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Effect of the Drying Temperature of the Drum on Moisture Content of Cotton Components

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Annotation. The article covers the drying process of cotton in the drum, and it has been shown that the unevenness of the initial moisture distribution in cotton is the main factor affecting the uneven drying of the fiber seed. The effect of drying temperature on moisture content of cotton, fiber and seed has been determined and their regression equations have been derived. The initial moisture differences of the cotton components are significantly larger, and it has been found that there is very little possibility to minimize them by changing the drying temperature. The amount of moisture released from cotton, seed and fiber at different drying temperatures has been determined and analyzed.

The average drying rates of the cotton components and the amount of moisture release have been determined, and it has been established that the effect of drying temperature and the average drying rate of cotton and seed were almost the same.

The drying rate of fiber at drying temperature up to 160 °C is lower than the drying rate of cotton and seed, and the reasons for this have been shown. The formula for determining seed moisture has been given. It has been recommended to obtain fiber and fiber moisture as indicators characterizing the state of moisture in technological processes of cotton processing.

1 Introduction

The main factors affecting the effective implementation of cotton cleaning are the efficiency of cleaning equipment, material moisture and initial impurity. During the initial processing of cotton, depending on its initial moisture and impurity, according to the recommendation “Coordinated technology of initial processing of cotton (PDI 75-2017)”, the performance of technological equipment and drying modes are determined [1, 2].

As we know, the moisture content of cotton during cleaning and ginning processes should be 8-9% depending on its variety. Bringing the moisture of cotton to the level of technological requirements is carried out due to the correct selection of the drying mode, mainly the drying temperature.

The moisture content of cotton produced in cotton gins from 7% to 22% and higher leads to a number of complications. This includes reducing the moisture content of high-moisture cotton to 8-9%, ensuring uniform drying of fiber and seed moisture, and not reducing fiber quality.

In some studies [3, 4, 5], it has been substantiated that the moisture content of cotton as an object of cleaning and ginning does not fully characterize the state of moisture, and fiber moisture is the main factor affecting the efficiency due to the interaction of the technological equipment with the working elements during the cleaning and drying processes. It should be noted that the conducted researches were mainly carried out in laboratory conditions, and its humidity does not always correspond to the results obtained in production conditions. The reason is that it is difficult to model the state of cotton under production conditions in laboratory, and the temperature of cotton fibers varies depending on the temperature mode of the drying drum. Even if the moisture content of the fiber is uniform, the temperature varies, but it affects the cleaning efficiency of the cleaners [6-9].

Although the rational moisture content of cotton fiber cleaning processes has been recommended, the problem of bringing it to that moisture content has not been solved.

The article covers the possibility of minimizing the uneven drying of cotton components due to the choice of drying temperature.

2 Methodology of the experimentation

As a research object, S65-24 1/3 selection variety of cotton with initial moisture $W_{\text{п}}$=11,14%, fiber moisture $W_{\text{т}}$=7,8%, seed moisture $W_{\text{ч}}$=12,5%, impurity 4,3% was taken. The experiments were conducted at the Chinobod cotton ginning plant. The cotton was dried in a drum dryer with a capacity of 7 t/h at a drying temperature of T=100-130-160-190 °C, cleaned in a UXK unit, ginned in a 5DP-130 gin, and cleaned in a 1VP fiber cleaner. Samples were taken and the amount of cotton, fiber, seed moisture, fiber impurity and defective compounds have been determined.

The obtained experimental results were mathematically and statistically processed [10].

In regression equations, the connection density between variables is estimated by empirical correlation ratio η_{yx}, correlation coefficient r and correlation index l. The constant coefficients in the equation are determined using the least square deviation method. Adequacy of regression equations was determined using the Fisher-Snedeker test.

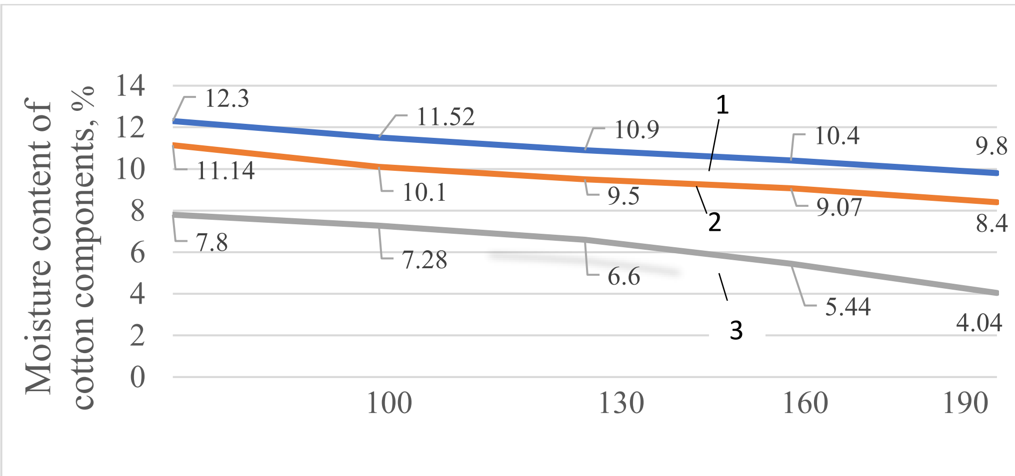
3 Results and discussion

Fig. 1 shows changes in moisture content of cotton components at different drying temperatures.

As can be seen from the Fig. below, there is a significant difference in the initial moisture content of the cotton components, the deviation of seed and fiber moisture relative to cotton moisture is 14.4% and 30%, respectively, and the deviation of fiber moisture relative to seed moisture is 3.76%, and these differences in values remain almost unchanged [11].

The difference between fiber moisture content and cotton moisture content is increasing.

This situation will definitely have a negative impact on cotton cleaning and ginning processes.



The temperature of the drying agent, ^{0}C 1- seed, 2- cotton, 3- fiber

Fig. 1. Effect of the temperature of drying agent on changes in moisture content of cotton components

It has been shown that it is not enough to take only cotton moisture as a basis in technological processes, because it cannot fully characterize the moisture condition of cotton, and it is necessary to take fiber moisture into account.

The regression equations of the obtained samples had the following form.

Cotton moisture

$$y_1 = -0{,}000009x^2 - 0{,}0115x + 11{,}14$$

Seed moisture

$$y_2 = -0{,}0000469x^2 - 0{,}0062x + 12{,}5$$

Fiber moisture

$y_3 = -0{,}000163x^2 + 0{,}0111x + 7{,}8$

If we take seed moisture as $W_{\text{ч}}=n^* W_{\text{п}}$, or $n = \frac{W_{\text{ч}}}{W_{\text{п}}}$, then in our experimental version n value can be changed from 1.1 to 1.17. Therefore, fiber moisture $W_{\text{т}}$ and cotton moisture $W_{\text{п}}$ can be obtained as indicators characterizing the state of moisture in cotton technological processes. The results show that seed moisture is close to cotton moisture. In this case, taking into account that the fiber is in contact with the working elements of the technological equipment, the moisture content of the fiber is considered the main indicator [12, 13].

One of the main technological indicators of drying drums is moisture absorption ΔW, which is defined as follows.

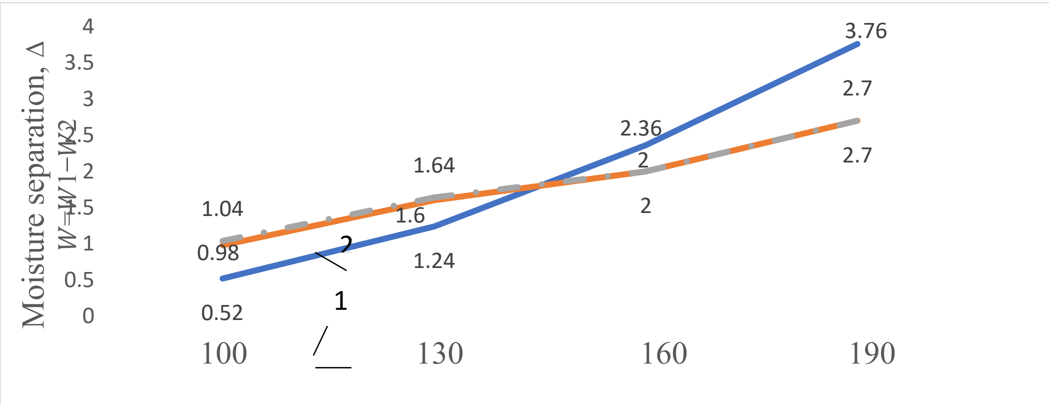
$$\Delta W = W_1 - W_2$$

where W_1 and W_2 are moisture content of cotton before and after drying. Using this formula, the effect of drying temperature on the amount of moisture extracted from cotton components has been determined. In addition, the average drying rate of cotton components in the drum is also determined by the following formula.

$$\frac{\Delta W}{\tau} = \frac{W_1 - W_2}{\tau} \ \%/m$$

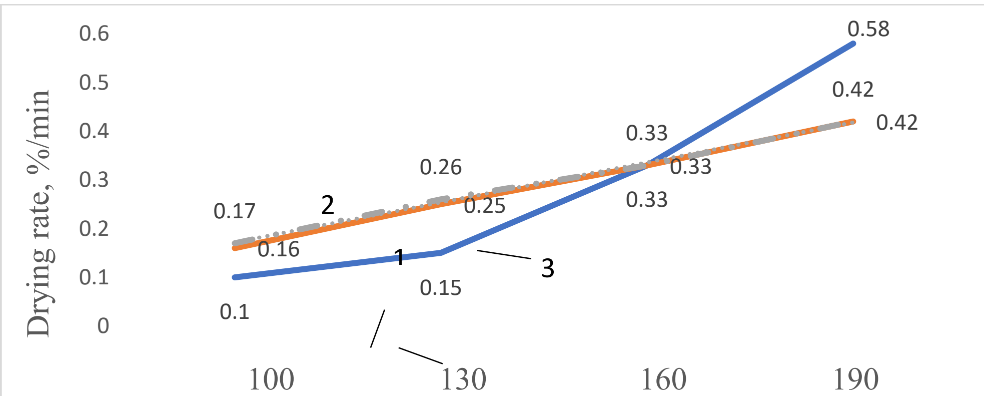
where τ is time of cotton drying in the drum, τ=6.5 min

The results are presented in Fig. 2.



1- cotton, 2- seed, 3- fiber

Drying temperature, ^{0}C



1- cotton, 2- seed, 3- fiber

Drying temperature, ^{0}C

Fig. 2. Moisture release and drying rate in cotton components

The moisture release ΔW from seed and cotton and the average drying rate are almost the same, and they are increasing significantly when the drying temperature is higher than 130 °C. The fiber moisture uptake and average drying rate decrease until the setting temperature reaches 160 °C and then increase sharply with increasing temperature.

As we know, the hot air supplied to the drying drum also performs the function of absorbing the moisture separated from the cotton and carrying it out. In this case, the ability of the air to absorb moisture should be at the level of complete absorption of the separated moisture. Otherwise, the air can become saturated with moisture and wet the fiber due to condensation in the final parts of the drum. When the temperature exceeds 160 °C, the process of heating the cotton accelerates, the ability to absorb moisture from the air is high, condensation of moisture from the air to the fiber is eliminated.

The amount of moisture extracted from seed and cotton and the average drying rate are close to each other, which is explained by the fact that at least 70% of the moisture in cotton corresponds to the seed.

4 Conclusions

According to the obtained results, the following conclusions can be made:

1. The main reason for drying unevenness is the non-uniform distribution of moisture in cotton components, and the possibility of reducing moisture unevenness due to drying temperature is limited.

2. When the drying temperature is up to 130 °C, the fiber does not over-dry, and when it exceeds it, the moisture content of the fiber decreases sharply. It was suggested that fiber and cotton moisture can be obtained as parameters characterizing the moisture condition of cotton in technological processes.

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