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HYDRAULIC STABILITY OF HEAT NETWORKS FOR CONNECTION OF NEW CONSUMERS

HYDRAULIC STABILITY OF HEAT NETWORKS FOR CONNECTION OF NEW CONSUMERS

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Abstract. Nowadays due to intensive urban construction, there is a need to connect new consumers to existing heating networks. Often the connection of new consumers leads to a hydraulic misalignment of the network, which in turn affects supplying existing consumers with heat. In order to minimize the possibility of misalignment, appropriate recommendations are needed that can be obtained during the research. In the article, the authors carried out a required experiment aimed at revealing the influence of the new consumers' connection on the hydraulic stability of the entire network. The result of the research is relevant recommendations that will be useful for engineering specialists both for the design of new networks and the reconstruction of the old ones.

1. Introduction
Since uninterrupted and high-quality heat supply determines not only economic [1] and energetic, but also social security of the state [2], the provision of heat energy for consumers is one of the most important tasks for both the energy sector of Russia and the entire country as well.

Prospects for development of centralized heating supply are determined by the tasks of improving efficiency of construction and operation of heat sources, transportation systems and heat consumers [3-4]. An important stage in the modern development of centralized heating in large cities, especially in connection with the construction of high-rise buildings, is an increase in the reliability of heat supply.

So, annually there is a connection or disconnection of consumers to heat networks, reconstruction of pipelines, commissioning or decommissioning of boiler houses. However, the existing methods of regulating heat release in water heat supply systems do not provide consumers with the required amount of heating energy during the whole heating season. All this leads to a discrepancy between actual and designed flow of heating agents to consumers [2]. As a consequence, there is a hydraulic misalignment of the heating network. [5]

2. Body of the study
To solve this problem, it is necessary to achieve a stable hydraulic regime or a maximum indication of the heating network hydraulic stability throughout the entire heating season [6-7].

The coefficient of hydraulic stability implies understanding the ability of the system to maintain a constant flow of heating agent at consumer inputs when the operating conditions of other consumers change.

The coefficient of hydraulic stability is determined by the formula:

$$K_s = Ga/G_{cacl}, \quad (1)$$

where Ga - actual consumption of network water at the subscriber input; Gcalc - calculated (maximum possible) consumption of network water at the subscriber input.

To investigate how consumers' connection affects hydraulic stability of heat networks, the authors created a model for the flow distribution of the heat network of a given microdistrict based on the method of hydraulic calculation according to the resistance characteristics [8-10]. Figure 1 shows the scheme of the heat supply system of the given microdistrict with three points of the subsequent new consumers' connection. The hydraulic calculation for the microdistrict via the resistance characteristics' method was performed using Microsoft Excel software.

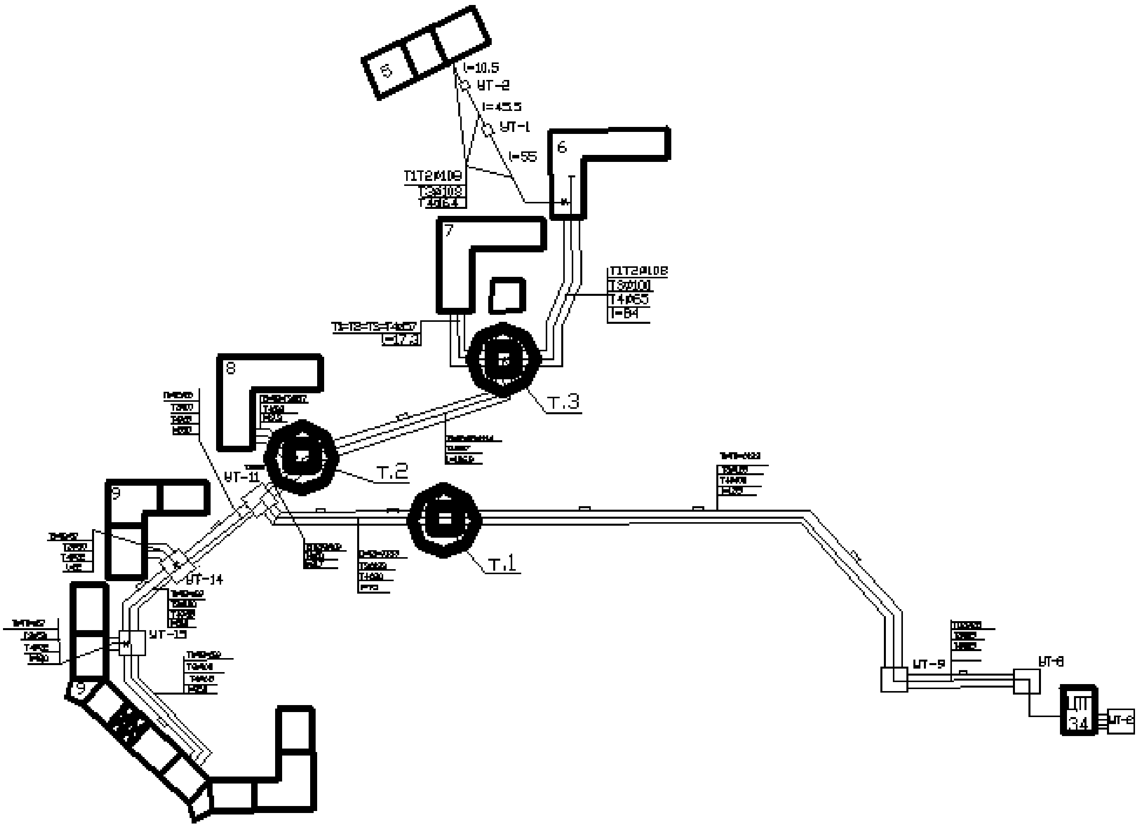

Figure 1. The scheme of the heat supply system of the given microdistrict with the points of the subsequent new consumers' connection

Having found the resistance characteristics of each section and the whole network, the authors determined the required number of experiments (recalculation of hydraulic characteristics) based on the theory of the full factorial experiment. [11]

A full factorial experiment is an experiment in which all possible combinations of factor levels are implemented. The required number of experiments n is determined by the formula:

$$n = N^k = 3^2 = 9, \quad (2)$$

where N is the number of factor levels, k is the number of factors.

In this case, the factors are the point of connection of a new consumer and its heat load. Thus, the number of factors is k = 2, the number of factor levels is N = 3. Thus, nine recalculations of the hydraulic characteristics will satisfy the requirements of a full factor experiment.

With the help of Microsoft Excel software, the hydraulic characteristics of the heat network were recalculated taking into account the alternate connection at point 1, point 2 and point 3 of a new consumer with a heat load equal to 10, 50 and 90% of the branch load.

According to formula (1), the coefficient of hydraulic stability for residential buildings was determined. The results of calculating the coefficient of hydraulic stability of residential house No. 6 were put into Table 1.

Table 1. The results of calculating the coefficient of hydraulic stability of residential house No. 6

$\frac{Q'}{Q_{total}}$ / $\frac{Q_i}{Q_{total}}$	0	0.42	1
0.1	0.965	0.982	0.987
0.5	0.843	0.921	0.944
0.9	0.750	0.871	0.907

where Q' - heat load after the point of connection of a new consumer, Gcal / h;

Q_{total} - total heat load per branch, Gcal / h; Q_i - heat load of the connected consumer, Gcal / h.

Relation $\frac{Q'}{Q}$ conditionally expresses the coordinate of the consumer's connection point.

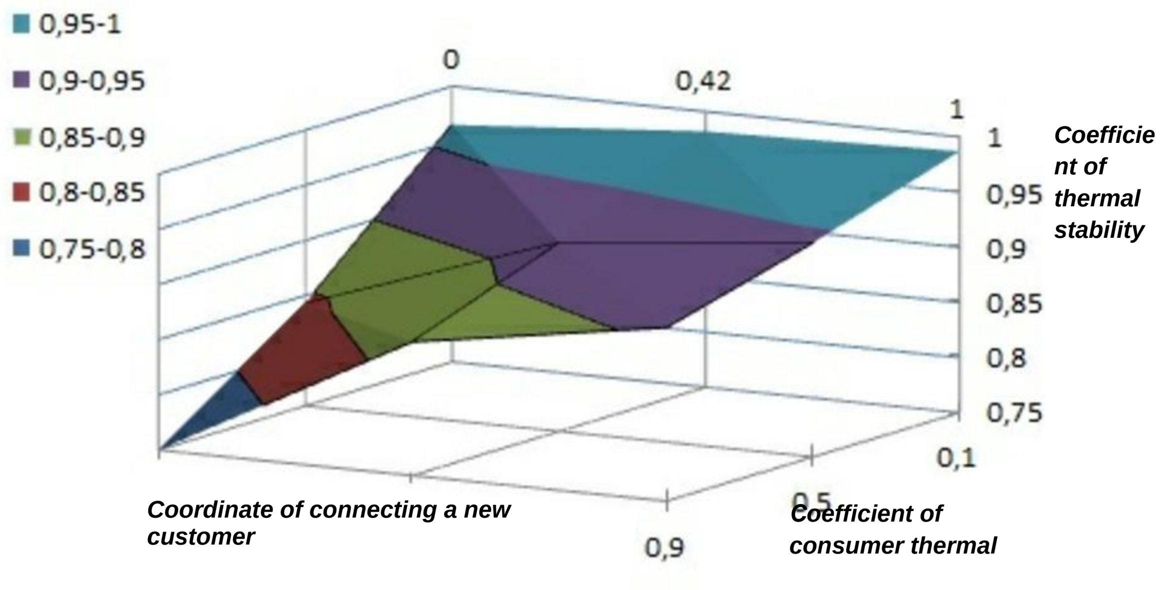

Figure 2. Dependence of the hydraulic stability coefficient of residential house No. 6 on the heat load and the connection point of a new consumer

Analysis of the results of hydraulic stability coefficient calculation for residential house No. 6 showed that the value of the change in the hydraulic stability coefficient is in the range from 1% to 25%. Lowering the coefficient of hydraulic stability negatively affects the reliability of the entire heat supply system. [6-7] Thus, Table 2 shows the dependence of the reliability index of the heat supply system on the coefficient of hydraulic stability.

In accordance with SP 124.13330.2012 "Heating networks" (updated version of SNiP 41-02-2003), the minimum permissible probability of failure-free operation of a centralized heating system (CHS) as a whole should be taken equal to P_{chs} = 0.86. And the minimum allowable indicator of operational readiness of the CHS is K_r = 0.97 [9]. Thus, the minimum permissible index of reliability of a centralized heating system is found by the formula:

$$H_{chs}= P_{chs}\cdot K_r= 0.86\cdot 0.97 = 0.83 \quad (3)$$

Reliability index H_{chs} = 0.83 corresponds to 0.11 share units of hydraulic stability change of the system according to Table. 2. Hence, with a decrease in hydraulic stability below this value, the heat supply system will not be reliable.

Table 2. Dependence of the reliability index of the heat supply systemon hydraulic stability coefficient

Change in hydraulic stability, share units.	Maximum reliability limit, share units.
Up to 0.05	0.93–0.91
0.060–0.10	0.90–0.84
0.11–0.15	0.83–0.79
0.16–0.20	0.78–0.71
0.21–0.25	0.70–0.66
0.26–0.30	0.65–0.61
0.31–0.35	0.60–0.56

Thus, according to Table 1, one can see that with the connection of a consumer at each considered point with a heat load equal to 10% of the branch load, the value of the change in hydraulic stability always remains within the permissible limits for ensuring the reliability of the heat supply system. And with the connection of a consumer in all considered points with a heat load equal to 90% of the load of the branch, the value of the change in hydraulic stability does not satisfy the level of reliability of the heat supply system. If a consumer is connected at points 1 and 2 with a heat load equal to 50% of the load of the branch, the value of the change in hydraulic stability remains within the permissible limits for ensuring the reliability of the heat supply system, and when connected at point 3 it does not satisfy the reliability requirements.

3. Conclusions

Thus, the higher the heat load of the connected consumer and the closer it is located to the end user, the higher the impact is on its hydraulic resistance coefficient. To eliminate misalignments, it is necessary to perform flow distribution calculations, and in case of deviation of actual flow from calculated values, the implementation of adjustment measures is required. Essentially, the adjustment measures consist in linking hydraulic resistances of heat-consuming installations, in accordance with the operation mode of the network equipment [5, 14] and the required heating agent flow rates.

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