THEORETICAL SUBSTANTIATION OF THE POSSIBILITY OF PRODUCING ROTOR SPUN YARN FROM FIBROUS WASTE

Makhkamova Shoira Fakhritdinovna[a], Gafurov Kabul Gafurovich[b], Valieva Zulfiya Fakhritdinovna[c], Rajapov Odil Olimovich[d], Tulaganova Mohinur Vohid qizi[e]

Article History: Received: 28.05.2022 **Revised**: 27.06.2022 **Accepted**: 10.07.2022

Abstract: This article has studied the possibility of production a rotor yarn of fibrous waste with a high content of short fibers. The effect of the fiber length and the diameter of the spinning rotor to capture factor of fibers, linear density and twist the stick-layer rotor yarn was researched. Experiments were carried out on the rotor spinning machine SCHLAFHORST AS-360. The results of the tests proved the possibility of obtaining high-quality rotor yarn of short fibers.

Keywords: fibrous waste, fiber, fiber length, rotor spun yarn, fiber capture ratio, twist.

[a]. PhD, Associate Professor, Tashkent Institute of Textile and Light Industry
[b]. PhD, Professor, Tashkent Institute of Textile and Light Industry
[c]. PhD, Associate Professor, Tashkent Institute of Textile and Light Industry
[d]. PhD, Associate Professor, Tashkent Institute of Textile and Light Industry,
[e]. PhD, assistant, Tashkent Institute of Textile and Light Industry

Email: shoira-0218@mail.ru, zulfiya-valieva-76@mail.ru, odil2005@rambler.ru, mohinurtulaganova92@gmail.com

DOI: 10.31838/ecb/2022.11.04.009

INTRODUCTION

One of the means of efficient and economical use of the raw material base in the cotton industry is the rational processing of spinning waste. To solve this issue, along with a wide range of purposeful design and technological developments, a lot of organizational work is required to coordinate the activities of all branches of the textile industry and the rapid introduction of promising innovations, the wide dissemination of the experience of enterprises processing waste from their own and related industries. Of particular importance are universal technologies and equipment created on the basis of existing modernized and newly created units, mechanisms and machines. It is also necessary to properly use the waste of cotton production, that is, to produce fabrics from them, the consumer properties of which allow the use of such raw materials. Yarn should be produced on specialized equipment installed in workshops adapted for its processing.

At present, the rotor spinning method is widely used to produce yarn from fibrous waste. Rotor spun yarns appear to be no different from ring spun yarns on the surface. However, there exist some rather important differences in the internal structures of the yarns, especially in fiber contiguity. These differences in internal structures are reflected in different performance characteristics. Rotor spun yarns tend to be more uniform in appearance and in linear density than ring spun yarns. It is conceivable that the better short-term evenness of rotor spun yarn is an obvious result of the suppression of the drafting wave and the large packages formed in rotor spinning. Also, rotor spun yarns are known to be somewhat more extensible, fuller, softer and less hairy. The main disadvantage is that rotor spun yarns are not as strong as ring spun yarns, and the maximum tenacity of rotor spun yarns is at least 10–30%, and in some cases even up to 40%, lower than that of ring spun yarns. It is pointed out that although significant differences exist between rotor and ring spun yarns, various fiber factors and spinning conditions could greatly alter the properties of rotor spun yarns [1].

The choice of raw material plays a dominant role in controlling yarn quality in rotor spinning**.** There is a general consensus of opinion that the raw material properties must be ranked in a different order of importance for rotor spinning than for ring spinning. Fiber length characteristics, particularly length uniformity, play only a minor role in rotor spinning, and long fibers offer no advantage. Longer fibers can adversely affect yarn strength and evenness due to the greater incidence of wrapper fibers and poor fiber orientation [2]. Therefore, the study of the possibility of producing rotor spun yarn from fibrous waste with a high content of short fiber is an urgent task.

MATERIALS AND METHODS

As is known, a part of the fibers of the incoming discrete stream clings to the open end of the yarn at the place of its separation from the surface of the spinning rotor [3] (Fig 1).

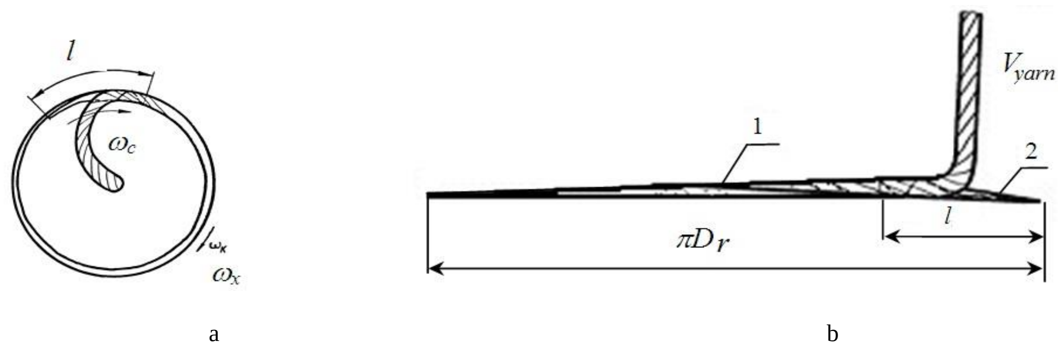

Figure 1. Formation of rotor yarn and its ends: a- ring of fibre; b- yarn ends: 1-long; 2-short

The fibers of the discrete flow entering the conical surface of the spinning rotor are located along the entire perimeter of the trough, forming a fibrous wedge. Part of the fibers inevitably gets to the lift-off point of the fibrous layer from the rotor groove. The ends of these fibers, which have fallen into the groove behind the lift-off point, are captured and carried away by the yarn. Any section of such fiber that falls on the twisted section of yarn at the its lift-off point is removed from the groove earlier than the rest of the fiber sections. These fibers are wound in different directions on the ballooning section of the yarn, forming the so-called wrapping U-shaped fibers or wrapping hook fibers with different lengths (long and short end) of the hooks directed forward in the direction of yarn movement. Changing the amount of short-ended fibers directly affects the respective properties of the yarn. Therefore, to estimate the number of wrapping fibers, such a concept as the catching coefficient K_c is introduced, which is determined by the ratio of the half-length of the fibers to the perimeter of the spinning rotor, i.e.

$$K_c = \frac{l}{2\pi D_r} \quad (1)$$

From the formula it can be seen that the catching coefficient is directly proportional to the length of the fiber, and to the diameter of the spinning rotor it is inversely proportional. The winding of the fibers mainly takes place at or behind the lift-off point with different lengths. In formula (1), the catching coefficient is expressed by the half-length of the wrapping fibers $\left(\frac{l}{2}\right)$.

Thus, in fact, not one fibrous wedge is formed in the groove of the spinning rotor, but two - a long and a short one. A long wedge forms the core of the yarn. The maximum number of fibers in the cross section of a long wedge, taking into account the catching coefficient, is:

$$m_{yarn} = m_{\text{f.r}}(1 - K_c) \quad (2)$$

where, $m_{\text{f.r}}$ - the maximum number of fibers in the cross section of the fibrous ribbon.

Part of the fibrous ribbon, formed from the fibers of a long wedge, is well twisted and forms the main core of the yarn. The fibers of a short wedge are wound around it, forming an external weak wrapping layer. These fibers have little resistance when the yarn breaks and are, as it were, additional, bringing the thickness of the yarn to its nominal value. The core part of the yarn, formed from a long wedge, resists breaking the yarn and determines its strength.

In the normal technological process of spinning, torsion in the core part of the yarn proceeds normally, and in the wrapping layer this process is uncontrollable. The twist of the core part is equal to the nominal twist. The linear density of the core part is determined by the formula:

$$T_{c.p} = T_{yarn}(1 - K_c) \quad (3)$$

where, T_{yarn} – nominal linear density of yarn, tex.
The twist multiplyer of the core part is equal:

$$\alpha_{c.p} = \alpha_n \sqrt{(1 - K_c)} \quad (4)$$

where, α_n - nominal twist multiplyer of yarn.

According to prof. A.G. Sevostyanov, a decrease in the diameter of the spinning rotor leads to an increase in the catching coefficient K_c, which means it leads to an increase in the possibility of forming yarn with a large proportion of the wrapping layer [3]. When determining the twist of rotor spun yarn, this statement is of great importance.

When calculating the twist intensity of rotor spun yarn, the formula for determining the number of twists of ring spun yarn is often used, taking into account which one can write

$$K_{c.p} = K_{yarn} \sqrt{(1 - K_c)} \quad (5)$$

The formation of the core layer in the groove of the spinning rotor from a long wedge and from a short wedge of the wrapping layer of yarn is the basis of the rotor spun yarn structure. The change in the proportion of layers in the yarn structure is related to the catching coefficient, i.e. reducing the catching coefficient improves the properties of the yarn. Therefore, the study of the possibility of reducing the catching coefficient is an actual task. When spinning relatively short fibrous waste, rotor spinning machines are mainly used. In order to study the causes of this phenomenon, the effect of changing the length of the fiber, the diameter of the spinning rotor, as well as the twist on the properties of the rotor spun yarn was investigated.

Results and Discussion. In order to study the validity of the above assumption, experiments were carried out in practice, i.e. the influence of the diameter of the spinning rotor on the structure and properties of the yarn on the rotor spinning machine SCHLAFHORST AS-360 was studied. The effect of changing the length of the cotton fiber, the diameter of the spinning rotor and the twist of the yarn on the catching coefficient, as well as on the linear density of the core layer, was determined by formulas (3-5), and their relationship with the catching coefficient was also studied.

In the work, a mixture of spinning waste of standards 3, 7 and 11, formed during the processing of fiber 4-I, was regenerated and the ranges of fiber length variation were adopted. The staple fiber length was changed from 22 mm to 28 mm, and the rotor diameter from 28 mm to 46 mm. The catching coefficient K_c was calculated by formula (1) and a histogram was constructed based on the results obtained (Fig. 2).

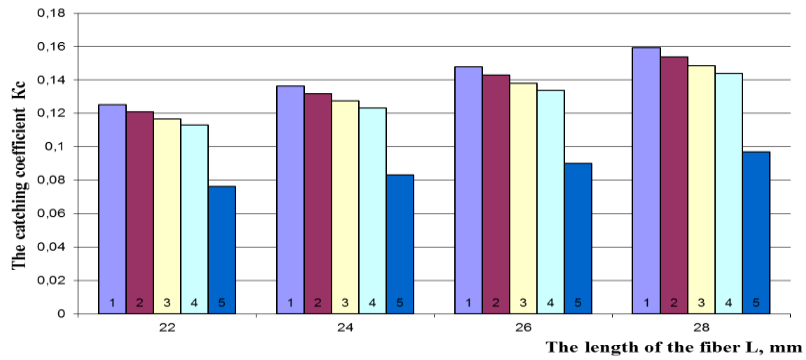

Figure 2. Dependence of the catching coefficient on the length of the fiber and on the diameter of the spinning rotor: 1 - 28 mm; 2 - 29 mm; 3 - 30 mm; 4 - 31 mm; 5 - 46 mm

As can be seen from fig. 2, with an increase in the length of the fiber, the value of the catching coefficient increases, and with an increase in the diameter of the rotor, the value of the catching coefficient, on the contrary, decreases. On fig. 2 it is also clearly seen that Kz = 8% (providing the best yarn formation according to A.G. Sevostyanov) when spinning a short fiber, it is possible with a rotor diameter of 46 mm.

If the linear density of the rotor yarn is close to the nominal value, then its breaking load is less than the breaking load of the yarn obtained on the ring spinning machine, which is mainly due to the linear density of the core layer of the rotor yarn. With this in mind, the influence of the fiber length and rotor diameter on the linear density of the core layer of yarn with a linear density of 50 tex was studied (Fig. 3)

The shorter the fiber length, the thicker the core layer, the yarn strength should also increase. Along with this, with an increase in the diameter of the rotor, the linear density of the core layer increases and the strength of the yarn increases. To increase the productivity of the spinning machine, it is necessary to increase the speed of the rotor, which in turn requires a decrease in the diameter of the spinning rotor.

As a result, the features of rotor spinning appear and the physical and mechanical properties of the yarn begin to change. For example, with an increase in the rotational speed from 60000 min^{-1} to 90000 min^{-1}, the diameter of a yarn with a linear density of 50 tex decreases from 0.245 mm to 0.222 mm. Relative yarn density increased from 1.055 mg/mm^3 to 1.274 mg/mm^3 [3]. It follows that when spinning short fibers, it is advisable to rotate the chamber at a higher speed, since the structural criteria that determine the performance of the fibers are the twist, density and migration of the fibers.

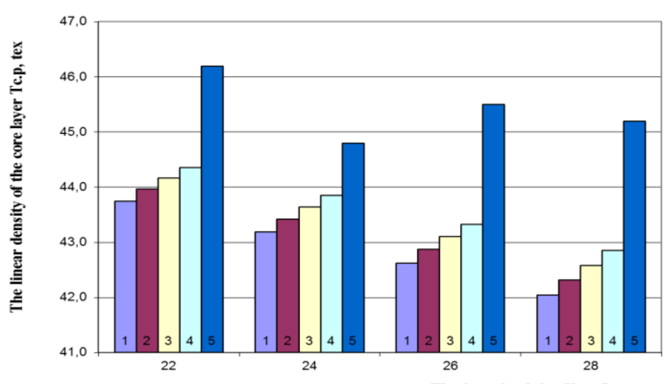

Figure 3. Dependence of the linear density of the core layer of rotor spun yarn 50 tex on the length of the fiber and the diameter of the spinning rotor: 1 - 28 mm; 2 - 29 mm; 3 - 30 mm; 4 - 31 mm; 5 - 46 mm.

The dependence of the twist of the core layer of rotor spun yarn 50 tex with a nominal twist of 630 twists/m on the length of the fiber and on the diameter of the rotor in the form of histograms is seen in Fig. 4.

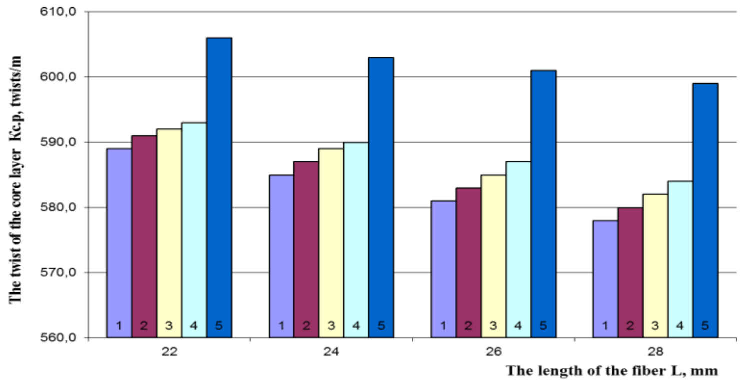

Figure 4. Dependence of the twist of the core layer of rotor spun yarn 50 tex on the length of the fiber and the diameter of the spinning rotor: 1 - 28 mm; 2 - 29 mm; 3 - 30 mm; 4 - 31 mm; 5 - 46 mm.

It can be seen from Fig. 4 that the twist of the core layer increases with an increase in the chamber diameter, i.e. with an increase in the linear density of the core layer, the loss of twist decreases. With a chamber diameter of 46 mm, the twist of the core layer, depending on the length of the fiber, is 95-96% of the nominal twist of the yarn, which should increase the breaking load of the yarn produced from the fibrous waste.

In addition to the diameter of the spinning rotor, the quality of the yarn is also influenced by its design. By selecting the appropriate rotor design, it is possible to increase the strength of the yarn, reduce its unevenness, and stabilize the spinning process.

CONCLUSION

As a result of the research, the dependence of the yarn structure on the catching coefficient was established. Its value decreases with a decrease in the length of the fiber, and with an increase in the linear density of the core layer, the loss of twist is eliminated. As a result, it can be concluded that despite the short fiber length, the breaking load of the yarn increases. From the above, it follows that when refueling equipment, it is necessary to make a compromise decision depending on the tasks solved by production

REFERENCES

i. C.A. Lawrence Advances in Yarn Spinning Technology Woodhead Publishing Series in Textiles 2010, Pages 431-446

ii. https://textilelearner.net/ring-spun-yarn-and-rotor-spun-yarn/

iii. Sevostyanov A.G. etc. Mechanical technology of textile materials, - M: Legprombytizdat, 1989 - 512 p.

iv. Pavlov Yu.V. Theory of processes, technology and equipment for spinning cotton and chemical fibers: Textbook. - Ivanovo: IGTA, 2000 -392 p.

v. Maxkamova Sh.F., Ismatova M.M., Ochilov T.A. Change of Mechanical Properties of The Yarns Depending on The Layer of Reiler// International Journal of Advanced Research in Science, Engineering and Technology. Vol. 6, Issue 4, April 2019, pp. 8826-8831

vi. Matismailov S. L., Aytymbetov S. R., Maxkamova Sh.F, Yuldashev A. T. Research of the Opportunity for the Production of OE Yarns from Regenerated Fibrous Waste// International Journal of Advanced Research in Science, Engineering and Technology. Vol. 6, Issue 5, May 2019, pp. 9301-9304

vii. Makhkamova SH.F., Gofurov K.G., Isakulov V.T., Valiyeva Z.F. Vliyaniye dliny volokna na svoystva pnevmomekhanicheskoy pryazhi// Problemy tekstilya - Tashkent, №1/2017. - S. 71-76

viii. Matismailov S.S., Makhkamova SH.F., Zokhidov U. Issledovaniye vliyaniya konstruktsii rotorov na kachestvo pryazhi // «Sovremennyye instrumental'nyye sistemy, informatsionnyye tekhnologii i innovatsii» Sbornik nauchnykh trudov XII-oy Mezhdunarodnoy nauchno-prakticheskoy konferentsii, g.Kursk, 19-20 marta 2015 goda (3 tom), S.49-52

ix. Gafurov K.G., Makhkamova SH.F., Valiyeva Z.F. Regeneratsiya pryadomykh otkhodov khlopkopryadil'nogo proizvodstva // Mezhdunarodnaya nauchno-prakticheskaya konferentsiya «Pererabotka otkhodov tekstil'noy i legkoy promyshlennosti: teoriya i praktika» Respublika Belarus', g. Vitebsk. Vitebskiy gosudarstvennyy tekhnologicheskiy universitet, 30 noyabrya 2016g, S. 32-35

x. Gafurov ZH.K., Makhkamova SH.F., Gafurov K.G. Snizheniye nerovnoty po mekhanicheskim svoystvam pnevmomekhanicheskogo sposoba pryadeniya pryazhi// «Innovatsionnyye tekhnologii v tekstil'noy i legkoy promyshlennosti» Materialy dokladov mezhdunarodnoy nauchno-tekhnicheskoy konferentsii, posvyashchennoy Godu nauki, Respublika Belarus', g. Vitebsk. Vitebskiy gosudarstvennyy tekhnologicheskiy universitet, 21-22 noyabrya 2017 g., S. 28-31

xi. Makhkamova SH.F., Valiyeva Z.F. Issledovaniye vozmozhnosti ispol'zovaniya regenerirovannykh voloknistykh otkhodov v pnevmopryadenii// Mezhdunarodnyy nauchno-prakticheskiy simpozium «Progressivnyye tekhnologii i oborudovaniye: tekstil', odezhda, obuv'», VGTU, Vitebsk, 2020g. 3 noyabrya, S.58-61.

xii. Aralbaevich, P. B., Abdumalik, P., Faridovich, R. F., & Zivaddinovich, M. S. (2022). Changes of cotton fiber properties in the ginning and automatic bale opener. European Chemical Bulletin, 11(1), 4-4.

xiii. Paluanov, B. A., & Pirmatov, A. P. (2021). Organization of compact spinning technology in textile clusters. Karakalpak Scientific Journal, 4(1), 17-22.

xiv. 14.Baxtiyar, P., & Abdimalik, P. (2021). Efficient organization of harvesting and processing of cotton seeds. Universum: технические науки, (3-4 (84)), 77-79.

xv. 15. Berdimuratova, A. K., & Mukhammadiyarova, A. J. (2020). Philosophical and methodological aspects of the interaction of natural environment and man. International Journal of Pharmaceutical Research. https://doi.org/10.31838/ijpr/2020.12.03.235

xvi. 16. Pirnazarov, Nurnazar; Eshniyazov, Rustam; Bezzubko, Borys; Alimov, Atabek; Arziev, Amanbay; Turdibaev, Alauatdin; ,Bachelor degree programs in building materials technology,European Journal of Molecular & Clinical Medicine,7,10,1780-1789,2021,

xvii. 17. Ploypailin Sriwiset, Pirnazarov Nurnazar; ,The Protection of Patents on Animal-related Inventions: Thailand's Problems and Solutions,Res Militaris,12,1,73-85,2022,