Using the ion exchange reactor of continuous action

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Abstract

Presents the development process for water softening in the ion exchange reactor continuous action, which helps to absorb hardness ions from the water, which cleared, and regeneration of the sorbent with a minimum energy consumption and reagent consumption.
On the waste ion exchange resin was studied the technology of continuous water treatment, as a sphere of living the aquatic organisms in the recirculating water.

Аннотация

Разработана технология и создан аппарат умягчения и очистки воды в ионообменном реакторе непрерывного действия, который одновременно совмещает процессы водоочистки и регенерации сорбента с минимальным потреблением энергии и реагента для регенерационной очистки ионообменной смолы. На отработанной ионообменной смоле изучена технология непрерывной водоподготовки замкнутого водооборотного цикла, как сферы жизни водных организмов.

Keywords: the ion exchange unit, filter, hardness, water, purification.

Introduction

The ion exchange unit of the type design is a cylindrical vessel, which has a water supply system, which is purified and the regenerate solution , which consists of a the stationary layer of the adsorbent (the ion exchange resin), through it occurs the movement of liquid. The usual technological task - to reduce the content of hardness salts from 10-15 mg-eq/dm^3 to 0.1-0.01 mg-eq/dm^3. The main disadvantage of the sorption of ions in that apparatus is the formation in the stationary layers of resin the parasitic channels, through which the process fluid moves with the lowest hydraulic losses. This leads to the premature breakthrough of ions, that quickly leads to the necessity of regeneration of the ion exchange resins, which, in its turn, causes an additional stasis unit and high consumption of the regenerating agent. Suspended solids, mechanical impurities, which are present in the initial process liquid, in case of contact with the resin, contaminate the filter layer, which leads to an increase of the hydraulic resistance and disturbance of sorption - desorption of ions; using the periodic regeneration process does not allow to use all the exchange capacity of ion exchange resins. With a high content of calcium ions there are conditions of colmatation.

To stop that, it has been proposed the structure of an ion-exchange apparatus with moving bed of ion exchange resin.

Description of the technological scheme

The fundamental unit the ion exchange filter is shown in Figure 1.

The action of the ion exchange filter is, that the process liquid, which is to be cleaned flows into the distribution manifold 5 through the inlet pipe 12, then into the upper working layer of sorbent 4, where there is the sorption of hardness ions by the ion-exchange material. The working layer of sorbent 4 moves toward the movement of process liquid, regenerated sorbent falls down on the working layer of sorbent from the labyrinth channel 3. The waste of sorbent flows into the zone of sorbent regeneration 16. Water, which cleared from the hardness salts supplied for the appointment through the drain connection 15. The regenerating solution is fed through the inlet pipe 11, which enters into the zone of regeneration through the distribution manifold 6. The regenerated sorbent is supplied into the drainage glass 13 with the help of the airlift 19, the liquid, which contains the desorbed ions and mechanical impurities, is reset into the sewer through the drainage pipes 9,10. The grid of the drainage glass 14 serves to separate the solids and solutions, which contain the desorbed hardness ions.

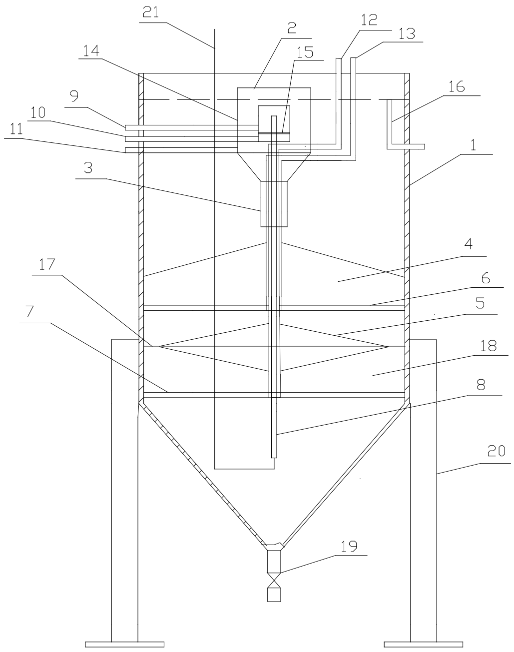

Figure 1 The scheme of device of the ion-exchange filter.

The dewatered sorbent mass falls out over the edge of the drainage glass 13 and falls down into the labyrinth channel 3 and as the liquid level in the washing unit below the liquid level in the filter, then do the washing of sorbent by the purified liquid. The drainage liquid, which was obtained - released through the drainage pipe 11. Difference of levels performed with the help of branch pipes 9,10,11. In this way, occurs the countercurrent washing process of the regenerated sorbent in the labyrinth channel 3 and then it goes to the upper part of the working layer of the sorbent. In this way, there is a process of simultaneous countercurrent sorption of hardness ions from the process liquid and regeneration of the sorbent and removing the mechanical impurities, which can be in the process liquid.

The basic geometric dimensions of the filter: total height -1 m; the inner diameter of the body - 0.145 m; the height of the working layer of sorbent - 0.45 m.

Methods

During the researches, to determine the total hardness has been used the standard Complexometric method, which based on using the Trilon B.

Results and Discussion

For research it has been used the strong acid cationite of brand KU-2-8, as the regenerating solutions used the solutions with different technical concentrations of calcium chloride. The hardness of water (was used the tap water) generally was 4.0-4.2 mEq/dm^3. The total maximum flow rate of water was $3,9 \cdot 10^{-5}$ m^3/s($140 dm^3/h$). The water temperature, which was applied was $15C^0$. The total exchange capacity of cationit KU-2-8 was 2.72 mEq/g. The performance of the airlift (for resin) was 200 cm^3/min.

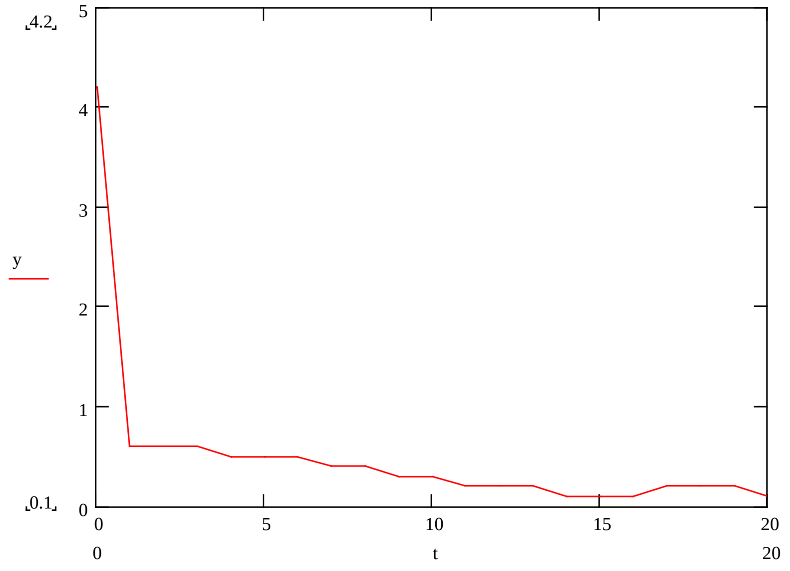

Figure 2 Change of the rigidity of purified water "Y" (mEq/dm^3) from time «t» (hour).

Figure 2 shows a graph of the hardness of treated water from the time of experiment .As these graphs show, that the time of transition of the filter to the stationary regime is approximately 2-3 hours.

Obtained data allow us to conclude, that the proposed construction of the ion-exchange filter allows to get the softened water with residual stiffness not more than 0,1 mEq/dm^3, that provides the simultaneous sorption of hardness ions and the process of regeneration of the resins.

Based on these data we can say, that the use of the ion-exchange filter of continuous action, allows to use all the exchange capacity of the ion exchange resin; in a moving bed of sorbent is impossible the formation of parasitic channels, through which the adsorbed ions skips; mechanical impurities, that is, in purified water, that removed with a constant washing of the resin in the labyrinth channel, which eliminates their accumulation in the resin layer, and this leads to a reduction and stabilization of hydraulic resistance; the constant dosage of regenerating solution minimizes the amount of reagent; constancy of concentration gradient of the reagent removes sudden changes in concentrations, that minimizes the osmotic impact on grain of cationite, which reduces the number of flawed pellets.

Problems and their solutions

Importance of decision the problem of obtaining food protein of animal origin, in necessary quantity, for modern society is not in doubt. The most high-quality food animal protein, from the point of view of science like dietology, provide the water organisms. The growth of catching them in the seas and oceans, and other natural waters is almost exhausted. The intensive increasing production of fish, molluscs, leatherback turtles and other aquatic organisms can only be in systems of recirculation of (RAS).

The Chinese firm “Zhejiang Tianlong Biologic Engineering Co.”, Ltd (Jiaxing city) during the visit of Ukrainian delegation to China briefed our staff with specific difficulties of growing the Leatherback turtle in artificial conditions.

It was necessary to solve the following problems:

- reducing the contaminants of source of water;

- Reducing the cost of fuel for heating the additional water;

- Reduce heat loss due to the return of warm water of basins;

- Minimization of release of water with complete prevent loss on living organisms.

To solve these problems was signed the agreement about scientific and technical cooperation. Were carried out the complex research by the Ukrainian side, which were focused at solving these problems. They are interrelated in the terms of life of living organisms in UZV. As the modeling of life of aquatic organisms was used an ordinary carp and a catfish. Based on these studies we got the data, that allow you to create the block system of water treatment and water purification, almost without blowdown. When using the biofilter and filter elements, then there is the minimization of the number of toxic compounds, which come from the water. The heating of the initial water to the working temperature proposed to take place in the devices of cavitation, that reduce energy consumption of heating to 15-17%.

The most responsible was the research, which is associated with the minimization of the volume of "Purging" (water), with high-quality water purification in the cycle and receiving comfortable conditions for the existence of aquatic organisms. As the commercial requirements tell carry out a high density of landing of turtle in the conditions of UZV, that is the question of purification of process water of the pool from the mechanical toxic impurities (rests of a forage, waste products of the Leatherback turtle) and chemical contaminants, first of all, nitrogen compounds (ammonium ion). Were developed and patented the new equipment and water treatment technology from these contaminants, which led to a minimum consumption of fresh water, which must be cleaned and heated.

Figure 3 Exterior view "Biosphere-500V"

Figure 4 Aquatic Organisms in "Biosphere-500V"

The Ukrainian side has developed two pilot plants of close water supply "Biosphere-300A" and "Biosphere-500V". Figures 3 and 4 show the "Biosphere-500V" and figures 5, 6 show "Biosphere-300A".

The technological scheme for the installation of "Biosphere-300A" included a sump with special design and the biofilter - sand filter, which regenerated. The volume of "Biosphere-300A" was 300 dm^3. The Initial stocking density of fish 5%.

In the installation of "Biosphere-500V" the biofilter is equipped with an air airlift, with device for ozonation. The initial stocking density of fish in the plants - 3%. As food was the special forage, the basis of which - recycling wheat, other cereals and supplements.

Figure5 Exteriorview of "Biosphere-300V"

Figure 6 Aquatic Organisms in "Biosphere 300V

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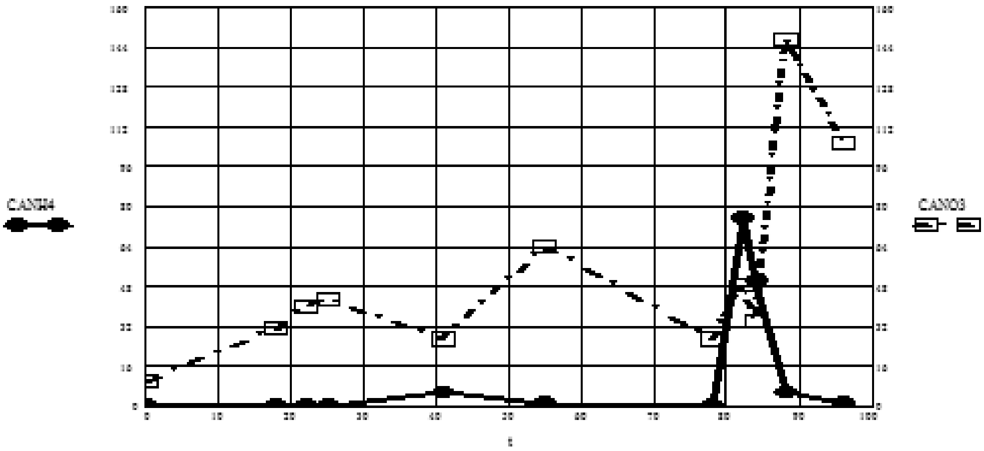

Figure 7 Change of concentration of ammonia nitrogen C_BNH_4 (mg/dm^3) and nitrate nitrogen C_BNO_3 (mg/dm^3) from time t (day) "Biosphere-300A".

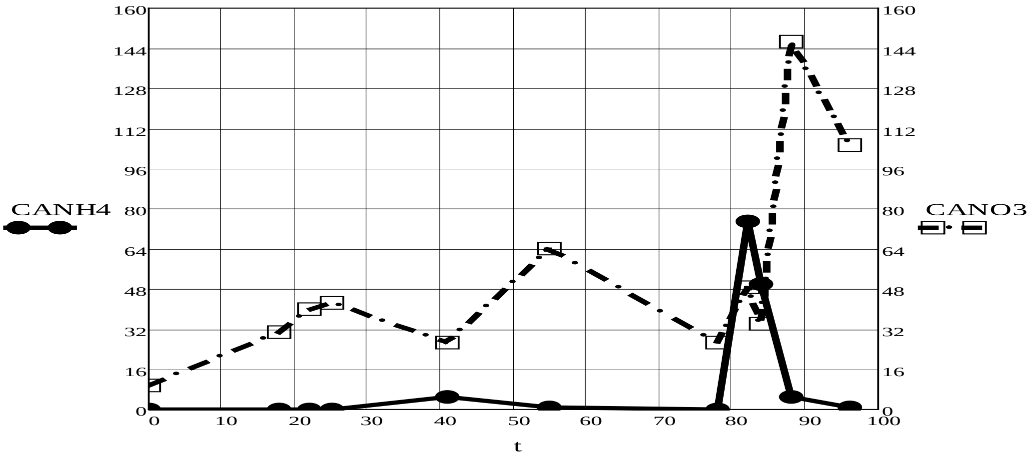

Figure 8 Change of concentration of ammonia nitrogen C_BNH_4 (mg/dm^3) and nitrate nitrogen C_BNO_3 (mg/dm^3) from time t (d) in the "Biosphere-500V".

The experiment, which lasted for many months, it was shown, that the developed construction of UZV allows you to perform the task of intensive co-cultivation of common carp and catfish. The figures 7 and 8 shows the graphs of change of concentration of ammonium and nitrate nitrogen from time in "Biosphere-300A" and "Biosphere-500B", respectively.

On the 80th day the ammonium nitrate has been added into the both systems to obtain information about the speed of recycling a harmful concentration of ammonia nitrogen by microorganisms, which live in the biofilm. As seen from the graphs, both systems are transferred ammonium nitrate to nitrogen almost for ten days and then, over the next ten days, nitric nitrogen was removed from the habitat of aquatic organisms. "Biosphere -300A" showed a great efficiency of transformation higher concentrations of toxic substances.

Conclusions

Based on these data, it was developed the technology of joint cultivation of carp, catfish and other aquatic organisms in the UZV with high technical and economic indicators.

The Ukrainian side, after two years, is ready to continue cooperation with Zhejiang Tianlong Biologic Engineering Co., Ltd. for the implementation of the technology both in Ukraine and in the Republic of China.

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