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Evaluation of Thermal Insulation Type Impact on the Value of Regulatory Heat Losses in Heat and Power Systems

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Abstract: This study presents the algorithm of computational study performance in order to determine the magnitude of normative heat losses in heat network areas. The results heat network tests of OJSC "Kazenergo" (Kazan) were presented in order to determine the magnitude of the actual heat losses in different parts of a thermal network pipeline with different types of thermal insulation. A correction factor was calculated on the basis of these data, taking into account a thermal insulation type.

Key words: Heating system, normative losses, heat supply organization, OJSC, Kazan

INTRODUCTION

For a long period of time the heating system in Russia developed on the basis of heat and electrical energy combined production. The result of this is the prevalence of the centralized heat supply system. The main load of heat energy in large and medium cities is performed by TPS (Semenov and Khomyakov, 2006). According to Melnikova almost 72% of thermal energy produced in Russia is generated by TPS. Of course, the combined production of electricity and heat is more cost-effective, however the process of mass cogeneration led to a large-scale construction of extended and branched thermal networks (Bukhin, 2002). Now a days about 180 thousand km of heat networks (in two-pipe calculation) is constructed in Russia. The heat supply radii often exceed 30 km which is highly inefficient, it leads to great losses and causes a considerable waste of electricity for a heat carrier pumping.

Russian heat supply infrastructure should satisfy the global improvement. The level of loss in the thermal networks of the country reaches 20-30% which is approximately four times higher than in Europe (4-8% (Shishkin, 2010)).

There is a large number of government and industry regulations regulating the heat supply of the country however, they have some drawbacks. In this regard, the problem of normative and actual loss reliable determination is a vital one until now.

MATERIALS AND METHODS

Loss determination methods: The issue of loss study through the thermal insulation of pipeline structures during a heat carrier transfer was developed by many scientists: H.H. Arefiev, S.A. Baybakov, N.V. Bukarov, V.V. Vasilenko, V.P. Vitalyev, V.L. Gudzyuk, V.V. Ivanov, G.V. Ivanov, G.V. Kuznetsov, L.I. Munyabin, G.P. Petrakov, V.Y. Polovnikov, A.N. Rondell, V.S. Slepchenok, V.G. Semenov, L.V. Stavritskaya, S.V. Chernysh, V.G. G.H. Umerkin, Hromchenkov, B.M. Shoikhet, A.V. Shishkin, E.V. Shomov, N.N. Shapovalov, A. Dalla Rosa, H. Li, S. Svendsen, D. Eriksson.

Safonov and Shubin 1954 noted that the actual heat loss can be determined only by the means of special test performance on thermal networks. The finding the heat losses by the calculation leads to a rough estimate as the correction factors that take into account the changes of thermal protection insulation over time, have considerable variation intervals.

Usually, the experimental evaluation of heat losses is carried out according to the set of method using the flow measurement and heat carrier temperature reduction in a circulation ring which consists of a supply and a return line with the bridge between them on the first and the last sections at blackouts. However, quite during a relatively good condition of thermal insulation and a steady temperature and hydraulic mode, the heat carrier temperature decrease over the length of a heat conductor is insufficient and makes 0.6°C/km on the average (Chernysh, 2000). Therefore, in order to obtain the minimum required temperature difference (8°C) the circulation ring length should be about 13 km. The performance of testing within short distances is possible only with a sharp decrease of a heat carrier flow rate which will result in hydraulic mode breach.

The heat wave method proposed by Lewkowich (1971), Lewkowich (1956) and Lewkowich *et al*. (1974) to determine the actual heat loss can be applied in relatively

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short sections of a heating network. The use of this method allows you to perform the turning off of heat systems, but requires the change of a heat source operation mode the creation of thermal waves. The application of the method also requires the performance of high-precision temperature contact measurements at the beginning and at the end of the calculation area, a heat carrier flow rate determination and the actual value of a pipeline internal diameter determination taking into account the overgrowth, etc.

Another way of heat loss determination can be based on the measurement of soil temperature (Kryukov and Myagkov, 1980) surrounding an operational hot water system. Heat losses are determined by known relations. The disadvantage of this method is the need for temperature sensor installation in the array of soil which requires an underground heating system opening. This method is a contact one and it has no mobility.

Due to the complexity of the actual heat losses experimental evaluations the interest in theoretical research during recent years. The analytical determination of heat losses without the replacement of the experimental methods, allows to evaluate the state of a large amount of heat networks quickly and less costly.

Thus, we made the following conclusions after the study of the existing methods. There are three methods of heat loss evaluation determination.

The first method (Safonov and Shubin, 1954) is the determination of losses on the basis of experimental data. Of course, this method is the most reliable one however, the performance of testing is not always possible in practice because of the experiment requirements performance necessity the disconnecting of consumers from a test ring, the provision of differential temperature no <8°C, the maintaining of a constant flow rate during tests. Therefore, this heat loss determination method is used very rarely and basically, on the main heat pipe systems while heat losses occurring in distribution networks have a greater specific weight (Baybakov, 2010).

The second method for heat loss determination is the measurement of the indicators according to consumer metering devices. Several techniques are developed according to this method (Baybakov, 2010; Semenov, 2003; Gudzyuk and Shomov, 2010; Khomchenkov *et al*., 2006; Baybakov and Timoshkin, 2009). However, the difference of readings between a released thermal energy and the thermal energy recorded by a consumer, one can evaluate only the mean losses of a heating main. This method does not allow to determine the losses at a particular location of a heating network. This method has no practical interest, since it does not allow to identify a heating pipeline section with the largest losses.

The third method of heat loss determination is based on the method of specific heat loss mathematical modeling during the change of applied insulation heat-shielding properties (Ivanov *et al*., 2002; Ivanov and Vershinin, 1998; Ivanov and Shkrebko, 1998; Kuznetsov and Polovnikov, 2006a, b; Kuznetsov and Polovnikov, 2009; Polovnikov, 2006; Kuznetsov and Polovnikov, 2008a, b; Kuznetsov and Polovnikov, 2006). However, the results of studies (Kuznetsov *et al*., 2011) showed that the heat loss increase is not influenced by moisture insulation problem, as described by Ivanov *et al*. (2002), Ivanov and Vershinin (1998), Ivanov and Shkrebko (1998), Kuznetsov and Polovnikov (2006a, b), Kuznetsov and Polovnikov (2009), Polovnikov (2006) and Kuznetsov and Polovnikov (2008a, b) but by insulation faults related to its physical wear and the integrity damage of an insulating layer.

Thus, there is no universal method of thermal loss determination, despite the fact that this problem is one of the most important ones since the determination of heat losses during a heat carrier transportation makes the influence on the structure of heat supply organization tariff. The understanding of this value also contributes to the proper selection of main and auxiliary equipment power, the temperature graph of heating networks as well as the choice of a heating system structure with its possible decentralization. The determination of the actual heat losses and its comparison with standard values proves the effectivenessof thermal network improvement operations with the replacement of pipelines or their isolation.

Determination of regulatory losses: The determination of heat supply company normative losses is the most interesting one because this value makes its impact on a tariff amount. The method of normative losses determination is regulated by the Energetic Ministry Order “On the approval of technological loss standards determination order during heat energy and a heat carrier transmission 325 issued on 30.12.2008”.

The standards of technological losses during thermal energy transfer consist of the following indicators: heat carrier losses and costs (steam, condensate, water); heat losses in heating networks by heat transfer through heat-insulating structures of heat conductors with the losses and the costs of heat carriers (steam, condensate, water); Electricity costs for heat transfer.

The analysis of existing determination methods concerning the standards of technological losses showed that it does not take into account some important characteristics: the type of thermal insulation and thermal network condition.

Table 1: Comparative analysis of regulatory heat losses in thermal network areas according to existing and proposed procedures

Site name	$D_н$ (m)	L (m)	Thermal insulation material		Gasket type	Commissioning year (rerun)		--------K------		-------K_1------		Hour heat, losses (kcal/h)		Standard losses during heating season,Gcal	
Boiler room TK1 Vysotnaya. 30 (CHDS)	0.273	17.5	Min. wool	Min. wool	Surface supply	Until 1989	Until 1989	1.18	1.18	1.0	1.13	3344.028	3778.752	70.41	79.561
Boiler room TK1 Vysotnaya. 30 (CHDS)	0.273	17.5	Min. wool	Min. wool	Surface supply	Until 1989	2015	1.18	1.0	1.0	1.13	2446.182	2342.531	51.50	49.322
Boiler room TK9	0.273	10	Min. wool	Basalt	Surface supply	Until 1989	2015	1.18	1.0	1.0	1.07	1910.873	1732.741	70.41	63.845
Boiler room TK9	0.273	10	Min. wool	Basalt	Surface processing	Until 1989	2015	1.18	1.0	1.0	1.07	1397.819	1267.513	51.50	46.703
TK9 L.Strelkov, 10a	0.108	100	Min. wool	PPU	Underground canal	Until 1989	2015	1.15	1.0	1.0	0.65	11388.864	6437.183	82.53	46.646
L.Strelkov, 10a L.Strelkov, 12	0.057	10	Min. wool	PPU	Underground canal	Until 1989	2015	1.14	1.0	1.0	0.65	833.057	474.989	60.90	34.721

It is believed that the losses should not exceed the standard value at any form of isolation. This is achieved by a different thickness of an insulating layer for different types of insulation. However, this technique is applicable to an insulating material such as mineral wool. Modern insulation materials are available with factory thickness (PPU, TILIT, etc.) which can't be changed by operating organizations. Thus, the current methodology does not allow to take into account the peculiarities of modern insulating materials, as well as to evaluate the effect of the obsolete insulation replacement into modern one.

We developed the algorithm of computational study performance in order to determine the magnitude of regulatory heat losses in heat network areas .

Experimental part: They performed the testing of OJSC "Kazenergo" (Kazan) heating networks in order to determine the magnitude of the actual heat losses in different parts of thermal network pipelines with different types of thermal insulation. The dynamics of Kazan thermal network length from the source of OJSC "Kazenergo"

Comparing the obtained values with the normative losses of these same areas, calculated according to the existing method, we got the correction factor, taking into account the thermal insulation type .

They proposed the method of standard value determination concerning hour losses, Gcal/h for the average annual (average seasonal) operating conditions of heat network pipelines according to the following formula:

$$Q_{ИЗ.Н.ГоД} = \sum \mathbf{K}_{1i} \times (q_{ИЗ.Нi} L_i \beta_i) \times 10^{-6}$$

where $?_1$ the coefficient which takes into account the type of insulation (mineral wool, basalt, reinforced foam concrete, polystyrene foam, polyurethane foam, foamed rubber).

The mathematical modeling of heat loss normative values using the example of 82 heating network sites was carried out using the boiler Vysotnaya, 30 (Kazan).The comparative analysis of computational research according to the existing technique of RF Ministry of Energy Order No. 325 issued on 30.12.2008 and the methods developed by us is presented in Table 1.

Summary: It is clear from these results that the type of thermal insulation and the value of a heating network reliability have a significant impact on the normative value of thermal losses. Thus, the normative losses, the losses of thermal insulation consideration, the losses with insulation replacement into a new one and the losses with the entire insulation replacement on PPU for the heat supply company OJSC "Kazenergo" were calculated.

CONCLUSION

Thus, the method which provides a heat carrier standard value estimate loss during a year with its normalized leakage, m^3 and includes the additional factors not accounted for in the existing procedure.

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