European Journal of Technical and Natural Sciences 2026, No 4
ISSN 2414-2352

PREMIER Publishing
ppublishing.org

DOI:10.29013/EJTNS-26-4-73-81

SYSTEMS FOR THE REGENERATION AND RECIRCULATION OF PROCESS FLUIDS (Modular systems for the regeneration and recirculation of process fluids, including water and aqueous solutions)

Kurilov Vadim [1]

[1] Chief Executive Officer (CEO) ICar Dnipro, Ukraine

Cite: *Kurilov V. (2026). Systems for the Regeneration and Recirculation of Process Fluids. (Modular systems for the regeneration and recirculation of process fluids, including water and aqueous solutions). European Journal of Technical and Natural Sciences 2026, No 4.* https://doi.org/10.29013/EJTNS-26-4-73-81

Abstract

This publication examines the current approaches to the treatment and purification of water used for technological purposes in various industrial sectors. Particular attention is devoted to the existing methods employed for the treatment of water contaminated by products and by-products generated during industrial processes, as well as to their technological capabilities, limitations, and areas of application.

The study analyzes the three principal categories of water treatment technologies currently used in industry. These include chemical reagent-based treatment methods, which remain the dominant technology and account for more than 70% of the water treatment market; chemical-free water treatment and purification methods, represented by several technological modifications with different operational characteristics and covering less than 20% of the market; and various combined treatment technologies that integrate elements of both approaches together with additional process solutions adapted to specific industrial operating conditions. These combined technologies currently account for approximately 10% of the market and continue to expand their range of industrial applications.

Special emphasis is placed on the challenges currently facing water treatment and water conditioning technologies. The publication demonstrates that the requirements imposed on modern industrial production can no longer be satisfied through the application of individual treatment methods or existing combinations of conventional technologies. The continuously evolving technical, environmental, and operational requirements necessitate the development of comprehensive and integrated technological solutions capable of addressing the entire range of water treatment objectives.

Taking these considerations into account, and incorporating a number of innovative concepts developed in recent years, the author proposes an integrated technology for the treatment of industrial wastewater. The proposed solution is based on a sequence of consecutive yet functionally independent processing operations, providing a comprehensive

technological approach to the regeneration, purification, and recirculation of industrial process water.

Keywords: *Process fluids; Process fluid regeneration; Process fluid recirculation; Module; Modular architecture; Water; Aqueous solutions; Industrial use of water in technological processes; Water treatment and purification methods; Chemical reagent-based water treatment; Chemical-free water treatment and purification; Current challenges in water treatment and water conditioning; Integrated technology for the treatment of industrial wastewater comprising a series of sequential, yet functionally independent, processing operations*

Introduction

At present, various industries using water for technological purposes apply the following methods for the treatment and purification of water contaminated by products and wastes generated during these technological processes:

Chemical reagent-based treatment. Several modifications of this method, as well as combinations of this method with other technologies, are employed. This method and its modifications are the most widely used, accounting for more than 70% of the water treatment technology market.

Chemical-free water treatment and purification. Several principal modifications of this method are employed, differing in their range of capabilities and performance characteristics. These methods account for less than 20% of the water treatment technology market.

Various combined treatment methods, generally consisting of combinations of the first two methods supplemented by additional technological processes determined by the specific local operating conditions of technology users. These methods and technologies account for approximately 10% of the market and demonstrate a continuing tendency toward wider application.

The problems of water treatment and water conditioning identified to date are, in practice, impossible to solve on the basis of the currently known methods and technologies. The solution must be comprehensive, since partial solutions do not satisfy the requirements of any modern industrial production. Therefore, the application of individual methods or combinations of existing methods does not address all of the new requirements that have emerged and continue to emerge.

Taking the above into consideration, and additionally incorporating innovative concepts developed in recent years, the author proposes an integrated technology for the treatment of industrial wastewater, comprising a series of sequential yet functionally independent processing operations.

More specifically, all stages of water treatment may be represented as successive treatment processes applied to the water. Each of these processes is based on different physical and chemical principles of operation.

In combination with the latest innovative concepts proposed and published by innovative specialists, primarily Dmytro Lysenko, the author proposes an integrated technology that can be implemented by means of complete, autonomous, standardized technological modules configured as follows:

Of all the modules presented, Module 5 – the power supply module is comparatively universal, whereas the remaining eight modules have more specialized fields of application:

Module 1 – Sedimentation Module, which may be configured either as a sedimentation column or as a sedimentation tank having the shape of a rectangular parallelepiped.

Module 2 – Turbo-Aeration Module, which may be implemented in at least two configurations: one employing foam generators and the other utilizing a mixing and in-line homogenization unit.

Module 3 – Ion-Exchange Treatment Module, which may be implemented in a wide variety of configurations, one of the most effective being ion-exchange columns incorporating capsules for ion-exchange resins manufactured from carbon-carbon composite fabrics.

Module 4 – Coagulation Module, utilizing aluminum ions produced in electrochemical reactors equipped with aluminum anodes as the coagulant.

Figure 1. *Illustrates the nine principal modular technological configurations comprising all technological stages and operations required for the formation of a modular process equipment system intended for the purification, regeneration, and recirculation of process fluids, including water and aqueous solutions*

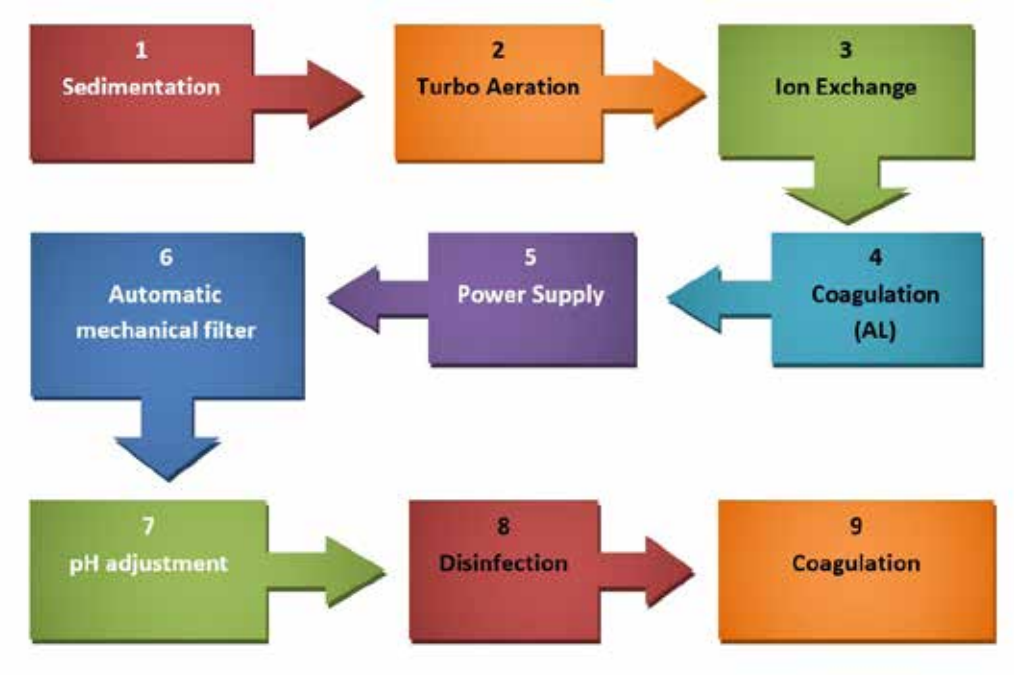
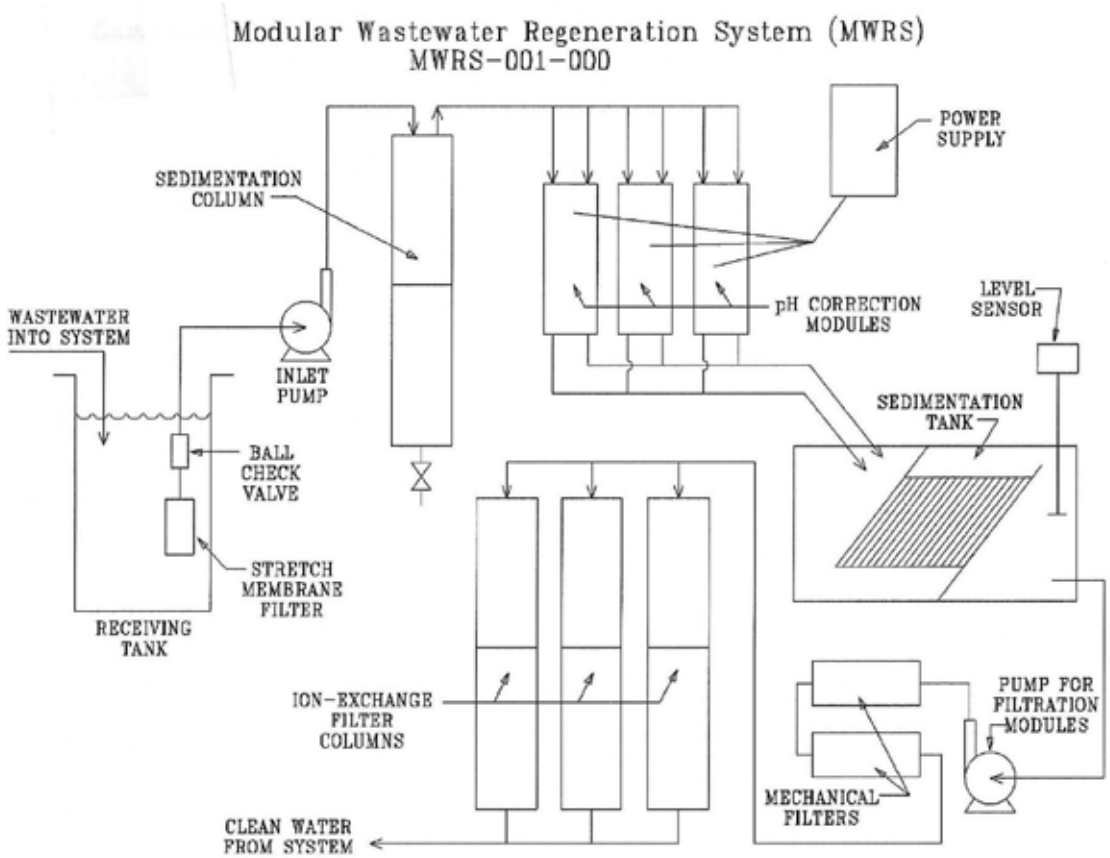


Figure 2. *Illustrates an example of a modular configuration of a system for the regeneration of process fluids, including water and aqueous solutions*



Module 6 – Automatic Mechanical Filtration Module, incorporating automatic cleaning of the filter sections and in-line regeneration of the filter elements.

Module 7 – pH Adjustment Module for the regulation of acidity and alkalinity.

Module 8 – Electrochemical Chemical-Free Disinfection Module.

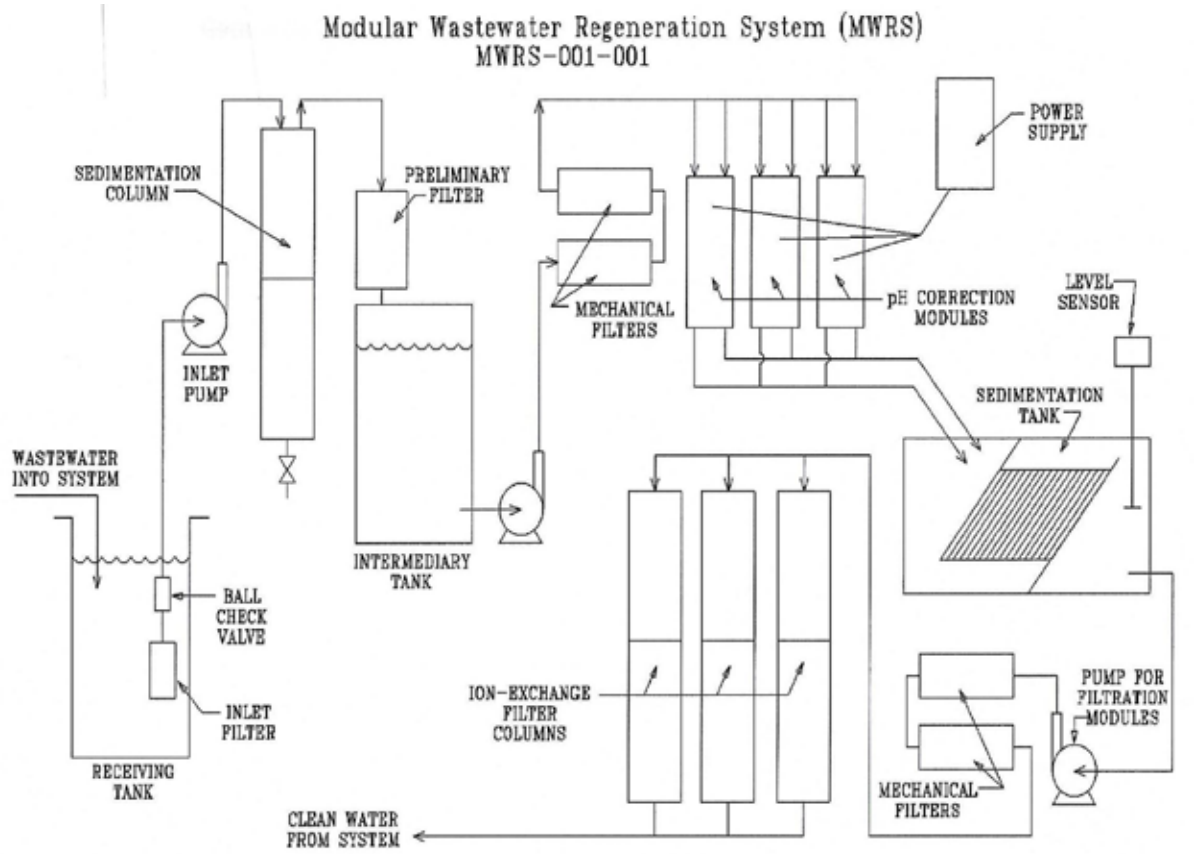
Module 9 – Final Electrochemical Coagulation Module.

As shown in the diagram, the system inlet is equipped with a receiving tank incorporating several components that perform the preliminary treatment of the process fluid after completion of its operating cycle. The fluid passes through a membrane filter connected to the inlet pump via a check valve. The pump delivers the fluid to the inlet of the sedimentation column, which, depending on the process flow rate, may consist of one, two, or three sections.

Following the first stage of sedimentation, the fluid is supplied to electrochemical reactors for the adjustment of acidity or alkalinity. These reactors are controlled and supplied with electrical power by a multifunctional power supply unit.

After pH adjustment, carried out to establish alkaline conditions providing the most favorable environment for sedimentation, the fluid is directed to a dedicated sedimentation module with a special geometric configuration that enables the separation of the formed sedimentation conglomerates from the liquid within an upward flow.

Figure 3. *Illustrates a modular system incorporating an intermediate module with a preliminary filter at the inlet and a system of sequential mechanical filters at the outlet of the intermediate module, positioned upstream of the electrochemical reactors for the adjustment of acidity and alkalinity*



Upon completion of the sedimentation process, the liquid is transferred, upon a signal from the level sensor, by a centrifugal pump to the mechanical filtration modules, where conglomerate particles that have not settled within the sediment layer are removed by mechanical filtration.

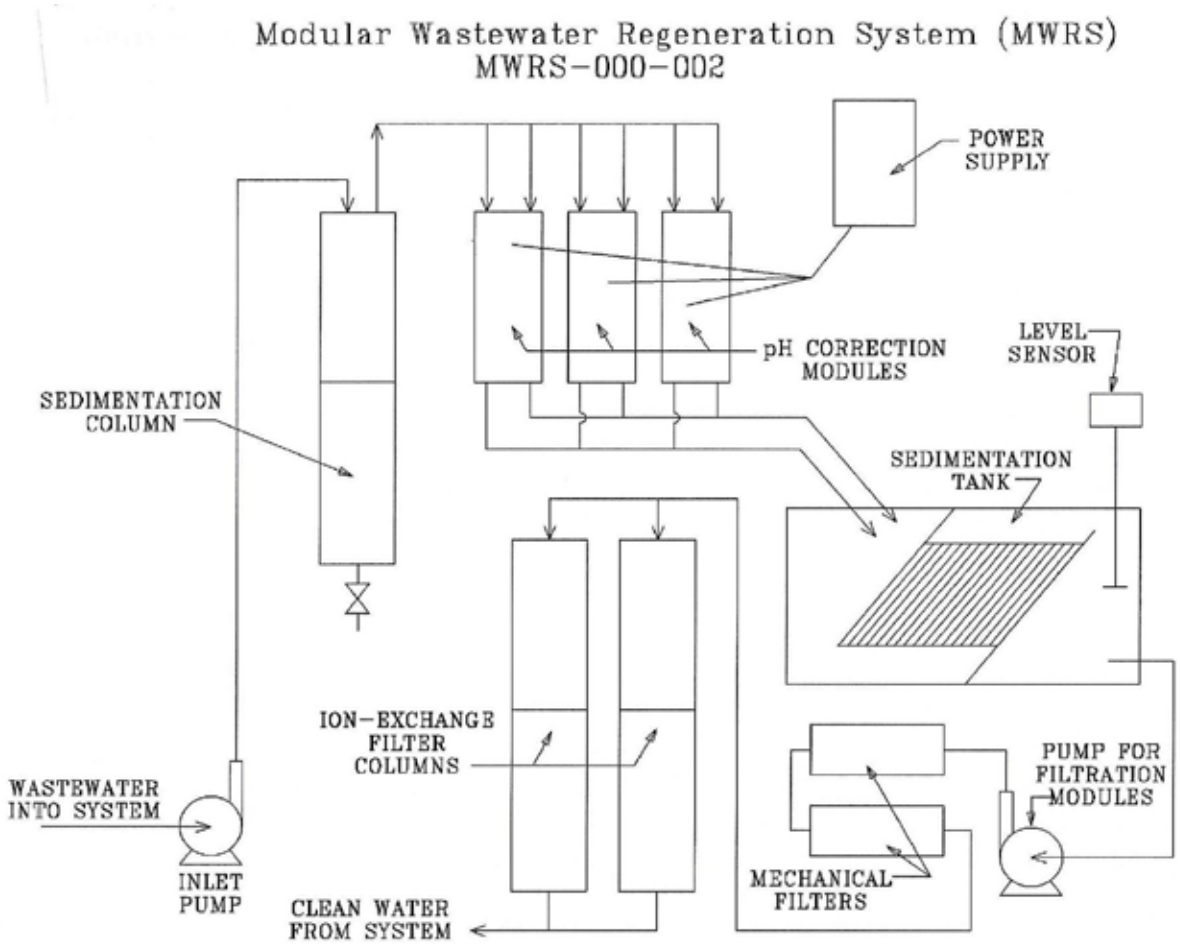
Since the mechanical filters operate in an in-line mode, the pressure generated by the filter pumps is sufficient to deliver the me-

chanically filtered fluid to the inlets of the ion-exchange treatment columns.

Based on the conclusions and proposals presented in the publications and patent applications of Dmytro Lysenko, as well as on his multifunctional forecast for the development of environmentally sustainable engineering and technological systems for industrial process organization, the author of the present publication has significantly expanded the technical capabilities of ion-exchange treatment columns. This aspect warrants more detailed consideration.

It is particularly important to note that ion-exchange treatment should employ not only synthetic ion-exchange resins but also natural materials, among which zeolite represents one of the most effective ion-exchange media.

Figure 4. *Illustrates the most compact modular system, designed without intermediate technological and structural elements*



According to the modular configuration of ion-exchange treatment columns proposed by Dmytro Lysenko, in which each column consists of at least two modular sections, it becomes possible to incorporate several ion-exchange materials with different exchange capacities within a single column. For example, zeolite may be installed in the upper section, while ion-exchange resin may be used in the lower section.

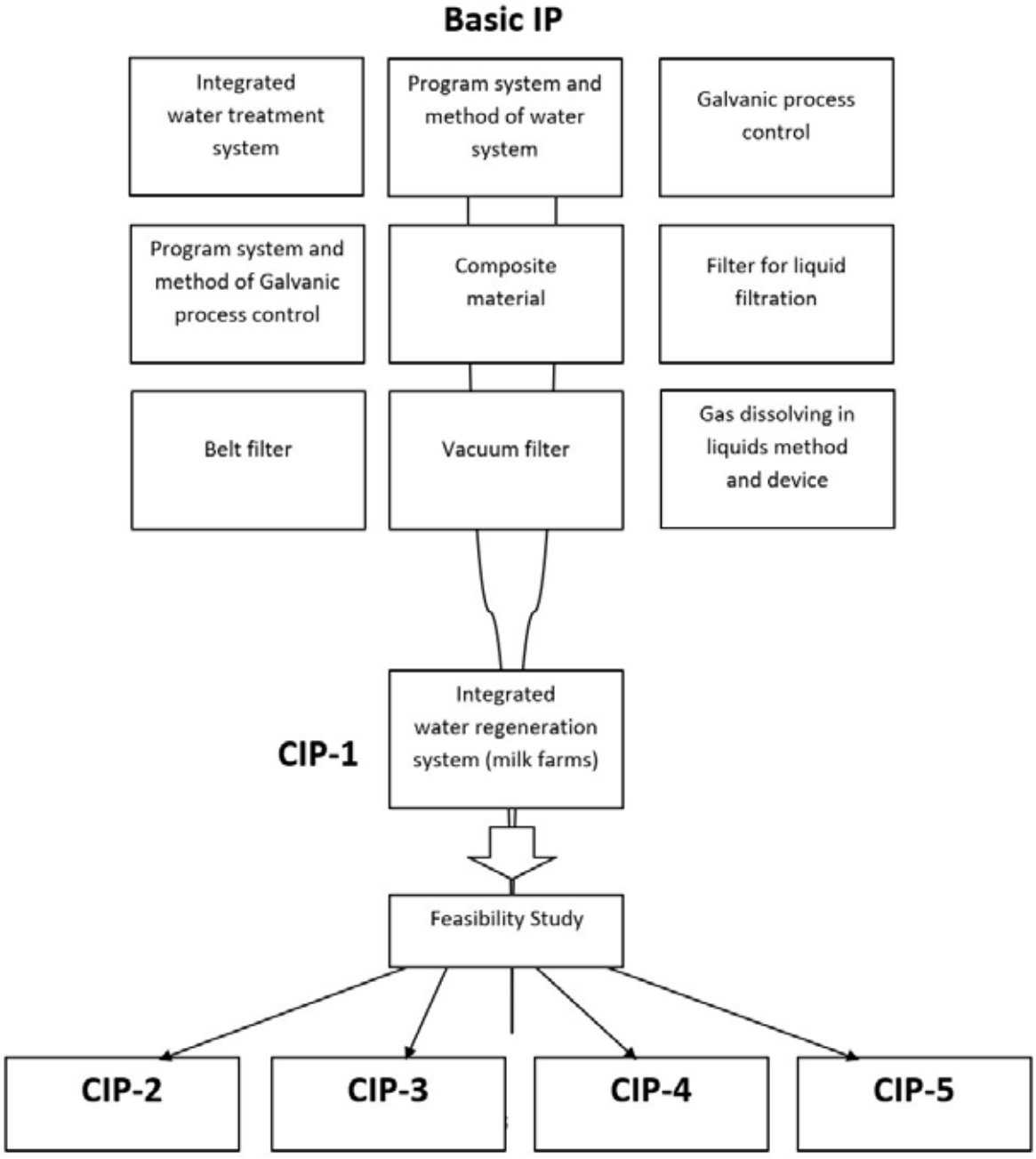
The combination of these materials provides the most effective implementation of purification, regeneration, and recirculation technologies.

This modular configuration has been developed by analogy with the inventions of Dmytro Lysenko, a recognized advocate of chemical-free integrated intensive treatment technologies for process fluids, including water and aqueous solutions, operating in real time within directed-flow systems.

Practical application has demonstrated that the hierarchical system of technological

modules proposed and developed by Dmytro Lysenko, characterized by narrow technological specialization while remaining highly autonomous, possessing independent production and technological cycles, and operating without the use of chemical reagents or synthetic activating additives, makes it possible to assemble higher-level technological modules from lower-level hierarchical modules while maintaining full economic and technological efficiency.

Furthermore, the absence of chemical reagents introduced into the process makes it possible, immediately upon completion of the regeneration operations, to initiate and successfully perform in-line recirculation, while maintaining a consistently high quality of process fluids and aqueous solutions.



Thus, the presented figures and diagrams demonstrate that the hierarchical structure of vertically integrated modular systems makes it possible to simultaneously achieve a comprehensive solution to technological and environmental challenges while meeting the requirements of industrial facilities of any profile and for any degree of process waste contamination through the complete regeneration and subsequent recirculation of process fluids.

Accordingly, this approach also addresses the challenges associated with the grad-

ual transformation of industrial facilities of all types and levels of organizational flexibility into so-called smart manufacturing systems.

As shown in the presented algorithmic diagram, which has also been developed taking into account the innovative concepts and proposals arising from the inventions and publications of Dmytro Lysenko, a total of 14 objects are considered and presented. Each of these objects, in turn, represents a complex of modules consisting of autonomous modules belonging to a lower combinatorial level.

Each of the presented modules constitutes an independent subject of patent protection, and all possible combinations of these modules likewise constitute independent subjects of patent protection and legitimate objects for subsequent patent continuation in accordance with the current patent legislation of the United States.

At present, users of water treatment technologies face a number of challenges that prevent the efficiency of auxiliary water treatment operations from reaching the level of efficiency achieved by the principal technological processes. The major challenges include:

- the continuous limitation of water resources available for use in technological processes;
- the continuous deterioration of the quality of natural water resources suitable for technological applications;
- the continuous increase in the cost of water resources;
- increasingly stringent regulatory standards governing the quality of water discharged into sewerage systems, resulting in higher wastewater treatment costs;
- continuously increasing requirements for the quality parameters of water used in technological processes;
- the continuous introduction of new synthetic and organic materials as technological processes evolve and existing manufacturing technologies are improved, thereby requiring continuous modernization of water treatment facilities or the development of systems possessing a significantly broader range of operational capabilities, which substantially increases both equipment costs and the overall cost of water treatment processes;
- the existence of a large number of industrial facilities operating with conventional technologies whose equipment has reached the end of its service life, while replacement of such equipment requires considerable investment or, in some cases, is technically impracticable.

Patent and Licensing Status of the Proposed Technologies and Patentability of the Proposed Technological Methods

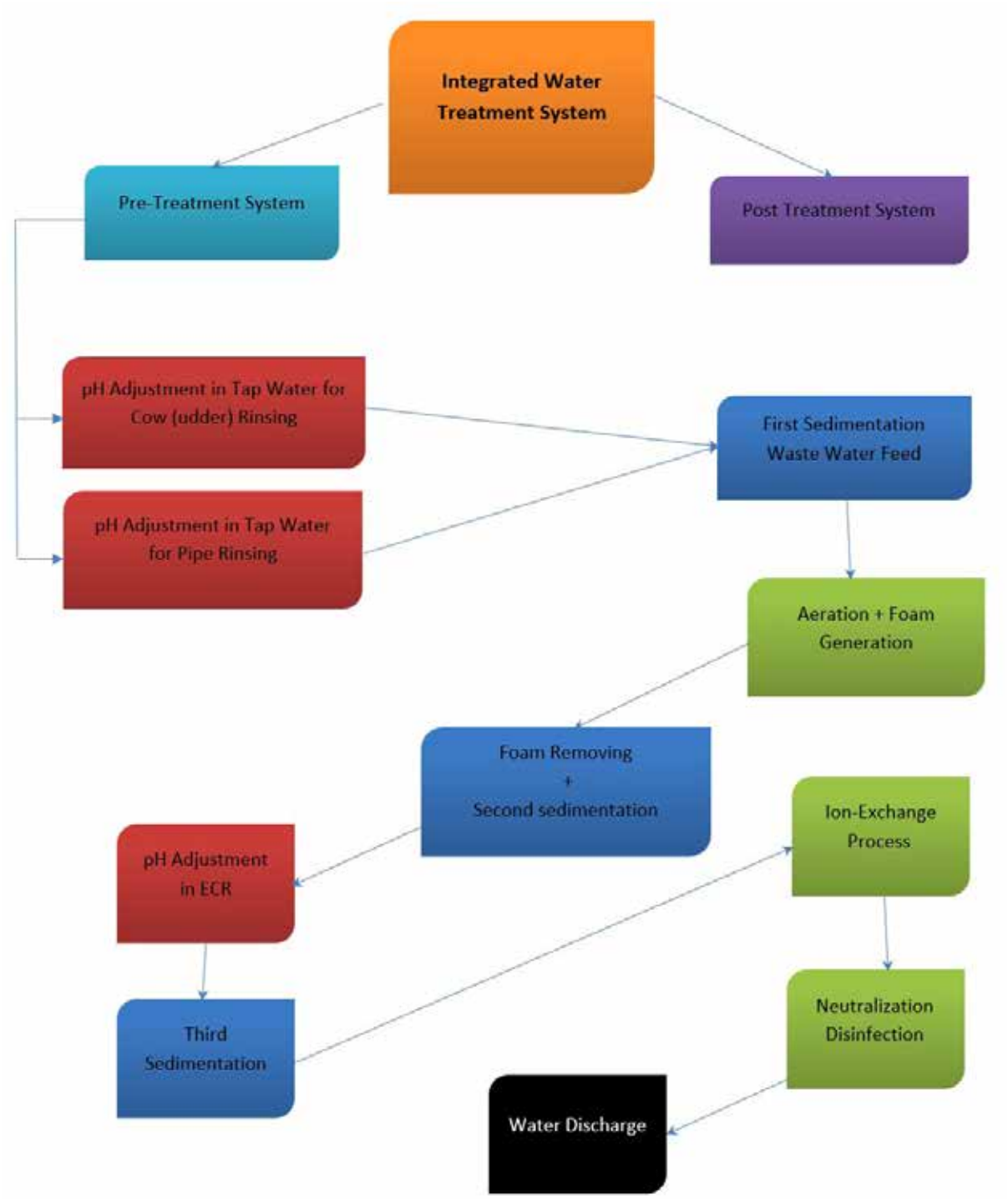
Based on the proposed water treatment methods, preliminary technical studies and patent searches have identified the following subjects for patent applications:

- a complex of modules for advanced treatment of water and aqueous solutions, together with the associated method of use;
- a comprehensive method for water treatment and technological modules for implementing the proposed method;
- a method for the electrolytic extraction of metals from a water or aqueous solution stream, together with electrode cells for implementing the method;
- a method for aerodynamic foaming of water in a continuously flowing stream, together with a foam generator for implementing the method;
- an integrated filtration method combined with ion-exchange treatment and biosorption;
- an electrocoagulation electrode cell with coaxial electrodes;
- an electrocoagulation electrode cell with a continuously moving belt cathode;
- an electrode cell for acidity and alkalinity adjustment incorporating blocks of polarizable soluble electrodes;
- an electrode cell for acidity and alkalinity adjustment utilizing volumetric porous electrodes;
- an electrode cell for acidity and alkalinity adjustment utilizing continuously moving belt electrodes;
- an electrode cell for electrochemical disinfection together with electrode cells for implementing the proposed method.

For each proposed patent application, prototypes and analogous technical solutions have been identified among the developments of Dmytro Lysenko, the author of the proposed new methods. Based on the results of the preliminary patent search and structural analysis, the above technical solutions have been determined to possess full patentability.

Based on the foregoing, it becomes possible, in combination with vertically integrated modularization, to develop a block diagram of an integrated technological complex in which the flexibility and selectivity of each technological process are achieved at the level of each individual module belonging to the lowest level of the hierarchical structure.

Integrated water treatment technology



References and Patent Literature

United States Patent Application No. 20100224506. *Process and Apparatus for Complex Treatment of Liquids*. Published September 9, 2010.
United States Patent Application No. 20100224497. *Device and Method for the Extraction of Metals from Liquids*. Published September 9, 2010.
United States Patent Application No. 20110069579. *Fluid Mixer with Internal Vortex*. Published March 24, 2011.
United States Patent Application No. 20100193445. *Foaming of Liquids*. Published August 5, 2010.
United States Patent Application No. 20150130091. *Foaming of Liquids*. Published May 14, 2015.
United States Patent No. 6,139,714. *Method and Apparatus for Adjusting the pH of a Liquid*. Issued October 31, 2000.
United States Patent No. 9,144,774. *Fluid Mixer with Internal Vortex*. Issued September 29, 2015.

submitted 26.06.2026;
accepted for publication 10.07.2026;
published 31.07.2026

Contact: lysenko.dmytrous@gmail.com