Comparative efficiency of pipeline heat-insulating materials

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Annotation. The paper considers the problem of reducing heat losses in the heat supply systems of the FEC facilities (fuel and energy complex) due to the use of heat insulation of the pipelines. A comparative analysis of heat insulation of the heat lines: PUF (polyurethane foam), mineral wool, foam rubber, ultrathin heat insulation of the mark "Corund". The graphical dependences of heat losses and the efficiency factor of heat insulation on a diameter of the pipelines are obtained.

Insulation of the pipelines is a very important measure that protects them from various external influences, but also increases the efficiency and also the operational life of the main pipeline. The structure of heat insulation consists of a main heat-insulating layer, an external protective coating and fastening. The main heat-insulating layer provides protection of the insulated surface from heat loss, the outer protective coating protects the main heat-insulating layer from mechanical damage, moisture, exposure to aggressive environments, etc. To isolate the heating networks of the FEC facilities, the task of which is to deliver heat from boiler houses to consumers, different insulating materials are used (tabl. 1). First of all, such materials are faced with the task of reducing heat losses.

When choosing heat-insulating materials and coating layers, the resistance of elements of the heat-insulating structure to aggressive environmental factors should be taken into account, including possible effects of the substances contained in the insulated object, and also these materials must meet hygiene requirements and fire safety ones [1, 2, 10].

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Foam concrete insulation is a light, environmentally friendly material, it is not susceptible to corrosion and over the time it only gains strength.

Table 1. Characteristics of insulating materials

| Name of heat-insulating material | Heat conduction coefficient, W/m² K | Heat resistance, °C | Combustibility             |
|---------------------------------|-------------------------------------|---------------------|---------------------------|
| Polyurethane foam (PUF)         | 0.036                               | -100°C…+150°C       | C (combustible) 2-C4       |
| Foam concrete                   | 0.06                                | -150°C…+660°C       | NC (non-combustible), LC (low-combustible) |

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Mineral wool 0,070 -180°C…+700°C NC, C1
Superthin heat insulation «Corund» 0,0012 -60°C…+260°C NC, C1
Foam rubber 0,03 -200°C…+5°C C1-C3

PUF insulation is a synthetic substance of a cellular structure from the group of gas-filled plastics, it is environmentally friendly, durable and easy to use. [1].

A liquid ceramic heat-insulating coating «Corund» is a liquid composition based on water. It consists of closed-porous microgranules of foamglass, as well as pigmenting, inhibitive, antipyrene and rheological additives [2,5].

A foamed synthetic rubber has minimal hygroscopicity and vapor permeability, reliably protecting the pipeline from moisture which is condensed with sharp variations in temperature, it does not decay, it is also not subject to burning.

According to the methodology in [3,4, 7-9], a comparative analysis of the following heat-insulating coatings of a heat pipe during above-ground routing was carried out: mineral wool with a coating layer of galvanized steel; polyurethane foam (PUF) with a coating layer of galvanized steel; foam concrete with a coating layer of galvanized steel; ultrathin heat insulation of a mark «Corund»; foam rubber.

The heat calculation of the pipeline was carried out with the following parameters: a temperature of the heat carrier was 100°C; an ambient temperature was -10°C; a wind speed was 5,1 m/s; a diameter of the pipeline was considered in the range of 15-500 mm; a thickness of the heat-insulating material depending on the diameter was 34-54 mm, thin heat-insulating materials were 0,21-25 mm.

Graphical dependences of the efficiency and heat loss coefficients of various heat-insulating materials on a diameter of the pipeline are obtained (Fig. 1, 2).

Fig. 1. Dependence of heat losses on a diameter of the pipeline:
1 – PUF; 2 – foam concrete; 3 – mineral wool; 4 – ultra-thin insulation «Corund»; 5 – foam rubber; 6 – pipeline without insulation

Having considered various heat-insulating materials when laying the pipelines above ground, it is advisable to give preference in favor of PUF insulation. The figures 1 and 2 show that it has a high
coefficient of heat insulation efficiency and insignificant heat losses compared to other insulating materials.

![Figure 2](image)

Fig. 2. Dependences of the efficiency coefficient on a diameter of the pipeline: 1 – PUF; 2 – foam concrete; 3 – mineral wool; 4 – ultra-thin insulation «Corund»; 5 – foam rubber

Based on the data obtained, in order to increase the efficiency of this heat-insulating material, 2 options for installing a coating layer are proposed: 1st option - the use of PUF insulation with a coating layer of foam rubber; 2nd option – the use of PUF insulation with a coating layer of galvanized steel and ultra-thin heat insulation «Corund».

![Figure 3](image)

Fig.3. Percentage diagram of the average values of heat losses in three ways of installing a coating layer of PUF insulation: 1 – a coating layer of foamed rubber; 2 – a coating layer of galvanized steel and ultra-thin heat insulation «Corund»

With the expansion of construction activities, reliability of the operation of pipelines and cost
effectiveness of laying them become increasingly important, which requires the development of the most rational solutions, confirmed by a technical and economic feasibility. The figure 3 shows that the most effective way of insulating the pipelines during its laying is the use of polyurethane foam insulation with a coating layer of galvanized steel and ultra-thin heat insulation «Corund». This method of insulation has the lowest percentage of heat losses compared with the other proposed. In the proposed methods of insulation, an attempt is made to generalize the existing experience in the design, construction and operation of pipelines and improve this knowledge by introducing new means of insulating pipelines during above-ground routing.

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