ANALYSIS OF FRICTION FORCE BETWEEN FIBER BELT AND FIBER TAPE WITH RECOMMENDED FEED CYLINDER

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Abstract. *In the article, the scheme of the rubber bushing, which provides the discretizing zone of the spinning machines, is designed with a cylinder structure, a gasket, and prismatic working elements with different grooves. On the basis of theoretical studies, the formulas for determining the friction force in the interaction of the fiber tape with the working elements of the supplying cylinder were derived, and the system parameters were justified based on the numerical solution.*

Keywords: *discretization, supply cylinder, rifle, prismatic, coupling, rubber bushing, fiber tape, friction, surface, force, weight, singularity.*

In the process of interaction between the supply cylinder and the fiber tape, the following forces are generated: cylinder gravity force, centrifugal force, rubber bush unit force, fiber tape unit force, friction force and reaction force.

Figure 1 shows the computational scheme of the discretizing zone affecting the fiber tape with the supply cylinder [1, 2].

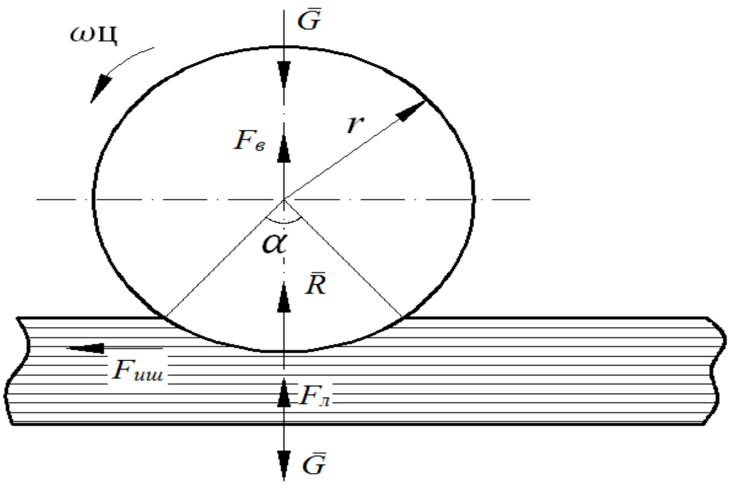
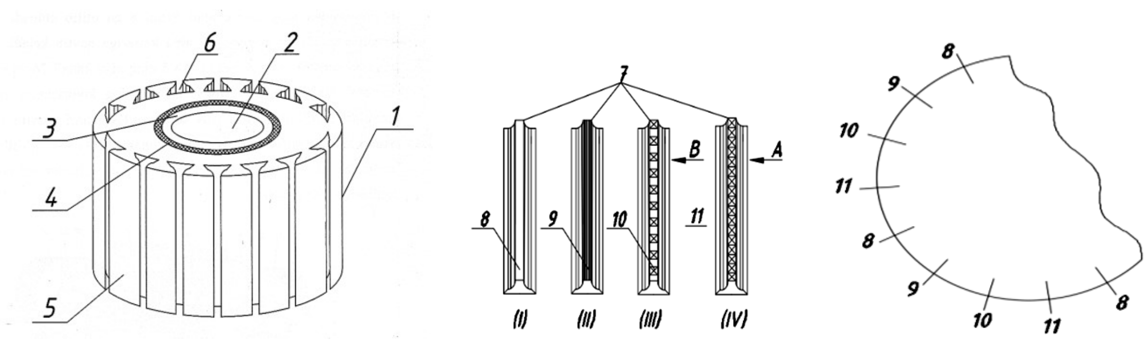


Figure 1. Calculation scheme of exposure with a composite cylinder and fiber tape

In this scheme, the friction force between the cylinder seat (rifles) and the fiber cylinder is almost constant and continuous during operation. The contact of the fiber tape with the supply cylinder with prismatic working elements of different riffles is recommended, both the surface of contact with the fibers and the friction force of different riffles will change. Figure 2 shows the scheme of the proposed supply cylinder [3].



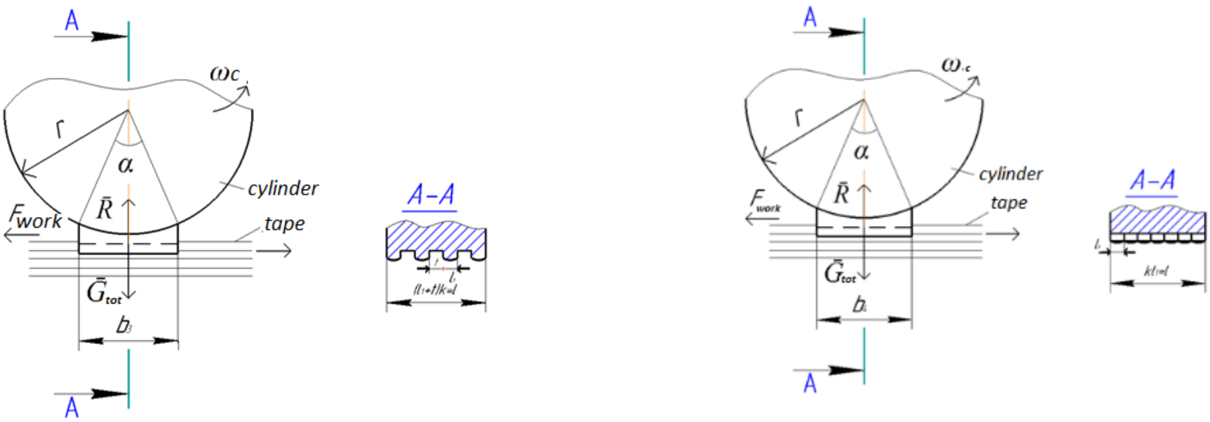
b) c)

d) e)

Figure 2. Scheme of the working element with different grooves

From the given scheme, we consider the schemes of interaction of various corrugated prismatic working elements with fiber tape (Fig. 3).

a) b)



c) d)

a-working element with a smooth surface; b-working element with a longitudinally ribbed surface; c-discretely located pointed fluted working element; d-serial pointed fluted working element

Figure 3. Schemes of interaction of the recommended supply cylinder with various corrugated prismatic working elements with fiber tape

The method of determining the frictional force on the working zones of the supply cylinder: According to the calculation scheme (Fig. 1), the pressure force on the fiber tape is basically equal to the total weight of the supply cylinder, shaft, rubber bushing and gasket [4, 5, 11].

$N = G_{ум} = G_{в} + G_{рв} + G_{г}$ (1)

Taking into account the movement of the supply cylinder, an additional inertial force, a rubber bushing restoring force, and a centrifugal force are added to the top (1) [6, 7, 12]:

$$F_k = \frac{G_{ум}}{g}\ddot{z}$$

$$F_{мк} = \frac{G_в+G_{рв}+G_г}{g}\left(\frac{\pi\, n_ц}{30}\right)^2 \qquad (2)$$

$$F_т = \frac{С_{рв}С_л}{С_{рв}+С_л}\,(1 - cos\frac{\alpha}{2})$$

here $С_{рв}$, $С_л$ – rubber bushing and fiber tape uniformity coefficients; g – free fall acceleration; $n_ц$- supply cylinder rotation frequency; α – coverage angle; π =3,14; We consider that the vertical vibration acceleration of the supply cylinder in the mode of steady motion is zero, and in this case F_i=0.

Correspondingly, the frictional forces between the working elements of the prismatic fluted cylinder and the fiber tape are for each option:

$$\left.\begin{matrix} F_1 = N(f+k_1); & F_2 = N(f+k_2) \\ F_3 = N(f+k_3); & F_4 = N(f+k_4) \end{matrix}\right\} \qquad (3)$$

here $k_1, k_2, k_3, k_4 -$ additional friction coefficients in the engagement of the teeth of the prismatic element with the feed cylinder flutes on the fiber tape.

These coefficients are mainly determined by the ratio of the toothed surfaces to the tips of the prismatic fluted elements:

$$k_1 = \frac{S_{k_1}}{S_0};\ k_2 = \frac{S_{k2}}{S_0};\ k_3 = \frac{S_{k3}}{S_0};\ k_4 = \frac{S_{k4}}{S_0}; \qquad (4)$$

$S_{k_1} = l \cdot b_1;\quad S_{k_2} = \frac{1}{2} l \cdot b_2;\quad S_{k_3} = (l_1 + t)k \cdot b_3;\quad S_{k_4} = k \cdot l_1 \cdot b_4$

$S_{k_1}, S_{k_2}, S_{k_3}, S_{k_4}$- mating surfaces of prismatic fluted elements of the corresponding cylinder, S_0- total surfaces.

Based on the Amonton-Coulon law, taking into account the friction coefficients [13, 14, 15, 16] in the mutual movement of two surfaces, putting (1), (2), (4) into (3), the following expressions are formed:

$$F_1 = \left(f + \frac{l \cdot b_1}{S_0}\right)\left[(G_в + G_{рв} + G_г) + \frac{G_в + G_{рв} + G_2}{2}\left(\frac{\pi\, n_ц}{30}\right)^2 + \frac{С_{рв}С_л}{С_{рв} + С_л}\,(1 - cos\frac{\alpha}{2})\right]$$

$$F_2 = \left(f + \frac{l \cdot b_2}{2 \cdot S_0}\right)\left[(G_в + G_{рв} + G_г) + \frac{G_в + G_{рв} + G_2}{2}\left(\frac{\pi\, n_ц}{30}\right)^2 + \frac{С_{рв}С_л}{С_{рв} + С_л}\,(1 - cos\frac{\alpha}{2})\right] \qquad (5)$$

$$F_3 = \left[f + \frac{1}{S_0}(l_1 + t)k \cdot b_3\right]\left[(G_в + G_{рв} + G_2) + \frac{G_в + G_{рв} + G_г}{2}\left(\frac{\pi\, n_ц}{30}\right)^2 + \frac{С_{рв}С_л}{С_{рв} + С_л}(1 - cos\frac{\alpha}{2})\right]$$

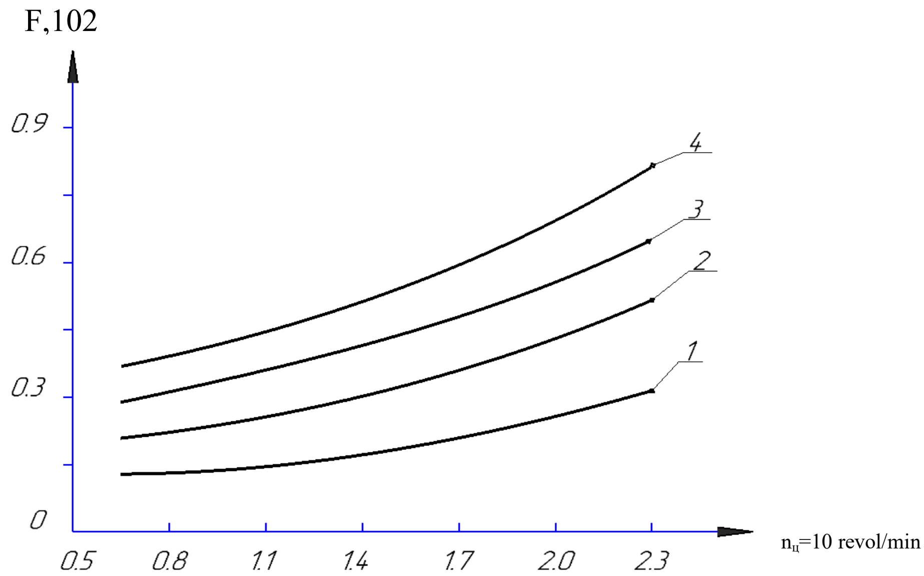
$$F_4 = \left(f + \frac{k \cdot l_1 \cdot b_4}{S_0}\right)\left[(G_в + G_{рв} + G_2) + \frac{G_в + G_{рв} + G_г}{2}\left(\frac{\pi\, n_ц}{30}\right)^2 + \frac{С_{рв}С_л}{С_{рв} + С_л}(1 - cos\frac{\alpha}{2})\right]$$

hare $b_1 b_2, b_3, b_4 -$ width of working elements; l – total length of working elements; l_1 – tooth thickness; k – number of teeth.

Numerical solution of the problem and analysis of the results. The frictional forces in the interaction of the fiber tape with the ribbed prismatic working elements of the supply cylinders are expressed by the expression (5). In this case, the initial values of the parameters are obtained as follows:

$n_ц$=(8,0÷21) revolutions/minute; r=(9,0÷12) $\cdot 10^{-3}$m; m_b=(10÷25) $\cdot 10^{-2}$ kg;
m_{pb}=(1,5÷2,6) $\cdot 10^{-2}$ kg; m_2=(3,0÷4,5) $\cdot 10^{-2}$ kg; α=(9^0÷15^0);
C_{pb}=(20÷30) cN/mm; $С_л$=(3,5÷6,5) cN/mm; f=(0,15÷0,205);
$l_1 = 0$; $b_1 b_2, b_3, b_4$=(1,8÷2,5) м; k=(6÷8); l=(1,8÷2,2) $\cdot 10^{-2}$ m;
π=3,14; g=9,8 m/s^2.

Based on the obtained results, the friction forces between the working elements of the supply cylinder and the fiber tape were calculated separately for each option, and graphs of the dependence on the change of the corresponding parameters were constructed. In particular, Fig. 4 shows graphs of the dependence of the friction forces between the fluted working elements of the discretizing link and the fiber tape on the frequency of the cylinder rotation .



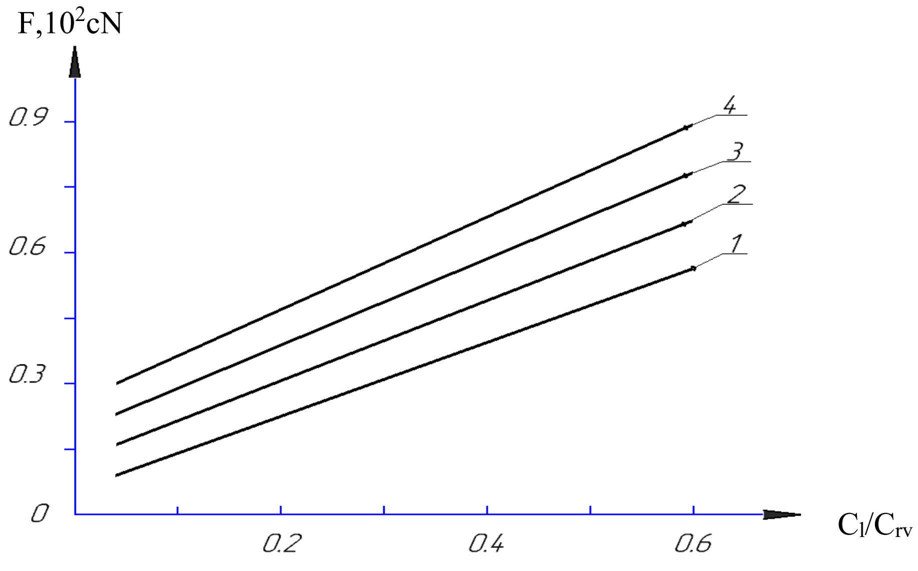
$1 - F_1 = f(n_ц)$; $2 - F_2 = f(n_ц)$; $3 - F_3 = f(n_ц)$; $4 - F_4 = f(n_ц)$

Figure 4. Graphs of dependence of the friction forces between the working elements of the discretizing link and the fiber tape with the cylinder gasket on the frequency of rotation of the cylinder

The constructed graphs show that the frictional forces between the working elements of the knurled gear and the fiber tape increase nonlinearly when the frequency of rotation of the supply cylinder increases from 8.0 rev/min to 22 rev/min. Correspondingly, the friction force increases from 0.14·102 s to 0.39·102 s at ($l_1' = 0$) without prismatic working element riffles (Fig. 4, graph 1). Also, when the teeth of the working element with prismatic grooves are continuous in the gear set (variant 4), the friction force with the fiber tape increases from 0.33·102 s to 0.86 ·102 s in a non-linear pattern. The main reason for this is that the grooved teeth penetrate into the fiber tape, increase the contact surface, and reduce mutual sliding. Therefore, it is desirable that the frequency of rotation of the supply cylinder is up to (12÷18) rev/min in order for the friction force to be high. In this case, the change of the friction force during the cycle is in the range of $\Delta F_{friction}$=(0.35÷0.42) ·102 s, the mutual separation and transfer of fibers is accelerated, and the possibility of obtaining high-quality yarn is created.

Fig. 5 presents graphs of the variation of the friction force between the ribbed working elements of the discretizing zone supply cylinder and the fiber tape depending on the ratio of the rubber bushing of the cylinder and the fiber tape units [17].

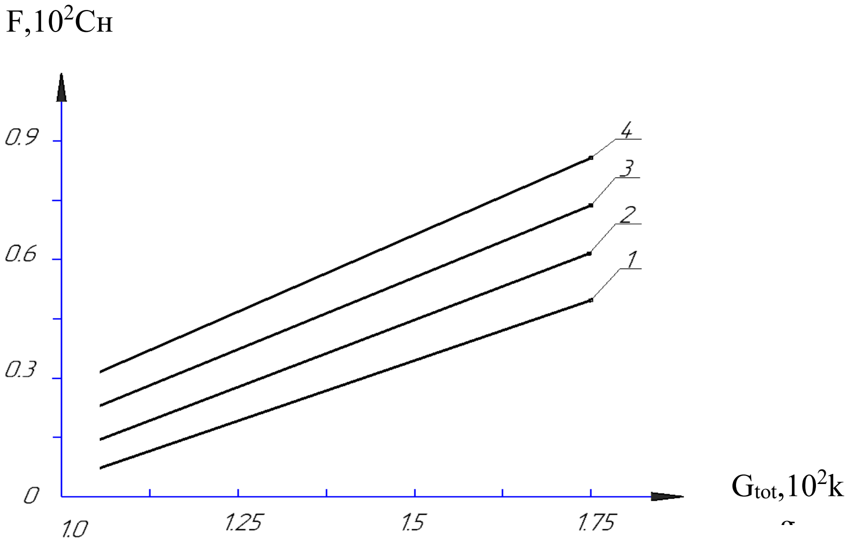
Connection graphs are linear (Figure 5, graphs 1-4). In particular, in case 1, when the values of Si/Srv increased from 0.12 to 0.55, the values of F_1 increased from 0.16·102 s to 0.57·102 s in a linear relationship, and for the fourth case, the values of F_4 increased from 0.305·102 s to 0. It was found to increase up to 85 ·102 s (Fig. 5, graph 4). Therefore, increasing the uniformity of the rubber bushing of the content supply cylinder, or decreasing the density of the fiber tape, and decreasing the uniformity will increase the friction force. S_{rv}≥(35÷45) s/mm to ensure that the friction force does not change in one cycle for cases 1-4 (0.35÷0.42) ·102s; S_l≤(4.0÷4.5) s/mm is recommended.



$$1 - F_1 = f\left({}^{C_л}/{}_{C_{рв}}\right);\ \ 2 - F_2 = f\left({}^{C_л}/{}_{C_{рв}}\right);\ \ 3 - F_3 = f\left({}^{C_л}/{}_{C_{рв}}\right);\ \ 4 - F_4 = f\left({}^{C_л}/{}_{C_{рв}}\right)$$

Figure 5. Discretization zones of the friction force between the grooved working elements of the supply cylinder gasket and the variation of the friction force between the zones and the ratio of the cylinder rubber bushing and fiber tape units

It is known that increasing the total weight of the system increases the effect of fiber tape, that is, increases the friction force. Fig. 6 shows the graphs of dependence of the friction forces of the contact of the prismatic working elements with the fiber tape on the system generalized weight values. According to the analysis of the correlation graphs, when Gum values increase from 1.1·10 g to 1.75·10 g, F_1 values increase linearly from 0.14·102 s to 0.31·102 s. It is recommended that the total weight of the supply cylinder be in the range of (1.75÷1.85) ·10 g in order to ensure the limit values of the change of friction forces in the case of one rotation of the supply cylinder [18].



$1 - F_1 = f\ (G_{\text{ум}})$; $2 - F_2 = f(G_{\text{ум}})$;
$3 - F_3 = f(G_{\text{ум}})$; $4 - F_4 = f(G_{\text{ум}})$

Figure 6. Dependence graphs of system generalized weight values of the frictional forces of the contact of the prismatic working elements with a fiber tape

Summary. The formulas for determining the frictional forces in the interaction of the ribbed prismatic working elements with the fiber tape in the zones of the cylinder set with the recommended composition of the spinning machine were obtained. Based on the analysis of the constructed graphs, the recommended values of the parameters are determined.

REFERENCES

1. Djuraev A.Dz., Mirzaev O.A., N. Urakov. Sovershenstvovanie konstruktsiya pitayushchego tsilindra pryadilnogo stroystva. "Actual problems of innovative technologies in the context of integration of science, education and production. A collection of articles of the Republican scientific-practical conference held on the theme "Weaver - 2017". Part 1. Tashkent-2017. P.6-8.
2. Mirzaev O.A. Improvement of high-performance constructions of working bodies of discretization zone of spinning machines and justification of parameters //abstract. T.-2018. P-44.
3. Patent UZ No. IAP 06783. Pitayushchii tsilindr pryadilnogo ustroystva / Djuraev A.Dzh., Urakov N.A., Akhmedov K.I., Mirzaev O.A., Toraev F.F. // Registered in Tashkent city on 28.02.2022.
4. Djuraev A.Dzh., Mirzaev O.A., Akhmedov K., N. Urakov. Development of high-efficiency constructions, setting methods, calculation of parameters of working organs, zone discretization of machine tools. Monograph. T. "Science and Technology", 2018, 164 pages.

5. Djuraev A.Dz. Mirzaev O.A., Akhmedov K.I., N.Urakov., // Development of effective structural schemes of the working bodies of the discretization zone of spinning machines // International scientific and practical conference held on the topic "Problems of increasing work efficiency and energy resource efficiency of modern production" Andijan 2018. Page 728-732.
6. N. Urakov, Djuraev A.Dzh., Mirzaev O.A., Optimization of the parameters of the pneumomechanical pryadilnyx machine. Vestnik TashGTU - Tashkent. - 2019g. - No. 2, S. 140-145.
7. Jumayevich, M. O., & Shuhratovna, A. A. (2022). Tolali chiqindilar bolgan changli havo tarkibini organishda olib borilgan nazariy tadqiqotlar. RESEARCH AND EDUCATION, 262.
8. Voronkov I.M. Course teoreticheskoy mechanics, izd. Technik.-teor., literatury, M., 1964, p. 552.
9. Targ S.M. Kratki course teoreticheskoy mechanics. 12-izd., "Vysshaya shkola", M., 2005, p.439.
10. Djuraev A. Modelirovanie dynamici mashinnyx aggregateov khlopko-pererabatyvayushchix mashin. I., Science, 1984. -128p.
11. Djuraev A., Toraev F.F. M.T. Urazbaeva AN RUz. "Problems of Mechanics" magazine No. 2, 2022. Pages 98-103.
12. Juraev Anvar Juraevich & Turaev Farkhodjon Farmonovich “Determination Of The Rigidity Of A Rubber Bushing Of A Composite Feeding Cylinder Of A Spinning MachineWith A Discreting Zone”// “Journal of optoelectronics laser”. 2022,Vol41.Issue5.pp.673-679. Scopus.Q4/Impact Factor/0,144.
13. Murodov, O. J. (2021). New design of the cotton saw cylinder on elastic bearings. FUTURE OF SCIENCE. Kursk-2021, 212-213.
14. Juraev Anvar Juraevich & Turaev Farkhodjon Farmonovich “Determination of the friction force between the composite feeding cylinder and the fiber rove”// Scientific and Technical Journal Namangan Institute of Engineering and Technology. 2023.Vol 8. Issue 2.pp.241-245.
15. Муродов, О. Ж. (2021). Снижение повреждаемости семян в сепараторе хлопка-сырца. Технологии и качество, 3(53), 48.
16. Муродов, О. Ж., & Адилова, А. Ш. (2021). Теоретические исследования по повышению эффективности моделированных циклонов. Ташкентский институт текстильной и легкой промышленности.«Текстильный журнал Узбекистана,(4), 129-137.
17. Murodov, O. Improvement of the design and justification of the parameters of the raw cotton separator.
18. Murodov, O., & Rajabov, O. Results of an experimental study of the load and the character of a multi-face net vibrations on elastic cotton cleaner supports.
19. Yahshimurodovich, R. I., & Jumaevich, M. A. (2023). Application of the Screw Device in Cotton Cleaning and Analysis of the Results of the Full Factorial Experiment. JOURNAL OF ENGINEERING, MECHANICS AND MODERN ARCHITECTURE, 2(3), 7-12.