TRANSPORTATION AND STORAGE OF OIL AND GAS

Increasing of reliability of work of rotating machines of oil and gas industry

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УДК 629.424.1

The paper proposes two ways to improve the reliability of rotating machinery of oil and gas industry through the use of rolling bearings that allow evenly distribute the pressure of lubricating fluid to the surface of the shaft.

In the oil and gas industry the machines and equipment are often used, which construction structure includes the knots of bearing type. The failures of bearing knots are often caused by an uneven distribution of load along the contact of a rotating body with the bearing unit. This in its turn leads to overheating, jamming and loss of productivity of machinery or equipment. In this regard, the durability and compactness of bearings, which are used in oil and gas industries, must meet rather strict requirements. This problem can be solved by creation of new progressive methods of working of the bearing units.

In the oil and gas industry the classic slide bearings are mainly used, which are widely used in gas-pumping equipment, pumps and drilling equipment. Such bearings consist of a shaft and upper and lower liners, which are provided with the holes for the feeding of lubricant fluid [1]. However, this type of bearings does not ensure the equal distribution of pressure of lubricating fluid on the surface of the shaft. Therefore, the author suggests two ways to solve the abovementioned problem.

Hydrostatic slide bearing

The basis of the hydrostatic slide bearing is the using of hydro layer as the lubricant fluid and accommodation the whole with opening for feeding of lubricant fluid in the top liner.

The developed hydrostatic slide bearing which has the similar features with the classic analogues such as the shaft, upper and lower linear has the hole with openings for feeding of lubricant fluid.

It is provided to locate additionally in the upper liner the hole and opening for feeding of lubricant fluid and two screws for closing the openings and at this the hydro layer is used as the lubricant fluid (in mass.

%) polyvynil chloride resin of the trade mark M (20…10), dibutyl-phthalate(59...88), calcium stearate (0,5...1), vacuum oil (20,5…1), and the openings in the body and in the upper and lower liners have the inner thread.

Effect of combination of the cavity with a hole in the top liner with the using of hydro layer as the lubricant liquid to obtain the indicated technical result is that it provides the equal access of lubricating fluid across the whole surface of the shaft, and the use of hydro layer, as it is known from [2], is based on the principles of the third Pascal's law, according to which the pressure on the liquid, placed in a closed vessel, is transmitted simultaneously in all directions with equal strength.

Hydrostatic slide bearing (Fig. 1) is prepared for work so: before pouring of hydro layer 6 guide hydrostatic slide bearing is set on shaft 1 and heated to the temperature 120-160 degrees C.

After that, lubricating fluid, hydrolayer 6, is pumped through the hole 4; at first it gets to the top bearing liner with a cavity and hole for the feeding of lubricant fluid 2 and goes to the low linear of bearing with a cavity and hole for the feeding of lubricant fluid 3, simultaneously the hydrolayer 6 fills the space between the shaft 9 and surface of liners 2 and 3, and through the hole 4 the release from air of cavities of upper and lower liners 2 and 3. If the cavities of the upper and lower liners 2 and 3 are fully filled with the hydrolayer 6, the holes 4 and 5 are to be closed with the screws 7 and 8.

Hydrostatic slide bearing works so. The shaft 9 rotates creating efforts which, are felt by the lubricant fluid, hydroplast 6, which locates in the space between the shaft and the surfaces of liner 2 and 3 and in the cavities of liner 2 and 3. In the case of stationary (permanent) load to the hydrolayer 6 through the screws 7 and 8 according to the third Pascal law the equal distribution of the load will occur in the process of the work of the shaft 9 on the surfaces of upper and lower liners 2 and 3.

Magnet slide bearing

The base of the magnet slide bearing is the principle of using of magnets in the upper and lower liner and additional location of cavity with the hole in the upper liner for the feeding of lubricant fluid as well as the using of magnet lubricant as the lubricant fluid (in mass. %): magnetite – 30; oligoether – 40; diether carbon acid – 30.

It is provided to locate additionally the magnets in the upper and lower liners in the developed magnet slide bearing which has the similar features with the classic analogues (the body with the upper and lower liners and the cavity with holes for the feeding of lubricant fluid in the lower liner).

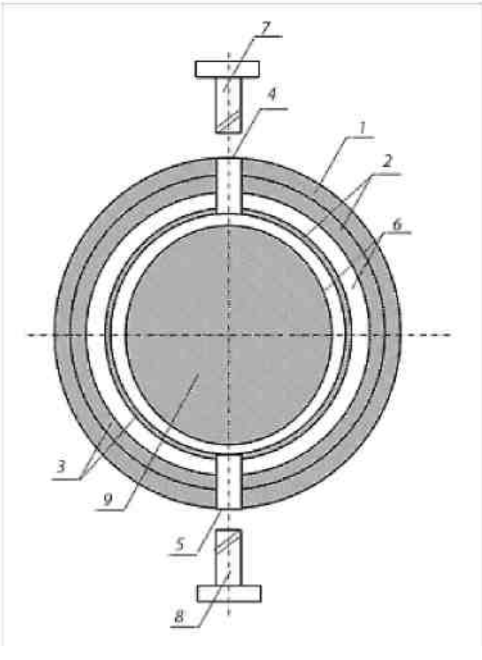

Fig. 1. Hydrostatic slide bearing

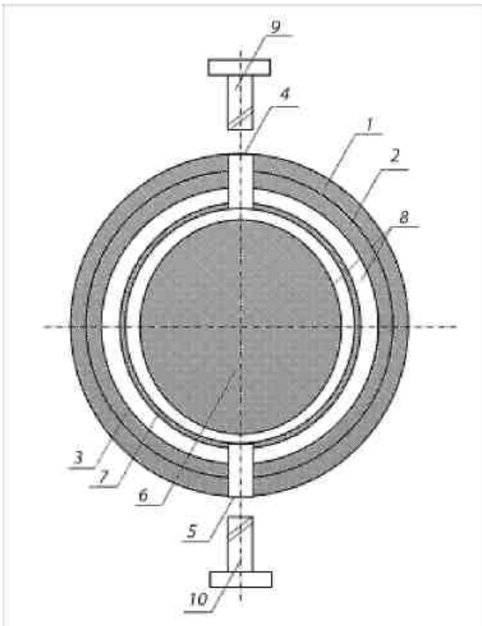

Fig. 2. Principle scheme of developed magnetic bearing

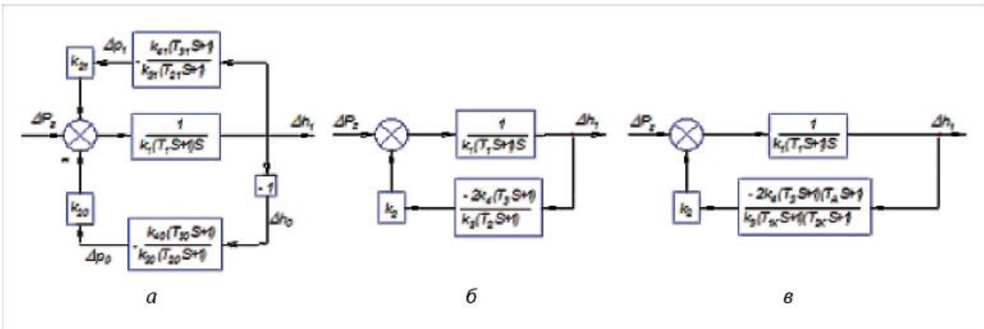

Fig.3 Structural schemes of functioning of system “bearing units-shaft”for general case (а) with symmetrical supports (б)and with the automatic correction (в)d

Also it is offered to locate in the upper liner the cavity with the holes for the feeding of the lubricant fluid and at this the magnet lubricant is used as the lubricant fluid, which components are given above. The influence of combination of location in the upper and lower liners of magnets, cavity with the hole in the upper liner with the using of magnet lubricant as the lubricant fluid for receiving the indicated technical result is based upon the fact that the equal access of the lubricant fluid on the whole surface of the shaft is provided due to the creation of the magnetic field. Because of location of magnets along the upper and lower liners the even magnetic field occurs which acts on the magnetic lubricant and enforce it to lean the surfaces of the shaft and evenly fill the radial gap. [4].

Magnetic slide bearing works so: before pooring the lubricant 8 the hydrostatic slide bearing is set on the shaft 6 (Fig. 2). After that the lubricant fluid, magnetic lubricant is pumped through the hole 4;

First it gets the upper liner of the bearing with the cavity and hole for the feeding of lubricant fluid 2 and then goes to the lower liner of the bearing with the cavity and hole for the feeding of lubricant fluid 3, simultaneously the space between the shaft 6 and magnets 7 is filled with the magnetic lubricant 8 and through the hole 4 the release of air of cavities of upper and lower liners 2 and 3 is provided. If the cavities of upper and lower liners 2 and 3 are fully filled with the magnetic lubricant the holes 4 and 5 are closed with the screws 9 and 10. The shaft 6 rotates creating the efforts which are felt by the lubricant fluid, magnetic lubricant 8 which is located in the space between the shaft 6 and magnets 7 and in the holes of liners 2 and 3. The even distribution of the pressure of lubricant fluid, magnetic lubricant 8 on the surface of the shaft 6 is reached hecause of creation of the magnetic field by the magnets 7. Thus, during the rotation of the shaft 6 the magnetic lubricant 8 from the holes of the upper and lower liners of the bearing 2 and 3 by the magnet forces is pressed to the surface of the shaft 6 filling the whole space between the magnets 7 and shaft 6.

The mathematic working model of the machine installed on two slide bearings under the recommendations indicated in [5], can be presented so:

$$\begin{cases} M\ddot{h}_1 = P_z - \dfrac{p_0 - p}{2}(lB + bl) - \mu\dot{h}_1\left(\dfrac{1}{4h} + \dfrac{1}{4h}\right)\begin{bmatrix} l\times(B-b)^3 \\ +b\times(L-l)^3 \end{bmatrix}, \\ Q_H = \dfrac{p_1 \times h_1^3}{3\mu}\times\left(\dfrac{l}{B-b} + \dfrac{b}{L-l}\right) + \dfrac{V_{\text{пр}1}}{E_{\text{м}}}\dot{p}_1 + \dot{h}_1(Bl + bl - 2bl), \\ Q_H = \dfrac{p_0 \times h_0^3}{3\mu}\times\left(\dfrac{l}{B-b} + \dfrac{b}{L-l}\right) + \dfrac{V_{\text{пр}0}}{E_{\text{м}}}\dot{p}_0 + \dot{h}_0(Bl + bl - 2bl), \\ h = h_\Sigma - h_1, \end{cases} \quad (1)$$

where M – given mass of spindle unit; h_0 and h_1 – gaps in left and right bearing units; p_0 and p_1 – pressure of fluid in the left and right bearing units; P_Z – external load; B, L – width and length of bearing supports; b, l – width and length of hydraulic hopper of support; μ– dynamic viscosity of the liquid; $V_{\text{пр}}$ – given volume of the hopper of bearing unit; E_M – module of the volume condensability of the fluid; $h_\Sigma = h_0 + h_1$ – sum diameter gap in the system "shaft-bearing units".

To simplify the analysis the linearization of nonlinear equations (1) is made by the spreading in Taylor row. Further it is convenient to make transformation of lineared system under Laplas going to operator form of the recording of equations and introducing the designation of coefficients and constants of the time.

As a result we get the mathematics model:

$$\begin{cases} k_1(T_1S+1)\cdot S\cdot\Delta h_1 = \Delta P_Z + k_{21}\Delta p_1 - k_{20}\Delta p_0, \\ -k_{41}(T_{31}S+1)\Delta h_1 = k_{31}(T_{21}S+1)\Delta p_1, \\ -k_{40}(T_{30}S+1)\Delta h_0 = k_{30}(T_{20}S+1)\Delta p_0, \\ \Delta h_1 = -\Delta h_0, \end{cases} \quad (2)$$

where k_i and T_i – coefficients and constants of time; S – operator of differentiating.

The structural schemes of functioning of slide bearing units which correspond the system of equations (2) are given in the fig. 3.

So two methods of functioning of slide bearing are proposed in the article which give the opportunity to increase the reliability of work of rotating machines of oil and gas industry due to the even distribution of the pressure of the lubricant fluid on the shaft surface.

The developed mathematic models for the calculation of dynamic characteristics of slide bearings helped to define (fig. 4), that the gradient of change of value of the relevant displacement in the developed slide bearings of masses centre dependently of the degree of rotation of the shaft deviates in the range 5…8mcm which testifies the evenness of distribution of lubricant fluid on the shaft surface.

If the magnetic slide bearing is used (see fig. 2). the level of displacements of centre of masses is less than the indicators of hydrostatic slide bearing which is connected with more active action of the magnetic field on the magnetic lubricant.

Fig. 4. Results of mathematic modeling of relevant displacement of centre of masses of the bearing of the degree of rotation of the shaft at the frequency of rotation 1000 rev/min and loading 1500 H: *1* – traditional slide bearing with the lubricant fluid; *2* – developed hydrostatic slide bearing, lubricant fluid-hydrolayer; 3- developed magnetic slide bearing, lubricant fluid – magnetic lubricant

As a result of the carried out investigations the working model of slide bearings is created and two patents for the useful model are registered.

The task of optimization of construction and technologic parameters of the developed bearing units can be resolved by means of development of the simulation model on the base of the received mathematic models.

The further plans are to conduct the experimental researches of work efficiency of such bearing constructions to develop the practical recommendations as for their implementation in the production process.

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