Analysis of process parameters of wastewater treatment of edible oils production

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***Abstract* – Investigated the liquid extraction method for possibility to sewage treatment of oils production plants. The mixture of organic solvent (extractant) for selective removal of the main pollutants of wastewater was selected. The resulting equilibrium line and operating line process was obtained. Established transfer steps number. The mathematical model of liquid-extraction wastewater treatment was built. The solution of model allows to predict the kinetics of wastewater extraction for implementing the technology in practice. The equipment to design the flowsheet of liquid extraction method for wastewater treatment of food oils production was matched.**

Keywords – liquid extraction, extractant, rafinate, extract, wastewater, mass transfer coefficient, mathematical model.

I. Introduction

The growth of production capacity of enterprises edible oil at this stage of the food industry led to the formation of huge amounts of waste water that form wastewater production process. The main components of polluting waste water is neutral fats, phospholipids, organic acids and other substances of organic origin that existing treatment plants are unable to clear the level of sanitary requirements. This creates a significant environmental problem, as is the pollution of surface waters by organic substances. For many enterprises of the industry the proper treatment of wastewater is a serious problem. So finding ways of industrial wastewater treatment is an urgent task [1-2]. Our previous goal was the emulsions destruction, which are the main wastewater polluter component [3]. Now our task was to continue further illuminated water purification method using liquid extraction. On the basis of experimental results we propose the equipment for efficient treatment.

II. Material and Methods

The methodology of experimental research is as follows: 50 ml of wastewater and 50 ml extractant (40 ml ethyl acetate (butyl acetate) and 10 ml of the appropriate alcohol) is mixed in the mixer for 30 minutes, then in the sump separated into two layers, extract and raffinate. The concentration of the contaminant in wastewater was determined by photocolorimetry analysis. The essence of the method is light absorption by pollutant in the visible spectrum at a wavelength of 490 nm. For this purpose the calibration graph using the pre-known values of concentrations of conventional pollutants was built. Then the concentrations of actual pollutants in the water layer and extractant after liquid extraction were determined.

III. Results and Discussion

Thorough analysis of physical and chemical methods of wastewater treatment used after the emulsions destruction shows the liquid extraction to be the most appropriate method for the final disposal of pollutants [4], [5], [8].

To achieve the maximum degree of wastewater treatment the extractant, which has selective solubility with respect to pollutants was chosen. Moreover, it was found that a substantial increase in extractive properties of ethyl acetate and butyl acetate is achieved by mixing them with alcohol (methanol, ethanol, propanol, butanol, isobutanol).

The extraction efficiency of the mixture ethyl acetate–alcohol and butyl acetate–alcohol is significantly higher during the extraction of pollutants from wastewater of oils production, than in the case of using of pure extractants. It was established that the increase in molar mass of alcohol leads to increasing the concentration of pollutants in the extract. From the list of studied alcohols there are the most appropriate using butyl alcohol (butanol)].

The target component distribution between the liquid phases was defined by balance conditions. Typically equilibrium determined by a straight line equation: a $y = kx$, where y – the concentration of the target component in the extract; x-concentrations in the raffinate; k – coefficient of distribution. But line character really depends on many factors: temperature, pressure, natural substances, concentration and so on.

The next step was to study the operating line of the process. The line shows the concentration of pollutant in wastewater after reaching equilibrium.

Therefore, the line of equilibrium in the studied conditions takes the form of the curve and is curved. Constructed line workers allowed to determine the transfer degrees number of the system using two types of extractants; ethyl atcetat-butanol and butyl acetate – butanol [6].

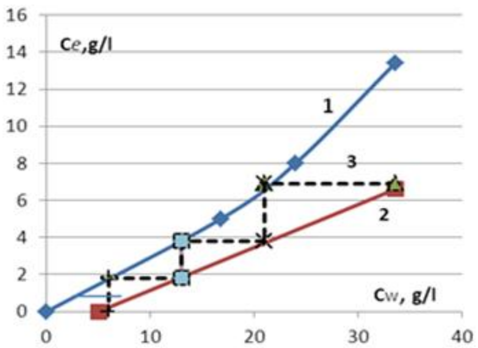

Fig. 1. Equilibrium line (1), operating line (2) and number of transfer stages (3) for ethyl acetate; counter-current process

Among a variety of liquid extraction apparatuses that can be recommended for the wastewater treatment of edible oils production, counter-current columns with mechanical stirring (vibrating, rotary-disc, pulsating) are the most rational ones. If the counter-current scheme is used for liquid extraction the number of transfer stages is significantly reduced (Figs. 1 and 2).

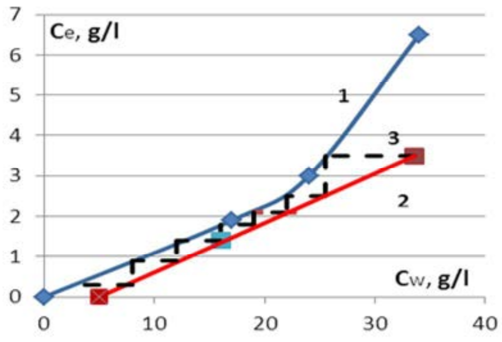

Fig. 2. Equilibrium line (1), operating line (2) and number of transfer stages (3) for buthyl acetate; counter-current process

Mathematical models of liquid extraction in the perforated-plate column are already known [8].

However, when we need an apparatus equivalent to a high number of theoretical stages of mass transfer (Figs. 1 and 2), and have to strongly control and correlate the concentration and composition of the extract on the individual stages of mass transfer the mixing-settling extractors should be used.

The mathematical description of the mixing-settling extractor [7] can be represented by the model with specific characteristics. The entire volume of the apparatus or their system is represented as individual extractor. All extractors were connected in series. Ideal mixing occurs in each extractor and is lacking between them. It is represented in Fig. 3, where C_1, C_2, C_3 – concentrations in 1, 2, 3 extractors, respectively; C_m – concentration in "*m*" extractor.

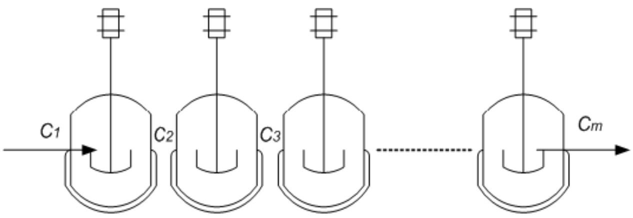

Fig. 3. Scheme of mixing-settling extractors

Since ideal mixing occurs in each extractor and output of the previous apparatus is the input for the next, it is possible to write a system of mathematical equations:

Eq. 1:

$$\left\{ \begin{array}{l} \frac{dC_1}{d\tau} = \frac{C_{in} - C_1}{\tau_1} \\ \frac{dC_2}{d\tau} = \frac{C_1 - C_2}{\tau_2} \\ \cdots\cdots\cdots\cdots\cdots \\ \frac{dC_m}{d\tau} = \frac{C_{m-1} - C_m}{\tau_m} \end{array} \right\} \quad (1)$$

In the system of "*m*" equations where m – number of extractors; t_1, t_1, ... , t_m – holding time of flow in the first, second, ..., last extractor. The system is a mathematical description of the liquid extraction process in the system of mixing-settling extractors.

Conclusion

As the experimental researches result suitable extractants are selected – a mixture of ethyl acetate and butyl acetate with butanol, also are set the maximum alcohol content that provides heterogeneous region in the extraction system. An operating line and equilibrium line and set transfer steps number. The multistage extraction installation is the most appropriate and gives strong results for sewage treatment from oil production plants. and A mathematical model of multi-staged liquid extraction for wastewater treatment was developed. Its solution allows evaluating an order of diffusion coefficient of wastewater basic pollutants.

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