CLEANING SUNFLOWER OIL USING THE ULTRASONIC FIELD

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Abstract: The options for using the ultrasonic field for primary cleaning of sunflower oil are considered. Developed an experimental installation with ultrasonic generator for purification of sunflower oil under the influence of ultrasonic field. Experimental studies of the effect of ultrasonic cavitation by changing the frequency and power of the electrical signal supplied to a magnetostrictive transmitter are presented. The technological parameters of the process of purification of sunflower oil by ultrasonic treatment have been determined.

Keywords: sunflower oil, ultrasonic field, cleaning process, magnetostrictive emitter, ultrasonic generator, ultrasonic cavitation.

INTRODUCTION

The oil and fat industry produces a wide range of fat products. The most significant part of these products are vegetable oils [5]. Compared to other foods, oils are high in calories and are primarily the main source of energy. Human energy costs are provided by fats by about 33% [5, 14].

Sunflower oil is obtained from finely ground heated sunflower seeds by pressing (squeezing) or extraction. Due to their composition, vegetable oils are physiologically active substances, and their nutritional value is determined by the content of polyunsaturated fatty acids necessary for the human body to build cells [1, 6].

BACKGROUND AND MEANS FOR SOLVING THE PROBLEM

Among the factors that form the quality of vegetable oils, there are: raw materials and production technology. The quality indicators of the oils of the same name are closely related to the degree of their purification. When assessing the quality of vegetable oil by physical and chemical indicators, the most important are: color number, acid number, mass fraction of moisture and volatile substances, mass fraction of phosphorus-containing substances [3, 7].

Organoleptic indices are significant in determining the type and raw material belonging of vegetable oils, physical indices - in identifying vegetable oils, reveal the refractive index, viscosity, pour point [13]. Oil is rejected if it has unsuitable physical and chemical parameters, the content of pesticides, heavy metals, mycotoxins, is higher than the permissible amounts. The lion's share of all quality indicators falls on the cleaning process. Therefore, the better the refined oil, the better it is [2, 4].

The use of physical methods for purifying liquids has certain advantages, which are low energy consumption, environmental friendliness, low hydraulic resistance of devices [12]. All kinds of vegetable oils, animal fats, their solutions, various petroleum products, biofuels of vegetable origin, transformer oil, etc. are among the liquids that can be purified using an ultrasonic field [9, 11].

Taking this into account, a promising direction is the improvement on the basis of existing equipment, complex oil purification. Using physical fields that provide an increase in the coagulation of related substances, as a result of which it is easier to remove them from oils and obtain a high quality finished product.

PURPOSE OF THE STUDY

The purpose of this study is to determine the recommended technological parameters for ultrasonic treatment of vegetable oils by conducting experimental modeling of the filtration process under the action of an ultrasonic field. This will make it possible to intensify the process of refining sunflower oil and obtain a high quality product.

EXPERIMENTAL PLANT FOR SUNFLOWER OIL FILTRATION USING ULTRASONIC WAVES

An experimental installation for the purification of sunflower oil using an ultrasonic field was developed and built (Fig. 1).

A magnetostrictive emitter was used as a working element for the formation of ultrasound. This installation assumes the use of appropriate equipment for the pressure filtration process. Based on the analysis of literary sources - the installations that were used earlier to conduct experiments in this direction, provided for filtration using inertial forces. This indicates the difference between the created experimental setup from other facilities that are currently used [8, 10].

The technological scheme is as follows. The apparatus consists of a primary reservoir with a valve, which is connected by a pipeline to a "cavitation chamber" (since the process of cavitation takes place in it, it was called a cavitation chamber). It has an opening for feeding raw materials, and an ultrasonic emitter is located in the middle. The so-called "ultrasonic mirror" is located in the lower part. The "cavitation chamber" is connected by a pipeline to a gear pump, which is driven through a rigid coupling with an electric motor. The pump is connected by a pipeline to a filter, which in turn is connected to the finished product reservoir.

Figure: 1. Experimental setup for the purification of sunflower oil using an ultrasonic field

Specifications:

Power supply unit (generator). Transistor. Made as a separate unit. Can be installed separately from the unit.

Designed for work in dry rooms at an air temperature of 15 - 35□C, and an air humidity of no more than 80%.

Supply voltage - 220 V.

The frequency control range is 17 - 320 kHz.

Amplitude adjustment range - 5 - 50 V.

Width - 650 mm.

Length - 350 mm.Высота - 175 мм.

Weight no more - 10 kg.

The experiments were carried out on 2 types of oil:
- obtained by hot pressing from last year's sunflower seeds;
- obtained by cold pressing from fresh sunflower seeds.

Method for the experimental determination of the parameters of ultrasonic waves

The primary tank is filled with pressed unfiltered, partially settled sunflower oil. A pre-weighed filter element is inserted into the filter. The ultrasonic generator is tuned to the desired frequency. The timer is set at the desired time. A container for the final product is being prepared. An oscilloscope for voltage measurements is turned on, which is connected to the generator output. The ultrasound emitter is also connected there.

After opening the damper, the oil enters the cavitation chamber by gravity. The ultrasonic generator is turned on and the oil is processed by ultrasonic vibrations for a specified time. An "ultrasonic mirror" reflects and directs ultrasonic waves to improve the efficiency of the irradiation. Then the generator turns off and the electric motor turns on. Sunflower oil is pumped into the filter by a gear pump and filtered under pressure <0.2 MPa. After the filter, the oil enters the finished product tank. The filter is disassembled and the filter element is weighed.

The pump is driven by an electric motor. The electric motor runs at a predetermined frequency and is controlled by pressing a button. Reusable filter with replaceable filter element (belting - fabric).

The article presents ultrasonic cavitation during sounding of sunflower oil with a flat vibrator. Sounding takes place at a frequency of 24 kHz and a power in the vibrator of about 900 W. A black vibrator is visible in the center of the cuvette. At its end, a kind of "fog" spreads - this is ultrasonic cavitation. It can be observed for the appearance of "fog", as well as for the appearance of a characteristic hiss, the level of which increases with increasing power.

Ultrasonic cavitation with a round vibrator with a diameter of 8 mm takes place at a frequency of 43 kHz and a power in the vibrator of about 800 W.

The vibrator, the main part of which is immersed in oil, excites ultrasonic vibrations in it, which lead to liquefaction and squeezing of the liquid. The microbubbles combine (coagulate) into stable embryos, which can then be separated from the bulk (filtered).

The restructuring of the medium during ultrasonic cavitation is achieved by the adiabatic compression of voids and the formation of a low-temperature plasma mode when the cavitation microbubbles collapse.

The value of the intensity of the acoustic field in the medium substantially depends on its initial state. If the system is in a state close to thermodynamic instability (metastable state), then an external influence, even of low intensity, can bring it into a qualitatively new state.

The system goes into a state of instability when the value of any characterizing parameter (pressure, temperature) is close to critical.

This mode promotes the destruction of macromolecules of impurities, pollutants and living organisms.

The experiments were carried out in a heated room with good lighting and ventilation.

RESULTS OF STUDIES

In the course of experimental studies of the effect of ultrasound on the oil purification process, the following were determined:

- oil filtration temperature when changing the frequency of ultrasonic vibrations of the emitter, which is presented in Table 1.

Table 1: Oil filtration temperature when changing the frequency of ultrasonic vibrations of the transmitter

Ultrasound emission time, s	Ultrasonic vibration frequency, kHz				
	25	50	75	100	150
100	24	26	28	35,2	40,4
200	30	36,3	44	52,6	58
300	38,9	47	52,2	59,3	65,6
400	44,8	52	57,8	62,6	67,8
500	48,5	56	60,4	65,2	68,9
600	48,5	56,1	60,4	65,2	68,9

- the amount of sediment at an irradiator power of 1.3 kW, and different oil temperatures, which are presented in Table 2.

Table 2: Amount of precipitate separated after filtration at a feed power of 1.3 kW and a frequency of ultrasonic oscillations of the feed of 120 kHz

Filtration time, s	Oil temperature, ^{0}C				
	20	30	40	50	60
30	0,5	1,2	2	2,89	4,18
60	2	2,93	3,84	4,85	5,64
90	2,5	3,5	4,65	5,4	6,2
120	3,34	4,23	5,3	5,89	6,54
150	3,94	4,69	5,5	6,7	6,78
180	4,36	5	5,85	6,45	6,9
240	4,66	5,28	6,06	6,56	7,07
280	4,9	5,49	6,12	6,66	7,16

- the amount of sediment obtained during the filtration of oil with different intensities of the ultrasonic signal is shown in fig. 2.

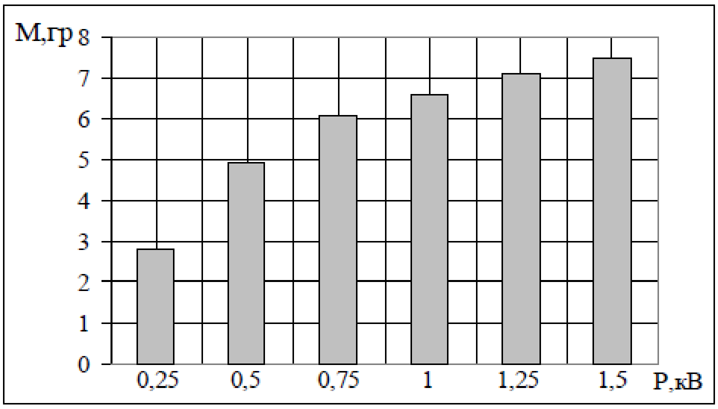

Figure: 2. Determination of the amount of sediment in 200 seconds of filtration at an oil temperature of 50 ^{0}C and changing the power of ultrasonic vibrations

- the amount of sediment for 200 seconds of filtration and the change in oil temperature is shown in fig. 3.

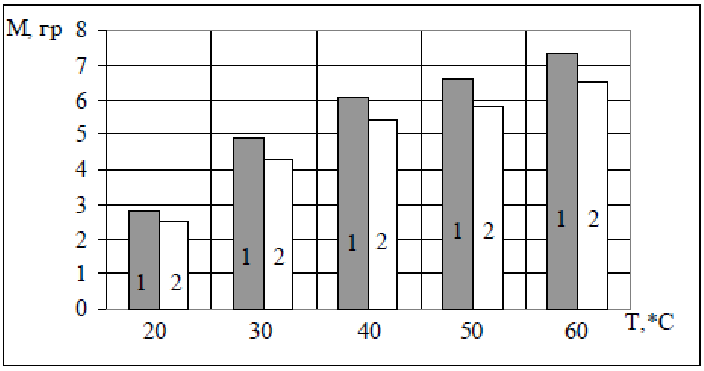

Figure: 3. Determination of the amount of sediment in 200 seconds of filtration and change in oil temperature:

1 - power of ultrasonic vibrations 1.3 kW;

2 - without the use of ultrasonic vibrations

Analyzing the obtained experimental data, the determination of the oil filtration temperature with a change in the frequency of ultrasonic vibrations, we see an increase in the oil temperature with time, with an increase in the radiation of ultrasonic waves. This can be explained by the fact that when ultrasound is absorbed in a liquid medium, acoustic energy is converted into thermal energy. The graph shows that the heating time at an ultrasonic frequency of 24 kHz is three times longer than at 130 kHz. However, the difference in heating in the 115-130 kHz range is negligible. Therefore, we determine the rational vibration frequency of 120 kHz.

As for the determination of the amount of sediment after a certain filtration time at a certain frequency of ultrasonic vibrations, we see an increase in the amount of sediment over time with increasing temperature. So at a temperature of 20 □C, the amount of sediment obtained is one and a half times less than at a temperature of 60 □C - for the same oil filtration time. Comparative analysis of the difference in the amount of the precipitate obtained at a filtration temperature of 55 ° C without the use of ultrasonic vibrations and with its use was 10% in favor of ultrasound. With a change in the irradiation power, we also see the dependence of an increase in sediment removal with an increase in the power of ultrasonic vibrations.

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In the range of 0.25-1.5 kW, the amount of sludge more than doubled. But the increase in sludge production in the ranges of 1-1.5 kW varies insignificantly, therefore, we take a rational oscillation power of 1.3 kW. Using the obtained data, taking into account certain effective parameters of exposure to ultrasonic vibrations, we take a filtration time of 200 seconds. The time taken is sufficient to remove the maximum amount of sludge with rational energy consumption.

The above experimental studies indicate that when using ultrasonic waves in the process of sunflower oil filtration, there is an increase in the amount of removed sediment and a reduction in the process time. Compared to conventional filtration, the removal of impurities by ultrasonic field treatment increased by 12%.

During the experiments, it was found that the following technological parameters for using the ultrasonic field can be recommended: the power of ultrasonic vibrations is 1.3 kW, the frequency of ultrasonic vibrations is 120 kHz, the processing time is 200 seconds, and the oil temperature is 55 55C. At the same time, an optimal effect on the removal of suspended solids is achieved and, accordingly, an intensification of the filtration process occurs.

CONCLUSION

With the help of the created experimental setup, sunflower oil is filtered using ultrasonic waves, where it is processed with a magnetostrictive emitter.

The recommended technological parameters have been determined, at which there is a decrease in filtration time and an increase in the amount of recovered accompanying substances.

Using this technology, an oil is obtained that meets the standard, without hydration and processing at low temperatures. This leads to a reduction in energy costs and equipment in the oil refining process.

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