The design model of the electrical conductivity of a poroelastic thrust bearing

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Abstract. The article is devoted to the formation of calculation of hydrodynamic models of a poroelastic thrust bearing profile adapted to the friction conditions, taking into account the dependence of the penetrability of the porous layer on the guide surface, the electrical conductivity and the viscosity of the liquid lubricant under pressure. There has been the evaluation of the elastodynamic parameter ($M$), adapted to friction conditions with the profile and parameters, characterizing the dependence of the electrical conductivity, viscosity of the lubricant and penetrability of the porous layer under pressure on the carrying capacity and friction force.

1. Introduction

It is known that in modern mechanic engineering, tribonodes for new machines are usually designed based on the increase in static and shock loads acting on the skid base, which is determined by the tasks of modern engineering practice. It should be noted that one of the most important equitable constructive elements of the bearing is the lubrication medium. Recently, practical interest has been developed in the research of mechanical devices using sealing and lubricating materials, like magnetic fluids. It is widely used in bearing assemblies as lubricants with electrically conductive properties.

A significant amount of research [1-2] is devoted to the friction bearing, working on electrically conductive lubricants, possessing damping properties. An analysis of most publications [3-11] shows that they do not take into account the dependence of the viscosity and electrical conductivity of a liquid lubricant, as well as the penetrability of a porous layer on pressure. In addition, the deformation of the supporting surface of the bearing bushing and the profile adapted to friction conditions are not taken into account.

The key to solving the problem lies in the possible increase in the bearing capacity of bearings as a result of refinement of their design models. This is based on the formation of calculated hydrodynamic models of thrust bearings taking into account deformation of the supporting surface of the bearing bushing and the profile adapted to friction conditions. The solution is realized for a "thin layer" while taking into account the dependence of the electrical conductivity, the viscosity of the lubricant and the penetrability of the porous layer on pressure.

2. Materials and methods

A new mathematical model describing the motion of an incompressible electrically conductive liquid lubricant in the approximation for a “thin layer” is proposed. The continuity equation, Darcy and
Lame, for determining the deformation of a bearing surface with a friction-resistant thrust bearing profile is adapted to the friction conditions, taking into account the rheological properties of the electrically conductive liquid lubricant. Penetrability of the porous layer on the guide surface due to the pressure and a number of additional factors makes it possible to compare a comparative study of the newly obtained results and those already available, which confirms the approximation of the model obtained for the solution of practical problems.

3. Results
The proposed work summarizes the factors that have not yet been investigated and justifies the dynamics and lubrication models that reflect the real processes in the lubricating layer. It is necessary to take into account the rheological properties of the electrically conductive lubricant under the influence of electromagnetic fields, the penetrability of the porous layer of the guide surface and the dependence of the viscosity of the lubricating layer on the pressure of the elastic. This is also adapted to the conditions of the friction profile of the supporting surface. The developed mathematical models allow creating algorithms and software for solving practical problems. Numerical analysis of the theoretical models obtained and a comparative analysis of the experimental data prove the advantage of using poroelastic with adaptation to friction conditions profile of thrust sliding bearings (reduction of the coefficient friction by 43%). The obtained results can be used in all mechanic engineering sites operating on small-sized thrust bearings.

3.1. Formulation of the problem
The steady-state flow of an electrically conductive liquid lubricant in the working gap of a thrust sliding bearing with an inclined liner operating in the hydrodynamic lubrication mode with a porous layer on the guide surface under the action of an electromagnetic field is considered. It is assumed that the liner is stationary, and the way moves in the gap at a constant velocity $u^*$ (Figure 1).

In the Cartesian coordinate system, the equations of the adapted and deformable contours 1, 2 and 3 and the guide with a porous layer on its surface will be written as: $C_1: y' = h_0 + x'tg\alpha - a'sin\phi x' = H(x')$ – the equation of the adapted non-deforming contour of the slider.

Let us look for the equation of a deformable adapted contour in the form:

$$C_2: y' = h_0 + x'tg\alpha - a'sin\phi x' + a\phi\left(\frac{x'}{L}\right) = H(x') ,$$

$C_3: y' = h_1 + x'tg\alpha$ – equation of a non-deforming contour.
$C_4 : y' = 0$ — equation of the guide.

$C_5 : y' = -\tilde{H}$ — equation of guide with a porous layer.

where $\tilde{H}$ — the thickness of the porous layer; $\alpha$ — angle of inclination of the liner to the axis $\alpha'x'$; $L$ — length of the thrust bearing; $h_0$ — thickness of the lubricating film in the initial section; $h_1 - h_0$ — the thickness of the elastic layer; $a\varphi \left( \frac{x'}{L} \right)$ — characterizes the deformation of the working surface of the bearing bush; $\tga$ — angular coefficient of the linear contour; $\omega$ and $\alpha'$ — relatively, the frequency and amplitude of the contour disturbances describing the degree of deviation of the slider from the rectilinear one.

It is assumed that $h_0$ is much smaller than the length of the slider.

The dependence of the electrical conductivity, penetrability of the porous layer and the viscosity of the liquid lubricant on the pressure can be written as:

$$\mu' = \mu_0 e^{p\rho'}, \quad k' = k_0 e^{p\rho'}, \quad \sigma' = \sigma_0 e^{p\rho'},$$

(2)

where $\mu'$ — the coefficient of dynamic viscosity of the lubricant, $\sigma'$ — the electrical conductivity of the lubricant, $k'$ — the penetrability of the porous layer, $\mu_0$ — the specific viscosity, $k_0$ — the specific penetrability of the porous layer, $\sigma_0$ — characteristic of electrical conductivity of the lubricant, $p'$ — the pressure in the lubricating layer, $\beta'$ — the experimental constant.

### 3.2. Initial equations and boundary conditions

The movement of the electrically conductive liquid lubricant in the working gap between the inclined slide and the guide is described by the following equation:

$$\frac{\partial^2 v_x}{\partial y'^2} = \frac{1}{\mu'} \frac{dp'}{dx'} - \frac{1}{\mu'} \sigma' B(E'_z - B'v'_{y'}),$$

(3)

where $B' = \{0, B_y, 0\}$ — the vector of magnetic induction, $E' = \{0, 0, E_z\}$ — the vector of electric field strength; $B$ — the component of the vector of magnetic induction, $E_z$ — the component of the vector of electric field strength. In analyzing the problem under consideration, the system of equations (3), continuity equation, Darcy and Lame for the case of a “thin layer”:

$$\frac{\partial^2 v_{x'}}{\partial y'^2} = \frac{1}{\mu'} \frac{dp'}{dx'} - \frac{1}{\mu'} \sigma' B(E'_z - B'v'_{y'}), \quad \frac{\partial v_{x'}}{\partial x'} + \frac{\partial v_{y'}}{\partial y'} = 0, \quad \frac{\partial^2 p'}{\partial x'^2} + \frac{\partial^2 p'}{\partial y'^2} = 0,$$

$$\lambda + G \frac{\partial u'}{\partial x'} + G \Delta u'_y = 0, \quad (\lambda + G) \frac{\partial u'}{\partial y'} + G \Delta u'_y = 0.$$

(4)

where $v_{x'}, v_{y'}$ — the components of the velocity vector; $P'$ — the pressure in the porous layer; $\varepsilon = \frac{\partial u'_{x'}}{\partial x'} + \frac{\partial u'_{y'}}{\partial y'}$ — relative change in volume; $\lambda$ — the Laplace operator; $u'_{x'}, u'_{y'}$ — the components of the displacement vector; $\lambda$ — the Lame constant; $G$ — the shear modulus, $E' = \{0, 0, E\}$ — the vector of electric field strength; $B' = \{0, B_y, 0\}$ — the vector of magnetic induction. It is assumed that the magnitude $E'$, $B'$ and the flow velocity of the electrically conducting liquid are such that the influence of the flow on the electric and magnetic fields can be neglected.

In this case $B' = \{0, B_y, 0\}$ and $E' = \{0, 0, E\}$ are assumed to be defined and satisfy the Maxwell equations ($B_y = B = \text{const}$, $E_z = E = \text{const}$):

$$\text{div} B' = 0, \quad \text{rot} E' = 0.$$

(5)
To describe the processes in the lubricating, porous and elastic layer, the dimensional quantities are related to the following corresponding dimensionless relationships:

- in the lubricating layer:
  \[ v_x = \frac{v_x^*}{u}, \quad v_y = \frac{v_y^*}{v}, \quad \alpha = \frac{h_0}{L}, \quad x = \frac{Lx^*}{h_0}, \quad p = \frac{p^*}{p^*}, \quad \rho = \frac{\rho^*}{\rho^*}, \quad \sigma = \sigma^* \]

  \[ u = \frac{u_x^* k}{k_0}, \quad \omega_0 = \frac{\omega_0 L}{\omega}, \quad \beta = \frac{\beta^*}{\beta^*} \]  

- in the porous layer:
  \[ x = \frac{Lx^*}{h_0}, \quad y = \frac{Ly^*}{h_0}, \quad P = \frac{P^*}{P^*} \]  

- in the elastic layer:
  \[ u = \left( \frac{h_1 - h_0}{L} \right) y, \quad x = \frac{Lx^*}{h_0}, \quad \tilde{u}_x = \tilde{u}_x = \tilde{u}_x \]

where \( \tilde{a} \) – the characteristic magnitude of the displacement vector.

Taking into account the transition to dimensionless variables in the porous, lubricating and elastic layer, omitting the dashes with accuracy \( O \left( \frac{h_1 - h_0}{L} \right) \) we arrive at the following system of equations:

\[ \frac{\partial p}{\partial y} = 0, \quad \frac{\partial^2 v}{\partial y^2} = \frac{dp}{dx} e^{-p}, \quad \frac{\partial u}{\partial x} + N v = 0, \quad \frac{\partial^2 p}{\partial y^2} + \frac{\partial^2 P}{\partial y^2} = 0, \quad \frac{\partial^2 u}{\partial y^2} = 0, \quad \frac{\partial^2 u}{\partial y^2} = 0. \]  

(9)

where \( N = \frac{\alpha_0 B h_0^2}{\mu_0 \mu} - \) the Hartmann number, \( \Lambda = \frac{\sigma_0 \beta L h_0^2}{\mu_0 \mu} - \) the magnitude determined by the presence of an electric field.

And the equations of contours:

\[ y = 1 + \eta x = H_1(x), \quad y = 1 + \eta x + \eta \varphi(x) - \eta_3 \text{sin} \alpha = H_2(x), \quad y = \frac{h_1}{\delta_1} + \eta_2 x = H_3(x), \quad y = 0, \quad y = -\frac{H}{L}. \]  

(10)

where \( \eta = \frac{L \alpha}{h_0}, \quad \eta_1 = \frac{\alpha}{h_0}, \quad \eta_2 = \frac{L \alpha}{\delta_1}, \quad \eta_3 = \frac{\alpha}{h_0}, \quad \delta_1 = h_1 - h_0. \)

Equations (9) are solved taking into account that:

- in the lubricating layer: \( v = 0, \quad u = 0 \) at \( y = 1 + \eta x + \eta \varphi(x) - \eta_3 \text{sin} \alpha = H_2(x), \quad v = -1, \quad u = 0 \) at \( y = 0, \quad p(0) = p(1) = \frac{P_0}{\tilde{a}} \)  

(11)

- in the porous layer:

\[ p = P \left|_{y=0} \right., \quad u \left|_{y=0} \right. = M \left. \frac{\partial p}{\partial y} \right|_{y=0}, \quad \left. \frac{\partial p}{\partial y} \right|_{y=-\frac{H}{L}} = 0 \]  

(12)

where \( M = -\frac{k_0}{h_0^2} \).

- in the elastic layer:

\[ M \left. \frac{\partial u}{\partial y} \right|_{y=H_1(x)} = -\tilde{P} u \left|_{y=H_1(x)} \right. = 0, \quad u \left|_{y=H_1(x)} \right. = 0, \quad u \left|_{y=H_1(x)} \right. = 0, \]  

(13)

where \( M = \frac{G(1+\alpha^*) \tilde{a}}{(1-\alpha^*) p_0 \delta_1}; \quad \alpha^* - \) Muskhelishvili’s constant; \( \tilde{P} = \max P_x; \)
\( P = \left( 1 + \frac{\beta p_1}{2p} \frac{\beta^2}{4} \left( \frac{p_a}{p} \right)^2 \right) \eta(x - x^2) \left( \frac{3}{2} (N + A) + \frac{1}{4L} \frac{H}{1 + \frac{\beta p_1}{2p} - \frac{\beta^2}{4} \left( \frac{p_a}{p} \right)^2} + \frac{1}{3} \right) + \frac{p_a}{p} \)

The value \( P \) is found in the article [11].

The boundary conditions (11) indicate the conditions for the adhesion of the lubricant to the surface of the slide and the guide, as well as the equality of atmospheric pressure in the initial and final sections, conditions (12) show the continuity of the hydrodynamic pressure at the surface of the separation between the porous layer and the lubricating film. In addition, on this surface the normal component of the velocity is determined by Darcy's law. On the impenetrable surface of the porous layer, the normal velocity guide is zero.

For \( u_y \) and \( u_x \), the boundary conditions mean the zero equality for tangent and normal stresses on the non-deformable elastic surface adjacent to the lubricating layer, as well as the equality of the displacement vector components adjacent to the rigid supporting surface of the bearing.

We will look for the exact self-similar solution of the problem associated with the definition of the velocity and pressure field in the lubricating layer in the form:

\[
\psi = \psi(\xi), \quad \varphi = \varphi(\xi) = \frac{y}{h(x)}. \quad (14)
\]

Substituting (14) into the first four equations (9) taking into account the boundary conditions (11)-(12), we arrive at a system of ordinary differential equations and boundary conditions:

\[
\psi(\xi) = \bar{C}_2, \quad \bar{\psi} = \bar{C}_1, \quad \bar{u} - \bar{v} = 0, \quad e^{-\varphi} \frac{dP}{dx} = \frac{C_1}{H^2_2(x)} + \frac{C_2}{H^3_2(x)} + A + N. \quad (15)
\]

And boundary conditions are:

\[
\psi' = 0 \text{ at } \xi = 0, \bar{\psi} = 0, \bar{u} = 0 \text{ at } \xi = 1, \bar{v} = 1 \text{ at } \xi = 0. \quad (16)
\]

Solving the differential equation (15) in accordance with the boundary conditions (16), we get:

\[
\psi = \frac{\bar{C}_2}{2}(\xi^2 - \xi) + \frac{\bar{C}_1}{2} + \frac{1}{2} \xi + 1. \quad (17)
\]

### 3.3. Determination of hydrodynamic pressure

To determine the dimensionless hydrodynamic pressure in a deformed elastic layer, we find from the equation that:

\[
e^{\psi} \frac{dP}{dx} = \frac{C_1}{H^2_2(x)} + \frac{C_2}{H^3_2(x)} + A + N. \quad (18)
\]

Integrating equation (19), we obtain:

\[
p = \bar{C}_2 J_2(x) + \bar{C}_1 J_3(x) + (A + N)x + \frac{p_a}{p}. \quad (19)
\]

where \( J_k(x) = \frac{\int_0^x dx}{H^k_2(x)} \).

To determine the hydrodynamic pressure, it is first necessary to find a function \( \eta(x) \phi(x) \) integrating the fifth equation of the system (9). Taking into account the boundary conditions (13), we obtain:
\[ U_y = -\frac{\bar{p}}{M} y + \frac{\bar{p}}{M} \left( \frac{\eta_1}{\delta_1} + \eta_2 x \right). \]  

(20)

We use the approximate formula \[ |H_2(x) - H_1(x)| \approx U_y \bigg|_{y=H_1(x)} \]

Taking into account formulas (10) for \( \eta \varphi(x) \), we finally obtain the following expression:

\[ \eta \varphi(x) \approx \frac{\bar{p}}{M}. \]  

(21)

Then \( H_2(x) = \left(1 + \frac{\bar{p}}{M}\right)(1 + \eta_4 x - \eta_5 \sin \omega x) \), where \( \eta_4 = \frac{\eta}{1 + \frac{\bar{p}}{M}}, \eta_5 = \frac{\eta}{1 + \frac{\bar{p}}{M}} \).

It follows from the formula (21) that the value of the dimensionless function \( \eta \varphi(x) \), determined by the deformation of the supporting surface is directly proportional to the dimensionless value of the maximum pressure \( \bar{p} \) and inversely proportional to the value of the elastodynamic parameter \( M \), when \( M \to \infty, \varphi(x) \to 0 \).

We introduce the notation \( -\beta \rho \) and differentiate both sides of the equality with respect to \( x \). We write equation (18) in the form:

\[ \frac{dz}{dx} = -\beta \left( \frac{1 - \eta_4 \omega^2 (\cos \omega - 1)}{1 + \frac{\bar{p}}{M}} + \frac{1}{1 + \frac{\bar{p}}{M}} \left( \frac{3}{2} \eta_4 \omega^2 (\cos \omega - 1) - (A + N) \right) \right). \]  

(22)

Integrating the equation (22) within terms of the second order of smallness \( O(\eta^2) \) and using the boundary conditions \( z = (0) = z(1) = e^{-\beta \rho} \), we solve equation (22) relatively to \( \tilde{C}_1 \) within the accuracy of terms \( O(\eta^2) \):

\[ \tilde{C}_2 = -\tilde{C}_1 \left(1 + \frac{\bar{p}}{M}\right) \left(1 + \frac{1}{2} \eta_4 + \frac{\eta_5}{\omega} (\cos \omega - 1) \right) - (A + N) \left(1 + \frac{\eta_4}{\omega} (\cos \omega - 1) \right) \left(1 + \frac{\bar{p}}{M}\right)^3. \]  

(23)

Taking into account (23), equation (22) takes the following form:

\[ z = -\beta \left( \frac{\eta_4}{2} (\cos \omega - 1) - \frac{\eta_5}{\omega} (\cos \omega - 1) \right) \left( \frac{\tilde{C}_1}{1 + \frac{\bar{p}}{M}} \right) + e^{-\beta \rho} \]  

(24)

Or

\[ e^{\beta \rho} - e^{-\beta \rho} = -\beta \left( \frac{\eta_4}{2} (\cos \omega - 1) - \frac{\eta_5}{\omega} (\cos \omega - 1) \right) \left( \frac{\tilde{C}_1}{1 + \frac{\bar{p}}{M}} \right). \]  

(25)
We perform the analytic expansion of the function \( e^{-\beta p} \) and \( e^{-\beta^* p} \) to the Taylor series. Then, from (25) within the accuracy of terms \( O(\beta^2), O(\eta^2), O\left(\beta \left(\frac{p_a}{p}\right)\right) \) for \( P \), we obtain the following expression:

\[
P = \frac{p_a}{p} + \left(1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left(\frac{p_a}{p}\right)^2 \right) \left(\eta_1 - \frac{\eta_5}{\omega} \cos \alpha x - 1 - \frac{x}{\cos \omega - 1}\right) \times \left(\frac{\tilde{C}_1}{1 + \frac{\tilde{p}}{M}}\right) x + 3(A + N) \] (26)

Taking into account (26), we will look for the pressure of the filterable lubricant in the porous layer in the form:

\[
P(x, y^*) = R(y^*) + \left(1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left(\frac{p_a}{p}\right)^2 \right) \left[1 + \frac{1}{2} \eta_1 (x^2 - x) + \frac{\eta_5}{\omega} \cos \alpha x - 1 - \frac{x}{\cos \omega - 1}\right] \times \left(\frac{\tilde{C}_1}{1 + \frac{\tilde{p}}{M}}\right) x + 3(A + N) + \frac{p_a}{p} \] (27)

Substituting (27) into Darcy’s equation of system (9) for the definition of functions \( R(y^*) \), we arrive at the following differential equation:

\[
R^*(y^*) + \left(1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left(\frac{p_a}{p}\right)^2 \right) \left(\eta_1 - \eta_5 \cos \alpha x\right) \times \left(\frac{\tilde{C}_1}{1 + \frac{\tilde{p}}{M}}\right) x + 3(A + N) = 0. (28)
\]

And the boundary conditions are:

\[
R(0) = \frac{p_a}{p}, \quad \frac{\partial R}{\partial y}\bigg|_{y^* = \frac{y}{L}} = 0. (29)
\]

The direct integration of equation (28) taking into account (29) for the function \( R(y^*) \) makes it possible to obtain the expression:

\[
R(y^*) = -\left(1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left(\frac{p_a}{p}\right)^2 \right) \left(\eta_1 - \eta_5 \cos \alpha x\right) \times \left(\frac{\tilde{C}_1}{1 + \frac{\tilde{p}}{M}}\right) x + 3(A + N) + \frac{p_a}{p} \] (30)

This way, the solution of the problem will be found after determining the constant \( \tilde{C}_1 \). Integrating the continuity equation on \( \xi \) from 0 to 1, we arrive at the following equation:

\[
\tilde{M} \frac{\partial R}{\partial y}\bigg|_{y^* = 1} = \int_0^1 \tilde{v}(\xi) d\xi. (31)
\]

Taking into account (17) and (30) for \( \tilde{C}_1 \), we obtain the following expression:

\[
-\tilde{M} \left(1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left(\frac{p_a}{p}\right)^2 \right) \left(\frac{\tilde{C}_1}{1 + \frac{\tilde{p}}{M}}\right) x + 3(A + N) \frac{\tilde{H}}{L} = -\frac{\tilde{C}_1}{12} + \frac{1}{2}. (32)
\]
Solving equation (32) relatively $\tilde{C}_1$, we will have:

$$
\tilde{C}_1 = \frac{12 \left( 1 + \frac{\bar{p}}{M} \right)^2 \left( 3\tilde{M} - \frac{\tilde{H}}{L} (A + N) + \frac{1}{2} \right)}{-12\tilde{M} \frac{\tilde{H}}{L} \left( 1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left( \frac{p_a}{p} \right)^2 \right) + \left( 1 + \frac{\tilde{p}}{M} \right)^2}
$$

(33)

So, equation (26) with regard to (33) can be represented in the form:

$$
p = \left[ \frac{\eta_1}{2} (x^2 - x) + \frac{\eta_3}{\omega} (\cos \omega x - 1 - x(\cos \omega - 1)) \right] (1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left( \frac{p_a}{p} \right)^2) + \frac{12(3\tilde{M} - \frac{\tilde{H}}{L} (A + N) + \frac{1}{2})}{-12\tilde{M} \frac{\tilde{H}}{L} \left( 1 + \frac{\tilde{p}}{M} \right)} + \frac{p_a}{p},
$$

(34)

It is necessary to note that the basic operating characteristics of the bearing have been determined. The authors have obtained the following expressions:

$$
W = \frac{\mu \omega' L^4}{k_0^2} \int_0^1 \left( p - \frac{p_a}{p} \right) dx = \frac{\mu \omega' L^4}{k_0^2} \left( 1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left( \frac{p_a}{p} \right)^2 \right) \left( 12(3\tilde{M} - \frac{\tilde{H}}{L} (A + N) + \frac{1}{2}) \right) \times
$$

$$
\left( -\frac{\eta_1}{12} + \frac{\eta_3}{\omega} \left( -1 + \frac{1}{2} \cos \omega - 1 \right) \right).
$$

(35)

$$
L_{CP} = \frac{\mu \omega' L^4}{k_0^2} \left( \psi'(0) + \frac{\psi'(0)}{H_2^2(x)} \right) dx = \mu \omega' L^4 \left[ H_2^2(x) \right] \times
$$

$$
\left( 1 + \beta \frac{p_a}{p} - \frac{\beta^2}{2} \left( \frac{p_a}{p} \right)^2 \right) ^2
$$

(36)

To verify calculations on the base of the received theoretical models, the authors used the following values:

$$
p_a = 0.08 \pm 0.101325 \text{ MPa}; \; k_0 = 10^{-7} \div 2 \cdot 10^{-6} \text{ m}; \; L = 0.1256 \div 0.1884 \text{ m}; \; \mu = 0.0608 \text{ MPa}; \; u^* = 1 + 3 \mu \text{ c}; \; \tilde{M} = 0.1 \pm 3; \; \eta_1 = \eta_3 = 0.2 \pm 0.5; \; M = 0 \div 30; \; \tilde{H} = 0.0055 \text{ m}, \; \omega = 0 \div 2 \pi; \; A = 0.1 \div 2; \; N = 0.1 \div 0.9, \; p = 0 \div 16 \text{ MPa}, \; \beta = 0 \div 1.
$$

Based on the results of numerical calculations, the graphs shown in Figures 2-7 have been made.
Figure 4. The graph of the elastohydrodynamic parameter $M$ and $\omega$, the parameter characterizing the adapted profile of the bearing bushing.

Figure 5. The graph of the dependence of the frictional force on the parameter $A$, determined by the presence of the electric field $\omega$, a parameter characterizing the adapted profile of the bearing bushing.

Figure 6. The graph of the dependence of the frictional force on the parameter $A$, determined by the presence of the electric field $N$, the Hartmann number.

Figure 7. The graph of the dependence of the frictional force on the elastohydrodynamic parameter $M$ and $\omega$, a parameter characterizing the adapted profile of the bearing bushing.

4. Conclusion

As a result of the theoretical studies, the authors have identified the main regularities of mutual influence on the load-bearing capacity and the frictional force of the bearing with the parameters. They are the elastohydrodynamic parameter $(M)$, the $\omega$ adapted profile of the supporting surface of the bearing bushing, as well as parameters $A$ and $N$, determined by the presence of an electric field and the Hartmann number.

It is established that the bearing capacity and the friction force increase with the increase of the elastohydrodynamic parameter $(M)$. With $M \to \infty$, frictional force and bearing capacity tend to the proper values of the bearing with a rigid supporting surface.

With the use of an adapted profile, the bearing capacity of the bearing bushing is characterized by the presence of a maximum viscosity characteristics if $\omega = \frac{3}{2}$, which leads to a reduction in this region of frictional force and an increase in bearing capacity of the bearing.

As the values of the parameters $A$ and $N$ increase, the bearing capacity increases, and the frictional force decreases insignificantly.
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