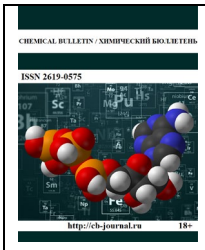

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Extraction of sodium hydroxide from cotton processing facilities

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Abstract: *the process of extracting technological contaminants from textile materials is considered as a mass transfer process, for the intensification of which pulsed exposure to an ultrasonic field is chosen.*

A lightweight fabric was selected for the study in order to eliminate the influence of surface density and fabric thickness on the kinetics of the process. The results of an experimental study of the kinetics of the extraction of sodium hydroxide during washing after mercerization of a light standard cotton fabric are presented. The studies were carried out in laboratory conditions on a model installation with a different washing bath module without intensification and with the use of ultrasonic exposure as an intensifier. At the same time, the optimal distance from the ultrasound source to the washed tissue was determined based on previous studies. Exposure to ultrasound significantly reduces the duration of the process, especially at the initial stage. Equations for approximating the kinetics curves of sodium hydroxide extraction from cotton fabric without intensification and with intensification by ultrasonic action are obtained, and their parameters are determined. The correlation of calculated and experimental data is acceptable for approximate kinetic calculations. The obtained equations can be practically used in engineering practice for a preliminary assessment of the duration of the process of extrusion-washing of cotton fabrics belonging to the group of light cotton fabrics from alkali in various modules of the washing bath.

Keywords: *cotton materials, finishing, extraction, kinetics, washing, approximation*

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Introduction

The process of extracting technological contaminants from textile materials, including cotton processing facilities, is implemented in washing processes, in which unfixed dyes, surfactants, alkalis, including sodium hydroxide, etc. are removed from fabrics. The quality of washing ultimately determines the operational and hygienic properties of fabrics, coloristic indicators of coloring, and significantly affects the economic characteristics of finishing processes [1, 2]. Quantitative assessment of the effect on the efficiency of the process of the main technological factors and intensifying influences, obtaining equations for engineering calculations is impossible without an experimental study of the kinetics of washing from various technological impurities [2-4].

Cotton fabrics are among the most common, and their processing in the finishing production of textile factories with a difficult-to-wash reagent-sodium hydroxide in the mercerization process is widely used, therefore, the choice of object and process for research is relevant [1, 2].

The aim of the work is to obtain equations based on experimental curves of the kinetics of the extraction of sodium hydroxide to calculate the kinetics of the extraction process (washing) of a typical cotton fabric from sodium hydroxide in various modules of the washing bath, including with the intensification of the process by ultrasonic action.

Materials and methods of research

The object of the study is a typical lightweight cotton fabric and the process of washing it. A lightweight fabric was selected for the study in order to eliminate the influence of surface density and fabric thickness on the kinetics of the process. The washing process refers to non-stationary mass transfer processes in a heterogeneous system: solid material (fabric) – extractable technological contamination (sodium hydroxide) – washing solution.

The characteristics of the examined tissue are presented in Table 1.

Table1

Characteristics of the research object.

Type of fabric	Surface density, kg/m^2	Fabric thickness, mm	Fabric width, m
cotton	0,101	0,42	1,20

The main component of cotton fiber is cellulose, which is a high-molecular compound. All technological operations of finishing production are based on the interaction of fabric fibers with various chemical reagents and dyes. The most widely used reagent is sodium hydroxide, which is used at various stages in the chemical technology of fabric finishing. After each stage, an alkali wash is carried out, sometimes after washing, the alkali residues are neutralized with acid and then washed [2].

Results and discussions

Experimental studies were carried out on a model laboratory setup, which made it possible to obtain kinetic curves without intensification and under the influence of an ultrasonic field with an ultrasonic vibration frequency of 22 kHz. The study of the effective-

ness of ultrasonic action on the washing process was carried out at a distance of 5 mm from the ultrasound source and different values of the washing bath module [1]. The concentration of sodium hydroxide in the tissue was determined by reverse titration [2].

Fig. 1-3 shows the results of an experimental study of the kinetics of washing from alkali of the selected object under laboratory conditions with a different ratio of the mass of the washing solution and the mass of the tissue, i.e. with a different module of the washing bath μ, without intensification and with the use of ultrasonic exposure (ultrasonic) as an intensifier.

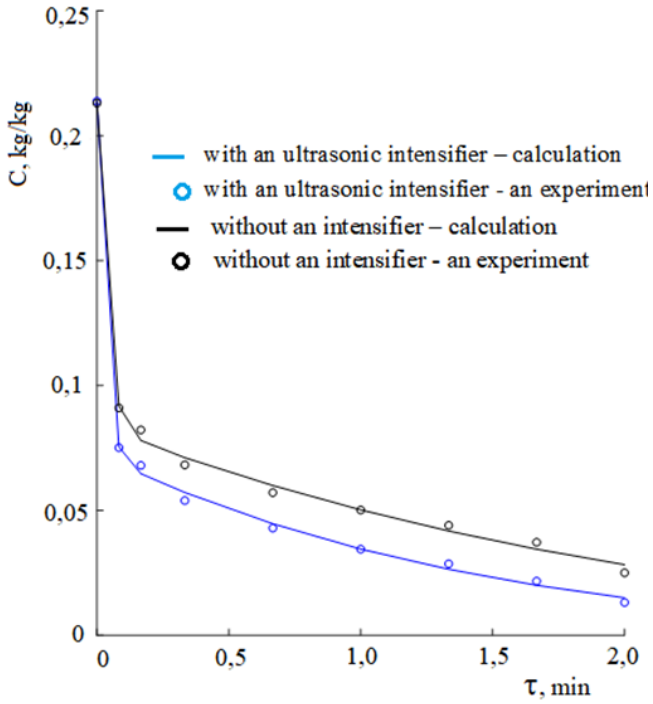

Fig. 1. Kinetics of washing cotton fabric from sodium hydroxide with a bath module μ = 100.

As can be seen from the graphs shown in Fig. 1, the kinetics curves of washing without intensification and with intensification of ultrasonic include two periods (by analogy with the drying process). The first period is a period of constant process speed and the second period of falling speed. At the beginning, alkali is removed from the material, which is located on the surface of the fibers, while an external mass transfer task takes place. When removing technological contamination from the fiber volume, the internal task of mass transfer is considered.

As can be seen from the kinetic curves, ultrasonic exposure accelerates the pro-cess in both the first and second washing periods.

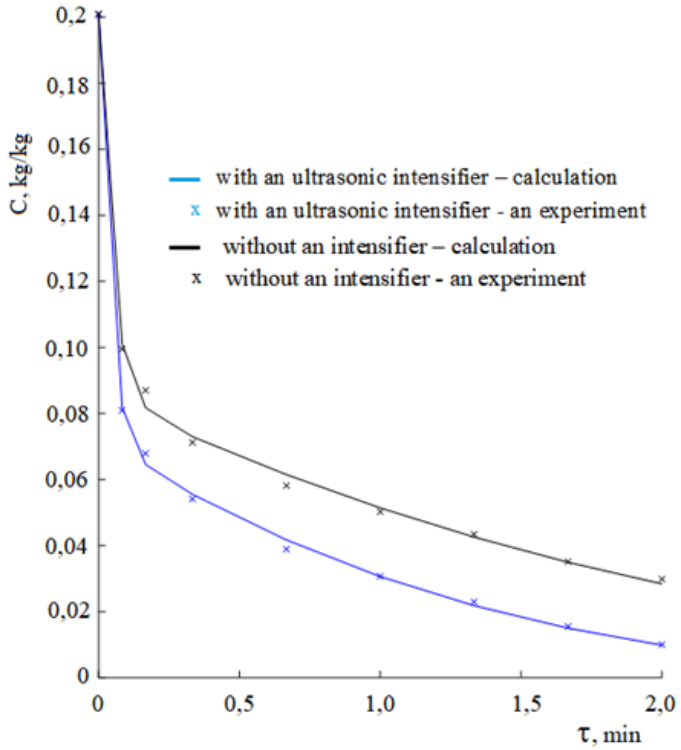

Fig. 2. Kinetics of washing cotton fabric from sodium hydroxide with a bath module μ = 200.

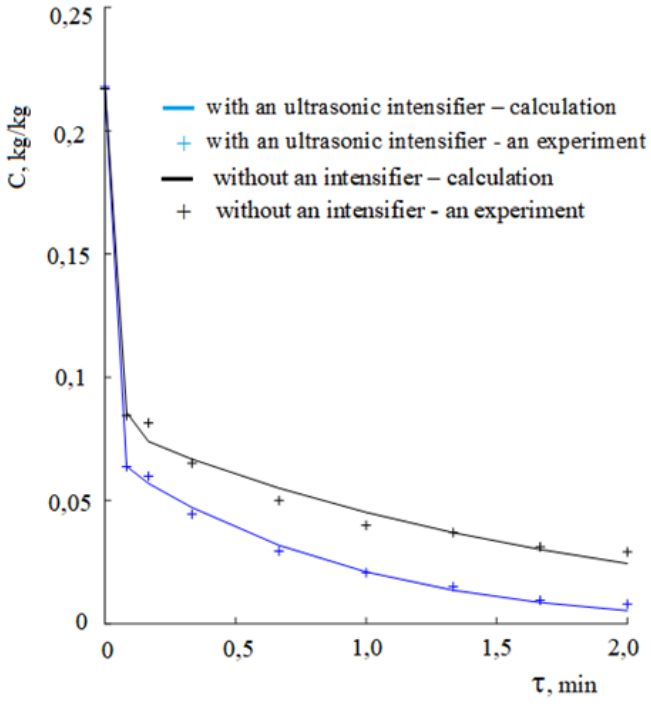

Fig. 3. Kinetics of washing cotton fabric from sodium hydroxide with a bath module μ = 500.

A number of papers [5-7] consider the issues of modeling and calculating heat and mass transfer processes, including the diffusion extraction process from solid materials. The theoretical foundations of modeling these processes are given in [8-10] and in [11]. The mathematical description and calculation of extraction processes from the solid phase, including from flat fibrous materials, are given in [12-14].

However, the above models and equations, which are of considerable scientific interest, are difficult to use in engineering practice when calculating the washing process, including those intensified by an ultrasonic field [1, 2, 15].

In this paper, equation (1) is obtained to describe the kinetics of the flushing process without intensification and with intensification by ultrasonic action:

$$C = a_1 U_1 e^{-(\frac{\tau - b_1}{c_1})^2} + a_2 U_2 e^{-(\frac{\tau - b_2}{c_2})^2} \quad (1)$$

Without the intensifying effect of ultrasound:

$$U_1 = U_2 = 1 \quad (2)$$

With intensification by ultrasonic action:

$$U_1 = (e_1 + d_1\tau) \quad (3)$$

$$U_2 = (e_2 + d_2\tau) \quad (4)$$

The values of the coefficients of equations (1, 3, 4) for washing with different modules of the washing bath with and without ultrasonic action are presented in Tables 2-4.

Table 2

The values of the coefficients of equation (1) for calculating the kinetics at μ = 100.

a_1	b_1	c_1	a_2	b_2	c_2	d_1	d_2	e_1	e_2
$3{,}9\cdot10^{3}$	-0,64	0,20	0,85	-7,35	4,67	-1,59	-0,22	0,99	1,02

Table 3

The values of the coefficients of equation (1) for calculating the kinetics at μ = 200.

a_1	b_1	c_1	a_2	b_2	c_2	d_1	d_2	e_1	e_2
$8{,}9\cdot10^{12}$	-2,38	0,42	0,60	-5,18	3,58	-4,33	-0,25	1,11	0,84

Table 4

The values of the coefficients of equation (1) for calculating the kinetics at μ = 500.

a_1	b_1	c_1	a_2	b_2	c_2	d_1	d_2	e_1	e_2
$5{,}7\cdot10^{11}$	-1,15	0,21	1,36	-5,61	3,24	-3,05	-0,01	0,996	1,00

The results of the conducted studies show the high efficiency of using ultrasound as an intensifier for washing light cotton fabrics after treatment with sodium hydroxide.

Equation (1) can be used for an approximate calculation of the kinetics of the extraction (washing) process of cotton fabrics of a widespread group of light tissues from sodium hydroxide at various parameters of the washing bath, including with the intensification of the process by ultrasonic exposure without conducting sufficiently complex and lengthy experiments.

The comparison of experimental and calculated data shown in Fig. 1-3 shows their good correlation.

Conclusions

On the basis of experimental curves of the kinetics of the sodium hydroxide extraction process, equations and their parameters are obtained for calculating the kinetics of the extraction (washing) process of a typical light cotton fabric from sodium hydroxide with various modules of the washing bath with and without intensification of the process by ultrasonic action. The equations can be used in engineering calculations of the kinetics of the alkali extraction process from tissues belonging to the group of light tissues, without conducting complex experiments, to approximate the duration of the process.

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