Heating network topology

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Abstract. The article proposes an algorithm for the topology of the heat network by generating trees of the initial redundant heat network diagram, conducting a directed search of possible system states. The technique allows you to choose the optimal configuration scheme for dead-end heating networks.

1. Tracing of heat networks

The problem of optimizing the topology of heat networks is directly related to the problem of choosing the optimal heat supply scheme. When developing a scheme, there is always a question of choosing a heat supply source, its capacity and distance from the consumer, and the problem of transport of the heat carrier is also considered.

When building a residential area or industrial sector, existing heat sources are considered, and their ability to connect an additional load. However, due to the current existing development and the availability of spare capacity at the sources, it is necessary to conduct an optimization assessment of the connection of consumers.

According to clause 6. 1 [1] "the choice of the object's heat supply system is made on the basis of the heat supply scheme approved in accordance with the established procedure". The adopted heat supply scheme should ensure the energy efficiency of heat supply and heat consumption.

The regulatory documentation does not contain criteria and recommendations for choosing the optimal scheme of the heat network. Solutions for trace heating networks are accepted in the best case, the comparison of several variants of traces using linear optimization techniques. The problem of optimizing the topology of heat networks is not considered by design organizations. The result of this work is the configuration of heat networks with the indication of the lengths and diameters of sections, hydraulic and emergency modes of calculations are performed.

Optimization of the configuration of heating network schemes in some cases provides greater energy efficiency than only optimization of pipeline diameters. Rational arrangement of loads in the...
main branches in the future gives a reduction in costs, which further contributes to the economic component.

2. Methodology of trace heating networks
The most effective method for tracing heat networks is to iterate through the trees of the original redundant scheme and select the optimal subnet in the form of a tree. This method is successfully used in solving problems with a pre-planned redundant heat network tree, which is a calculated scheme constructed by the researcher as a set of all possible variants of the heat network. The method of sorting trees of the original redundant scheme was successfully used to find the optimal configuration and parameters of heat networks of complex structure in large cities, where it is necessary to take into account such factors as the need to reserve highways of large diameters, binding to the urban plan, the need to install pumping or throttling substations in changing terrain[2]. This method, unfortunately, is not used by design organizations, due to the high special qualification requirements for developers.

For the purposes of designing new local developments, reconstruction of heat supply systems in small cities and development of practical (normative) recommendations regarding the topology of heat networks, the study is provided using the methodology proposed by B. L. Shifrinson [3].

To solve the problem of building a heat network, the following wording is adopted: it is necessary to determine the groups of consumers who are supplied through common branches, and consumers who are supplied through individual branches from the main network. The initial data for solving the problem is the location of the heat source, the location of consumers and their loads.

It is necessary to perform a directional search of possible system States, i.e. it is proposed to generate a new heat network tree each time by conducting a directional search of possible system States. This technique is given in [2]. The initial state of the system is characterized by a tree (Fig. 1), when each consumer is supplied from the backbone network through an individual branch. In other words, the number of tie-ins in the backbone network is equal to the number of consumers. All other States are generated starting from the first one.

![Figure 1. Enumeration of trees at the first iteration](image)

In intermediate iterations, the described algorithm is applied repeatedly "within itself" until the lowest hierarchical level is reached when considering consumers (Fig. 2). In turn, connecting consumers to the branch is also possible either through individual sections of the heat network, or by other means. Thus, the task of searching for common and individual branches arises again, but at a lower hierarchical level.
In the final iteration, the original main highway is "degenerated" when building trees. Figure 3 illustrates the process of building trees using an example.

The main highway in the last iteration runs perpendicular to the original direction. The "in-itself" algorithm is repeated at this stage as many times as possible compared to previous iterations. Thus, at the last iteration, it is necessary to consider the initial state of the system, which can be characterized by the location of the main highway perpendicular to the one accepted at the beginning of the algorithm.

The number of iterations is determined by the minimum of the target function, which is determined by the economic component.
3. Specific pressure loss when selecting heat supply schemes

When choosing the diameters of heat inputs from the mains of heat networks, the design usually uses the value of specific pressure losses of 5-10 mm of water.St./m. The datum was determined several decades ago and is typical for the "economic" flow rate in the main highways at the appropriate ratios of metal and electricity costs for that time. Unfortunately, there is a very common misconception among design and operating organizations that these values are a standard value.

Modeling schemes of heat networks suggests the need for an individual approach and the adoption of higher values of specific losses in the calculations.

In addition, when connecting to the consumer's heat network according to an independent scheme, the sufficient available set for the consumer varies between 1.5-2.0 ATM (for two-stage schemes for connecting hot water systems) and 1.0-1.5 ATM (for single-stage schemes for connecting hot water systems), which is significantly lower than the available differential at the point of connection, and the speeds at the heat inputs can be increased to values limited by noise exposure and network operation at pressure differences corresponding to emergency modes.

4. Conclusion

The proposed algorithm assumes a directed search for the optimal state of the system—the heat network. The search is implemented by generating heat network trees based on the formulated problem statement: it is necessary to determine the groups of consumers that are supplied through common branches and consumers that are supplied through individual branches from the backbone network. When comparing the generated configurations, the optimal system state is selected.

The results obtained by the algorithm are the optimal configuration and optimal parameters of the heat network.

References

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