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DEVELOPMENT OF THEORETICAL FOUNDATIONS FOR THE USE OF GAS KINETIC ENERGY DURING LIQUID SPRAYING IN MASS TRANSFER APPARATUSES ON THE EXAMPLE OF A VEGETABLE OIL EXTRACTION PRODUCTION LINE

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Our Republic is very rich in vegetable raw materials for food production, in particular, vegetable oil from oil-containing crops, such as cotton seeds, soybeans, sunflowers, etc.

The production of vegetable oil from oil-containing crops at the factories of the Republic is carried out by two methods of pressing and extraction, which are accompanied by various technologies, using a complex of mechanical, hydraulic, heat transfer, mass transfer processes.

In the extraction method of production, the final distillation of vegetable oil miscella, which is part of the complex of mass transfer processes, is carried out in apparatuses of various designs.

Spray distillation, film, layer distillation methods are used. When miscella is sprayed, the interface between the liquid and gaseous phases increases significantly, which ensures a high intensity of the distillation process.

From a physical point of view, the process of distillation of vegetable oils refers to the heat and mass transfer process and is one of the methods of distillation.

Distillation is the separation of a mixture of mutually soluble components due to the evaporation and condensation of vapors enriched in a volatile component. In distillation or simple distillation, the molecules leaving the evaporation surface move in the same direction until they reach the condensation surface. The separation of components depends on many factors and, first of all, on the physicochemical properties of the mixture, phase hydrodynamics, geometric characteristics of the apparatuses and their operating conditions.

Our scientific research is aimed at studying the hydrodynamics of the opposite phases, providing the maximum contact surface of the latter, minimizing the

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residence time of the product in the apparatus and metal consumption, during the process of final distillation of cottonseed oil miscella.

To improve the process of final distillation, we propose a new design of the apparatus for the final distillation of vegetable oil miscella based on multi-stage spraying of moving phases. In this case, the kinetic energy of live steam is used to form drops from the general flow of liquid-miscella.

As a result of our studies of the process of the final distiller proceeding on the new design, we determined such parameters as the mass of the volatile component, the diameter, the speed of the mycella drop during spraying, which is of great practical importance. The mass of the volatile component can be determined as follows.

$$M = (\frac{\pi^2 \cdot D}{4 \cdot R^2}) \cdot (y - y^*)$$

$$M = (\frac{\pi^2 \cdot D}{4 \cdot R^2}) \cdot (x^* - x) \quad (1)$$

where, R is the radius of the miscella drop, m; D is the diffusion coefficient at =90%, =1050C.

The radius of a miscella drop formed in a final distillation apparatus with a spray nozzle can be determined by the following formula:

$$R_k = \sqrt{\frac{4{,}5 \cdot \pi \cdot G_L \cdot d_{con}{}^2}{(\rho_L + \rho_G) \cdot \omega_L{}^2}}, \text{ м.} \quad (2)$$

where, G_L is the volumetric flow rate of the miscella, d_sop is the diameter of the nozzle nozzle, ρ_L is the density of the miscella and ρ_G is the density of the gas phase, ω_L is the initial velocity of the miscella.

We calculate the initial radius of the miscella drop in the following sequence:

Droplet shape oscillation starts at Re>500-1000, and to determine the critical Reynolds numbers, we use the formula:

$$Re = \frac{\omega \cdot d}{\nu} \quad (3)$$

Where, is the fluid velocity, d is the characteristic length, and ν is the kinematic viscosity of the miscella.

When analyzing the processes of heat and mass transfer during spraying, an important characteristic is its velocity of the drop. The speed of the drop is determined by the initial speed and the process of movement - the dynamic interaction on the drop.

The thermal effect on the drop due to its movement manifests itself, in particular, through the deformation of the drop due to the temperature dependence

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of viscosity and surface tension, as well as through mass transfer. All these data are used to determine the conditions for droplet fragmentation.

In the works cited by V.V. Beloborodov that with a sawing nozzle, with an increase in the pressure of the sawn miscella, a decrease in the mass transfer coefficient occurs according to a law close to linear. This character of the dependence is observed for any practically important changes in the concentration and temperature of the miscella. And he had to introduce what about the increase in pressure with an unchanged diameter of the nozzle outlet, i.e. In parallel with pressure, the specific load of the spray chamber on the outlet miscella increases. Therefore, despite the increase in dispersion of the spray with increasing pressure, in general, there is a decrease in the mass transfer coefficient .

Therefore, it is important to study the structure of the hydrodynamic flow in the development and design of a new device for the final distiller of vegetable oil miscella based on multi-stage sawing, and it is extremely important to study the effect of the diffusion coefficient, which depends on the droplet radius.

Numerous experimental studies and visualization made it possible to present the process of crushing a drop in the following form.

On the surface of a liquid particle, a streamlined flow creates a pressure distribution (close to the distribution on a ball), which deforms the drop. At a certain ratio of parameters, the external forces of aerodynamic action ρ_G ω^2·πd^2 overcome the forces of surface tension, πd^2·σ_L, causing the drop to break up.

Quantitatively, the ratio of these forces is determined by the value of the Weber number deformation criterion (We) :

$$We = \frac{2 \cdot \rho_G \cdot w^2 \cdot R}{\sigma_L} \qquad (4)$$

where, ρ_G is the density of the gas phase, w is the relative velocity of the phases, R is the radius of the miscella drop, σ_(L-) is the surface tension of the miscella drop.

The relative phase velocity is determined by the following formula:

$$w = \omega_G - \omega_L \qquad (5)$$

Where, ω_G is the initial velocity of the gas phase, ω_L is the initial velocity of the liquid phase-miscella.

The following characteristic values of the Weber criterion are given in the literature: At We < 10.7, the droplet in the flow is deformed, but does not yet disintegrate; at We = 10.7, the lower limit of fragmentation is reached, the drop breaks into two parts, while 10-20% of the total number of drops breaks up.

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As the Weber criterion increases in the interval 10.7≤We< 14, the drop is divided into 3, 4, 5, etc. drops and shattered drops as a percentage increases. At We=14, the upper limit of crushing is reached - all 100% of the drops are crushed into many small particles (drop spray mode). Further, for all modes, which, We>Wecr=14, the fragmentation of drops is preserved. The resulting drops will be the smaller, the greater the value of the Weber number -We.

Thus, when designing the installation of the final distiller, one must proceed from the fact that miscella drops under certain conditions are destroyed, their crushing and evaporation occur.

To select the parameters of the experimental installation, we took into account this feature, to select the initial parameters of this apparatus for the final distillation, which is currently used.

In the case of the experimental setup, the miscella parameters were chosen: initial mass flow rate - G_G, miscella density -ρ_L, nozzle radius -r_sop, nozzle diameter d_sop.

To calculate the Weber number, you will need the initial velocity of the miscella, and it can be calculated from the initial flow parameters of the miscella using the following formula:

$$\omega_L = \frac{G_L}{S_L} \qquad (6)$$

where, S_L is the cross-sectional area of the miscella nozzle, which is equal to: S_L=π· 〖r_L〗 ^2

To calculate the Weber number, we first calculate the volumetric flow rate of the miscella:

$$G_L = \frac{q_L}{\rho_L}$$

Once the volumetric flow rate of the miscella has been determined, its initial velocity can be calculated:

$$\omega_L = \frac{G_L}{S_L}$$

The parameters of the gas phase: the volumetric flow rate of the gas phase is -G_G, the radius of the gas phase nozzle is -r_G, the density of the gas phase at a temperature of 1300C is -ρ_G.

Therefore, the cross-sectional area of the gas phase nozzle is determined as follows:

$$S_G = \pi \cdot {r_G}^2$$

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Thus, we determine the initial velocity of the gas phase according to the following formula.

$$\omega_G = \frac{G_G}{S_G}$$

Now you can determine the relative speed of the phases.

$$w = |\omega_G - \omega_L|, \frac{\text{м}}{\text{сек}}$$

Using the proposed research method, we studied the structure of hydrodynamic flows of opposite phases on a new design of the final distiller by multi-stage spraying of vegetable oil miscella. A calculation equation (1) has been obtained to determine the mass of the volatile component, which depends on the diffusion coefficient and the radius of the miscella drop during spray distillation with a nozzle.

Based on the obtained calculation equation, the influence of the diffusion coefficient, which depends on the radius of the miscella drop, was studied.

The above proposed method was used to study the effectively influencing factors on the hydrodynamic structures of phase flows to improve the design of the apparatus, which proceeds the final distillation process based on multi-stage spraying of vegetable oil miscella with a nozzle, and this research method can be used in solving problems of the same mass transfer processes in research work.

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