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Study Of The Hydrodynamics Of A Convex-Concave Disc Column

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Abstract: The article describes the dependence of the angle of inclination of the tray in the column used in mass transfer processes on the angle of rise of the flow in the tray. Also presented are the bubbling regime of the liquid during undulating motion, the mode of intermediate transition from the bubbling regime to the flow regime, and the hydrodynamic flow regimes that characterize the rise in the liquid level in the direction of the flow
Key words: angle of inclination of scales, scales, convex-concave plate, hydrodynamic regime, angle of flow rise.

Introduction

In the improvement and development of mass exchange devices, issues such as obtaining more products per volume unit of the device, reducing the hydraulic resistance corresponding to one separation step, and reducing the relative metal consumption of the device are aimed at.

Plate devices are widely used in chemical and food industry enterprises. S-shaped hood plates are plates where liquid and vapor move in one direction. The advantages of these plates are that the kinetic energy of the steam flow is transferred to the liquid and increases its flow rate. This allows to increase the load of the plate on the fluid. In addition, the movement of steam in the direction of this liquid prevents mixing of the liquid on the plate. Coin plates are also of the unidirectional liquid and vapor type.

Coin plates are made in two versions. The first view is arched coins, which only emit steam in one direction, determining the angle of inclination of the coin to the horizon. The second form is a three-way cut body, in which the steam moves not only in the direction of liquid movement, but also from the side.

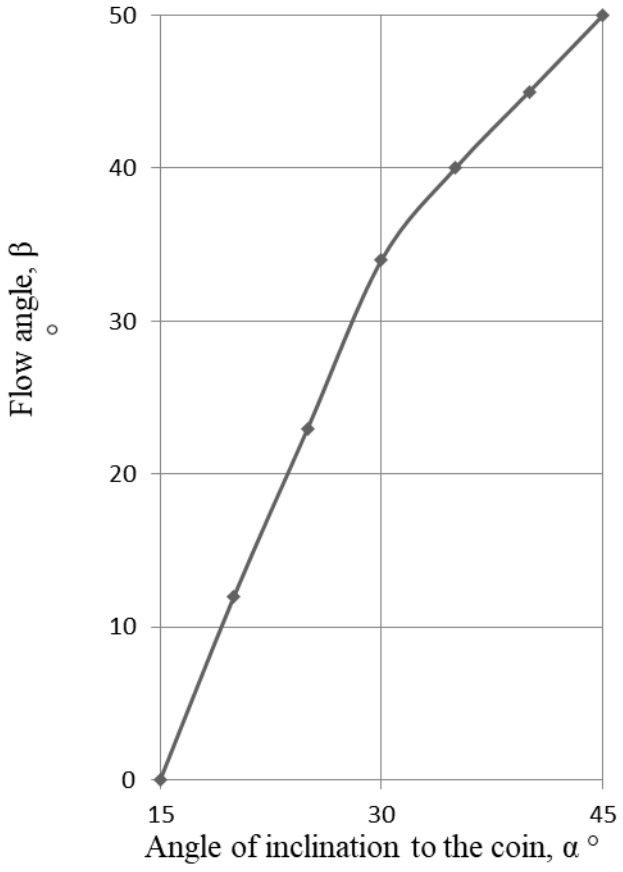
The coin width, length, and angle of inclination a, which changes the direction of the steam flow, can have different dimensions. The dimensions of the most used body are as follows: width 50 mm, length 50 mm, slope angle a=15÷20.

The degree of openness and location of the contact element, which changes the level of steam exposure to the liquid stream on the plate, allows changing the cross-sectional surface of the

steam stream coming out of it. In the liquid-vapor system, the edges of the particles are raised to provide an intensive bubbling process around the contact element.

The composition (arrangement) of plates in the column consists of a body, a concave plate, a central pouring pipe, a bubble plate, an edge (small) pouring pipe, a spill (pouring) barrier, and particles.

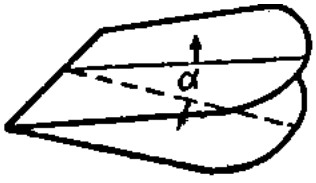
The raw material is supplied in liquid-gas form from the upper part of the column body, the distillate is removed from the upper part of the column, and the cube residue is removed from the lower part. The liquid phase moves along the plate and falls through the pouring pipe to the pouring barrier, from where it flows to the plate below. The vapor phase passes through the contact elements of the plate and contacts the liquid phase on the plate. Due to the formation of intensive bubbling in the vapor-liquid system, it provides a high-level process of substance exchange.



Due to the local distribution of the liquid phase flow, the composition scheme of the contact elements on the plates is considered for concave and convex plates.

Contact elements (coins) are made in the form of a circle by stamping the metal sheet from which the plate is made. In addition, placing the contact elements close to the column body causes a part of the liquid flow that does not participate in the process of mass exchange to participate in the process and prevents the formation of a wall effect.

The device works as follows: in the vapor (gas)-liquid system, raw materials are fed to the column to separate the light volatile components of the liquid phase. The liquid phase moves from the body wall towards the center because the concave plate of the receiver has an inclined angle of ∠3-5°. During movement, the liquid comes into intensive contact with the vapor phase coming out between the contact elements of the plate - coins. Coins in a concave plate are circular, spaced at a certain distance from each other, the open side of the coin is



opened at an angle of ∠15° from the body wall to the center. The liquid falling from the spill barrier to the convex plate after the central discharge pipe moves from the center towards the casing wall and through the peripheral discharge pipe, passing through the spill barrier that prevents the vapor phase from escaping through the discharge pipes, falls into the lower plate. The coins in the convex type plate are also circular, at a certain distance from each other, the open side of the coin is opened at an angle of ∠15° from the center to the body wall, not from the body wall to the center. The liquid, purified from light volatile components, is removed from the bottom of the device as a cubic residue. Light volatile components separated from the raw material are removed from the top of the device in the form of distillate.

The angle of inclination of the coin determines the angle of rise of the current on the plate. The figure shows the dependence of the flow angle b on the slope angle a. As can be seen from the figure, the angle b is greater than the angle a, which is explained by the action of the lifting force.

The total volume of products produced by oil industry enterprises is almost 40% of the gross food products produced in the republic. For this reason, in order to increase the range of products with a guaranteed quality and low cost, the problem of introducing effective technologies that allow saving material and energy resources and compact and intensive technological equipment to food industry enterprises is considered urgent.

The use of plate devices in oil extraction plants is one of the promising directions. Therefore, issues of using a column column distiller in the final distillation of mistella were considered.

Plate devices are widely used in chemical and food industry enterprises. S-shaped hood plates are plates where liquid and vapor move in one direction. The advantages of these plates are that the kinetic energy of the steam flow is transferred to the liquid and increases its flow rate. This allows to increase the load of the plate on the fluid. In addition, the movement of steam in the direction of this liquid prevents mixing of the liquid on the plate. Coin plates are also of the unidirectional liquid and vapor type.

The parameters of the column and convex and concave plates in the conducted experiments are presented in Table 1.

Table 1.

№	Indicators	Convex plate	Concave plate
1.	Column dimensions (length x width) mm	600x200	600x200
2.	Plate thickness, mm	1	1
3.	Plate diameter, mm	200	200
4.	Angle of inclination of the plate, °	355	5
5.	The number of rows of seeds on the plate, pcs	3	3

6.	The number of coins on the plate, pcs	48	48
7.	Angle of inclination to the coin, °	15-45	15-45
8.	The distance between the coins, mm	25	25
9.	Step, mm	10	10
10.	Column cross-sectional area, m^2	0,0314	0,0314
11.	Surface of all slots, m^2	0,0072	0,0072
12.	Free surface area of the plate, m^2	22,92	22,92

For coin plates, as well as other types of plates, several hydrodynamic operating modes are established. In slotted plates similar to sieve plates, at low velocities of steam, liquid spills out between the plates. Spilling of liquid from the tank slot stops when the vapor velocity in the tank slot is equal to 6.5 ÷ 7.5 m/s. (This speed is called the first critical speed.) Experiments where this rate was determined were conducted in an air-water system with a liquid irrigation density of 10.8-36 m^3/m^2•s. In this case, the slot construction did not significantly affect the value of the critical speed, which determined the lower limit of the working zone of the plate. At small velocities of steam in the slot, the plate works unstable. When the speed on the plate exceeds the first critical speed, the wave-bubble mode of operation is established. In this mode, the wave-like movement of the liquid from the receiving barrier to the spill zone is observed, and uniform bubbling is observed over the entire area of the plate. In this case, a significant slope of the liquid level towards the spillway is observed. This mode of plate work is little different from sieve plate work. When the speed is further increased, the liquid level in the plate becomes equal, at a certain speed called the second critical speed, the liquid level is parallel to the plane of the plate, such a regime is called an intermediate regime. For this mode, the vapor velocity varies depending on the density of the liquid irrigation. These changes are listed in Table 2 below:

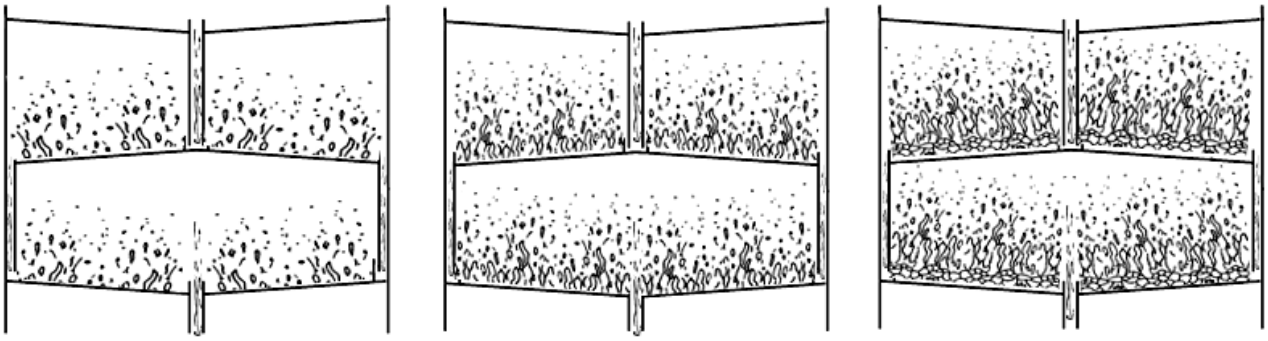
Table 2.

Irrigation density by liquid, m^3/m^2•s	**Steam velocity in the slot, m/s**	
	bottom	above
10,8	9	12
21,6	9	14
36	9	16

In the intermediate mode, the liquid level in the plate remains horizontal, the bubbling process occurs in the plates, but the direction of the vapor flow, which attracts the liquid, is shown.

When the steam velocity in the slots is further increased, the intermediate regime switches to the flow regime. A characteristic difference of the flow regime is the rise of the liquid level in the direction of the liquid flow. This phenomenon is triggered by the vapor stream attracted by the liquid, as well as by the impingement of the vapor-liquid stream on the column wall. The greater the height of the vapor-liquid mixture layer in the spill zone, the greater the vapor velocity in the cracks. At certain vapor velocities in the slits, some of the liquid breaks away from the plate and moves over the plate, increasing the liquid blowout. A further increase in speed will cause the column to jam.

The working mode of the coin plate is the flow mode. In this case, the upper limit of the speed on the plates is determined by the permissible value of the liquid flow. If the permissible value of flyaway is taken as ε=0.1 (kg liquid)/(kg vapor), then the limiting velocity can be found by an empirical formula, the form of the equation depends on the characteristic properties of the plate. Below are the flight and limit speeds of the coin disc. The scheme of the main hydrodynamic regimes of the coin plate is shown in Fig. 1.



a) b) c)

Figure 1. Hydrodynamic regimes of a coin plate: a) bubbling; b) intermediate; c) flowing.

Fig. 1.a shows the scheme of the bubbling mode of liquid in wave motion. Figure 1. b shows the intermediate transition from the bubbling regime to the flowing regime. Figure 1.b shows the horizontal level of the liquid, so that the liquid level drops to the point of discharge. Figure 1.v shows a flow regime that characterizes the rise of the liquid level in the direction of flow. This mode of operation is the optimal mode for increasing the contact surface of the phases.

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