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CALCULATION OF THE COEFFICIENTA OF HEAT AND MOISTURE EXCHANGE OF DRYING OF RAW COTTON IN SOLAR-DRYING PLANTS

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ABSTRACT

In this article, one of the urgent tasks that is energy-saving and relevant has been studied, an analytical calculation of the drying rate of raw cotton in solar-drying plants has been made. In addition, the average value of the speed of convective drying of high grades of raw cotton in the first drying period has been determined in the height of the drying chamber, which depends mainly on the speed of the drying agent in the drying chamber section free of dried raw cotton, the temperature of the drying agent at the entrance to the drying chamber,the size of the raw cotton.

Keywords: Solar-drying plant, raw cotton, humidity, drying agent, relative drying speed, temperature, drying chamber, heat transfer, constant speed period, coefficient, moisture content, relative speed, humidity, regularity, equation, value.

Among the generally accepted criterion equations β and α_1 convective drying, formulas for calculating $\alpha_к$ –

$$N_u = 0{,}395^{Re^{0,64}Pr^{1/3}} \quad (1)$$

And for calculation β –

$$Sh_3 - 0{,}395^{Re^{0,24}Se^{1/3}} \quad (2)$$

at $30 \leq Re \leq 105$ и $0{,}6 \leq Pr \leq 6 * 104$

As comparedto the others, equations (1) and (2) are as follows:

- applicability to the elements of the dried products, regardless of their shape;
- experimental confirmation of the analogy of heat and mass exchange rates (the same coefficients (0.395) and the degree of criteria Ree (0.64) and Pr, Se (1/3));"
-with a sufficient degree of accuracy for practical calculations, the heat transfer coefficient (α_1) can be calculated through the moisture exchange coefficient (β).

The criteria of Sherwood (Sh),, Nusselt (Nu,), and Reynolds (Re,). The determination by the equivalent diameter of the channel between thee-lements (i.e., the steam tunnel) - $d_э$, as well as Schmidt (Sh) and Prandtl (Pr)in (13) and (14) in turn, are determined from the relations [1]

$$Sh_3 = \frac{\beta d_э}{D}. \quad (3)$$

$$Nu_3 = \frac{\alpha_1 d_э}{\lambda}, \quad (4)$$

$$Re, = \frac{€ d_э}{V} \quad (5)$$

$$Se = \frac{V}{D} \quad (6)$$

$$Pr = \frac{V}{a}, \quad (7)$$

whereD is the diffusion coefficient of moisture vapor in the drying agent; λ , Vanda–respectively the coefficients of thermal conductivity, kinematic viscosity and

conductivity of the drying agent; Vc is the average speed of the drying agent in the space between the elements of the dried raw cotton.

The values de andvэin (3) – (5) are defined from the expression[2]

$$d_э = \frac{4\varepsilon_{хл}}{a_{хл}}, \quad (8)$$

$$€_э = \frac{v}{\varepsilon_{хл}}, \quad (9)$$

Where is

$$a_{хл} = \frac{F_{mхл}}{V_{хл}}, \quad (10)$$

external specific heat exchange surface of the dried raw cotton; v- the flow rate of the drying agent along the cross-section of the drying chamber.

$$a_{0a} = \frac{F_{m1}}{V_1} = \frac{6}{d_{cp}}, \quad (11)$$

and cylindrical shape

$$a_{0a} = \frac{6}{d_{cp}}\left(\frac{2}{3} + \frac{1d_{cp}}{3H}\right) \quad (12)$$

where Hand d_{cp} respectively the height and average diameter of the cylinder.

From the comparison (11) and (12), it can be seen that at (d_{cp}), and not the equivalent diameter of the steam channel ($d_э$). In this regard, the criterion equations (1) and (2), taking into account (9) and (10), are represented as[3]:

$$Sh = 0{,}4508\,\frac{(1-\varepsilon_{хл})^{0,16}}{\varepsilon_{хл}} R_e^{0,64} P_r^{1/3}, \quad (13)$$

$$N_u = 0{,}4508\,\frac{(1-\varepsilon_{хл})^{0,36}}{\varepsilon_{хл}} R_e^{0,64} P_r^{1/3}, \quad (14)$$

Where is

$$Sh = \frac{\beta d}{D}, \quad (15)$$

$$Nu = \frac{\alpha d}{\lambda}, \quad (16)$$

$$R_e = \frac{vd}{V}, \quad (17)$$

$$\varepsilon_{сл} = 1 - \left(\frac{n_o}{n_o}\right)^2 \left\{0{,}61 + 0{,}288\left[-\left(\frac{n_o}{n_o-1}\right)^2 - \left(\frac{n_o-2}{n_o-1}\right)^2\right]\right\} \quad (18)$$

where $n_o = \frac{D_{cp}}{d_{cp}}$ (19)

The ratio of the inner diameter of the dryingchambers (D_{cp}) to the average diameter of the raw cotton lobe (d_{cp}).

$$Sh = 0{,}976^{Re^{0,64}} Sc^{1/3} \quad (20)$$

$$N_u = 0{,}976^{Re^{0,64}} Pr^{1/3} \quad (21)$$

On the basis of the criterion equations (20) and (21), it is possible to obtain an analytical expression for $\frac{\beta}{\alpha_к}$the ratio , which is necessary to determine the average height of the drying chamber ($\ddot{\&}_{вл}$) and the relative (N) rate of convective drying of wet raw cotton, i.e. the rate of convective drying of raw cotton.

$$\frac{\beta}{\alpha_к} = \frac{D}{\lambda}\left(\frac{a}{D}\right)^{1/3} \quad (22)$$

Taking into account the dependence of the coefficient of thermal conductivity (λ) specific heat (c_p) and density (ρ)

$$\lambda = ac_p\rho \tag{23}$$

the relation (22) can be rewritten as:

$$\frac{\beta}{\alpha_к} = \frac{1}{c_p\rho} * \frac{D^{\frac{2}{3}}}{a^{\frac{2}{3}}} = \frac{1}{c_p\rho {L_e}^{2/3}} \tag{24}$$

where $L_e = a/D -$ (25)

Lewis-Semenov number [3].

Substituting (24) in Solutions

$$\ddot{\&}_{вл} = 0{,}2205\frac{v\rho_c d_{cp}}{\alpha_к(1-\varepsilon_{св})L_{св}}\left(\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_o} - \varphi_1\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_o}\right), \frac{кг}{м^2с}$$

(2) and taking into account theaverage value $\varepsilon_{хл} = 0{,}39$ ... for the values $\ddot{\&}_{вл}$ and N when drying high grades of raw cotton in the drying period, we obtain:

$$\ddot{\&}_{вл} = 0{,}3625\frac{v}{L_{хл}}\frac{d_{cp}}{Le^{2/3}}\left(\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_o} - \varphi_1\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_1}\right), \frac{кг}{м^2с} \tag{26}$$

$$N = 217{,}4914\frac{v\left(1+\beta_x\frac{W_x}{100}\right)}{\rho_c L_{хл} Le^{2/3}}\left(\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_o} - \varphi_1\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_1}\right), \frac{\%}{с} \tag{27}$$

From the equality of analytical parameters for the difference in absolute humidity of the drying agent at the entrance to the drying chamber and at the outlet of it –Xand $x_u - x_o = (0{,}3217t_1 - 4{,}104)10^{-3}кг/м^3$during the period of constant drying speed, [4]. i.e.

$$(0{,}3217t_1 - 4{,}104) * 10^{-3} = 1{,}323 * \left(\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_o} - \varphi_1\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_1}\right) \tag{28}$$

define that $\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_o} - \varphi_1\frac{10^{\frac{7{,}45*t_o}{235+t_o}}}{T_1} = (0.243t_1 - 3{,}102) * 10^{-3}$,

Substituting the result into the solution (26) and (27) taking into account the expression (23) for the values $\ddot{\&}_{вл}$ and N, respectively, we have

$$\ddot{\&}_{вл} = 0{,}0881565\frac{v}{L_{хл}}\frac{d_{cp}}{Le^{2/3}}(t_1 - 12{,}76) * 10^{-3} \tag{29}$$

$$N = 52{,}8939\frac{v(t_1-12{,}76)}{\rho_c L_{хл} Le^{2/3}}\left(1+\beta_x\frac{W_x}{100}\right)10^{-3}, \frac{\%}{С} \tag{30}$$

For convenience in further calculations, decisions (2) and (30) can be rewritten as:

$$\ddot{\&}_{вл} = 0{,}3174\frac{v}{L_{хл}}\frac{d_{cp}}{Le^{2/3}}(t_1 - 12{,}76) * 10^{-3}, \frac{кг}{м^3 * ч}, \tag{31}$$

$$N = 190{,}418\frac{v(t_1-12{,}76)}{\rho_c L_{хл} Le^{2/3}}\left(1+\beta_x\frac{W_x}{100}\right), \frac{\%}{ч} \tag{32}$$

Findings:

From the decisions (31) and (32) received, it follows that [5].:

- the average height of the drying chamber value of the convective drying rate of high grades of raw cotton in the first drying period ($\ddot{\&}_{вл}$), as expected, depends mainly on the speed of the drying agent in the drying chamber section free of dried raw cotton (U), the temperature of the

drying agent at the inlet to the drying chamber (t_1), the size of the raw cotton lobe (d_{cp}), as well as the total height of the layer of dried raw cotton in the drying chamber $L_{хл}$;
- the relative rate of convective drying of high grades of raw cotton in the first drying period (N), as well as $\ddot{\&}_{вл}$, depends mainly on the temperature of the drying agent U, and $L_{хл}$, at the entrance to the drying chamber (t_1), but, unlike $\ddot{\&}_{вл}$, does not depend on the size of the raw cotton slice (d_{cp}).

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