ANALYSIS OF THE PROPERTIES OF THE HYDRAULIC CYLINDER FLUID WHEN USING SEALING MATERIALS.

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If dirt gets into the hydraulic cylinder, it primarily affects the viscosity of the liquid, which leads to a pressure and temperature drop in the hydraulic cylinder.

Viscosity is a property of a liquid that resists shear or relative displacement of layers [1]. The shear resistance force is called the internal friction force.

The center of the stem axis is located along the Oh axis. Then the resistance force of the liquid in the cylinder will have the form:

$$F = \pm \mu S \frac{du}{dx}, \text{ Pa·s}, \quad (1)$$

where μ – viscosity, Pa·s;
S – cross-sectional area, mm^2;
$\frac{du}{dx}$ – fluid flow velocity, mm/s.

The fluid pressure in the hydraulic cylinder is expressed by the formula

$$p = \frac{F}{S} \text{ (or } F = pS\text{), Pa}. \quad (2)$$

From formulas (1) and (2) we get:

$$pS = \pm \mu S \frac{du}{dx}.$$

Shortening by S we have:

$$p = \pm \mu \frac{du}{dx}, \text{ Pa}. \quad (3)$$

From equality (3) we determine the viscosity of the liquid:

$$\mu = \frac{p}{\frac{du}{dx}}, \text{ Pa·s}. \quad (4)$$

Fluid fluidity is the inverse property of viscosity. Denoting it by σ_T , we get:

$$\sigma_T = \frac{1}{\mu} = \frac{\frac{du}{dx}}{p}, \frac{1}{\text{Pa·s}}. \quad (5)$$

If from equation (3) we express the velocity of fluid movement along the hydraulic cylinder, then it has the following form:

$$\frac{du}{dx} = \frac{p}{\mu}. \qquad (6)$$

This means that the fluid velocity is constant.

Equation (6) is a first-order differential equation with separable variables.

Solving equation (6), we obtain

$$u = \frac{p}{\mu}x + C, \qquad (7)$$

where C is an integral constant.

The integral constant C can be found using the initial conditions $u = u_0$ by $x = 0$ (here $0 \leq x \leq l$, l – stem length). Substituting these expressions into the equation (7), we find C:

$$u_0 = 0 + C, \text{ where from } C = u_0 .$$

$$\text{Then } u = \frac{p}{\mu}x + u_0. \qquad (8)$$

It follows from this that the velocity function is a linear function. In this case, we conclude that the plot (trajectory) of the velocity function is a straight line.

Since the velocity of the fluid is constant, the acceleration will be zero, i.e. $\frac{d^2u}{dx^2} = \left(\frac{p}{\mu}\right)' = 0.$

Now that the expression for determining the viscosity (4) has been obtained, then using data on the pressure and velocity of the liquid, it is possible to calculate its value when the liquid meets the technical requirements. Using the obtained experimental data for pressure $p = 38$ MPa, $l_{max} = 2120$ mm (stem length), calculate the viscosity value μ.

Taking into account the time of movement of the rod along the hydraulic cylinder (forward or backward), we get the velocity of the fluid:

$$\frac{du}{dx} = \frac{l}{t} = \frac{2120 \text{ mm}}{4 \text{ s}} = \frac{2{,}12 \text{ м}}{4 \text{ s}} = 0{,}53 \text{ m/s}.$$

Then

$$\mu = \frac{p}{\frac{du}{dx}} = \frac{38 \text{ MPa}}{0{,}53 \text{ m/s}} = 7{,}17 \text{ MPa} * \text{s/m}. \qquad (9)$$

Considering the above and using experimental data, it is possible to calculate the viscosity, fluidity and pressure of the liquid when using a sealing protective ring and without it. As a result, comparing the results obtained in all cases, it is possible to draw final conclusions. [2-15]

It should be noted that in the future, when using the amount of pollutants in calculations $G_{загр}$, note that $G_{загр}$ it consists of total pollutants consisting of silicon $G_{кр}$, sodium $G_{нр}$, potassium $G_{к}$, water $G_{в}$ and other types of pollutants that appear depending on weather conditions, geographical location of the deposit, climatic conditions, etc. We denote it in the form:

$$G_{загр} = G_{кр} + G_{нр} + G_{к} + G_{в} + \cdots + G_{n}.$$

Reasoning that if dirt gets into the liquid, then it becomes more viscous, we come to the conclusion that the proportionality of viscosity and contamination, and it is linear.

In this case, the mathematical model, based on (3), has the following form:

$$p \cdot G_{загр} = p\left(G_{кр} + G_{нр} + G_{к} + G_{в} + \cdots + G_{n}\right) = \mu \frac{du}{dx}. \qquad (10)$$

From here we determine the pressure of the liquid taking into account pollutants:

$$p = \frac{\mu \cdot \frac{du}{dx}}{G_{загр}} = \frac{\mu \cdot \frac{du}{dx}}{(G_{кр}+G_{нр}+G_{к}+G_{в}+\cdots+G_{n})}, \text{ Pa}. \qquad (11)$$

Taking into account the expression (3.25), we obtain the formula for determining the viscosity:

$$\mu = \frac{p \cdot G_{загр}}{\frac{du}{dx}} = \frac{p\left(G_{кр}+G_{нр}+G_{к}+G_{в}+\cdots+G_{n}\right)}{\frac{du}{dx}}, \text{ Pa·s}. \qquad (12)$$

Considering that $\mu = 7{,}17\ \text{MPa} * \text{s/m}$, $G_{загр} = 68{,}71\ \text{mg/kg}$ – total amount of pollutants without the use of a protective ring, $G_{загр} = 30{,}2\ \text{mg/kg}$– when using a protective ring and u=0.53 m/s fluid velocity can be determined by the pressure, viscosity and fluidity of the fluid.

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ISSN: 2835-3196 **Website:** econferenceseries.com

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