**Theoretical Principles of Developing a One-Step Twisting Thread Device**

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**Abstract.** The product produced as a result of twisting single yarns has a complex structure. Various techniques and technologies are used to carry out this process. Today, the most popular and widely used in the production of twisted yarns is the double-twisted twisting machine, and this study analyzes the technological and assortment capabilities of this machine. According to the results of the analysis, the design of a single-stage, complex-structure, i.e., multilayer yarn twisting machine was theoretically studied. In theoretical studies, the operation and state of the ball nozzle during the twisting process of the yarns were studied, and the optimal parameters for the production of twisted yarns were determined. The technology for the production of multilayer twisted yarns was improved and the technological indicators of the new device were theoretically substantiated.

**Keywords:** thread, twisting, joint, spherical dish, ball, nozzle, sled, vibration, angle, speed.

# **INTRODUCTION**

Cotton fabrics made of fibre and yarn, used in the production of fabrics, writing, brocade and other technological processes, are highly technological and adaptable. In the process of working on materials and their implementation, addresses various aspects of science, technology, and technology, as well as issues related to technology development.

In order to avoid confusion in the name, it is necessary that all IP written in the C programming language be indicated in the name of the group.

Yarn is used to make yarn, knitted fabrics, technical yarns, and sewing products. One of two or more hydrogen isotopes formed by the interaction of two or more hydrogen atoms formed by the interaction of two hydrogen ions with the same molecule.

When baking, according to the instructions on the label, all the ingredients are mixed well. The goal that AI sets for itself is to ensure compliance with certain properties, properties, properties, and data structure. Unlike many other types of ICS, several ICS have the same structure and properties, which makes them very similar in structure and properties to ICS.

In recent years, various designs of warping machines have been developed based on a completely new method. The advantage of the machine is that it uses a pulley that provides two twists to the yarn during one rotation of the disk. Several companies have developed various models of such machines.

If we consider the patents for the first double-twist warping machine granted to the authors [1], its working process is more similar to that of a two-stage warping machine. The main work on the creation and improvement of the warping pulley belongs to scientists from the former Soviet Union, and this research led to fundamental changes in the improvement of the technology of warping yarn production. The research of K.I. Koritsky [2], I.P. Safonov [3], M.Ya. Galburt and V.V. Chistoserdov [4], A.M. Nessler [5], G.V. Semenov [6] on the improvement of the combined knitting machine was implemented.

The regularity of the formation of each type of knitted yarn consists of some general and special cases. Ensuring these necessary conditions is carried out by varying the constructive structure of the parts of the machines. If the special cases are brought closer to each other and to the "universal" level by aligning the parts, the range of yarns that can be produced on the machine (or device) increases.

# **METHODS**

The purpose of the research described in this article is to improve the quality of yarn and increase the range of export textile products by creating an improved technology for the production of spun yarns, and based on the analysis of the results of theoretical and practical research, to create a device for the production of multi layer spun yarns using improved technology.

The method of this research is to analyze the characteristics of the techniques and technologies for the production of spun yarns and study the state of their development, identify their main shortcomings, determine the range and technological capabilities of existing spinning machines and solve such issues as substantiating technological modes to increase their use, building mathematical models of the working parts of a new spinning device and substantiating technological parameters.

# **ANALYSIS AND THEORETICAL STUDIES**

The first use of an internal air jet in the spinning and spinning process was a great innovation at the time. In this method, various improved methods of spinning and twisting were created, the technique and technology of which were created.

One of such technological innovations was the twining machines. The production of textile machines developed to such an extent that from year to year various companies produced models of machines with high productivity, low labor consumption, and aimed at reducing technological costs.

In twining machines, yarns began to be spun using twining jets. Many scientists simultaneously conducted research on the creation and improvement of this twining jet. Among them: G.A.Lapushkin, K.I.Koritsky, P.L.Boldyrev, V.P.Osipenko, V.A.Chernyshev's researches were effective and were put into production by various textile machinery manufacturers [7].

Advantages of the two for one twisting machine over the ring wrapping machine: productivity is twice as high, there is no additional winding process (for 2-layer yarns), the number of supplied and finished packages is high, worker productivity is three times higher and the working area is reduced, as well as the consumption of electricity and operating costs for the machine are reduced. Despite the above advantages, shortcomings have been identified even in the most modern machines:

In the twisting machine, the yarns travel a large distance during the twisting process. As a result, the twisting of the yarn is uneven due to the uncontrolled twisting of the yarn. Although this unevenness in the twist generally meets the requirements for the twisted yarn, it is of great importance in the production of yarns with high mechanical properties.

2. As a result of the analysis of the characteristics of the techniques and technologies for processing twisted yarns, it was found that yarns of different assortments are produced on machines of different designs. Thus, the main drawback of twisting machines is the small assortment of yarns produced on them.

3. Based on the requirements for twisted yarn from cotton fiber, the technological, constructive and assortment capabilities of existing twisting machines were analyzed. When the number of individual yarns is more than three, and when using the multiple twisting method, the number of technological passes increases. This results in increased waste, increased labor requirements, excessive energy consumption, and inefficient use of production space.

In order to improve the quality of spun yarns and expand the range of textile products obtained from them, it was determined that it is necessary to conduct theoretical and practical research to create a design for a new one-stage device for the production of multi-ply spun yarns.

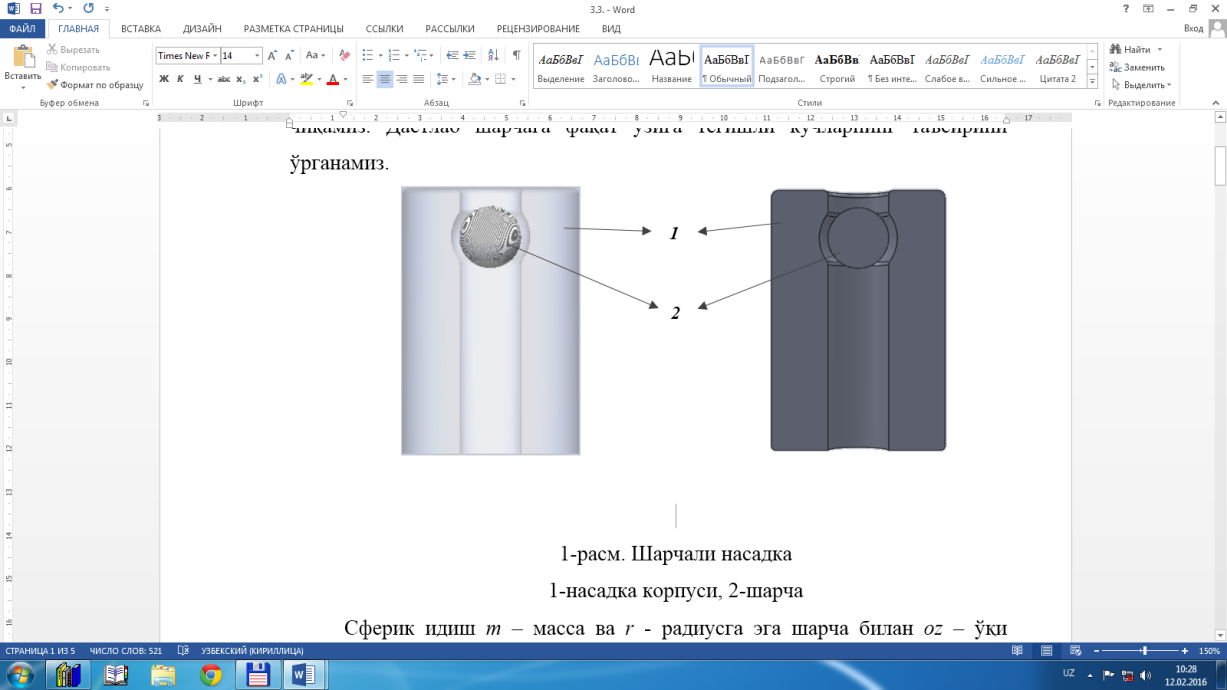
In order to achieve the set goal, in addition to research, patents and copyright certificates for developments created by scientists were studied. As a result of research and studies on the production of a wide range of one-stage spun yarns, a State Patent of the Republic of Uzbekistan was obtained for the “Device for unwinding warp yarns” [8].

In the new spinning device, research was conducted on spinning yarns from 3 to 12 plies in a single-stage method, mainly from cotton fiber.

One of the main requirements for increasing the range of possibilities in the production of spun yarns is the even distribution of the twists given to them as the number of splices increases. In order to evenly distribute the twist to the multilayer spun yarn in the device, a nozzle with a ball is inserted into the inner air nozzle. The main purpose of the ball is to evenly distribute the twist given to the spun yarns that are unwound from the package installed on it as a result of the rotation of the nozzle. The even distribution of the twist, in turn, leads to better quality indicators of the yarn. It is recommended to use these spun yarns for weaving textiles and technical fabrics.

If the single spun yarns are supplied to the twist zone with the same tension in the production of spun yarns and the more evenly the twist is distributed, the more ideal the yarn will have a structure. This ensures the quality of the spun yarn.

In a newly spun yarn production machine, a nozzle is attached to the end of the spindle to distribute the yarn evenly. The ball (see Figure 1) placed inside the nozzle has a certain mass and moves due to the rotation of the spindle. We will study the motion of the ball through theoretical studies. First, we will study the effect of forces on the ball only on itself [9].



**FIGURE 1.** Ball nozzle. 1-nozzle body, 2-ball.

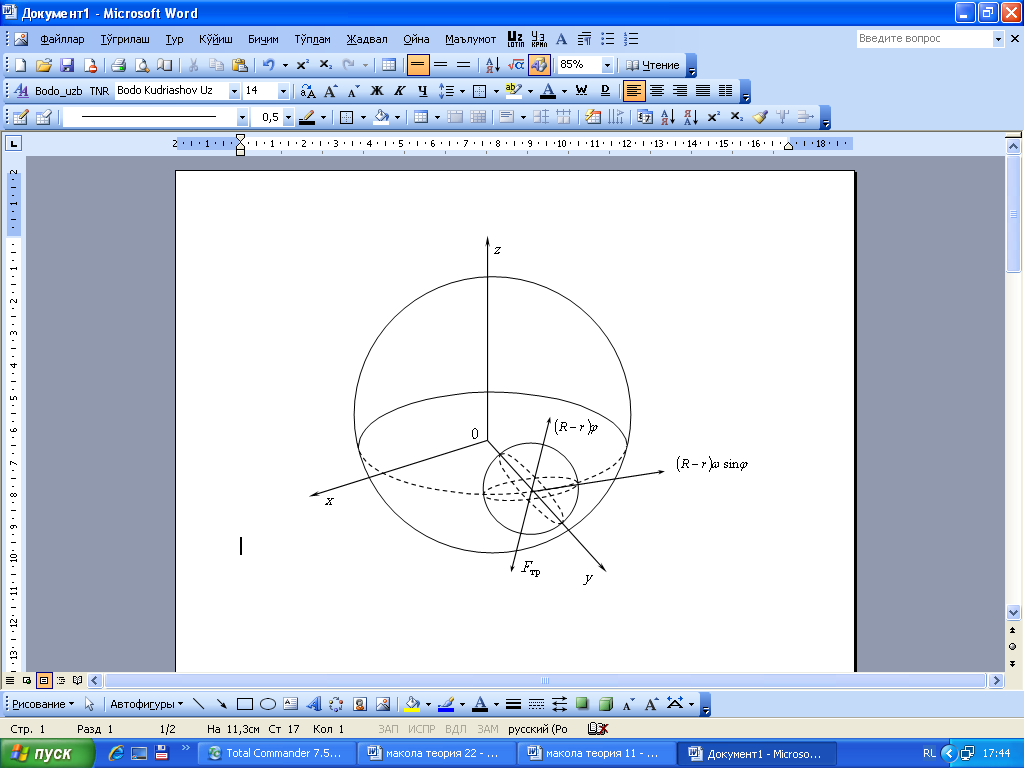
A spherical container rotates together with a sphere of mass - m and radius - r about the axis - oz. We set the origin of the coordinates at the center of the spherical container. We direct the coordinate axis along the axis of rotation of the sphere (Fig. 2). The sphere moves along a circle lying in the zoy plane under the action of a centrifugal force. The kinetic energy of the sphere, taking into account the rotation of the spherical container at an angular velocity of - , is as follows:

(1)

where: J – is the moment of inertia of the sphere about its axis; R – is the radius of the sphere; r – is the radius of the sphere, М – is the mass of the spherical container.

The motion of a certain mass on the inner surface of a sphere was studied by M.I. Bat' in [10].

We assume that the sphere rotates about its axis parallel to the axis of rotation, without slipping on the inner surface of the sphere. We ignore the resistance zoy to vibration, and the friction force on the surface of the sphere allows the sphere to roll on the surface of the sphere, and its work is zero [11-14].



**FIGURE 2.** A diagram of the location of a ball inside a spherical container

- - we choose the angle as the generalized angle of the coordinates and formulate the second-order Lagrange equation:

(2)

where: -- the generalized force is equal to:

(3)

Substituting Т and the expressions, we make an equation:

(4)

By introducing dimensionless quantities, we express the last equation as follows :

(5)

We set the initial conditions for the problem, assuming that at τ=0, ϕ ̇=0 and ϕ=ϕ₀. If at τ=0, ϕ ̈≥0, the angle ϕ can increase. The condition ϕ₀=0 corresponds to a state of rest (the equilibrium state of the sphere). Therefore, we will henceforth assume that ϕ₀≠0. If a≥1, then ϕ ̈≤0, meaning the sphere's motion is directed in the opposite direction. From this point on, we assume a<1, and from expression (1) we find that if cos⁡ϕ₀ ≥ a, then ϕ ̈≥0, and if cos⁡ϕ₀ ≤ a, then ϕ ̈≤0.

In the first case, the sphere moves towards increasing angle ϕ if the following condition is met:

(6)

In this case, the angular velocity of the sphere's rotation is sufficient for the sphere to move from the state ϕ=ϕ₀ towards an increase in the angle ϕ. If the condition cos⁡ϕ₀ ≤ a is satisfied, then we have:

(7)

In this case, under the influence of gravity, the sphere will begin to move in the opposite direction. Assuming the condition holds, then <. Considering , we get .

Integrating with the initial condition at , we obtain the following equation:

,

where:

The angle at which the sphere's velocity becomes zero is determined by the subsequent equation:

Table 1 shows the calculated values of for various values of a. For the calculations, we adopted the values R = 9.0 mm, r = 6.0 mm, ω = 800.0 s⁻¹. As a result, is equal to 70.56° (degrees).

**TABLE 1.** Angle values of for different values of a.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1 |
| **(grad)** | 169 | 53.7 | 58.2 | 62.7 | 67.2 | 71.7 | 76.2 | 81 | 85 | 90 |
|  | 7.05 | 14.11 | 21.2 | 28.2 | 35.3 | 42.3 | 49.4 | 56.45 | 63.5 | 70.5 |
|  | 169 | 163 | 157 | 150 | 144 | 137 | 130 | 123 | 116 | 109 |

The values in the table above show that as the initial angle ϕ₀ increases, the centrifugal force acting on the sphere, , first increases (for ) and then decreases (for ) according to this law. Therefore, for small initial values of , the centrifugal force increases with the angle . The calculations show that the maximum angle of rotation for the sphere, , increases according to a linear law along the circumference of the zoy plane relative to the initial angle.

In addition, assuming that a ball of a certain radius is in equilibrium inside a spherical container with constant angular velocity, the equilibrium state of the ball inside the spherical container was determined at different values of the angular velocity.

Theoretical studies were also conducted to determine the laws of motion of a ball that evenly distributes the helix, taking into account the force of a thread moving on the surface of the ball.

# **CONCLUSION**

A theoretical study was conducted on the operation of a ball-based nozzle, which regulates tension and ensures uniform yarn distribution, in a new spinning device. The equations of motion for the ball, both independently and together with the yarn, were formulated for the following parameters: inner cone surface diameter R = 9.0 mm, ball diameter r = 6.0 mm, friction coefficient f = 0.3, ball mass m = 8.2 g, and a spindle angular velocity of ω = 800 s⁻¹. The equilibrium state of the ball was also determined.

The dependence of the ball's rotation angle on time for various initial angle values was established. It was observed that as the angle increases, the ball's lifting angle decreases, and correspondingly, its lifting time is reduced.

The analysis of the ball's position relative to a rotating spherical container showed that the ball's lower position corresponds to a container angular velocity of ω = 84 s⁻¹. When ω < 84 s⁻¹, the centrifugal force is insufficient to alter the ball's position relative to the container. Furthermore, under the influence of gravity and friction, the ball remains in an equilibrium state. The coordinate of the ball's center of gravity shifts favorably along the oy-axis as ω increases, and remains unchanged for ω > 400 s⁻¹.

Preliminary experiments were carried out on the new spinning device to observe the results of the theoretical studies and to investigate the role of the ball inside the nozzle for achieving uniform yarn distribution along the yarn length. The experimental results confirmed the theoretical findings.

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