New Results in Development of Methods for Optimization of Heat Supply System Parameters and Their Software Implementation

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ABSTRACT

Modern practice of solving the problems of heat supply system design generates the need to solve the problem of choosing optimal parameters for a considerable set of equipment. The problem of choosing optimal parameters involves determining the diameters of new heat pipelines, searching for the methods to reconstruct existing network sections, and choosing the pressure heads of pumping stations and their sites. To solve this problem the authors suggest a dynamic programming method for optimization of branched networks and a multiloop optimization method for calculation of loop networks, both being developed in the theory of hydraulic circuits. The paper presents new versions of algorithms for the implementation of these methods and describes their capabilities. These algorithms are implemented in the software package SOSNA-M. This software was developed on the basis of a methodological approach created to develop algorithms and methods for optimization of heat supply system parameters, flexibly control the computational process, optimize heat supply system parameters on a feasible set of equipment and improve the types of reconstruction of the existing components.

Keywords: Algorithms, Concurrent Computing, Dynamic Programming, Heat Supply System, Optimal Parameters, Optimization Methods, Software

DOI: 10.4018/ijeoe.2013100105
INTRODUCTION

Designing heat supply systems (HSSs) of modern cities and industrial centers, we have to solve the problem of choosing optimal HSS parameters which implies determining diameters of new heat pipelines, pressure heads of pumping stations and their sites as well as the ways to reconstruct existing network sections. The development of market for heat pipelines, equipment and technologies used in HSS construction significantly increases the opportunities for the implementation of technical solutions. This, in turn, requires that the opportunities be taken into account in HSS modeling and optimization, since each type of equipment has its own characteristics and is described by its set of mathematical models that characterize its parameters and techno-economic relationships.

Analytical methods were the first theoretically substantiated methods for calculating optimal diameters of the pipeline network. The most well-known among them is the method suggested by Grashof in 1875 for a water main with point loads. He solved the problem of search for a constrained minimum of the water main cost function in terms of the given total pressure loss and on the basis of the Lagrange multiplier method.

The first studies in the field of heat supply to focus on the considered problem appeared in the 1930s (Davidson, 1934; Yakimov, 1931). Besides their authors aimed at calculating the main with point loads and tried to apply the Grashof method to calculate branched heat networks. The papers by A.M. Zanfirov (1933, 1934) present an analytical solution to the problems of optimal diameter selection for the branched network with random topology and an available head in the sources.

The development of analytical methods for technical and economic HSS calculation by assuming not pipeline diameters but pressure losses in the network section to be independent variables.

This made it possible to state the problems for randomly configured branched heat networks (but without loops and with one heat source), and significantly simplify the way of solving them. B.L. Shifrinson obtained a number of key results, which largely underlie the theory and practice of HSS calculation. V.Ya. Khasilev (1957) summarized and studied the properties of continuous models of HSS parameter optimization and discovered the flatness of the economic criterion (calculated costs) in optimal solutions.

Analytical methods for solving the problems of parameter optimization of branched HSSs had been widely spread in the international design practice before the discrete optimization methods appeared (Heindrun, 1968). The analytical methods for calculation of optimal pipeline diameters in multiloop heat networks did not evolve because they were hard to apply.

Today the most developed and popular methods are the methods of discrete optimization. Their major competitors are the methods of linear and dynamic programming (Bellman, 1957; Dantzig, 1963). Years of experience in solving network problems have proved that the dynamic programming method is the most effective, since it allows the global minimum to be found taking into account the diversity of physical and technical constraints, discreteness of equipment parameters and location, and other specific features of the system and its components. This method can be successfully applied to optimize newly created systems and solve the reconstruction problems of the expanding ones. This method was first implemented by A.P. Merenkov in 1963 to optimize the parameters of branched heat networks (Merenkov & Khasilev, 1985). Later on, these problems were called the scheme and parameter optimization problems, and the dynamic programming method was repeatedly implemented at Energy Systems Institute in the form of standard programs for different types of computers (Merenkov & Khasilev, 1985).
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