

PAPER • OPEN ACCESS

Assessment of transport losses of heat at change of properties of thermal isolation

To cite this article: Yu.V. Vankov *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **288** 012127

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the [collection](#) - download the first chapter of every title for free.

Assessment of transport losses of heat at change of properties of thermal isolation

Yu.V. Vankov¹, E.R. Bazukova², A.S. Gavrilov³

^{1,2,3}

Kazan state power engineering university, 420066, Krasnoselskaya st., 51, Kazan, Russian Federation

¹yvankov@mail.ru, ²ell17@mail.ru

Summary. Research is devoted to increase in system effectiveness of transportation of thermal energy. The control system of thermal insulation properties realized in the environment of LabVIEW is developed. Assessment of transport losses of heat taking into account real service conditions of pipelines and heterogeneity of thermal insulation properties is carried out. Influence of extent of aging of thermal isolation on increase in size of density of a thermal stream is shown. Calculation of specific thermal losses of an elevated steam line taking into account thermal destruction of isolation is carried out.

Introduction

There are 10% of oil production in the world are extracted in the Russian Federation. Explored reserves of "lungs" of oil decrease and increase stocks of high-viscosity oil and natural bitumens. The known technologies of production of high-viscosity oil and natural bitumens are energy-intensive, a large amount of steam is used in them. Reduction of power losses at production of high-viscosity oil and bitumens is one of the most important tasks of oil production.

In process to transportation of steam from a source to the well there are thermal losses to which reduction apply different types of thermal insulation. At operation of steam lines the indicator of the long-term properties of isolation confirming her service life at the level of the established requirements is important.

It is known that the materials applied in Russia can lead to increase in coefficient of heat conductivity by 20-30% already for the first time 5 years of operation [1-3]. For example, producers guarantee that polyurethane foam works at a temperature of 150 °C. However at a temperature of 120 °C there is his destruction (figure 1).

Timely assessment of thermal insulation properties of heat conductors with the subsequent her replacement will allow to save energy resources significantly.

Methods

In spite of the fact that in modern scientific literature much attention is paid to the questions connected with definition of thermal losses now there is no method of calculation of thermal losses considering heterogeneity of thermal insulation on length of the pipeline and the factors leading to decrease in heat-shielding properties of a covering: aging, change of thickness, sagging, partial lack and moistening of isolation.





Figure 1. End face of two-layer thermal isolation (basalt + polyurethane foam).

Check of a condition of pipelines isolation is under operating conditions offered to be carried out by means of the device of which operation the method of an additional wall is the cornerstone. It consists in the fact that the additional wall with the known thermal resistance λ_0 / δ_0 densely nestles on a surface of a wall which thermal losses need to be defined (figure 2).

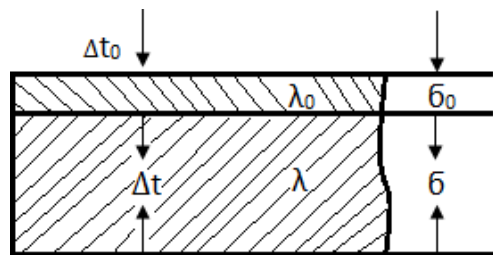


Figure 2. Illustration of an "additional" wall method.

Measuring temperature drop in an additional wall, it is possible to find the thermal stream passing through it from the equation

$$q = \frac{\lambda_0}{\delta_0} \Delta t_0$$

If the thermal resistance of an additional wall in comparison with the thermal resistance of the main isolation is small, then at the established thermal state the same thermal stream will pass also through the main wall. This stream also makes thermal losses of the pipeline.

The converter of the device represents a belt length equal to perimeter of the surveyed pipeline (figure 3). In places of a belt, to the corresponding 3, 6, 9 and 12 hours there are sensors of a thermal stream.

Sensitive element of the thermopair sensor is the hyper battery of copper-constant couples executed on galvanic technology. On square centimeter of the sensor about 1500 thermocouples are fitted.

Their total signal is proportional to the difference of temperatures on thickness of the sensor and, therefore, to a thermal stream through him. Density of a thermal stream is defined by the sensor by multiplication of a signal by the calibration factor having a value of 5 to 40 W/m²·mV. Thickness of thermal stream sensors – 2 mm.

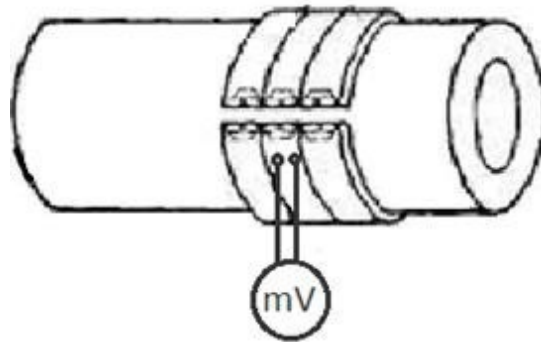


Figure 3. Converter arrangement on the surveyed pipeline.

For registration and information processing, coming from sensors of a thermal stream, the program, in a development environment of virtual LabVIEW devices is created.

Functionality of the virtual device is defined by his block diagram which is graphic realization of an algorithm.

The block diagram of the developed program is represented in figure 4.

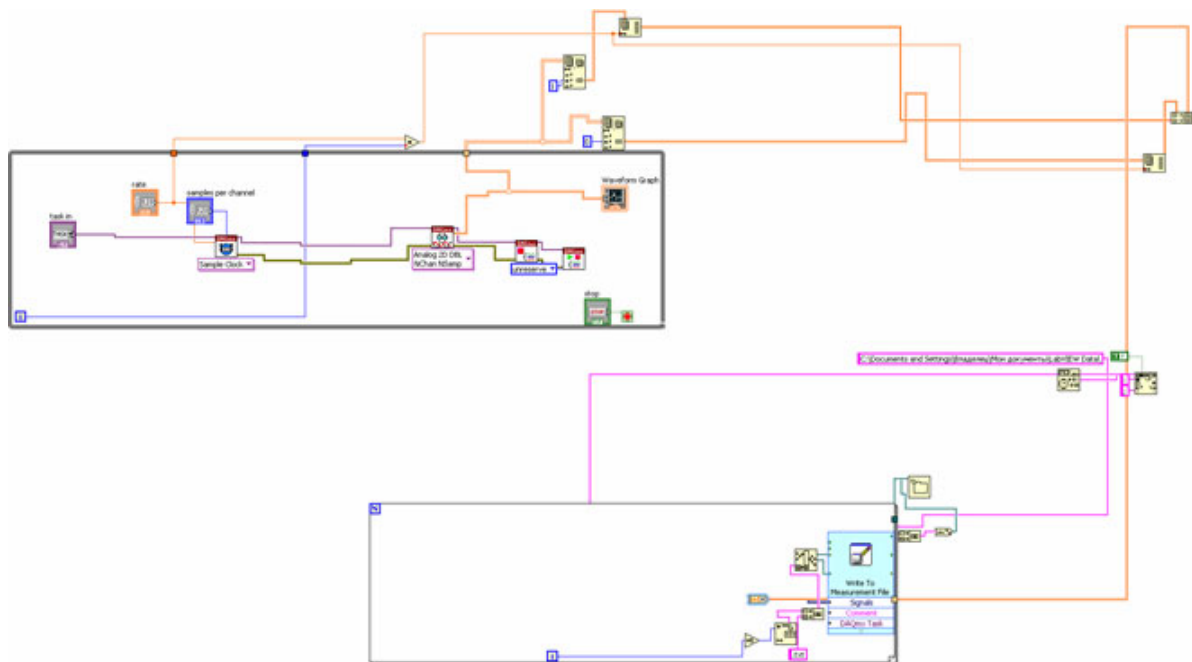


Figure 4. Block diagram of the developed program.

Before carrying out researches calibration of measuring system has been carried out. As the model device serially released measuring instrument of a thermal stream ITP-MG4.03/X(Y) "Stream" was used.

For assessment of thermal losses, during aging isolation, measurements with four models of isolation with different extent of destruction are executed:

- a sample No. 1 - not damaged isolation (100%);
- a sample No. 2 - 90% of an initial state;
- a sample No. 3 - 50% of an initial state;
- a sample No. 4 - 30% of an initial state.

Conclusion

By the technique given to Construction Norms and Regulations 41-03-2003 "Thermal isolation of the equipment and pipelines" (updated version of 61.13330.2012) calculation of specific thermal losses of steam lines of elevated laying d-76 of mm and d-159 of mm by which steam with a temperature of 194 °C of initial thermal isolation and with destruction was transported has been made. Results of calculation are presented on the chart (the figure 5).

Difference in thermal losses, during accounting thermal destruction and without her account, significantly. In case of thermal destruction of thermal insulation of loss when transporting steam increase by 39%. This circumstance acquires special relevance in connection with increase in energy costs. From the figure 5 it is visible that operation of thermal network in the conditions differing from design leads to essential increase in thermal losses.

The received results testify to need of accounting of real service conditions at assessment of thermal energy losses.

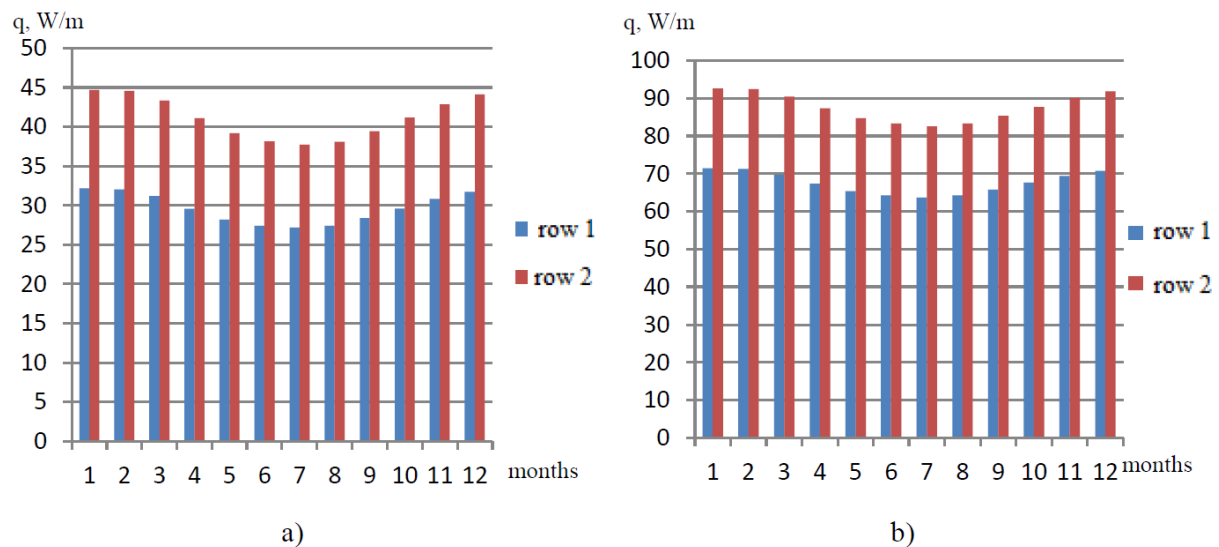


Figure 5. Results of calculation of specific thermal losses of a steam line a) d-76 mm, b) d-159 mm. A row 1 – specific thermal losses without temperature destruction of PPU-isolation. A row 2 – specific thermal losses at increase in coefficient of heat conductivity owing to temperature destruction for 20%

Timely definition of "problem" places by means of the developed system will allow to provide implementation of energy saving programs. Considerable economy of energy resources can be reached due to local repair and insulating works on concrete sites of pipelines with abnormal thermal losses.

References

- [1] Smorodova O V 2016 Tool assessment of dynamics of mineral-cotton thermal isolation aging *Innovative science* **7-8** pp. 90-92
- [2] Bazukova E R, Vankov Yu V 2015 Thermal losses at deterioration in properties of isolation in use *Engineering bulletin of Don* **3** ivdon.ru/ru/magazine/archive/n3y2015/3249.
- [3] Dementiev A G 2000 Assessment of polyurethane foam service life for thermal insulation *Penopoliuretan* **2** pp. 38-41
- [4] Gerashchenko O A 1971 *Basics of thermometry* (Kiev: Naukova thought) p. 191
- [5] Vankov Yu V, Bazukova E R, Islamova S I, Busarov A V 2017 Estimation of heat transport losses during aging isolation *Innovative, information and communication technologies* **1** pp. 572-576