

Observation of Damage of Cotton Fiber in the Processes of Blowing, Cleaning and Carding

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Abstract. The quality of the produced yarn mainly depends on the properties of the raw material, its preparation for spinning, the condition of the equipment, and the preservation of the natural quality of cotton fiber during processing. The question of the number of defects in cotton fiber and their total content is a very important issue for cotton spinning. The non-standardized number of defects in the raw material reduces the quality indicators and yarn yield, which requires additional technological processes; therefore, on the part of production, the requirements for reducing the share of cotton fiber defects are constantly increasing. During processing in blowing and cleaning units and on carding machines, the cotton fiber is mechanically damaged. To observation the damaged fibers, we used the Congo-Roth red paint according to the method of Ch. Dore. Despite the carding is considered the last stage in the process of cleaning the fibers from impurities and defects in the spinning system, 30% of impurities and fiber defects still remain on the card sliver. Besides, it should be noted the carding machine is also considered an additional occurrence of defects, in particular (neps), which reduce the quality indicators of the card sliver and the finished product.

1 Introduction

The observation of damage to cotton and other textile fibers is an extremely important task. The appearance of damage can be caused by a variety of reasons, ranging from the vegetation conditions of the plant, the collection, storage of cotton fiber, as well as from the whole chain of its various processing into yarn and finished fabric [1].

Fiber damage can be created both by isolated mechanical, physicochemical and bacterial causes, and by their mixed effects. Mechanical damage factors are basically simple. However, they can be accompanied by secondary changes, causing changes in physical or chemical properties in the fibers.

To solve the above problems, the following work is required:

- study of types of damage to cotton fibers.

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- creation of new sets of working parts of textile machines, taking into account the properties of the processed product.
- recommendation of the modes of blowing, cleaning and carding, taking into account the properties of the cotton fiber.
- development of effective operating modes of the carding machine (brands TC-11, TC-15 and TC-19i of "TRUTZSCHLER" company) and optimal geometric parameters of the card clothing of its working parts (front and rear angles; steps and heights of teeth; surface roughness, etc.) ...
- optimization of the speeds of the working parts, taking into account the properties of the processed product.

To determine the mechanical damage of cotton fiber, fiber samples are taken from each technological process.

The initial stage of yarn production is the process of blowing and cleaning cotton fiber on machines of a blowing and cleaning unit. The operation parameters of subsequent transitions and the properties of the final product of spinning production largely depend on the optimal and well-coordinated operation of the machines of the unit. Blowing and cleaning units of TRUTZSCHLER (Germany) and RIETER (Switzerland) firms have been successfully installing and are operating at many enterprises.

We have carried out a comparative analysis of the results of the operation of the units. When determining the properties of fibers in the mixture, the average top length (UHML) was 29,6 mm, the Mean length (ML) was 24,8 mm, the content of short fibers (SFC) with a length of 12,7 mm was -7.8% [2, 3, 4].

After the blowing and cleaning process, the amount (SFC) of short fibers with a length of 12,7 mm was 7,5 %, when the fibers entered the feed hopper of the cards, the amount (SFC) of short fibers with a length of 12,7 mm was 7,6 % and after carding on exit the amount (SFC) of short fibers with a length of 12,7 mm was 8,4 %.

As we know, from theory, the mean length of fibers in the web after the removal of short fibers should have increased, but no changes were observed.

The Upper Half Mean length remained within the limit of 29,5 mm, and the Mean length was 24,8 mm, since the amount of short fibers did not decrease.

Based on the above, it can be concluded that fiber damage occurs in the processes of loosening and carding, and this requires a thorough analysis of the technical parameters of the working bodies of the opening and carding machines. For this, we have carried out the following work:

- the operating technological modes (speed, gauge between the working parts) and the geometric parameters of the working parts have been studied.

Based on the results of theoretical and practical studies, we recommend the modes of blowing, cleaning and carding [5, 6, 7].

To study the damaged fibers, we used the Congo-Roth red paint according to the method of Ch. Dore [8].

2 Materials and Methods

When observing the properties of cotton fiber, the Standard of the Republic of Uzbekistan O'zDSt 604: 2016 and the HVI (High Volume Instrument) measuring complex were used.

The HVI complex allows to quickly, objectively, more accurately assess the quality characteristics of cotton fiber.

In addition, the laboratory equipment AFIS PRO 2 from USTER® (Switzerland) and Micronaire KMA were used to study the quality indicators of the fiber.

The test was carried out as follows, kept in water under vacuum, a sample of cotton fiber weighing about 0.1 g is transferred for 5 minutes in an 11% NaOH solution. Then, after rapid

washing in water, it is placed in a saturated solution of Congo-Roth red, where it is left with continuous shaking for 6 minutes. The colored sample is then washed in water until the pink color is still washed off. Then the fiber is treated with 18% NaOH solution to obtain a material suitable for observation under a microscope. Several fibers are taken from the sample together with alkali, which in the preparation should play the role of a liquid medium, and the preparation is examined.

Sequential processing of normally mature and damaged fiber gives the following:
-mercerization with the first alkali solution after fiber swelling, leaving the cuticle intact;
- upon further processing with 18% NaOH solution, the fiber swells even more and breaks the cuticle, which in this case exposes the uncolored layers of fiber cellulose, while the cuticle becomes slightly pink.

Damaged mechanical fibers, which have an incomplete cuticle from blows or scratches, receive intense staining at the sites of damage.

With fungal damage, as well as with heating damage (4-hour heating at 150°), colored spiral dressings are found on the fiber.

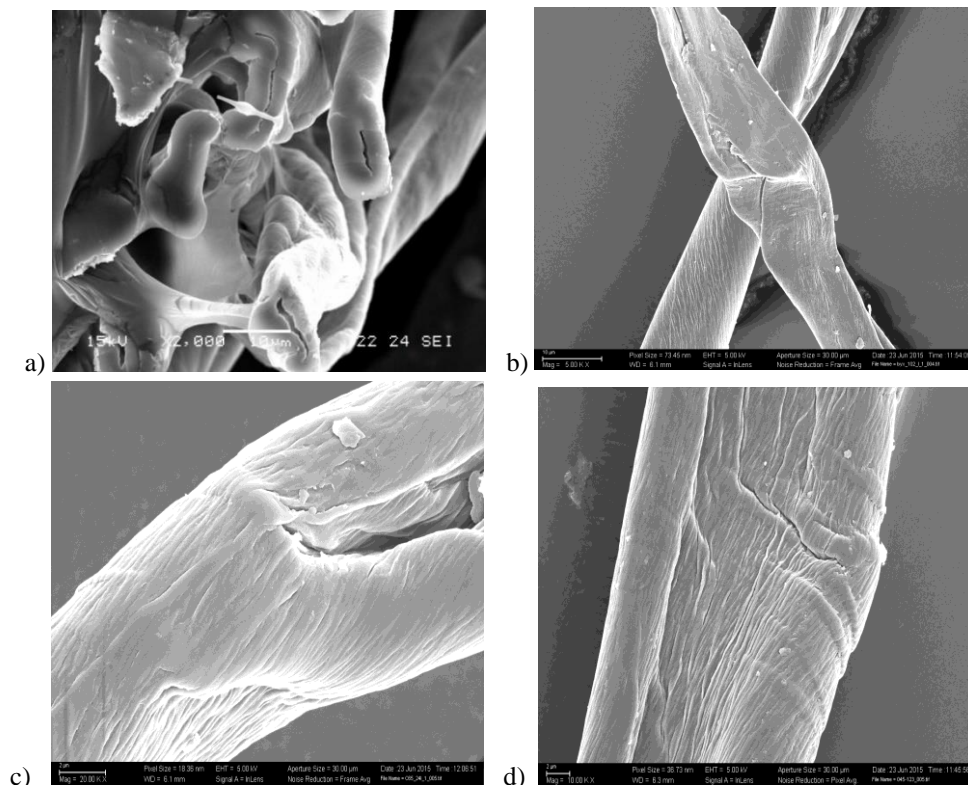


Fig. 1. Cotton fiber of selection C 6524 tested for damage

Mathematical modeling is used for theoretical research and optimization of technological processes.

Optimization of the technological process of the carding machines depends on many factors, determining their optimal performance requires a lot of experiments. The main issue in optimization is to determine the essential factors affecting the operation of the working zones of the carding machines, such as the speed parameters of the cylinder, top flats and taker-in. The essence of optimization lies in the normalization of fibrous waste in the

production of yarn, in order to increase the service life of the machine and increase the competitiveness of the products.

Despite the fact that the carding is considered the last stage in the process of cleaning the fibers from impurities and defects in the spinning system, 30% of impurities and fiber defects still remain on the card sliver.

In addition, it should be noted that the carding machine itself is also considered an additional occurrence of defects, in particular (neps), which reduce the quality indicators of the card sliver and the finished product.

Based on the results of experiments carried out at the URG TEX LLC, a carding machine TRÜTZSCHLER® TC-15 was analyzed to optimize the speed modes of the working parts.

3 Results

The significance of the regression coefficients was assessed using the Student's test. The resulting regression was determined using Fisher's criterion, which showed that the resulting mathematical model is adequate, that is, a correct reflection of the real carding process.

Regression equations are obtained that adequately characterize the estimates,
- defects of ring-spun yarn, neps / 1000 m:

$$Y_R = 182 - 22,75x_1 - 25,1x_2 + 32,6x_3 + 13,0x_1x_3 - 17,1x_1^2 - 15,5x_2^2 \quad (1)$$

In the IT- technologies of the Namangan Engineering and Technological Institute at the Pascal Programming Research Center, on the basis of numerical models (1), isolines are taken, representing the change in the parameters of the external initial deflection of the relationship (Fig. 2 , 3, 4).

The following conclusions were drawn from the analysis of the obtained isolines:
- the indicators of the number of neps on the yarn decrease with an increase in the frequency of rotation of the cylinder and the speed of movement of the top flats.

It should be remembered that the speed of rotation of the cylinder and the speed of movement of the flat do not allow achieving the expected result in terms of yarn quality at the minimum rotation speed.

It turned out that the minimum value of the quality indicators of unevenness and neps of the yarn is achieved at the optimal value of the following research factors: rotation speed of the cylinder - 560 min-1; speed of the flats- 360 mm / min; taker-in drum speed - 1200 min-1.

The analysis of the surface deflection of the isolines in the analytical solutions of the regression relations obtained as a result of practical and three-factor experiments showed that the rotation speed of the cylinder and the speed of the heads in carding have a more effective effect than the rotation speed of the taker-in drum.

The change in the rotation speed of the taker-in drum, the cylinder and the speed of the flats on the carding machine characterize quality indicators such as neps and unevenness formed on the yarn.

Surface deflections of isolines of interrelationships of the amount of neps of the strength of the input factors by the technological process.

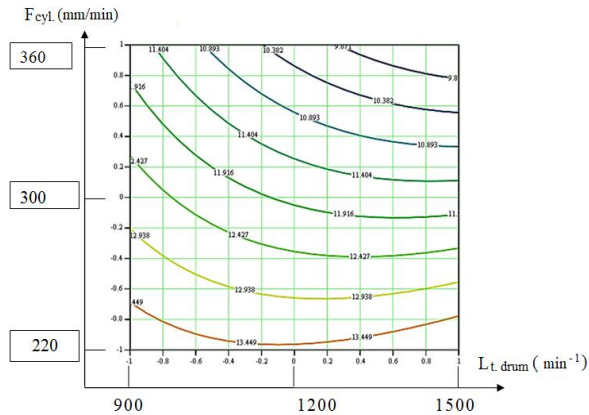


Fig. 2. Isolines of the influence of the speed of the taker-in drum and top flats on the number of neps, $N=f(L_{taker-in} \cdot F_{flats})$

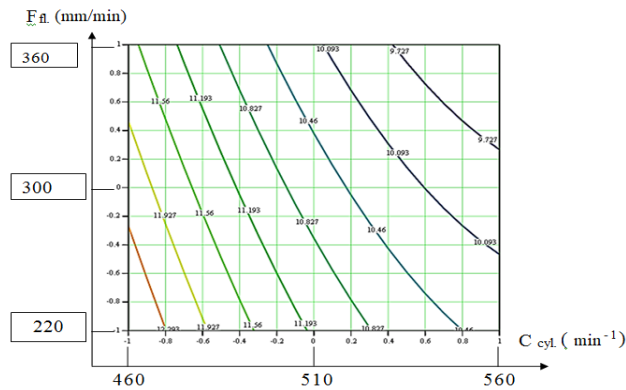


Fig. 3. Isolines of the relationships between the speed of the cylinder and the flats on the count of neps, $N = f(C_{cylinder} \cdot F_{flats})$

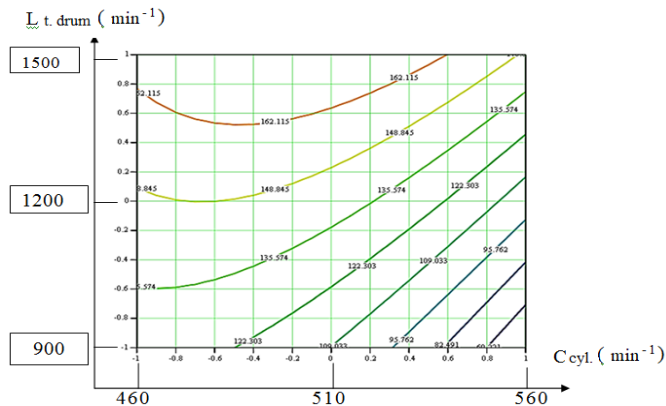


Fig. 4. Isolines of the relationship between the speed of the taker-in drum and the cylinder on the count of neps, $N=f(L_{taker-in} \cdot C_{cylinder})$

4 Discussion

With an increase in the taker-in drum speed, the effect of the rough teeth of the taker-in drum on the fibers also increases. Fiber breakage or damage in turn leads to an increase in the amount of short fibers in the fibrous materials. This means that the mass-length of the fiber staple will also decrease. Fiber breakage and damage, degradation of fiber length directly affect yarn properties.

With an increase in the speed of movement of the top flats, the number of flats entering at a time during the processing of a fibrous product increases, due to continuous interaction with the fibers, and they lead to a decrease in neps.

Also, due to the increased speed of the flats, the flats have a greater interaction with the cleaning roller, which ensures the cleanliness of the flats, which leads to intensive carding proces.

As the speed of movement of the flats increases, the unevenness of the yarn decreases. With an increase in the speed of movement of the flats, the proportion of neps and short fibers (SFC%) decreases, the paralelization of the fibers increases and the unevenness of the yarn decreases.

It should be noted again that regardless of the speed of movement of the flats, as the fineness of the yarn decreases, its unevenness may increase.

At a high speed of the cylinder of the carding machine, the IPI of the yarn is reduced (thick place + 50%, thin place -50%, and neps + 200%).

5 Conclusions

As a result of mathematical planning of the experiment to optimize the parameters of the carding machine it was found that the number of Neps and yarn unevenness indices have the lowest values when the rotation speed of the cylinder is 560 min^{-1} , the speed of the flats is 360 mm / min . and the rotation frequency of the taker-in drum is 1200 min^{-1} .

The influence of the speed of movement of the top flats on the quality of the card sliver and yarn was studied, where increasing the speed of the flats improved the quality of the yarn. Although the yarn quality improved at a flats speed of 360 mm / min , it was recommended that the flats be run at a speed of 320 mm / min to prevent the loss of fibers.

Optimal technological parameters for the production of yarn for weaving and knitting purposes have been developed, which makes it possible to increase the productivity of the carding machines up to $80\text{-}100 \text{ kg / hour}$.

When the taker-in drum speed was increased from 1000 min^{-1} to 1500 min^{-1} the intensity of the carding process increased and the Neps Removal Efficiency (NRE%) increased. Based on the analysis of the research results, it was recommended to keep the taker-in drum speed within 1200 min^{-1} .

Based on the experiments carried out, recommendations were developed for various yarn numbers, taking into account the characteristics of the micronaire of fiber. For yarns of medium linear density (Ne 30-40), the micronaire index of cotton fiber is 3.8-4.3 and for yarns with high linear density (Ne 16-24) the micronaire index is 4,5-4,8. It was found that the unevenness (U%), total defects (IPI) and Rkm of the property values fully meet the requirements of Uster®.

Local medium staple cotton is considered coarse because it has a micronaire index of 4,4 to 5,0 but fiber length code 38 (staple length 35/36 mm), a spinning machine to produce high quality products using improved machines in spinning technology has proven the need optimization.

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