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Analysis Of the Effect of The Physical Properties of Liquids on External Forces (Factors)

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Abstract: When a fluid flows, the coercive stress is created by internal friction forces. This property of a liquid depends on its type and temperature. The viscosity of a fluid decreases with increasing temperature in the rubbing surfaces.

With a variable flow of liquid, a cavitation process can occur. The consequence of cavitation is the eurorosion of the material of the inner surface of the tubes, the sound phenomenon and the vibration of the installation. All this leads to reduced pressure, power and efficiency of the feed of the working machine. But cavitation is not always negative; it is used in a cavitation regulator.

Therefore, when calculating, it is necessary to take into account the physical state and physical properties of the liquid. Of great importance is the observance of the temperature regime, especially at the junction of the working parts of the machines. when calculating the characteristics of cavitation, it is necessary to study the essence of cavitation in relation to the system under consideration.

Key words: volumetric, state of aggregation of liquid, cohesion, interstitial space, pressure, temperature, compression, viscosity, friction force, stress, steam and gas bubbles (caverns), sound phenomenon, vibration, contraction (expansion), cavitation regulator

A liquid is a bulk informal compound consisting of gas and droplets. It includes water, gasoline, kerosene and other liquids.

According to the state of aggregation, liquids differ from solids by the interaction of atomic molecules. In solids, atoms are located very close to each other and at a close distance from each other.

Molecules in a liquid must move and be in chaotic motion. Therefore, forces acting on a fluid are less likely to change its shape. In other words, the liquid itself assumes the full shape of the vessel in which it is placed. (In gaseous bodies, molecules do not have cohesion, i.e., interstitial space).

The physical state of a liquid is characterized by density (ρ), relative volume (v), relative weight (γ), compressive strength (χ) and viscosity (μ). As the pressure on the liquid increases, the density increases. If we increase the temperature at constant pressure, the density decreases. Then its size would be inversely proportional to density. Its compression is a change in density and a decrease in volume under the action of external pressure, but in practice this value is not taken into account due to the smallness of the values (Δ).

When a fluid flows, coercive stress is created by internal friction forces. The ability of a fluid to withstand stress is referred to as its viscosity. This property of a liquid depends on its type and temperature. Viscosity decreases with increasing temperature. For example, the high pressure of diesel oils increases its viscosity, while the change in the viscosity of water is almost negligible.

Therefore, the actual use of the liquid must take into account its physical state and physical properties.

Consider the movement of lubricating oil on flat plate surfaces that work side by side. The distance between the surfaces of two plates (Δ) on which the liquid is located, one of the plates rotates with a certain frequency (v) compared to the other. In this case, the interlayer adhesion force acts on the liquid layer between the plates, causing the liquid layer to stick to the surface of the plate. During this time, the fluid velocity changes from 0 (from the side of the fixed plate) to v0 (from the side of the movable plate). The moving plate (v0) must be subjected to the force of internal static friction (P).

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The magnitude of this force that hits the field is directly proportional to. v_0, that is

$$P/F = \mu v_0/\Delta$$

Taking into account the coefficient of proportionality

$$P/F = \mu v_0/\Delta$$

Here the ratio P / F gives the shear stress P / A , then

$$\tau = \mu v_0/\Delta$$

If the frequency changes from 0 to v_0, i.e. it is linear $v(y) = v_0/\Delta$.
Then, by means of abyssal differentiation, we obtain Newton's law for fluid friction of the type

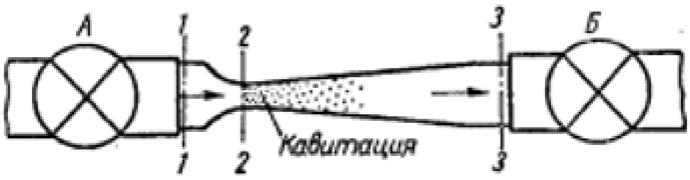
$$\tau = \mu\,(dv/dy)$$

In practice, the state of most of the fluids used obey this law.

Thus, the fluid flow between the rubbing machine parts can be calculated in accordance with the above rules. In this case, it is necessary to take into account the physical state and physical properties of the liquid. It is especially important to observe the temperature regime.

Associated with a change in the state of aggregation of the liquid during movements in pipelines, phenomena called cavitation occur.

Cavitation is a local discontinuity in the flow with the formation of steam and gas bubbles (caverns) due to a drop in flow pressure. Such a phenomenon can be demonstrated in a simple conventional scheme 1.



Scheme 1. The well-known scheme of the tube for demonstrations of cavitation

It is known that, at low values of fluid velocity (flow rate), the pressure drop in sections 2-2 is constant with increasing pressure in sections 1-1. But the dimensions of the cavitation zone increase as the valve is opened further, i.e. cavitation process can occur in a changeable liquid flow. The consequences of cavitation are as follows:

1.Erosion of the material of the inner surface of the tubes.
2. Sound phenomenon and vibration of the machine.
3. All results in reduced head, power and feed efficiency (or working machine)

Then, cavitation in normal cases is an undesirable phenomenon and should not be allowed in pipelines and other elements of the hydraulic system. It can occur in all local hydraulic resistances, where the flow undergoes local narrowing (expansion), also in pipes of constant cross section with an increase in geometric height.

The initial stage of cavitation in local resistance, called critical cavitation (χ_{cr}), is determined mainly by the local resistance formula. Simple cases (scheme.1) can be determined by the Bernoulli equation for the cross section 1-1 and 2-2 assuming that $\alpha_1 = \alpha_2 = 1$ $\xi = 0$ (energy loss)

$$\mathbf{P_1/\rho + \vartheta_1^2/2 = P_2/\rho + \vartheta_1^2/2;}$$

where P_1, ϑ_1 are the absolute pressure and flow velocity in the tube in front of the local resistance from here

$$\mathbf{P_1 = [(P_2/\rho + \vartheta_2^2/2) - \vartheta_1^2/2] x\, \rho;}$$

Substituting it into the formula, the cavitation number [2, p.67]

$$\chi = \frac{2(\boldsymbol{P_2} - P_{\text{пм}})}{\rho * \vartheta_1^2} + \frac{\vartheta_2^2 - \vartheta_2^2}{\vartheta_1^2}$$

because cavitation occurs when $P_1 = P_{\text{н.п}}$ then

$$\chi_{\text{кр}} = \frac{\vartheta_2^2}{\vartheta_1^2} - 1 = \frac{s_1^2}{s_1^2} - 1$$

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where s_1 and s_2 are the area of sections 1-1 and 2-2 in practice, the cavitation characteristics of local hydraulic resistances are obtained at a constant flow rate with decreasing pressure. then they are presented in a dimensionless form $\xi = f(\chi)$ at $\chi < \chi_{кr}$ the loss factor (ξ) does not depend on the cavitation number (χ), and at $\chi = \chi_{кr}$ it increases sharply.

In this case, for resistances 1 and 2 at $\xi_1 > \xi_2$ and $\chi_{kr1} > \chi_{kr2}$ are valid only for a certain value of the number R_e. Usually strive to prevent cavitation. their significance in production conditions can be determined by passive experiments [1].

But cavitation is not always negative, for example, it is used in a cavitation regulator, the principle of which is shown in diagram 1, the pressure in section 1-1 when $P_1 = P_{in}$ is constant, and the pressure in section 3-3 ($P_3 = P_{in}$) is gradually reduced by increasing the degree tap opening. As a result, the flow through the tube increases and the pressure P_2 in section 2-2 decreases, so it will continue until the pressure $P_{2\ abc}$ becomes equal to the value $P_{н.п}$ at which cavitation occurs in section 2-2 with a further increase in the degree of opening of the valve In the cavitation area in the narrow place of the tube will increase, and the pressure $P_{2abc} = P_{н.п}$, the flow rate will remain practically constant, despite the pressure drop P_3

Thus, to double stabilize the fluid flow through the regulator under conditions when the backpressure P_3 changes from critical $P_{3кr}$, corresponding to the beginning of cavitation, to zero.

The test results [2] of such a cavitation flow controller show that the accuracy of flow stabilization is very high (Fig. 2).

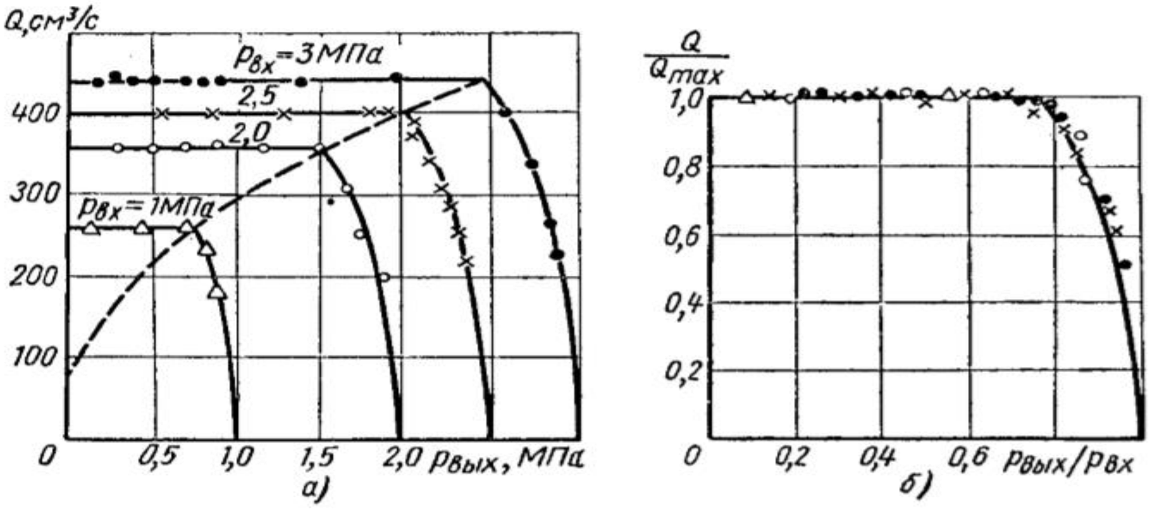

Fig.2. The dependence of the liquid flow through the cavitation tube from inlet and outlet pressures

here $P_{out}/P_{in} = P_3/P_1$ as well as χ can be considered as a criterion of cavitation. In some cases, the P_{out}/P_{in} criterion is more convenient than χ.

Thus, when calculating the characteristics of cavitation, it is necessary to study the essence of cavitation in relation to the system under consideration.

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