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Determination of the Quantity of Paddy in the Dryer Drum

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ANNOTATION

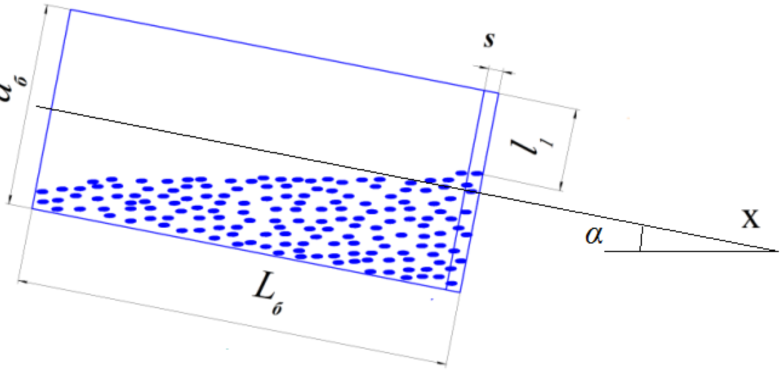
This article provides information on the scheme for determining the amount of paddy (brown rice) in the drum of a mobile paddy dryer, which can be used to calculate the mass, taking into account the volume and density of the paddy mound in the tumble dryer, as well as to design a new design of the tumble dryer in order to increase efficiency of the proposed device.

KEY WORDS: *paddy, drying drum, polymeric material, drying agent.*

Studies have been carried out to develop a mobile paddy dryer [1,2,3]. As a result of the research, a mobile dryer for a paddy was developed, in which one of the main working bodies is a drying drum [4] and its technical parameters were substantiated [5]. In the drying drum, a heat-insulating polymeric material was used [7]. Drying the paddy in the drum is carried out with hot air (drying agent) (Fig. 1).

1- dryer drum; 2 screw conveyor; 3-trailer. Figure 1. Mobile paddy dryer.

The complete placement of the paddy mound inside the dryer drum is impractical, since this condition limits the movement of the drying agent inside the drum, which leads to a decrease in drying efficiency. Therefore, to ensure the movement of the drying agent inside the drum, we fill the mound of the paddy by about 1/3 of the drum volume. The layout of the paddy mound in the dryer drum is shown in Figure 2.



α- angle of inclination of the dryer drum to the horizon; $L_б$ – dryer length; $d_б$ – dryer diameter; *s* – tumble dryer slot width.

Figure 2. Scheme of the location of the paddy mound in the dryer drum.

If the bulk of the paddy occupies 1/3 of the dryer drum, then to determine the mass of the paddy in the dryer drum, you can use the scheme shown in Figure 2. Let's take the distance $l_1 \approx 5s$ depending on the width of the adjustable slot of the dryer drum s of the dryer drum (Fig. 2). Depending on these dimensions, we determine the volume occupied by the paddy mound in the drying drum according to the scheme shown in Figure 3.

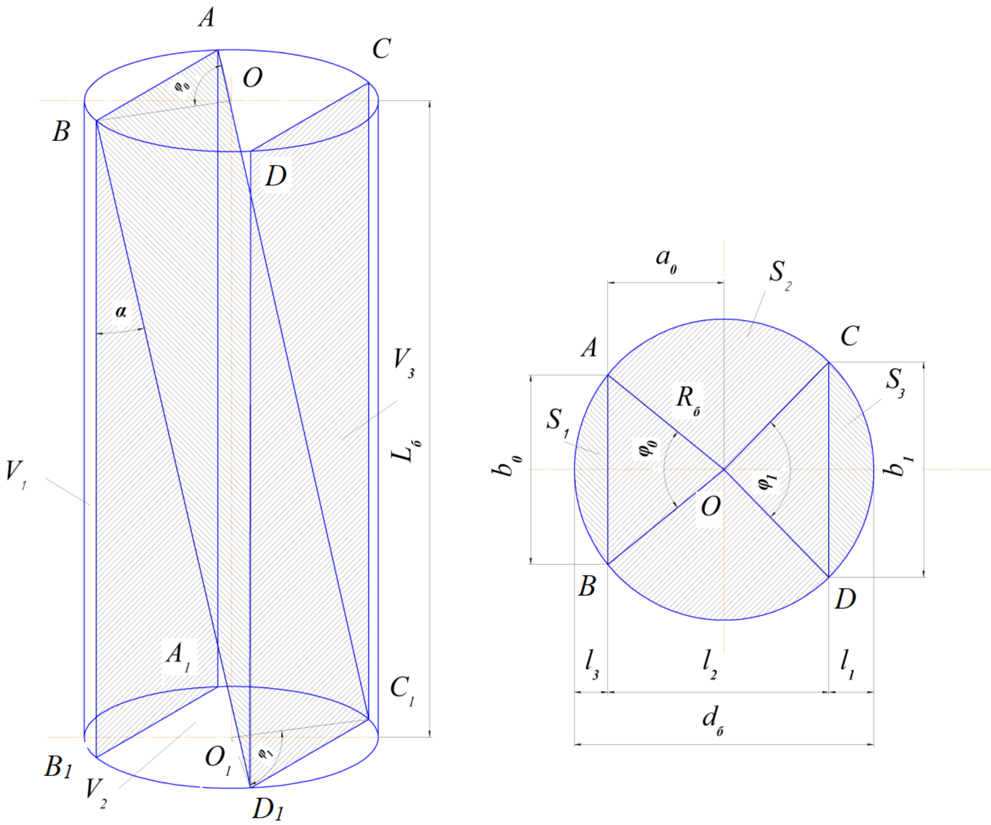


Figure 3. Scheme for determining the volume of the paddy mound in the dryer drum.

According to the scheme for determining the volume of the paddy mound in the dryer drum, the area S_1 is equal to

$$S_1 = S_{c1} - S_{\Delta 1} = \frac{\varphi_0}{2\pi}\pi R_б^2 - R_б^2 \frac{Sin\varphi_0}{2} = \frac{R_б^2}{2}(\varphi_0 - Sin\varphi_0), \quad (1)$$

where, S_{c1} – arc sector surface area АБ, m^2; $S_{\Delta 1}$ – triangle surface OAB, m^2; $R_б$ – drum radius, m. Surface S_3 looks like this

$$S_3 = S_{c3} - S_{\Delta 3} = \frac{\varphi_1}{2\pi}\pi R_б^2 - R_б^2 \frac{Sin\varphi_1}{2} = \frac{R_б^2}{2}(\varphi_1 - Sin\varphi_1), \quad (2)$$

where, S_{c3} – arc sector surface CD, m^2; $S_{\Delta 3}$– triangle surface OCD, m^2.

The surface area S_2 of the rectangle ABDC is as follows:

$$S_2 = \pi R_б^2 - (S_1 + S_3) = \pi R_б^2 - \frac{R_б^2}{2}(\varphi_0 + \varphi_1 - (Sin\varphi_0 + Sin\varphi_1)). \quad (3)$$

The total volume of the dryer drum is as follows

$$V = V_1 + V_2 + V_3, \quad (4)$$

where, V_1 – the volume of the shape by the basis of the arc segment AB, m^2; V_2 – volume according to shape ABCD, m^3; V_3 – the volume of the shape by the basis of the arc segment CD, m^3.

According to the scheme for determining the volume of the paddy mound in the drying drum (Fig. 3), the following ratio can be written:

$$V_1 = \frac{R_б^2}{2}(\varphi_0 - Sin\varphi_0)L_б, \quad (5)$$

$$V_3 = \frac{R_б^2}{2}(\varphi_1 - Sin\varphi_1)L_б, \quad (6)$$

$$V_2 = \left[\pi R_б^2 - \frac{R_б^2}{2}(\varphi_0 + \varphi_1 - (Sin\varphi_0 + Sin\varphi_1))\right]L_б. \quad (7)$$

In this case, the volume of the paddy mound in the dryer drum can be found as follows:

$$V_д = V_1 + \frac{V_2}{2} = \frac{R_б^2}{2}(\frac{\varphi_0}{2} - \frac{Sin\varphi_0}{2} - \frac{\varphi_1}{2} + \frac{Sin\varphi_1}{2} + \pi)L_б. \quad (8)$$

For calculations by formula (8) according to Figure 3, the following relationship can be used:

$$Sin\frac{\varphi_0}{2} = \frac{b_0}{2R_б}, \; Sin\frac{\varphi_1}{2} = \frac{b_1}{2R_б}, \; Sin\varphi_0 = 2Sin\frac{\varphi_0}{2}\sqrt{1 - Sin^2\frac{\varphi_0}{2}}, \; Sin\varphi_1 = 2Sin\frac{\varphi_1}{2}\sqrt{1 - Sin^2\frac{\varphi_1}{2}},$$

$$l_2 = L_б tg\alpha, \; l_3 = 2R_б - (l_1 + l_2), \; a_0 = R_б - l_3 = l_1 + l_2 - R_б,$$

$$b_0 = 2\sqrt{R_б^2 - a_0^2} = 2\sqrt{R_б^2 - (l_1 + l_2 - R_б)^2}, \quad b_1 = 2\sqrt{R_б^2 - (R_б - l_1)^2}. \quad (9)$$

If we take into account that the length $L_б$ = 2 m, the radius of the dryer $R_б$ = 0,44 m and the angle of inclination of the dryer to the horizon α = 20^0, then the following values can be given:

$$l_2 = L_б tg\alpha = 0{,}728 \;, \quad l_3 = 2R_б - (l_1 + l_2) \;, \quad a_0 = R_б - l_3 = l_1 + l_2 - R_б = 0{,}413 \text{ m.}$$

$$b_0 = 2\sqrt{R_б^2 - a_0^2} = 2\sqrt{R_б^2 - (l_1 + l_2 - R_б)^2} = 2\sqrt{(0,44)^2 - (0,413)^2} = 2\sqrt{0,364} = 2\cdot 0,603 = 1,206m$$

$$b_1 = 2\sqrt{R_б^2 - (R_б - l_1)^2} = 2\sqrt{(0,44)^2 - (0,44 - 0,125)^2} = 2\sqrt{0,094} = 2\cdot 0.306 = 0,612 \text{ m.}$$

$$Sin\frac{\varphi_0}{2} = \frac{0,728}{2\cdot 0,44} = 0,827 \quad , \qquad Sin\frac{\varphi_1}{2} = \frac{0,612}{2\cdot 0,44} = 0,695 \quad ,$$

$$Sin\varphi_0 = 2Sin\frac{\varphi_0}{2}\sqrt{1 - Sin^2\frac{\varphi_0}{2}} = 2\cdot 0,827\sqrt{1-(0,827)^2} = 2\cdot 0,827\cdot\sqrt{0,316} = 0,929 \quad ,$$

$$\varphi_0 = \arcsin 0,929 = 68^0 \quad , \quad Sin\varphi_1 = 2Sin\frac{\varphi_1}{2}\sqrt{1 - Sin^2\frac{\varphi_1}{2}} = 2\cdot 0,695\sqrt{1-(0,695)^2} = 0,999 \quad ,$$

$$\varphi_1 = \arcsin 0,999 = 87 \quad , \quad \varphi_0 = 68^0\frac{\pi}{180^0} = 1,19rad \quad , \qquad \varphi_1 = 87^0\frac{\pi}{180^0} = 1,52rad.$$

In view of the foregoing, the volume of the paddy mound in the dryer drum according to the formula (8) is equal to

$$V_д = 0,291m^3$$

In this case, the mass of the paddy mound in the drying drum is equal to

$$m = \rho V_д = 426\cdot 0,291 = 123,9\,kg$$

where, ρ – paddy mound density, kg/m^3 [5].

Conclusions

- according to the scheme for determining the volume of the paddy mound in the dryer drum its mass was calculated taking into account the volume and density of the paddy's embankment;
- The scheme can be used to design a new drying drum to improve the efficiency of the proposed device.

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