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HYDRAULIC REGIME CHARACTERISTICS OF BRANCHED DISTRICT HEATING NETWORKS

VOLODYMYR LYKHATSKYI, post-graduate student
KONSTANTIN MIAGHKOKHLIB, associate professor
ANNA KOTOVA, Associate Professor, PhD in Education, Language Adviser
V. N. Karazin Kharkov National University, Kharkov, Ukraine

The desire to reduce heat losses in centralized heating systems has led to the emergence and development of the idea of replacing traditional four-pipe district heating networks with two-pipe ones. When conducting preliminary assessments of the thermal state of heating networks, it is convenient to use simplified methods developed under a set of assumptions and simplifications, given the limited input data. In real networks, the change in heat carrier flow rate along the length of the network has a stepwise nature with constant values on certain sections.

The development of simplified methods[1] for calculating thermal and hydraulic indicators of heating networks involves replacing the actual stepwise law of variation of heat carrier flow rates with a monotonic one and using the average diameter of the heat pipes. The study uses a stepwise distribution law of heat carrier flow rates along the length of the pipeline:

$$\bar{G}(\bar{x}) = 1 - \bar{G}_{\text{branch}}\,\bar{x}^{n}$$

where $\bar{G} = G / G_{max}$ is local relative flow rates of the heat carrier in the branch; G_{max} is the flow rate of the heat carrier at the branch inlet; $\bar{G}_{branch} = G_{branch} / G_{max}$ are relative flow rates of the heat carrier through all branches in the branch; $\bar{x} = x / L$ is relative coordinate; L is the branch length.

For n > 1, there is a sharp decrease in the flow rate of the heat carrier on the sections close to the entrance to the branch of the heating network, with a gradual decrease in flow rates to a minimum value of G_{min} on the branch. The value of n = 1 determines the linear nature of the flow rate change. For n < 1, there is a slight decrease in flow rates at the input sections and a sharp decrease in flow rates at the output sections.

For a branched heating network, the average diameter of the pipelines can be determined using the diameter value at the input of the heat carrier into the supply pipeline D_{max}, the diameter value at the input to the heating system of the most remote building on the branch D_{min} , and the coefficient that takes into account the features of the distribution of flow rates along the length of the branch $К_G$,

$$D_{\text{ср}} = 0{,}5(D_{max} + D_{min})К_G. \qquad (1)$$

The diameters of pipelines can be determined depending on the heat carrier flow rate (G) and the average pressure loss for overcoming friction forces during the movement of the heat carrier (R_{avg}) using the formula D = $(1{,}34 * 10^{-5} * G^2/R_{avg})^{0{,}19}$. To account for the peculiarities of changes in heat carrier flow rates along the length of a network segment, the ratio of average flow rates within the main branch G_{avg} and flow rates through the branch G_{branch}. The results of calculating the coefficient K_G for the heating network of idealized groups of buildings are generalized by the formula[2]:

$$К_G = (2 - 1{,}075\bar{G}_{min})\left(\frac{G_{avg}}{G_{\text{branch}}}\right)^{0{,}41}.$$

The heat carrier flow rates are determined based on the magnitude of thermal loads, the range of which is taken to be $1{,}25 \le Q_s \le 10$ MW. Such a range of loads is the most expected for micro district systems in large cities. When calculating the values of minimum relative flow rates in the branch, the values of $\bar{G}_{min} = 0{,}1; 0{,}2; 0{,}4; 0{,}5$. After transformations, formula (1) takes the form:

$$D_{avg} = 14{,}56*10^{-4} * Q_s^{0{,}38}(1 - 0{,}466\bar{G}_{min})\,(G_{avg}/G_{\text{branch}})^{0{,}41}/{R_{avg}}^{0{,}19}.$$

where Q_s is the total heating load of the buildings connected to the heating network branch.

The maximum deviation of the calculated results of the average diameters of heating network pipelines from the actual values, fixed by the proposed formula, does not exceed 6%, which can be considered satisfactory for preliminary assessments of the state of heating networks.

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