Stability of feeding cylinder shell under torsion in pneumo-mechanical spinning machines

O A Mirzaev[1], *Z Z* Uzakov[1*], *Z U* Uzakov[2], *D I* Kilicheva[1], and *B X* Shomuratov[1]

[1]Karshi engineering-economics institute, Karshi, Uzbekistan
[2]Karshi Branch of the Tashkent University of Information Technologies named after Muhammad Al-Khwarizmi, Uzbekistan

Abstract. The essence of the pneumo-mechanical spinning method lies in the transformation of the tape into a discrete stream of fibers, in the formation of a wedge-shaped ribbon from this stream in the form of an open end in the groove of the spinning chamber and in the formation of yarn from the ribbon by torsion, which is removed from the chamber and wound into a bobbin. Yarn obtained on a rotor spinning machine differs in structure from yarn from ring spinning machines, it has a lower breaking load and is produced with a higher filling twist.

1 Introduction

Pneumo-mechanical spinning is characterized by the fact that the feed tape is separated by an appropriate discretizing body into individual elements (fibers). After separation, the ends of individual fibers are not in contact with other fibers. This fact reflects the concept of "open end". During the discretization process, an extra high thinning, i.e. the supply tape is thinned by 3000-9000 times, and in the section of the discrete flow with ideal separation there are 2-6 non-contacting fibers.

The fibers are fed into the rotor of spinning machines and slide along its walls into the groove where they are collected. Due to the rotation of the rotor of the spinning machines, the formed fibrous tape is immediately twisted with the end of the formed thread. Spinning is an ancient textile art in which plant, animal or synthetic fibers are drawn out and twisted together to form yarn [1]. The recommended design of the yarn-output tube allows increasing the strength characteristics of the pneumomechanical yarn [2].

2 Materials and methods

The feeding cylinder of the spinning device, consisting of an outer corrugated bushing and an inner bushing, interconnected by means of a barrel-shaped rubber bushing along the outer surface, while the inner bushing is rigidly mounted on the drive shaft, characterized in that the outer surface of the corrugated bushing is curved and has a concave shape, the

* Corresponding author: uzakovzafar40@gmail.com

diameter in the middle of which is less than the diameters along the edges of the corrugated sleeve by 2.0 mm.

The design of the supply cylinder of the spinning device (Figure 1) consists of symmetrically arranged composite outer sleeves 1 and 2 with inclined corrugations, forming a chevron shape, which is mounted on the inner sleeve 4 by means of a rubber sleeve 3. Sleeve 4 is rigidly mounted on the drive shaft 5.

The design works as follows. The fibrous mass (cotton, wool, chemical, and other types of fiber) in the form of tape enters through the sealing funnel and into the feed zone between the table (not shown in the figure) and the feed cylinder.

At the same time, due to the chevron arrangement of the corrugations of the composite outer bushings 1 and 2, the captured fiber is distributed evenly along their entire length. This is ensured by the displacement of parts of the fibers from the middle and edges of the outer bushings 1 and 2 due to the horizontal components of the forces of action of the corrugations on the fibers. When the corrugations of the outer bushings 1 and 2 interact with the fibrous tape due to clamping force, the rubber bushings 3 are deformed, damping these forces. This actually eliminates damage to the fibers.

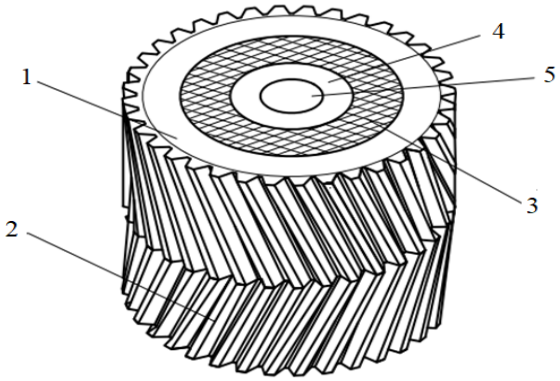

Fig. 1. Feeding cylinder of the spinning device.

3 Results

From the action of the twisting moments, the elements of the shell of the composite supply cylinder experience only shear. At the same time, in the transverse sections, the linear tangential force. Although this method can get a series of whole field configurations of time structure, it is discrete in time coordinate, often only do some qualitative analysis, but not quantify it [3]. However, the capabilities of commercial finite elements software are rather limited when dealing with the nonlinear dynamics of structures [4].

$$q = \tau\delta = \frac{M_k}{2\pi R^2} \tag{1}$$

Theoretical discussing that the supply cylinder itself is directly mounted on an electric motor which has a rated power having

$$\mathrm{N_{nom}} = 0.006\ \mathrm{kW} \tag{2}$$

With such power he gets the moment:

$$M_0 = 9.55\frac{N_{nom}}{n} = 3Nm = 3000Nmm \tag{3}$$

With free movement, the shell of the composite supply cylinder itself does not receive a moment.

The global vehicle industry and market structure experienced an unprecedented scale of change in the 1990s. There has been an increasing demand on vehicle safety, environmental protection and intelligent control. We present a comparative analysis for an accurate representation of the feeding process in the feeding zone of rotor spinning machines (Figures 2 and 3).

In this case, the sample can be stretched almost to destruction without significant residual deformations [5].

The spinning force is used as the monitoring quantity to realize the auxiliary determination of the spinning process state, but the determination of the state is not clear and needs a lot of experimental data to verify the model [6].

The conditions for the formation of core-shell structures are favored when immiscible alloys are processed using powder metallurgical techniques such as high-pressure gas atomization or drop-tube techniques [7]. One aspect of this is the theoretical description of encapsulated microbubbles be understood since it is the shell material that determines many of the functional properties of the microbubble contrast agents [8].

$$\mathrm{M_k} = \frac{\mathrm{M_0} + 2\mathrm{J_1}\mathrm{M_y}}{(\mathrm{J_2} + \mathrm{J_1})}\mathrm{f_{fe}} = \frac{3000 + 2 \cdot 1.8 \cdot 300}{50} = 81\ \mathrm{Nmm} \tag{4}$$

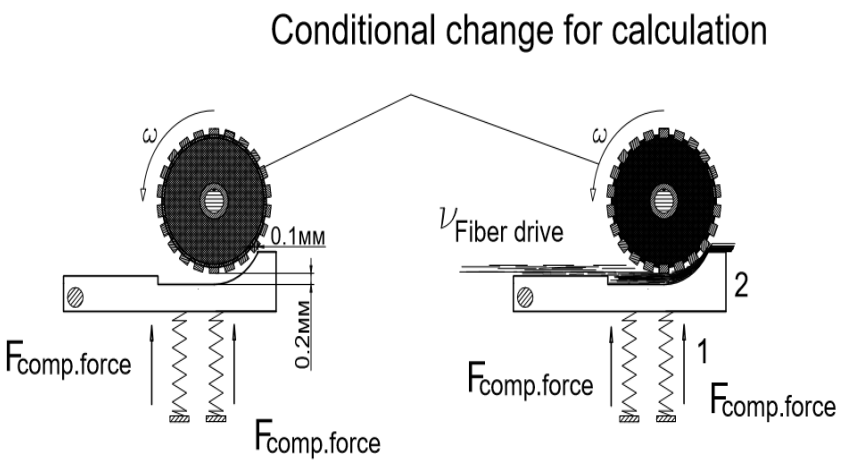

Fig. 2. Comparative analysis of the feeding process in the feeding zones of rotor spinning machines.

Looking at Figures 1 and 2, one can tell that this is a complex process. What forces and what movements can be learned from Figure 4. Thus, printing nips have a central role in the overall success of printing. As a result, a problem of repairing often occurs, reconstruction of individual parts of feed cylinders or their complete replacement. As half of the main components of the feed cylinder is made with high accuracy and low surface roughness and it has a "mirrored" surface, so parts treatment is closely connected with grinding and with grinding tools and equipment. This helps us to accurately represent in the process of feeding rotor spinning machines, especially the use of compound feed cylinders.

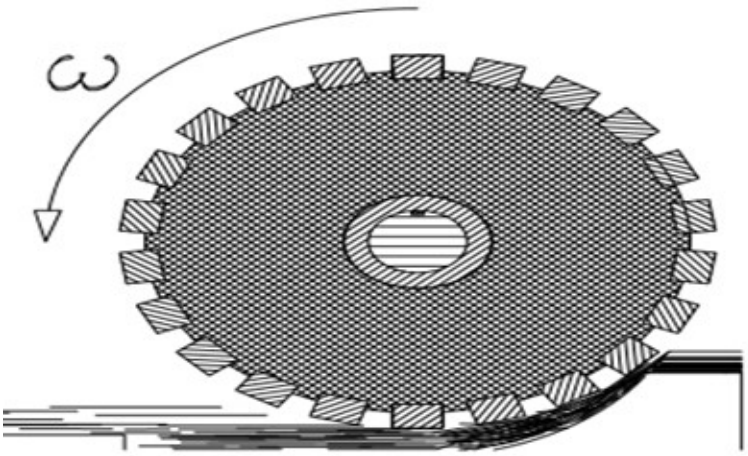

Fig. 3. Comparative analysis of the shell of the composite feed cylinder of the process of feeding the fibrous material (tape).

On the basis of scientific research, the possibilities of waste transportation to increase the efficiency of waste transportation in the waste pipeline by ensuring the uniformity of the vacuum (suction) level along the entire length of the waste pipeline were studied [9]. Mechanical compact spinning is an important alternative for compact yarn production. The system is cheaper and less complicated than pneumatic compact yarn spinning systems [10].

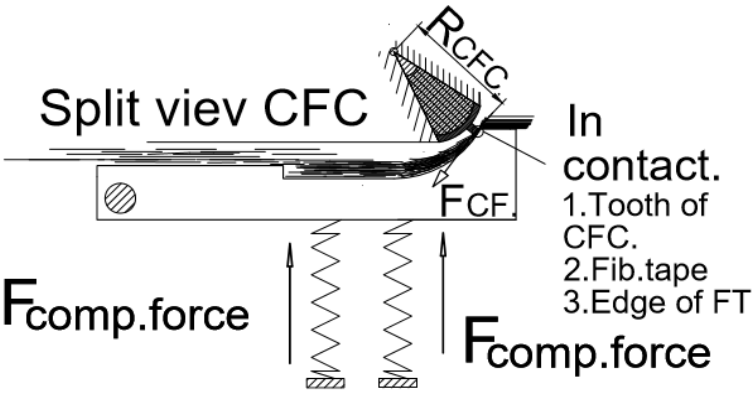

Fig. 4. Additional representation of the analysis of the process of movement of fibrous material in the feeding zone of spinning machines.

At critical values of these forces, qkp, the shell loses stability with a violation of the circular shape of the section. In this case, the individual rings of the system begin to bend, normal stresses and other dynamic forces appear in the cross sections of the structure. In recent years, the textile industry of developing countries in Africa and India has seen significant economic growth. The Government of Africa and India have also, since the last

five decades, given priority to the textile sector in order to diversify exports, since cotton cultivation is environmentally acceptable and requires cheap labor and equipment.

Moreover, qualitative experiments have also been carried out on hemispherical shells to unravel some of the physical mechanisms of their response under indentation [11].

Without such a theoretical basis, shape-independent elastic properties cannot be extracted from the experimentally measured force–displacement curves, and the sole readout is therefore the force required before puncture, which gives information on the strength of the material but not the elasticity [11]. When stability is lost under the action of torques, the straightness of the generatrices of the system disappears. The radial interleaving at this position is determined from the formulas,

$$\varpi = f_m \sin\left(\frac{m\pi x}{L} + n\varphi\right) = f_m[\phi_1(x)\cos n\varphi + \phi_2(x)\ \sin\ n\varphi] \quad (5)$$

Where f_m −the amplitude value is the radial displacement and it is determined from formulas.

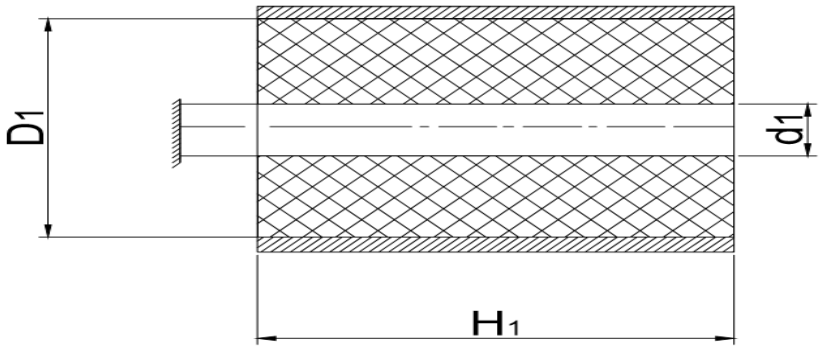

Fig. 5. Feeding cylinder with a rubber-metal elastic element.

$$f_m = \Delta_r = \frac{2F_r H_1}{[\pi G D_1 (D_1 - d)]} \quad (6)$$

For the specified geometric dimensions presented, see Figure 4, F_r − radial force. Large scale vortex structures are formed behind triple point at inner shear layer of jet. The maximum of the velocity fluctuations of the composite feeding cylinder is recorded in the internal shear layers on the axis of the jet behind the direct shock wave. There is an intensification of mixing in the jet coming out of the nozzle with vortex generators. At the same time, the results of this paper can be used as reference data for future researches in this field [8].

The aim of the present study is to formulate for the first time a local- nonlocal mixture stress-driven integral model for axial and torsional vibrations of nano-beams [9]. The issue is relevant virtually in all fields of engineering: structures composed of beams can resist by virtue of its geometry. Such structures can be found from large scale, such as bridges and buildings located in seismically active regions to microbeam systems used in modern electronic equipment which is subject to vibration environment [5]. They obtained vibration modes and frequencies of the hyper-elastic membrane by analytical and numerical methods and then reduced the order of the models for noncolinear dynamic analysis, which was

achieved by the Galerkin method. They used the finite element model to check the accuracy of the reduced order model [10].

Cylindrical shells are the most studied type of shell and their behavior describes many theories and solutions [10]. In recent decades, a number of research studies have been carried out around laminated cylindrical shell structures, which are fully recorded in the literature [11].

The radial force in the teeth of a compound feed cylinder is determined from the formulas,

$$F_r = \frac{2T}{d}\frac{tg\alpha}{cos\beta} \tag{7}$$

From the condition of non-extensibility of the supply cylinder shell in the annular direction, the circumferential displacements,

$$v = -\int \varpi d\varphi = -\frac{f_m}{n}[\phi_1(x)\sin n\varphi + \phi_2(x)\cos n\varphi] \tag{8}$$

4 Discussion

A new design of the composite feed cylinder of the spinning unit has been developed; an expression has been obtained that makes it possible to determine the laws of distribution of the radial and axial displacements of the corrugated bushing of the supply cylinder.

On fig. 6 shows similar curves for the distribution of the radial displacement of the rubber layer for two values of the cylinder revolution.

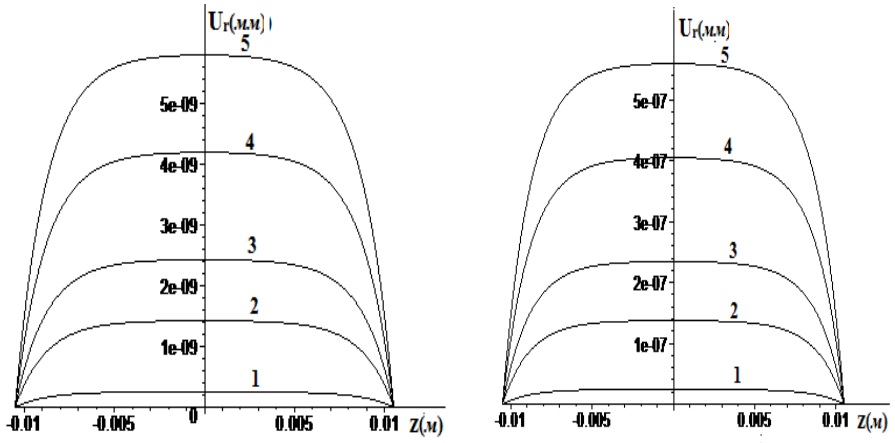

Fig. 6. Distribution of the radial displacement of the layer along the axis of the cylinder for two values of the rotation of the cylinder n at different distances from its centre: *r(m): 1 - r = 0.4R, 2 - r = 0.5R, 3 - r = 0.6R, 4 - r = 0.8R.*

Figure 7 shows the distribution of the axial displacement of the layer along the axis of the cylinder for two values of the cylinder revolution From the analysis of the curves, it follows that the radial and axial displacements of the rubber layer for the case under consideration are of the same order and are practically insignificant, so their deformation can be neglected.

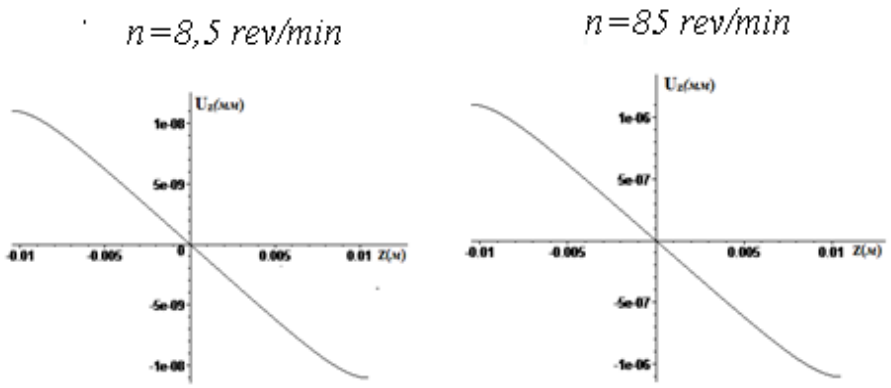

Fig. 7. Distribution of the axial displacement of the layer along the axis of the cylinder for two values of the revolution of the cylinder *n*.

Table 1 presents the main designations values, functions, parameters, coefficients and their numerical values characterizing the proposed composite chevron type feed cylinder.

Table 1. The main designations values, functions, parameters, coefficients and their numerical values characterizing the proposed composite chevron type feed cylinder.

No.	Notation	Functions and parameter	Numerical values
1	M_k	The moment of the elastic cylindrical shell of the supply cylinder during shock loads received from the ribs of the table, mutually its springs	81:650 *N* mm
2	J_1	The moment of inertia of the feeding table;	48kg mm^2
3	J_2	Moments of inertia of the engine reduced to the shaft of the supply cylinder;	1.8kg mm^2
4	f_m	Amplitude value of radial displacement	0.4:0.8 mm
5	m	Number of half waves	1
6	n	Number of waves	1
7	x	Shell length of compound feed cylinder depending on coordinatesχ	4:22 mm
8	v	District movements	-(0.07:0.13) mm
9	ϖ	Radial movements	-(0.2:0.7) mm
10	u	Longitudinal movement	(0.15:0.3) mm
11	L	Shell length of compound feed cylinder	22 mm

5 Conclusion

One of the main factors to ensure the growth of production capacity is the introduction of new high-performance equipment. The introduction of new, more productive equipment and technology at existing enterprises will ensure an increase in the production of competitive products with the best technical and economic indicators on the same or smaller areas. A comprehensive solution to this problem is the modernization of the entire fleet of spinning machines, which would ensure a reduction in cost items and an increase in the competitiveness of yarn in terms of cost and quality indicators, as well as creating prospects for the development of new models of machines.

The results of the work can be used in scientific and industrial research, in the design of new equipment and modernization of existing spinning production, in the practical work of textile enterprises.

Scientific study of structured supply cylinders at the same time as natural fibers, chemical fibers can be mixed between them to create thread extraction technology with high quality performance in pneumomechanical spinning machines.

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