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DIFFERENTIAL EQUATIONS OF MOVEMENT OF A LIQUID IN PNEUMATIC HYDRAULIC PATHS PUMP HOUSE-AIR-LIFT INSTALLATIONS DURING START-UP

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Mesherskiy has established that if the weight of a point changes during movement the basic differential equation of movement of Newton is replaced with the following equation of movement of a point of variable weight:

$$m\frac{d\bar{v}}{dt} = \bar{F} + \bar{R},$$

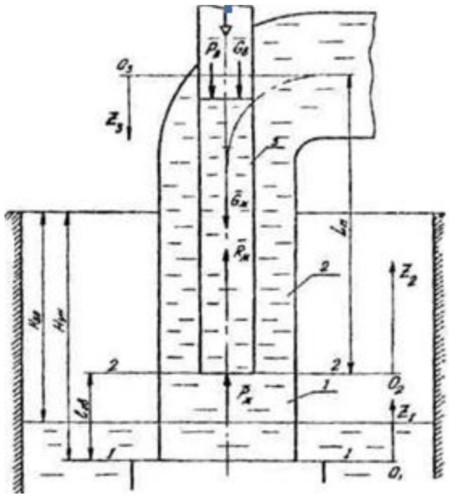
Where $\bar{F}$ and $\bar{R} = \frac{dm}{dt}\bar{U}_{\Gamma}$ — the set and jet forces.

Let's consider transients in pneumatic hydraulic paths pump house-air-lift installations which circuit is resulted in figure where the 1-delivery pipeline of the pump and the having pipeline air-lift ; 2-elevating pipe; a 3- air pipe.

Transients during start-up are considered in the assumption, that the pump already works and submission of compressed air in an air pipe air-lift starts to be carried out. The period of replacement of a liquid from an air pipe by the compressed air down to his break through the amalgamator in an elevating pipe air-lift is investigated. For drawing up of the differential equation of movement of a liquid in an air pipe we use the equation of dynamics of a body of the variable weight, written down in projections to an axis Z_3:

$$m\ddot{Z} = \sum F^{e}_{kz3} + \frac{dm}{dt}\cdot U_{z3},$$

Where m—weight of a liquid in an air pipe, kg; Z_3 — coordinate of a free surface of a liquid in an air pipe; $\sum F^{e}_{kz3}$ — the sum of projections to an axis Z_3 of the external forces working on a liquid moving in an air pipe, H; U_{z3} — a projection to an axis Z_3 of a vector of speed of weight of water moving in an air pipe during its branch, m/s.



The settlement circuit pump -air-lift adjustment

$$\sum F_{kz}^{e} = P_{\text{вз}} + G_{\text{в}} + G_{\text{ж}} - P_{\text{ж}} - R_{\text{ж}},$$

Where $P_{\text{вз}}$ —force of pressure of compressed air, H; $G_{\text{в}}$ —a gravity of volume of air, H; $G_{\text{ж}}$ —a gravity of volume of a liquid, H; $P_{\text{ж}}$ —force, pressure working on weight of a liquid in an air pipe on the part of the bringing pipeline; $R_{\text{ж}}$ —force of resistance to movement of a liquid in an air pipe, H.

$$\ddot{Z}_3 = \frac{1}{N_1 + N_2 Z_3} \cdot \left(\frac{N_3}{\dot{Z}_3} + N_4 \frac{Z_3}{\dot{Z}_3} + N_6 Z_3^2 + N_8 + N_9 P_2\right) + N_5 + N_7 \dot{Z}_3^2,$$

Where $N_1 = \rho \cdot L_n F_{\text{вз}}$, $N_2 = -\rho \cdot F_{\text{вз}}$,

$N_3 = V_0 P_a$, $N_4 = \rho_0 V_0 g$,

$N_5 = g$, $N_6 = -\rho \cdot F_{\text{вз}}$, $N_7 = -\dfrac{\lambda_3}{(2d_{\text{вз}})}$, $N_8 = -P_a F_{\text{вз}}$, $N_9 = -F_{\text{вз}}$.

Thus, in view of the equation of indissolubility of a stream of movement of a liquid in pneumatic hydraulic paths pump house-air-lift to installation it is described by the following system of the nonlinear differential equations of the second order:

$$\begin{cases} D_1 \ddot{Z}_1 + D\dot{Z}_1^2 + D_3 \dot{Z}_1 + D_4 Z_1 = P_2 + D_5, \\ M_1 \ddot{Z}_2 + M_2 \dot{Z}_2^2 = P_2 + M_3 \\ \ddot{Z} = \dfrac{1}{(N_1 + N_2 Z_3)} \cdot \left(\dfrac{N_3}{\dot{Z}_3} + N_4 \dfrac{Z_3}{\dot{Z}_3} + N_6 \dot{Z}_3^2 + N_8 + N_9 P_2\right) + N_5 + N_7 \dot{Z}_3^2, \\ \dot{Z}_1 F_{\text{хв}} + \dot{Z}_3 F_{\text{вз}} = \dot{Z}_2 F_n \end{cases}$$

Where P2- hydrostatic pressure in section 2-2, $F_{\text{хв}}$ - the area of section of the bringing pipeline, $м^2$, *Vo* -productivity of the compressor at atmospheric pressure $P_a = 9{,}8 \cdot 10^4$ Pa, $м^3/с$, ρ_0- density of air under normal conditions, $кг/м^3$. λ_3 - Coefficient of hydraulic resistance at movement of a liquid in an air pipe; $d_{\text{вз}}$ - diameter of an air pire,m.