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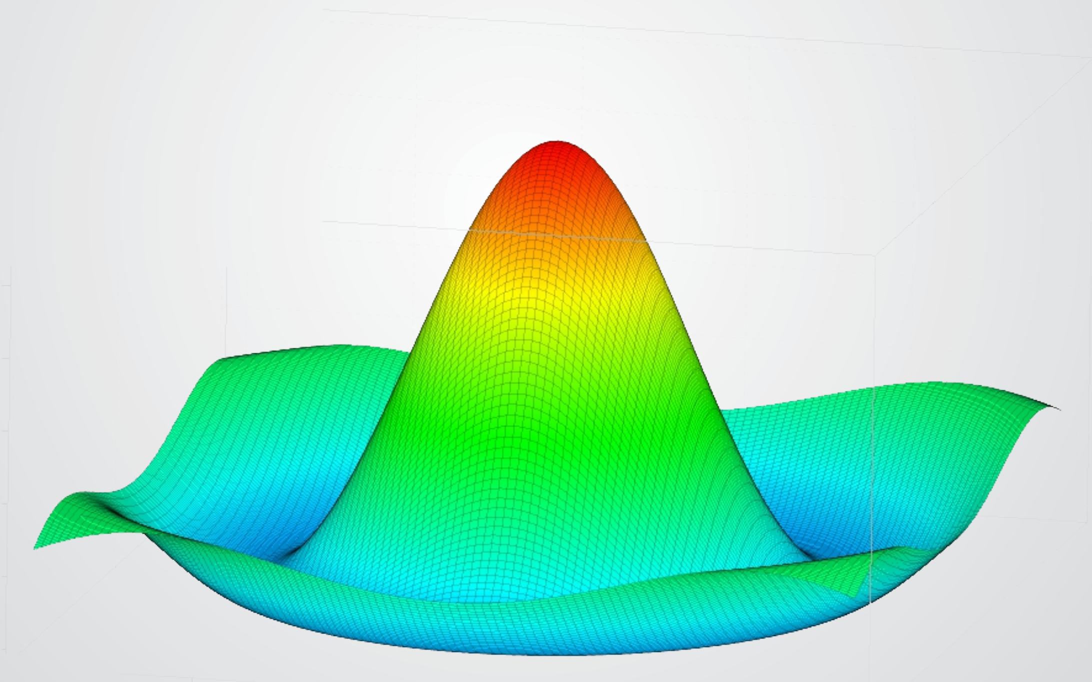

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National Academy of Packaging - Bulgaria

Web-site: http://mahvp.uft-plovdiv.bg/

Address: 26, Maritza Blvd., 4002, Plovdiv, BULGARIA

Phone: +359 32 603 814
+359 32 603 805

E-mail: mahvp@mail.bg
mahvpuht@gmail.com

CONTENS

SELECTION AND DEVELOPMENT OF COSSETTES SCALDER CALCULATION METHOD

L.V. Zotkina, G.L. Verkhola, N.A. Tkachuk

National University of Food Technologies, Kiev, Ukraine

Abstract: *The requirements for the process of cossettes scalding are examined. The exploration objective is the development of calculation methods for the parameters of the countercurrent cossettes scalders.*
The formulas for calculation of scalder diameter, the length of countercurrent and mixing parts, as well as the diameter of defoamer are proposed reasoning from optimum hydrodynamic conditions in a scalder. The basic dimensions for the scalders of different productivity are adduced.

Key words: scalder, beet cossettes, countercurrent heat exchange, foam-formation, gas bubbles, foam breaking, juice-shaving mixture, extraction plant.

Introduction.

At the present time in world sugar beet industry the vast majority of diffusion plants are equipped with horizontal countercurrent hydrators with the system of forced removal of the foam. These SCALDERS were developed to equip columned diffusers by the "WMA" and "Buckau Wolf" firms [1], but then they began to be also used for equipping installations of rotary and inclined two-screw type.

In the sugar industry the scalding process has to meet the following technological and thermal engineering requirements:

- implementation of denaturation of cell membranes by means of thermal treatment (~ 70 ^{0} C) for about 10 min.;
- heat recovery of raw juice by countercurrent heat exchange with the cossettes incoming into the hydrator;
- removal of juice-shaving foam mixture formed during scalding;
- preparation of a homogeneous juice-shaving mixture for its pumping by centrifugal pumps;
- minimization of mechanical damages of beet chips .

When the hydrator works some processes having different nature occur: mechanical, hydrodynamic, thermal, biochemical, diffusional, etc. They are interrelated, so in the design all the factors, the nature and strength of their influence should be taken into account.

Domestic researchers have studied various aspects of the hydrator. V.M. Lysyansky [2] developed the theory of calculation of heat and mass exchange processes. However, the methodology of calculating the basic geometric dimensions of hydrators considering hydrodynamic processes, as well as the processes of foam-formation during scalding is poorly developed.

There is no system of forced removal and destruction of the foam in the present hydrators. At developing new hydrators this shortcoming should be remedied. An urgent task is to develop a modern hydrator producing 4 - 6 thousand tons per day.

Experimental part.

The aim of the study is to improve the methods of calculating the geometric dimensions of the countercurrent hydrators for diffusion installations of various types.

Methods and techniques: mathematical modeling, based on physical and chemical laws of phase transformations, data processing about structures and modes of operation of similar equipment made by the leading companies.

The scalding process in the countercurrent hydrator is subdivided into several stages.

1.Preheating the chips to ~60^{0}C in a countercurrent section of the hydrator. At such temperatures the gassing of shavings is slight. Significant foaming on this site occurs because of not observing technological requirements: reduced level of juice, immature beet processing, strong microbiological activity, air in the pumps, etc. In these cases antiseptic and defoaming agents are applied and process conditions are adjusted .

2. The final heating of chips to 70 - 75 ^{0} C in the mixing section. Here the formation of foam is a natural process caused by gas bubbles forming from beet chips. The formed foam with the flow of circulating juice loop of de-foaming is removed from the hydrator.

3. Foam collapse occurs in the vessel of foam-breaker. The de-foamed juice returns into the hydrator.

When calculating the hydrator design it is necessary to determine the following: body diameter, length of countercurrent and mixing sites; vessel defoamer diameter. The basis for the calculation is inependence expressing the laws of the main processes.

The diameter of the hydrator body determines the flow velocity in the raw juice in intercossettes space. It has an optimum value which is determined by the interaction of two factors:

- Emissivity of the surface of the chip juice;
- Compression of the chip layer under the action of the hydrodynamic friction.

A reduction in the degree of turbulence in the flow decreases the heat transfer, the process requires a larger working volume of the countercurrent part.

Increasing the speed causes the compression of the layers of the chip up to the point where the selection of a predetermined amount of juice from the hydrator becomes impossible.

S.M. Grebeniuk [3] determined the value of the critical velocity for the chips produced from beet of different quality: 0,027 m /s for fresh, 0,021 m /s for frostbitten, 0,016 m /s for frozen chips. In the counter part of the hydrator chips undergo additional compression between the screw and counter-blades of the transport and mixing system. Thus, a considerable part of the cross-sectional hydrator is overlapped by conveying blades and ribbons of the screw. With this in mind, we take the design speed of the juice flow in the intercossette space as equal to 0,008 m /s.

Consumption of raw juice withdrawn from the hydrator is determined by a formula , m^3 / s :

$$q = \frac{A}{24 \times 3600} \times \frac{\alpha}{100} \times \frac{1000}{\rho}, \qquad (1)$$

where A - estimated productivity of the hydrator, t / day; α - selection of raw juice, % to beets weight; ρ - density of the diffusion juice, kg/m^3.

The estimated value of the total living section of the intercossete space is determined by a formula, m^2:

$$F = \frac{\pi}{4} \times (D_1^2 - D_2^2) \times \frac{(1000 - \gamma\ )}{1000}, \qquad (2)$$

where D_1 - internal diameter of the hydrator body, m; D_2 - outer diameter of the tube-roller, m;γ- a specific strand content of the working space of the countercurrent area, kg/m^3.

The rate of the juice flow in the intercossete space is equal to, m/s:

$$v = \frac{q}{F}. \qquad (3)$$

For design calculation of the hydrator we accept the following values: v = 0,008 m /s; α = 110 % of the weight of beets; ρ = 1060 kg/m^3; D_1 = 0,385 D_2; γ = 500 kg/m^3. Substituting these values for formulas (1), (2) and (3) we get the calculated dependence for the inner diameter of the case:

$$D_1 = 0{,}0671 \times \sqrt{A}.\ . \qquad (4)$$

The duration of heat exchange is determined by the length of the countercurrent area. Its increasing provides better thermal engineering indicators, but at the same time it expands the zone where the temperature of the juice-shaving mixture is 35 - 65 ^{0} C, and an active decomposition of sugar is made by enzymes and microorganisms. The operating experience of hydrators of different types showed that good thermal engineering results with acceptable values of sugar losses from decomposition were achieved when the duration of countercurrent heat exchange was 600 - 900 s.

The duration of countercurrent heat exchange is determined by a formula with

$$\tau\ = \frac{\pi \times (D_1^2 - D_2^2) \times L}{4} \times \qquad (5)$$

$$\frac{\gamma}{1000} \times \frac{24 \times 3600}{A} \times \frac{\rho}{1000},$$

where L – the hydrator length of the countercurrent area, m.

Substituting dependence (4) for formula (5) and the parameter values accepted above, we get:

$$L\ = 0{,}00725 \times \tau\ . \qquad (6)$$

For a design calculation of the hydrator we accept τ = 720s, respectively L = 5,22 m.

The source of the gas bubbles are the air contained in the intercellular substance and pores of the beet tissue as well as gases released from the cellular juice, due to the decrease of the solubility at heating. The mechanical impact on the chips speeds up the air outlet.

The gas outlet process is caused by a thermal expansion of gases and compression of the sugar beet tissue at scalding.

The experimental data show that when heated to t 70 ^{0} C the cossettes shrink rapidly for 2 - 3 min. At this time the most of gases evaporate. When the gases go out of the beet tissue capillaries the bubbles of different diameters are formed. The dissolution time of the bubble in the diffusion juice is determined by a formula with:

$$\tau_1 = \frac{r^2}{2 \times D_g \times (C_s - C)}, \qquad (7)$$

where: r - the radius of the bubble, m; D_g - the coefficient of gas diffusion in the liquid, m^2 / s; C_s - gas solubility in the liquid, m^3/m^3; C - gas content in the liquid m^3/m^3.

The ascent rate of a gas bubble in the diffusion juice is determined by the formula, m / s:

$$v_1 = \frac{2 \times \rho \times g \times r^2}{9 \times \mu}, \qquad (8)$$

where: μ- the liquid viscosity, Pa × s; g - acceleration of gravity, m/s^2.

The ascent time of the gas bubble from the bottom of the hydrator is determined by the formula:

$$\tau_2 = \frac{9 \times \mu \times D_2}{2 \times \rho \times g \times r^2}, \qquad (9)$$

In the mixing section the juice-shaving mixture typically has the temperature of ~70 ^{0}C. Condensates are used as the extractant, in the column apparatus the diffusion juice does not contact with air, so the diffusion juice has a small degree of air saturation. For design calculation of the hydrator we accept: D_g = 2,9 × 10^{-9} m^2 / s ; C_s = 0,0116 m^3/m^3; C = 0,00116 m3/m3 ;μ = 0,859 × 10-3 Pa × s ; g = 9.81 m/s^2.

Substituting the formula(4) for formula(9) we determine the value of some characteristic bubble radius r, the dissolution time of which is equal to the time of ascent from the bottom of the hydrator to the screen (the corresponding curves are intersected in Fig.2):

$$r_1 = 68{,}8 \times \sqrt[4]{A}. \qquad (10)$$

The ascent rate V formula(8) and the ascent time τ formula (9) correspond to the radius of the bubble r. During τ all the bubbles, for which r <r_1, dissolve and the bubbles, for which r> r_1 reach the screen and are removed from the hydrator. For design calculation of the hydrator we assume that the time of the juice-shaving mixture being in the merging portion should not be less than 1,25 × τ .. We define the length of the mixing section of the hydrator L using formulas (4),(5) and the value of a specific content of the mixing area γ = 286 kg/m^3 :

$$L_1 = 0{,}0159 \times \tau_3. \qquad (11)$$

The magnitude of the cross-section of the foam-breaking vessel should be such that the downstream rate of the de-foamed juice can be less than 0,5 × V. The consumption of the circulating juice loop de-foaming of the hydrator makes up 100% of the beets weight.

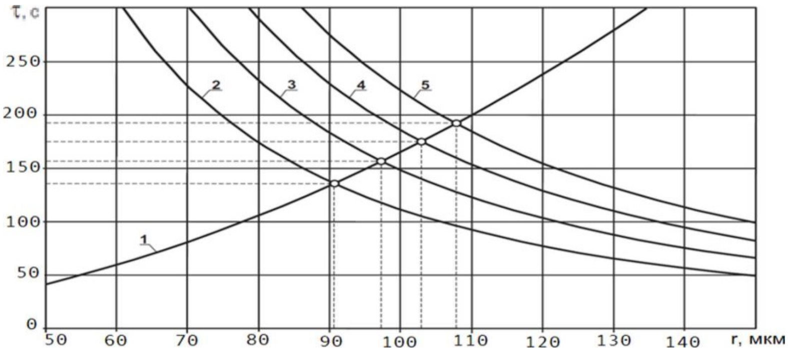

Fig.2. Time vesicles dissolution (curve 1) dependence on their radius and ascent time of the bubbles for hydrators D_2 = 3, 4, 5, 6 m of the (respectively curves 2, 3, 4, 5).

Diameter of the foam-breaking vessel is determined by the formula, m:

$$D = \sqrt{\frac{A}{24 \times 3600} \times \frac{1000}{\rho} \times \frac{4}{0{,}5 \times \pi \times V}}. \qquad (12)$$

Conclusion: the method of calculation of basic geometric parameters of the countercurrent hydrators for beet chips has been carried out. Calculation formulas are based on empirical data about the processes that occur in the diffusion installations of hydrodynamic and heat exchange type. The results of optimal size calculation for different performance hydrators are given. The results obtained should be considered when designing hydrators for diffusion units of column, rotary and two-screw types.

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