Hamidovich, J Textile Sci Eng 2017, 7:2
DOI: 10.4172/2165-8064.1000290

Journal of Textile Science & Engineering

Research Article OMICS International

The Influence of Drying Regimes in Moisture of Raw Cotton and its Components

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Abstract

Choosing the drying mode of cotton, from the point of view dehydration its components up to the normalized humidity is an actual problem. In this article the pattern of changing of the humidity of a fibre, seeds in various modes, and frequency rates of drying by which it will be possible to recommend optimum parameters of drying for uniform dehydration cotton and its components are determined.

Keywords: Cotton seed; Fibers; Drying; Regime; Dryer; Dry agent; Moisture

Introduction

In the drying and cleaning shop (DCS) of storage units, raw cotton with moisture content up to 19% is exposed to a single dried, with a humidity of 19-29% double dried, and more than 29% triple dried to reduce their moisture content to 14% for low and to 11% for the first commercial varieties [1].

For cleaning shops (CS) of cotton plants, recommended to bring the single drying moisture of raw cotton, to 7-8% for the first and 8-9% for low sorts respectively. Moreover, the initial moisture content of raw cotton, entering the CS, must not exceed the 14%.

These recommendations include cotton ginneries drying in a continuous chain to a moisture content of 7-10% depending on the sorts and cotton varieties. However, the recommendations are rigidly installed efficiency of raw cotton passing through the drying units, compliance with which is in practice not always possible. Cotton factories often operate with a capacity of less than recommended, and the temperature of the drying agent remains constant or decreases unnecessarily. It should be noted that the cotton-drying mode does not guarantee the fiber moisture within the norms [1], as fiber moisture has a significant impact on the quality of yarn. These facts have been confirmed in several studies [2-4].

Currently, the DCS and CS of cotton factories used two – 2SB-10 dryer or SBO (SBT) for the preparation of the cotton to the storage and processing. High quality cotton fiber and seeds can be obtained by rationally using and applying the optimum drying regimes in these dryers. Studies conducted on cotton factories showed that the connectivity option dryers significantly affect the quality of the fiber [5].

The results showed that for each drying embodiment same with the initial moisture content, depending on the embodiment dryer's connection achieved varying degrees of defects and littered content of fiber. This shows that the rationale choice version of drying with optimal values of temperature of drying agents depending on the initial moisture content of cotton can significantly improve the performance of the producing cotton fiber.

Moreover, the moisture content of fiber and seed for each embodiment of drying with the same of initial moisture content and moisture of raw cotton after drying, depending on the embodiment of dryers connection obtain different results. This shows that the connection option of dryers significantly affects the uniformity of drying. It is obvious that, in the different ways of drying, the temp of heating of raw cotton is different as well as the intensity of the drying process depends on the heating temperature of raw cotton components.

In practice, single, double and parallel drying are widespread. However, even these options do not meet the requirements due to insufficient substantiation. It concerns, primarily using of different ways of drying at each initial moisture content, depending on the temperature of the drying agent and efficiency of skipping dried cotton to provide producing high quality fiber and seeds. It follows that, the important task is to choose the optimal variant of drying of modern cotton varieties depending on their initial moisture content.

Objects and Methods

The drying process, which depends on a number of factors, should be research under the production conditions using modern methods of planning and carrying out the experiment, which would allow finding solutions close to the optimal and minimal costs.

One of the closest methods to the target is a method of mathematical planning of the experiment [6]. For our research method, a full factorial experiment like FFE 2^3 is selected. Researches were conducted on 2SB-10 dryer when drying agent temperature T=100 ($-x_3$) and 200°C ($+x_3$), performance 3.5 (x_2) and 10 t/h ($+x_2$) for wet raw cotton. The object of the study was raw cotton varieties of C-6524, II of commercial sort, with initial moisture content W=10.5 ($-x_1$) and 22.3% ($+x_1$).

The experiments were at single, double, and triple drying.

Results and Discussion

The analysis of the regression equations shows that all the factors taken substantially affect the output parameters, either alone or in collaboration.

Mathematical processing of experimental results let gets the separate regression equations for each multiplicity of drying.

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Received March 22, 2016; **Accepted** April 03, 2017; **Published** April 07, 2017

Citation: Hamidovich KMV (2017) The Influence of Drying Regimes in Moisture of Raw Cotton and its Components. J Textile Sci Eng 6: 290. doi: 10.4172/2165-8064.1000290

We analyzed the regression equations to determine the effect of drying agent temperature and drying performance on moisture of raw cotton and its components can be written as follow:

for a single drying: for moisture of raw cotton: $У_1=12,8+4,75x_1+0,97x_2-1,10x_3-0,47x_1x_3$; for moisture of fibre: $У_2=7,98+3,07x_1+1,3x_2-1,66x_3+0,3x_1x_2-0,69x_1x_3$; for moisture of seed: $У_3=14,76+5,46x_1+0,72x_2-0,74x_3-0,11x_1x_2-0,39x_1x_3$;

-for double drying: moisture of raw cotton: $У_1=9,81+3,85x_1+1,54x_2-1,68x_3-0,66x_1x_3$; moisture of fiber: $У_2=5,64+2,08x_1+1,25x_2-1,63x_3-0,58x_1x_3$; moisture of seeds: $У_3=10,87+4,18x_1+1,53x_2-1,58x_3-0,62x_1x_3$;

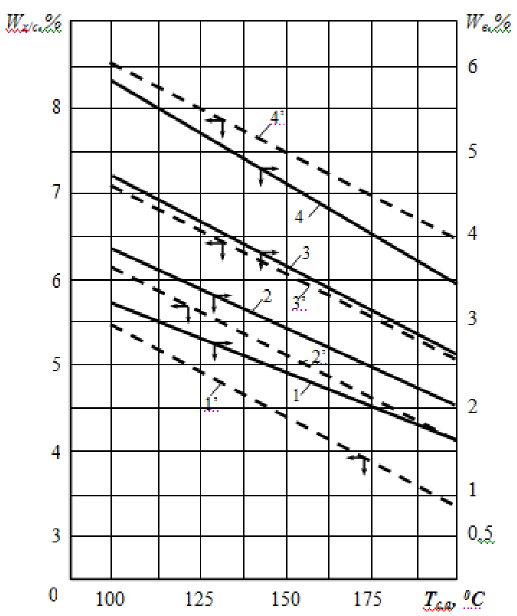
-for a triple drying: for moisture of raw cotton: $У_1=7,49+3,13x_1+2,1x_2-1,94x_3-0,75x_1x_3$; moisture of fiber: $У_2=4,45+1,78x_1+1,51x_2-1,74x_3-0,67x_1x_3-0,34x_2x_3$; moisture of seeds: $У_3=7,99+3,33x_1+2,14x_2-1,91x_3-0,77x_1x_3$.

To analyze these dependencies organized numerical calculation of output parameters for different values of the main factors. The results of numerical calculation after mathematical processing are presented in the form of graphs in Figures 1-7.

Analysis of the graphs shows that when single drying (Figures 1 and 2) with increasing the temperature of the drying agent and decreasing of performance on wet cotton, the moisture separation increases. The fiber intensively dried than seeds, so the fiber is in direct contact with the drying agent and heats up quickly.

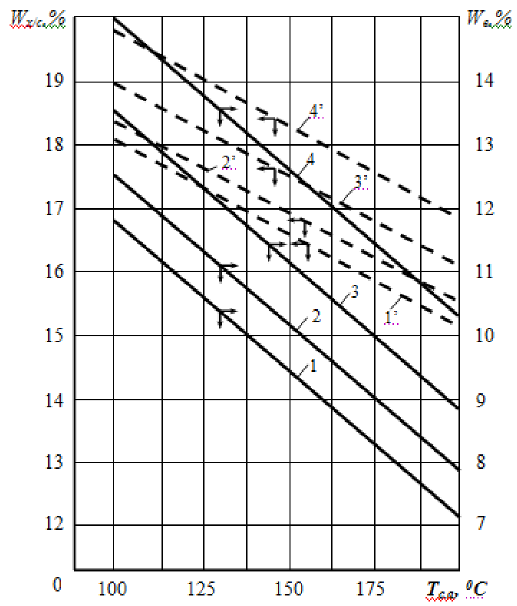
After first multiplicity of drying of raw cotton and it is feed to the second multiplicity by pneumatic transport. Then the fibers are cooled, but the seed of coated fiber is not cooled. Therefore, generally seeds dried in the beginning of the second drum, the graphs show that the fibers are dried slowly in a low productivity than the raw cotton (Figures 3 and 4).

It was previously established that, with a lower productivity, the heating of seeds is greater than at high fiber productivity, while cooling in pneumatic transportation; it is obvious that they are moistened and in the second drum are dried more slowly. In addition, with less moisture, the fibers do not have free moisture and, therefore, with a lower moisture content of the fiber, more heat is required. With high humidity, the fibers have more free moisture, therefore at a productivity of P=10 ton/h (Figures 3 and 4) are dried faster than raw cotton. A similar picture is observed when the cotton is triple dried (Figure 5).



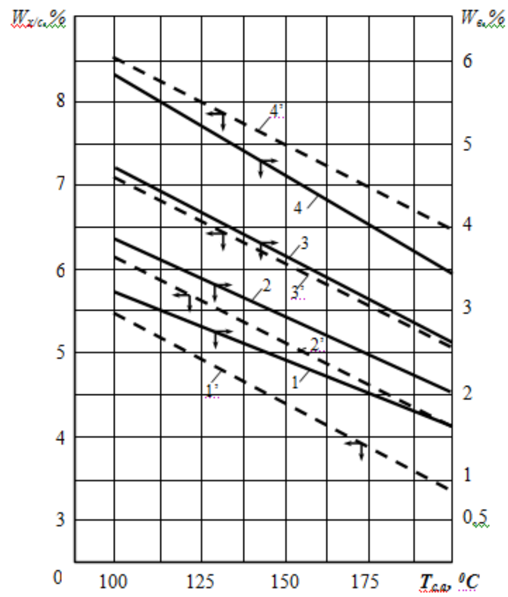
$W_{x/c}$=10, 5%:1, 2, 3, 4 and 1', 2', 3' и 4' – respectively fiber and cotton with performance 3,5; 5; 7 and 10 t/h.

Figure 1: The dependence of raw cotton moisture and cotton fiber from the drying agent temperature at reference humidity.



$W_{x/c}$=22, 3%: 1, 2, 3, 4 and 1', 2', 3', 4' – respectively fiber and cotton with performance 3,5; 5; 7 and 10 t/h.

Figure 2: The dependence of raw cotton moisture and cotton fiber from the drying agent temperature at reference humidity.



$W_{x/c}$=10, 5%: 1, 2, 3, 4 and 1', 2', 3' and 4' respectively fiber and raw cotton with performance 3, 5; 5; 7 and 10 t/h.

Figure 3: The dependence of raw cotton moisture and cotton fiber from the drying agent temperature at reference humidity.

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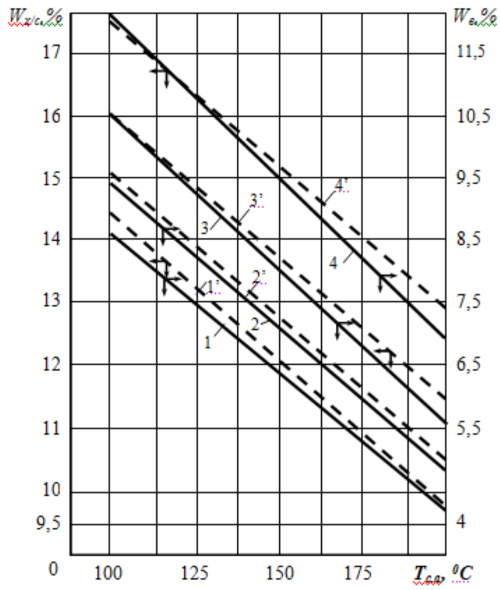
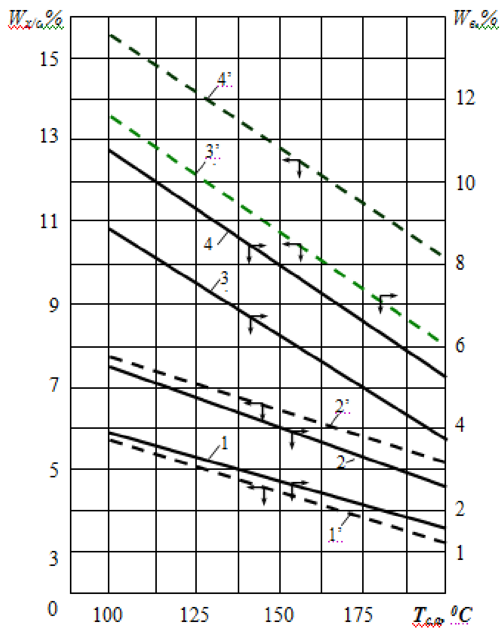


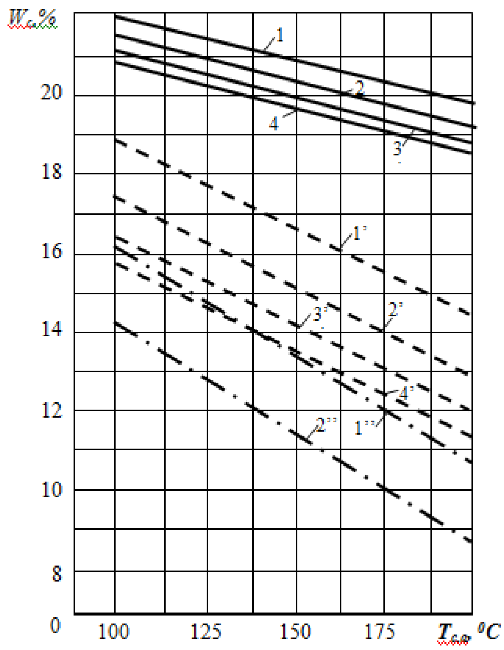
$W_{x/c}$=22,3%:1, 2, 3, 4 and 1', 2', 3' and 4' – respectively fiber and raw cotton with performance 3,5; 5; 7 and 10 t/h.

Figure 4: The dependence of raw cotton moisture and cotton fiber from the drying agent temperature at reference humidity.



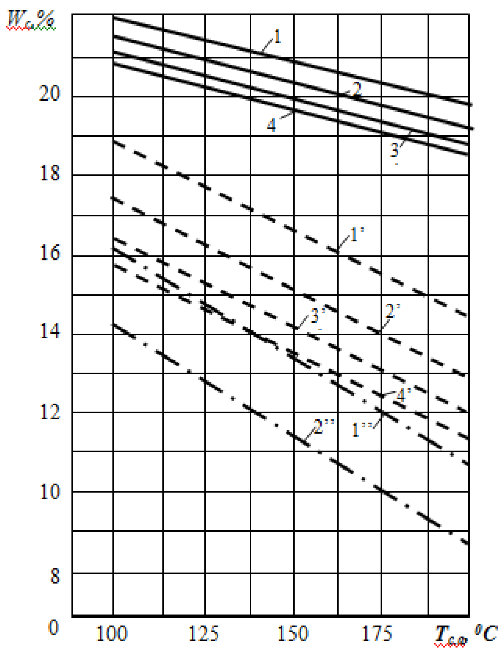
$W_{x/c}$=10, 5%; 3, 4 and 3', 4' – respectively fiber and raw cotton with performance 7 and 10 t/h at reference humidity $W_{x/c}$=22, 3%.

Figure 5: The dependence of raw cotton and cotton fiber moisture from the drying agent temperature: 1, 2 and 1', 2' – respectively fibers and raw cotton with the performance 7 and 10 t/h at reference humidity.



$W_{x/c}$=10, 5%: 1, 2, 3, 4 and 1', 2', 3', 4'- respectively with performance 10, 7, 5 and 3,5 t/h with single and double drying; 1'', 2'' – with triple drying, respectively with performance 10 and 7 t/h.

Figure 6: Dependence of seed moisture from the drying agent temperature at reference humidity.



$W_{x/c}$ 22, 3%:1, 2, 3, 4 and 1', 2', 3', 4' – respectively with performance 10, 7, 5 and 3,5 t/h with single and double drying; 1'', 2'' – respectively with performance 10 and 7 t/h with triple drying.

Figure 7: Dependence of seed moisture from the drying agent temperature at reference humidity.

It can be seen from the graphs (Figures 6 and 7) that, with increasing frequency of drying, moisture removal from the seeds increases. This is explained by the fact that in the first fold of the drying the seeds are mainly heated, and the moisture extraction from the seeds is slower, i.e., the heating process is in progress. In subsequent drying processes (2-3-fold) there is an intensive drain of moisture from the seeds. It is known [7] that, for the intensification of the drying process it is necessary to heat the seeds, followed by drying the raw cotton in the drum dryers.

Conclusion

The regularities of the distribution of moisture between the components of raw cotton during sequential and parallel work of drum dryers are determined.

Moisture of fiber and seeds with each drying option at the same initial humidity and humidity of raw cotton after drying, depending on the option of connecting the dryers, different indicators are obtained.

The moisture content of raw cotton and its components after drying is affected to a greater extent by the initial moisture content of raw cotton, the higher the initial humidity, the higher the moisture content of raw cotton and its components after drying. With the increasing of drying rate, the influence of the initial moisture content of raw cotton on the parameters Y_1-Y_3 decreases.

For the moisture content of raw cotton, with a single drying, the regression coefficient is b_1=4.75; at a double drying 3.85, and with a triple drying 3.13. For the moisture content of the fiber (Y_2) with a single drying b_1=3.07; with a double drying 2.08, with a triple 1.78. For the moisture content of the seeds (V_3), with a single drying b_1=5.46, with a double drying 4.18, with a triple drying 3.33. The decrease in the regression coefficient b1 with the increase in the drying rate is explained by the fact that the residual moisture content of raw cotton and its components, which is the initial moisture for the subsequent multiplicity, gradually decreases, as cotton enters the subsequent dryers.

Also, humidity of raw cotton and its components after drying significantly influences the temperature of the drying agent. The higher temperature of the drying agent, the lower moisture content of raw cotton and its components after drying. However, the effect of the temperature of the drying agent on the moisture content of raw cotton and its components is not the same.

For example, in a single drying for fiber moisture, the regression coefficient is b3=1.66, for raw cotton moisture 1.1, and for seed moisture 0.74. This means that increasing the temperature of the drying agent drastically reduces the moisture content of the fiber, while the rate of moisture reduction of raw cotton and seeds is much lower.

With a double and triple drying of raw cotton, the regression coefficient b3 of the temperature of the drying agent is, respectively, 1.68 and 1.94 for the moisture content of the raw cotton; 1.58 and 1.91 for the moisture content of the seeds and 1.76 and 1.74 for the moisture content of the fiber. This shows that an increase in the rate of drying contributes to a more uniform drying of raw cotton components.

The efficiency of the drying drum for wet cotton also significantly affects the moisture content of raw cotton and its components after drying. From the regression equations (Y_1, Y_2 and Y_3), it can be seen that when the raw cotton in a single drying, the productivity of the drying drum on moisture of raw cotton significantly affects the moisture content of the fiber (b_2=1.3) than the moisture content of the raw cotton (b_2=0.97), and seeds (b_2=0.72). This means that the more moisture of the raw cotton in the drum, the greater the moisture content of the fiber. It follows that in order to avoid fiber drying, it is necessary to feed wet cotton raw material to drums with higher capacity. It is evident from the regression equations that when double drying b_2=1.54 for moisture content of the raw cotton, b_2=1.25 for the moisture content of the fiber.

The results can be used to develop optimal drying modes, depending on the initial moisture content of raw cotton, the performance of the dryer on wet cotton.

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