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«Optimization of costs for production and transportation of heat carrier in the district heating system»

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Problem statement

The target function is the sum of financial expenses for the production and transfer of heat energy for heating and hot water supply from heat sources to consumers (electric energy consumption by pumping stations):

$$F(\boldsymbol{q},\boldsymbol{h}^p,\boldsymbol{x})=\sum_{i=1}^{k} q_i z_i(q_i)+\sum_{\substack{l=1\\ j\in I_h^p}}^{n_h} z_e \frac{x_j h_l^p}{\rho\eta_l}+\sum_{\substack{l=n_h\\ j\in I_h}}^{n} z_e \frac{x_j h_l}{\rho\eta_l}\to \min$$

Optimization problem constraint system:

$$\begin{cases}\mathbf{Ax}=\mathbf{g}\\ \mathbf{By}=0\end{cases},$$

$$\mathbf{y}+\mathbf{h}=\mathbf{SXx},$$

$$\sum_{i=0}^{k}|g_i|=\sum_{i=k}^{m-k}|g_i|.$$

$$q_i^{\min}\le q_i\le q_i^{\max},\ i=1,\dots,k,$$

$$p_i^{\min}\le p_i\le p_i^{\max},\ i=1,\dots,m.$$

$$y_i^{\min}\le y_i,\ i=1,\dots,m.$$

$$x_j^{\min}\le x_j\le x_j^{\max},\ j=1,\dots,n;$$

$$t_i^{\min}\le t_i,\ i=1,\dots,m.$$

Solution methods

The tariff for thermal energy includes financial costs for the purchase of fuel, electricity, water, costs for chemical preparation of the heat carrier, as well as costs for the payroll, depreciation, taxes and other costs. As shown by the research the tariff for thermal energy is inversely proportional to the capacity of the manufacturer and is represented as a hyperbolic function:

$$z_i(q_i) = \frac{a_i}{q_i} + b_i$$

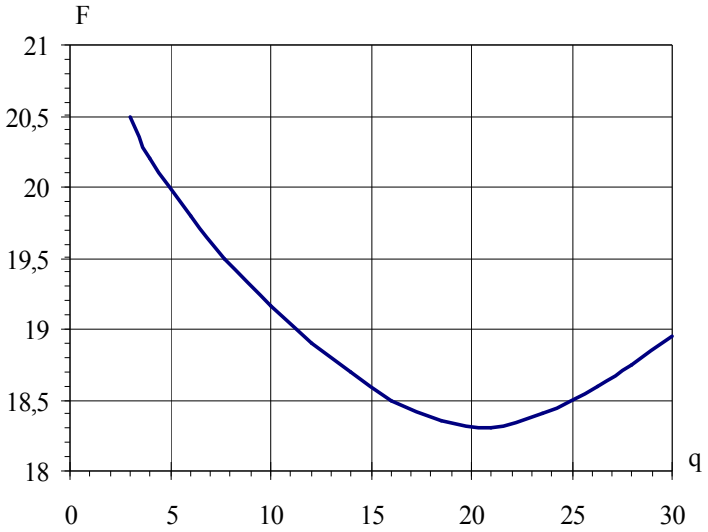

Figure 1. The dependence of the total cost of production and transportation of the heat carrier on the power of the heat source

Table 1. Results of calculations of test problems under various scenarios.

Scenario number	Number of heat sources	Number of consumers	Number of pressure regulators	Number of branches	Number of nodes	Number of iterations
1	2	35	0	81	80	3
2	4	45	0	119	115	3
3	4	45	4	119	115	33
4	5	45	0	119	115	4

Conclusions

1. The presented optimization algorithm allows to minimize the cost of production and transportation of the heat carrier, to determine the optimal head of the heat carrier in various sections of a multi-circuit heat network with a different number of consumers and producers for a finite number of iterations. In the case of calculating networks without pressure regulators, the target function has a linear form. In this case, the proposed method for solving the problem showed rapid convergence. If there are pressure regulators, the target function becomes nonlinear, which worsens the convergence of the iterative process.
2. Optimal regulation allowed to reduce total costs in the test calculation to 10%.
3. The results of the research can be used to optimize the thermal capacity of power – and - heating plants or boiler houses operating in a single multi -circuit heat network.

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