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Comprehensive definition of thermal losses taking into account to the conditions of thermal networks

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Abstract. The article presents an analytical evaluation of heat losses through the thermal insulation of pipelines, taking into account the actual operating conditions of thermal networks. Calculations confirmed a significant influence of the main operational factors on the increase in heat loss and the possibility of energy saving in heating networks.

1. Introduction

Now the considerable attention is given to a problem of savings of power resources [1]. A necessary condition of economically effective work of thermal networks is decrease in unproductive transport losses of heat through the isolated designs of pipelines.

While in service there can be situations when some sites of pipelines have the humidified, deformed or destroyed thermal isolation. of operation of a heating main (flooding of channels rain, soil or thawed snow, accidents in heat supply and water removal system, sharp temperature drops of environment, long operation and isolation ageing). In these conditions actual value of factor of heat conductivity of isolation of the pipeline differs from help value [2]. The known analytical way of definition of thermal losses [2] does not consider influence of the listed factors and, accordingly, leads to insufficiently exact calculation of transport thermal losses.

Therefore working out of tools for operative revealing of the high thermal losses allowing as more as possible precisely to define loss in a thermal network, not conducting expensive tests [3], is actual.

The purpose of this work is creation of the analytical tool for an estimation of losses of heat considering not only geometrical characteristics and ways of a lining of pipelines, but also influence of supernumerary conditions of operation and a real technical condition of isolation on change of thermal losses.

2. Problem statement

Testing of the developed method is spent on an example of a fragment of a typical two-trumpet thermal network of Mariinsk (Figure 1). Characteristics of sites and typical conditions of their operation are presented to tab. 1. Isolation type - mineral cotton wool, a way of a lining - underground in the channel not through passage. Initial climatic data [4]: the temperature of external air is equal 273 K, the average temperature of a ground on depth of 8 m is equal 278 K, the temperature of direct network water is equal 363 K, the temperature of return network water is equal 323 K.

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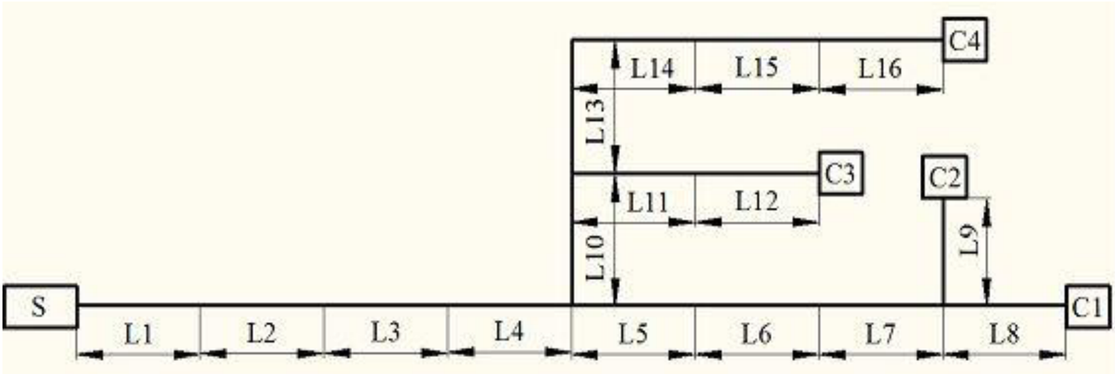

Figure 1. Fragment of a thermal network: L1 – L6 – sities of a thermal network with various conditions of operation and an isolation condition, S – thermal sourse, C1 – C4 – heat consumers № 1-4.

Table 1. Sites characteristics of a thermal network

№ site	Length, m	Conditional diameter, mm	External diameter of isolation, mm	Conditions of operation and an isolation condition
1	1700	400	560	Design conditions
2	300	400	560	Isolation is humidified on 50 %
3	150	400	560	Isolation is humidified on 70 %
4	200	400	560	Isolation is humidified on 100 %
5	230	300	450	Isolation is humidified on 100 %
6	1240	300	450	Design conditions
7	440	300	450	Damp air in the channel
8	100	50	125	Isolation is absent
9	100	150	250	Isolation is deformed
10	510	250	400	Damp air in the channel
11	250	100	180	Isolation is humidified on 10 %
12	390	100	180	Design conditions
13	310	100	180	Isolation is humidified on 40 %
14	100	100	180	Isolation is absent
15	180	100	180	Isolation is deformed
16	420	100	180	Design conditions

The problem of definition of heat losses for a thermal network (fig. 1) is solved at following assumptions:

- heat technical characteristics of substances are constant and known sizes. In a considered range of change of the basic influencing parametres (temperature, pressure) heat technical properties of substances change slightly [2, 5] and this change can be neglected;
- thermal resistance of walls of pipelines and the channel is not considered. Their thermal resistance much less than thermal resistance of the insulation layer [6];
- heat-carrier leaks are absent.

The basic engineering formulas used for the account of influence of negative factors (tab. 1), are presented in [7]. In this case for the purpose of optimisation of calculations for definition of thermal losses earlier developed and registered program complex [8] is used. The program allows to define losses of thermal energy and heat-carrier temperature drop on length of pipelines for any configuration of thermal networks. The step-by-step calculation of specific thermal losses realised in the program allows to recalculate on each individual site of a heating main a variable on length air temperature in the channel and to consider change of factor of thermal return in the course of heat-carrier cooling.

Comparison of the thermal losses calculated in a program complex [8] with the losses received on the basis of natural tests on concrete sites of a thermal network, show convergence of results comprehensible to practice [9].

3. Results and conclusion

Values of the thermal losses calculated taking into account a condition of isolation and conditions of operation of heat conductors ($Q_{cal.}$), are resulted in tab. 2 and on fig. 2. For comparison and the analysis of the received results in tab. 2 and on fig. 2 the losses defined by an official technique [2] - $Q_{d.}$ and standard losses of heat - $Q_{norm.}$ [10].

Table 2. The results of definition of transport thermal losses

Heat consumer	Length, m	Thermal losses, kWt			$(Q_{cal.}- Q_{d.})/ Q_{d.}$, %	$(Q_{norm.} - Q_{d.})/ Q_{d.}$, %
		$Q_{cal.}$	$Q_{d.}$	$Q_{norm.}$		
C1	5160	847.3	331.9	472.7	155	42
C2	5160	830.7	332	475	150	43
C3	4300	701.7	276.5	378.9	154	37
C4	4670	763.3	289.7	397.5	163	37

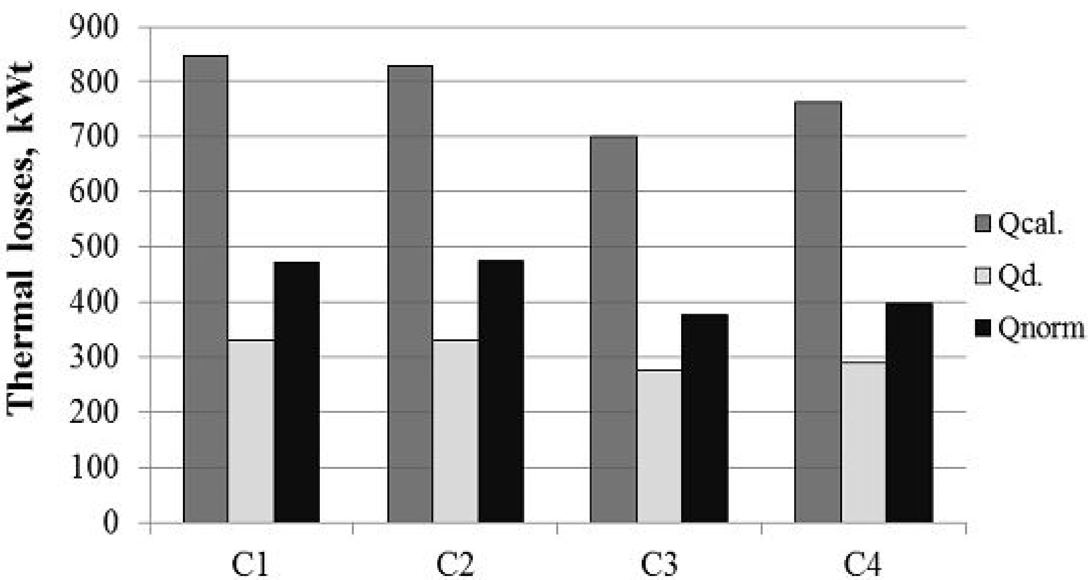

Figure 2. The results of definition of transport thermal losses: Q_{cal} – calculated thermal losses, Q_d – design thermal losses, Q_{norm} – normal thermal losses, C1 – C4 – heat consumers № 1-4.

From the received results (tab. 2, fig. 2) follows, that at the account of the operational factors influencing thermal resistance of mineral cotton wool, for all consumers the expected increase in the calculated thermal losses in comparison with design losses [2] is observed. Depending on size and the importance of factors, thermal losses can change in a wide range, in many exceeding design losses. For this case the calculated thermal losses on 150 … 163 % have exceeded design values.

The received results confirm advantages of the offered approach [7] for definition of heat losses on each characteristic site of pipelines taking into account supernumerary conditions of operation and not standard technical condition of isolation in comparison with [2]. Together with modern ways of diagnostics of a condition of underground heat conductors [11] the offered method will allow to reveal sites with thermal losses above permitted standard, to prove necessity of carrying out of repair work, drainages of channels, an additional waterproofing. Operative reduction of the overestimated thermal losses to design level will allow to provide partial performance of the program of savings of power resources [1].

On the basis of results of tab. 2 it is possible to recommend application of a method [7] and a program complex [8] for more exact in comparison with [2], and also more operative and less expensive in comparison with [3] estimations of thermal losses in heat supply system.

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