccentricity ε in comparison with the bearing having a single-layer insert. Hence, anisotropy of permeability of porous layers in a circumferential and radial direction has a defined possibility of practical application of this new model.

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Keywords: hydrodynamics; radial bearing; two-layer insert; anisotropy of permeability of porous layers in radial and circumferential directions.

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1. Introduction

Modern machines widely use the antifrictional porous materials obtained by methods of powder metallurgy, and also the porous coverings put by a gas-thermal dusting. Powder materials possess higher oil absorption and damper ability, than compact ones [1-5].

Porous bearing materials are made by methods of powder metallurgy. The standard technology in a bearing bushing provides 25-30 % of pores: blind, one-side open and transverse. Soaked in vacuum by a heated liquid lubricant, powder bearings absorb up to 5-6 % of oil weight.

Porous bearings operate usually under relatively small load in a self-lubricating mode, as a result of oil allocation under the exposure of thermoexpansion from heat generated by friction. Hence, in this case the boundary friction is realized, and only occasionally and for short periods of time - hydrodynamic. Unfortunately, modern researchers pay insufficient attention to the specified phenomena, there are practically no papers devoted to working out of mathematical models, describing the physics of this phenomena. There are very few papers which only with certain assumptions attempt to examine the performance of porous plain bearers [6-9].

These statements testify that nowadays practice of application of porous journal bearings in a mode of hydrodynamic lubrication outruns theoretical researches. Hence, continuous and accurate research in the field of the porous bearings, greased with modern lubricants, is claimed by practice.

In papers [10, 11] it is shown, that porosity of powder details essentially reduces their strengthening parameters. High contact pressure in high-pressure bearings, deforming a porous surface, reduce a filtration of a lubricating fluid and possibility of its feeding through pores. In its turn, a compact bearing bushing, maintaining considerable loadings, demands special devices for feeding of a lubricating fluid.

This problem has found the solution in working out of compound plain bearers in which the lubricating fluid can move through a porous part, or this porous part will be so-called depot of lubricant.

The further development of this idea resulted in necessity of reception of models for compound bearings with multilayered porous inserts.

A number of papers are devoted to analytical consideration of performance of radial plain bearers of finite length with constructive elements or coverings from porous pseudo-alloys [12-15], including stability of liquid mode of friction.

The analysis of papers [16-18] devoted to calculation of the similar bearings operating under the pressure of feed shows that permeability anisotropy of porous layers, simultaneously in radial and circular directions, is not considered. Anisotropy consideration only in a circumferential direction does not allow presenting factor of permeability in the form of the continuous function, which is necessary for calculation and depending on radial and circumferential co-ordinates.

We have made an attempt to feel this want for problems in nonlinear statement.

2. Problem statement

Let us consider the established current of viscous incompressible liquid in the clearance of the radial bearing of final length with a compound two-layer porous insert. We consider the bearing bushing to be motionless, and the shaft to be rotating with angular speed Ω. The lubrication material is fed into the operating clearance of the bearing in an axial direction under the pressure of feeding.

Let us assume that in two sections the lubrication pressure is set as follows:

$$p\big|_{z=0,r=\eta} = p_H, \quad p\big|_{z=l,r=\eta} = p_K \tag{1}$$

Here P_H and P_K are the set values.

Let us place the beginning of cylindrical system of co-ordinates (r, θ, z) on the bearing shaft in its left end (fig. 1).