BACKGROUND OF VIBRATION EXPOSURE INFLUENCE ON THE EXTRACTION PROCESS IN THE SYSTEM OF "SOLID – LIQUID"

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Abstract: The article is dedicated to theoretical justification and experimental studies intensification of the extraction process of vegetable raw materials using vibration exposure.
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Introduction

Extraction is widely used in the preparation of vegetable and essential oils, sugars, proteins and other food products. Extraction of various substances from the product in water or oil, usually always is accompanied by cooking and frying foods. Extraction processes occur on receipt of tea, coffee and other beverages. Despite the rapid development of synthetic medicines, the majority of biologically active substances are obtained by extraction from natural raw materials of vegetable or animal origin.

Therefore it is natural that there are a number of unresolved scientific and applied problems related to the mechanism and kinetics of the process, its mathematical description and technology of extraction of various substances.

Extraction in the system "solid - liquid" is a mass-transfer process, which consists mainly of two stages: the molecular diffusion inside the solid to the interface and mass transfer in the liquid, washing the solid.

If molecular diffusion within a solid depends on the properties of this body and the temperature of the process, the mass transfer in a liquid, washing the solid, is determined mainly by the hydrodynamic conditions of fluid flow through a layer of solid particles and, therefore, depends on the design of apparatus in which takes place the extraction process.

Now generally is accepted the resistance of boundary liquid films on the surface of solid particles extractable substances transition from the one phase to another. According to the Nernst film theory, developed further by Langmuir, to the solid surface adjoins thin layer of stationary liquid, in which occurs component diffusion.

From the modern theory of liquid films on the surface of extractable solid can make the following practical conclusions:

- is necessary actively to influence on the film, the processes must occur during developed turbulent flow, that will allow turbulent diffusion mechanisms dominate over the molecular;

- intensification of the process must include an energetic influence on the viscous sub layer for distribution of turbulent fluctuations on its greater depth.

As a single criterion for comparative analysis of different methods of intensification of extraction processes is advisable to use a parameter called intensity *i*, which is defined as the ratio of target quantitative characteristic - extracted mass per unit time to the volume of material (or surface) of the apparatus [1]:

$$i = \frac{dM \cdot \varphi}{d\tau \cdot V}, \quad (1)$$

where V - volume of loaded material into the apparatus, m^3;

M - mass of the substance being transported, kg;

τ - time, s;

φ - fill factor of the apparatus.

It is known that M is determined by the basic equation of mass transfer:

$$dM = k_M S \Delta C d\tau , \quad (2)$$

where k_M - mass transfer coefficient;

S - solid lavage surface (surface of phase contact), m^2;

ΔC - driving force of the process, which is a function of time and is given by formula:

$$\Delta C = \frac{\Delta C_б - \Delta C_м}{2{,}3 \lg \dfrac{\Delta C_б}{\Delta C_м}} \quad (3)$$

where $\Delta C_б$ and $\Delta C_м$ - biggest and respectively the less difference in the concentrations of the phases, kg/m^3.

The same mass of being transported substance, let down from the interior of a solid, to the interface (internal diffusion), is determined by the formula:

$$dM = -D_1 S \left(\frac{\partial C_2}{\partial n} \right)_n , \quad (4)$$

where D_1 represents mass conductivity coefficient (of internal diffusion), m^2/s;

C_2 - concentration of a substance in a porous body, kg/m^3;

n - distance along the normal to the surface of the particle, m

Relationship between internal and external diffusion in the extraction process establishes diffusion Bio criterion (Bi), defined as the diffusion and hydrodynamic conditions of the process [2]:

$$Bi = \frac{k_M R}{D_1}, \quad (5)$$

where R - defining (characteristic), the linear dimension of the particle, m.

When Bi << 1 extraction mode - externally diffusive, when $Bi \to \infty$ - internal diffusive.

If we accept that

$$S = a \cdot V \quad (6)$$

where a represents the specific surface of the solid, then from (1) - (6) we can obtain the expression

$$i = \frac{Bi D_1 \Delta C \varphi a}{R} . \quad (7)$$

From (7) it follows that to increase the intensity of extraction apparatus should follow the path of the growing influence on speed process of diffusion and hydrodynamic factors by increasing Bi, D1, ΔC, as well as of solving purely structural optimization problems to maximize value φ.

We experimentally investigated the intensity of extraction, depending on the hydro module, temperature, time, parameters of low-frequency mechanical vibration, ultrasound, etc. Several examples show that the use of low-frequency mechanical vibrations generated in the fluid by vibrant working body really leads to a significant intensification of the process compared to other methods.

The analysis of the extraction of dry substances, obtained by varying the amplitude and frequency characteristics of vibration during extraction, shows more intensifying influence on the frequency process of vibration of the working body in comparison with amplitude. Processing of received data for vibration effects on the process of mass transfer, for example, for extraction of raw tea (Fig. 1) allows us to establish a linear relationship of increase vibration acceleration $A\omega^2$ on the intensification of the extraction process. The degree of intensification process by frequency, amplitude oscillation of working body and vibration acceleration $A\omega^2$ is determined.

Obtained experimental data on extraction were the basis of the design of apparatus - vibrating extractor with continuous action [3].

While task was creation in this extractor the conditions under which extraction process would take place most intensive by increasing the contact surface between the phases and reducing the thickness of the boundary layer.

The task is achieved by using vibrating working body, operating in the mode of tossing material movement (Fig. 2).

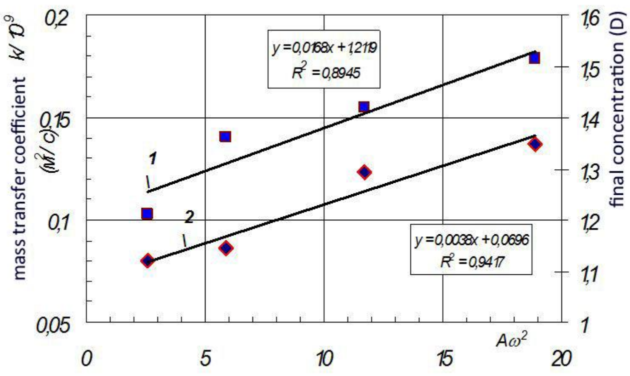

Fig. 1. Dependence of mass transfer coefficient (2) and the final concentration of extract (1) from vibration acceleration of the working body

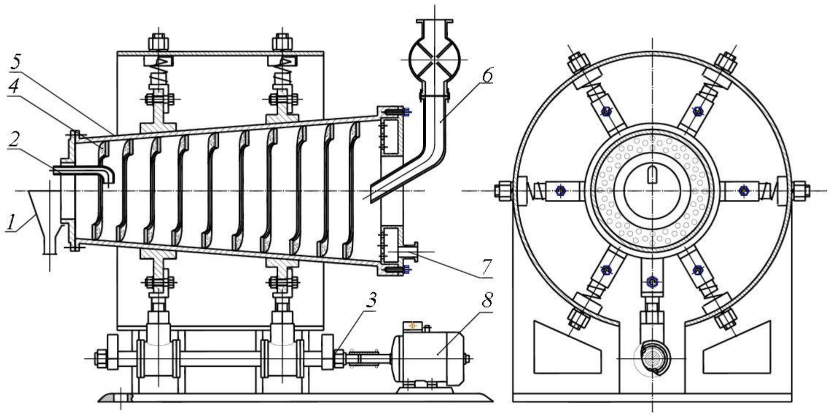

Fig. 2. Vibrational extractor 1,6 - loading and unloading of raw materials, 2,7 - extractant supply and discharge branch pipes; 3 - eccentric weight, 4 - perforated spiral gutter, 5 - conical drum; 8 - electric motor

While extractable material is as if suspended, and pulsates, increases surface collision between material and extractant, accelerates renewal of contact between them and boundary layer thickness decreases. Extraction in a suspended state completely rejects the question of hydraulic resistance of the particle mass of the material, i.e. allows working with a variety of external structure of the particles.

When using volatile extractants, such as gasoline, alcohol-water mixture, boiling water, etc., vibratory extractor can be made airtight. While the end caps of the extractor are joined with the environment (external supply and removal) by rubber seals and floodgates.

The proposed construction of vibratory extractor has the following advantages:

- simple design and operation;
- allows to accelerate process of extraction, to hold it continuously in small tonnage production;
- universality of use in different areas of food industry, pharmaceutical and chemical technology.

References

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