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About One Method of Parametric Optimization of Engineering Networks Taking Into Account the Probabilistic Nature of The Process of Target Consumption Product (Ptcp)

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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. 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: water taps, uneven pressure, internal water supply and sewerage of buildings, utilities, pressure instability, pump, tanks, pressure, network failure, internal water supply systems, frequency converter, water supply and distribution systems.

The mathematical models of engineering networks considered in previous articles [1,2] are, in fact, an extension of the models of steady flow distribution to the case of a probabilistic representation of PTCP. 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, the search for the network structure and the 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. At the same time, however, it should be noted that in the real conditions of the development of engineering networks, the possibilities of structural optimization are often very limited.

For example, it is required to lay water supply lines along all streets of the city and the structure of these streets almost completely determines the structure of the network, of course, the tasks of optimal placement of active sources (pumping stations) on the network lines remain.

Therefore, the most practically significant for the types of engineering networks of heat, water, gas supply considered in this article is the problem of parametric optimization, i.e. the task, which is also called the technical and economic calculation of networks and consists, for example, in determining "such diameters of network pipes and conduits at which the costs of construction and operation of water lines and pumping stations that supply water to them will be the smallest for the estimated period of their operation" [3].

First of all, we note that at present all parametric optimization methods can be used only if some initial flow distribution is known, for which, unfortunately, there are no reasonable algorithms. The initial flow distribution is determined intuitively, taking into account the reliability requirements [4] of providing consumers with the target product in case of failures of various network elements. This provision leads to the fact that, for a given a priori, the flow vectors along all lines of the network $|q|$ for which the first Kirchhoff law is satisfied, the parametric optimization problem is solved so that the required matrix (diagonal) of hydraulic resistance coefficients $diag|S|$ provided also, and only such, values of the vector of the transverse variable (losses) in the lines of the network $|h| = |q| \times diag|S|$, under which the second Kirchhoff law is calculated.

Thus, the problem of parametric optimization is reduced to some analysis of the problem of calculating the steady flow distribution - the search for a solution, i.e. "linking" of the network is set by sorting through various variants of the matrix ordered according to some algorithm $diag|S|$.

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Historically, one of the most reasonable methods of parametric optimization is the method of "fictitious costs" proposed by L.F. Moshnin [4]. 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 on the network graph, which connects the active source with the dictating point, i.e. the point where the excess pressure is minimal and equal to the required one. Considering that the choice is not unambiguous, since the indicated points in the graph with cycles can be connected in various ways, L.F. Moshnin proposed to determine the desired source vector in the form:

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

Where X - are some weighty coefficients (in fractions of units, characterizing the role i - oh line, i.e. its contribution to the total required head of the source;

N - set of all network lines.

At the location of the active source, only one network node is introduced into the network, 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, one should immediately recognize the incomplete analogy of (1.1) and [1,2] (1.32), and (1.32) is the general case, and (1.1) is a particular case, when the head difference is determined only between the balancing node of the network and its dictating point. Indeed, the value of the pressure difference between any network node and balancing according to (1.32) is equal to:

$$H_\Delta = C_t h \ (1.2)$$

and the desired head of the source (without taking into account the statistical head, determined by the difference in geodetic marks) is

$$H = \max\{H_\Delta\}, \ (1.3)$$

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

From comparison (1.1) and (1.2) we have that "fictitious expenses" X can be just one side of the matrix of generalized network parameters - $D = C_t$ [2,3,5]. This side corresponds to the dictating node (dictating point). The second part of L.F. Moshnin's algorithm [4] is that the network is "linked" by fictitious costs. In this case, the fictitious resistances of the network sections are taken equal to $l \cdot \sqrt{q}$, where l - length of the section, a q - pre-planned flow. In the process of "linking" there is a redistribution of "fictitious costs" X so that for each closed head of the network K the condition:

$$\sum_{i\in k} l\sqrt{q}X^{-0.75} = \sum_{i\in k} h_f = 0, \qquad (1.4)$$

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

$$h = h_f \cdot M, \ (1.5)$$

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

Thus, in accordance with (1.5), the network linked by "fictitious costs" turns out to be linked by actual ones, since

$$\sum_{i\in k} h = M\sum_{i\in k} h_f = 0, \ (1.6)$$

that is, the second Kirchhoff's law is fulfilled, and the first one is fulfilled a priori at the stage of pre-flow assignment. In accordance with the mathematical model proposed in [1,6,7,8], the values of pressure losses in linear networks can be calculated as the values of the elements of the column vector:

$$h = diagS\left|CQ\right|^2, \quad (1.7)$$

where Q – load matrix in nodes; C – load distribution coefficient matrix;

$diagS$ – diagonal matrix of hydraulic resistance coefficients.

The application of this method allows us to get more economic solutions when developing systems for supplying target products to consumers.

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