Improvement of product drafting process in drafting devices of the spinning machines with the application of straps

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Abstract. This paper covers the analysis of operation drafting devices of the spinning machines, the technological requirements for the processes of product straightening, product drafting, straightening and parallelization of fibers and the basic theoretical prerequisites. The main geometrical parameters of design of drafting pairs, their interaction, influencing factors as the process of yarn formation after drafting, with the use of straps, are considered. Analysis of the operation of the existing design of drafting devices of technological machines of spinning production has the following disadvantages: low reliability and service life of rubber straps, insufficient strength characteristics and elastic-mechanical properties of the frame element made of technical cotton fabrics. It is necessary to select a pair of straps that meets all the requirements of conditional operation of a pair of straps as a frame element for the upper and lower straps made of thin-layer metal fabric made of metal thread, make adjustments to additional calculations of the design parameters of the drafting devices, taking into account the straps made with a thin metal fabric base.

1. Introduction
Existing spinning mills in our country are effectively using high-speed, high-effective ring spinning machines manufactured by world-famous companies at domestic enterprises.

Spinning machines and the processes performed on them are complex. In order to produce quality products on these machines and increase their productivity, it is necessary to thoroughly study and analyze the physical nature of the processes performed on them, to determine the optimal performance of technological processes.

In the process of yarn production, the focus is on the spinning steps, as well as a good knowledge of the relationships between the properties of the yarns obtained from them.

For example, the thickness and fineness of the fibers are of great importance in the spinning process. For example, the properties of removable yarns depend on the thickness and fineness of the fibers. From thin fibers, thin, flat and strong yarns that meet the demand are obtained [1].

Fine yarns are used to produce elegant, light fabrics and knitted fabrics. The thinner the fiber, the more fibers there will be in the cross section of the yarn of the same thickness. This increases the contact surface area of the fibers in the structure of the yarn and increases the friction force, resulting in higher yarn strength. The relative strength of yarns spun from thick fibers is small, a figure that is significant for thin yarns. In the spinning process, a certain amount of fiber must be present in the cross section of the yarns in order to obtain normally quality spun yarns. The linear density of the fiber is crucial to
obtain yarns with a minimum linear density. It follows that the minimum number of fibers in the cross section of yarns of minimum thickness will vary. There are also downsides to very thin fibers. Such fibers cause more confusion during the spinning process, and knots are formed, which leads to deterioration of the appearance and quality of the yarn [2].

Moreover, the unevenness of the yarns in terms of thickness is the most important quality indicator. Because of unevenness, streaks are formed in the items and their appearance is spoiled. As the linear density of yarns increases, the strength of the fibers in the yarn and the strength of the individual fibers in the yarn decreases, resulting in poor mechanical properties of the yarns, increased breakage during spinning and weaving. In addition, mechanical properties of cotton fiber, i.e. hence its resistance to abrasion, compression, bending, and sliding of the fibers [3].

The length, strength and linear density of the fiber are important in the production of quality yarn in the spinning mill. The higher the quality of the fiber, the more demanding yarn can be produced.

2. Materials and methods

Modern spinning machines produced by “Penzamash” SC (Russia) are equipped with drafting devices VR-1, VR-2, SKF of “RIETER” company (Switzerland), GTSVP, SVV, VB-1, and drafts the product (cotton roving) up to 200 times. The process of drafting-thinning the product, accompanied by straightening and parallelization of fibers between the drafting pairs and the upper lower straps depends on the rotation frequency of the pressure rollers, grooved cylinders, the number of drafting pairs in drafting device. It is known that the simplest drafting device used on spinning machines for spinning cotton (figure 1) consists of feed and draft-out 4 cylinders and two rollers 2 and 3, which clamp the outflow of fibers. The drafting device used on spinning machines for spinning cotton consists of a feed 1, a drafting cylinder 4 and two pressure rollers 2 and 3, which clamp the fiber web, with elastic coatings.

In this case, the drafting is determined through the peripheral speed of drafting pairs

\[ E = \frac{V_1}{X_2}, \frac{V_2}{V_3}, \ldots, \frac{V_n}{n_1} = E_1, E_2, \ldots E_n \]

Where \( E_1, E_2, E_n \) are private drafts between drafting pairs. The gravity force of the pressure rollers or by means of load springs generates the clamping force.

The sliver (roving) entering the rear feed pair is deformed under the action of the load \( P \) of the upper roller, from round it turns into an oval shape and compacted in the middle, forming a friction force in
the section AB of the field, characterized by the ACB curve. The ordinate in the diagram shows the stresses \( P \) of the friction force field (the value of the friction force per 1 mm of fiber length), and its length is plotted along the abscissa [4]. Let us consider the main indicators affecting the field of friction forces. With increasing pressure, for example \( P \) on the pressure roller, the compaction of the fibers increases, the friction force field lengthens, the stress of the force field increases (figure 2 curves f). With an increase in the diameter of the “pressure roller - corrugated cylinder” drafting pairs, the contact surface of the pair with the fiber and the length of the friction force field increase, and its intensity decreases smoothly (curves f).

![Figure 2. Changes in the load along the length of the field of friction forces between “pressure roller – grooved cylinder” pairs. 1-grooved cylinder; 2-pressure roller; 3-spring; 4-supports; f-field intensity of friction forces.](image)

With an increase in the linear density of the product, its thickness and its contact with the drafting pair with the fiber increase. In this case, the field intensity of friction forces decreases, and its length increases (curves f). It should be noted that the strength and extent of the friction force field depend on the rigidity of the elastic coating and its physical and mechanical properties. With a decrease in the rigidity of the elastic coating, its deformation increases, the length of the field of friction forces increases, the tension fits and inversely. With metal rollers that are not deformed, the normal pressure from the middle to the edges decreases sharply and the extreme fibers are not pinched. Therefore, a pressure (frictional) elastic coating is widely used, providing almost complete coverage of the fibrous product and smooth, uniform changes in the clamping force of the fiber along the entire surface line of the “pressure roller – grooved cylinder” system. Cotton fibers passing between the drafting pair can be divided into two groups by the type of their movement in drafting device: controlled and uncontrolled (floating).

3. Results and discussion

It is known that the controlled fibers are fibers whose length is equal to the wiring of the drafting device (wiring is the distance between axes of cylinders of drafting pair - R). These fibers will all the time be under the influence of the field of forces of friction of one or the pairs control another pair of the drafting device and their movement. Uncontrolled or floating fibers are short fibers, the length of which is always less than the wiring [5]. Coordination of movement of floating fibers is very difficult; their movement speed is accompanied by long fibers due to the cohesion force. The movement of uncontrolled fibers is random and is a source of unevenness in the manufactured product. The above theoretical and experimental studies have shown that the best is such a movement in which all fibers (long and short) move at the speed of the supply pairs until the moment when their front ends reach the next pairs [6,7]. In this case, the main condition for the correct operation of the drafting device is the stability of the clamping line, maintaining the constancy of the friction force field, ensuring control of the movement...
of short fibers using the lower and upper straps in the intermediate drafting pairs. This allows the reduction of unevenness, yarn breakage during the formation process. As studies show, with an increase in drafting, the pulling forces increase up to the set limit and then fall to zero (figure 3).

This is explained by the fact that at the first stage of drafting, up to a certain limit, there is no movement of the fibers, i.e. drafting is absent, but there is extension of the fibers and their slight elongation [8]. To ensure a uniform distribution of forces between the pairs, an original design solution was adopted in the gap between the pair of the drafting device, the use of a pair of straps - upper and lower, facilitating the transportation and extension, drafting of the product, maintaining the constancy of the friction force field $P_t$ during the movement of the fibers (broken-thread).

In the existing designs of the upper and lower straps, a fabric made of cotton yarn No. 20 is used as a frame element. However, during long-term operation, they lose their strength characteristics and elastic properties (figure 4). For example, there is a process of “sagging” of the middle part of straps due to additional elongation, will gradually often jam between pairs, the working life of the straps with a 3-shift operation will be within 2980-3020 hours and the design standards are set up to 9060 hours.
To eliminate the shortcomings of the existing straps, it is required to analyze all the geometrical parameters of the straps, to replace the frame element with a highly reliable structure. Thin-layer metal fabric, which ensures reliable and durable operation of the straps of the drawing devices of technological machines, makes it possible to increase the efficiency of the process of producing high-quality yarn in spinning production (figure 5).

4. Conclusion
Analysis of operation of the existing design of drafting devices of technological machines of the spinning production has the following disadvantages: low reliability and service life of rubber straps, insufficient strength characteristics and elastic-mechanical properties of the frame element made of technical cotton fabrics.

It is necessary to select a pair of straps that meets all the requirements of the conditional operation of a pair of straps as a frame element for the upper and lower straps made of thin-layer metal fabric made of a metal thread.

It is necessary to adjustment the additional calculations of the design parameters of the exhaust devices, taking into account the straps made with a thin metal fabric base.

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