Study of the influence of the output surface of the confusor inside the adapter on the location of fibers in the yarn in a rotor-spinning machine

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Abstract. In the article, the influence of the confusor inside the adapter on the output surface of the rotor-spinning machine on the location of the fibers in the yarn was studied. The properties of carding sliver for yarn production were investigated. In the experimental work, the uniformity and stability of the velocity field of each channel for moving fibers in an aerodynamic device were checked. Airflow was carried out at a speed of 20 m/s. During the research, 20-tex yarns were produced in 3 different samples by changing the output surfaces of the confusor inside the adapter S_1=19.6 mm^2, S_2=12.6 mm^2, S_3=7.1 mm^2 in the rotor-spinning machine. The cross-section and length of the produced yarns were examined under a microscope. The location of the fibers in the conical channel in the yarn was studied.

1 Introduction

The rotor-spinning technique is widely used in the textile industry due to its excellent economic prospects. The rotor is the most important component of the rotor-spinning machine, and its speed has a significant impact on the yarn quality. In the study of Chen and Slater [1], the flow behavior in the rotor changes significantly with increasing speed. Kocyo and Lawrence [2] conducted studies on twisting mechanics and rotor spinning under different operating conditions. Effect of rotor speed and geometrical parameters on airflow Xiao et al. analyzed by [3] and they found that the angular velocity and the slip angle have reached a good axisymmetry of the spiral structure in the meridional plane of the rotor.

Some studies have been done on the airflow in the rotor spinning machine's confusor. Lawrence and Chen [4, 5] used a high-speed camera to capture the fiber morphology during the fiber transfer process and optimized the design of the confounder combined with the empirical formula. Kong and Platfoot [6, 7] found that changing the geometric dimensions of the mixer or the speed of the opening roller affects the shape of the airflow in the mixer. The airflow then changes the configuration of the fibers flowing inside the channel. They also studied the effect of rotating zones on the fiber configuration during transmission within the channel. Lin et al. [8, 9, 10] studied the influence of the geometrical parameters of the

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confusor, the spatial position between the rotor and the channel on the characteristics of the airflow in the rotor spinning machine.

The perfect use of cotton fiber and the study of its properties are of great importance. Correct evaluation of the properties of fibers and selection of their amount in the mixture by the structure of the yarn to be spun should be based on science. At first glance, it seems possible to spin yarn on the arbitrary input and output surfaces of the confusor in a rotor-spinning machine. However, if the dimensions of the entrance and output surfaces of the confusor are not taken into account, the appearance of the yarn structure will not be optimal. This does not ensure the production of yarn at the required level from the fibers [11]. This process is the process of fiber migration, which leads to a change in the yarn structure [12, 13]. Therefore, the influence of the geometric dimensions of the confusor on the yarn quality was studied. At the same time, two types of channel shapes were chosen for the fibers:

- rectangular channel;
- narrowing channel (confuser type)

It was compared to which of the selected channels is the most suitable for transporting cotton fibers.

2 Methods

To continue the research, it was checked whether the quality indicators of the semi-finished product met the requirements. The main stage of fiber processing before spinning in a rotor-spinning machine is carding. At the enterprise, fibers are carded on *TC 15* carding machines. Carding machines separate cotton pieces into individual fibers first by the action of sharp teeth, and then by the action of small dense teeth covered with the surface of the working bodies. In the process of carding, cotton is cleaned of sticky impurities and partially short fibers. As a result of working on a carding machine, the fiber layer turns into a thin strand of individual fibers that are adjacent to each other in length and width. From this yarn, the sliver is carded in the same carding machine. The fibers of the sliver obtained by the carding machine are carded, loosely interlaced, but not yet well straightened, only partially oriented along the length of the sliver.

The unevenness of the carding sliver affects the unevenness of the yarn because the effect of periodic addition in a rotor-spinning machine is manifested only in the unevenness of the shear along the length corresponding to the rotor circumference. If the sliver from the carding machine is uneven, unevenness is created during the drafting process [14, 15].

The damage of the sliver unevenness from the carding machine:

- the unevenness of the yarn is high;
- the strength of the fabric is low;
- various defects appear in the fabric (striped, zebra-like, etc.);
- demand decreases;
- labor productivity is sharply reduced;
- the service area is reduced;
- product cost increases;
- harms economic indicators.

If the amount of drafting is equal to 100, 1 m of yarn is obtained from 1 cm of sliver taken from the carding machine. So, the unevenness of the carding sliver in terms of 1m and 3m cuts affects the unevenness of the yarn.

Taking into account the above, the quality indicators of the carding sliver provided were evaluated by testing on the *Uster Tester 6* device, which was carried out in the production laboratory of the enterprise. Defects were quantified using the *Uster Afis Pro 2* instrument.

The test results are presented in Table 1.

Table 1. Quality indicators of the feed carding sliver.

Indicator name	Value	Uster class
Linear density, tex	5600	-
Metric number (N)	0.178	-
Unevenness of the sliver in cross-section -Linear, U -Coefficient of variation, Cv	 2.1 3.6	 - 50% class
Cv/U ratio	1.714	-
Coefficient of variation for sliver cutting mass, Cv% -1m -2m	 0.49 0.34	- - 25% class 50% class
The number of defects in one gram, pcs -Knots -Impurities	 55 49	 - -
Amount of short fibers, %	5.2	-

As can be seen from Table 1, the quality of the supplied carding sliver is quite good. The quadratic unevenness of the sliver on the cross-section is *Cv=2.1*, which meets the requirements of the 50% class of Uster Statistics. The distribution of fiber mass is uniform across the cross-section. This is confirmed by the *Cv/U ratio of 1.71* (in a normal distribution, this ratio should be *1.25*), which means that the normal distribution is good enough. The number of neps (knots) corresponding to 1 gram of sliver is 49, which is 89% of the total number of defects. The coefficient of variation in the mass of the sliver on the cross-section corresponds to the 25% class for the 1-meter on the cross-section, and the 50% class for the 3-meter on the cross-section.

It can be seen that the quality of the supply sliver is suitable for the production of *20-tex* yarn.

Before the start of the experiments, the uniformity and stability of the velocity field of each channel were checked in the aerodynamic device for blowing the fibers. Experiments have shown that the velocity profile in the suspended fiber zone satisfies the conditions of uniformity both in a rectangular channel (Fig. 1a) and in a narrow channel (Fig. 1b).

3 Results and discussions

The airflow speed was varied from 5 m/s to 30 m/s by gradually increasing the fan rotation speed. The flow rate was determined using a Pitot tube connected to a micromanometer *Benetech GM 8903* Thermoanemometer.

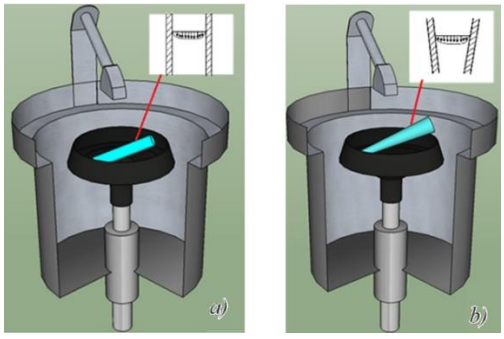

Fig. 1. A fiber-through confusor located in the spinning box: a) – rectangular channel, b) – conical channel.

Experiments on evaluation of the influence of the confusor device installed on the rotor-spinning machine on yarn quality Application and Research Center of Textile and Apparel Manufacturing, "EGE" University of Turkey ” conducted in the laboratory.

A high-magnification *LEICA* (Germany) microscope (Fig. 2) was used to evaluate the hairiness of the yarn and the location of the fibers in the cross-section.

In the rotor-spinning machine, the output surfaces of the confusor were changed to $S_1=19.6\ mm^2$, $S_2=12.6\ mm^2$, $S_3=7.1\ mm^2$, and *20-tex* yarns were produced in 3 different samples. The cross-section and length of the produced yarns were examined under a microscope. It is known that it is not possible to directly examine the cross-section of the yarn through a microscope. Therefore, samples were prepared for viewing the cross-section of the yarn under a microscope. For this, the sample was solidified with *1.02644.1000 Collodion 4%* substance produced in Germany (Fig. 3). *Collodion 4% substance* does not change the structure of the yarn and improves the visibility of the inner parts of the yarn. To see the cross-section of the solidified yarn, it was cut to a certain thickness using a microtome device of the *G103/02 model*, manufactured in England (Fig. 4). The prepared sample was examined using a *LEICA* microscope. Research work was carried out at a temperature of *20.8 C* with *61%* humidity (Fig. 5).

Fig. 2. «LEICA» microscope.

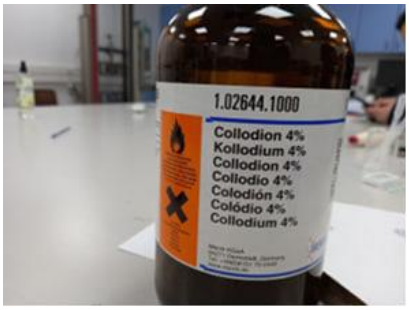

Fig. 3. Collodion 4% substance

Fig. 4. Microtome device of the G103/02 model.

Fig. 5. Humidity and temperature in the laboratory room.

Microscope *"LEICA"* (Fig. 2) is also designed to view textile fibers and other textile materials in a magnified image. *LEICA* microscopes are compact microscopes for clinical, laboratory, fundamental, textile, and educational research. The microscope is designed for viewing fibers, yarns, and textile materials in the research object. The image of the results obtained under the microscope is presented in Fig. 6.

During the research, the speed of the air inside the tube was increased to 20 m/s, and the output surface of the confusor was prepared in 3 different versions: $S_1=19.6\ mm^2$, $S_2=12.6\ mm^2$, $S_3=7.1\ mm^2$, and the yarn was produced.

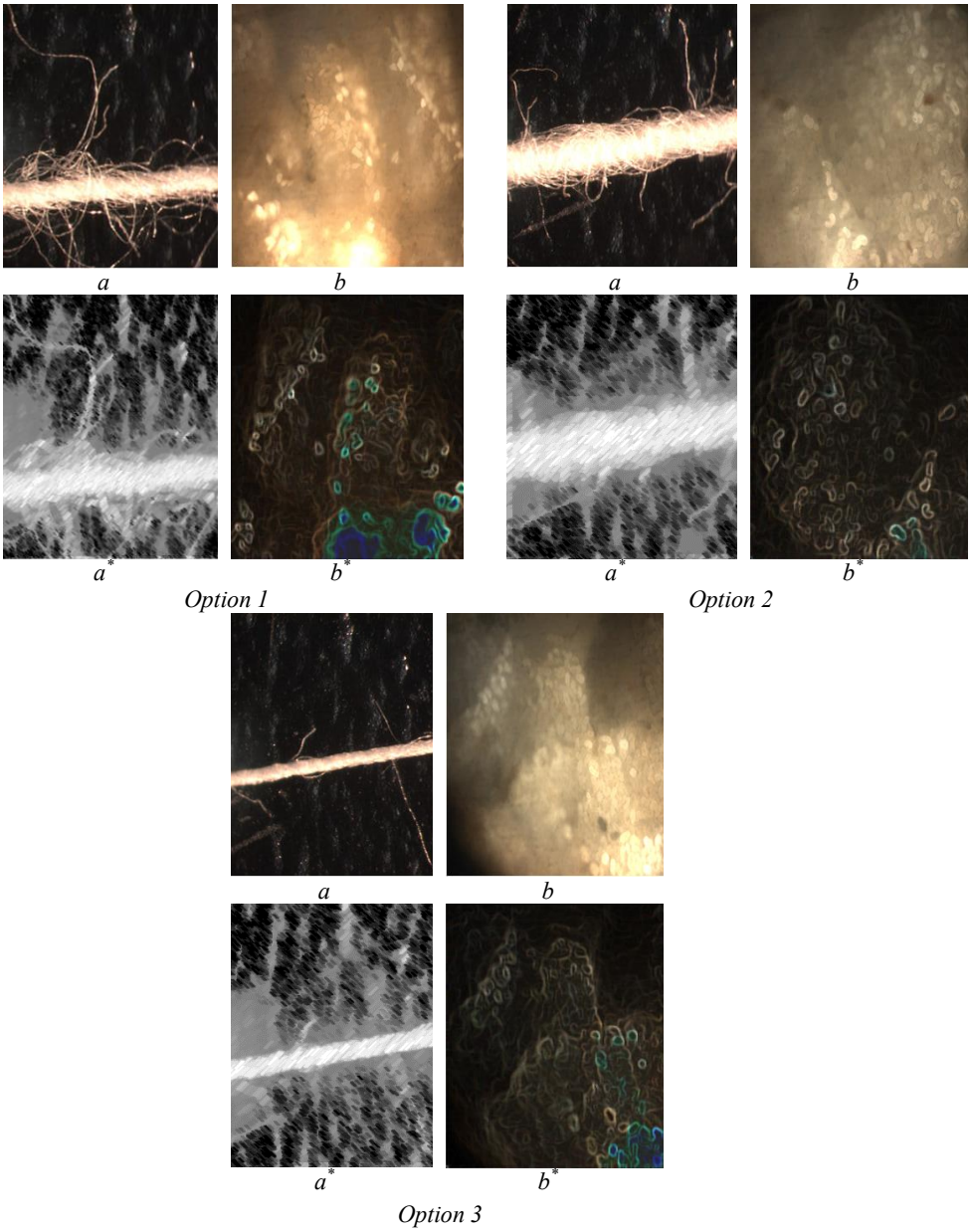

Fig. 6. Longitudinal and cross-sectional surface views of the samples under electron microscope. Longitudinal view of a-yarn, cross-sectional view of b-yarn.

In some cases, it is necessary to take a photomicrograph of the enlarged samples seen through a microscope to study their structure, width, and length.

The degree of hairiness and the location of the fibers on the surface of the cross-section of the samples of the cotton yarn with a linear density of *20-tex* were determined with the help of a microscope *"LEICA"*, and the pictures were taken using a digital camera, and the obtained pictures were transferred to the computer. The obtained photo samples are presented in Figure 6. In this case, in option 1, the yarn was produced when the output surface of the confusor was $S_1=19.6\ mm^2$. In the 2nd option, the yarn was produced when the output surface

of the confusor was $S_1=12.6\ mm^2$. In option 3, the yarn was produced when the output surface of the confusor was $S_1=7.1\ mm^2$ (a and a* are the longitudinal view of the yarn, and b and b* are the cross-sectional view of the yarn).

4 Conclusions

The quadratic irregularity of the sliver according to the section corresponded to the requirements of the 50% class of the Uster Statistics, the coefficient of variation of the shear mass corresponded to the 25% class for the 1-meter shear, the 50% class for the 3-meter shear, and the quality of the sliver is suitable for the production of *20-tex* yarn.

The smaller the output surfaces of the confusor, the lower the hairiness and the higher the density of the yarn, which leads to the thinning of the yarn. In the tested sample, a good result was achieved when the output surface of the 3rd option confusor was $S_3=7.1\ mm^2$. The smaller the output surfaces of the confusor, the lower the hairiness and the higher the density of the yarn, which leads to thinner yarn. Also, the correct use of the geometric dimensions of the confusor ensures high spinning stability due to the reduction of yarn hairiness, improvement of the yarn formation process, increase of class, and reduction of defects in appearance.

References

1. R.H. Chen and K. Slater, J Text Inst, **85**, 191–197 (1994)
2. E. Koc¸ and C.A. Lawrence, J Text Inst, **97**, 483–492 (2006)
3. M.N. Xiao, et al., J Text Res **35**, 136–141 (2014)
4. C.A. Lawrence and K.Z. Chen, J Text Inst **79**, 367–392 (1986)
5. C.A. Lawrence and K.Z. Chen, J Text Inst, **79**, 393–408 (1986)
6. L.X. Kong and R.A. Platfoot, Text Res J, **66**, 641–650 (1996)
7. L.X. Kong and R.A.Platfoot, Comput Struct, **78**, 237–245 (2000)
8. H.T. Lin, J. Wang and Y.C. Zeng, J Text Res, **36**, 98–104 (2015)
9. K. Gnanasekar, P. Chellamani, S. Karthikeyan, Indian Journal of Fiber and Textile Research **15**, 164-168, (1990)
10. Sh.A. Korabayev, S.L. Matismailov, J.Z. Salohiddinov, *Investigation of the impact of the rotation frequency of the discretizing drum on the physical and mechanical properties of,* Actual problems of modern science, education and training in the region 2018-III. pp. 65-69, Urgench, Uzbekistan (2018)
11. Sh. Korabayev, et al., Scientific and Technical journal Namangan Institute of Engineering and Technology **8(2)**, 18-22, (2023)
12. Jahongir Soloxiddinov, et al., AIP Conf. Proc. **2789 (1)**, 040115 (2023)
13. Slobodan Stefanovic, Sherzod Korabayev, Sanjar Tojimirzaev, *AIP Conf. Proc.* **2789(1)**, 040017 (2023)
14. Sherzod Korabayev, Jamoliddin Ergashev, Umarjon Meliboyev, Abbosbek Mukhtarov, *AIP Conf. Proc.* **2789 (1)**, 040130 (2023)
15. Jakhongir Soloxiddinov, Husanhon Bobojanov, Shavkat Fayzullayev, Sherzod Korabayev, *AIP Conf. Proc.* **2432 (1)**, 030038 (2022)