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INTERPRETATION OF OPERATION OF SLIDE JOURNAL BEARINGS IN UNSTEADY ENERGETISTIC DESCRIPTION

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Abstract

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The paper includes a proposal of interpretation that valuates operations, which (just like operation of Hamilton and Maupertius showed in classical mechanics and operation resulting from changes of body momentum) is considered as a physical quantity with a unit of measure: joule-second [joule x second]. Original method of analysis and estimation of slide journal bearing operation has been also presented with regards to its reliability and safety. The homogeneous process of Poison has been applied in order to substantiate the usability of such interpreted operation. This process has enabled constructing a model of run of getting-worse bearing operation with the operation time going by. Thus, the model is a random process of homogenous and independent gains in energy lost due to friction and bearing wear.

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Keywords: *friction heat, operation, friction energy, slide journal bearing, friction work*

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1. Introduction

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Methods of estimation of level slide journal bearing operation should enable preventing against failures. The need of elaborating such models issues from the fact that bearing failures cause usually big damages to constructional structures of machines and high operating costs. The proposed method of estimation of slide journal bearings operation refers to the bearings of composed systems like internal combustion engines used in shipping industry, internal combustion or steam turbines used in power engineering, etc. The method takes into account lubricating oil as a bearing element. It is necessary because characteristics of slide journal bearings depend mainly on physical-chemical properties of a lubricating film, which appears between swiveling pins and stationary bearing bushings during bearing operation.

Thus, slide journal bearing operation is analyzed here as operation of a tribological system consisting of [2,5]

- pin, as an element moving in relation to bearing bushing, in which the pin is placed;
- bearing bushing, as an element in relation to which a pin moves;
- convergent lubricating film (oil wedge) as an indirect element, created between a pin and a bearing bushing during operation.

Between these mentioned elements there are strictly determined relations, which undergo changes as characteristics of surface layers of pin and bearing bushing and characteristics of lubricating oil change. The changes depend on conditions of bearings operation and especially their load. Thus, slide bearings may be considered as tribological systems, of which operation is going to be disturbed by external load dependant on tasks performed by a machine, inside which they are installed and on external conditions, in which the tasks is to be performed [2.5.8.9].

In the result of the disturbances, wear of bearings differs. Because of great load of the bearings, it is necessary to determine the wear of top layers of the cooperating surfaces, after prior

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determining a value of heat energy, friction force and friction action [10]. Different kinds of friction may occur during slide journal bearings operation. Mixed friction, occurring while starting and stopping a machine, is especially unfavorable. At this friction, greater part of kinetic energy of bearing pins is being exchanged, in the form of friction work, into heat energy. A part of heat energy produced in this way will be carried away out of the bearing together with flowing lubricating oil and due to radiation.

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Tab. 1. Parameters of coolant

Name	Symbol	Range (normal state)	Unit of measure
1	2	3	4
Normal temperature	T_1	32	^{o}C
Working temperature	T_2	38,5 – 39,5	^{o}C
Ambient temperature	T_3	42,5 – 43,5	
Oil temperature	T_4	51 - 52	^{o}C
Fiducial temperature	T_5	44,0 – 45,0	^{o}C

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2. Formulating a problem of estimation of bearing operation

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Slide journal bearing operation is possible in case of producing inside them a resultant force being an effect of occurrence of a hydrodynamic pressure. The force is a bearing response to external load, under condition that it finds itself in static equilibrium. Thus, it characterizes the bearing capacity. Slide journal bearing capacity (just like thrust bearing capacity) depends essentially on ability of carrying away the inside-released heat. From this reason technical diagnosis of the bearings is based on lubricating oil temperature measures and bearing metal temperature measure in at least one characteristic point. Bearing capacity changes dependently on the torque transmitted inside machine and also due to changes of physical-chemical characteristics of lubricating oil. That is why the lubricating oil should be considered as an inseparable element of the bearing. Loss of required lubricating oil characteristics (like oil body, lubricating ability, base number, etc) must be treated as failure, and bearing having such oil – disable to operate.

During bearing operation lubricating oil undergoes coagulation [5]. It causes increase of its temperature. The reason is that, in the process of oil coagulation, internal friction work in oil is fully exchangeable into heat. Energy transmitted in the form of work and then in the form of heat may be considerable. In case of large-size and high-speed bearings (used in turbines) heat flux liberated under friction (friction force) may reach a value of even a few megawatts [5], at the capacity of even 7 MPa [2], in case of adequate selection of bearing materials and lubrication system. The flux is carried away from bearing mainly together with oil and through bearing elements making an oil clearance. Heat absorbance by oil causes increase of its temperature and reduction of its body. Moreover, heat is cumulated in bearing metal elements (pin and bushing). That causes thermal deformation of them and geometry change of bearing oil clearance.

Accompanying considerable changes of mechanical load (ex. in case of diesel engines, that cause pressure gain rate $\varphi p_{śr} > 0{,}7$ MPa/1° OWK [8,9]), pin rotational speed and also getting worse physical-chemical characteristics of lubricating oil may lead to quick increase of friction energy E_T and faster wear of bearing.

The law can be expressed in the form of diagram of energy conversion, considering a bearing as an energy converter. Such a diagram is presented below on the Fig. 1.

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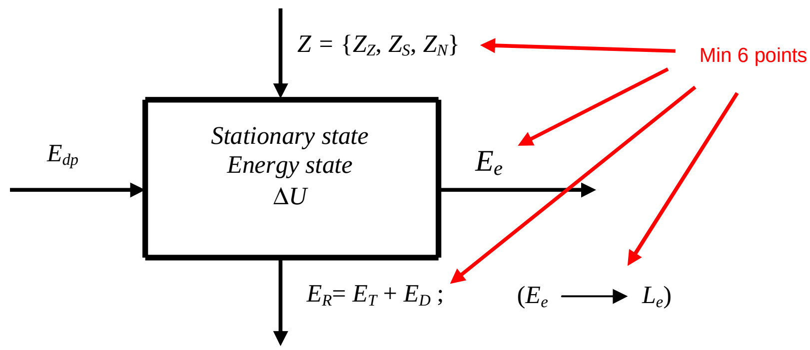

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Fig. 1. Diagram of a bearing as an energy converter: Z – disturbances, influencing the conditions for bearing operation; Z_Z – power supply disturbances; Z_S – control disturbances; Z_N – other disturbances; E_{dp} – delivered mechanical energy; ΔU – internal energy gain in accordance with the law of conservation of energy

For symmetrical distribution of oil shearing stresses, being directly at the surface of rotating pin along bearing, width the moment of friction can be expressed by the formula [5]:

$$L_T = M_T \alpha = M_T \omega t = 2\pi M_T nt , \qquad (1)$$

where:

L_T - friction action on the α angular path,
M_T - moment of friction,
α – angle of rotation of a pin in relation to a bearing brushing,
ω - angular velocity,
t – time of pin rotation,
n – rotational speed of a pin in relation to a bearing bushing.

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Processes of exchanging mechanical operation (occurred under overcoming oil coagulation resistances) into heat and appearing in the result heat energy in oil bearing interspace can be described with energy equations [1, 5, 10]. Further considerations may be developed applying general dependences defining friction work or power [5, 11, 12, 14]. However, the sense of interpretation of operation presented by the formulas (2), (4) and (7) will remain the same.

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