Determining the dynamics of the drying agent in the drying chamber

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Abstract: This article presents the results of determining the amount of heat and mass exchange in the cotton drying process, the dynamics of the movement of the cotton mass, and the movement of the drying agent in the dryer chamber.

Keywords: cotton processing, raw cotton, drying drum, drop zone, brake grid, air speed, air movement

Introduction. Improving the quality of textile products has always been an urgent production task. Instead, the quality of the product depends and is determined by the technological processes of raw cotton processing and the equipment used in the various processes.

Currently, many cotton processing enterprises mainly use dryers of the 2SB-10 and SBO brands to dry wet raw cotton. These dryers have a similar design with the exception of combining the drying and cleaning process (SBO), i.e. in the area of the cleaning section, the shell of the drying drum over a length of 3 m is made of perforated material with perforation dimensions (6 x 50) mm. The cleaning effect of the dryer on small debris is 35 - 40%. Drying of all types of raw cotton is mainly carried out on these dryers. At some cotton plants, the inclined auger from the feeder or the longitudinal gratings from the drum chamber have been removed from the dryers. All this is the experience of raw cotton processors, but does not have any scientific basis. Sometimes raw cotton is slaughtered in the feeder, and the movement of material inside the drum is hampered.

In drum dryers, the quality of drying raw cotton depends on the distribution of the velocity fields of the drying agent over the cross section of the drum. During one rotation of the drum, raw cotton is in a suspended state in the “Falling zone - in suspension” and in the “Zone of collapse and on the blades (laying)”. The “fall zone” in drum dryers is located above the drum axis, and the “collapse zone on the blades” is located below the axis. Therefore, to effectively use the drying agent flow, it must be directed above the drum axis, i.e. concentrate in the “Fall Zone - in suspension.”

In order to study the distribution of velocity fields of the drying agent in the drum, the drum was divided into vertical and horizontal axes and installed with a certain angle of inclination. The speed measurement points are located at the intersection of the vertical and horizontal axes. Vertical axes along the length of the dryer conditionally divide the drum into 10 even parts, which corresponds to the distance between the transverse rings equal to 1 m. The horizontal axes of the “Dropping Zone” pass above the axis of the drum, and the horizontal axis of the “Tracking Zone” passes below the axis of the drum[1].

Results. Experimental studies were carried out as follows. The gate valve of the blower fan (smoke exhauster) was fixed in one of positions I, II and in these positions the speed of the drying agent at the entrance to the drum was respectively:

1) ϑ_{in} = 0,7÷0,8 m/s, (V=20000÷22000 m3/h) - for a basic SBO type dryer installed horizontally $\alpha = 0^{\circ}$;

2) ϑ_{in} = 1,0÷1,1 m/s, (V=28000÷30000 m3/h) - for a drying drum with a mixed heat treatment mode installed with an angle of inclination towards the load $\alpha = -1{,}5^{\circ}$.

After starting the drying drum, hot air is supplied and the drum runs idle for 20-30 minutes, after the thermal regime has been established, the supply of wet raw cotton begins. With a continuous supply of raw cotton for 15-20 minutes, a stationary operating mode of the dryer is established. When the drying unit operated at a steady state, the drum stopped and the supply of raw cotton and drying agent stopped.

All the results obtained in the research work were processed by mathematical programs, a regression equation was obtained, due to which graphs of the distribution of drying speed were obtained for the "Fall Zone" and "Ballage Zone and on the blades."

From the graphical analysis in Figure 2 it is clear that the distribution of the speed of the drying agent in the main drying drum of type 2SB-10 is α = 0, and in Figure 1 - when the cotton raw material is distributed along the length and cross-section of the drum of type 2SB-10. Dryer type SBO, in the "Stop Zone" (under the drum axis), the "displacement" of the drying agent leads to inefficient use of the coolant.

In drum dryers with a mixed heat treatment mode, such a distribution of the speed of the drying agent leads to efficient use of the coolant. This distribution of drying agent velocities in drum dryers with a mixed heat treatment mode leads to efficient use of the coolant. This is confirmed by the fact that the heating of raw cotton and the amount of moisture removal in a drum dryer with a mixed heat treatment mode are 20-25% higher than in dryers with a horizontal arrangement. A brake grid is mounted on a section of the drum length L = 3-9 m.

In the existing dryer type 2SB-10 at ϑin =0,7÷0,8 m/s; *H*, *h* - height of fall of raw cotton; D - drum diameter.

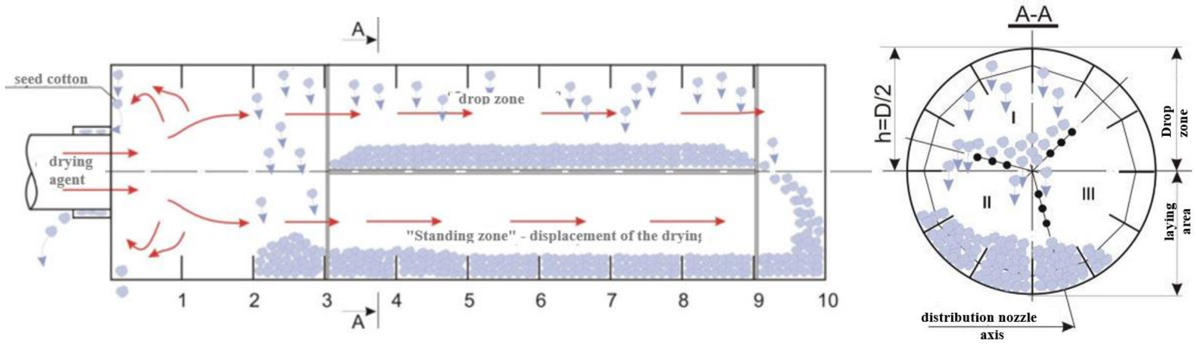


Fig.1. Distribution of raw cotton and drying agent along the length of the drum

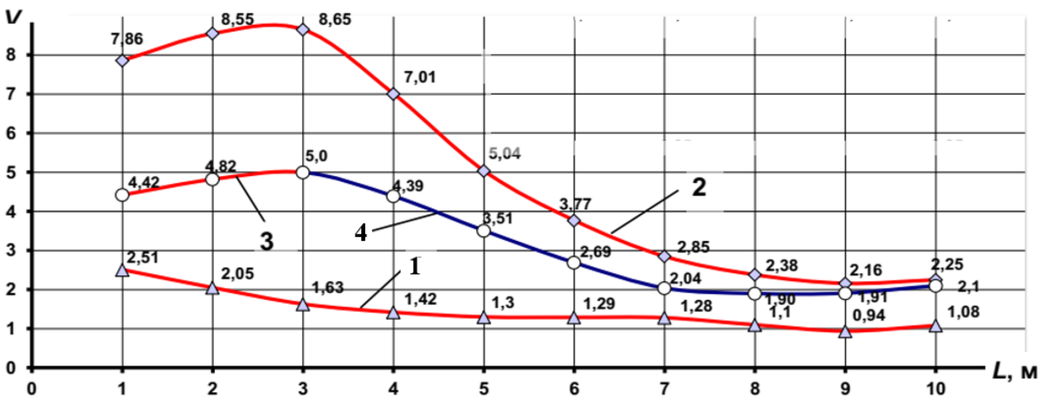


Fig.2. Distribution of the velocity fields of the drying agent in the "Fall Zone" and in the "Zone of Blockage and on the Blades" of raw cotton of the existing dryer type 2SB-10.

1, 2 - speed of the drying agent in the "Drop Zone"; 3 - speed of the drying agent in the "Fall Zone" (L=1-3 m); 4 - speed of the drying agent in the "blockage zone and on the blades" (L=3-10 m).

Intensification of the drying process and, accordingly, an increase in the productivity of the drum dryer for dried material, and a reduction in energy costs by 20-25% is ensured by installing the drum with an angle of inclination towards the load (α=1,5o; α=2o), and concentrating the drying agent in the "Drop Zone" of the dried material. This indicator can also be intensified by installing dampers on the dryer flue closer to the front axle of the drum with an external adjustable mechanism[2].

Researcher Kh. Ibragimov found the time of air release based on the size of the bababan.

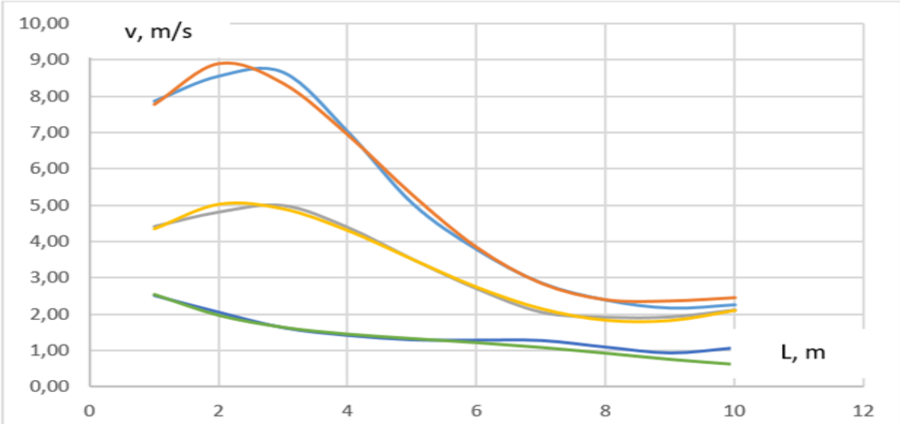


Fig.3. Diagram of air movement in a drying drum [2].

Based on this, the initial, average and final air velocities in the drying drum 2SB-10 were determined.

Table 1

Drum air speed

L	V_{L1}	V_{L2}	V_{L3}
1	7,86	4,42	2,51
2	8,55	4,82	2,05
3	8,65	5,00	1,63
4	7,01	4,39	1,42
5	5,04	3,51	1,30
6	3,77	2,69	1,29
7	2,85	2,04	1,28
8	2,38	1,90	1,10
9	2,16	1,91	0,94
10	2,25	2,10	1,08

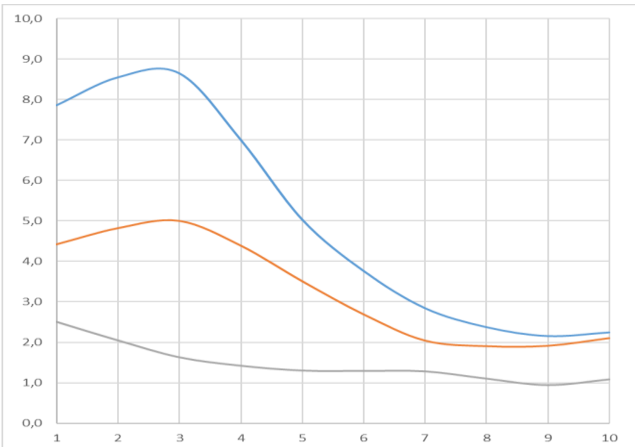


Fig.3. Graph of air speed in the drying drum according to Table 1.

$$t = \sum_i \Delta t_i \quad (1)$$

$$\Delta t_i = \frac{\Delta L_i}{\Delta v_i}, \Delta L_i = 1\ m, i = 1..10 \quad (2)$$

The parameters here are suitable for fairly small values.

In general, we use the following formula to find time:

$$\Delta t_i = \frac{v_{i+1}^2 + v_i^2}{2\Delta L_i} \quad (3)$$

Using (3) and table 1, we determine the time of air movement Δti along the drum and calculate t.

Table 2

Drum air movement time

Δt_i	t_1	t_2	t_3
Δt_1	0,12	0,22	0,44
Δt_2	0,12	0,20	0,54
Δt_3	0,13	0,21	0,66
Δt_4	0,17	0,25	0,74
Δt_5	0,23	0,32	0,77
Δt_6	0,30	0,42	0,78
Δt_7	0,38	0,51	0,84
Δt_8	0,44	0,52	0,98
Δt_9	0,45	0,50	0,99
Δt_{10}	0,44	0,48	1,00
t	2,78	3,64	7,73

Using Table 2, we form L1(t), that is, a table of air movement values over time.

Table 3

t	$L_1(t)$	t	$L_2(t)$	t	$L_3(t)$
0,12	0,96	0,22	0,96	0,44	1,10
0,24	1,95	0,42	1,94	0,98	2,22
0,37	3,06	0,63	3,00	1,64	3,28
0,53	4,22	0,89	4,11	2,37	4,33
0,76	5,36	1,21	5,25	3,15	5,33
1,06	6,50	1,63	6,38	3,92	6,34
1,44	7,59	2,14	7,42	4,76	7,41
1,88	8,64	2,66	8,42	5,74	8,49
2,34	9,62	3,16	9,37	6,73	9,42
2,78	10,61	3,64	10,38	7,73	10,50

Using Table 3, we present a mathematical model of the law of air movement along the bababan in the form of a 3-level polynomial in the correlation method [3].

$$L_1(t) = 0,7t^3 - 4,1t^2 + 9,9t - 0,1 \quad (4)$$

$$L_2(t) = 0,2t^3 - 1,8t^2 + 6,5t - 0,4 \quad (5)$$

$$L_3(t) = -0,06t^2 + 1,7t + 0,5 \quad (6)$$

Using the obtained mathematical model and data from Table 3, we obtain graphs of air movement along the drum

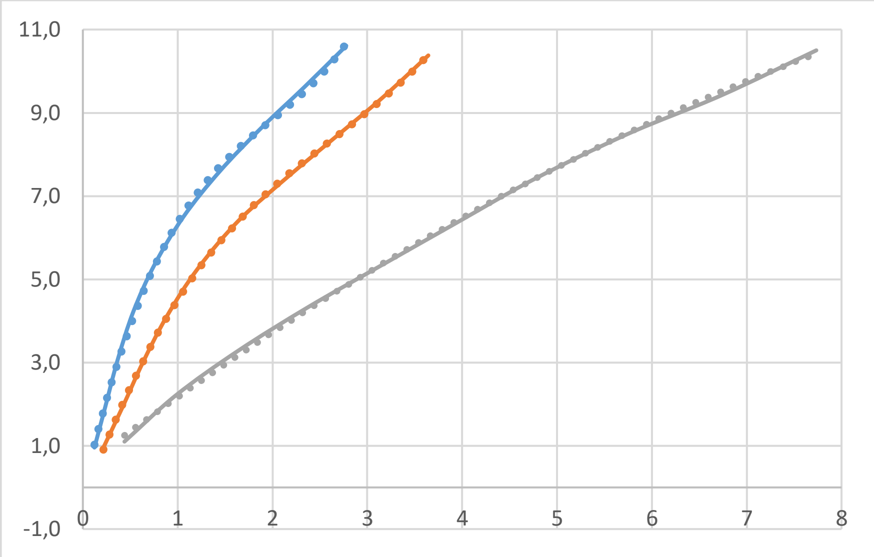


Fig.4. Graphs of air movement along the drum

According to the results, the air entering the dryer drum moves at different speeds due to collisions with cotton pieces, and the time taken to exit the drum varies. Time for air to leave the drum, taking into account collisions with pieces of cotton t=2.78; t=3.64; t=7.73 will correspond to the values.

The movement of the drying agent in the drum is a rather complex process, and not all situations can be controlled using the presented models. The process of a fire in a drum is characterized by a sharp increase in the concentration of carbon dioxide (CO) at the source of the fire. The resulting gas mixes with the air in the drum and begins to move with it and moves towards the outlet. This causes an increase in the concentration of carbon dioxide (CO) leaving the dryer drum. At this stage, by monitoring the gas concentration (CO), we will be able to recognize the danger of fire and take timely measures to eliminate it. The center of fire in the drum can be located at any point on the drum. Therefore, it is important to find the maximum time from the center of carbon dioxide (CO) concentration to the exit from the drying drum.

We know that the molecular weights of carbon dioxide (CO) and nitrogen (N2) are equal to each other, i.e. C12O16 12+16=28, N2=N14+N14=14+14=28, therefore, the drum volume and other elements of the movement of the drum dryer have been studied and tested. To do this, nitrogen was supplied to the car tire at a pressure of 210 kPa, and the nitrogen content in the tire was supplied to the input of the drying drum, that is, in the direction of the drying agent, for 8 seconds, and was measured using a gas analyzer GID400-N2 and the following result was obtained:

Table 4

Information about the amount and time of nitrogen entering the drum

t, seconds.	Complete process result	Result of the main process
0	78,0	78,0
1	79,1	79,1
2	81,2	81,2
3	81,3	81,0
4	81,3	80,0
5	81,4	79,1
6	81,0	78,5
7	80,0	78,1
8	79,1	78,0

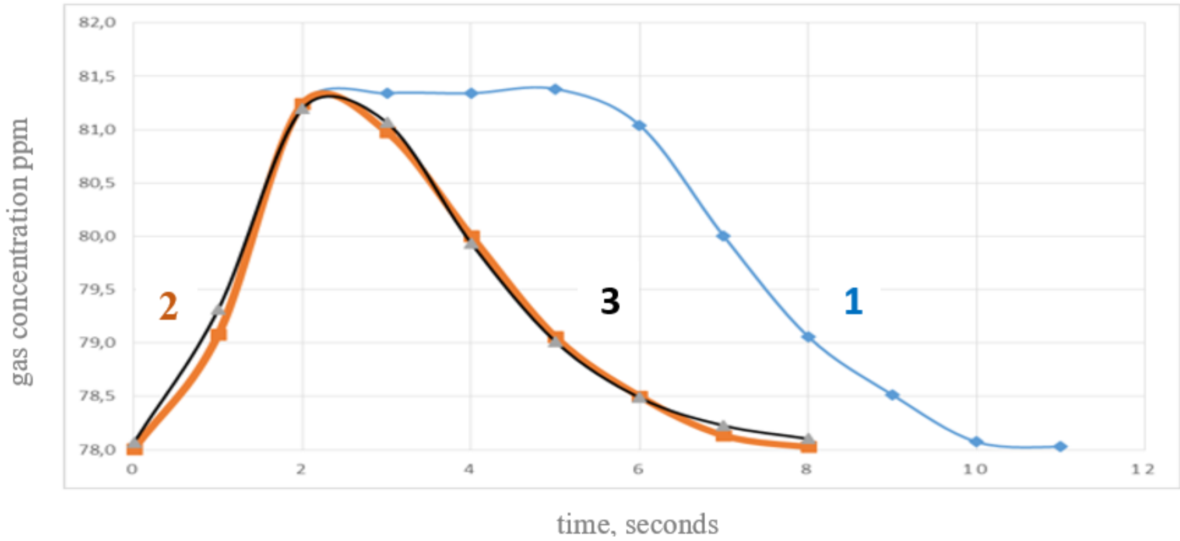
9	78,5	81,0
10	78,1	80,0
11	78,0	79,1

The "complete process result" shown in Table 4 is the nitrogen gas concentration in the drying drum as a function of the total time. The “result of the main process” is the time the gas leaves the drum[3].

Based on the data in Table 4, we obtain an empirical model of the main results of the process as follows:

$$C_{concentration} = 9.2e^{0.8(2.4-t)-e^{0.8(2.4-t)}} + 78 \quad (7)$$

We obtain graphs of the empirical model showing the entire process, the main process and the main process.



1-line complete process diagram; 2 - line main process graph;
3 - line of the empirical model.

Fig.5. Diagram of changes in the amount of nitrogen gas in the drum.

Graphs in Fig. 5 show that the empirical model we have chosen can adequately describe the main research process, thus, formula (7) allows us to call the process a mathematical model within the framework of the research.

Conclusion. From the obtained result we can conclude that since the molecular masses of the substances CO and N2 are equal, the dynamics of movement throughout the volume of the drum are the same. That is, part of the nitrogen gas (N2) leaves the drying drum in 10-3=7s. Mathematical processing of the experimental results shows a good correlation between the obtained regression equations and the obtained graphs.

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