Determination of the Speed of Convective Drying of Products at the Adjustment Power of the Heater Source in the Cradle-Conveyor Drying Equipment

Iskandarov Zafar, Norkulova Karima, Abdieva G, Jumaev Botir and Jasur Safarov*
Tashkent state agrarian University, Republic of Uzbekistan
Submission: July 14, 2016; Published: July 26, 2017
*Corresponding author: Jasur Safarov, Tashkent state agrarian University, Tashkent, Republic of Uzbekistan, Email: jasursafarov@yahoo.com

Abstract
Drying is not only the most complicated non-stationary process of heat and mass transfer, but also a very energy-intensive technological process. In connection with the foregoing, it is of great practical interest to establish the character of the drying rate distribution along the height of the drying chamber in question and on this basis to determine the average drying of the products in it. In convective dryers with a dense layer of dried products at a constant drying rate, in any (for example, h) section, the entire inflow of useful heat supplied by the drying agent to the products to be dried is expended on evaporation of moisture, i.e. due to the fact that at a constant drying rate, the temperature at the surface of the dried products \( t_{pr} \) is equal to the temperature of the drying agent by a wet bulb \( t_m \), and the value of the partial pressure of water vapor on the surface of the dried products \( P_{pr} \) is equal to the partial pressure a saturated drying agent.

Keywords: Heat source; Convective drying; Temperature; Cradle-pipeline drying equipment; Drying agent

Introduction
One of the features of convective drying of high-moisture agricultural products in a dense layer with the adherence of the product layer by the drying agent stream is the uneven drying process along the height of the drying chamber. The drying agent entering the drying chamber having the maximum drying potential first interacts with the primary (i.e., initial) elementary layer of products, where the heating and then the drying process proceeds at the maximum rate. Pouring through the primary elemental layer of the dried products, the drying agent partially loses its drying potential. By the next elementary layer of products, the drying agent on its way interacts already as spent in the primary elementary layer, i.e. with a weakened (compared to the primary) drying potential. At the same time, the elementary layers of products located in the zone of a dense layer close to the outlet of the drying agent from the drying chamber practically still “do not feel” the heating and drying effect of the drying agent, t. In this zone the latter comes with a “zero” or close to it drying potential.

Materials and Methods
In connection with the foregoing, it is of great practical interest to establish the nature of the distribution of the drying rate along the height of the drying chamber of the drying method in question and on this basis to determine the average drying of the products in it.

In convective dryers with a dense layer of dried products at a constant drying rate, in any (for example, h) section, the entire inflow of useful heat supplied by the drying agent to the products to be dried is expended on evaporation of moisture, i.e.

\[
\alpha_h (t_h - t_{pr}) = G_{min} R',
\]

where \( t_h \) and \( G_{min} \) - respectively, the temperature of the drying agent and the drying speed in the section of the drying chamber, located at a distance \( h \) from its initial section (i.e., inlet).

For the initial section of the drying chamber, which is taken as the primary, i.e. \( h=1 \), the analytic expression (1) has the form

\[
\alpha_1 (t_1 - t_{pr}) = G_{min} R',
\]

Where \( t_1 \) and \( G_{min} \) - the temperature of the drying agent and the drying rate in the drying chamber in question (i.e., in the initial section).

From the joint consideration of (1) and (2) we have

\[
\frac{G_{max}}{G_{max}} = \frac{t_1 - t_{pr}}{t_1 - t_{pr}}.
\]
The drying speed average of the drying chamber can be determined by integrating (5), i.e.

\[ \bar{\gamma}_p = \int_0^{L_p} \frac{\gamma_p \, dh}{L} \, kg/(m^2 \cdot c) \]  

Substituting (5) in (6) and after integration we have

\[ \bar{\gamma}_p = \frac{\gamma_p}{a_k + b_c k} \frac{g_{\gamma_p}}{L} \left( e^{-\frac{a_k + b_c k}{g_{\gamma_p} L} - 1} \right). \]  

As the results of calculations show, under real operating conditions of convective drying chambers with a dense layer of dried products \( a_k \, c_k \) and in connection with this, for practical calculations the solution of (7) with allowance for

\[ [dF]_L = \frac{c}{\delta F \cdot dl} \]  

and for products having a spherical shape can be represented in the form

\[ \bar{\gamma}_{\text{mois}} = \gamma_{\text{mois}} \frac{\partial \gamma_{\text{mois}}}{\partial \rho_c} \frac{\partial \rho_c}{\partial \alpha_k} \frac{\partial \alpha_k}{\partial L} = \gamma_{\text{mois}} \frac{\partial \gamma_{\text{mois}}}{\partial \rho_c} \frac{\partial \rho_c}{\partial \alpha_k} \frac{\partial \alpha_k}{\partial L}. \]  

As follows from (10), under the condition \( a_k + b_k k > 3 + 4 \)
the average height of the drying chamber, the value of drying speed in a dense layer, all other things being equal, depends on the drying speed in the current elementary layer, which is taken as the primary

\[ \gamma_{\text{mois}} = \beta (\gamma_{\text{pr}} - \gamma_1), \quad kg/(m^2 \cdot c) \]  

where \( \beta \)- moisture exchange coefficient for convective drying in a dense layer, \( m/c \); \( \gamma_{\text{pr}} \) \( \gamma_1 \) - respectively, the absolute humidity of the drying agent on the surface of the dried products and at the inlet to the drying chamber (kg/m³).

In accordance with

\[ P = \frac{0.289 F'}{T}, \quad kg/m^3 \]  

and

\[ Ph = \frac{E_{\Delta}}{E_{\Delta} + \sum_{\text{m} = 1}^{\text{d} = \text{H} = \text{v}} E_{\gamma}^{\text{m}} + T \Delta S_{\text{m}} + E_{\gamma}^{\text{m}} + E_{\gamma}^{\text{v}}}{E_{\gamma}^{\text{m}} + E_{\Delta}}, \quad kg/(m^2 \cdot c). \]

For values \( \gamma_{\text{pr}} \) and \( \gamma_1 \) in (11) we can write the corresponding expressions

\[ \gamma_{\text{pr}} = \frac{0.289 F'}{T}, \quad kg/m^3 \]  

\[ \gamma_1 = \frac{0.289 F'}{T}, \quad kg/m^3 \]  

Due to the fact that at a constant drying rate, the temperature at the surface of the dried products \( t_{pr} \) or \( T_{pr} \) is equal to the temperature of the drying agent by a wet bulb \( (t_m, T_m) \), and the value of the partial pressure of water vapor on the surface of the dried products \( (P_{pr}) \) is equal to the partial pressure saturated drying agent at the same temperature \( (t_m) \) · \( P_T \), for the difference \( \gamma_{\text{pr}} \) and \( \gamma_1 \) in (11), on the basis of the previously obtained solution [1-4].

\[ T_m - P_{pr} \cdot 1 = 1.323 \left( \frac{10^{0.45 t_{1}}}{(235 + t_{1})} \right) / T_m - P_{pr} - \chi_{1} \]

\[ \chi_{pr} - \chi_{1} = 1.323 \left( \frac{10^{0.45 t_{1}}}{Q_{\rho} - \phi \cdot 10^{0.45 t_{1}}} \right), \quad kg/m^3 \]

Substituting (17) into (11), and then obtaining the result in (10), we have

\[ \bar{\gamma}_{\text{pr}} = 0.220 \, \frac{P}{\alpha_k (1 - \varepsilon_k) O_{\rho} \left( \frac{10^{0.45 t_{1}}}{\phi \cdot 10^{0.45 t_{1}}} \right)} \]  

Conclusion

As follows from the solution (18), the value of the drying rate average for the drying chamber at a constant drying rate, with other things being equal, is directly proportional to the drying agent speed in the section of the drying chamber that is free from the layer of dried products · ✯ and the ratio of the diameter of the elements of the dried products in the dense layer \( (d_m) \) and inversely proportional to the height of the layer of the dried products in the drying chamber \( (H_m) \).

It also follows from the solution (18) that for constant \( v \), \( t_{pr} \), \( t_{m} \), \( d_m \), and \( H_m \), the value \( \bar{\gamma}_{\text{pr}} \) depends on the ratio \( \beta / \alpha_k \) and the depravity of the layer of dried products \( (\varepsilon_k) \).

References

1. (2005) Combined solar-fuel drying plants, Tashkent. FAN.

2. (2010) Increase of efficiency of two-chamber drying plants with the regime of power regulation of the heat source. Hiotechnologies. - №4, pp. 30-33.

3. Iskandarov ZS, Halimov AS (2014) Numerical calculation of the useful capacity obtained from regenerating an exhaust drying agent in a solar-fuel drying installation. J Applied Solar Energy 50(3): 138-142.

4. Norkulova KT, Halimov AS, Safarov JE (2016) Thermal efficiency of a combined cradle-conveyor type of solar-fuel drying installation. Journal of the Technical University of Gabrovo 53: 6-8.
How to cite this article: Iskandarov Z, Norkulova K, Abdieva G, Jumaev B, Jasur S. Determination of the Speed of Convective Drying of Products at the Adjustment Power of the Heater Source in the Cradle-Conveyor Drying Equipment. Agri Res & Tech: Open Access J. 2017; 8(5): 555747.

This work is licensed under Creative Commons Attribution 4.0 License
DOI: 10.19080/ARTOAJ.2017.08.555747

Your next submission with Juniper Publishers will reach you the below assets

- Quality Editorial service
- Swift Peer Review
- Reprints availability
- E-prints Service
- Manuscript Podcast for convenient understanding
- Global attainment for your research
- Manuscript accessibility in different formats (Pdf, E-pub, Full Text, Audio)
- Unceasing customer service

Track the below URL for one-step submission
https://juniperpublishers.com/online-submission.php