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Analysis of Foreign Impurities Contained in Fiber

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Abstract: This article presents experiments conducted in production conditions, changes in the structural composition of cotton and its characteristic parameters during technological processes.

Keywords: cotton cleaning, changes in the technological process of cotton structure parameters, cotton moisture content, cotton contamination, cotton class and grades.

A number of scientific studies have been conducted on preparing cotton for technological processes, including drying and cleaning. These studies examined the structure of cotton, indicators characterizing the degree of its loosening, as well as the influence of cotton moisture content and temperature on cleaning processes. However, to date, the indicators that comprehensively characterize cotton as a processing object have not been fully substantiated, and their optimal values have not been determined [1; 2].

At cotton ginning plants, the preparation of cotton for technological processes—especially for ginning—is not always carried out in accordance with the requirements of the technological regulations. At each cotton ginning plant, the technical condition of the process equipment varies, operating modes differ, and the technological clearances between the working parts of cleaning machines are not always correctly adjusted. As a result, their operational efficiency may be insufficient.

In this regard, there is a need at cotton ginning plants to prepare cotton for technological processes, analyze the quality of the produced fiber, and develop proposals for improving it.

It is known that at cotton ginning plants, up to 32 peg drums are installed to clean cotton from fine impurities, and four sections of saw drums are used to remove coarse impurities.

The results of calculating the required cleaning efficiency of a cotton ginning plant by cotton variety and grade—depending on the amount of impurities in the cotton in the gin tray, as specified by the technological regulations PDI 70-2017, as well as on the initial trash content of the cotton—are presented in Table 1.

Table 1. Required Cleaning Efficiency Depending on the Initial Trash Content of Cotton

Cotton					Cleaning Efficiency,, %	
Cotton Fiber Grade	Grade	Trash Content,%	Trash Content Before Ginning,%			
			Easily Cleanable	Difficult to Clean	Easily Cleanable	Difficult to Clean
I-II III IV	1	5,0 8,0 12,0	0,8-0,8 0,8 1,2	0,9-1,0 1,2 1,8	84-84 90 90	82-80 85 85
I,II,III IV	2	12,0 16,0	1,0-1,0-1,2 1,6	1,5-1,5-1,8 2,4	92-92-90 90	88-85 85
I,II,III IV,V	3	18,0 20,0	1,6-1,6-1,8 2,4-3,0	2,4-2,4-3,0 3,6-5,0	91-91-90 88-85	87-87-90 82-85

It can be seen from Table 1 that the required cleaning efficiency ranges from 80% to 92%. Therefore, determining and analyzing the effectiveness of cotton cleaning at cotton ginning plants is of practical importance.

To determine the cleaning efficiency and the quality status of the fiber, experiments were carried out at a number of cotton ginning plants (Khajaabad, Paituk, Shakhrikhan). Batches of cotton of various varieties and with different levels of trash content were processed. After each piece of process equipment, samples were taken, and standard methods were used to determine the trash content of the cotton and fiber, moisture content, and fiber quality indicators. During cotton processing, the throughput of the process equipment was: 5.5–6 t/h for grades I–II, and 7.5–8 t/h for the remaining grades. The experimental results are presented in Table 2.1.2. During cotton processing, three sections of saw drums and 24 peg drums were in operation [3,4].

Figure 1 shows a graph of the dependence of the amount of impurities in the fiber composition on the trash content of cotton in the gin tray; its regression equation has the following form:

$$y = 0{,}36x^2 - 0{,}6x + 1{,}4$$

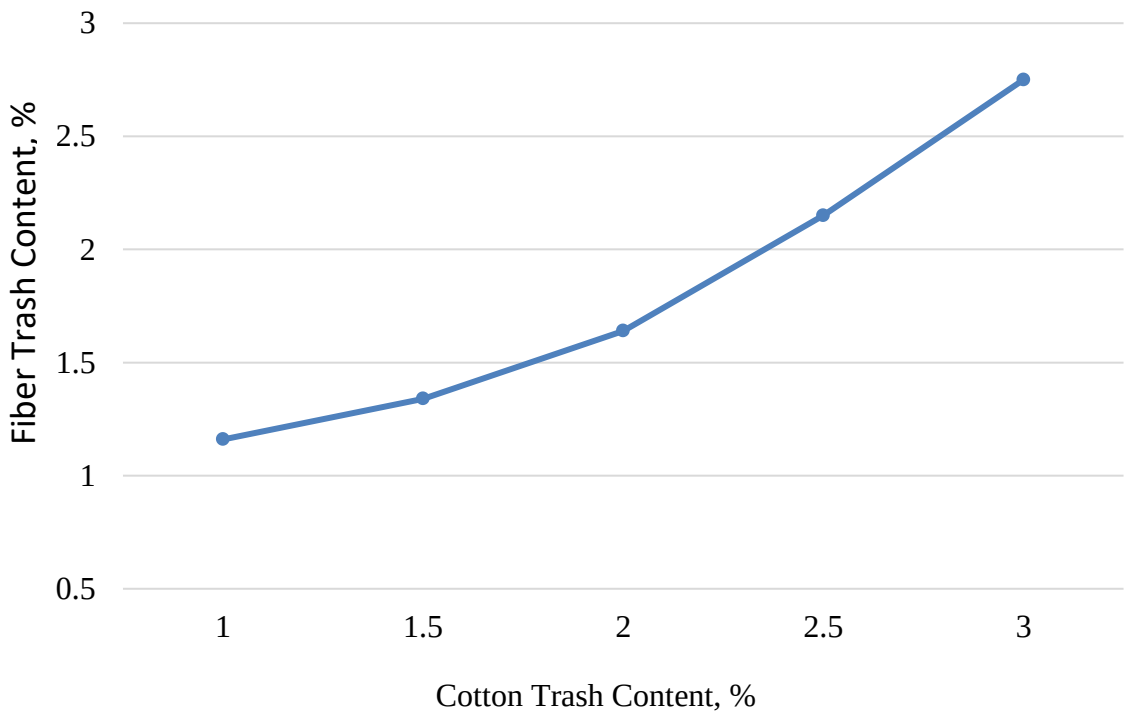

Fig. 1. Graph of the Dependence of Fiber Trash Content on Cotton Trash Content in the Gin Tray

Table 2. Results of Cotton Processing at Cotton Ginning Plants

№	Cotton Variety and Grade	Cotton Moisture Content, %	Cotton Trash Content,%;	Drying Temperature, ^{0}C	Засоренность и пороки на волокне		Cleaning Efficiency, %	Trash Content and Defects in the Fiber, %			Fiber Grade
					Moisture Content, %	Trash Content, %		Trash Content,%	Foreign Impurities, %	Total, %	
1.	C-6524, 1/2	9,07	4,66	80	8,0	0,9	80,7	1,2	1,4	2,6	Average
2.	An-35, 2/1	12,3	4,87	165	9,8	1,2	75,9	1,42	1,45	2,87	Good
3.	C-6524, 1/2	9,2	4,4	70	8,4	2,0	68,6	1,7	1,55	3,25	Normal
4.	C-6524, 4/1	15,0	3,8	170	8,4	2,7	58,9	2,4	3,4	5,8	Good
5.	An-35, 4/1	16,6	5,7	185	9,5	2,3	59,6	2,1	3,0	5,1	Good
6.	An-35, 5/3	21,4	6,8	200	10,7	3,0	55,4	2,9	5,7	8,6	Average

From Table 2 it can be seen that although the moisture content of the processed cotton meets the required level, the cleaning efficiency is below the requirements of the technological regulations given in Table 1 and ranges from 55.4% to 80.7%. It was found that the amount of impurities in the produced fiber increases in accordance with the trash content of cotton in the gin tray, and as the cotton grade decreases, this increase becomes more pronounced.

From Figure 1 and the equation it is evident that a cotton trash content above 1.5% leads to a sharp increase in fiber trash content. Therefore, it is advisable to minimize the trash content of cotton when feeding it into the gin.

Table 2 shows that fiber grades “average,” “normal,” and “good” were obtained from grades I and II cotton, whereas fiber grades “premium” and “good” should have been obtained. The analysis showed that the trash content of the fiber obtained from grade I cotton exceeded the standard requirement by 0.1%, which caused the fiber grade to decrease: from “good” (the standard allows trash content up to 2.5%) to “average,” and from “average” (the standard allows trash content up to 3.0%) to “normal.” For grade II cotton, the trash content of the produced fiber was 0.32% above the norm, so the grade decreased from “premium” to “good.”

A one-grade decrease in fiber quality reduces its price by 4–5%. This situation causes significant economic losses to cotton ginning plants.

An analysis of the cleaning efficiency of cotton ginning equipment shows that there are opportunities to improve it. By reducing the trash content of cotton in the gin tray, the amount of impurities in the fiber can be decreased.

The main problem here is the large amount of defective impurities. It is known that defective impurities in fiber are formed from defects arising during cotton cultivation, as well as from defects occurring in technological processes due to excessive cleaning and ginning. In all cases, the number of technological defects resulting from over-cleaning of cotton should be small, since the cotton was not subjected to excessive cleaning. Hence, it can be concluded that the increased number of defects in the fiber is mainly due to natural defects in the cotton composition.

This requires determining, at cotton ginning plants, the amount of natural defects in prepared cotton and technological defects by fractional composition, as well as conducting additional studies to establish the relationship between cotton cleaning efficiency and fiber trash content in order to obtain higher-grade fiber [5; 6].

It is known that the composition of cotton fiber includes total trash content and defective impurities.

The amount of contaminating impurities in the fiber depends on the initial trash content of the cotton and the cleaning efficiency, i.e., on the residual trash content of the cotton entering the gin working chamber.

Defective impurities in fiber are divided into two categories. The first category is present in prepared cotton and относится to natural defects: these are fiber (seeds covered with immature fibers) and plastics of immature fiber (a cluster of immature fibers stuck together). Their amount in the cotton composition depends on the agronomic practices of cotton cultivation.

The second category of defects arises during technological cotton-processing operations, mainly during cleaning and ginning. These include neps, combined neps, fibrous seed coat, small neps, and crushed seeds. Their amount depends on the cotton moisture content, the number of cleaning passes, and ginning conditions [7; 8].

Total trash content (overall impurities) in the fiber composition consists of three components:

$$C_{\text{ум}} = C_{\text{ифл}} + \left(C_{\text{утп}} + C_{\text{птп}}\right) + C_{\text{тн}} \quad (1)$$

In this case: $C_{\text{ифл}}$ - Residual trash content in the fiber**,** %; $C_{\text{утп}}$, $C_{\text{птп}}$ - Content of fiber and plastics of immature fiber in the fiber, %; $C_{\text{тн}}$- Technological defects in the fiber (defects formed during processing operations), %.

Therefore, to obtain “premium” grade fiber, it is necessary

For grade I fiber — accordingly…

$$C_{\text{ифл}} + \left(C_{\text{утп}} + C_{\text{птп}}\right) + C_{\text{тн}} \leq 2{,}0\ \% \quad (2)$$

$$C_{\text{ифл}} + \left(C_{\text{утп}} + C_{\text{птп}}\right) + C_{\text{тн}} \leq 2{,}5\ \% \quad (3)$$

For grade II fiber — accordingly…

$$C_{\text{ифл}} + \left(C_{\text{утп}} + C_{\text{птп}}\right) + C_{\text{тн}} \leq 2{,}5\ \% \quad (4)$$

$$C_{\text{ифл}} + \left(C_{\text{утп}} + C_{\text{птп}}\right) + C_{\text{тн}} \leq 3{,}5\ \% \quad (5)$$

When producing high-grade fiber, one of the most important tasks is to determine the optimal number of cleaning passes. Excessive cleaning, along with a partial reduction in trash content, causes technological defects to appear in the fiber. As a result, the fiber grade may decrease.

In order for the number of defects and contaminating impurities in the produced fiber to meet the requirements for the “premium” and “good” grades, the actual composition of the fiber trash components was analyzed and the issue of minimizing their amount was considered.

It is known that, according to the requirements of PDI 70-2017, “Agreed Technology for Primary Cotton Processing,” the trash content of cotton in the gin tray for grade I and II cotton, class 2, must not exceed 0.9% and 1.5%, respectively. As can be seen from the table, the cleaning efficiency of equipment at cotton ginning plants varies, and due to insufficient use of their capabilities, in almost all processing cases the trash content of cotton exceeded the standard. As a result, “premium” grade fiber was not obtained; mainly “average” and “normal” grade fiber was produced.

In a number of cases, the cotton moisture content was not reduced to 8–9%, and in some cases the cotton was not dried at all (at the Khajaabad gin). The cleaning efficiency of cotton—despite no major differences in its initial trash content—varied significantly among the plants and ranged from 24.1% to 81.9%. As a result, the trash content of cotton in the gin tray also differed and exceeded the requirements of the technological regulations, which led to an increase in its level in the fiber. The share of residual trash content relative to the total amount of defects and contaminating impurities in the fiber was high—starting from 35.5% and in most cases up to 88.9% [8; 9].

At all cotton ginning plants where the experiments were conducted, the trash content of cotton in most cases ranged from 1.8% to 3.73%. This undoubtedly indicates low cleaning efficiency and a reduction in fiber grade. The amount of technological defects in the fiber composition—except for variants 8, 13, 16, 19, and 20—is small; however, the share of natural defects—**ulyuk** and **plastics of immature fiber**—reaching up to 94.5%, certainly makes it difficult to obtain "premium" and "good" grade fiber.

During cotton cleaning, ginning, and fiber cleaning, a portion of the natural defects is separated to some extent and removed with waste, while the remaining portion passes into the fiber. Therefore, it is natural that the amount of natural defects in the cotton delivered to cotton ginning plants should be significantly higher than in the fiber [10; 11].

This situation indicates violations of cotton cultivation agronomic practices and requires serious measures in this direction.

At the same time, the fact that the number of technological defects differs among cotton ginning plants and varies sharply from one to another indicates differences in the technical condition of the process equipment and that it is not operated under the regimes established by technological (regulatory) requirements.

In conclusion, it should be noted that despite the existence of technological requirements and procedures that ensure the production of high-quality fiber at cotton ginning plants, in practice there are deviations from the technological regulations, as a result of which the quality of the produced fiber decreases and it is sold at lower prices. When processing cotton, it is necessary to strictly follow the cleaning plans and operating regimes of the process equipment depending on the initial moisture content and trash content of the cotton, and the cleaning efficiency should be increased to a level above 90% [12].

At some cotton ginning plants, the amount of natural defects in the cotton composition—fiber and plastics of immature fiber—is increasing. This makes it difficult to obtain "premium" and "good" grade fiber. The presence of natural defects in prepared cotton indicates violations of cotton cultivation agronomic practices and requires serious measures to reduce them.

At cotton ginning plants, the fiber grade decreases because the content of defects and contaminating impurities in the produced fiber exceeds the standard requirements by 0.1–0.2%. This shows the need to develop a method for preliminary forecasting of the quality of the resulting fiber.

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