ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

The Influence Of The Oxidative Polymerization Processes On The Energy Consumption Due To Friction In The Resource Defining Hydraulic Couplings Hydraulic Drive Mate.

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ABSTRACT

The article describes the developed method of quantitative assessment of the influence of temperature and other factors on the processes of oxidation and oxidative polymerization, which are the main factor of oil aging. The selection and deposition of organic acids and asphaltic substances clogging the oil lines and channels and increases the wear of friction parts of machines. This is demonstrated on the samples of friction surfaces in the course of the implemented multifactorial experiment, the analysis of which shows that in the field of the experiment, the wear of the samples of friction surfaces is most dependent on the load on the upper sample and the concentration of abrasive in the oil. Thus, a rational area of operation of the friction unit for the accepted wear conditions is found.
Keywords: temperature, oxidative polymerization, organic acids, asphalt resinous substances, corrosive wear, energy consumption, abrasive, hydraulic drive

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ISSN: 0975-8585

INTRODUCTION

Today hydraulic machines areoperated in various latitudes with a large range of ambient temperature. Experience in the operation of machines shows that their reliability depends on the climate. This becomes especially noticeable if the machine as a whole or its individual elements operate in a climate for which they are not designed.

Investigation of the reliability of the hydraulic machinery for various purposes shows that, 70...90% of all failures and malfunctions of hydraulic equipment falls to winter operation [1].

The main factor limiting the durability of the hydraulic system is the wear of parts. In this regard, it is important to search for new effective ways to preserve the potential properties of the structure in operating conditions, where it is important and effective to ensure a rational mode of lubrication of friction surfaces of parts. When characteristic of the hydraulic systems of agricultural machines unsteady load-speed and temperature modes of operation, an important parameter of the rational mode of lubrication is to reduce the rate of oil oxidation and the rate of receipt of abrasive impurities, the accumulation of which is associated with the gas exchange of the hydraulic cavity due to changes in its temperature regime.

MATERIALS AND METHODS

One of the methods of increasing the wear resistance of hydraulic units is to improve their lubrication mode by applying rational temperatures of hydraulic oils in service. This is due to the fact that modern agricultural tractors do not have effective means of heating and maintaining the temperature of the hydraulic oil within rational limits, which affects the overall performance of the hydraulic system, and the known design of thermal control systems in operating conditions do not fully take into account the peculiarities of the heat exchange process between the working fluid of the tractor hydraulic system and the environment. Due to the insufficiently studied effect of oil temperature on the process of changing the performance of the hydraulic system, the introduction of thermal control methods in real technologies and processes is of considerable theoretical and practical interest [2,3].

EXPERIMENTAL PART

As a result of laboratory wear tests and processing of experimental data on the computer, the dependence of the friction torque (M) on the oil temperature (T) is obtained (Fig. 1).

Analyzing the obtained dependence it is seen that with the growth of the oil temperature the value (M) changes along the parabolic curve, reaching the minimum at T = 40...50°C.This is probably due to the fact, that at an oil temperature of less than 40°C its supply to the friction surfaces is difficult, and at a temperature above 50°C they have areas with boundary friction. Thus, there is a temperature range at which the friction torque is the smallest. Consequently, the reduction of energy consumption can be achieved by adjusting the viscosity of the oil, and this is possible by changing its temperature regimes.

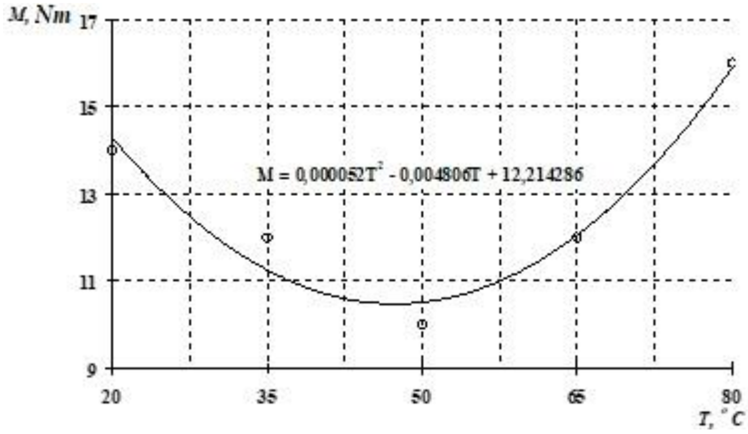

Figure1: Dependence of the friction torque on the oil temperature M-10G2.

ISSN: 0975-8585

As a result of the implementation of a multifactorial experiment to study the influence of operational factors (load-speed, temperature modes of the friction unit and contamination of lubricating oil with abrasive impurities) on the value of wear of friction samples, the values of the optimization parameter are obtained.

As a result of mathematical processing of the computer experiment results, the regression equation (second-degree polynomial) is obtained in coded form [4,5]

$$\widehat{y} = 0{,}29 \cdot X_1^2 + 0{,}12 \cdot X_3^2 - 0{,}04 \cdot X_1 + 0{,}21 \cdot X_2 + 0{,}2 \cdot X_3 + 1{,}07 \text{ , (1)}$$

Equation (1), reduced to the natural values of the factors has the form:

$$i = 0{,}33 \cdot 10^{-3} T^2 + 0{,}47 P^2 - 0{,}03T + 1{,}93C - 0{,}97P + 2{,}02 \text{ , (2)}$$

where ŷ (i) is the optimization parameter (wear of friction samples);

X_1 (T) – load on the upper sample, setting the contact pressure, kN;
X_3 (P) – bath oil temperature, °C;
X_2 (C) - concentration of abrasive impurities in the oil, % by weight.

Checking equation (1) by Fisher's criterion confirmed the hypothesis of its adequacy at the level of statistical significance α = 0.05.

Using equation (1) and fixing simultaneously two factors out of three at the main level, the dependences on the influence of each factor separately on the wear value of the samples are obtained (Fig. 2-4).

Analysis of the dependence shown in Fig. 2, shows that as the load in contact decreases, the wear of the samples decreases. The dependence is nonlinear. However, in production conditions, it is not possible to control the intensity of wear by changing the load in the coupling of the pump housing-gear.

The dependence of the friction wear of the samples to the oil temperature (Fig. 4) has an optimum corresponding to a certain temperature. In our opinion, the decrease in the wear value with an increase in the oil temperature from 40 to 60°C is due to the better flow of low-viscosity oil into the friction zone, a better heat sink and a more intensive removal of wear products from the friction surfaces. With an increase in temperature above 60°C, the wear of friction samples increases, which may be due to a violation of the hydrodynamic lubrication regime and a significant decrease in the thickness of the lubricant layer separating the friction surface and its strength.

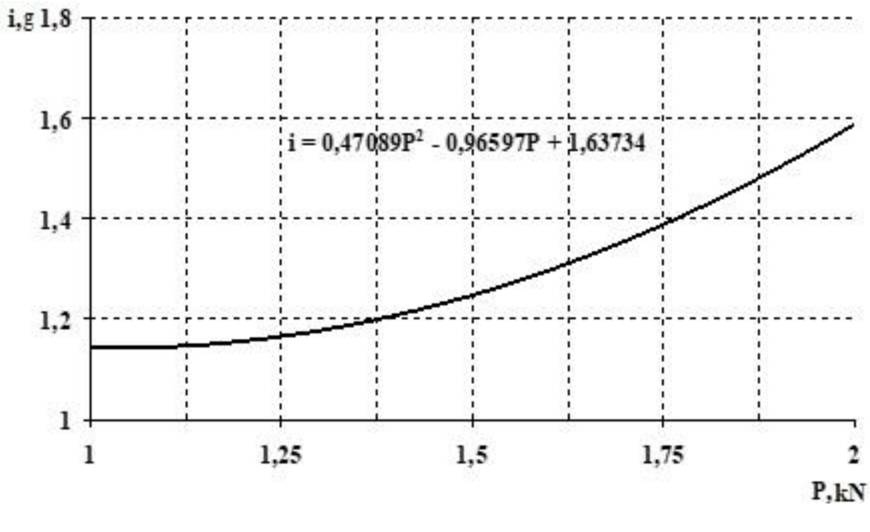

Figure 2: The dependence of the wear of friction samples (i) on the load (P), at T = 50°C, C = 0.25 % by weight

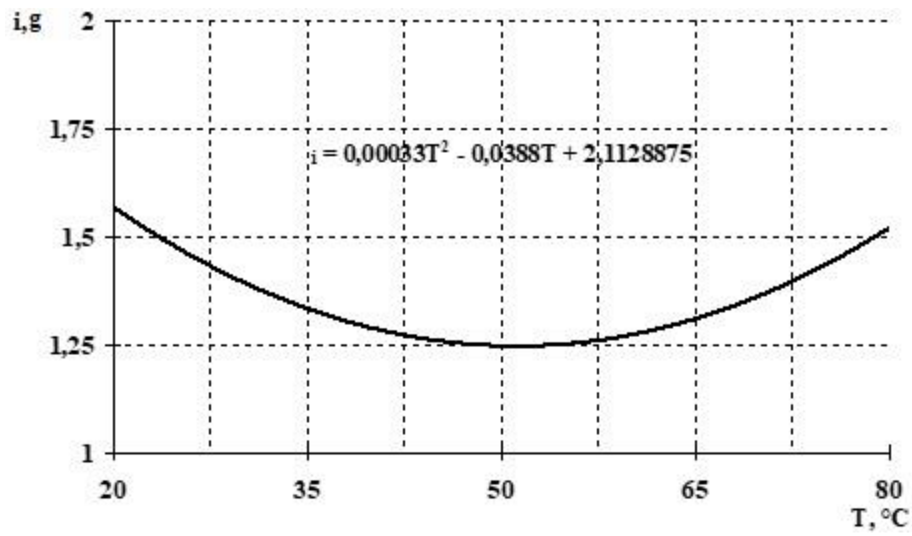

Figure 3: Dependence of wear of friction samples (i) on oil temperature (T), at p = 1.5 kN, C = 0.25 % by weight

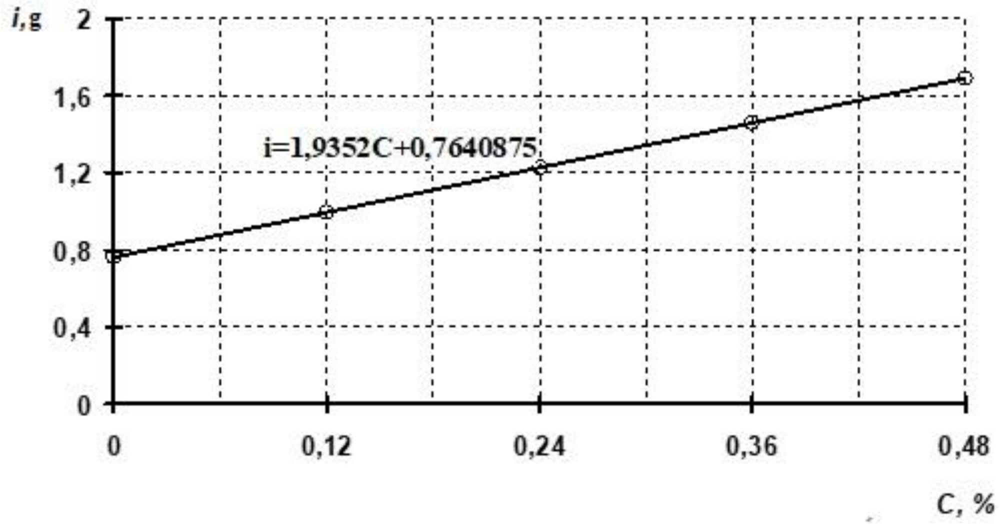

Figure 4: Dependence of wear of friction samples (i) on the concentration of abrasive impurities in oil (C), at p = 1.5 kN, tv = 50°C

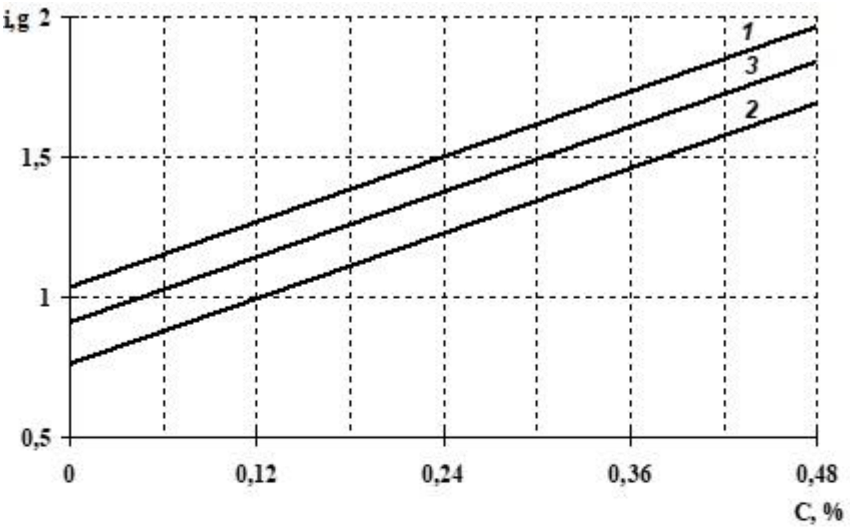

Figure 5: The dependence of the friction wear of the samples (i) the concentration of abrasive contaminants in the oil (C), (P = 1.5 kN), when the oil temperature (T): 1 – 30 operating system; 2 – 50°C; 3 – 80°C

An increase in the concentration of abrasive impurities in the oil leads to an increase in the wear of friction samples by linear dependence (Fig. 4).

Therefore, in order to reduce the wear of moving mates, it is necessary to take measures to prevent the entry of abrasive particles into the hydraulic oil under operating conditions, but it is impossible to completely exclude their entry [6,7].

It is also established that with a decrease in the concentration of abrasive impurities in the oil, the effect of oil temperature on abrasive wear increases (Fig. 5). This once again confirms the significant effect of oil temperature on the wear of friction samples.

Thus, of the three factors considered, only the hydraulic oil temperature is the most controllable.

To construct a two-dimensional cross-section in a three-factor experiment, one of the factors should be fixed at a certain level of interest to us and its value should be substituted in the equation of the response surface (2)

$$i = 0{,}33 \cdot 10^{-3} T^2 + 0{,}47 P^2 - 0{,}03T + 1{,}93C - 0{,}97P + 2{,}02$$

Convert it to the form $ax^2+bx+c=0$ and find the coefficients a, b, C. Then solve the resulting square equation. Having solved this equation, find the left and right boundaries of the measurement of the factor-argument. Giving the argument a number of values within these boundaries and calculating according to the obtained square equation the corresponding values of the function to build the graph in the form of a series of curves of equal output (contours) [6].

According to this technique, we have built the response surface (Fig. 6), characterizing the dependence of the wear value of friction samples on the concentration of abrasive in the oil and oil temperature (as well as: wear on the load and concentration of abrasive impurities; wear on the temperature and load). The appearance of the response surface indicates the presence of an optimum at which the wear of the samples is the smallest. The response surface was analyzed using two-dimensional cross sections (Fig. 7). The center of the ellipses is the minimum of the response function. When you move away from the center in any direction, the value of the optimization parameter increases.

CONCLUSION

As a result, the optimal area of operation of the friction unit for the accepted wear conditions, which corresponds to a load of 0.8, is found...Of 1.3 kN, the oil temperature is 40...63°C and the concentration of abrasive impurities in the oil – 0.03% by weight.

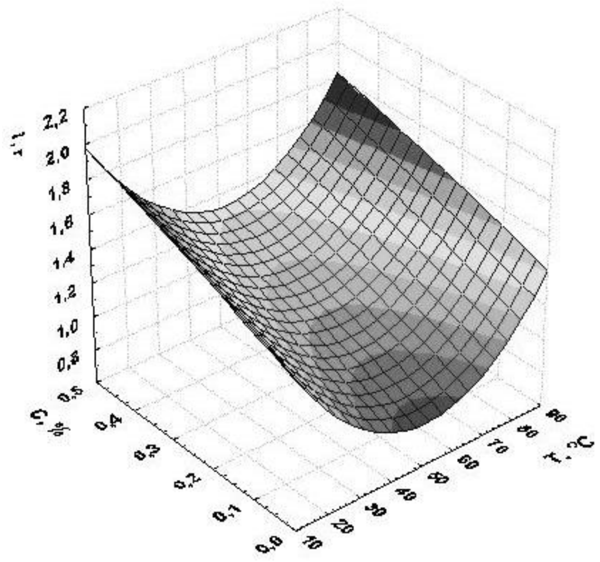

Figure 6:Response Surface, which characterizes the dependence of the wear value of friction samples on the concentration of abrasive in the oil and its temperature, under load on the upper friction sampleP = 1.5 kN

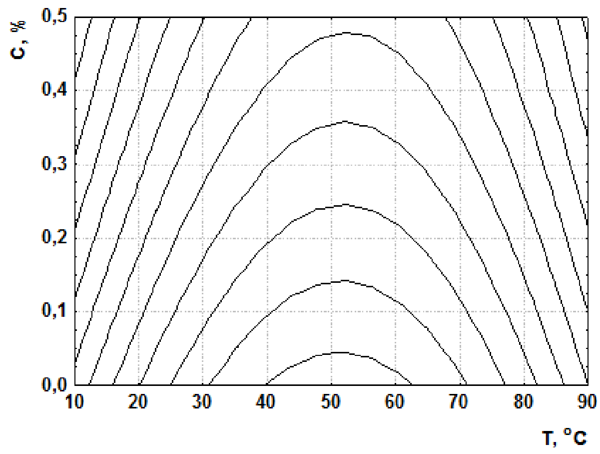

Figure 7: Two-Dimensional cross-section of the response surface, which characterizes the dependence of the wear value of friction samples on the concentration of abrasive in the oil and its temperature, with a load on the upper friction sample P = 1.5 kN

Thus, on the basis of search of optimum operation conditions of a friction component, it can be assumed that reducing the amount of wear and tear resource defining hydraulic couplings mate gear pumps (building-tooth gear, bushing-gear axle) of the tractor's hydraulic system, it is advisable to maintain the temperature of the working fluid in operating conditions in the range 40...63°C.

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