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STUDY OF CONDITIONS WITHOUT FOAM CONCENTRATING LACRIC ROOT EXTRACT

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ABSTRACT:

The process of evaporation of licorice root extract is accompanied by violent pricing.

Evaporation of licorice root extract in existing industrial evaporators of any design can be carried out only if the operating parameters and evaporation processes are investigated, ensuring effective non-foaming evaporation.

In the foam mode, entrainment increases significantly. The generation of foam and the entrainment of droplets are jointly influenced by the released surface energy during the destruction of bubbles and the kinetic energy of the flow that tears off the foam and droplets. The number of large droplets and the height of their toss increases. The level of foam generated can be significant.

In this case, due to a reduction in the height of the vapor space, exceeding the critical one, a sharp increase in vapor moisture occurs, and foam flocs can be carried away. A further increase in the vapor velocity leads to an almost complete disappearance of the foam; however, during this period, a third boiling crisis occurs, accompanied by an increase in vapor moisture and a decrease in liquid consumption.

1. BOILING OF FOAMING LIQUIDS:

The process of evaporation of extracts from plant raw materials obeys complex laws due to the influence of a large number of factors.

Evaporation of foaming solutions, for example, licorice root extract, is characterized by great difficulty in separating product droplets from the secondary vapor.

Currently, a sufficient number of evaporator separators have been developed to ensure the normal separation of liquid and vapor after evaporation. However, when a vapor-liquid mixture consisting of foam enters the separator of the evaporator (the foam of the licorice root extract is very stable), the separation efficiency drops sharply and the liquid in the form of foam enters the condensation unit.

Our analyzes have shown; that stable foaming in boiling pipes mainly occurs at the moments of the onset of boiling crises, especially at the time of the onset of the third crisis, defined by A.A. Artykov.

The third crisis in vertical boiling pipes with an upward flow of liquid is characterized by a low liquid flow rate during nucleate boiling. Here, with an increase in the concentration of the solution, the steam consumption increases and the intensity of nucleate boiling increases.

At the same time, a moment may arise when the volume of liquid in the boiling pipe will be less than the volume that is able to restrain nucleate boiling, but the vapor velocity will still be insufficient for the transition to the liquid-annular boiling mode. Then the vapor will entrain the liquid in the form of foams, i.e. there is intense pricing. This regime was determined on the basis of the bubbling theory of bubbles in a boiling pipe.

With regard to the case of boiling of non-forming solutions in a boiling pipe, the following stages of boiling can be considered (Fig-1): heating of a liquid, wall bubble boiling. If the wall is overheated, a vapor film will appear, drastically reducing heat transfer - this is the first crisis. Sometimes a breakout of the pair is formed, i.e. nucleate boiling is formed, which subsequently transforms into film boiling. Later, when the liquid film dries up due to insufficient liquid flow rate, the heating surface is exposed - this is the second boiling crisis in the pipes.

The boiling regime of solutions in pipes depends on many factors, among which the main role is played by the flow rate of the liquid and the concentration of the solution.

Thanks to the bubble theory of bubbles, it has been established that at certain flow ratios and liquid concentration below the critical one, a moment arises when there is not enough liquid to organize film boiling, then the boiling of the liquid will end with nucleate boiling and part of the liquid is carried away by the vapor. For foaming liquids, there comes such a moment that the resulting abundant amount of foam moves up the pipe into the separation part of the apparatus. In the foaming part of the boiling pipe, the heat transfer coefficient is sharply reduced.

At the third boiling crisis of the solution, its consumption is determined by the equation:

$$G_{кр} = \rho_{п} \cdot n \cdot \sqrt{\frac{\pi^2}{32} \cdot \frac{\rho_{ж} - \rho_{п}}{\rho_{ж}} \cdot q \cdot d_{тр}^5} \qquad (1)$$

where ρп, ρж - respectively density of vapor and liquid, kg / m3;

n - circulation rate

dmp - pipe diameter, m.

On the basis of this theory, the efficiency of the circulation of the solution can be explained. Experimenters mainly explain the effect of solution circulation by an increase in the heat transfer coefficient due to an increase in turbulization of the liquid flow. Without denying the influence of this effect, one can draw attention to another phenomenon: when the liquid circulates, the flow rate and concentration of the solution entering the boiling pipes increases, thereby reducing the likelihood of a third boiling crisis.

The study of the process of concentrating the extract of licorice root was carried out on an experimental installation Fig-1 in order to determine the effect of the flow rate and velocity of the secondary steam on the separation of droplets carried away by the steam.

2. DESCRIPTION OF THE EXPERIMENTAL SETUP:

The experimental setup is shown in Fig-1. The installation consists of a boiling pipe with an inner diameter of d = 38 mm and a height of H = 2700 mm, made of glass and vertically mounted on a tripod 2.

The installation includes a vessel 6 for the extract, a compressor 3 for supplying the extract from a vessel 6 to a boiling pipe 1, a reducer 4 to maintain a constant extract flow, a pressure gauge 5 to control the constant pressure in a vessel 6, a valve 7 to regulate the extract flow. The experimental setup has an air supply system with a compressor 8, a rotometer 10 for monitoring the air flow rate, separators 11 and 12 for separating a vapor-liquid mixture, made of glass and vertically mounted on racks 13 and 14, a container 15 for the separated liquid, a container 16 for condensate and container 17 - for drops carried away by the steam flow.

The principle of operation of the experimental setup.

The extract of a certain concentration is continuously fed into the boiling pipe. In this case, the compressor 6, the reducer 7, the container 5 and the tap 9 provide a continuous and uniform supply of the extract. The preset air supply is provided by the compressor 10 and is controlled by the rotometer 11 and the valve 9.

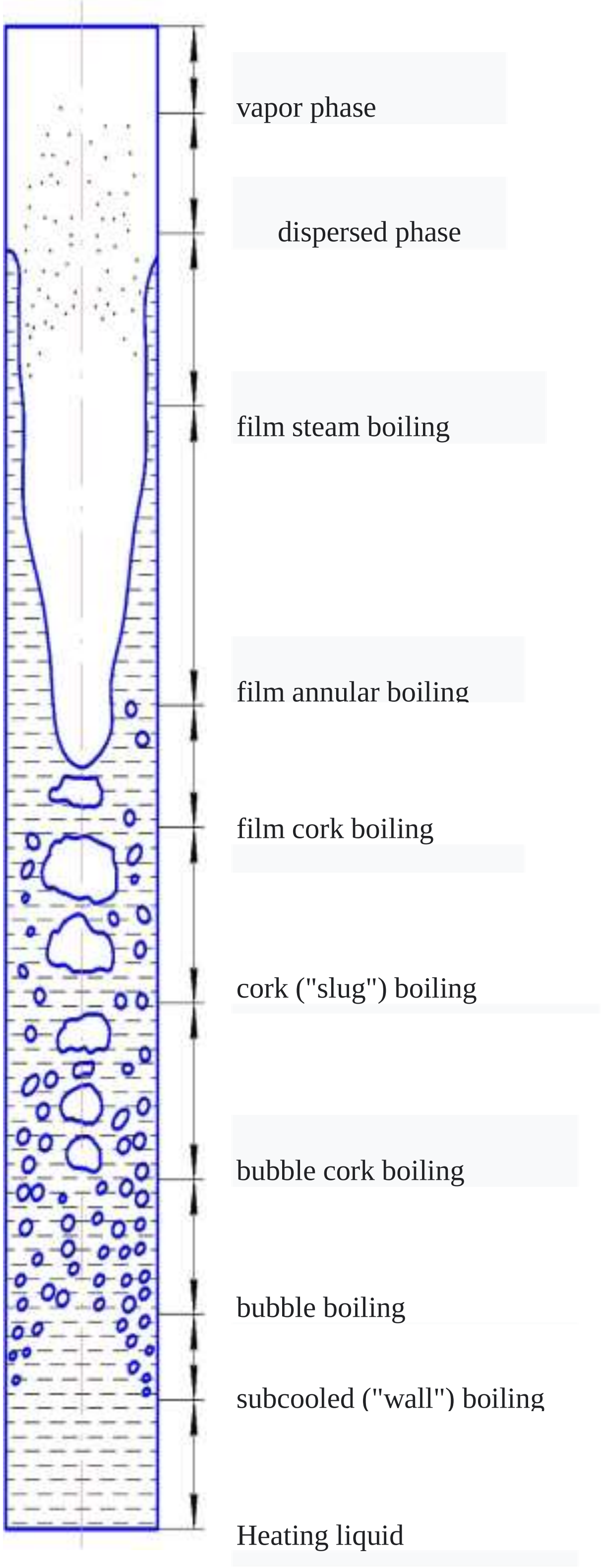

Fig- 1. Hydrodynamic structure of a two-phase flow when boiling an extract in a vertical pipe.

Inside the boiling pipe, a stream of licorice root extract interacts with air. The concentration of licorice root extract is determined using a refractometer. After filling the pipe with extract to a certain level, extract and air are fed into the pipe at the same time. Air with extract droplets enters the separator 12, in which the product droplets are separated from the air. The separated extract is collected in the collector 20. The liquid droplets not separated in the separator 12 are directed together with the steam into the separator 13. The extract drops separated in this separator enter the vessel 21. The unseparated product drops were then sent to the collector 22 together with air.

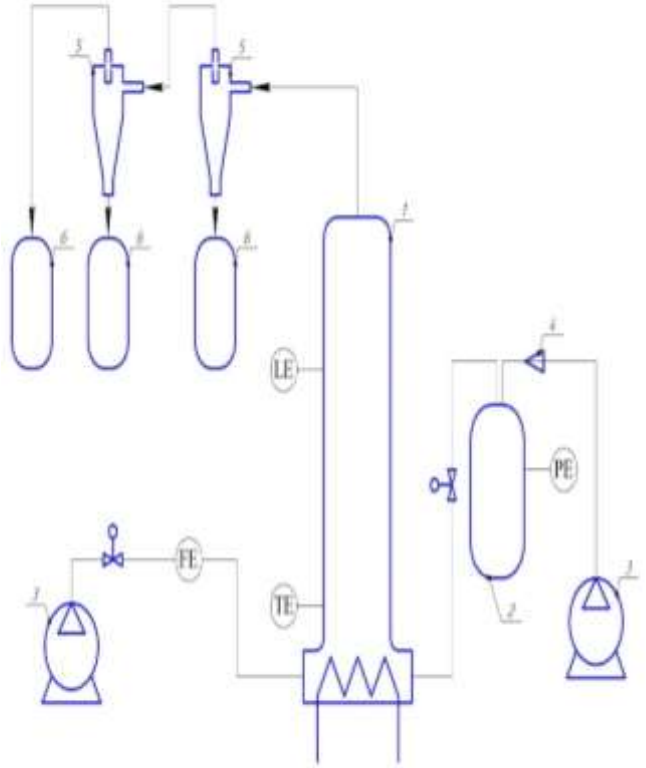

Figure 2. Experimental setup diagram

1- boiling pipe; 2- container with extract; 3- compressor; 4- reducer;
5- separator; 6- capacity.

3. EXPERIMENTAL TECHNIQUE:

The objective of the experiments on the experimental setup is as follows:

- Determination of the conditions for the non-foaming regime for the concentration of licorice root extract:
- Determination of the influence of the amount of secondary steam on the amount of carried away product by secondary steam;
- Establishment of the optimal circulation mode of the extract, providing a dewy mode of evaporation.

To maximize the approximation of the experimental conditions to real processes, licorice root extract of various concentrations was used.

The boiling pipe is filled with the prepared extract so that about 1/3 of the pipe remains free.

The compressor is switched on, the required pressure value in the container with the extract is set using the reducer, which ensures the required extract flow rate through the pipeline. The pressure in the tank is controlled by a pressure gauge. Using the tap, the liquid flow rate is set at which the level of the extract in the boiling pipe remains unchanged. When the steady state of the extract flow is reached, the volumetric flow rate of the extract is determined.

When determining the consumption of the extract, the extract is accumulated in a measuring vessel.

With the help of a rotameter, the air flow is monitored. During the experiments, air was used as secondary steam. In the experiments, such a flow rate of air (secondary vapor) and liquid is established, at which a mode of uniform boiling of the liquid with low foaming and normal separation of the secondary vapor in the separator is achieved. When the steady-state operating mode of the experimental setup is reached, the air velocity is determined using an anemometer. According to the readings of the rotameter, the air flow rate is recorded.

4. DISCUSSION OF EXPERIMENTAL RESULTS:

The experiments were carried out at atmospheric pressure in the installation and with varying values of the extract concentration from 10% to 40% and the ratio of air flow and extract in the range from 0.3 to 1.2. The experimental results are shown in table.

As can be seen, for the selected mode of liquid flow, the maximum volumetric ratio of the vapor and liquid phases is in the range of 0.5 - 1.0. In this mode, bubble boiling is observed in the boiler tube without the formation of foam. A further increase in steam consumption leads to pricing of the licorice root extract, as a result of which the performance of the separator deteriorates. Thus, for operating modes at certain ratios of liquid and vapor, the bubble mode of boiling is observed, while the above-mentioned ratio of the volumetric flow rates of water vapor (secondary vapor) and liquid should be observed:

$$\frac{V_n}{V_{ж}} = \frac{G_n}{G_{ж}} \cdot \frac{\rho_n}{\rho_{ж}} \qquad (2)$$

or

$$\frac{G_n}{G_{ж}} = \left(\frac{V_n}{V_{ж}}\right) \cdot \frac{\rho_{ж}}{\rho_n}$$

Based on the results of our research, the mass ratio of vapor and liquid will be 0.5 - 1.0.

Thus, on the basis of the results of the experiments, it was established that for the non-foaming boiling of the licorice root extract in a tubular evaporator, the required ratio of the secondary steam consumption to the amount of the extract should be in the range from 0.5 to 1.0. If this ratio is observed, the separation of the vapor-liquid mixture is carried out almost completely, if a deviation from this ratio is allowed, then the boiling pipe is filled not with liquid, but with foam, and a certain entrainment of product droplets is carried out by the secondary vapor.

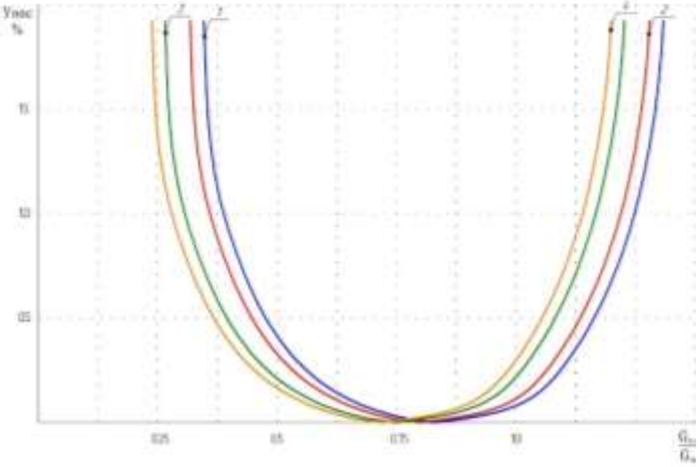

Figure 3. Dependence of the entrainment of product droplets by the secondary steam on the ratio of the volumes of the secondary steam and the evaporated extract at various concentrations.

1- 40% DM; 2 - 30% DM; 3 - 20% DM; 4-10% DM

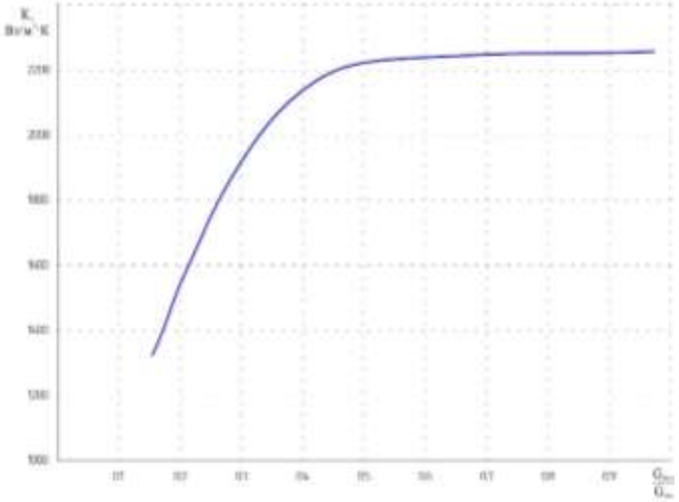

Figure 4. Dependence of the heat transfer coefficient on the ratio of the consumption of the secondary steam and the evaporated solution.

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