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ANALYSIS OF METHODS FOR CLEANING THE WORKING FLUID OF HYDRAULIC MACHINES

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Problem statement. The durability of the hydraulic drive of agricultural, construction and road machinery is significantly influenced by both the design parameters laid down at the design stage and the properties of the working fluid, which are maintained at the operation stage. Hydraulic drives of mobile machines The sensitivity of the system's safety indicators to changes in operational factors is considered to be a manifestation of the nature of the hydraulic drive. The intensity of wear of the friction elements of hydraulic drives of mobile machines, in particular the plunger pairs of axial-piston pumps, is significantly influenced by the state of the working fluid, therefore the issue of its cleaning is very important.

Main research materials. There are three methods of cleaning the working fluid: physical, physicochemical and chemical.

Physical methods allow you to remove solid particles of contaminants, microdroplets of water and partly resinous and coking substances from oils, and by evaporation, low-boiling impurities.Oils are processed in a force field using gravitational, centrifugal, and less commonly electric, magnetic, and vibrational forces, and filtration, water washing, evaporation, and vacuum distillation are also used. Physical methods for cleaning waste oils also include various mass exchange and heat exchange processes used to remove hydrocarbon oxidation products, water, and low-boiling fractions from the oil [1].

Physicochemical methods have found wide application in oil purification, including coagulation, adsorption, and selective dissolution of contaminants contained in oil. A type of adsorption purification is ion-exchange purification [2].

Chemical cleaning methods are based on the interaction of substances that contaminate used oils and reagents that are introduced into these oils. As a result of chemical reactions, compounds are formed that are easily removed from the oil.Chemical cleaning methods include: acid and alkaline cleaning; oxygen oxidation; hydrogenation, as well as drying and cleaning from contaminants using metal oxides, carbides, and hydrides [2].It is proposed to increase the efficiency of oil purification and the reliability of protection of friction pairs from contaminants by improving filter designs and using new filter materials. The work proves that the fractional coefficient of screening out particles of contaminants in a centrifuge is practically independent of the viscosity and oil flow rate.

Difficult operating conditions of agricultural, construction and road machinery (high dust content, temperature fluctuations, humidity) lead to increased wear of hydraulic units and, as a result, to a high percentage of failures in operation.Wear of hydraulic units of machines is caused by the presence of mechanical impurities in the working fluid and is caused mainly by solid abrasive particles. The lowest operating time before failure is for hydraulic units that contain plunger pairs – hydraulic pumps, hydraulic motors, and distributors.Due to the research conducted, methods for cleaning and dispersing mechanical impurities have been developed, the use of which provides a significant increase in the performance of the hydraulic drive.

The analysis of literary sources shows that the durability of the hydraulic drive of agricultural, construction and road machines is significantly influenced by both the design parameters established at the design stage and the properties of the working fluid maintained at the operation stage. Characterizing mobile machines as complex dynamic systems, their suitability and safety for practical use primarily depends on whether they satisfy the stability conditions and what is the sensitivity of the system, both as a whole and its elements. Regarding hydraulic drives of mobile machines, the sensitivity of system safety indicators to changes in operational factors is represented by the identification of the nature of the intensity of wear of friction elements, in particular plunger pairs of axial-piston pumps, depending on the state of the working fluid. The establishment of parameters, their qualitative and quantitative characteristics have not received a sufficiently accurate reflection in existing scientific developments. In friction units, the mixed (boundary) lubrication mode is widespread: some areas of the surface of the contacting bodies are separated by a hydrodynamic layer, and others by a boundary layer. For this type of lubrication, both the volumetric characteristic of the lubricant - its viscosity - and the ability of the lubricant to create strong boundary layers on the friction surfaces are of great importance. The higher the proportion of the hydrodynamic lubrication mode, the lower the friction coefficient in mixed lubrication [3]. The area of implementation of hydrodynamic, mixed and boundary lubrication in sliding friction units is determined by the Gersa-Stribek diagram (Fig. 1)

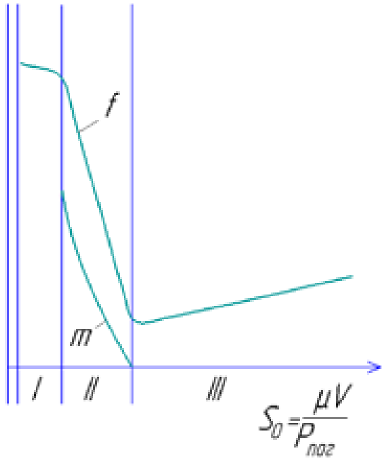
The diagram represents the dependence of the friction coefficient in a lubricated friction unit on a dimensionless criterion called the Hersey number, or the Sommerfeld criterion [3]:

$$S_o = \mu \cdot V / P_{пог} . \quad (1)$$

where μ – is the dynamic viscosity;

V – is the speed of relative movement of friction pairs;

$P_{пог}$ – is the linear load on the friction node (load related to the length of the coupling in the direction perpendicular to the direction of relative movement).

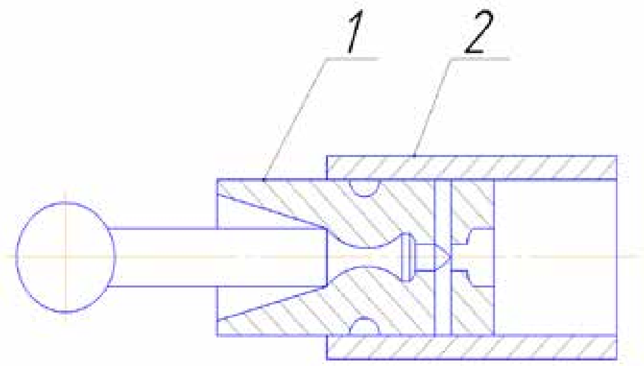


I-III- lubrication zones: I - boundary; II - mixed; III - hydrodynamic

Fig. 1. Gersa-Stribek diagram: dependence of the coefficient of friction and wear on the dimensionless parameter (Gersa number):

In the left part of the diagram, the zone of implementation of the limiting lubrication mode is localized, as the most solid. It is implemented at high specific loads in friction pairs, low speeds of relative movement of tribological pairs, elevated temperatures (which cause a decrease in dynamic viscosity) and is characterized not only by an increased friction coefficient, but also by constant wear of the parts of the friction pair. Among the tribological pairs of an axial piston pump, the friction pair "plunger-sleeve" is most subject to wear, which operates in a mixed lubrication mode.

A general view of one of the structural variants of the friction pair "plunger – block sleeve" of the pumping unit of an axial-piston hydraulic machine is presented in Fig. 2.



1 – plunger; 2 – sleeve

Fig.2. Friction pair "plunger – sleeve block" of an axial piston pump

This design of the plunger pair has found wide application in axial-piston hydraulic machines with an inclined housing to ensure an increase in the working stroke of the plunger, and hence the working volume of the hydraulic machine. The transition point between mixed and hydrodynamic lubrication is characterized by the lowest value of the friction coefficient and a reduction in wear to zero. Due to the fact that in the friction pair “plunger – sleeve” of an axial piston pump, it is impossible to achieve an exclusively hydrodynamic lubrication mode, in order to ensure the lowest wear in the tribological pair, the current task is to reduce the friction coefficient in it. When manufacturing the “plunger – sleeve” pair of an axial piston pump, steel 38X2LYUA and Br012 are used; the technological and design parameters of these materials are given in Table 1.

Table 1

Design and technological parameters of friction pairspumping units of hydraulic machines 210.25 and 223.25

№	Indicator name	Part name	
		piston	Sleeve (cylinder block)
1	Material	Сталь 38Х2МЮА	Бр 012
2	Hardness of the friction surface	$HB232$	$HB_{10^{95}}$
3	Diameter, mm	$25^{-0,021}$	$25^{+0,015}$
4	Length, mm	30	100
5	Plunger stroke, mm	70	-
6	Surface roughness, Ra ,μm	2,5	0,63
7	Angle of inclination of the sides of the roughness, a^0	7°50'	2°15'

Conclusions. Abrasive wear is predominant in the considered tribological pair. The term “abrasive wear” is understood as the destruction of friction surfaces under the influence of solid particles present in the friction zone. The task of further research will be to identify the nature and magnitude of wear of parts in the mating parts of the plunger pair: “block sleeve - plunger”, “plunger heel ring support - swash plate”.

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