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Comparative analysis of friction losses in long pipelines with profiled channel flow area

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Abstract. The paper discusses the matter of how friction losses change in long pipelines with profiled channel flow area and describes the method of calculating the reduction of friction losses. The reduction of friction losses in the pipeline components has been analyzed.

The friction calculation is an important component to select the pipe size for pipelining. The friction calculation uses many methods describing all the options for calculating the coefficient of friction, depending on the flow regime, type of fluid and its temperature, as well as on the roughness of the pipe, an equation with variation of its parameters and the introduction of various correction factors [1,9,10].

Heat exchangers are used to stabilize the fluid temperature. This case study used heat exchangers with low rolled fins on the side of high-viscosity oil and screw rolling, which have similar characteristics, and the discrepancy between these indicators was within ±10% [4].

Analysis of how the power consumption changes during the operation of the oil heater is shown in Fig. 1-2 [2]. Fig. 1 shows the analysis of the change in the required electric power N_e, while controlling the temperature conditions of the heat exchanger in the high heat period of operation.

$$\frac{(N_{\text{CḰ}})_i}{(N_{\text{CḰ}})_j}$$

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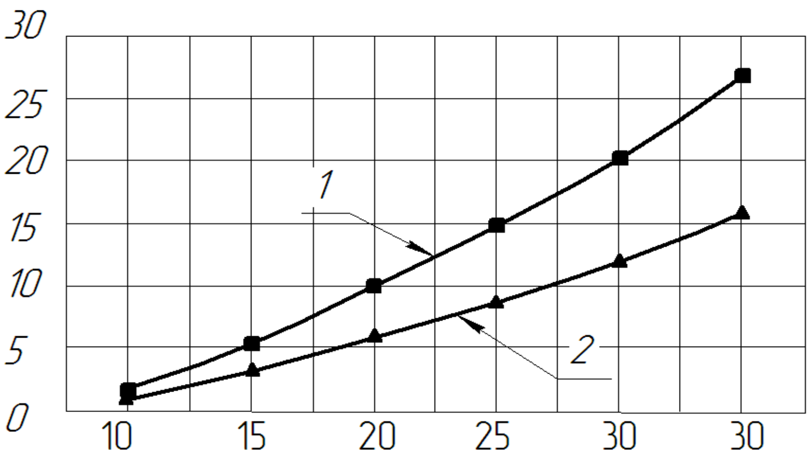

Fig. 1 The dependence of the cost of electrical power for transferring the coolants
1 - screw rolled pipe; 2 - bare pipe

The curve (Fig. 1) has been calculated using the following relationships:

$$N_э = \frac{\Delta P \cdot G}{\rho}; \quad (1)$$

$$\rho_i = \rho_j; \quad (2)$$

$$\frac{(N_э)_i}{(N_э)_j} = \frac{\Delta P_i}{\Delta P_j} \cdot \frac{G_i}{G_j}. \quad (3)$$

Formulas (1) through (3) refer to the following legend: ΔP is the pressure drop in the pipe, G is the water flow, kg/s; ρ is the water density, kg/m^3; i is the index corresponding to the design mode, j is the index corresponding to the base rating

Fig. 2 shows the correlation of the cost of electrical power and the thickness of buildup in bare pipes.

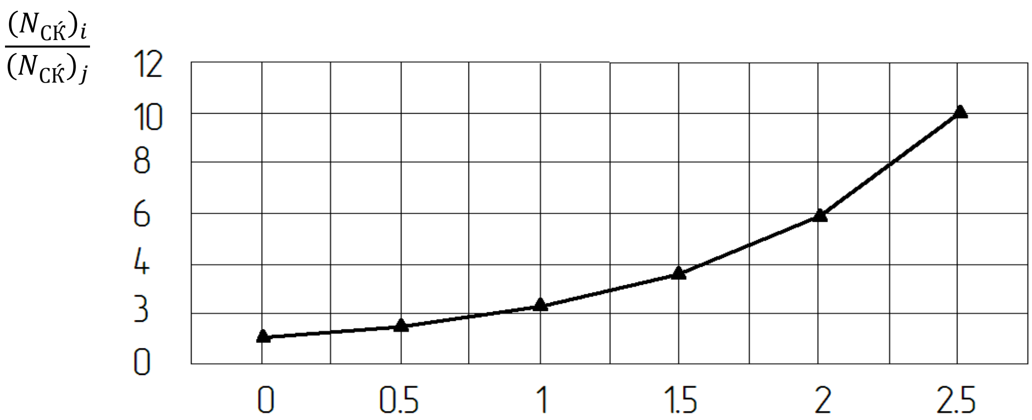

Fig. 2 Cost of electrical power vs. thickness of buildup in bare pipes

The curve (Fig. 2) has been calculated in the approximation of smooth friction using the relations:

$$\frac{(N_э)_i}{(N_э)_j} = \frac{\Delta P_i}{\Delta P_j} = \frac{\lambda_i}{\lambda_j} \cdot \frac{(d_э)_j}{(d_э)_i} \cdot \left(\frac{w_i}{w_j}\right)^2; \quad (4)$$

$$\Delta P = \lambda \frac{L}{d_э} \frac{\rho w^2}{2}; \quad (5)$$

$$\lambda = 0{,}316/\sqrt[4]{Re}; \quad (6)$$

$$G_i = G_j; \quad (7)$$

$$L_i = L_j. \quad (8)$$

Formulas (4) through (8) use the following legend: λ is the channel resistance coefficient; d_e is the equivalent diameter of the channel, m; *L* is the channel length, m; *w* is the flow rate in the channel, m/s; *Re* is the Reynolds number.

As can be seen from Figures 1 and 2, the relative increase in electric power costs when regulating the temperature conditions of an oil heater in the summer time can reach 18 times the values compared to the winter times, and the narrowing of the pipeline flow area will increase the power costs to 6 times the values [8].

Thus, conventional systems of oil heaters are not capable to achieve a significant energy-saving effect even in the case of using intensified heat exchangers, since all the removed thermal energy is then discharged into the atmosphere [3-7].

It is advisable to solve this problem by cutting the power consumption and transition to fundamentally new systems.

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