Research on the impact of preliminary electromagnetic treatment of chip soap on the technological features of detergents

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Abstract. The impact of preliminary electromagnetic treatment of chip soap on the technological features of detergents has been studied. A decrease in viscosity has been established when processing raw materials in a magnetic field with an induction. Because of mathematical processing of experimental data, a regression equation describing the technological process has been obtained. The influence of technological factors on the process of saponification of fatty acids has been determined. The significance and value of the constituents of the receipt of detergent components on the formation of the quality and properties of solid soaps have been scientifically and experimentally substantiated. The significance and value of soap chips based on palm and coconut oils has been established. Scientifically substantiated technological lines and modes for improving the quality and expanding the range of toilet soaps have been selected. Ecologically "clean" technologies for the production of detergents of a new assortment have been created. The rheological properties of sodium salts of fatty acids of industrial concentrations have been studied. The results of scientific and experimental research allowed expanding and supplementing the existing theoretical provisions on new formulations of detergents and improving the technology of their production based on palm and coconut oils.

1 Introduction

Lately, in the production of detergents special attention has been paid to the use of chip soap as the main raw material [1-5]. Such types of raw materials provide high washing properties of the produced detergents [6-9]. Features of the detergent can be improved using methods of raw material intensive processing. In this direction, the methods of using electromagnetic technology are of great importance. In this regard, the research on influence of preliminary electromagnetic treatment of chip soap is of scientific and practical interest.

The purpose of research is to study the influence of preliminary electromagnetic treatment of chip soap on the technological features of detergents, as well as to establish optimal

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technological modes by statistical processing and mathematical modeling of experimental results.

2 Methods of research

To analyze the quality and composition of raw materials, as well as detergents, modern methods of physical and chemical research, in particular, chromatographic and spectral methods, viscosimetry, methods of X-ray diffraction analysis have been used.

In laboratory experiments and pilot plants at the enterprise, an electromagnetic installation has been used as an intensifying factor for the activation of a soap solution [10]. This installation can simultaneously be used as a purification of liquids from certain types of impurities.

The force characteristic of the magnetic field is the vector of magnetic induction - B (Figure 1).

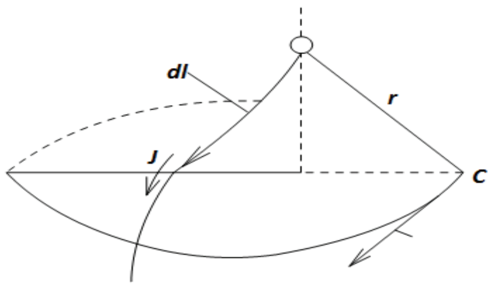

Fig. 1. The force characteristic of the magnetic field: J is the intensity vector; dB is the vector of magnetic induction;dl is the length of the conductor.

In the SI system, this vector is numerically equal to the limit of the ratio of the force acting from the magnetic field on the conductor element with electric current to the product of the current and the length of the conductor element, if the length of this element tends to zero, and the element is so located in the field that this limit has the maximal value:

$$B = \frac{1}{J}\left(\frac{dF}{dl}\right)\max \qquad (1)$$

In the Gaussian system of units:

$$B = \frac{C}{J}\left(\frac{dF}{dl}\right)\max \qquad (2)$$

where C is an electrodynamic constant equal to the ratio of charge units in the CGSM and CGSE systems and coinciding with the speed of light in vacuum ($C \approx 3 \cdot 10^{10}$ cm/s).

It should be noted that the change in the voltage of the electric current in the system obeys Ohm's law:

$$J = \frac{U}{R} \qquad (3)$$

where: J is current strength, Ampere;

U is voltage, Volt;

R is resistance, Ohm.

and therefore, in this case, the magnetic field strength is determined by the formula:

$$dH = \frac{1}{2\pi} \cdot \frac{J}{r^3}\left[dL \cdot r\right] = \frac{1}{4\pi} \cdot \frac{U}{R \cdot r^3}\left[dL \cdot r\right] \quad (4)$$

where: H is EMF strength;

π is constant value;

J is current strength, Ampere;

R is resistance, Ohm;

U is current intensity, Volt;

r is the radius of the conductor.

Considering the standard values of the magnetic field strength in the used electromagnetic installation within (0.4 ... 2.8) 10^{-5} A/m, in research, the change in the magnetic field strength within the specified limits was carried out by a rectifier in the corresponding values of the current resistance in the electrical circuit.

Considering the data obtained as a result of studying the rheological properties of chip soap, it can be concluded that it is necessary to identify factors that allow maximally destabilizing the structural bonds of chip soap in order to intensify the saponification process. Such an impact, namely the weakening or rupture of intramolecular and individual intermolecular bonds, has an electromagnetic effect on the object of study.

It is essential that the use of electromagnetic influences does not increase the energy intensity of the process and does not require complex expensive equipment.

It should be noted that research on water systems have shown the effectiveness of the impact of fields of low intensity, acting within a fraction of a second.

According to the data, electromagnetic treatment affects heterogeneous aqueous systems or processes associated with phase transformations to the greatest extent, which is probably due to the multiplying effect of the developed phase surface.

Thereby, considering the known data on the destabilizing effect of alternating electromagnetic fields on adsorption bonds, as well as on the viscosity of various structured systems, we studied the effect of electromagnetic activation on the structure of chip soap.

3 Results of research

The processing of chip soap by an alternating electromagnetic field was carried out on a bench installation, shown in Figure 2.

The installation is an improved model of an electromagnetic activator (EMA) with an external drive and design capabilities to change the induction of the electromagnetic field in the gap between the stator and the rotor.

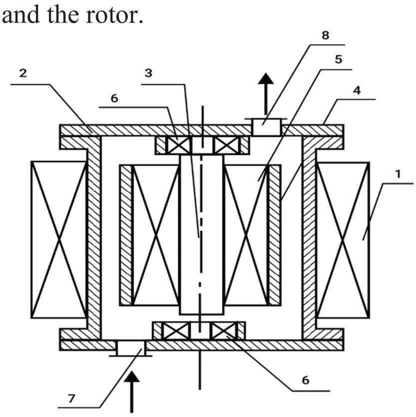

Fig. 2. Installation for preliminary electromagnetic treatment of soap solutions of detergents: 1- stator; 2- sleeve; 3- shaft; 4- rotor sleeve; 5- rotor; 6- bearings; 7- inlet pipe; 8- outlet pipe.

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Considering the results of previous research, the flow rate of the processed system passing through the electromagnetic activator was constant in all experiments and amounted to 4 m/s.

The magnitude of the magnetic induction varied from 0.1 to 0.6 T, while providing the same intensity of hydrodynamic action.

The results of the experiments are presented in Figure 3 and 4.

As can be seen from the presented dependencies, the use of electromagnetic treatment allows reducing the viscosity of chip soap.

A significant decrease in viscosity is observed when processing in a magnetic field, characterized by a magnetic induction of at least 0.3 T.

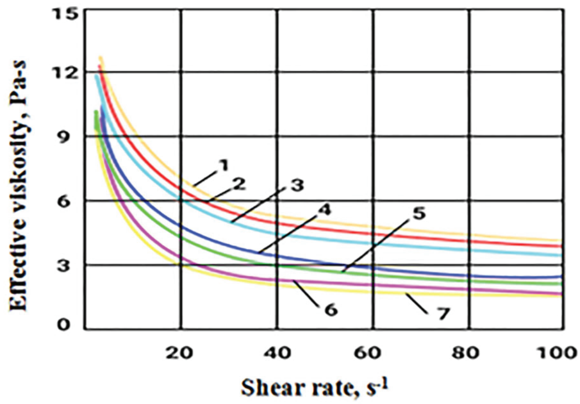

Fig. 3. Dependence of the effective viscosity of chip soap on the shear rate at a temperature of 25 °C: 1- without preliminary processing in EMA; 2-7 with preliminary processing in EMA at the value of magnetic induction: 2-0.1 T; 3- 0.2 T; 4 - 0.3 T; 5 - 0.4 T; 6 - 0.5 T; 7 - 0.6 T.

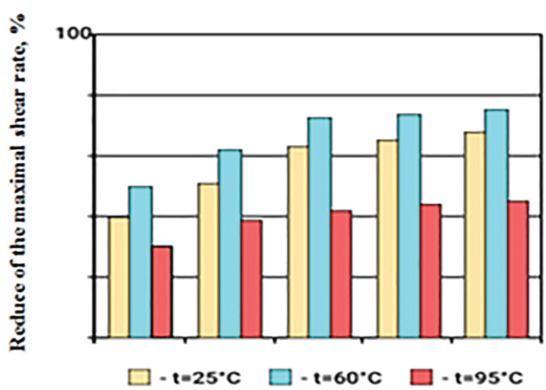

Fig. 4. Impact of the degree of dilution of chip soap with water and the temperature of electromagnetic activation on the reduction of the limiting shear rate of the system being processed: 1 - without dilution; 2 -10% water; 3 -25% water; 4 - 40% water; 5 -55% water.

The decrease in the viscosity of chip soap continues with an increase in magnetic induction up to 0.5 T, then the intensity of the electromagnetic effect decreases noticeably.

The presented data indicate that the addition of 40-60% water to chip soap and subsequent treatment of the resulting system with a caustic alkali solution at a temperature of 50 °C provides the maximum reduction in shear rate.

The decrease in processing efficiency at a temperature of 95 °C, considering the theory of the resonance mechanism of electromagnetic effects, can be explained by the mutual cancellation of vibrational motion of micelle-forming molecules due to thermal and electromagnetic activation.

Determination of the optimal modes of preparation of chip soap for saponification using an alternating rotating electromagnetic field was carried out by the method of mathematical planning of the experiment.

Processing temperature and magnetic field induction have been taken as variable factors.

As constant factors, the flow rate in the treatment zone has been taken, which was 4 m/s, the field rotation frequency was 50 s^{-1}, as well as the hydrodynamic modes of the process, due to the design of the installation.

4 Discussion

The value of the limiting shear rate (Sh) has been used as a response function. At the same time, the optimization of technological modes has been carried out, which has been reduced to minimizing the magnitude of the response function.

The working matrix of experiments is given in Table 1.

Table 1. Matrix of experiments.

Temperature, °C	**Magnetic induction, T**	**Shear rate, s^{-1}**	
		experiment	**calculation**
25	0.1	85	87
25	0.3	70	72
25	0.4	58	57
25	0.5	47	48
25	0.6	43	40
40	0.1	80	82
40	0.3	64	63
40	0.4	52	54
40	0.5	40	43
40	0.6	36	37
60	0.1	76	75
60	0.3	61	59
60	0.4	46	48
60	0.5	33	33
60	0.6	31	30

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80	0.1	81	83
80	0.3	65	66
80	0.4	50	52
80	0.5	38	37
80	0.6	35	34
95	0.5	93	94
95	0.3	80	83
95	0.4	65	66
95	0.5	50	52
95	0.6	48	49

Because of mathematical processing of the experimental results, a regression equation has been obtained that adequately describes the process (5):

$$Sh = 118.7014 - 1.331 \cdot x - 71.5841 \cdot y + 0.0122 \cdot x^2 - 0.1796 \cdot x \cdot y - 15.4762 \cdot y^2 \quad (5)$$

where x is the temperature, °C;

y is magnetic induction, T

The adequacy of the obtained equations to the real process was determined by the magnitude of the decrease in the predictable error θ_u, (6):

$$\theta_u = 100\left(\frac{S_y^2}{S_{res}^2} - 1\right), \quad (6)$$

where S_Y is the dispersion of the response function; S_{res} is residual dispersion

It has been established that the magnitude of the forecast error reduction satisfies the adequacy condition ($\Theta_u > 30$).

The results of the experiment in graphical interpretation are shown in Figure 5

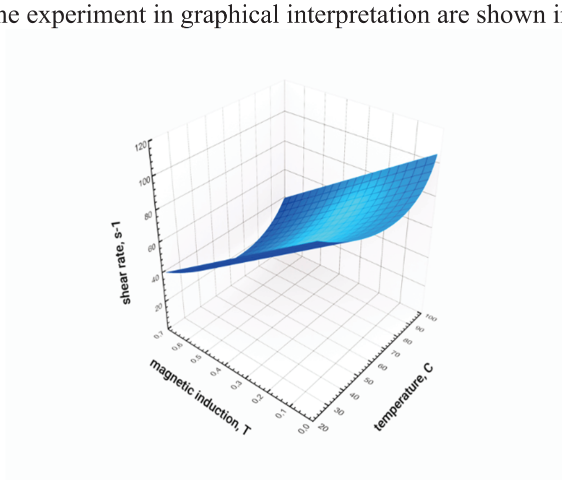

Fig. 5. Dependence of the temperature of solutions of chip soap on the modes of their electromagnetic processing.

5 Conclusions

An analysis of the coefficients of the equation shows that the effect of magnetic induction is more significant than the effect of temperature, and the cross effect of both factors is insignificant. The presence of the extremum of the response function confirms the hypothesis about the resonant nature of the impact of electromagnetic fields. Application of modern methods of physical and chemical research in the analysis and evaluation of the characteristics of detergents allows the production of solid soaps that meet the requirements of the current standards.

Improvement of technological processes and methods of production of detergents provide the creation of innovative technologies for the production of solid soaps. New types of raw materials, aromatizes, dyes, antioxidants have improved the washing properties of solid and liquid soaps and detergents. The methods of increasing the foaming ability of detergents with the use of new types of components in the formulation have been determined.

Improvement of the rheological properties of detergents using highly effective additives and improvers have been achieved.

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