SOCIAL SCIENCE AND HUMANITIES

Manuscript info:
Received September 14, 2018., Accepted October 12, 2018., Published October 30, 2018.

CHOOSING THE OPTIMUM REGIME FOR DRYING RAW COTTON IN DRUM DRIER

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http://dx.doi.org/10.26739/2573-5616-2018-10-2-17

Abstract: The article presents the results of the research on the work of drum dryer for drying raw cotton. A mathematical model of moisture extraction is obtained depending on the productivity of the dryer, the initial moisture of the raw cotton, the temperature and the air flow, the optimization of which is a regime map for drying raw cotton in a drum dryer.

Keywords: raw cotton, drum dryer, initial humidity of raw cotton, drying productivity, coolant temperature, coolant expenditure, moisture extraction.

Recommended citation: Parpiev Azimjon, Kupalova Yulduz Ilkhomovna, Usmonov Alisher Kodirulovich. CHOOSING THE OPTIMUM REGIME FOR DRYING RAW COTTON IN DRUM DRIER. 9-10 American Journal of Research P. 172-179 (2018).

Introduction: Analysis of drying of raw cotton at cotton ginning plants shows that a drum dryer (in Uzbekistan, Kyrgyzstan, Kazakhstan, Tajikistan) and a tower drier with a different number of shelves (Continental Moss-Vordin, USA) are currently used for drying wet cotton.

An analysis of their work showed that in a tower dryer, due to the short drying time (4-6 seconds), the moisture pick-up from raw cotton is 1-2%, at a capacity of up to 10 t/h, and the drum dryer at such a productivity makes up to 3-7%, depending on the initial moisture content of the raw cotton.

It is known that due to the climatic conditions of harvested raw cotton has a moisture content of 6% to 22% and more percent. Therefore, the dryer for raw cotton should have a maximum moisture pick-up with its possible flexible control.

As a result of the research carried

out [1, 2, 3, 4] on improving the drum dryer, their main parameters, in particular its diameter, length and internal devices, operating mode, are determined.

It is known that for high-quality processing of raw cotton in the technological process, it should have a moisture content of no more than 8-9%.

The regime of drying raw cotton in a drum dryer, depending on the initial moisture content of the raw cotton, is changed to obtain the necessary moisture removal. The required moisture extraction in the drum dryer is $\Delta W = W_H - 8\%$ for I and II qualities of raw cotton, $\Delta W = W_H - 9\%$ for III-V qualities, and depends on the drum capacity for raw cotton - Pr, hot air consumption - Q and its temperature - t.

The analysis of scientific publications [4,5,6,7] on this issue showed the inadequacy of the information set for the operation of drum dryers with an effective mode of operation.

In this regard, in order to determine the rational drying regimes and reserves for increasing the efficiency of the process in the drum dryer, we have presented experimental studies.

Methods of research and their analysis: Experiments were carried out in production conditions on a 2SB-10 dryer using mathematical experiment planning.

The criterion of optimization was taken by the moisture removal of dryers , and as factors:

- Initial moisture content of raw cotton (Wn), % - x_1;
- the productivity of the dryer (Pr), tn / h - x_2;
" temperature of the coolant (t), 0C - x_3;
- Coolant flow rate (Q), m3/h - x_4.

Table 1 shows the levels of variation of factors.

Table 1

Factors and their levels of variation

№	*Levels of factors*	Factors			
		Initial moisture content of raw cotton,% x_1	Drying capacity, t/h x_2	Temperature of coolant, ^0C x_3	Coolant flow rate, m^3/h x_4
1	Upper level	24,4	10	250	25000
2	Lower level	14,4	4	120	15000
3	Zero level	19,4	7	185	20000
4	Interval of variation	5	3	65	5000

For each experiment was taken 3 tons of cotton. Samples for analysis for moisture were taken after 10 minutes after starting the supply of raw cotton, and then every 2 minutes.

The plan for carrying out the experiments and the size of the moisture extraction - y are given in Table. 2.

Table 2

Matrix of planning experiment

№ of experience	Factors				Criteria optimization	
	x_1	x_2	x_3	x_4	experimental y	calculated y_p
1	+	+	+	+	8,94	8,61
2	-	+	+	+	4,16	4,33
3	+	-	+	+	10,42	10,20
4	-	-	+	+	6,34	6,11
5	+	+	-	+	4,21	4,42
6	-	+	-	+	1,85	1,91
7	+	-	-	+	6,07	6,01
8	-	-	+	-	3,37	3,49
9	+	+	+	-	6,2	6,39
10	-	+	+	-	4,65	4,44
11	+	-	+	-	7,62	7,98
12	-	-	+	-	5,69	5,82
13	+	+	-	-	2,06	2,20
14	-	+	-	-	2,08	1,80
15	+	-	-	-	4,09	3,79
16	-	-	-	-	3,15	3,39

The processing of the results and determination of the value of the coefficients of the equation was carried out according to [8].

To determine the significance of the regression coefficients, the calculated values of the Student's test (tp), were compared with the tabulated ($t_т$). If $t_p > t_T$, then the hypothesis with the significance of regression coefficients is not rejected.

Thus, after determining the significance of the coefficients, a mathematical model was obtained for the process of drying raw cotton in a drum dryer, in the following form:

y=5,03+1,168x1-0,795x2+1,645x3+0,581x4+0,441x1x3+0,526x1x4 (1)

The hypothesis on the adequacy of the presented equation was tested according to the Fisher criterion.

The calculated values of the Fisher test F_p were compared with the tabulated $F_т$. They are equal to F_p=1, 63, $F_т$=2, 79. Thus, $F_p<F_т$ the equation obtained is an adequate model for the drying process of raw cotton in a 2SB-10 dryer.

In table 2 shows the calculated values of moisture extraction, it shows that the difference between the actual and calculated values is negligible, which confirms the correctness of the model obtained.

The values of the coefficients entering into equation (1) allow one to judge the effectiveness of the influence of an individual factor or the interaction of factors on the optimization parameter y.

The nature of the influence of factors and their interaction is determined by the sign of the coefficient of regression and the direction of the change in the values of the optimization parameter when the process under study is favorable.

It follows from equation (1) that the temperature of the coolant x3 exerts the greatest influence of factors on moisture sampling, with a change in x3 from -1 to +1 in criterion y varies from 3.8% to 8.94%, i.e. by 2.4 times. The next factor affecting the optimization criterion, the initial moisture content of raw cotton, with an increase in its value from 14.45% to 24.36%, criterion y varies from 4.16 to 8.94, i.e. 2.15 times. When the value of the factor x2 varies from 4 t / h to 10 t/h, it varies from 8.94% to 6.07%, i.e. to increase the value of y, it is necessary to reduce the productivity of the dryer.

Analysis of equations (1) shows that all the factors investigated, independently or in interaction with others, influence the optimization parameter. To operate the dryer in a rational drying mode, it is necessary to search for the optimum value of the factors, which ensures maximum moisture sampling and preservation of fiber quality.

The initial moisture content of raw cotton in production (factor x1) is given. The choice of the drying temperature is related to the quality of the dried raw cotton and is given in the regulated technological process (PDI 70-2017), depending on the initial moisture content of the raw cotton [9].

In Fig. 1 shows the temperature dependence of the coolant on the initial moisture content of raw cotton, which ensures the preservation of quality parameters of fiber and seeds. They can be used to select the coolant temperature for drying raw cotton with given initial moisture content.

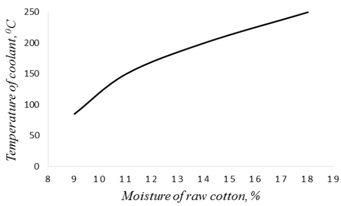

Fig. 1 Temperature dependence of the coolant on the initial moisture content of raw cotton

The dependence of the coolant temperature on the initial moisture content of raw cotton is approximated by the regression equation

$$t = -0,278W_н^2+26,39W_н-135$$

The optimization of the drying process in the drum dryer consisted in finding the optimum value of the factors - the productivity of the dryer (x_2) and the coolant flow rate (x_3) for the given raw cotton raw moisture. The search for optimal values of them was carried out by the method of steep ascent. The value of the coolant temperature is calculated from equation (1) for each value of the initial moisture content of the raw cotton.

It should also be noted that at present two dry drums of the type 2SB-10 are installed in the technological process of processing raw cotton, which can work in 3 ways: one dryer with a large capacity; two dryers in parallel or in series.

The main flow of the cotton processing plant equipment according to the technological regulations for the processing of I-II sorts of raw cotton works at a capacity of 9 t / h, with III-V varieties of 7 t / h.

Proceeding from this, the conjugation on the productivity of the drying drum and the rest of the process equipment must be ensured, which must be taken into account when choosing the drying regime in the drum.

The long-term experience of the cotton factories and the procurement of cotton raw showed that the moisture content of raw cotton varies within the following limits: first grade from 7 to 10%; the second - from 10 to 12%; third - from 13 to 15%; the fourth - from 13 to 18%; the fifth - from 18 to 25% or more.

On this basis, the optimum operating mode of the drum dryer is designed for a capacity of 7 t / h (for I-II qualities) and 9 t / h (III-V qualities).

Table 3 shows the optimum drying conditions in the drum dryer, depending on the initial moisture content of the raw cotton.

Table - 3

The regime map of the drum dryer operation, depending on the initial moisture content of the raw cotton

№	Initial humidity of raw cotton,%		Dryer capacity, t /h		Temperature of hot air, ^{0}C		Air consumption thou. m^3 / h		Moisture selection %	Moisture of raw cotton after drying,%
	X_1	$W_н$	X_2	Пр	X_3	t	X_4	Q	ΔW	$W = W_н - \Delta W$
1	-1,94	10	-0,83	4,5	-1,31	100	-0,6	17	2,6	7,4
2	-1,94	10	0,67	9	-1,31	100	0,8	24	0,83	9,17
3	-0,69	12	-0,83	4,5	-0,69	140	-0,2	19	3,5	8,5
4	-0,69	12	0,67	9	-0,69	140	0,4	22	2,90	9,1
5	-1,12	14	-0,83	4,5	-0,08	180	-0,6	17	4,3	9,7
6	-1,12	14	-0,83	4,5	-0,08	180	-0,2	19	4,3	9,7
7	-1,12	14	0,67	9	-0,08	180	-0,6	17	3,2	10,8
8	-1,12	14	-1,67	3,5	-0,08	180	-0,6	17	5	9,0
9	-0,71	16	-1,67	3,5	0,48	216	-0,6	17	6,2	9,8
10	-0,72	16	0	7	0,48	216	-0,6	17	4,9	11,1
11	-0,31	18	-1,67	3,5	1	250	-1	15	7,1	10,9
12	-0,31	18	0	7	1	250	0,4	22	6,3	11,7
13	0,12	20	-1,67	3,5	1	250	-0,2	19	8,0	12,0
14	0,12	20	0	7	1	250	0,4	22	7,3	12,7
15	0,51	22	-1,67	3,5	1	250	-0,2	19	8,7	13,3
16	0,51	22	0	7	1	250	0,4	22	7,9	14,1
17	0,92	24	-1,67	3,5	1	250	0,8	24	10,4	13,6
18	0,92	24	0	7	1	250	0,8	24	9,0	15,0

From table 3 it follows that when drying raw cotton I-II qualities having a moisture content of up to 12%, one dryer with a capacity of 9 t / h or two with a capacity of 4.5 t / h can be used. In both cases, the moisture content is reduced to 8-9%. When drying raw cotton with a moisture content of 14% (quality III), it is also possible to reduce their humidity to the technological norm by a single drying with a dryer capacity of 3.5 t / h. In this case, the two dryers must work in parallel to provide a capacity of 7 t / h.

The analysis shows that when drying raw cotton with an initial moisture content of 16% or more, it is necessary to dry twice with a drying capacity of 7 t / h. Coded values of factors are converted into quantitative factors according to the following formula:

$$X_1 = \frac{W_n - 19{,}5}{4{,}9}, \quad X_2 = \frac{Pr - 7}{3},$$

$$X_3 = \frac{t - 185}{65}, \quad X_4 = \frac{Q - 20}{5}$$

Inserting the natural value of the factors in equation (1), we obtain the following dependences of moisture extraction of the dryer in its natural form

$$\Delta W = 0{,}89 - 0{,}437W_н - 0{,}265\,Pr - 0{,}001t - 0{,}292Q + 0{,}0013W_н \cdot t + 0{,}021W_н \cdot Q \quad (3)$$

or by assuming that $W_к = W_н - \Delta W$ (where, $W_к$ - is the moisture content of the raw cotton after drying), we obtain

$$W_к = W_н - (0{,}89 - 0{,}437W_н - 0{,}265\,Pr - 0{,}001t - 0{,}292Q + 0{,}0013W_н \cdot t + 0{,}021W_н \cdot Q) \quad (4)$$

If the ginning plant works with a different capacity, then by the equations (2) and (4) it is possible to determine the corresponding drying regime in the drum dryer.

Conclusion: On the basis of studying the drying of raw cotton in a drum dryer, a regression equation is obtained that characterizes the dependence of moisture extraction on the regime parameters of the dryer and the initial moisture content of raw cotton.

A regime map for drying of raw cotton qualities is obtained, which ensures a reduction in the moisture content of raw cotton to the required technological norm.

It is recommended to dry the raw cotton once, having a moisture content of up to 14% and drying twice with a moisture content of more than 14%.

References

1. Kucherova L.I. Evaluation of the effect of drying on the structure and properties of cotton fiber and the quality of yarn and fabric produced from it // Diss. for the degree of candidate of science. Moscow. 1981. p174 .

2. Sadikov M. Conformation of the parameters and operating conditions of the feeding and internal devices of the drum dryer for the purpose of intensifying the drying process of raw cotton // Diss. for the degree of candidate of science.// 1984. p158

3. Mamatov A.Z. Modeling the technology of drying raw cotton in order to improve the quality of fiber // Diss. for the degree of doctor of technical sciences. Toshkent. 1995. p248

4. Kayumov A.Kh. Increasing the uniformity of drying raw cotton components by optimizing the temperature regime // Diss. for the degree of candidate of science. Toshkent. 1994. p177

5. Gapparova MA Improving the regime of drying of raw cotton in a drum dryer in order to maximize fiber quality preservation // Diss. for the degree of candidate of science. Toshkent. 1999. p162

6. Parpiev A., Usmonkulov A.K. Experimental research on the selection of the optimal design of the internal drums of a drying drum // Problems of mechanics. 1998. №1. Pp.56-58.

7. Usmonkulov A.K. Modeling of heat-exchange processes in raw cotton moving in a drying drum // International conference "Modern problems of gas and wave dynamics". Moscow State University named after Lomonosov. Moscow. April 21-23. 2009. P p 109-110.

8. Spiridonov A.A. Planning an experiment in the study of technological processes // Moscow. Mechanical engineering. 1981.p183

9. Regulated technological process of processing raw cotton (PDI 70-2017). Toshkent. 2017. Pp. 17-18.