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Influence Of Chemical And Disperse Composition Of Hydraulic Fluid Contamination On The Reliability Of Reclamation Machines In The Central Asian Region.

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ABSTRACT

The article presents an assessment of the impact of contaminated hydraulic fluid reclamation machines on the efficiency of the equipment, in the operating conditions of the Republic of Tajikistan. The main factors affecting the resource change of these units of machines are considered. The most characteristic causes of solid particles in the cavity of transport and technological machines are revealed. The influence of these particles on the wear processes in the interfaces of hydraulic equipment is established. To ensure the purity of working fluids in the design of hydraulic systems of reclamation machines, it is proposed to use centrifugal cleaners, the method of calculating the design and technological parameters of which is also given in the text of the scientific article.

Keywords: working fluid, physico-chemical pollution, reclamation machines, hydraulic system, reliability, centrifugal cleaning.

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INTRODUCTION

The main factor of agricultural production intensification in the conditions of irrigated agriculture in the Central Asian region, which includes Tajikistan, is given to land reclamation [1]. The area of irrigated land in the Republic reaches 35% of the total area of land suitable for cultivation. To perform such volumes of work, reclamation enterprises have a large number of reclamation machines for various purposes. However, due to the increase in prices for new equipment, energy resources, fuel and lubricants, the lack of spare parts and consumables, the imperfection of the technology of maintenance and repair of pumping stations and complexes, an increasing number of hectares of irrigated lands are being withdrawn from circulation.

One of the ways to solve this problem is the use of reclamation machines of increased power, which in turn leads to an increase in the flow of the working fluid and the pressure of hydraulic systems, and, accordingly, the requirements for the quality of the working fluids. The main characteristic of the working fluid, which has an impact on the reliability of hydraulic units, is the purity of the working fluid.

MATERIALS AND METHODS

Operation of hydraulic systems of agricultural machinery inevitably occurs in conditions of high dust content of the surrounding air. Solid particles of pollution, getting into the gaps of precision joints, cause wear of mating parts, as well as due to the appearance of increased frictional forces jam parts of distribution and control equipment [2,3].

As a result of wear caused by the presence of abrasive impurities in the working fluid of the hydraulic system, the details of the hydraulic units change their original sizes and shapes and also violated their regulation. Wear of mating surfaces can disrupt the mutual arrangement of parts (dimensional chain), as well as landing in the joints, which leads to a change in the modes of operation of hydraulic units, additional losses and a decrease in their feed rates [4,5].

The greatest pollution occurs during operation. Moreover, the level of pollution for different types and designs of hydraulic systems is different. Data on the average annual contamination of working fluids are given in table [6].

The different level of pollution can be explained by different operating conditions, different technical condition of the units, different sensitivity to contamination of the hydraulic system caused by its design features, conditions of maintenance, storage of equipment, its repair.

Table – Level of contamination of working fluids

Hydrosystem	Machine make	Total pollution concentration, %	Dispersed composition, %		
			up to 10 µm	up to 25 µm	up to 40 µm
Remote-cylinder hydraulic system	T-74 MTZ-50	0,15…0,08	72…80	15…20	3…5
Steering hydraulic system	T-150	0,15…0,143	90	6	4
Transmission hydraulic system	T-150	0,03…0,14	90	6	4
Separate-aggregate hydraulic system together with the hydraulic system of mineral fertilizer spreader	MTZ-50 + 1MSH-5	0,2…0,18	70	25	5

Thus, the main type of wear parts of hydraulic units is abrasive wear. This wear exposed body, bushings and axles are gear pumps, precision parts of switchgear, seals, valve cylinders, etc. It is caused by impurities contained in the working fluid, aggregates, etc. Impurities differ in their physico-chemical properties. The main physical characteristics of impurities can be considered the hardness and size of the particles, which are based on quartz, feldspar and metal oxides [6,7].

Currently, the practice has many progressive ways to reduce the pollution of hydraulic systems, the problem as a whole is not finally solved and additional research in this direction are of great scientific and practical importance, and the problem of improving the purity of hydraulic fluids reclamation machines is an urgent task.

RESEARCH RESULTS

The study and analysis of the works of many authors shows that one of the main disadvantages of hydraulic machines is its lack of reliability and durability. Structural, technological and operational factors influence the reliability of hydraulic system elements.

Analysis of the data of hydraulic drives operational tests shows that design, production and operational factors cause, respectively, – 27%, 26% and 47% of failures [8]. Moreover, as the design of hydraulic units is refined, conditions, technology and production organization are improved, the share of failures caused by operational factors increases.

The study of the processes of wear, failure and disruption of hydraulic systems show that the predominant effect on them has abrasive wear. The wear rate of parts of hydraulic units is related to the size, hardness, concentration of pollutant particles and operating pressure. With an increase in fluid contamination by 3...4 times compared to the standard value, the wear value increases by 1.5...2 times, and with an increase in operating pressure by 40% compared to the nominal value – by 1.2 times [7].

Reliable operation of hydraulic systems of agricultural machines depends on the quality of the working fluid. The parameters of the hydraulic system, significantly affecting the change in the physical and chemical properties of the working fluid include: the degree of aeration and ventilation of the tank, temperature and power mode of operation of the hydraulic system.

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Aeration and ventilation of the tank are associated with: increase in the flow and diffusion of air into the working fluid. This increases its solubility in the working fluid and, consequently, accelerates the oxidation of the liquid, and clogging it with dust particles in the air. Thus, when plowing for a seven-hour working day in the hydraulic tank of the tractor class 1,4...3,0 can receive from 0,1 to 2,4 g/m^3 of air containing from 0,2 to 3,4 g/m^3 of dust [2-5].

Studies [9] found that when performing agricultural work on tractors with mounted, semi-mounted and trailed hydraulic machines through the Sapun in the hydraulic tank comes to 0.3...0.35 m^3/h of air in 1 m^3 which contains from 0.16 to160 g of dust (depending on operating conditions).

These indicators are applicable to other hydraulic machines. So, for example, the tractor T-150K having an operating time in 600 motor hours, contains 5,526 g of dust in a hydraulic tank [10]. In real operating conditions, the quantitative value of pollution can be higher.

During different agricultural activities a level of saturation of the air with dust around the machine is high. During performing works related to plowing, it is 0.05 ... 1.1 g/m^3; when sowing – 0.2...2.5 g/m^3; cultivation – 0.9...2.2 g/m^3; during transportation – up to 2.1 g/m^3; when planning land – up to 3.15 g/m^3 [9,10]. The main part is silicon oxide up to 63% - one of the most aggressive abrasive components, with a hardness of 2...3 times higher than the hardness of some steels [7].

It was found [10] that the average concentration of pollution is 0.071% (by weight). The concentration of contamination of the working fluid from 0.06 to 0.08% has 31% of hydraulic systems, from 0.05 to 0.09 – 57.6% and from 0.04 to 0.1 – 78%.

The study and analysis of the scientific works of leading scientists who have studied the contamination of working fluids in operation, shows that almost the main drawback of hydraulic machines is their low reliability and durability. The reliability of hydraulic elements is affected by the influence of structural, technological and operational factors.

Factors caused by operating conditions, to a greater extent affect the technical resource of hydraulic units than design imperfection or technological errors. One of the main reasons for disrupting the normal operation of the hydraulic system is the contamination of the working fluid with metal particles, which serves as a catalyst for the wear process for rubbing interfaces of hydraulic units.

The study of wear processes, failures and malfunctions of hydraulic systems show that the predominant influence on them has abrasive wear. The wear rate of hydraulic components is related to the size, hardness, particle concentration and operating pressure. With an increase in fluid contamination by 3...4 times compared to the permissible value, wear increases by an average of 1.5...2 times, and with an increase in the operating pressure by 40% compared to the nominal, increases by 1.2 times [11].

Studies have shown that the dust content of the air is significantly affected by natural and climatic conditions, as well as environmental factors (soil and soil conditions, the presence of plants, etc.). Wind speed and direction have the greatest influence. With a change in wind speed from 1 to 8 m/s, the level of air dust will be: when planning a bulldozer 140...570 mg/m^3; when working a scraper 90...800 mg/m^3; when field work with a tractor 20...190 mg/m^3 [10].

After 600 hours of operation of the hydraulic system in its working fluid was 0.085 ... 0.125% of the volume of pollution for various transport and technological machines [7].

Thus, the analysis of working fluid samples and inspection of the technical condition of hydraulic systems during operation shows that many defects of hydraulic units are associated with contamination of the working fluid. Analysis of the existing works also showed that, although currently the most common cleaning of the working fluid is carried out by various filters, the highest quality cleaning is provided by centrifugal force cleaners. However, the successful operation of this method of cleaning depends largely on the correct choice of individual parameters of the centrifugal force cleaner.

The main parameters of centrifugal cleaners are:

1. Geometric – the length and diameter of the rotor, the diameter of the impeller, the diameter of the holes for the direction of the jet, the distance from the axis of the rotor to the nozzle, the number of nozzles;
2. Kinematic-flow and angular velocity;
3. Energy – power, torque;
4. Hydraulic-viscosity, pressure;
5. Efficiency – the subtlety and the cleaning rate, time.

Depending on the type of energy used, the parameters of centrifugal cleaners will also change. The flow rate of the working fluid in the recommended centrifugal cleaners for use on reclamation machines is in the range (0,333...5,06)×10^{-3} m^3/s.it is also found that at Q = (0,333...2,5)×10^{-3} m^3/s it is advisable to use nozzle centrifugal cleaners, and at Q > 2,5×10^{-3} m^3/s – hopeless centrifugal cleaners [12]. Research of parameters of nozzle centrifugal cleaners dedicated a number of works, while the parameters nozzleless centrifugal cleaners has not been studied. Based on this, further theoretical and research was aimed at determining the parameters of the nozzleless centrifugal cleaners and the choice of a parametric range of cleaners for hydraulic systems maintenance of reclamation machines.

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All ways to improve the main indicators of the centrifugal cleaner are reduced to increasing the angular velocity of the rotor. To determine the dependence of the angular velocity of the rotor on the main parameters of the centrifugal purifier, the expression [13-15]:

$$\omega = \sqrt{\frac{p-\mu\cdot\frac{\pi\cdot d_c^2}{2}\cdot p_1\cdot(1-\psi)\cdot[z_c\cdot\varphi_o\cdot(1-\cos\alpha_2+\mu_o]}{\mu\cdot\rho_l\cdot\frac{\pi\cdot d_c^2}{4}\cdot(r_2^2-r_1^2)\cdot[z_c\cdot\varphi_o\cdot(1-\cos\alpha_2+\mu_o]}}, \tag{1}$$

where p – the force acting on the rotor, N;

$\mu=\mu_o$ – the discharge coefficient of the hole;

p_1 – liquid pressure at the inlet of the guide apparatus, N/m^2;

ψ – coefficient of hydraulic losses in the area from the liquid inlet to the guide device to the partition opening;

ϕ_o – factor of the jet flow;

α_2 – the angle of supply of liquid;

ρ_l – the density of fluid, kg/m^3;

d_c – diameter of hole, m;

r_1 – distance from the axis of rotation to the inner surface of the partition, m;

r_2 – similar distance from the outer surface of the partition, m.

It follows from the expression (1) that the angular velocity of the rotor can be increased by the correct choice of d_c, p_1, z_c, p, α_2.

The angular velocity at which dirt particles are retained on the rotor walls is determined by a well-known formula with the introduction of the hydraulic efficiency (η) of the centrifugal cleaner [2, 14, 15]:

$$\omega_o = \sqrt{\frac{108\cdot\mu_ж\cdot Q\cdot\eta\cdot(\alpha\cdot f+1)\cdot\left[1-\frac{d}{2\cdot(R_2+R_1)}\right]}{\pi\cdot d\cdot f\cdot(\rho_r-\rho_ж)\cdot R_2\cdot(R_2^2-R_1^2)\cdot(R_2-R_1)}}, \tag{2}$$

where μ_l – is the dynamic viscosity of the liquid, m^2/s;

Q – flow rate, m^3/s;

α – coefficient of proportionality;

f – coefficient of friction;

d – particle diameter, m;

R_1 and R_2 – inner and outer radius of the liquid layer, m;

ρ_r – particle density, kg/m^3.

Calculations according to the formula (1) show that the angular velocity of the rotor is 415...710 s^{-1}.

To ensure the retention of dirt particles on the walls of the rotor according to the formula (2) for steel and quartz particles, we find ω_o = 700 s^{-1}.

CONCLUSION

Thus, the analysis of working fluids samples and inspection of the technical condition of hydraulic systems in operating conditions suggest that most of the defects of hydraulic units arise as a result of their pollution. As a result of the literature search, it was found that, despite the fact that the most often used for cleaning the working fluid filtration, this process does not always provide a sufficiently fine cleaning, the existing filter designs are not always reliable and durable in operating conditions and therefore ineffective. In this regard, there is a need to develop new and upgrade existing designs of cleaners, which could have a greater dirt holding capacity and the ability to work without disassembly before the planned replacement of the liquid, as well as to carry out a higher fineness and accuracy of cleaning the working fluid under different production conditions.

In addition, the calculations have shown the prospects of using the power of centrifugal cleaners to clean the working fluid of the hydraulic reclamation machines.

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