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Mathematical Modeling and Study of The Process of The Conversion of The Mellon on Juice and Puree

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Annotation: The universal model of process of multiphasic evaporation is received and the software received analytical and experimental models is carried out, optimum parameters are revealed at processing a melon in an offered line

Exist the different technological schemes of the conversion of the mellons (4). The Realization component operation existing line on scientific base forms the problems of the study. Some of them, in particular, reception of the melon mass, her(its) hydromechanical division on factions, fermenting juice, evaporation and reception of the concoction, are chosen by us as problems of the study.

The Literary study of the process boil-offs food solution has shown practicability of their evaporation in multicase vacuum- evaporating installation. We there is solve the problem of modeling of the process of the evaporation clarified juice of the melons (on example of melon juice) and choice amount body of the installation on base of the computer studies (3). For this purpose we prototype the process of the evaporation of water from composition of juice in single-unit vacuum- evaporating to installation. Hereinafter possible realize step-like transition to two-, three-, and four-case installation. We shall Mark input and output parameters of the process as follows.

H - a level to liquids in device, [m]; S - an area of the cross-section of the device, [m^2]; Gн - a consumption entering in device of juice, [kgs/with]; ан - a concentration entering juice, [kgs/kgs]; tн - a temperature entering but device of juice, [^{0}C]; ак - a concentration leaving juice, [kgs/kgs]; tк -a temperature leaving juice, coming out of device, [^{0}C]; m - an amount fluid mixture housed device, [kgs]; $G_н$ - a consumption fluid mixture, coming to body of the device, [kgs/with]; $G_к$ - a consumption fluid mixture, leaving through bottom of the device, [kgs/with]; G_2 - a consumption vaporizing liquids (the secondary pair), [kgs/with].

The Known that at modeling one step any process hydrodynamic structure of the flow is taken in the manner of ideal melange or ideal displacement. When formation of our models object modeling is accepted for one cell ideal hashing. On the following stage when turning from one body separate cells ideal is taken to the whole installation each body device hashing. They unite accordingly, and is taken mesh model countercurrent flow.

Change amount to liquids for time is expressed by equations of the material balance i.e. she depends on differences of the expenses coming and leaving liquids and vaporized moisture.

$$\frac{dm}{d\tau} = G_н - G_к - G_2 \qquad (1)$$

For expression of the mass through volume, and density use following equations:

$$mV\rho = SH\rho \qquad (2)$$

where V - a volume to liquids in device, [m3]; ρ - density to liquids, [kg/m3].

The having Used formula (2), for capacity of the body of the device, change level to liquids in device express following below differential equation:

$$\frac{dH_к}{d\tau} = \frac{1}{S\rho}\left[G_н - G_к - G_2\right] \qquad (3)$$

where Hк - a current level to liquids in separator evaporating device, [m]; S - an area of the cross-section evaporating device, [m^2]; ρ - density fluid mixture, [kg/m^3].

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Importance of density fluid mixture is found within density of clean water and dissolved in water dry material. Density possible to calculate on formula, brought below

$$\rho = \rho_ч * a_к + 1000 * (1 - a_к) \qquad (4)$$

$\rho_ч$ - density of the clean product, [kg/m^3]; ак - a current concentration dry material in juice, [kgs/kgs]; 1000 - density of clean water, [kg/m^3].

The consumption to liquids, flowing down from device, has a functional dependency from height of the liquids in device i.e. than more hydrostatic pressure, that more consumption to liquids. If consider this dependency in the most simplest event proportional, that equation for consumption takes following type:

$$G_к = k_1 H_к \qquad (5)$$

Indeed this dependency not proportional, but has a more complex nature. Aside from that, equation (4) does not take into account viscosity evaporated to liquids.

The consumption of the water vapor (pair)s, selected from mixture in one body of the device is defined from the main equation heat-exchanging process. Operative power of the process is a difference of the temperature.

$$G_2 = k_2 (t_к - t^*) \qquad (6)$$

where t*- temperature of the boiling to liquids, residing housed device under vacuum (equilibrium temperature), [^{0}C].

The Definable consumption entering in device of the liquids, amount dry material, entering together with liquid, consumption flowing down from device of the liquids, consumption heating for evaporation moisture deaf pair, consumption vaporized moisture possible get the equation for determination of the concentrations dry material in flowing down liquids.

$$\frac{da_к}{d\tau} = \frac{1}{SH\rho}[G_н a_н - G_к a_к] \qquad (7)$$

Having Used by heat balance possible to get differential expression of the change the temperature to liquids on time

$$\frac{dt_к}{d\tau} = \frac{1}{SH\rho c}\left[G_н c t_н - G_к c t_к - G_2 i_{vp} + D i_p - D i_k\right] \qquad (8)$$

where with - thermal capacity fluid mixture, [кДж/(kgs ^{0}C)]; i_p, i_k - enthalpy pair, given in interpipe space of the device and condensate, [кДж/(kgs ^{0}C)]; D_p, D_k - a consumption deaf pair, given in interpipe space, [kgs/with].

Since calculation of the process of the evaporation of the vapor (pair)s of water is connected with thermodynamic parameter of the condition of water necessary to get the equations to dependencies of the temperature of the boiling of the water, heats of the vaporization of water, enthalpy pair, enthalpy of water from pressure. Experimental given are received long ago, are successfully used, however united fitted equations, used all researcher do not exist [1].

Using possibility of the program MATLAB, way statistical of the processing tabular data, provided in functioning [2], shall get the fitted equations in the manner of multinomial for condition of water and water pair, describing real picture with accuracy 98% and more.

The Empirical dependency of the temperature of the boiling to liquids from pressure in device, got by processing tabular data is of the form of:

$$t = -0.00059 * p2 + 0.48 * p + 51 \qquad (9)$$

Empirical dependency of the heat of the vaporization of water from pressure in device, got by processing tabular data is of the form of:

$$i' = -2.5 * p2 + 2000 * p + 210000 \qquad (10)$$

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The Empirical dependency энтальпии to liquids from pressure in device, got by processing tabular data is of the form of:

$$r = 1.4 * p2 - 1200 * p + 2400000 \qquad (11)$$

The Empirical dependency enthalpy dry saturated pair from pressure in device, got by processing tabular data is of the form of:

$$i'' = - p2 + 800 * p + 2600000 \qquad (12)$$

Us having used possibility of the program MATLAB, way of the statistical processing tabular data, are received fitted equations in the manner of multinomial for condition of water and water pair. Such multinomials describe the real picture with accuracy 99,9% and more. These fitted equations are enclosed in composition of the mathematical model of the process of the evaporation of melon juice also.

The System of the equations (1-6) is a mathematical model speakers process of the evaporation to liquids in однокорпусном vacuum device. Using part SIMULINK program MATLAB possible to form the computer model of the decision of the equations.

$$\begin{cases} \dfrac{dH_к}{d\tau} = \dfrac{1}{S\rho}\left[G_н - G_к - G_2\right] \\ G_к = k_1 H_к \\ G_2 = k_2\left(t_к - t^*\right) \\ \dfrac{da_к}{d\tau} = \dfrac{1}{SH\rho}\left[G_н a_н - G_к a_к\right] \\ \dfrac{dt_к}{d\tau} = \dfrac{1}{SH\rho c}\left[G_н ct_н - G_к ct_к - G_2 i_{vp} + Di_p - Di_k\right] \\ \rho = f(a) = \rho_ч * a_к + 1000*(1 - a_к) \\ m = V\rho = SH\rho \\ t = -0.00059*p2 + 0.48*p + 51 \\ i' = -2.5*p2 + 2000*p + 210000 \\ r = 1.4*p2 - 1200*p + 2400000 \\ i'' = -p2 + 800*p + 2600000 \end{cases} \qquad (13)$$

For simplification of modeling we shall enter row of the admissions:
- hydrodynamic structure flow is taken for ideal displacing and ideal melange;
- thermal capacity fluid mixture - juice or concoction is taken constant;
- in mathematical model and accordingly in calculation is not taken into account change hydrostatic pressures of the pole to liquids.

Brought above equations unite in the general system of the equations (2-12), presents itself mathematical description acting single-unit unceasing vacuum- evaporating of the installation. The Mathematical model includes the equations material and heat balances in MVU, as well as fitted equations of the dependencies of the temperature of the boiling, heats of the vaporization and enthalpies of water, as well as enthalpies pair from pressure in device.

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The Study to mathematical model of the process выпарки flying component within the range of variations input parameter process and analysis got result allows to judge about speaker of the process of the evaporation in single-unit device. By accepting output parameters of the process are for input following body possible to calculate installation with any amount body.

To define height of the pole to liquids N from equation (3) necessary to execute following calculation:

$$H = \int_0^{\tau} \frac{dH}{d\tau} \qquad (14)$$

This method is used and at decision of the equations (7) and (8), hereunder define the concentration dry material in expiring liquids aк and temperature fluid mixture.

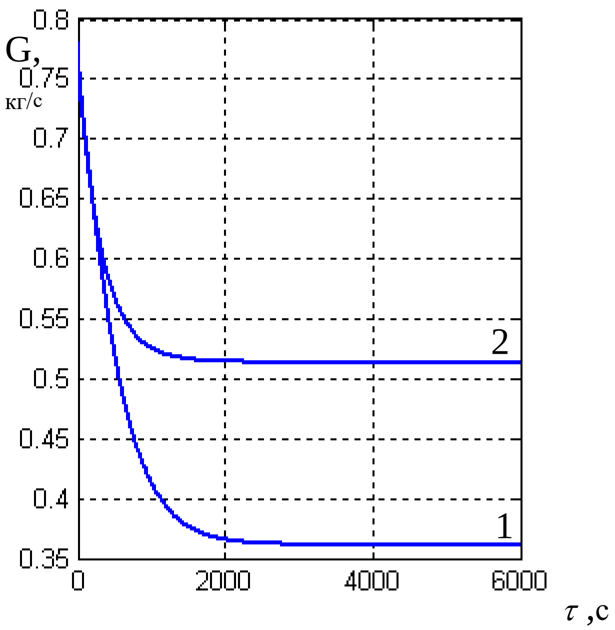
The Results of modeling required for scheduling the mathematical description of the economic factors.

We shall Consider the process of the evaporation of melon juice in single-unit vacuum- evaporating to installation. Installation consists of casing tubular device with separator and capacitor supplied vacuum-pump. The Vacuum-device contains the system of the heating deaf ferry and tap of the condensate. For support of the vacuum in unceasing installation is used barometric capacitor.

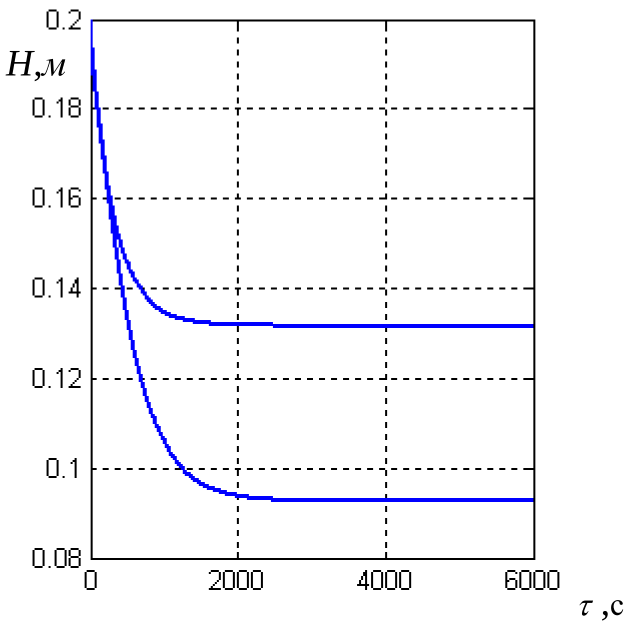
The executed procedure of the basic researches to mathematical model, are received results, are discussed and used for optimization of the processes фракционированной conversions of the melon melons on example.

For instance, dependency of the change the consumption to liquids on output on time (ris.1) - a track record of the process. The Formed mode of the evaporation but consequently output of juice from device with consumption G3 = 0,52 kgs/with in single-unit device approaches through 1800 with after begin functioning(working) the device, but at double-hull to installation - through 2200 with G3 = 0,355 kgs/with. The Difference in consumption 0,52 - 0,355 = 0,165 are reached to account of the increase evaporations water when using double-hull installation.

The Dependency of the change the height to liquids in device on time (ris.2) - a track record of the process. The Height to liquids in single-unit device changes from 0,2 before 0,13 refer to during 2400 s. Difference in 0,20-0,13 refer to = 0,07 refer to accounts for aperiodic period. When use double-hull of the installation height to liquids decreases from 0,2 before 0,095 refer to Difference in height forms 0,2 refer to - 0,095см = 0,105 refer to This height of the pole to liquids on each of device double-hull vacuum-evaporating of the installation.



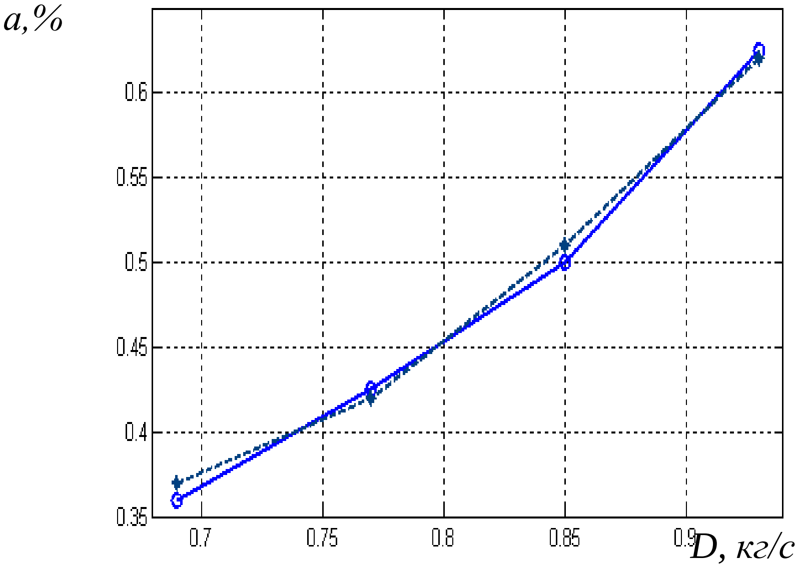
Ris.1. Graph of the change the consumption to liquids on output on time



Ris.2. Graph of the change the height to liquids in device on time

In contrast with single-unit height to liquids above on 0,105 refer to - 0,095 refer to = 0,01 are refer to conditioned that that evaporation moisture in double-hull to installation accounts for two bodies, and so in they appear the difference.

The Series crooked for different importance of the consumption pair D(i) (ris.3) in single-unit vacuum- evaporating device graphically demonstrates that than more consumption pair accordingly than above temperature mixture in device, that more intensively runs the process of the evaporation of melon juice. On ris.3 is presented profile of the change to concentrations of juice on output vacuum- evaporating of the device on consumption deaf pair, spent on evaporation.



Ris.3. The Dependency to concentrations of juice on output выпарного device from consumption deaf pair (the utter line - on mathematical model, штрихная - on experimental given).

The Analysis crooked shows that with growing of the consumption deaf pair on heating of the device it is intensified the process of the evaporation moisture and accordingly grows the concentration of juice on output from device.

The Table 1.

Comparison result experiment with accounting data, got by means of mathematical model

№	Consumption deaf pair on body MVU	Importance of the concentration of juice on mathematical to models	Importance of the concentration of juice	Difference absolute	Difference relative	Square to differences
	D, кг/с	*a*, %	*a*, %	Δa	$\Delta a/ a$	$(\Delta a/ a)^2$
1	0,93	0,625	0,62	0,005	0,81	0,650
2	0,85	0,500	0,51	-0,010	-1,96	3,845
3	0,77	0,425	0,42	0,005	1,19	1,417
4	0,69	0,360	0,37	-0,010	-2,70	7,305
Amount square						13,217
Standard deviation						3,304

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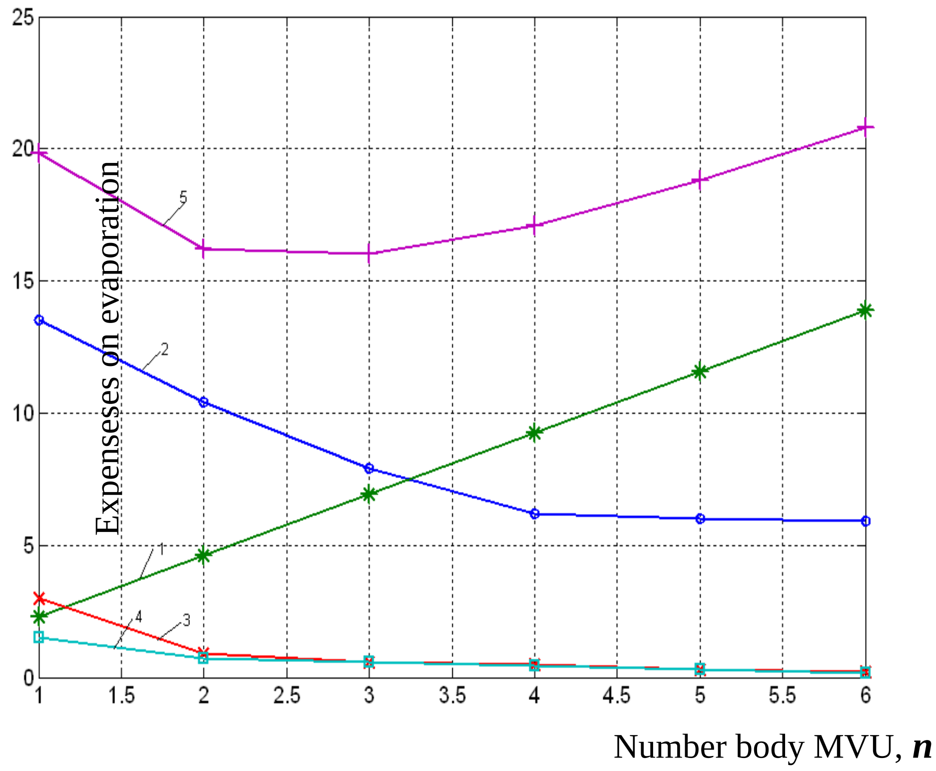
Possible conclude that theoretical and experimental factors with 3,304% -an ной by accuracy.

For discussing result studies to mathematical model of the process multicase vacuum evaporation food solution, including melon juice necessary studies one-, two, and three-case device and installation with the most amount device.

The having Researched process отгонки влаги in one-, two-, three- and four-hull evaporators complex possible to form the mathematical model of the economic factors of the process. For achievement of this purposes are received mathematical expressions of the depreciation charge A, current costs on вакуумирование in evaporating complex $Z_{вк}$, on heating of the body of the device deaf ferry $Z_{гп}$ and on condensation secondary vapor (pair)s by cool water $Z_{хв}$:

$$\begin{cases} A = C_{вву} E_н / G_к \tau_{сез} 3600 \\ Z_{вк} = N_{\max} C_э / 3600 * G_к \\ Z_{гп} = C_n D_{гп} / 1000 * G_к \\ Z_{хв} = C_{хв} * G_{хв} \\ Z_в = A + Z_{вк} + Z_{гп} + Z_{хв} \end{cases} \quad (4)$$

Here Savvy - a cost vacuum- evaporating of the installation, bags; N_{max} - a power of the electric motor, greatly required for vacuum-pump of the installation [kVt] S_e - a prime cost to electric powers [bags]; J_v cost 1 t pair, [sum]; S_{hv} - a prime cost of cool water [bags]; $G_{хв}$ -a consumption of cool water [kgs/with].



Ris.4. The Dependency of the expenses on unit выпариваемого juice from capacity MVU.
1-cost device, 2-expenseses on heating device deaf ferry, 3-expenseses on making the vacuum in MVU, 4-expenseses on конденсирование secondary vapor(pair)s by cool water, 5-curve of the amount of all expenses on evaporation in MVU.

In interval of the change the final consumption of juice Gк from 0,2 before 0,5 kgs/with expenses on production of the unit to product decrease from 22 before 8,8 kgs/with. This is indicative of that that than more capacity device that expenses less on production of the unit to product. In interval of our studies when increase of capacity in 0,5/0,2=2,5 times expenses on unit of the product also decrease in 22/8,8 = 2,5 times.

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This speaks of that that curve of the change the expenses Z_v on capacity $G_к$ carries symmetrical-proportional nature. The Best value of the expenses on unit of the product is chosen coming from possibility of the choice input parameter process and design feature device complex MVU.

The Literature:

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