Research of Simulation Model of Electrocoagulation Process

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Abstract— **The mathematical model of the electrocoagulation process has been constructed, taking into account the geometric dimensions of the reactor, the volumetric flow rate of the liquid and the applied current. A simulation model has been developed that describes the processes occurring in a coagulator, on the basis of which was studied the influence of current, changes in the concentration of inlet contamination on the concentration of the target component at the outlet of the reactor.**

Keywords— electrocoagulation; simulation model; automation; sewage; regulation.

I. Introduction

Significant rates of industrial development lead to a number of pressing environmental problems that need to be addressed. One of the most important state-controlled tasks is the level of wastewater pollution. Depending on the type and concentration of impurities, various purification schemes are used. The promising directions include electrocoagulation. The advantages include: high productivity, low sensitivity to changes in the composition of the aquatic environment, no need for preliminary removal of dissolved organic substances, the presence of industrial release of various electrocoagulation units, no need for additional introduction of coagulants [1].

The study of electrocoagulation process is a priority area of work of many authors [2-5]. The influence of various parameters, such as: electrode material, distance and size of plates, magnitude of applied voltage, and concentration of pollutants on the efficiency of the electrocoagulation process was researched in [3-4]. In [3] it was also found that the main advantage of this process is that it does not require additional coagulants, and the energy source in this installation is a direct current. However, the problem of developing and researching the model, as well as the automation of the process, has arisen. As an object of automation, the electrocoagulation unit was considered in [6], where an information scheme of a complex sewage treatment system and a mathematical model for each channel were developed. All things considered, the purpose of this work is:

1) to study the simulation model of the process of electrocoagulation when changing control effects using the pdepe application of the MatLab environment;

2) check the operation of the developed regulator in conditions close to the real ones;

3) to develop a system of automation of sewage treatment of textile production with observance of the established ecological norms of concentrations of pollution with the minimum expenses of electricity.

II. Formulation of the problem

To study the production of coagulant during industrial wastewater treatment, we use the mathematical model developed in [1]. Thus, the following dependencies are used to find the distribution of contamination concentration and temperature in the electrocoagulator:

$$\begin{cases} \dfrac{\partial C}{\partial t} + v \cdot \nabla C - f\left(x,t,C\right) = \nabla\left(D(T)\nabla C\right), \\ \dfrac{\partial T}{\partial t} = a_1 \cdot \nabla\left(\dfrac{\lambda_m}{\lambda}\nabla T\right) + \dfrac{I \cdot U \cdot e^{\frac{a_2}{t}}}{c\rho}, \end{cases} \qquad (1)$$

$$C\left(x,0\right) = C_0(x),\; T\left(x,0\right) = T_0(x),$$
$$\left.\frac{\partial C}{\partial x}\right|_{x=L} = 0,\; \left.\frac{\partial T}{\partial x}\right|_{x=L} = 0,\; \left.\frac{\partial C}{\partial x}\right|_{x=0} = 0,\; \left.\frac{\partial T}{\partial x}\right|_{x=0} = 0. \qquad (2)$$

where C – concentration of the specified component in water; T – water temperature in the reactor; I – current supply; a_1, a_2 – empirical coefficients; c – specific heat of a liquid; ρ – water density; λ_m – turbulent thermal conductivity; λ –

thermal conductivity of the electrolyte; ν – the rate of water leaking from the electrocoagulator; $f(x,t,C)$ – source function [2]; $D(T)=\overline{D}+D_T$ – the total diffusion coefficient; $\overline{D}$ – the molecular diffusion coefficient depends on the temperature ($D_T=\dfrac{\mu_T}{\rho Sc_T}$, $Sc_{T\infty}\approx 0.85$).

$$Sc_T=\left(\frac{1}{2Sc_{T\infty}}+\frac{0.3}{\sqrt{Sc_{T\infty}}}\frac{\mu_T}{\rho D}-\left(0.3\frac{\mu_T}{\rho D}\right)\left(1-e^{-\frac{\rho D}{0.3\mu_T\sqrt{Sc_{T\infty}}}}\right)\right)^{-1} \text{ [2].}$$

III. RESULTS

To study the mathematical model (1), a simulation model was developed, which is presented in Fig. 1. This model includes: Random number block, which simulates a random change in the input concentration of contamination; the "Step" block, which is used to study the system for switching off the applied voltage; subsystem "Regulator", which controls the magnitude of the applied voltage, depending on the input concentration of pollution; the coagulator subsystem, which simulates the operation of an electrocoagulator according to dependencies (1).

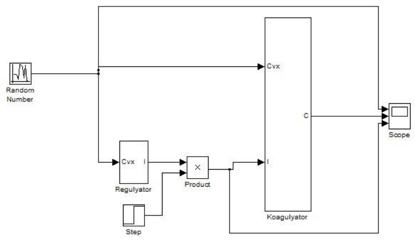

Figure 1. Simulation model of electrocoagulator

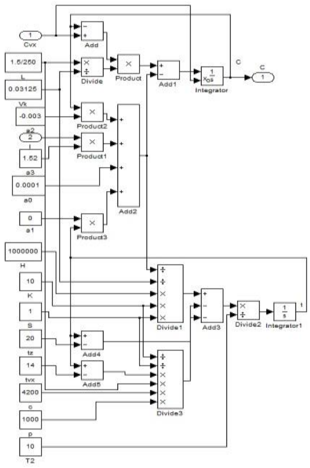

Figure 2. Subsystem «Koagulyator»

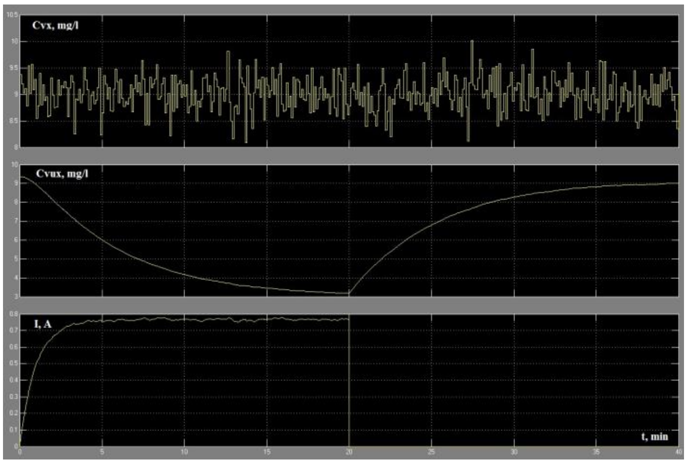

Figure 3. Change in Cvx inlet concentration, Cvux outlet concentration, and current I between plates

IV. CONCLUSIONS

A model describing the process of obtaining divalent iron as a coagulant from the applied current and variable concentration of input contamination was constructed. A solution to the corresponding model problem was found using the Simulink feature of the MatLab environment. The results of calculations of the distribution of the concentration of the coagulant with time at the exit of the coagulator, the current between the plates were given. As can be seen from Fig. 3. the coagulator does not immediately have enough divalent iron to efficiently purify the waste. Despite such inertia at steady-state start-up, changing the input concentration of contamination does not actually affect the level of permissible impurities at the system exit. Also, such inertia in the short-term failure of the electrocoagulator allows you to continue to clean the projected volumes of wastewater efficiently.

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