WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 6, Issue 2, February- 2025

PARAMETRIC OPTIMIZATION OF ENGINEERING NETWORKS TAKEN INTO ACCOUNT OF THE PROBABILISTIC CHARACTER OF THE TARGET PRODUCT CONSUMPTION PROCESS (PPCP)

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Abstract
In article the developed mathematical methods of the accounting of stochastic water consumption are given in systems of giving and distribution of water to water consumers.

Keywords: Engineering networks, water pipelines, pumping stations, water supply.

Introduction
The mathematical models of engineering networks discussed in previous articles [1, 2] are essentially an extension of models of steady flow distribution in the case of a probabilistic representation of the PPCP. The use of these models is possible if and only if the structure of the network and the parameters of all its passive elements are known. At the same time, searching for the network structure and parameters of passive and active elements is the most important task, the solution of which is necessary at all stages of managing the development of engineering networks. However, it should be noted that in real conditions of development of engineering networks, the possibilities of structural optimization are often very limited. For example, it is required to lay water supply network lines along all city streets and the structure of these streets almost completely determines the structure of the network; of course, the task of optimal placement of active sources (pumping stations) on the network lines remains.
Therefore, the most practically significant for the types of heat, water, and gas supply engineering networks considered in this article is the problem of parametric optimization, i.e. a task that is also called technical and economic calculation of

networks and consists, for example, in determining "those diameters of network pipes and water pipelines at which the costs of construction and operation of water lines and pumping stations supplying water to them will be the least over the estimated period of their operation" [3].

First of all, we note that currently all parametric optimization methods can be used only if some initial flow distribution is known, for the selection of which, unfortunately, there are no well-founded algorithms. The initial flow distribution is determined intuitively with some consideration of reliability requirements [4] for providing consumers with the target product in the event of failures of various network elements. This situation leads to the fact that, given a priori of the flow vector along all network lines for which Kirchhoff's first law is satisfied, the parametric optimization problem is solved so that the desired matrix (diagonal) of hydraulic resistance coefficients also provides, and only such, values of the transverse variable vector (losses) in network lines $|h| = |q| \times diag|S|$, under which Kirchhoff's second law is calculated.

Thus, the problem of parametric optimization is reduced to some analysis of the problem of calculating steady flow distribution - searching for a solution, i.e. The "linking" of the network is specified by sorting through various variants of the matrix, ordered according to some algorithm.

Historically, one of the most substantiated methods of parametric optimization is the "fictitious costs" method proposed by L.F. Moshnin [3]. The main idea of this method is that when determining the total value of the vector of active sources, it was proposed to abandon the calculation $H = \sum_{i \in R}^{k} h_i$, where the summation is carried out over all elements included in the path R on the network graph that connects the active source to the dictating point, i.e. the point where the excess pressure is minimal and equal to the required one. Considering that the choice R is not clear, because the indicated points in a graph with cycles can be connected in different ways, L.F. Moshnin proposed defining the required source vector in the form:

$$H = \sum_{i \in N}^{n} Xh, \qquad (1.1)$$

where X - is some significant coefficients (in fractions of units, characterizing the role i - oh line, i.e. its contribution to the total required source pressure; N - the set of all network lines.

At the location of the active source, it is introduced into the network only at one network node corresponding to the dictating point. It should be noted that (1.1) is satisfied for any values X, which satisfy the requirements of Kirchhoff's first law. In addition, you should immediately recognize the not complete analogy of (1.1) and [1,2]

$$H_\Delta = D \cdot h = C_i \cdot h \quad (1.2)$$

(1.2) is the general case, and (1.1) is a particular case, when the pressure difference is determined only between the balancing node of the network and its dictating point. Indeed, the magnitude of the pressure difference between any network node and the balancing one assording to (1.2) is equal to:

$$H_\Delta = C_t h \quad (1.3)$$

and the required source pressure (without taking into account the statistical pressure determined by the difference in geodetic elevations) is

$$H = \max\{H_\Delta\}, \quad (1.4)$$

those. equal to the maximum element of the vector $|H_\Delta|$

From a comparison of (1.1) and (1.3) we have that "fictitious expenses"X can be just one side of the matrix of generalized network parameters - D = C_t [2,3]. This side corresponds to the dictating node (dictating point). The second part of L.F. Moshnin's algorithm is that the network is "linked" according to fictitious expenses. In this case, the fictitious resistances of network sections are assumed to be equal to $l \cdot \sqrt{q}$, where l - length of the section, and q - pre-planned consumption. In the process of "linking" there is a redistribution of "fictitious expenses" X so that for each closed network head К the condition was met:

$$\sum_{i \in k} l\sqrt{q} X^{-0.75} = \sum_{i \in k} h_f = 0, \quad (1.5)$$

which are analogous to Kirchhoff's second law for "fictitious expenses". It is important to note the connection between "fictitious" h_f and actual pressure losses h across network sections:

$$h = h_f \cdot M, \quad (1.6)$$

where, M - some constant for all sections of the network.

Thus, in accordance with (1.6), a network linked by "fictitious costs" turns out to be linked by actual ones, because

$$\sum_{i \in k} h = M \sum_{i \in k} h_f = 0, \quad (1.7)$$

those. Kirchhoff's second law is satisfied, and the first is satisfied a priori at the stage of assigning preliminary flow distribution. In accordance with the mathematical model proposed in [1], the values of pressure losses in linear networks can be calculated as the values of the elements of a column vector:

$$h = diagS|CQ|^2, \quad (1.8)$$

where, Q – load matrix in nodes; C – matrix of load distribution coefficients; diagS – diagonal matrix of hydraulic resistance coefficients.

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