In this manner, the results of the investigations make it possible to design new elastic elements and to make test calculations of the existing designs of these elements used in vibration dampers of drilling columns. This makes it possible to significantly raise the effectiveness of their use for drilling oil and gas wells.

LITERATURE CITED

INVESTIGATION OF HEAT TRANSFER IN PIPING FITTINGS

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Thermal calculations for piping fittings are carried out on a computer by mathematical methods with assignment of boundary conditions of the third kind, the main parameters of which are the working-medium temperature, its rate of change, and the heat-transfer coefficient. Problems of selection of the rate of change of the working-medium temperature were considered in [1].

Relations recommended for the calculation of heat transfer in straight annular tubes with turbulent flow of the working medium are used in the determination of the heat-transfer coefficient in the flow-through part of fittings [2]. However, in the calculation of the thermal state of the body and a flanged joint, it is necessary to know the heat-transfer coefficient in the throat of the fitting. Together with the Institute of Physicotechnical Problems of Power Engineering of the Academy of Sciences of the Lithuanian SSR, the Central Design Office of Fitting Manufacture carried out a set of studies on the determination of heat transfer in the flow-through part and the throat of a gate valve and a cutoff valve. The investigation was carried out with simplified models of the cutoff valve and gate valve (see Fig. 1) made on a scale of 1:1. The inner surfaces of the models, coated with an insulating material (Textolite), were lined with a 0.2-mm-thick ribbon of Constantan foil serving as a heat-transfer surface. Copper-constantan thermocouples were welded to the foil for determination of the temperature in different zones of the heat-transfer surface, for heating of which a dc generator with voltage 6/12 V was used. Copper thermocouple wires were used for measurement of the voltage drop with respect to the foil length. A system for gathering of experimental data made it possible to measure the emf and voltages repeatedly and to carry out their averaging according to a preassigned program.

The experiments were carried out in the following order: the necessary flow rate of the heat-transfer agent ensuring the required flow rate of the stream in the experimental setup was established; the generator was switched on, and the heating current ensuring the necessary temperature drop between the stream and the heat-transfer surface was established; the temperature of the heat-transfer agent was controlled to obtain steady-state conditions; and the parameters being measured were recorded while the stream and wall temperatures became constant with respect to time.

The local heat-transfer coefficient was calculated according to the equation \( \alpha_i = q/(t_w - t_c) \) (here \( q = I \Delta U/F \) is the specific heat flow; \( I \) is the current; \( \Delta U \) is the voltage drop; \( F \) is the heat-transfer surface area; and \( t_w \) and \( t_c \) are the temperatures of the wall and the heat-transfer agent, respectively).

Models of the cutoff valve and the gate valve were mounted in closed aerodynamic and hydrodynamic circuits, the detailed description of which and also the method for determination of the heat-transfer coefficients are given in [3]. The flow rate of water was 5, 7, and 10 m/sec, and that of air was 10-30 m/sec.

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TABLE 1

<table>
<thead>
<tr>
<th>Fitting</th>
<th>$K_1$</th>
<th>$K_2$</th>
<th>$K_3$</th>
<th>$K_4$</th>
<th>$K_5$</th>
<th>$K_6$</th>
<th>$K_7$</th>
<th>$K_8$</th>
<th>$K_9$</th>
<th>$K_{10}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate valve</td>
<td>1</td>
<td>0.7</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Cutoff valve</td>
<td>1/3</td>
<td>2/3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.2</td>
<td>0.125</td>
<td>0.1</td>
<td>0.125</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*The subscripts correspond to the subscripts at the local heat-transfer coefficients in Fig. 1.*

**The coefficients for feed of the medium to beneath the plug are given in the numerator, and the coefficients for feed of the medium onto the plug are given in the denominator.

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A characteristic of the heat transfer in the flow-through part of the piping fittings of the different types was manifested in intensification of the process due to flow perturbations. In the cutoff valve the flow perturbations occurred during a two-time change of the flow direction by 90° and passage of the stream through an opening of complex cross-section beneath the plug. As a result of flow turbulization in the zone of the plug, heat transfer increased approximately three-fold in comparison with heat transfer before the valve. In the flow-through part, flow turbulization was promoted by the presence of a gap between the seats and the tapered cutoff plug. Collision of the stream with the packing surfaces of the seats caused a 1.5-2-fold increase of heat transfer. In the throat of the gate valve, consisting of a semiclosed volume, the heat-transfer intensity was an average of 2-4-fold lower than in the flow-through part. The minimum $\alpha_1$ in the angular zones of the gate-valve throat constituted the fifth part of $\alpha_1$ in the flow-through part. There was a 1.2-1.4-fold increase of the heat transfer in the stem zone.

The intensity of the heat-transfer process in the valve throat changed in wide ranges both with respect to the perimeter and with respect to the height. The heat-transfer coefficient attained a maximum value (approximately equal to the value of $\alpha_1$ at the valve inlet) in the narrow gap between the body and the plug ($\delta = 0.6$ mm) and a minimum value in the direction of the outlet. During feed of the medium to beneath the plug, the ratio of the maximum and minimum values of $\alpha$ did not depend on the velocity of the medium and was equal to 4. During feed onto the plug, this ratio increased with increasing velocity of the medium. For example, it was 4 at air velocity 11 m/sec, and it attained 8 m/sec at air velocity 28 m/sec. The difference between the maximum and minimum of the heat transfer decreased with respect to the height of the throat, and the heat-transfer intensity in the zone above the plug was practically constant with respect to the throat perimeter and did not depend on the flow direction of the medium. With increasing distance from the inlet to the throat, the heat-transfer intensity decreased, and $\alpha_4$ in the zone of the lower flange was five- to eight-fold less than $\alpha_1$ in the flow-through part at the valve inlet.

Fig. 1. Models of the gate valve (a) and the cutoff valve (b).