METHODS FOR INTENSIFICATION OF THE TRANSFER PHENOMENON IN THE CHEMICAL TECHNOLOGICAL PROCESS OF ELECTROLYSIS

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Abstract

The article discusses the technological process of electrolysis from the point of view of the transfer phenomenon and the position of physical chemistry. It is shown that taking into account the transport phenomena and associated processes depends on the state of the medium and is determined by the functions of the transport coefficients: (momentum, mass, heat). Physicochemical processes in a mechatronic electrolyze have been experimentally investigated, mechanisms of intensification have been proposed, and the regularities of transfer processes have been studied. The influence of ultrasonic cavitation, vibration on the electrolysis process, the was investigated, and the dependences of the potential of the electrolyzer required for the splitting of water on the temperature with intensification modules were obtained.

Keywords: transfer phenomena, transfer coefficient, treatment levels of the system, foaming, cavitation.

INTRODUCTION

The study of the phenomenon of transfer (energy, mass, momentum), as well as the study of work processes is an important scientific problem, which has both theoretical and applied significance. The transfer phenomenon is known to be an effective means for solving problems associated with the intensification of various chemical technological processes. As an example, we can cite the prospects of taking into account the features of the transfer phenomenon when considering the following classes of processes: hydromechanical, separation and mixing of heterogeneous systems, thermal conductivity and diffusion, chemical and physicochemical problems. The peculiarity of this approach is that the transfer coefficients are variable functions and depend on a number of factors - temperature, viscosity, density, pressure drop, and compressibility.

In this case, the transfer phenomena in physicochemical and hydrodynamic processes associated with irreversible kinetic transfer processes: mass, energy, momentum, charge, due to the movement and interaction of microparticles of molecules, liquids, etc.

As an example, let us consider the intensification of transfer processes in electrolysis processes presented by famous scientists such as Kapitsa, Sedov I., V. Levich, Z., Shulman [1-4]. Depending on the operating and physicochemical conditions and properties, there is a need for a rational choice of transfer coefficients. Considering that such coefficients - viscosity, thermal conductivity, diffusion - are commensurate quantities, therefore, their choice is associated with real intensification processes according to the data of physical phenomena. The key position in the transfer processes is the input data and the gradient equations along with the transfer coefficients. Specific definitions for physical chemistry can characterize the activation energy and the mean free path of molecules

EXPOSITION

Based on the physicochemical data of the transfer, the basic processes equations are formed and the corresponding mathematical model is constructed.

Equations describing transport phenomena:

$$\begin{cases} \text{Impulse transfer:} \\ \tau = -\mu \times \text{grad}\, u \\ \text{Mass transfer:} \\ j = -D \times \text{grad}\ C \\ \text{Heat transfer:} \\ q_e = -\lambda \times \text{grad}\ T \\ \text{Transfer of electrical energy:} \\ i = -\rho \times \text{grad}\, \varphi \end{cases} \quad (1)$$

where: τ – shear stress [Pa]; j - diffusion flow [kg/s]; q – heat flow [W]; μ - dynamic viscosity [Pa·s]; D - diffusion coefficient [m^2/s]; λ - coefficient of thermal conductivity [W/(m·K)]; u - flow velocity [m/s]; C - concentration of molecules in the substance [kg /m^3]; T - temperature of the medium [K], ρ - the coefficient of electrical conductivity [Ω·m], φ- potential of the electric field [V].

Ways to intensify transfer processes. An in-depth analysis of transfer processes and intensifying effects through, for example, the use of vibrational vibrations, increases the performance of this type of apparatus and increases energy efficiency.

Promising methods of water decomposition by electrolysis [3].

- temperature control (at elevated temperatures, the reaction intensifies).

- use in the process of high-pressure electrolysis (from 10 bar).

-activation and increase of the surface of the electrodes in order to reduce the overvoltage.

-reduction of the distance between the electrodes to 0.1 mm.

- an increase in the current density on the electrodes.

-transition to a macro-steam environment.

-application of electrode materials for catalysts.

-Application of a magnetic field of more than 1 Tesla (displacement of water balance).

-Application of solid polymer electrolytes.

-application of photolysis (absorption of a quantum of light destroys the hydrogen bond).

-application of ultraviolet radiation.

As a first approximation, the electrolysis process can be calculated according to Faraday's law [3-6]:

$$m = k \times q \quad (2)$$

where m - mass of the isolated substance, k- electrochemical equivalent of the substance, q is the charge.

Physical and chemical processes can be intensified by changing the transfer coefficients of diffusion, viscosity and thermal conductivity. The transfer coefficients of macromechanics, depending on the exchange in space, can dynamically change and are a function of a number of parameters that characterize the electrolysis process.

Thus, it has been established that the intensification of working processes in devices can be realized through the physical values of the fundamental scale constants in the gradient representation: concentration, diffusion, viscosity, heat transfer, diffusion, viscosity and electrical transfer, etc.

For example, the diffusion coefficient, viscosity, thermal conductivity of hydrogen can have the following values depending on the temperature of the table. 1-3 [3]. Analysis of the tabular data showed that the transfer coefficients are a transfer function that depends on external and internal conditions.

Table 1

Diffusion of the coefficient values versus temperature

A couple of species	T, K	D, m^2/c
Hydrogen	12	14×10^{-5}
Hydrogen	20	18×10^{-5}
Hydrogen	28	26×10^{-5}

Table 2

Values of the coefficient of viscosity depending on temperature

A couple of species	T, K	μ, Pa · s
Hydrogen	12	0.1×10^{-6}
Hydrogen	20	1×10^{-6}
Hydrogen	28	4×10^{-6}

Table 3

Values of the coefficient of thermal conductivity depending on temperature

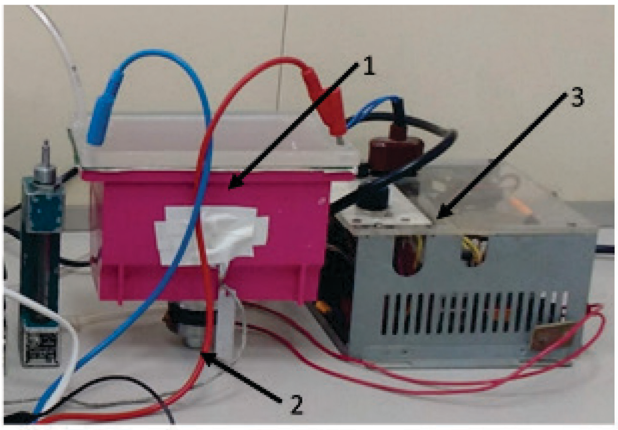
A couple of species	T, K	λ, W/ (m·K ^{2}/c
Hydrogen	14	106×10^{-3}
Hydrogen	18	114×10^{-3}
Hydrogen	28	130×10^{-3}

During the experiments, it was found that during the operation of the electrolyzer, hydrogen and oxygen bubbles are temporarily retained on the surface of the electrodes, which leads to a decrease in the effective area of the electrodes and, accordingly, to a slowdown in the rate of release of combustible gas [7-9]. To increase the productivity of the hydrogen generator, it is necessary to accelerate the separation of gas bubbles, due, for example, to «turbulization» of the electrolyte in the electrolytic cell, for example, using ultrasonic cavitation or low-frequency vibration vibrations. Three options were proposed for shaking these bubbles from the surface of the electrodes:

- using a vibration unit of low-frequency vibrations;
- using ultrasonic cavitation;
- due to the use of a pulse-width method of excitation of ultrasonic emitters;
- a combination of all three options.

When high-frequency low-amplitude oscillations are introduced into the electrolyzer using an ultrasonic emitter, provided that their intensity exceeds the threshold for cavitation in the volume of the electrolyte, ultrasonic cavitation occurs. The effects that accompany the phenomenon of ultrasonic cavitation - intense microflows, shock destructive spherical waves and high-energy cumulative jets lead to intense oscillations and separation of bubbles adhered to the electrodes, active degassing of the electrolyte due to the adhesion of gas microbubbles in a turbulent medium and cleaning of the electrode surface from stuck gas bubbles , oxides and pollution.

The methods for increasing the efficiency were tested on an experimental stand (Fig. 1). The stand allows you to introduce ultrasonic



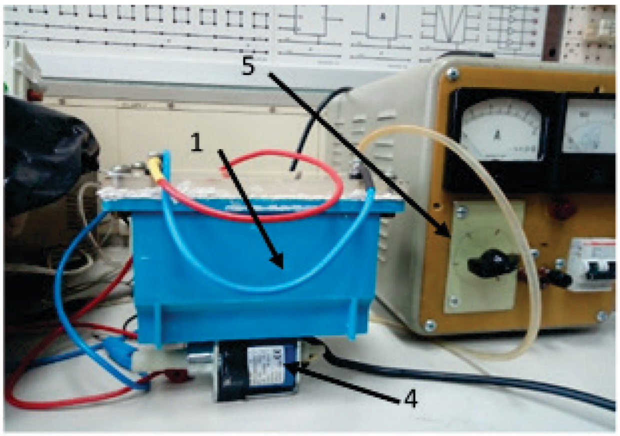


Fig. 1. *General view of the experimental stand*
(1-electrolyzer, 2-unit ultrasonic emitter, 3-ultrasonic generator, 4-vibrating element, 5-power supply)

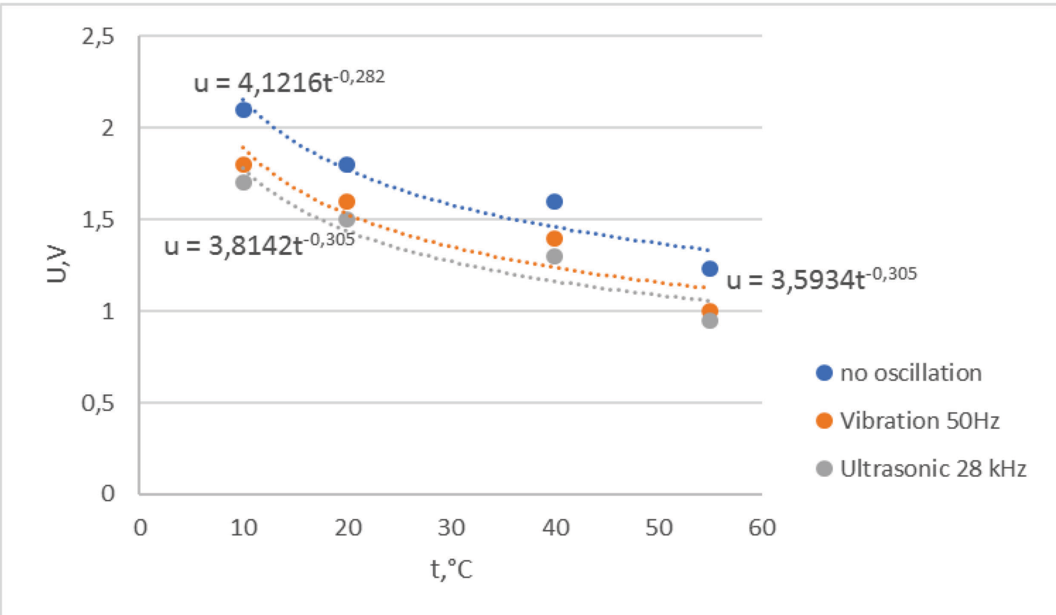


Fig. 2. *Dependence of the potential of the electrolyzer required for the splitting of water on the temperature*

vibrations into the working chamber of the electrolyzer and the effect of an oscillatory nature.

A comparison is made of the dependence of the potential of the electrolytic cell, required for separating water, on the temperature of the HHO generator without oscillations, with vibration and ultrasonic oscillations. (Fig. 2), in the presence of vibration, the intensity of degassing increases by about 20% compared to the original sample. The introduction of ultrasonic vibrations made it possible to increase the productivity of the electrolyzer by 30%.

The influence of fluctuations is observed over the entire operating temperature range. According to the Le Chatelier-Brown principle, an increase in temperature decreases the energy required to decompose water in the physicochemical process of electrolysis. Thus, the overall efficiency is increased and enhanced by: vibration and ultrasonic field, which affects the transfer process as a whole in electrolysis processes. Namely, on the processes: heat transfer, diffusion, viscosity and electrical transfer.

The electrolyzer works most efficiently at a temperature of 50-55 ° C.

CONCLUSION

On the basis of the analysis, a promising direction of research in the field of physicochemical hydromechanics for the improvement of machines and devices of systems and chemical industries becomes obvious.

The problem of accumulation of gas bubbles on the surface of the electrodes during the operation of the cell is revealed. Options for its solution are offered.

The processes of transfer in the electrolyser reactor are considered according to the proposed approach, taking into account the transfer coefficients and electrical energy, they can organize more efficient working processes under certain conditions. Therefore, the use of the energy approach to the analysis of the behavior of physical objects is a priority area for improving fundamental and applied research methods among other approaches.

It is shown that the transfer phenomenon has a physicochemical nature of the processes. According to the research results, the dependence of the potential of the electrolyzer required for the splitting of water on the temperature, as well as the rate of the chemical reaction.

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