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REGENERATION OF PROCESS WATER IN SMART TEXTILE MANUFACTURING. (Regeneration of process water in smart textile manufacturing without the use of chemical reagents)

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Abstract

This paper outlines a structured technological framework for water treatment and regeneration within smart home infrastructure, designed to ensure the delivery of water at the required consumption level in compliance with applicable quality standards. The proposed system is based on established experience in electrochemical water treatment and integrates aerodynamic and electrochemical processing modules.

Keywords: *Integrated water treatment systems; Integrated aqueous solution treatment systems; Base industrial modules; Capacity of a base industrial module; Operational performance of a single base module; Minimum capacity of a base industrial module; System – modular complex*

For water supplied to the smart home distribution system from linear (centralized) sources, preliminary treatment is performed using aerodynamic foam generators. These units separate organic contaminants while simultaneously dissolving atmospheric oxygen into the water, achieving oxygen saturation levels of up to 96%, as confirmed by laboratory testing conducted in leading research facilities.

For independently located smart homes supplied by artesian wells, inlet treatment is additionally carried out through electrochemical cells integrated into an electrochemical reactor. The system enables the following operations:

– desalination via accelerated electrolytic salt deposition onto a movable cathode manufactured from carbon–carbon composite fabric;

– pH adjustment to neutral levels;

– controlled dosing of coagulants to facilitate sediment formation and subsequent separation of precipitates from purified water;

– aeration through aerodynamic foam generators.

Where required, water disinfection is achieved through sequential pH modulation, involving temporary acidification followed by restoration to neutral pH.

For treated wastewater, the same electrochemical processing system enables removal of contaminants introduced during use. The purified fraction of the water stream can then be activated for recirculation within the smart home system, while the remaining treated water may be directed for irrigation purposes.

The proposed integrated approach supports resource efficiency, water reuse, and compliance with modern environmental and quality standards within intelligent residential infrastructure systems.

Applications of Water Treatment Technologies

Classification of Integrated Water and Aqueous Solution Treatment Systems

Integrated industrial systems for the treatment of water and aqueous solutions are designed with a modular structure.

The minimum capacity of one base industrial module equipped with a single two-section ion-exchange column is 500 liters per hour.

Figure 1.

The operational performance of one base module equipped with two two-section ion-exchange columns is 1,000 liters per hour. The minimum capacity of one base industrial module equipped with a single three-section ion-exchange column is 750 liters per hour. The operational performance of one base module equipped with two three-section ion-exchange columns is 1,500 liters per hour. For all specified systems, ion-exchange treatment columns are designed in a two-section configuration. Where increased system capacity is required, a modular complex configuration is implemented using three-section ion-exchange columns.

A brief description of the technologies of electrochemical treatment of water:

1. Technology of water treatment from radioactive pollution

The technology represents a combination of consecutive stages of electrochemical and biological treatment. Electrochemical treatment, taking into account the properties of water contaminated with radioactive isotopes, is based on two stages of treatment, -the impact on the volume of water through aerodynamic pulsation of compressed gas from a compartment of the purified volume of water, foam consisting of organic substances and other contaminants with a low level of conductivity, after which the impact on the stream of water, through the help of neutral electrodes, made from carbon composite materials, and stimulation of the formation in the stream of water, of oxides of radioactive materials contained in it, with a subsequent separation of the specified oxides from the stream of water.

The biological treatment is based on the principle of absorption of crushed particles of algae (for example the algae type «Ozolla»), ions of radioactive isotopes, contained in the water. The proposed technological scheme of treatment can reduce the concentration of radioactive contamination to a level of one trillionth of a gram, which exceeds the requirements of existing standards.

2. Technology of desalting seawater, based on the method and technology of accelerated electrochemical processes

The technology represents the process of electrolytic sedimentation of salt on a constantly running infinite conveyer (cathode) from coal composite fabric. Sea water is moved on special insoluble anodes, which direct it to the surface of the cathode-conveyor. With this the sea water is regarded as an electrolyte with a salt content of 35–42 grams per liter. At such a sodium content of salt sedimentation, at the delivery into the zone of treatment of an electrical current with a density of 35–50 amperes per one square of decimeter electrodes, it is enabled to achieve a rather high speed of sedimentation, in order to ensure efficient expediency of the project. Installations should have a modular principle of design.

The prospective efficient productivity of such a module is 50 cubic meters per hour.

The specified modules can be used as means of preliminary treatment of seawater before the installation of reverse osmosis, for increasing the service life of membranes, or as autonomous complexes for desalination.

3. Technology for the reduction in water of the concentration of salt hardness.

The technology is based on the principle of consecutive electrochemical changes of the level of acidity and alkalinity in a stream of water, separation of the resulting sediment and final adjustment of the specified level depending on the end user of the water. The water treatment is expected in electrochemical reactors with various types of electrodes and electrode cartridges, changes of types and materials of electrodes which can change depending on the type of hardness salts, their concentration, and end-user requirements. As the finishing stage of treatment, the application of ultra-filtration or other equivalent membrane technology is presumed. The proposed technological complex of special equipment can also include flotation modules, aeration units, and different kinds of filtration. After treatment in electrochemical reactors for more deep cleaning of water from hardness salts, there need to be used special column-modules with capsules, filled with natural coarse-grained zeolite, previously heat-treated in a special way.

4. Technology for adjusting the level of acidity or alkalinity in water or aqueous solutions;

The technology is based on the oxidation of water in an ascending flow in the electrode cell with neutral electrodes, separated by a permeable membrane from polypropylene fabric; the electrodes are insoluble; variations of electrode materials and coating material on the electrode surface are possible. On the basis of the indicated technology it is possible to present the design of the original technological equipment, while it is also possible to present a version of the integrated system in which are combined electrocoagulation and adjustment of acidity or alkalinity, and in this case, the electrode cell anodes must be soluble; technological speculations have been tested on electrode cells with polarizable and selectively soluble electrodes, the results of the tests were positive, and it is supposed, that for the first time the effect of the correction of acidity and alkalinity is achieved with the use of polarizable electrodes;

5. Technology of electrochemical disinfection of water or aqueous solutions;

The technology is based on the insertion into an ascending flow of water or aqueous solution, of current impulses of high density combined with the initiation of a regional effect of electrodes on the input and output of the inter-electrode space; a technique which is frequently tested on insoluble electrodes; The proposed progress of the technology, allows the application of new composite materials and new configurations of electrochemical cells for disinfection; on the basis of this idea is a conceptual design of original technological equipment, according to preliminary estimates, having a necessary level of novelty, non-obviousness, and utility; as the prototype of the indicated technology and equipment, can be used a previous patent application;

6. Technology for the decontamination of surfaces by means of a combination of water flow charged with positive and negative electrical potential

The technology is based on the properties and possibilities of the electrochemical reactors in the division of the fluid flow of the aqueous solution or water into two streams with different levels of acidity or alkalinity and accordingly charged positive and negative electrical potentials from the anode and the cathode.

The technology is based on the oxidation of water in an ascending flow in an electrode cell of an electrochemical reactor with neutral electrodes, divided by a permeable membrane from polypropylene fabric; the electrodes are insoluble; variations of electrode materials and special coatings of the working surface of the electrodes in cases of particular necessity for the quality of deactivating the liquid for chemical purity are possible.

After the division of both flows using the original injector are released into one point of the surface, and neutralize the static electricity at this point and simultaneously deactivate the surface at this point, and, during scanning of the surface, the neutralization of the static electricity on all the scanned surface occurs, and, accordingly, so does the decontamination of the entire surface.

7. Technologies of neutralization of static electricity on the surface by means of a connection on the surface of the flows of water, charged with positive and negative electrical potentials.

The technology is based on the properties and possibilities of the electrochemical reactors in the division of the fluid flow of the aqueous solution or water into two streams with different levels of acidity or alkalinity;

The technology is based on the oxidation of water in an ascending flow in the electrode cell with neutral electrodes, separated by a permeable membrane from polypropylene fabric; the electrodes are insoluble; variations of electrode materials and coating material on the electrode surface are possible.

After the division of both flows using the original injector are released into one point of the surface, and neutralize the static electricity at this point, and at the scanning of the surface there occurs a neutralization of the static electricity on all the scanned surface.

8. Technologies of electrocoagulation by means of coaxial electrochemical reactors

The technology is actualized by means of an electrochemical reactor with coaxial tubular electrodes; such a reactor differs by having extremely small dimensions in relation to the volume of the treatable liquid.

Otherwise, the principle of operation of the electrochemical reactor is analogous to conventional reactors, developed by the company and possesses the same technological and operational advantages.

The main operational advantage of this technology is the possibility during the work process of such a reactor to carry out the regulation of the reciprocal position of the cathode and anode without stopping the process of coagulation.

9. Technologies of electrochemical treatment of water and other liquids using electrochemical reactors with elastic, polarizable tape electrodes

The technology is realized in an electrochemical reactor that incorporates flexible porous strip electrodes, made of composite carbon fabric.

Such electrodes are extremely chemically stable and such a process of treatment does not bring into the treatable water any products of the destruction of the electrodes.

Such a process is precise and has a maximally low rate of collateral contaminants, which provides it a high efficiency in the process with full regeneration and recirculation of working solutions and technological liquids.

10. Technologies of electrochemical treatment of water and aqueous solutions by means of electrochemical reactors with planar polarized electrodes;

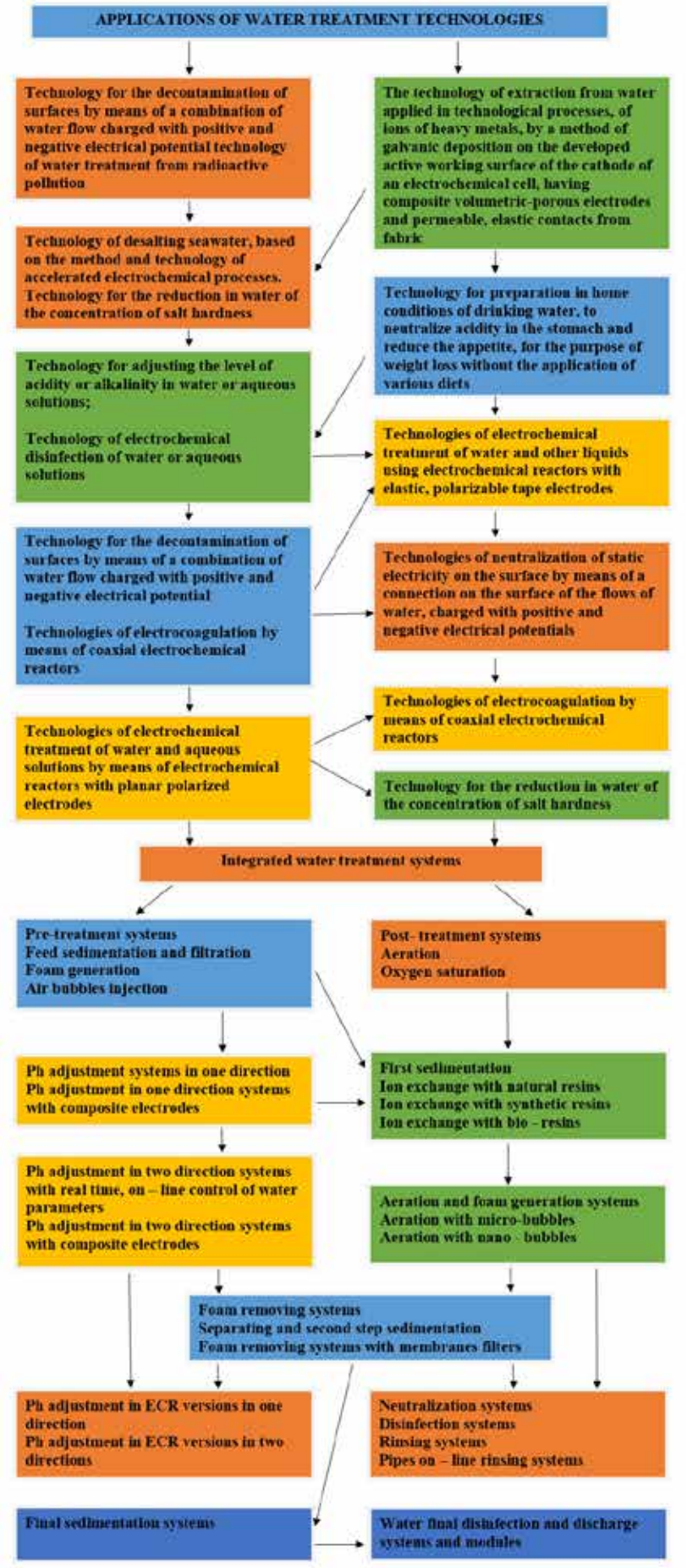
The combination of the factor of the application of planar polarizable electrodes with the execution of the specified electrodes from carbon composite materials gives, in comparison with traditionally known designs of elec-

trochemical reactors with typical electrodes, a tangible economical and qualitative effect.

11. Technology for preparation in home conditions of drinking water, to neutralize acidity in the stomach and reduce the appetite, for the purpose of weight loss without the application of various diets

The technology is based on the possibility of increasing the level of alkalinity of drinking water by electrochemical influence, without applying any chemical reagents; the device is connected to the water supply system, has its own portable power source; the electrodes can be made of various materials, composites, and from titanium coated with ruthenium oxide; productivity is 10 liters per hour; possibilities to reduce the appetite by means of partial neutralization of the gastric juice were discussed with experts in alternative medicine and received unequivocal approval; there is a conceptual design of the device for home usage, which in combination with technological use, on a preliminary assessment, possesses intrinsic novelty, a non-obvious technical solution, and usefulness;

Figure 2.


APPLICATIONS OF WATER TREATMENT TECHNOLOGIES
Technology for the decontamination of surfaces by means of a combination of water flow charged with positive and negative electrical potential technology of water treatment from radioactive pollution
Technology of desalting seawater, based on the method and technology of accelerated electrochemical processes. Technology for the reduction in water of the concentration of salt hardness
Technology for adjusting the level of acidity or alkalinity in water or aqueous solutions;
Technology of electrochemical disinfection of water or aqueous solutions
Technology for the decontamination of surfaces by means of a combination of water flow charged with positive and negative electrical potential
Technologies of electrocoagulation by means of coaxial electrochemical reactors
Technologies of electrochemical treatment of water and aqueous solutions by means of electrochemical reactors with planar polarized electrodes
The technology of extraction from water applied in technological processes, of ions of heavy metals, by a method of galvanic deposition on the developed active working surface of the cathode of an electrochemical cell, having composite volumetric-porous electrodes and permeable, elastic contacts from fabric
Technology for preparation in home conditions of drinking water, to neutralize acidity in the stomach and reduce the appetite, for the purpose of weight loss without the application of various diets
Technologies of electrochemical treatment of water and other liquids using electrochemical reactors with elastic, polarizable tape electrodes
Technologies of neutralization of static electricity on the surface by means of a connection on the surface of the flows of water, charged with positive and negative electrical potentials
Technologies of electrocoagulation by means of coaxial electrochemical reactors
Technology for the reduction in water of the concentration of salt hardness
Integrated water treatment systems
Pre-treatment systems
Feed sedimentation and filtration
Foam generation
Air bubbles injection
Ph adjustment systems in one direction
Ph adjustment in one direction systems with composite electrodes
Ph adjustment in two direction systems with real time, on – line control of water parameters
Ph adjustment in two direction systems with composite electrodes
Post- treatment systems
Aeration
Oxygen saturation
First sedimentation
Ion exchange with natural resins
Ion exchange with synthetic resins
Ion exchange with bio – resins
Aeration and foam generation systems
Aeration with micro-bubbles
Aeration with nano - bubbles
Foam removing systems
Separating and second step sedimentation
Foam removing systems with membranes filters
Ph adjustment in ECR versions in one direction
Ph adjustment in ECR versions in two directions
Neutralization systems
Disinfection systems
Rinsing systems
Pipes on – line rinsing systems
Final sedimentation systems
Water final disinfection and discharge systems and modules

12. The technology of extraction from water applied in technological processes, of ions of heavy metals, by a method of galvanic deposition on the developed active working surface of the cathode of an electrochemical cell, having composite volumetric-porous electrodes and permeable, elastic contacts from carbon-carbon composite fabric

The effect of the technology is achieved and ensured due to a roughly 100,000 times more advanced contact surface in both electrodes. This, in turn, provides significantly greater exchange capacity of the cathode and the possibility for the apparatus to work longer without replacing the electrodes, and without stopping the production line.

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