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INDUSTRIAL WATER USAGE NETWORK SYNTHESIS: SUPERSTRUCTURE METHOD

A significant problem of post-Soviet industrial production facilities is the excessive resource and energy intensity that causes additional environmental damage, affecting the cost of production.

As part of a set of problems solved at the stage of industrial enterprise reconstruction, there is a rational organization of the enterprise's water management. A number of studies are devoted to the optimization of pure water and wastewater treatment subsystems under production-line conditions.

It is practically assured that the water usage subsystem is a key component of industrial water economy. Nonetheless the problem of optimal organization of the water usage subsystem is not traditionally considered in water economy optimization projects. Instead of this the issue of optimal water usage is taken into account when calculating the heat and mass balances of an enterprise.

An approach that implements the principles of process integration in area of industrial water economy is the so-called Water pinch analysis method [1]. Along with a number of undoubted advantages, this concept has some drawbacks, not least of which is a weak formalizability.

This work presents the part of research program related to the mathematical optimization of water economy networks in alternative to Water pinch analysis. Optimization approach to the synthesis of industrial water usage networks involves the following steps:

1. Preparation of the input data [2].
2. Compilation of a generalized water consumption network (superstructure), that takes into account all possible options for the distribution of fresh and reused water flows.

3. Composition of a mathematical programming model based on the superstructure [3].
4. Solution of the model by one of the methods followed by the interpretation of the results.

It should be noted that the methodology in the proposed form is a variation of the well-known generalized process flowsheet method (also known as structural parameters method). The proposed superstructure differs from traditional generalized process flowsheets primarily by the type of structural parameters.

Typically, the flow separation parameters that characterize the branching of flows in splitters are coefficients (relative values) that are in the interval [0; 1]. Such an approach is justified in the general case, when the values of different flows of the network are widely diverging. Then to calculate the optimality criterion, one needs to bring them into a consistent system. In our case, the spread of flowrates is slight. So, it is advisable to use the representation of structural parameters in the form of not relative, but absolute values.

As a goal function, a linear fractional expression is proposed that minimizes the fresh water consumption and increases water reuse, which is the design goal. The goal function also takes into account the impact of fresh water streams on reused water streams. Mathematical model constrains are based on water network mass balances and ensure model adequacy.

The resulting model is a constrained nonlinear programming problem, which contains both equality constraints and inequalities. The number of model variables (structural parameters) is proportional to the number of water usage units squared.

Table 1. Water usage balance data

Unit/ process	Nominal water flowrate, tons/hour	Contaminant	Maximum contaminant inlet concentration, ppm	Maximum contaminant outlet concentration, ppm	Mass load, kg/ hour
1.	35	A	80	240	5,6
		B	30	90	2,1
2.	400	A	0	100	4
		B	25	75	20
Σ	435				

The case study presented below illustrates described methodology. The water usage network includes two users and contains two groups of contaminants (labeled as A and B in Table 1).

The values of structural parameters obtained by optimization of water usage network (Fig 1.) are shown in table 2.

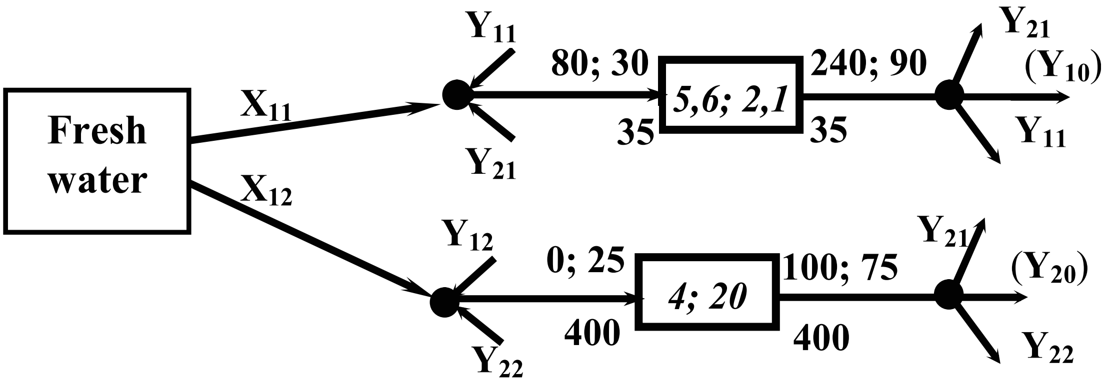

Fig 1.The superstructure of water use network:
Xij - fresh water flows; Yij– reuse water streams flows

Table 2. Structural parameters, tons/hour

X_{11}	X_{12}	Y_{11}	Y_{12}	Y_{21}	Y_{22}
10.70	201.80	1.83	41.40	22.50	179.30

It can be observed that the total usage of fresh water after optimization is 212.5 tons/hour, which suggests a significant water saving.

The method of mathematical optimization can be used both independently (as an alternative to Water pinch analysis) and within the framework of the integrated methodology former suggested by the authors [4]. In the latter case, the reliability of the obtained solution increases, since the obtained optimum is invariant to optimization method used.

The paper presented is part of an ongoing research project "Development of sustainable industrial water networks" (state registration No 0117U005297).

This paper is dedicated to the memory of Prof. Jacek Jeżowski (Rzeszów University of Technology) and Prof. Gennady Statyukha (National Technical University of Ukraine, "Kyiv Polytechnic Institute, elder friends and respected colleagues.

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ИССЛЕДОВАНИЕ СВОЙСТВ ПЛЕНОК ДИОКСИДА ТИТАНА НА САПФИРОВОЙ ПОДЛОЖКЕ

Возможность формирования тонких пленок на диэлектрических и полупроводниковых подложках открывает широкие возможности для конструирования функциональных устройств (фотоэлектрических преобразователей и чувствительных элементов газовых датчиков). Одной из важных особенностей газовых датчиков на основе тонких пленок диоксида титана (TiO_2) является возможность их работы при высоких температурах из-за химической стабильности пленки [1].

Для получения пленки диоксида титана на сапфировой подложке использовался метод центрифугирования с последующим отжигом в муфельной печи. Слой диоксида титана наносили из 0,3 М раствора диизопропоксида титана бис (ацетилацетонат) (75 % вес. в изопропаноле) в 1-бутаноле (99,8%, Sigma-Aldrich) на сапфировую подложку толщиной 0,43 мм методом центрифугирования (центрифуга SPIN NXG-P1, скорость вращения ротора 4000 об./мин., время нанесения 40 сек.). Сушка пленки диоксида титана осуществлялась в термошкафу при температуре 125 ^{0}C в течение 5 мин., а затем подвергалась отжигу при 500 ^{0}C в муфельной печи в течение 30 мин.

Проведены исследования пленки диоксида титана на сапфировой подложке методом атомно-силовой микроскопии,