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The Modernization of the Front Part of Raw Cotton Drying Drum

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ABSTRACT: The article is about the results of an analytical research of the raw cotton movement on the surface of the blade of a drum dryer. The equation of motion of particles of raw cotton was obtained, numerical experimental studies were carried out, which allows determining the dependence of the particles movement of raw cotton of influencing factors.

KEY WORDS: drum dryer, raw cotton, moisture, raw cotton bat, drying agent of the drum dryer blade, friction force vector, upgraded part of the blade, friction coefficient.

I.INTRODUCTION

Nowadays, drum dryers are used for drying raw cotton, which have several shortages: in particular, insufficient heat and mass transfer rate, due to poor loosening and uneven distribution of raw cotton over the drum section.

II.SUBJECTS OF THE STUDY

They are drying drum 2SB-10 and SBO during drying process.

III.OBJECT OF THE STUDY

It is established that the signal raw cotton additional heat from the heated shell of the drum increases moisture collection.

IV. LITERATURE SURVEY

Improvements of the drum dryer are devoted to a number of works [1,2,3,4,5], as a result of which the main structural and technological parameters of the dryer are determined. In the drum dryer, heat transfer occurs in a convective way between the drying agent and the drum shell with conductive (contact).

Mathematical models of the convective heat exchange process between the drying agent and raw cotton have been developed. The regularities of changes in the temperature of raw cotton under various regime parameters of drying, which contributed to creating the best conditions for heat exchange and increasing the drying efficiency were determined.

However, an analysis of previous studies and the operation of drum dryer showed available reserves for increasing conductive heat exchange by additional heating of the drum shell.
It is known that the volumetric heat transfer coefficient, which takes into account the transfer of heat from warmer parts of the internal device and the drum shell to raw cotton is determined by the formula [6]

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$$\alpha_v''' = \frac{\alpha_\kappa''' * F_{r/c}(\mathrm{T}_{aver.drum} - \mathrm{T}_{aver.r/c})}{\Delta\mathrm{T}_{aver.}} kJ/(m^3 * h * grad)$$

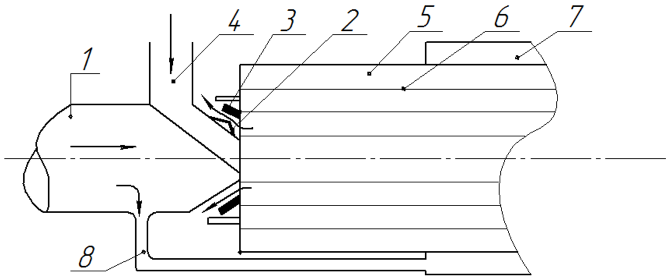
whereα_κ''' - is the heat transfer coefficient from the drum shell to the raw cotton located in the damarea and on the drum blades,$kJ/(m^3 * h * grad)$; $F_{r/c}$-,the surface of raw cotton referred to the unit o f drum volume in contact with the drum sidewall, m^2/m^3;$\mathrm{T}_{aver.drum}$,$\mathrm{T}_{aver.r/c}$– respectively, the average temperature of the drum and raw cotton shell ,^{0}C; $\Delta\mathrm{T}_{aver.}$ – the average temperature difference between the coolant and raw cotton,^{0}C.

As can be seen from the formula (1), the value of the coefficientα_v''' depends on the temperature difference $\Delta\mathrm{T}' = \mathrm{T}_{aver.drum} - \mathrm{T}_{aver.r/c}$and the surface of raw cotton $F_{r/c}$.

According to this, we [7] proposed a modernized dryer, where an increase in moisture removal is achieved by maintaining a high drying potential along the length of the drying drum, by sending additional heat to the raw cotton from the heated drum shell. To operate heating of the shell, the drum is wrapped around the insulating chamber which a drying agent is supplied from the heat generator.

V. THEORICAL RESEARCH

In the drum dryer, raw cotton is activated along the length of the drum due to the impact of the drying agent. Stable operation of the drying drum is ensured by supplying the drying agent in the volume from 15000 to 24000 m^3/h, depending on the performance of raw cotton. The supply of hot air in a volume below 15000 m^3/h leads to the accumulation of raw cotton at the beginning of the drum and the bottom, as well as the departure of the raw cotton through the gaps between the drum trunnion and the cone inlet of the drying agent (Fig. 1) above 24000 m^3/h to the ash particles of raw cotton through the exhaust pipes of exhaust air.



1 - hot air pipe; 2 - cone pipe input of the drying agent; 3 - drum trunnion; 4 - feeder; 5 - dryer; 6 - drum blades; 7 - air chamber; 8 - hot air transfer pipe
Fig 1: Diagram of the front of the dryer drum.

In the modernized dryer, hot air for heating the drum shell is supplied from the hot air pipe 1, as a result of which the drying agent of coming in front part of the drum decreases and there is an accumulation of raw cotton in the drum. The accumulation at the end of the drum prevents blowing hot air and the promotion of raw cotton along the drum, and this, in turn, significantly affects the quality of drying and stable operation of the drum. One of the most rational ways to solve this problem is to upgrade the location of the blade in the drum section.

We made bench top experimental studies to change the coordinates of the part of the blade. Tests have shown that if a part of the blade with a length of 1 m is located at a certain angle α, then the accumulation in the end part and the amount of mass output from the drum ceases.

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In the research [7], a technique was developed for determining the time and coordinates of the location of the drum at which the mass of raw cotton begins movements on the surface of the blade. The formulas are given that make it possible to establish the dependences of time and coordinates at which the masses begin and complete relative movements on the surface of the blade on the speed of rotation and the radius of the drum, as well as its own mass of raw cotton stones.
In this process, the masses of raw cotton should make relative movements along the length of the inclined part of the blade, and, reaching the horizontal part, along the width of the blade. We consider the task of setting the parameters of the rectilinear motion of the masses along the length of the modernized part of the blade.

Up to a certain point in time — until the moment of rotation of the considered section of the drum through the angle φ, the mass remains stationary relative to the surface of the blade — it performs only a rotational movement together with the drum. When the critical value of the angle γ is reached, the mass of raw cotton on the surface of the modernized part of the blade makes a complex movement - rotational with the drum and relative on the surface of the blade.

If the masses of raw cotton move only in the longitudinal direction - along the length L_b of the blade, then a part of the drum with a length $L_b \cdot cos\varphi$ will be less loaded - not very effective in terms of profitability and quality of drying. To prevent this, it is necessary that a portion of the raw cotton should move along and a portion across the length of the blade. In this case, the front part of the drum will be relatively less littered compared to the existing drum. Therefore, in theoretical models, it is necessary to take into account three possible movements — along or across the length of the blade, as well as curvilinear movements. Below we consider the parameters of the motion of those masses that perform rotational-transverse motion on the surface of the modernized part of the blade.

In this case, the mass of raw cotton will move along the circumference of the drum with the speed

$$v_{enc} = \omega_{drum} \cdot R_{drum} \quad (1)$$

whereω_{drum} иR_{drum} are the coal rotation speed and the radius of the drum cross-section (Fig 2).

When the drum rotates at a constant speed, the angle value φ increases according to a linear law.

$$\omega = \varphi . t \quad (2)$$

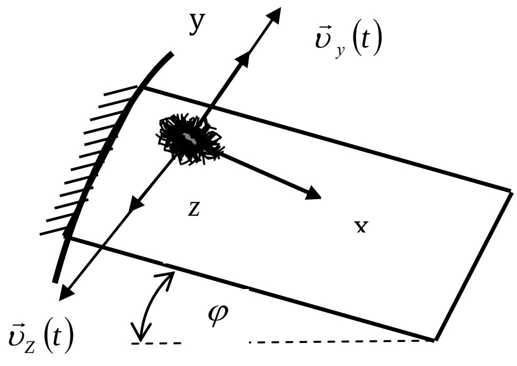

Fig 2. Action forces

The movement of mass on the vertical axis is variable - until the beginning of the slide will only move upward with speed

$$\dot{y_t} = v_{enc} . sin\varphi \quad (3)$$

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At the moment when the mass begins to slide at a speed $z_{slide}^{\cdot}$ over the surface of the upgraded part of the blade, the speed of mass lifting up along the y axis takes the following value

$$y_t^{\cdot} = v_{enc}.sin\varphi - z_{slide}^{\cdot} cos\theta$$

where θ is the angle formed between the vertical axis and the direction of the blade position at a given point in time (Fig 1).

The differential equation of mass slip along the z axis takes the following form (Fig 3)

$$mz^{\cdot\cdot} = mgsin\theta - F_z^{TP}. \quad (4)$$

The magnitude of the friction force is determined from the Culon's law

$$F_z^{Tp} = fN = fmgcos\theta. \quad (5)$$

The line action of the friction force vector is located on the surface of the blade and the friction force vector is directed perpendicular to the direction of the friction force vector.

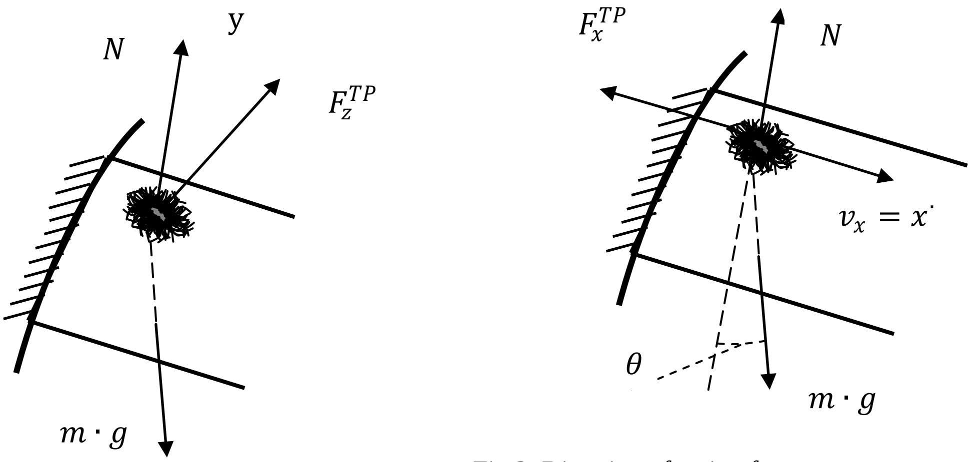

Fig 3. Direction of action forces

Substituting expression (5) into the differential equation (4), we obtain

$$z^{\cdot\cdot} = g(sin\theta - f\ cos\theta). \quad (6)$$

Integrating by t, we find

$$z^{\cdot} = g(sin\theta - fcos\theta)t + c. \quad (7)$$

Suppose that at the moment $(t < 0)$ of touching the surface of the upgraded part of the blade, the mass of raw cotton has a speed v_0. Therefore, the initial sliding velocity at $t = 0$ is

$$c = z^{\cdot}(0) = v_0\ sin\varphi.$$

Given the initial condition, the solution (8) is reduced to the form

$$z^{\cdot}(t) = g(sin\theta - fcos\theta)t + v_0 sin\varphi. \quad (8)$$

We find the law of motion of mass. Integrating the differential equation (8) with respect to t, we get

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$$z(t) = g(sin\theta - fcos\theta)\cdot\frac{t^2}{2} + v_0 sin\varphi\cdot t + c_2. \quad (9)$$

At the initial moment of time, we have $z = 0$. Substituting this condition in (9), we get $C_2 = 0$. Substituting the last condition, the solution (10) is reduced to the final form

$$z(t) = g(sin\theta - fcos\theta)\cdot\frac{t^2}{2} + v_0 sin\varphi\cdot t \quad (10)$$

Solutions (8) and (10) make it possible to establish the dependences of the speed of movement and the movement of mass on the given values of the friction coefficient f, the angles θ and φ, the initial velocity v_0 and the time t.

The considered case of mass movement on the surface of the blade along the z axis may occur in cases where the mass is on the surface when the blade deviates at relatively large angles φ or the path to movement along the x axis turns out to be cluttered.

VI. NUMERICALRESULTS

Tables 1 and 2 show the dependences of the displacement $z(t)$ on time t and the friction coefficient f.

Table 1. Dependence of the displacement $z(t)$on time t andfriction coefficient f

t	$Z(t)$			
	$Vo = 0.05,\ \theta = 30^\circ,\ \varphi = 30^\circ$			
	$f = 0.1$	$f = 0.2$	$f = 0.3$	$f = 0.4$
0.10	0.0227	0.0185	0.0142	0.0100
0.20	0.0 860	0.0690	0.0520	0.0350
0.30	0.1898	0.1516	0.1134	0.0751
0.40	0.3342	0.2662	0.1982	0.1303
0.50	0.5191	0.4129	0.3066	0.2004
t	$Z(t)$			
	$Vo = 0.1,\ \theta = 30^\circ,\ \varphi = 30^\circ$			
	$f = 0.1$	$f = 0.2$	$f = 0.3$	$f = 0.4$
0.10	0.0252	0.0210	0.0167	0.0125
0.20	0.9105	0.0740	0.0570	0.0400
0.30	0.1973	0.1591	0.1209	0.8267
0.40	0.3442	0.2762	0.2082	0.1403
0.50	0.5316	0.4254	0.3191	0.2129

Table 2. Dependence of the displacement $z(t)$ on time t andfriction coefficient f

t	$Z(t)$			
	$Vo = 0.1,\ \theta = 50^\circ,\ \varphi = 30^\circ$			
	$f = 0.1$	$f = 0.2$	$f = 0.3$	$f = 0.4$
0.10	0.0394	0.0362	0.0330	0.0299
0.20	0.1476	0.1350	0.1223	0.1097
0.30	0.3246	0.2962	0.2678	0.2394
0.40	0.5704	0.5200	0.4695	0.4190
0.50	0.8851	0.8062	0.7274	0.6485
t	$Z(t)$			
	$Vo = 0.1,\ \theta = 50^\circ,\ \varphi = 40^\circ$			
	$f = 0.1$	$f = 0.2$	$f = 0.3$	$f = 0.4$
0.10	0.0408	0.0376	0.0345	0.0313

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0.20	0.1504	0.1378	0.1252	0.1126
0.30	0.3289	0.3005	0.2721	0.2437
0.40	0.5761	0.5257	0.4752	0.4247
0.50	0.8922	0.8134	0.7345	0.6556

VII.CONCLUSION

From the analysis of the results of numerical experimental studies, the following conclusions follow:

With an increase in the friction coefficient from 0.1 to 0.4, the displacement values of $z(t)$shortage more than twice. As the time$t$ increases, the displacement value increases.

The width of the modernized part of the blade is$L_b = 0.5\ m$. Moving $z(t)$ distance $L_b = 0.5\ m$ reaches only at $f = 0.1$and $0.5 > t > 0.45$, in all other cases considered in table 1, the mass of raw cotton, the center of which touches the inner surface of the drum, reaches the edge of the blade only in the case of $f = 0.1$, in all cases it does not. An increase in the value of the initial velocity Vo leads to an increase in the value of the displacement $z(t)$.

The mass of raw cotton, which center is located in the middle of the distance $L_b = 0.5\ m$ wide, reaches the edge of the blade in cases of friction coefficient values, except in the case of $f = 0.4$.

The results of numerical experimental studies presented in table 2 were obtained for $\varphi = 30^{\circ}$and $\varphi = 40^{\circ}$, all the other calculation data are completely the same. It is seen that increasing the value of the angle φ - the slope of the modernized part of the blade leads to a relative increase in the value of the displacement$z(t)$.

The data presented in Tables 1 and 2 were obtained for $\theta = 30^{\circ}$and $\theta = 50^{\circ}$, all other calculation data are the same. Comparing the data of these tables, we observe that increasing the angle θ, the rotation of the drum at which the raw cotton mass glides along the width of the modernized part of the blade, leads to a significant increase in the displacement value $z(t)$. At $f = 0.4$, this increase is more than three times.

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