THE INFLUENCE OF THE DELIVERY CYLINDER OF RING SPINNING MACHINE ON YARN QUALITY INDICATORS

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Abstract
This article investigates the influence of the flutes (grooves or notches) on the surface of the delivery cylinder (i.e., the final drafting pair) in a ring spinning machine on yarn quality. The study examines the geometric shape, depth, spacing, and orientation of the fluted cylinders as variable parameters and analyzes their impact on key yarn quality indicators—strength, elongation, hairiness, and unevenness. Experimental work was conducted using yarns made from natural fibers (cotton). The obtained results demonstrate that properly designed fluted cylinders ensure controlled fiber movement, improving yarn uniformity and reducing hairiness. At the same time, incorrect flute parameters may lead to fiber breakage and degradation of yarn quality. The article concludes with recommendations for optimal flute geometry and parameters.

Keywords: Ring spinning machine, delivery cylinder, flute, groove, yarn quality, hairiness, unevenness, strength, elongation, geometric parameters, fiber motion.

Introduction

The textile industry is one of the oldest industrial sectors in human history. Even in the modern era, it continues to play a vital role in ensuring human prosperity and maintains sustainable development. Spinning technology, as the most critical and foundational stage of textile production, directly influences product quality. Although yarn spinning has been known since ancient times, it continues to evolve, enriched by technological advancements.

The quality of spun yarn not only affects the yarn itself but also directly impacts the quality indicators of semi-finished and finished products. Particularly in subsequent processes such as weaving, dyeing, or finishing, defects present in the yarn can lead to a decline in overall product quality. Therefore, modern production places great emphasis on key quality parameters such as structural uniformity, smoothness, hairiness level, and strength.

In Uzbekistan, cotton fibers of medium length and linear density are predominantly cultivated. To produce high-quality yarn from this raw material base, it is essential to select optimal technological parameters during spinning. Ensuring controlled fiber movement during spinning, preventing excessive tension or breakage, and producing yarn with minimal defects and high uniformity are among the primary objectives of the process. In this regard, the design of fluted delivery (final) cylinders in ring spinning machines holds particular significance.

Modern automated spinning machines enable controlled fiber spinning, establishing the ring spinning system as the most efficient yarn production method. In practice, yarn spun using the ring system is often compared with yarn produced by other spinning methods, serving as a benchmark for quality assessment. Improving yarn quality and cost-efficiency is closely linked to the technological progress of the spinning industry. Consequently, extensive research is being conducted to enhance yarn quality under high-speed production conditions.

Materials and Methods

To obtain high-quality yarn in ring spinning, delivery cylinders with diagonal flutes at a 20° angle were developed and installed in parallel between two drafting zones of the machine. Based on this design approach, Ne=30 count ring-spun yarns were produced. Test results were compared and analyzed against the physical-mechanical properties of commercially available Ne=30 count yarns.

In order to obtain high-quality ring-spun yarns, the groove angles of the drafting rollers were modified at different degrees, and yarns were spun using various configurations. In this study, diagonal grooved rollers with a 20° angle were applied to improve the ring spinning process. The newly designed grooved rollers help concentrate the fiber flow along the central axis between the drafting roller pairs, which leads to a reduction in the size of the spinning triangle. As part of the experiment, scientific observations were conducted on yarns with a count of N_e=30 ktex using an operational ring spinning machine. During this process, one set of yarn samples was produced on a conventional ring spinning machine, while the other set was spun on a modified machine equipped with drafting rollers having altered groove angles. In the yarn spun using the conventional method, some fibers deviate from the main fiber stream and exit the twisting triangle in a dispersed manner. These stray fibers do not sufficiently bind with the core fibers during twist insertion, leading to an increase in yarn hairiness.

By changing the groove angle of the drafting rollers, it is possible to retain fiber ends within the yarn structure during the twisting process, thereby preventing them from protruding outward. As a result, the yarn smoothness and overall quality indicators are improved.

In the ring spinning process, the insertion of twist into the yarn occurs along a curved path between the traveler and the delivery rollers of the drafting system. The twist is transferred to the yarn in the direction opposite to the fiber flow. The traveler delivers the twist to the fibers emerging from the delivery roller as close as possible to the nip point. However, the twist never

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fully reaches the nip point, since the fibers exiting the front drafting rollers are already aligned along the axis of twist.

During spinning, both the core and surface fibers that make up the yarn form a spinning triangle—a characteristic feature of the ring spinning process—along their movement trajectory. The length of this rotating spinning triangle depends on the geometry and intensity of the twist insertion. The shape and size of this spinning triangle significantly influence the structure, physical-mechanical properties, and surface characteristics of the yarn being spun. In some cases, fibers located at the edge of the spinning triangle may not fully integrate into the yarn structure. These stray fibers contribute to increased yarn hairiness.

During the spinning process, the twist is gradually transferred to the yarn through the traveler, resulting in the formation of a spinning triangle. This process creates a certain level of tension within the fiber bundle that constitutes the yarn. A cross-sectional analysis of the yarn reveals an asymmetric distribution of fibers: fibers located at the edges of the spinning triangle are subjected to less twist, while those in the central region receive a higher degree of twist.

Due to this asymmetric distribution, the likelihood of fiber breakage increases depending on their position. The outer fibers bear a greater portion of the axial load of the yarn, which over time leads to fiber breakage. This negatively impacts the overall tensile strength of the yarn and prevents full utilization of the fibers' strength potential.

Table 1. Yarn Quality Indicators Before and After Modification of the Drafting Roller Grooves

№	Quality Indicators	Yarn Produced in the Factory (Conventional)	Yarn Produced with Modified Drafting Rollers
1	**Unevenness [U%]**	**10.70**	**10.36**
2	**Coefficient of Variation by Count (CVm %)**	**13.42**	**13.12**
3	**Neps, 200% /km**	**126**	**121**

In the conventional ring spinning system, the fibers entering the drafting zone have an almost uniform linear density and are predominantly oriented parallel to the yarn axis. In the newly proposed system, however, the gradual decrease in compression of the yarn width by the front rollers leads to the formation of a slit-shaped spinning triangle.

In this scientific study, a comparative analysis was conducted between ring-spun yarns produced using the traditional ring spinning system and those produced with modified drafting rollers featuring grooved surfaces. During the experiment, the physical and mechanical properties of the yarns were analyzed using modern laboratory equipment manufactured by the Swiss company USTER, which enabled the identification of differences between the two yarn types.

In the yarn spinning industry, unevenness refers to the repeated occurrence of thick and thin spots in the yarn. Based on the studied samples, the unevenness in the yarn produced using the traditional method was 10.70 U%. On the other hand, in yarns spun with modified drafting rollers at a 200° angle, the unevenness was reduced to 10.36 U%.

The coefficient of variation by count (CV m %) for the unevenness of yarn produced using the conventional method was 13.42%. However, after modifying the drafting roller grooves, the coefficient of variation decreased to 13.12%. These results indicate that the quality of the yarn produced using the new experimental method has improved.

The smoothness, evenness, and color consistency of clothing largely depend on the yarn's hairiness level. The reduction of surface defects in spun yarns improves the quality of fabrics made from them. Surface defects or "neps" in yarns are related to their hairiness. During the study, surface defects were tested using the **USTER TESTER 6** equipment. The yarn produced in the factory had an average of 126 neps/km. However, after changing the drafting roller grooves, the number of neps decreased to 121 neps/km. These results demonstrate that yarns spun on the G 32 machine with a N_e=30 ktex count showed a 4% improvement compared to those produced in the factory.

Additionally, the hairiness of the yarn is a critical factor in fabric production. Depending on the type of product being made, the yarn's hairiness level is selected. For example, hairy yarns are used for producing soft and warm fabrics such as bumazey, bayka flannel, and others. Hairiness is defined as the number of fibers sticking out of the yarn, with one end of the fiber being part of the yarn and the other end protruding from it. In the study, the hairiness level of the spun yarn was measured using laboratory equipment. The results showed that after modifying the drafting roller grooves, the hairiness of the yarns decreased. This process is clearly shown in the 3rd histogram.

Conclusion

The results of this study show that modifying the drafting roller grooves of a ring spinning machine is an effective solution for improving yarn quality. The primary goal of this modification is to stabilize the yarn and prevent its spreading in the drafting zone. Additionally, this change increases the frictional force acting on the fibers, improving their control.

Results

When comparing the characteristics of the yarns produced in the factory and those produced with modified drafting rollers, we observed a 3.2% improvement in the unevenness coefficient. Furthermore, the number of neps in the yarn decreased by 4%. These changes confirm that the yarn quality has directly improved as a result of these modifications.

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