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Research Article

INTERACTION OF RAW COTTON WITH INTERNAL STRUCTURAL ELEMENTS OF DRUM DRYERS

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ABSTRACT

This research focuses on the study of the interaction between raw cotton and the internal structural elements of drum dryers. A system of equations is presented to analyze the equilibrium of raw cotton clouds on the surface of the blades and the annular layer, determining the conditions for clod sliding or rolling. The conditions necessary for the formation of an annular layer of raw cotton inside the dryer are established. The mechanism of twisting of fibrous bonds during the rolling of excess raw cotton along the annular stand inside the dryer is examined. Examples of the calculation of fibrous bond twisting between cotton balls are provided, and recommendations are developed to mitigate ignition risks in drum dryers.

KEYWORDS

The annular layer, determining the conditions for clod sliding or rolling.

INTRODUCTION

The most advanced in terms of design are dryers of the SBO, SBT and MS brands, designed for drying both medium-fiber and long fibrous varieties of raw cotton [1]. On fig. 1 shows: a - a diagram of a transverse and b - a longitudinal section of drum dryers. Here: 1 is the body of the dryer, 2 is the shell of the drum, 3 is the blades, 4 is the layer of raw cotton on the shell and on the blades, 5 is the trajectory of the fall of lumps of raw cotton from the blades, 6 is the trajectory of the movement of raw cotton along the axis of the drum, 7 - a device for supplying wet raw cotton into the interior of the dryer chamber, 8 - an output device. The most characteristic sections of the trajectory of raw cotton movement are located in the drum chamber. On fig. 3a shows an exemplary fan of trajectories for the fall of clumps of raw cotton from the blades. Raw cotton begins to fall when the angle of inclination of the blades reaches its critical value - the angle of friction.

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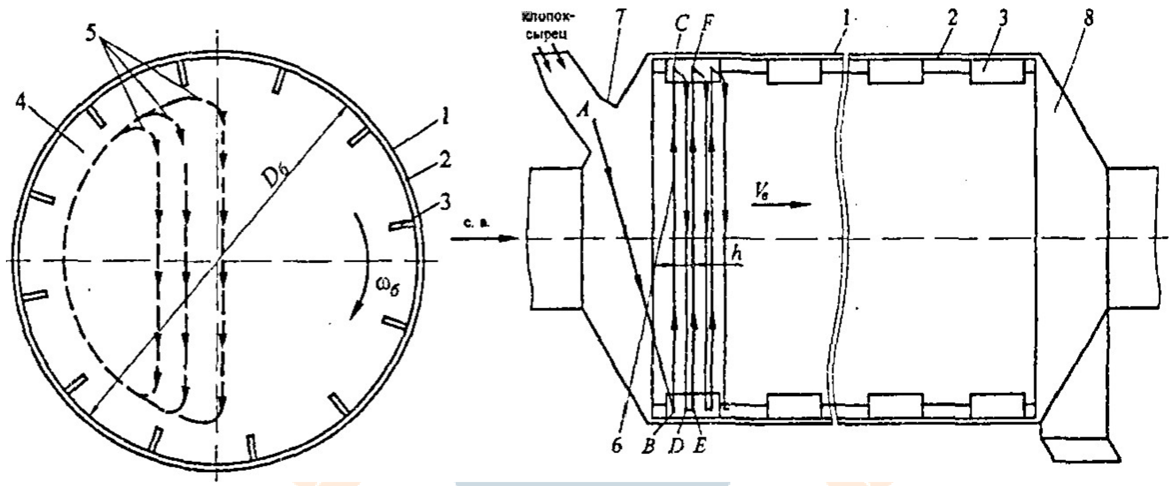
With the vertical position of the blade, all the raw material will be thrown down, i.e. the rise of cotton by the blades lasts no more than half a revolution of the drum. On fig. 1b is marked: AB is the section of the trajectory when loading raw cotton, BC is the rise of raw cotton on the blades and the shell of the drum, SD is the section of the trajectory of the fall of lumps of raw cotton. Then the cycle is repeated.



a b

Figure 1. Cross (a) and longitudinal (b) sections of the dryer

The relationship between the kinematic parameters of the rotation of the drum and the time of the cycle of movement of raw cotton inside the dryer has been determined.

Taking into account the cycle time, the residence time of raw cotton inside the dryer with a known technological length of the drum, the amount of movement in one cycle can be determined [2,3]

$$h = \frac{L_0}{Z} = \frac{T_Ц L_0}{T_0} = \frac{L_0\left(\frac{60}{2n} + \sqrt{\frac{2h_1}{g}}\right)}{T_0}. \quad (1)$$

where T0 is the residence time of raw cotton inside the dryer; Lc is the length of the dryer drum; Tch - cycle time; D - the height of the fall of raw cotton from the blades; Z is the number of cycles; n is the number of revolutions of the drying drum.

The analysis shows that in the existing drum dryers, both the technological volume (about 50%) and the heat carrier are inefficiently used (half of the hot heat carrier passes bypassing the flow of raw cotton). This is one of the main disadvantages of existing drum dryers for raw cotton.

MATERIALS AND METHODS

To increase the efficiency of cotton dryers, we have developed a number of technical solutions, the most important of which is a dryer drum with separating nozzles [4] Fig.2.

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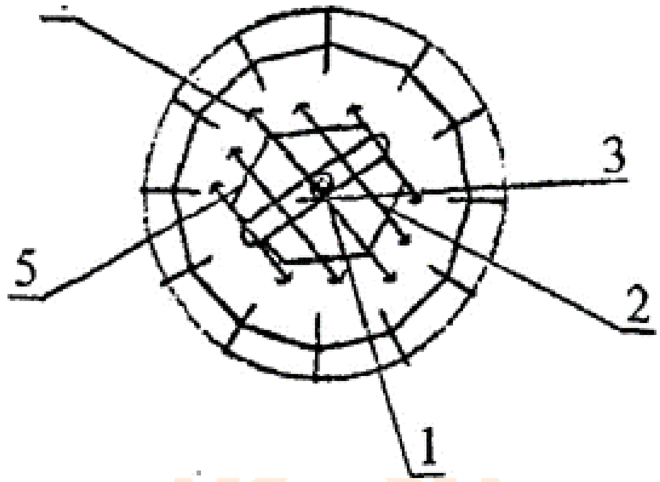

Figure 2. Tumble dryer with separating nozzles

Another development [5] is a dryer with a mesh separating drum (Fig. 3). The proposed device consists of a body 1, a cylindrical drum 2, blades 3. A small mesh drum 4 is installed inside the main dryer drum with blades 5 attached to the outer part. The remaining components and mechanisms of the proposed device are similar to other dryers for raw cotton. The main part of the hot air (coolant) passes in the annular gap between the drums, and part of it (approximately 30 - 40%) is fed through the small mesh drum.

The use of the proposed device in dryer drums eliminates the known disadvantages of dryers, the effectively used volume of the main drum chamber increases and the heat carrier is used more efficiently.

Our most efficient and cost-effective development is the use of special blades on the main dryer drum.

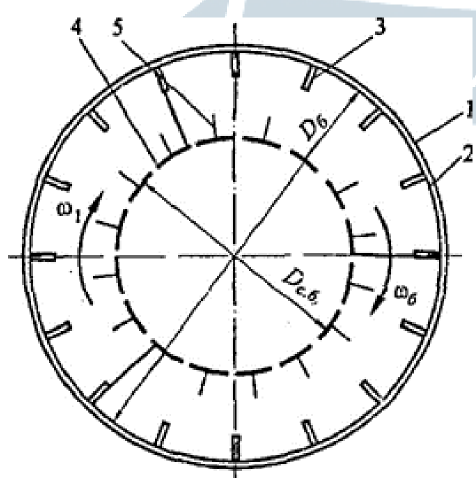

Figure. 3. Dryer for raw cotton with mesh

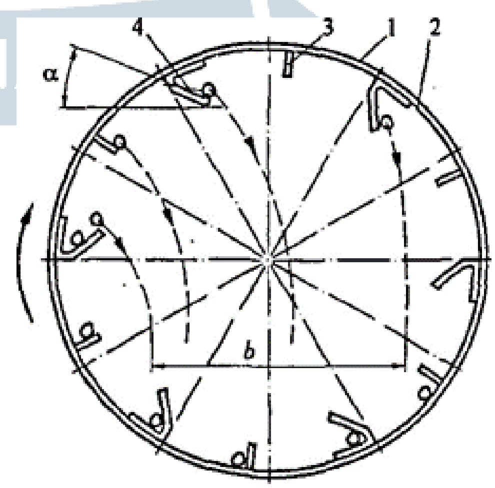

Figure. 2. Drying unit with curved separating drum blades

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The cross section of the drum with new blades is shown in fig. 3. Drum 2 is placed in housing I, on the shell of which ordinary straight blades 3 and special curvilinear blades 4 alternating with them are fixed. close to the vertical axis of the drum.

Such a design of the drum provides a wide fan of the flight paths of raw cotton particles after dropping from the blades (the value of b can reach the entire width of the drum section). Straight blades will drop the raw cotton on the left side of the drum chamber volume, and curved blades closer to the middle and on the right side.

To substantiate the main parameters of new developments, the following tasks were solved in the work, namely:

– the issues of the movement of raw cotton along the working surface of the blades were considered and the relative speed of the particles leaving the blades was determined;

— found the parameters of the trajectory of the particles after leaving the blades; the conditions for the movement of particles on the surface of additional mesh nozzles are determined.

The proposed new technical solutions and the developed method for calculating the main parameters of new devices for improving the design of drum dryers will reduce the volume of the falling lump of raw cotton, increase the specific area of the heat-receiving surface of the material, maximize the use of the volume of the drum chamber and the drying agent, increase the moisture extraction of the dryer and preserve the natural properties of the fibers and seeds.

Some of the harmful defects that occur during the production of cotton fiber are soft defects (flagellums, nodules, neps), as well as tap:e like skin with fiber (the result of seed damage during cleaning and ginning) and the content of litter in the fiber.

RESULTS AND DISCUSSIONS

The paper considers the theoretical foundations for the formation of the ignition of raw cotton particles during its processing in drum cotton dryers, for example, in 2SB-10. Experience in the operation of cotton dryers of the 2SB-10 type shows that when processing raw cotton with high humidity (at W = 25% or more during the first drying and at 17–20 At the exit from the dryers, the appearance of raised cotton and whole bundles in the form of ropes is possible.

An analysis of the interaction of the working elements of dryers with cotton allows us to distinguish two main transitions where lumps or particles of cotton can be subject to twisting - this is when they move along the surface of the blades and when excess cotton moves along the inner surface of the annular layer of raw cotton formed during the rotation of the drum.

To determine the conditions for the twisting of fibrous bonds that exist between lumps during their rolling, the scheme shown in Fig. 1 is considered. 7. Two lumps 4 and 5 are modeled here, having a fibrous bond 6 between them and rolling down along the annular layer 3. An annular layer of raw cotton is formed when the drum I rotates between the blades 2.

In order to show how the fibrous bond will twist between lumps having different radii r1 and r2, we found the dependence of the angle θ of an arbitrary lump with radius r1 moving down the annular layer from the top position to the bottom

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$$\varphi_{K_i} = \frac{(\varphi_K + \varphi_6)R_1}{r_i}, \quad (2)$$

where (φk is the total angle of rotation of the i-th lump when moving it down;

- the critical angle of rotation of the drum during the lifting of the lump, at which it began to move down; is the angle of rotation of the drum during the movement of the lump, = ωt , where t is the travel time.

4. Conclusion

Analyzing expression (2), one can see that depending on r, a wide range of values is possible. Even with a slight difference in the radii of the lumps, a large difference is possible in the angles of their rotation, and hence in the twisting fibrous connection between them.

On figure. 5 shows a graph of the dependence of the angle of rotation of the lump when rolling down the rotating drum depending on its radius. The calculations were carried out at φk = 600, r1 =1.5m = 1500 mm. The graph was built without taking into account the angle φb.

As can be seen from the graph, even small differences in the difference r1 can lead to different angles of rotation of the lumps and, as a result, to the ignition of fibrous bonds.

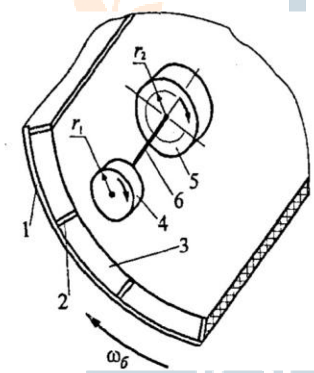

Figure. 4. Simulation scheme of two lumps,

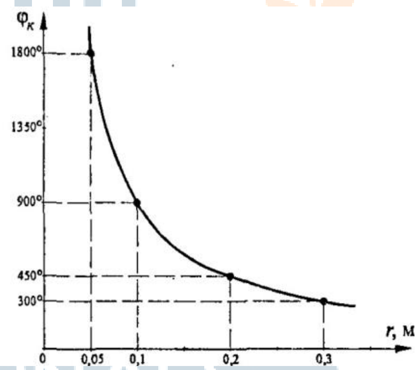

Figure.5. Graph of the dependence of the angle of rotation having a fibrous bond and a lump of raw cotton when rolling down in rolling down the annular layer depending on its radius

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