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INVESTIGATION OF THE SLOPE ANGLE INFLUENCE ON A DRUM WITH A MIXED HEAT TREATMENT MODE ON THE DRYER PERFORMANCE

Abstract. The article presents the results of an experimental study on drying raw cotton. As a result of experimental and pilot industrial tests, the possibility of concentrating the drying agent in the "Drop zone" of raw cotton, leading to improve work efficiency of the drum dryer has been proven. A criterion equation for calculating the technological parameters of the raw cotton drying process in drum dryers with a mixed heat treatment regime has been obtained.

Within the process of studying the influence of the slope angle of the drum with a mixed heat treatment mode on the technological parameters of the drying process, the following was revealed, the rational slope angle drum towards loading is α=(-1)÷(-2°) at the speeds of the drying agent at the drum entrance is ϑ_{in}=1.98÷2.12 m/s. The same speed values, rational filling of the drum with material ensures optimal dryer performance.

Keywords: drum dryers; slope angle; speed, drying agent; productivity, stay period.

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Introduction. Agro-industrial complexes and farms face the difficult task of meeting the increasing demand of the population for high-quality agricultural products and minimizing losses of the harvest.An important factor consists not only in an increase of crop yields, but also their highly efficient heat treatment, required for creating conditions during their long-term storage.

Being an important and energy-intensive process – drying is one of the heat treatment types. Drum dryers are most widely used in cotton factories. These units are easy to maintain and they are reliable in operation.

With the growth of raw cotton production and the requirements for improving the quality of cotton products, mechanical engineering faces the task of continuously increasing the production of new progressive machines and aggregates for primary processing of cotton.

Today, increasing the quality of products produced by the cotton ginning industry, increasing labor productivity, reducing its cost, increasing the manufacturability of reliability and machines, at the same time, comprehensive mechanization and automation of the technological process of primary cotton processing require the creation of more and more modern technologies and equipment in this industry.

2SB-10 type drum dryers are installed in drying departments at cotton cleaning factories in Kazakhstan and other Central Asian countries [1]. After drying the raw cotton, the cotton seeds are separated from the fiber and sent to the nearest fat-and-oil plant and stored before processing to obtain vegetable oil.

In the production of primary processing of raw cotton, a special feature is the continuous operation of the technological process. When processing a material, which involves different equipment functions that are interconnected in terms of output performance [1].

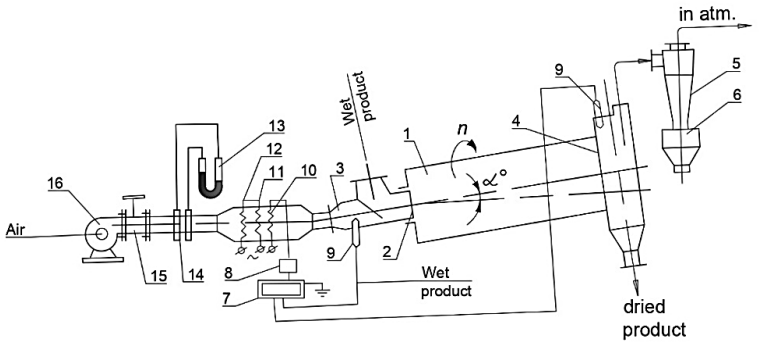
As a result of experimental and pilot industrial tests, the possibility of concentrating the drying agent in the "Drop zone" of raw cotton has been proven, leading to an improve in the efficiency of the drum dryer. A criterion equation for calculating the technological parameters of the drying process of raw cotton in drum dryers with a mixed heat treatment regime has been obtained [1].

Preliminary and innovative patents for inventions have been obtained for the device and methods of raw cotton drying [2,4,8,9].

As a result of modernization, drum dryers have become highly efficient and competitive with modern drying equipment, and even surpass it in ease of manufacture and maintenance. This paper presents the theoretical and practical results of many years of research [2-10].

Materials and methods. An experimental drying installation was developed and manufactured and experimental studies of the raw cotton drying process were carried out.

The drum is loaded with the test sample through the feeder *3* (Fig. 1), the air heated to the desired temperature in the electric heater of the drying drum (*10, 11, 12*). At the inlet of the drying drum, the air temperature is constantly maintained using the control elements (*7, 8, 9*). The control of the supplied air volume is carried out using a diaphragm and a pressure gauge *14, 15* – adjust the valve.



1 – heat carrier; 2 – loading; 3 – feeder; 4 – unloading; 5 – cyclone; 6 – bunker; 7 – potentiometer; 8 – relay; 9 – thermocouple; 10,11,12 – electric heater; 13 – differential pressure gauge; 14 – diaphragm; 15 – valve (damper); 16 – drying fan.

Fig. 1. Drying installation

From the unloading chamber the dried raw cotton is extracted *4*, and the treated particles from impurities and dust *5* are discharged to the outside.

The distinctive side of the proposed solution is that the drum dryer is installed with a slope towards the loading material. Also, the design of the drum has undergone a change. This in turn increased the productivity of the installation. An improved drum with an inclination towards loading the material makes it possible to increase the residence time of this material in the drying zone, as a result of which the process of heat treatment of raw cotton is improved [11]. The installation is automated and operates in both batch and continuous modes.

Research results. To determine the optimal values of the modernized drum dryer technological parameters experiments were carried out. The research methodology involved studying the influences of the following parameters in the drum dryer:

- influence of the slope angle of the unit (α^o) on the stay period of raw cotton in the drum when changing the speed of the heat carrier ϑ, m/s;

- the influence of the slope angle of the unit (α^o) on the performance of the drum when the speed of the heat carrier changes ϑ, m/s.

When determining the effect of the slope angle of the unit (α^o) on productivity, the stay period of the material (raw cotton) in the drum dryer was based on the production conditions for drying raw cotton in 2SB-10 drum dryer.

The studies were carried out at the following speeds of the heat carrier at the entrance to the drum: ϑin = 1.56 m/s (which corresponds to V = 22000 m^3/h, which corresponds to production conditions); ϑin = 1.70 m/s (V=24000 m^3/h); ϑin = 1.84 m/s (V=26000 m^3/h); ϑin = 1.98 m/s (V=28000 m^3/h); ϑin = 2.12 m/s (V=30000 m^3/h); ϑin = 2.26 m/s (V=32000 m^3/h) and the slope angle of the drum towards the loading side is $\alpha = 0^o$; -1°; -2°; -3°.

Before the start of the experiment, a given slope angle of the drum, rotation speed and coolant flow were established based on the pressure drop across the diaphragm. A stationary mode was established within 20 minutes, after which raw cotton was fed into the drum.

Samples of cotton raw material are taken in a stable state and the performance of the drum is measured (kg/s). During this period, loading of material does not stop. All parameters of the experimental device were selected, analyzed and recorded 3 times, and the obtained data were averaged.

After sampling is completed, feeding the raw cotton was stoped, all the raw cotton from the drum was placed into a special container, the residence time of the material in the drum was measured and determined by formula:

$$\tau_{cp} = \frac{G_a}{G} \quad (1)$$

where: τ_{av} – average residence time of the material in the drum, s; G – drum performance, kg/s; G_a – amount of material in the drum, kg [11].

The results of the experiments are summarized in Table 1. Based on the experimental data, graphs were constructed of the influence of the drum inclination angle (α^o) on the stay period of raw cotton in the drum (Fig. 2) and on the performance of the dryer depending on the speed of the drying agent (Fig. 3).

Table 1

Study of the influence of drum angle on stay period and performance of the drum dryer

No.	Drum slope angle, α°	Drum performance		Amount of material in the drum G_a, kg	Average stay period, τ_{cp}, c	Rotation number, n, rot/min
		kg/min	kg/s			
Θ_{in} = 1.6 m/s; Δh = 9.0 mm.water column						
I	0	0.66	0.011	1.50	133.2	10
	-1	0.51	0.0085	1.60	187.2	10
	-2	0.38	0.0063	1.72	271.8	10
	-3	0.28	0.0047	1.60	344.4	10
Θ_{in} = 1.70 m/s; Δh = 11.0 mm.water column						
II	0	0.67	0.0112	1.20	109.2	10
	-1	0.58	0.0097	1.70	174.6	10
	-2	0.46	0.0077	1.93	252.0	10
	-3	0.37	0.0062	2.0	330.0	10
Θ_{in} = 1.84 m/s; Δh = 13.0 mm.water column						
III	0	0.68	0.0113	1.03	91.2	10
	-1	0.64	0.0107	1.66	155.4	10
	-2	0.55	0.0092	2.20	240.0	10
	-3	0.43	0.0072	2.20	309.6	10
Θ_{in} = 1.98 m/s; Δh = 15.0 mm.water column						
IV	0	0.68	0.0113	0.92	81.6	10
	-1	0.68	0.0113	1.64	145.2	10
	-2	0.63	0.0105	2.43	231.0	10
	-3	0.58	0.0097	3.06	316.8	10
Θ_{in} = 2.12 m/s; Δh = 18.0 mm.water column						
V	0	0.68	0.0113	0.77	68.4	10
	-1	0.68	0.0113	1.62	143.4	10
	-2	0.68	0.0113	2.58	222.0	10
	-3	0.63	0.0105	3.22	306.0	10
Θ_{in} = 2.26 m/s; Δh = 20.0 mm.water column						
VI	0	0.68	0.0113	0.65	57.6	10
	-1	0.68	0.0113	1.46	129.0	10
	-2	0.68	0.0113	2.35	207.0	10
	-3	0.68	0.0113	3.20	282.0	10

Discussion. From the analysis of the graph (Fig. 3) of the influence of the drum slope angle on the performance of the drying unit depending on the speed of the heat carrier, it can be seen that with an increase in the slope angle towards the load, the productivity increases and, having reached the inclination angle α=(-1°) further decreases. The graph also shows that the rational slope angle of the drum towards the loading side is α=(-1)÷(-2°) at drying agent speeds ϑ=1.98÷2.12 m/s. At the same values, rational filling of the drum with material is ensured, which leads to efficient heat and mass transfer.

The experiments were carried out at the drum speed n=10 pot/m, because the design of the discharge blades of the 2SB-10 dryer at a drum rotation speed of n=10 rpm ensures stable operation of the dryer with rational filling of the drum (35%), when it contains up to 1500 kg of raw cotton [10].

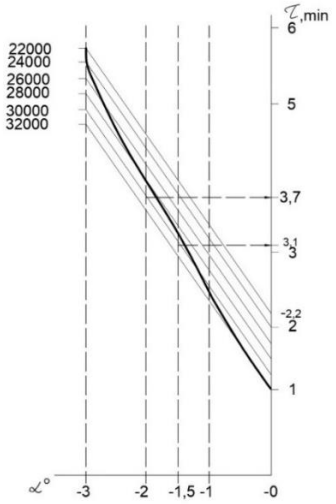


Fig. 2. The influence of the drum slope angle (α^o) on the stay period of raw cotton in the drum depending on the speed of the heat carrier

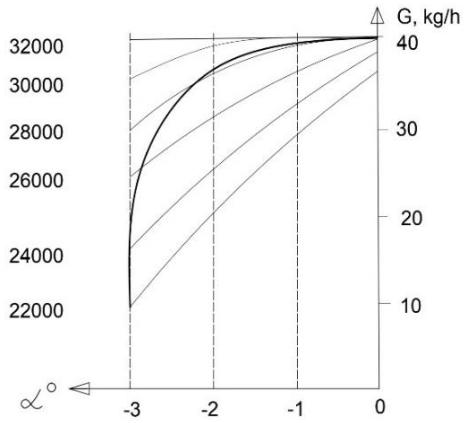


Fig. 3. The influence of the drum slope angle (α^o) on the performance of the drying drum depending on the speed of the heat carrier

Conclusion. In the process of studying the influence of the slope angle of the drum with a mixed mode of heat treatment on the technological parameters of the drying process, it was revealed that the rational slope angle of the drum towards the loading is $\alpha=(-1)\div(-2°)$ at the speed of the drying agent at the inlet into the drum $\vartheta in=1.98\div2.12$ m/s. At the same speed values, rational filling of the drum with material and optimal dryer performance are ensured.

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АРАЛАС ТЕРМИЯЛЫҚ ӨҢДЕУ РЕЖИМДІ (SB-CRT) БАРАБАННЫҢ КӨЛБЕУ БҰРЫШЫНЫҢ КЕПТІРГІШТІҢ ЖҰМЫСЫНА ӘСЕРІН ЗЕРТТЕУ

Аңдатпа. Мақалада шитті мақтаны кептіру бойынша тәжірибелік зерттеулердің нәтижелері берілген. Эксперименталды және тәжірибелік-өнеркәсіптік сынақтардың нәтижесінде кептіргіш агентті шитті мақтаның «тамшылау аймағында» шоғырландыру мүмкіндігі дәлелденді, бұл барабанды кептіргіштің тиімділігін арттыруға әкелді. Аралас термиялық өңдеу режимі (КБ-АТӨ) бар барабан қондырғыларында шитті мақтаны кептіру процесінің технологиялық параметрлерін есептеудің критериалды теңдеуі алынды. Аралас термиялық өңдеу режимі бар барабанның көлбеу бұрышының кептіру процесінің технологиялық параметрлеріне әсерін зерттеу барысында келесілер анықталды: барабанның көлбеу бұрышы α=(-1)÷(-2°) болғанда рационалды кептіру агентінің барабанға кіру жылдамдығы $\vartheta_{вх}$=1,98÷2,12 м/с жүктемеде болады. Осы жылдамдық мәндерінде барабанды материалмен ұтымды толтыру және кептіргіштің оңтайлы өнімділігі қамтамасыз етіледі.

Тірек сөздер: кептіру барабаны, көлбеу бұрышы, жылдамдық, кептіру агенті, өнімділік, тұру уақыты.

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ УГЛА НАКЛОНА БАРАБАНА СО СМЕШАННЫМ РЕЖИМОМ ТЕРМООБРАБОТКИ (СБ-СРТ) НА ПРОИЗВОДИТЕЛЬНОСТЬ СУШИЛКИ

Аннотация. В статье приведены результаты экспериментальных исследований по сушке хлопка сырца. В результате экспериментальных и опытно-промышленных испытаний доказана возможность сосредоточения сушильного агента в «зоне падения» хлопка-сырца, ведет к повышению эффективности барабанной сушилки. Получено критериальное уравнение расчета технологических параметров процесса сушки хлопка-сырца в барабанных агрегатах со смешанным режимом термообработки (СБ-СРТ). В процессе исследования влияния угла наклона барабана со смешанным режимом термообработки (СБ-СРТ) на технологические параметры процесса сушки выявлено, что рациональным углом наклона барабана в сторону загрузки является α=(-1)÷(-2°) при скоростях сушильного агента на входе в барабан $\vartheta_{вх}$=1,98÷2,12 м/с. При этих же значениях скорости обеспечивается рациональное заполнение барабана материалом и оптимальная производительность сушилки.

Ключевые слова: сушильный барабан, угол наклона, скорость, сушильный агент, производительность, время пребывания.