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SCIENTIFIC AND TECHNOLOGICAL BASES FOR DESIGN OF INDUSTRIAL ENTERPRISE'S RESOURCE-SAVING WATER MANAGEMENT SYSTEMS

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НАУЧНЫЕ И ТЕХНОЛОГИЧЕСКИЕ ОСНОВЫ ПРОЕКТИРОВАНИЯ РЕСУРСОСБЕРЕГАЮЩИХ СИСТЕМ ВОДНОГО ХОЗЯЙСТВА ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ

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Abstract

Introduction: the conceptual regulations of the theory of sustainable socio-economic development provide the creation of resource-saving environmental friendly production, the basis of which are the effectively operating resource-saving water-use chemical processes (WUCP) of industrial plants. So, the objective of this investigation was the development of the designing methodology for scientific-reasonable resource-saving chemical processes of water management system for textile enterprises, which use the basic dyeing-finishing technology of cloth. **Methods and materials:** the thermodynamic exergy and thermodynamic water pinch methods of synthesis of resource-saving WUCP of industrial plants have been used and refined upon by us. The efficiency of proposed wastewater purification techniques — electrocatalytic destruction, photocatalytic destruction, catalytic destruction by hydrogen peroxide, coagulation, clarification filtration, magnetic treatment was studied on model and real effluents. The metal oxides were used as catalysts. The special eperimental technique for development of technology of heavy metals ions utilization as useful products, such as mineral pigments, has been proposed. **Results:** a seven-steps scheme was investigated for project design: 1) the source data gathering: environmental-oriented analysis (inventory) of industrial enterprise's technology; 2) the design of integrated resource-saving water management system of industrial enterprise; 3) the design of repeatedly-serial water integrated chemical process system of industrial enterprise's shops (process lines); 4) the development of wastewater purification techniques; 5) the development of intelligence (computer) system of resource-saving water management system of industrial enterprise; 6) the technological risk assessment and safety management system; 7) the estimation of ecologic and economic efficiency of the project. **Conclusion**: the methodology of designing of resource-saving WUCP of textile enterprises has been developed. The functional diagram of resource-saving WUCP of dyeing-finishing production of textile plant has been proposed. The structure of intelligence system application and software of resource-saving WUCP designing and operation has been developed. Wastewater purification techniques have been investigated. The electrocatalytic plus photocatalytic destruction and coagulation methods are proved to be most perspective in practice of sewage treatment. The basic technical-economic parameters of the project were estimated.

Keywords: methodology of designing water management systems, water-use technological processes, thermodynamic exergy method, thermodynamic water pinch method, wastewater purification techniques, electrocatalytic metod, technological risk, ecologic-economic effectiveness.

Аннотация

Введение: концептуальные положения теории устойчивого социально-экономического развития предусматривают создание ресурсосберегающего экологически безопасного производства, основой которого служат эффективно действующие ресурсосберегающие водопотребляющие процессы (РСВП) промышленных предприятий. Таким образом, целью данного исследования было развитие методологии проектирования научно обоснованных ресурсосберегающих систем водного хозяйства текстильных предприятий, использующих базовые красильно-отделочные технология обработки тканей. **Методы и материалы**: термодинамический эксергетический метод и термодинамический водный пинч-метод синтеза РСВП промышленных предприятий были использованы нами и доработаны. На модельных и реальных стоках исследована эффективность предложенных методов очистки сточных вод: электрокаталитической деструкции, каталитической деструкции пероксидом водорода, коагуляции, фильтрации, магнитной обработки. В качестве катализаторов использовали оксиды металлов. Предложена специфическая методика по реализации технологии утилизации ионов тяжелых металлов в качестве полезных продуктов, таких как минеральные пигменты. **Результаты:** разработана семиэтапная схема проектирования: 1) сбор исходных данных: экологический анализ (инвентаризация) технологии промышленного предприятия; 2) разработка интегрированной ресурсосберегающей системы водного хозяйства промышленного предприятия; 3) проектирование повторно-последовательной схемы водопотребления промышленного предприятия (технологических линий); 4) разработка методов очистки сточных вод; 5) разработка интеллектуальной (компьютерной) системы управления ресурсосберегающей схемой водного хозяйства промышленного предприятия; 6) оценка технологических рисков и управление системой технической безопасности; 7) оценка экологической и экономической эффективности проекта. **Заключение:** разработана методология проектирования РСВП текстильных предприятий. Предложена функциональная схема РСВП красильно-отделочного производства текстильного предприятия. Разработаны структура интеллектуальной (компьютерной) системы и программное обеспечение для проектирования и эксплуатации РСВП. Исследованы методы очистки сточных вод. Показано, что методы электро-, фотокаталитической деструкции и коагуляции являются наиболее перспективными в практике обработки сточных вод. Проведена оценка основных технико-экономических показателей проекта.

Ключевые слова: методология проектирования систем водного хозяйства, водопотребляющие технологические процессы, термодинамический эксергетический метод, термодинамический водный пинч-метод, методы очистки сточных вод, электрокаталитический метод, технологический риск, эколого-экономическая эффективность.

Introduction

The conceptual regulations of the theory of sustainable socio-economic development provide the creation of resource-saving environmental friendly production, the basis of which are the effectively operating resource-saving WUCP of industrial plants. In particular, it's generally known that textile production is extremely water-retaining and power-consuming. Therefore, the problem of resource-saving chemical process analisys and synthesis (designing) of industrial enterprises is of great importance. This problem is of particular importance because of the basic requirements to chemical process: ecological compatibility, efficiency, stability and reliability.

So, the objective of this investigation was the development of the designing methodology for scientific-reasonable resource-saving chemical processes of water management system for textile enterprises, which use the basic dyeing-finishing technology of cloth. This water management system should to ensure the reduction of specific flowrates of fresh water consumption and wastewater disposal, the reduction of pollutants mass in sewage discharge into natural water basins, high-performance technology of a local wastewater treatment aimed at water reuse.

In order to reach the objective, mentioned above, it was needed to solve the following tasks:

1) to perform a comprehensive environmental and technological analysis of the main production processes of textile plants;

2) to develop and to apply the thermodynamic exergy analysis method for the design of resource-saving chemical processes of water management system, allowing scientifically to argue the problem of separation — mixing of water streams of textile enterprises;

3) to apply thermodynamic water pinch method for the design of resource-saving chemical processes of water management system aimed to re-organize the traditional straight-flow system of WUCP to repeatedly-serial one, that will provide the significant reduction of the specific flowrates of fresh water consumption and wastewater disposal;

4) to study and to use in practice the high effective methods of wastewater treatment;

5) to assess the environmental, technical and economic benefits of the proposed innovative technological solutions.

Methods and materials

The thermodynamic exergy and thermodynamic water pinch methods of synthesis of resource-saving water management systems of industrial plants have been used and refined upon by us. The exergy value change can be used for definition of energy potential decrease in water system in the process of mixing of technological water streams. In practice this value can serve as a measure of substance and energy degradation (dissipation) which is taking place at dilution (in the course of mixing) of technological water streams, for example, sewage. The application of thermodynamic water pinch method is fruitful in designing of water-supply and water-disposal systems as well. It helps to re-organize the traditional straight-flow system of WUCP to repeatedly-serial one, that will provide the significant reduction of the specific flowrates of fresh water consumption and wastewater disposal. The appropriate numerical experiment was held.

The efficiency of proposed wastewater purification techniques — electrocatalytic destruction, photocatalytic destruction, catalytic destruction by hydrogen peroxide, coagulation, clarification filtration, magnetic treatment was studied on model and real effluents. The metal oxides were used as catalysts.

The special eperimental technique for development of technology of heavy metals ions utilization as useful products, such as mineral pigments, has been proposed.

Results

In an extended sense there are two methods of resource-saving chemical process designing in practice. These are: 1) the construction of minimal structure and 2) the construction of hypothetic hyperstructure (hypertechnology). Decompositive-searching and decompositive-heuristic principles show the search procedures of optimal technological decisions based on knowledge of theoretic basics of chemical technology, physicochemical process essence, environmental-oriented aspects and thermodynamics laws. We've proposed the combination of advantages of these two approaches and have established the next following principle steps of WUCP designing.

The basic processes of dyeing-finishing cotton and union cloth manufacture were analyzed in environmental-oriented aspect at some large textile factories of Russia and China.

The methodology foundations of designing of integrated WUCP of industrial plants, proposed by us [1] and developed further [2–6], was the theoretical basis of work described below.

Step 1. The source data gathering: environmental-oriented analysis (inventory) of industrial enterprise's technology

First of all the scheme of "analisys and synthesis" (designing) of textile enterprise have been developed as shown in Fig. 1. We considered in detail the following sequence of such hierarchy levels as: the enterprise as a whole, manufacturing departments, processing lines, equipment units, processes, phenomena, effects. So, the analysis was held in top-down order and the synthesis in reverse: bottom-up order.

It's very important to perform a comprehensive environmental and technological analysis of the main production processes of textile factory in all following basic shops: desizing, kiering, mercerization, bleaching, dyeing, printing, top finishing and engraving.

The textile company's water management system includes usually three main subsystems: water-supply (water-intake, water-conditioning, water-pumping); water-use (water as a solvent, as an extractant, as a washing liquid, etc.); water-disposal (water-removal (drainage)), water-treatment (regeneration, purification, disinfection), water-discharge (to central sewage systems of population aggregates or to natural water basins). So, for obtaining the expected results of this environmental-oriented analysis (inventory) we should to:

1) analyze the methods of organization and operation modes of all these subsystems;

2) determine the flowrates (the volume, cub. m. per hour) of technological fresh water and sewage;

3) analyze the quality (the ingredients composition, mg per l) of fresh water and wastewater;

4) choose the criterial pollutants, contained in the wastewater, their characteristics in terms of environmental risk;

5) analyze the literature data on the methods of organization and operation of water management system and on the effectiveness of textile factories wastewater treatment by advanced methods.

The identification of criterial polluting substances in textile technological water of individual process lines provided the following results obtained (see data in Tables 1 and 2). These tables contain the average values data, obtained by us in the course of inventory of emissions by chemical processes of textile dyeing-finishing enterprises.

Step 2. The scheme design of integrated resource-saving water management system of industrial enterprise

It has been shown by us earlier [1] that mixing of individual wastewater streams, generated in separate (specific) processes, as they practice now, does not meet the principles of chemical thermodynamics, concerning the exergy (or "energy" from the narrow point of view) efficiency of water management system of textile enterprises.

The thermodynamic approach to the designing of resource-saving water management system is developed by us. This methodology is based on the simultaneous accounting of the following principles: 1) the principles of chemical thermodynamics; 2) the basic environmental protection principles (system analysis, integrated approach, recycling, rational architecture, environmental safety demands); 3) real technical and organizational opportunities of the textile enterprises. There are some literature data regarding the methodology for the designing of resource-saving industrial systems [7–16]. But we didn't find out in these works the complex approach

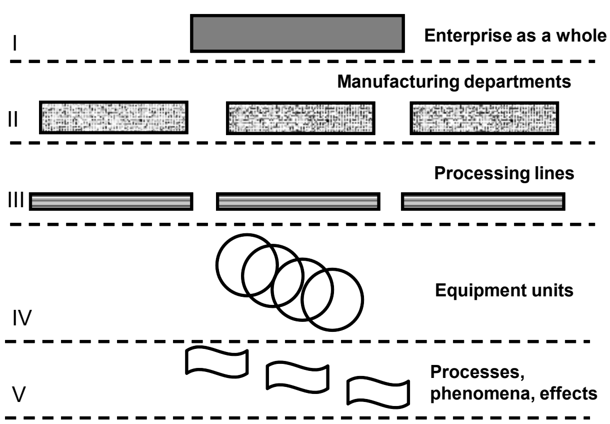

Fig. 1. The scheme of "analisys and synthesis" (designing) of textile enterprise

(including analysis and synthesis) to development of the resource-saving water management systems.

As one of the main component of thermodynamic approach is thermodynamic exergy method of WUCP designing was carried out by us.

The availability of thermodynamic exergy analysis for designing of chemical processes of industrial plants water management systems have been carried over for consideration. In particular, the advantage of exergy method in the case of solution of one of the most relevant problems — designing of water-streams network has been demonstrated. It has been shown that the mixing of individual waste water streams, generated in separate (specific) processes (as they practice now), does not meet the principles of chemical thermodynamics concerning efficiency of water-use and water-disposal systems of textile company.

An efficient technique to fulfill the design tasks is the water pinch method, which is a modification of the thermodynamic pinch method for designing of economically optimal energy-saving integrated chemical engineering systems. The application of water pinch method at the step of designing of water removal systems is fruitful as well. Advantages of this method are particularly pronounced if there are organizational, economic and technical possibilities of treatment (regeneration) of wastewater from individual chemical process systems (individual process lines, groups of process equipment, etc.).

Table 1

The presence (*) of criterial pollutants in textile enterprise's technological water

№	Pollutant	Bleaching shop	Dyeing shop	Printing shop
1	Medium reaction, pH	*	*	*
2	Chemical oxygen demand COD)	*	*	*
3	Suspended matter	*	*	*
4	Solid residual	*	*	*
5	Sulphides			*
6	Sulphates	*	*	*
7	Chlorides	*	*	*
8	Surface-active substances (nonionic)	*		*
9	Surface-active substances (anionactive)	*		*
10	Petrochemicals	*	*	*
11	Chromium (3+)		*	
12	Chromium (6+)		*	
13	Zinc (2+) ion content		*	*
14	Copper (2+) ion content		*	*
15	Iron (total) content		*	

According to the basic principles of resource saving, if the removed wastewater is impossible to use in downstream processes, it must be treated (regenerated) and then recycled to the water consumption cycle. This principle of recycling is the basis for designing of environmental friendly WUCP. Minimization of fresh water consumption and reduction of contaminants content in wastewater are among the most important ways of improving the economic efficiency and environmental safety of textile plants.

So, the design of such so called "narrow-purpose" (for single process line) local wastewater treatment facilities (LWTF) is a topical challenge in synthesis of resource-efficient integrated chemical engineering systems, especially for textile plants to be constructed. However, in the most of currently operating textile plants, it is most realistic to implement so called "medium-purpose" LWTF for treatment of wastewater from individual shops, groups of shops, and departments. And, of course, so called "wide-purpose" LWTF for treatment of wastewater from an enterprise as a whole or at least from a group of enterprises, using similar technologies, must be, surely, implemented.

In the order from "wide-purpose" LWTF to "narrow-purpose" LWTF, organizational and technical problems become more severe, but in the same order, the environmental and economic efficiency of implementation of the proposed engineering solutions are usually increases. This is because the capital cost of implementation of water treatment facilities is usually proportional to the treated wastewater flowrate, rather than to the contaminant concentration, whereas the operating cost most often increase with decreasing contaminant concentration in wastewater. The water pinch method enables one to design the optimum integrated chemical process systems for water removal (treatment, regeneration) with separated technological water process flows.

Fig. 2 shows the essence of methodology proposed. The quintessence of it is the use of thermodynamic approach to "analysis and synthesis" (designing)

Table 2

Characteristic wastewater composition of the basic chemical processes of dyeing-finishing manufacture

Chemical process	Suspended matter, mg/l	COD, mg O_2/l	Heavy metals, mg/l
Desizing (Bleaching shop)	1000–1500	2400–3700	traces
Kiering (Bleaching shop)	750–1150	1700–2500	traces
Mercerization (Bleaching shop)	80–110	170–220	traces
Bleaching (Bleaching shop)	150–200	250–400	traces
Dyeing (Dyeing shop)	350–450	800–1200	0,1–2
Printing (Printing shop)	300–350	700–1000	0,5–3
Top finishing (Dressing shop)	200–250	1100–1500	traces
Galvanic and etching operations (Engraving shop)	500–700	130–200	100–250

of technological processes — the application of thermodynamic exergy method and thermodynamic water pinch method in common with other important units (as shown on the periphery of the scheme). They are: the unit for development of innovation technique and equipment for water-resource saving; the unit for quality control system of water and of water treatment products; the unit for WUCP's ecological and economic efficiency evaluation. The functioning of all these units aimed at the optimal designing of resource-saving water management system of textile enterprise, subsystems of which (as shown in the central part of the scheme, Fig. 2), respectively, are: water consumption system, production sub-units system of serial and recycling water use, water disposal system, wastewater local treatment facility. The most part of water treated must be recycled and the rest of it must be discharged. The lack of water must be compensated by fresh water inlet.

One of the most important problems, occurring the designing of the resource-saving water consumption and water disposal systems of textile factories is a search of the optimal variant of individual water flows division or mixing. This procedure demand taking into account the type of technological flow (consumable water, partly treated technological water or sewage). While mixing the individual water flows, the number of specific components in mixed water flow increases. It leads to increase of the total system entropy as characteristic of more probability of system macro-state occurrence while micro-states quantity increases. That's why the availability of exergy method of designing of resource-saving chemical processes water management system of industrial plants has been carried over for consideration by us. It has been shown that mixing of individual water streams, generated in separate (specific) processes (as practices now), does not meet the principles of chemical thermodynamics concerning efficiency of water-use and water disposal-systems of textile enterprise.

If to consider the scheme for flows mixing of WUCP, shown in Fig. 3, it is possible to write down the equation for exergy value, Ex, which is a convenient factor in this case to characterize the technical performance or the maximum capacity of the system to execute the work with taking into account the interaction with environment:

$$Ex = H - T_0 S, \tag{1}$$

where H, S and T_0 — are enthalpy, entropy and absolute temperature of the system, respectively (index «0» means the state of the system at environment conditions).

The value of exergy loss, ΔEx, when the system composition is changing, in particular, owing to the mixing of water flows can be calculated as:

$$\Delta Ex = \Delta H + RT_0 \sum_i^n n_i \ln X_i, \tag{2}$$

where ΔH — mixing enthalpy; n_i — components molar flowrates; X_i — components mole fraction.

Relative exergy loss, $\%\Delta Ex$, (in regard to the system's state before mixing) at water flows mixing can be evaluated as:

$$\%\Delta Ex = \frac{\left[k\sum_i^n \left[m_{i\ out} \ln \frac{m_{i\ out}}{\sum_j m_{j\ out}} \right] - -k\sum_i^n \left[m_{i\ in} \ln \frac{m_{i\ in}}{\sum_j m_{j\ in}} \right] \right]}{k\sum_i^n \left[m_{i\ in} \ln \frac{m_{i\ in}}{\sum_j m_{j\ in}} \right]}, \tag{3}$$

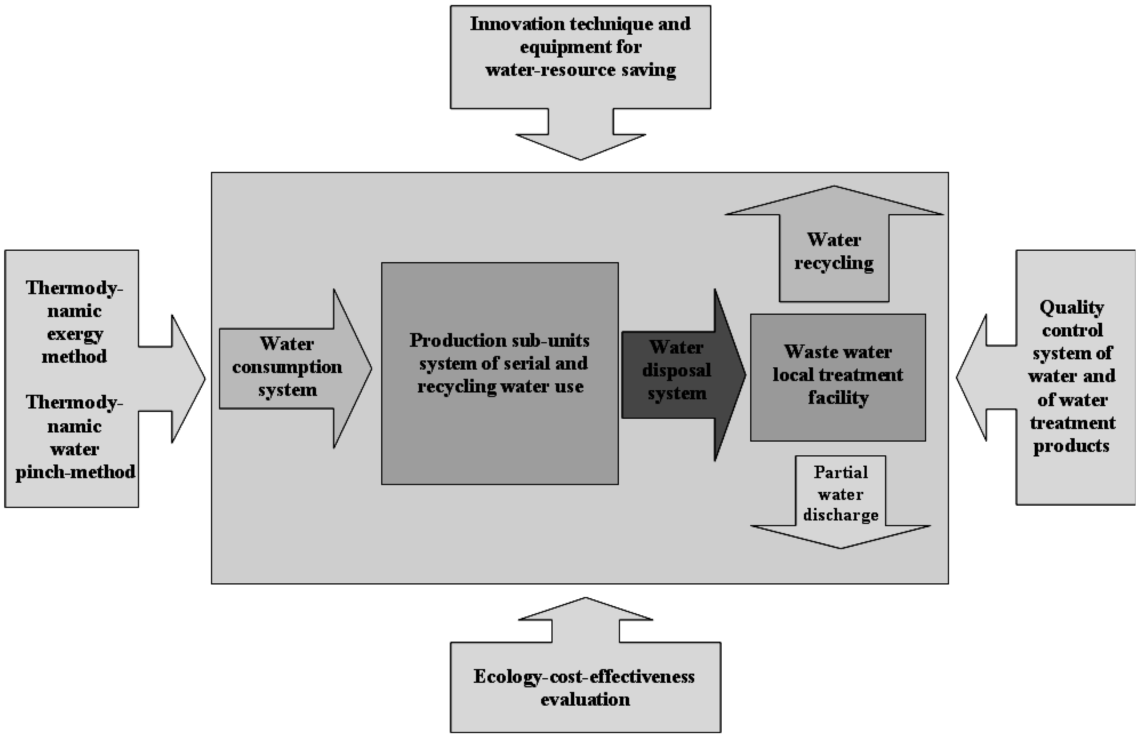

Fig. 2. The scheme illustrating the essence of the proposed methodology for design resource-saving water management system of textile enterprises

where k — konstant at given temperature; $m_{i\ in}$, $m_{j\ in}$, $m_{i\ out}$, $m_{j\ out}$ — mass flowrates of components and water; index «*i*» refers to given component and index «*j*» refers to all components set.

So, the search of an optimum variant of division and mixing of individual water streams has been carried out by us for some large textile plants aimed at wastewater treatment and the re-use of purified waste water.

The common-used textil plant's water-use flow charts are not serial — the individual water operations use the fresh water separately. But it is of grate interest and advantage to use the fresh water step-by-step and to connect the water-use operations in series. So, the application of water pinch method for designing of serial resource-saving WUCP of textile plants has been demonstrated. This method is used to design water recycling systems on the base of purified wastewater re-use. Water pinch-method allows to estimate the fresh water and wastewater re-use flowrates target values. The flowrates values and usage sequence of rinsing water on operations of dyeing-finishing textile production have been set. The design fresh water-use efficiency as compared with common processes is equal to 30–40 %.

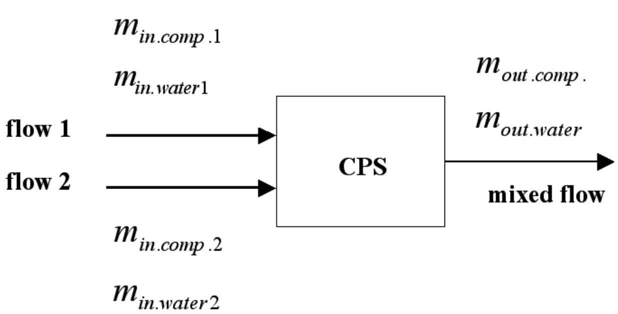

Fig. 3. The scheme of flows's mixing of water-use chemical processes system

The functional diagram of resource-saving WUCP of dyeing-finishing textile plant is proposed (see Fig. 4). It is inherently the separation scheme of general water streams of dyeing-finishing textile factory on individual flows. This scheme combine the high-performance cleaning of wastewater aimed at it reuse and the opportunity of plants redesign implementation with minimum investment.

The appropriate numerical experiment was held to calculate all the parameters of the resource-saving chemical processes water management system

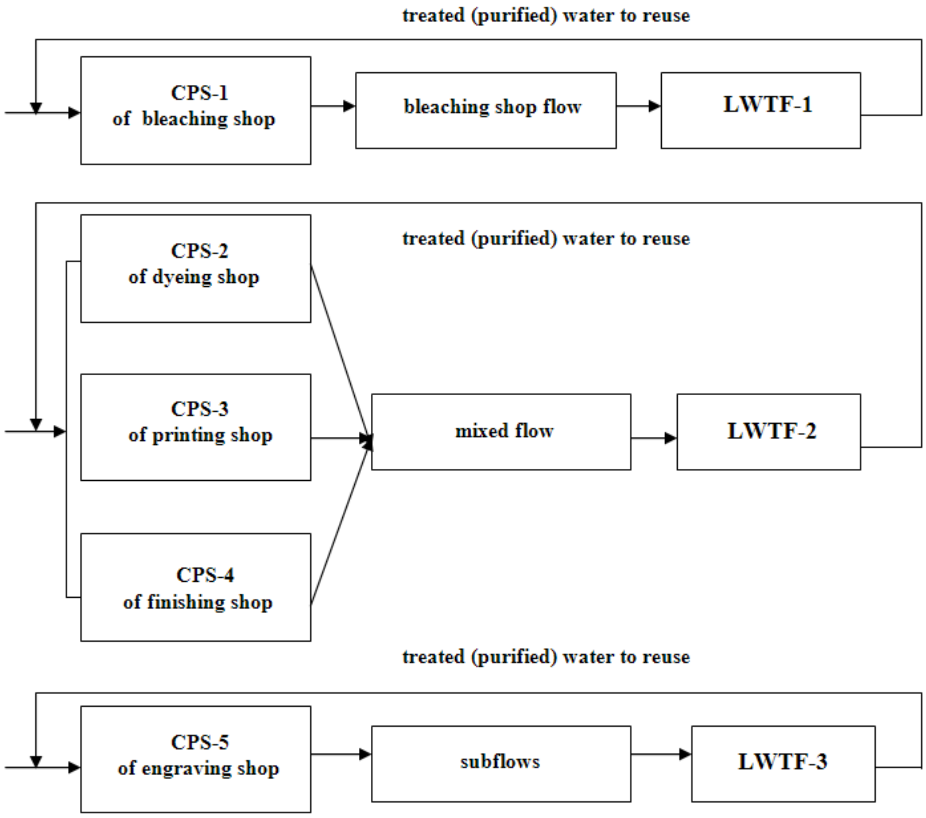

Fig. 4. The functional diagram of resource-saving water-use chemical processes of dyeing-finishing textile plant (LWTF — local wastewater treatment facilities)

of textile plants. For this purpose the structure of computer application intelligence system of water resource-saving chemical processes designing and operation has been developed. The initial codes of basic modules of this intelligence system, diagram of data flows, describing the interaction of components of an application package (software), have been designed.

Step 3. The design of repeatedly-serial water integrated chemical process system of industrial enterprise's shops (process lines)

An efficient technique to fulfill the design tasks is the water pinch method, which is a modification of the thermodynamic pinch method for designing of economically optimal resource-saving integrated water management systems. The application of water pinch method is fruitful in designing of water-supply and water-disposal systems as well [17–19]. It helps to re-organize the traditional straight-flow system of WUCP to repeatedly-serial one, that will provide the significant reduction of the specific flowrates of fresh water consumption and wastewater disposal.

So, the schemes of textile enterprise's shops (process lines) resource-saving water management systems should be proposed. These schemes will combine the high-performance cleaning of wastewater aimed at it reuse and the opportunity of textile enterprises to redesign implementation with minimum investment. The appropriate numerical experiment was held.

Step 4. The development of wastewater purification techniques (wastewater treatment methods)

The next step of our research was to investigate the efficiency of wastewater treatment methods aimed at possibility of treated water re-use. We've studied such water purification techniques as electrocatalytic destruction, photocatalytic destruction, catalytic destruction by hydrogen peroxide, coagulation, clarification filtration, magnetic treatment. If it will be the opportunity, afforded by Journal, we'll publish the comprehensive results of this part of our work. And now we can say, as a whole, that the electrocatalytic, photocatalytic destruction and coagulation methods are proved to be the most perspective in the practice of sewage treatment. For detailed learning we've chosen a variant of deep destruction method of contaminants under the influence of strong oxidants in the electrochemical reactor directly on electrodes coated by a catalyst, and in reactor with the following catalytic afterpurification with filtration of the treated water through catalyst-filled layers.

The essential distinction between electrocatalytic processes and conventional heterogenic-catalytic processes is that the electrocatalysis is capable to regulate speed, selectivity and direction of process by changing electrode catalyst potential. Besides, adsorption of solvent molecules and products of its electrochemical transformation create conditions for proceeding such reactions which not take place in conventional catalysis.

Technological advantages of this sewage treatment are high efficiency, relative economy and small amount of reagents demand at further treatment steps.

However, despite of the universality of the method, it is necessary to study in details the conditions of its practical realization in order to establish the technological modes, construction parameters of electrochemical reactors, the destruction process of particular sorts of contaminants in real sewage composition and flowrate conditions.

We've investigated the influence of such parameters as contaminants nature, electrical action demand (EAD), medium pH, temperature, sewage composition, catalytic and sorption properties of a catalyst on the efficiency rate of model and real sewages purification.

One of the most important factor influenced the contaminants destruction degree in the electrocatalytic sewage treatment is EAD — the electricity amount per the volume of water treated. We've obtained the results of EAD influence on the kinetics of the electrocatalytic destruction of criterial contaminants — dyes and surfactants. We've realized that under dynamic conditions the destruction degree increases when EAD values increase. The rate of the contaminants concentration reduction, in all probability, submits to the second-order equation. The destruction degree of individual criterial contaminants and the investigated sewage's electro-, photo-catalytic purification efficiency in general are within 80–90 % [20, 21].

The environment-oriented analysis of chemical process of electroplating, pickling, engraving and other galvanic shops of textile plants and thermodynamic analysis of their water consumption and water disposal systems confirm the necessity of individual streams segregation (see diagram in Fig. 4). The technology of galvanic wastes (containing chromium, copper, iron, lead, zinc) utilization aimed at production of mineral pigments used for lacquer coatings of general and anticorrosive purposes has been developed. The results of testing of five mineral pigments characteristics according to technical and sanitary-hygienic requirements have been obtained.

The flow charts of individual wastewater streams local treatment were designed. The equipment designed passed the long test to satisfaction and is now in operation at some companies.

However, despite of the universality of these methods mentioned above, it is necessary to study in details for their practical realization (for establishing technological modes, construction properties of equipment, etc), the real basic technological process of production (textile or some other), to examine particular sorts of contaminants, containing in real sewage of real enterprise.

The proposals are made on development and rework of physical, physical-chemical and biotest quality control methods of wastewater and products of wastes treatment. It is shown that there is the possibility of combination of instrumental measurement and biotest method (Daphnia magna and Paramecium caudatum as test-organisms) for rapid and precise analysis of wastewater and products of pollutants utilization.

Step 5. The development of Intelligence System of resource-saving water management system of industrial enterprise

The development of engineering tool of our methodology realization — an Intelligence System of functioning data accumulation, storage and processing of resource-saving water management system of textile enterprise should be made.

The software for computer calculation of flow diagrams of textile enterprise's WUCP should be designed which permit to obtain the values of technological and constructive parameters of the basic equipment with high efficiency and accuracy.

Step 6. The technological risk assessment and safety management

The estimation of technological risk of textile enterprise's water chemical processes should be held. This assessment should include the examination of hazards of technological units at emergency conditions and determination of possible consequences with the aim of necessary working out measures of technological risk assessment and safety management [22, 23]. These measures should be as follows: prevention of man-caused accidents, plan of actions working out in emergency situations, technical-organizational activities working out of accident risk and its consequences scaling down. For all that the modern approaches of technological safety guarantee based on optimal risk conception should be applied.

Step 7. The estimation of ecologic and economic efficiency

The estimation of ecologic-economic effectiveness of textile enterprise's water chemical processes should be held. The main purpose of the project designing is the development of clean production, which significantly reduce the consumption of water resources, raw materials, energy and possess high ecologic and economic efficiency. High ecologic-economic efficiency of the project is achieved by significantly reducing of the: 1) volume of fresh water consumption, 2) volume of wastewater, 3) mass of pollutants discharged into natural water basins; 4) due to profit, stipulated by the sale of products obtained by treating of wastewater streams.

Conclusion

The methodology of designing of resource-saving chemical processes of textile plants water management systems has been developed.

The functional diagram of resource-saving WUCP of dyeing-finishing textile plant has been proposed.

The structure of computer application intelligence system of water resource-saving chemical processes designing and operation has been developed.

Water purification techniques such as electrocatalytic destruction, photocatalytic destruction, catalytic destruction by hydrogen peroxide, coagulation, clarification filtration, magnetic treatment were investigated. The electrocatalytic plus photocatalytic destruction and coagulation methods are proved to be most perspective in practice of sewage treatment.

The flow charts of individual wastewater streams local treatment were designed. The equipment designed passed the long test to satisfaction and is now in operation at some companies.

The basic technical-economic parameters of the project will guarantee the following results.

- The reduction of fresh water consumption of the Company will be up to 30–40 %.
- The local wastewater treatment facilities of the Company will have an efficiency of specific pollutants destruction or extraction at a level of 70–95 %.
- The reuse amount of purified wastewater of the Company will be up to 50–70 %.
- The treatment technology of the Company's wastes, containing chemical compounds of heavy metals, will be realized aimed at manufacturing of useful products — mineral pigments (optionally).
- The anticipated profit of proposed engineering solutions implementation at the Company will be at the range of $ 200–300 thousand annually.

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