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Уміщено матеріали конференції, в яких висвітлено питання технології підготовки питної та технічної води; технічні аспекти водопостачання; біологічні та біохімічні аспекти очищення комунально-побутових та промислових стічних вод; утилізацію осаду та активного мулу; моніторинг та прогнозування стану природних водойм в умовах інтенсивного водоспоживання.

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ON PRELIMINARY ANALYSIS OF INDUSTRIAL WATER SYSTEMS

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Presented paper deals with the problem of synthesis of optimal industrial water networks (WN). It is known that two general approaches to synthesis WN are used (fig. 1).

The effective pinch methodology (in conventional form) consists of two stages [1]: 1) Pinch analysis of initial state of system with the purpose of finding "bottle-neck" point; 2) Heuristic design of WN structure based on pinch analysis results. The main limitation of pinch methodology is "semi-manual" way of implementation of these two stages.

The group of systematic superstructure synthesis method (SSM) consists in solving a class of mathematical programming problem, formulated on the basis of WN superstructure. These methods are more conducive to implementation in software. The main reason of applying systematic optimization-based methods is their robustness, i.e. possibility of calculating the global optimum independent of number of variables (scale of the problem).

It is a fact that generally the mathematical model of WN structure leads to non-linear programming problem (NLPP) with linear or non-linear goal function.

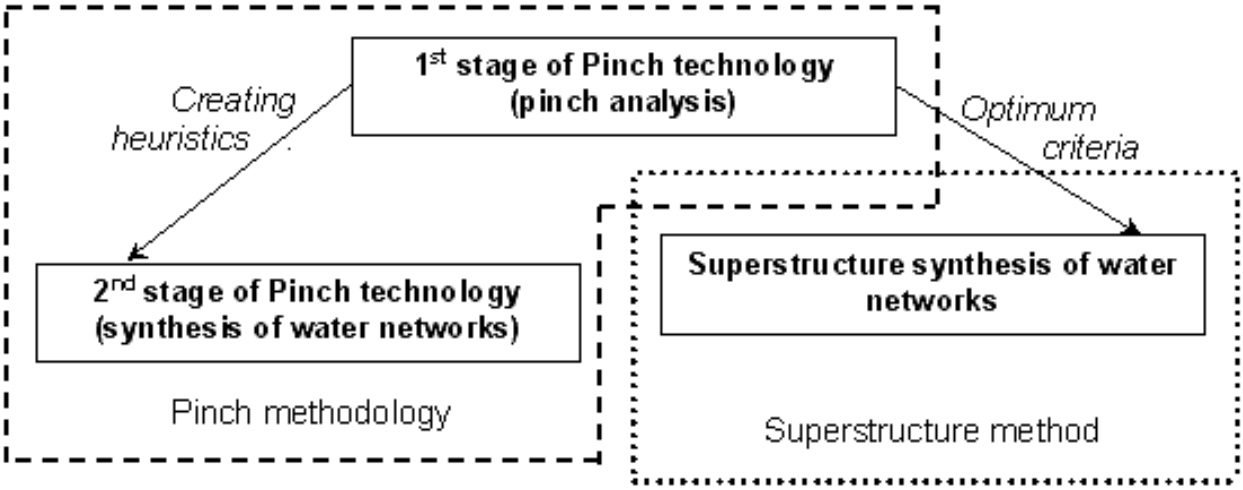

fig. 1. Approaches to WN synthesis

It stands to reason that available methods of solving the NLPP are not universal. The effectiveness of NLPP optimum searching depends on many factors (number of variables, the smooth of goal surface and so on). Additionally, the investigations showed that size of optimization problem tends to extend during the number of water usage operations and external fresh water sources, which WN includes.

Grassroot as well as retrofit design practice of WN enables one to identify some methods which guarantee the achievement of global optimum of the problem. Some groups of these methods you can see below.

1. From the optimization point of view
    1.1. Usage of specialized commercial software
    1.2. The principle change of optimization procedure used

2. From the WN model point of view

2.1.The transformation of WN design problem

2.2 The simplification of WN model by way of selection the non-optimal variants

The procedure of optimum search in commercial software is generally the combination of well known methods of determined optimum search. That is why announced software being partially effective can't guarantee the satisfactory results for every case of synthesis of WN structure.

Let us see the example of non-effectiveness of commercial software. The synthesis of WN structure for test problem [1] was implemented by optimization NLPP [2]. Announced test example is simple (two processes use water, two contaminants and one external source of fresh water). The optimal meaning of total freshwater usage (known from the literature) is 54 t/hr.

The experiment was made using the Matlab 7.0 Optimization Toolbox. The initial values $\overline{X}_0$ of variables vector $\overline{X}$ were changed simultaneously. The results of experiment are on Fig 2.

As we can see on Fig. 2 in the given range of values vector $\overline{X}_0$, are present not only optimal values but non- optimal, which are bigger than optimum criteria.

The reason of incapacity of the optimization results probably is degeneracy of system constraints on some stage of optimization routine. Notice, that during the synthesis of the same WN by the other superstructure method [3, 4] in Matlab Optimization Toolbox software the satisfactory results were found [4].

Another alternative is to use the modern methods of non-determined (stochastic) searching of optimum. These methods have been applied rather frequently lately. The reason of such growing popularity is the peculiarity of stochastic methods. As we know the non-determined methods of searching optimum guarantee the achievement of global optimum by limited number of steps. For instance, the effective Luus-Jaakola stochastic algorithm was used by Authors for the WN synthesis [5, 6].

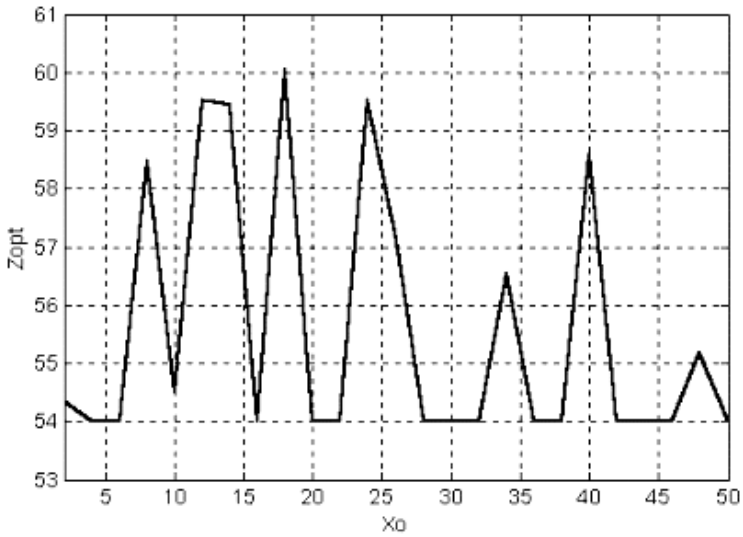

Figure 2 – The dependence of optimization results (total fresh water usage) from initial values of optimization variables (Matlab Optimization Toolbox).

But there are a lot of defects in stochastic methods of optimum searching. The most important defect is high demand of calculation resources. Considering the level of modern computers development one can see that talking about catholicity of non-determined methods for searching optimum as parts of WN structure synthesis is not reasonable.

The design task transformation involves some change of initial task. For example in [3] water usage units were aggregated by location and functions. So that water streams were distributed between water usage blocks (6 blocks contra 16 water usage units). It results in an decrease in dimension of optimization problem by a decade. But, however, the problem of optimal allocation of water streams inside of water-usage block is still topical.

The other example of transformation is making the WN model to guarantee the optimum finding in every case of WN structure synthesis. In this case class of linear programming problems (LPP) is the most convenient. Using LPP in WN structure synthesis excludes “hangs” in local optima. The dimension of the optimization problem stops beeng an obstacle.

Furthermore, it can be shown [7] that pinch analysis results can be used to increase efficiency of alternative approach to WN synthesis –SSM. One can make SSM more effective by reducing the superstructure and adding special optimum criteria. To improve such integrated procedure of WN synthesis the alternative way of pinch analysis was proposed. Alike in HEN and MEN synthesis cases, it is possible to present and solve the pinch analysis problem as “transportation-like” linear programming problem [8].

As in conventional pinch method, both water-usage processes and fresh water streams must be divided on concentration intervals. In terms of transportation model water-usage processes, divided by intervals, are sources of contaminant transported. And fresh water streams, divided by intervals, are sinks of contaminant transported. Partial mass loads give the total production volume of sources. The total demand of sinks depends on freshwater flowrates in WN.

Conclusions

Thus, each of the common approaches to synthesis of WN have some drawbacks. Using of integrated combinatorial/conceptual routine gives us a possibility to make a design process effective and at the some time to save it’s universality. The method of pinch analysis proposed in this paper has more advantages than traditional one has. The most important of these advantages are high level of formalization and the possibility to include the presence of several fresh water sources.

Note, that in this paper the authors considered the situation when only one group of contaminants gets into water. This case is not general but this can occur in practice.

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ECONOMIC MULTIVARIATE ANALYSIS IN SEWAGE SYSTEM DESIGNING FOR RURAL SETTLEMENT

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Paper presents application of multivariate economic analysis to decision making process concerning selection of the most economically suitable concept of sanitary sewage system for a selected rural settlement in Poland, Drelow, Lublin Voivodeship. Nowadays, approx. 40% of Drelow commune residents have access to centralized water supply system and there is no existing municipal sanitary wastewater removal system. Thus, sewage management is performed by septic tanks of uncontrolled quality, sometimes supported by drainage/drain field systems. Our analysis covered a rural settlement with 121 households with 421 residents and several municipal services such as school, kindergarten, bakery, library, printing office, barber, gas station etc. etc.

Three variants of sewage removal and treatment were developed: unconventional gravity-pressure sewer network, gravity-pressure sewer network combined with local domestic wastewater treatment plants and full pressure sewerage network. In all the tested variants, the container wastewater treatment plant of daily capacity 450 m^3 day^{-1} of sewage was applied. Investment and exploitation costs estimations for 30 years period of system operation were performed for all the variants applied. Our economic multivariate analysis was based on one simple and three dynamic indicators of financial efficiency: payback period, Dynamic Generation Cost (DGC), Net Present Value (NPV) and Benefit-Cost Ratio (BCR). Then, the obtained indicators were the input data for the objective function allowing to select the most appropriate variant.

Our analysis showed that the most suitable was variant No 1, covering unconventional sewerage network. However, it was also noticed that all of the tested designs were ineffective economically. None of the tested variants was assessed as profitable due to negative values of NPV indicator and value of BCR lower than 1.0.

The presented studies proved usefulness of multivariate analysis and applicability of economic efficiency indicators in decision making concerning wastewater removal and treatment.