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Resource-Saving Technology of Wastewater Treatment of Factories of Reinforced Concrete

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Abstract. A low-waste resource-saving technology for wastewater treatment from emulsified contaminants at the construction industry enterprises was developed. The technology allows reusing purified water, processing organic pollutants into secondary raw materials.

Laboratory and industrial tests were carried out. The experimental data were obtained with the use of instruments, equipment, providing the required accuracy, reliability of the measurement results, processed using the mathematical statistics of experiment planning, confirmed by implementation in production.

The conditions for the destruction of water-organic emulsions by a constant electric current in a device with insoluble anodes have been studied. The main factors were identified and analyzed: electrode material, solution electrical conductivity, current density, electrolyte composition, hydrogen value, temperature and processing time. The optimal parameters of the purification process are established. The kinetics of the process has been studied. A probabilistic mechanism for the destruction of emulsified organic substances in the investigated medium is presented.

On the experimental unit, the operations of averaging, sedimentation, electrochemical treatment, secondary sedimentation and the return of purified water to the technological cycle were worked out and introduced into production. The technological regulations were developed.

1. Introduction

At the heart of the solution to the problem of saving water resources in Russia is the balanced development of the water supply and drainage system in the regional industries. Rational uses of water resources in the construction industry requires the widespread use of recycling and re-supply systems based on efficient low-waste technologies for the purification of wastewater, as water consumption in enterprises is enormous - ten times higher than the amount of water consumed by the population.

At the enterprises for the production of reinforced concrete products there is the very low efficiency of water recycling in the technological cycle, which is caused by the lack of an effective method for wastewater treatment, that allows not only to increase the water turnover coefficient, but also to use pollutants from the "waste" category, contained in the runoff, calling them not waste, but "secondary raw materials" [1].



2. The main part

In wastewaters of factories of reinforced concrete products, in addition to inorganic, mineral impurities, there are emulsified organic contaminants formed during washing equipment and concrete pipes, in steam chambers (condensate), and in pipe-forming stations [2]. The production site for research was JSC Volgograd Plant of Reinforced Concrete Products No. 1, in the molding shops of which there are technological lines with heat and humidity processing tubes of pit type, equipment for tensioning armatures and stands for inspection and repair of products. The molding post of each line consists of a concrete paver, a vibroplatform and a form-laying machine [3].

Lubricants used for the manufacture of prefabricated reinforced concrete in steel molds should have the following: increased adhesion to the metal and reduced one to the concrete, the absence of harmful effects of lubricants on the physicomechanical and decorative properties of the surface layer of concrete. Lubricants must not cause corrosion of the metal, must be mechanically applied, be economical and meet the requirements of safety and fire safety.

The lubricants based on emulsol EKS are the most suitable for these requirements. Two types of such lubricants are used: direct emulsions (for example, emulsol EKS - 10%, soda calcined 0.6%, water-condensate - 89.4%) and back emulsions (emulsol EKS - 20%, saturated lime solution at $t = 60^\circ \text{C}$ - 80% or emulsol EKS - 20%, solar oil 5 - 10%, saturated solution of lime - 70 - 75%). The most widely used is a reverse emulsion, which, unlike a straight line, is well retained not only on horizontal, but also on vertical surfaces of molds. Acceleration of the hardening process is achieved when the product is steamed, i.e. steaming them for some time in the chambers [4].

As a result of heat and moisture treatment, condensate is formed, which is pumped to the industrial sewerage system. Pollutants of the condensate are mainly represented by organic compounds contained in lubricants used to lubricate steel molds and suspended solids.

In the armature departments of the above-mentioned shops the correct-cutting, bending machines and welding machines also work. Cooling of machine tools can also occur at the expense of circulating water supply. To return to the production of treated sewage, the concentration of emulsified organic contaminants, as well as oil- and resin-forming substances, should not exceed 0.1 mg / l [5].

In the wastewater formed, there are components that are more appropriate not to be transferred to waste, but to be used as secondary raw materials. Therefore, when choosing a method for purification of said wastewater, it is necessary to choose a method in which the release of pollutants occurs with their smallest chemical change.

In view of the high stability of waste water contaminated with emulsified organic compounds, discharges to common treatment facilities impair the quality of urban wastewater treatment, since emulsified particles of organic origin do not linger in sedimentation tanks and disrupt the work of post-treatment filters. In this connection, the effluents are pretreated by filtration, air purging and other purification methods. An alternative way of treating emulsions is to break them.

Having data on wastewater costs, their detailed characteristics, including the content of impurities, as well as the requirements for purified water, several methods can be selected for testing. Then, on the basis of experimental studies, taking into account technical and economic indicators, the optimal method for wastewater treatment can be chosen [6].

Analysis of scientific and technical literature on cleaning, neutralization, regeneration and utilization of industrial effluents containing pollutants of organic origin shows that this problem has been intensively studied and is studied by scientists [2,5,8].

In order to select the most effective method of wastewater purification of iron and steel works from emulsified organic compounds, and also to predict the composition and properties of the precipitate released as a result of purification in one way or another, it is necessary to determine the structure and concentration of organic compounds that make up the contaminant.

3. The research part

Some physico-chemical and chemical purification methods were tested in the laboratory. In Table 1 there are data on the results of purification by the indicated methods, the degree of purification during application, which exceeded 30 - 34%. [10]

The results of preliminary studies have shown that the most effective are reagent purification methods, sorption and electrochemical methods. However, each of these methods has a number of drawbacks. The method of sorption purification is complicated and economically unprofitable, since regeneration of the sorbent is necessary, which, in turn, leads to additional costs for the reagents. In addition, the sorption method does not meet the main criterion - it does not allow to extract organic contaminants without destroying their structure.

The method of reagent oxidation is also not expedient from the economic point of view, since it includes considerable expenses for reagents, besides the method is fire-dangerous and explosive, and, like the method of sorption purification, it does not allow to isolate polluting components without changing their chemical composition and structure - there is a complete oxidation of organic compounds, that make up the contaminants, to carbon dioxide and water.

The disadvantages of electrochemical processing include the need to select anode material and basic parameters of electrochemical cleaning, as well as constant monitoring of the anode potential and, most importantly, electricity consumption. But only this method can allow the extraction of organic substances with a minimal change in their structure.

In this study, it was found that the main requirement for the method of wastewater treatment of the plant of concrete products, namely the maximum release of pollutants with a minimal change in their structure, as well as the return of purified water to production meets the method of electrochemical cleaning. Further studies were carried out on the basis of the electrochemical method, for which it was required to select and work out the conditions for treating water drains, without destroying completely the structure of molecules of organic substances.

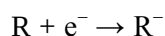
Table 1. Comparative characteristics of wastewater treatment methods.

Cleaning method	Degree of purification, %	Notes
Sorption	47 – 52 %	It is difficult and economically unprofitable to regenerate the sorbent, irretrievable loss of organic substances.
Reagent purification (oxidation by hydrogen peroxide)	52 – 55 %	Oxidation occurs to CO ₂ and H ₂ O; the oxidation process is explosive, the method is very sensitive to the concentration of H ₂ O ₂ , temperature and light; partial loss of steam in the form of steam.
Electrochemical treatment	45 – 52 %	Need for selection of electrode material; constant monitoring of anode potential; electricity consumption.

For further studies, the kinetics of the reactions occurring in the near-electrode spaces was studied and the products of the indicated reactions were analyzed. The obtained results showed that in the near-anode space the destruction of the EO of contaminants proceeds to the predicted structures and only a small part of them is polymerized at the cathode. The data obtained allowed us to formulate the probabilistic mechanism of the anodic reaction using the example of contained naphthenes.

In the near-cathodic space, there are mainly reactions of electroreduction of organic substances in aqueous media connected with the mechanism of hydrogen evolution on the electrode and, therefore, they speak of various reconstructive agents of different nature: electrons, ions or hydrogen atoms. Molecules of organic matter, turning into organic anions, often participate in the electrochemical

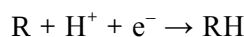
reaction on the cathode directly:



The subsequent stage of the process is the neutralization of the anion to form the hydrogenation product:



It is also possible to simultaneously participate in the discharge of a hydrogen ion and a molecule of organic matter:



At a high cathode potential, free radicals can be formed as intermediate products of the reaction, which promote high reactivity of organic compounds [7].

The nature of the substituent (electronegative and electropositive groups) and its position in the molecule to be reconstructed, the cathode material, the electrolysis conditions and, especially, the composition of the solution affect the course of the reduction process [8].

Organic compounds are electrolytically reduced on metals with high overvoltage (Hg, Pb, Cd, etc.) [9], which requires a significant consumption of electricity and is practically unworkable in conditions of cleaning large volumes of sewage. However, the cathodic reduction processes occurring in electrolyzers are associated with anodic oxidation processes, but they make an insignificant contribution to the overall process of isolating organic compounds.

Since electrochemical neutralization of wastewater is more expedient to carry out the oxidation of organic compounds at the anode, special attention should be paid, as already noted, to the choice of anode material. The main difficulty arises from the fact that most metals are thermodynamically unstable under the conditions of anodic polarization (they dissolve or passivate).

In particular, in the processes of electrochemical cleaning, the high overvoltage of hydrogen evolution at the cathode and oxygen at the anode affects the increase in the spontaneously consumed energy [10]. It follows that metals with a low overvoltage, for example platinum, are the most suitable electrode material, however, due to economic factors, graphite and stainless steel electrodes were used for the study.

Polarization curves of the pre-anode process were obtained to determine the oxidation potential of organic compounds polluting the wastewaters of the concrete products plants, the current density, and the anode material. While removing the polarization curves, platinum was used as the anode material, however, based on the reasons for increasing the efficiency of the purification process, the possibility of using electrodes made of graphite was investigated, since graphite is an electrochemically active anode material with high electrical conductivity and electrodes made of stainless steel.

The studies were carried out on 8 model solutions containing inorganic compounds of the same concentration as in real drains and individual fractions of organic contaminants.

As shown by the conducted experiments, the degree of sewage treatment from emulsified organic substances is directly proportional to the current density and the time of water treatment. The maximum degree of purification is achieved at a current density of 1.0 A / dm². However, it is economically inexpedient to conduct wastewater treatment on an industrial scale at this current density. Therefore, the optimum current density is in the range of 0.5 to 0.7 A / dm².

In electrochemical systems, an increase in the temperature of the electrolyte reduces the overvoltage of electrode reactions. The temperature coefficient of overvoltage ($d\eta/dT$)_i of hydrogen and oxygen release is 2-4 mV / °C [89]. An increase in temperature from room temperature to 60 - 80 °C reduces the overvoltage of these processes by 6 - 7%.

Investigation of the influence of the process temperature on the degree of purification of the designated wastewater was carried out on model solutions.

Based on the results of the conducted studies, it is evident that an increase in temperature from 20 to 80 °C did not significantly affect the speed and efficiency of the process of electrochemical sewage treatment, but somewhat reduced power consumption. This is explained by an increase in the electrical conductivity of the solution and, due to this, a decrease of the voltage between the electrodes.

The reduction in the electric power consumption (Wel) established in the work is insignificant, therefore it is not advisable to specifically aim at increasing the temperature of the treated wastewater. The optimum temperature for carrying out the process of electrochemical purification of waste water from factories of concrete products from emulsified organic contaminants is 20-25 ° C in a medium close to neutral.

4. Conclusions

The possibility of destruction of organo-water emulsions by oxidation has been proved, and the oxidation-reduction process has been chosen as the main method; an analysis of the main factors contributing to the destruction of water-organic emulsions under the action of a constant electric current; it is established that the optimal conditions for the destruction of water-organic emulsions by a constant electric current are: the electrode material is stainless steel, the current density is 0.63 A / dm², the pH is 6.9-7.5, the temperature is 20-22 ° C, 6 - 7 minutes; it is proved that the maximum degree of purification is achieved when the ratio of the areas of the anode and cathode surfaces is not less than 8: 1, respectively; the mechanism of emulsion destruction in the investigated medium is proposed, the use of which allows controlling the composition of the precipitate formed; the field of application of the separated organic sediment is determined and recommendations for the use of the formed sediment as a secondary raw material are developed.

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