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DETERMINING THE DIRECT RESISTANCE COEFFICIENT OF COTTON FIBER IN THE CONFUSOR TUBE

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Abstract: This study focuses on determining the direct resistance coefficient of cotton fibers within a conical confusor tube, which is essential for optimizing rotor spinning processes. By employing mathematical modeling and computational fluid dynamics (CFD), the study investigates how airflow characteristics impact fiber behavior. The resistance coefficient, Cx, was calculated from experimental data and compared with theoretical models for both laminar and turbulent flows. The effects of key parameters, such as Reynolds number and airflow velocity, on fiber resistance were analyzed. The findings indicate that an increase in airflow velocity results in a decrease in the direct resistance coefficient. The research highlights the influence of geometric factors in the confusor on fiber dynamics and yarn quality, providing insights for enhancing rotor spinning efficiency.

Keywords: Rotor spinning, cotton fibers, airflow, direct resistance coefficient, confusor tube, CFD, Reynolds number, yarn quality.

Introduction. Rotor spinning is a prominent technology in modern textile manufacturing, celebrated for its cost-effectiveness, high productivity, automation capabilities, and versatility in producing various yarn types [1-4]. The rotor component is central to this spinning process, playing a critical role in channeling fibers through the airflow, transporting them into the rotor, and facilitating their collection in the rotor shaft. However, the interaction between airflow and fiber orientation can adversely affect yarn quality [5]. Consequently, understanding and optimizing airflow dynamics is crucial for improving the rotor spinning process. Analyzing the airflow characteristics helps elucidate how different geometric and spinning parameters influence airflow patterns and yarn properties [6].

Numerous studies have utilized computational fluid dynamics (CFD) to investigate airflow within rotor spinning systems. In 1996, Kong and Platfoot [7] introduced a two-dimensional (2D) model to simulate airflow patterns in the conveying zone of a rotor spinning machine. Their findings indicated that changes in fiber configuration, geometric dimensions of the confusor, or the speed of the opening roller could alter airflow directions. Yang and colleagues [8] later developed a three-dimensional (3D) simulation of the airflow in both the transfer channel and the rotating rotor, revealing that airflow velocity decreased at the slip wall and high-pressure regions were concentrated at the slip wall and rotor blade. Further insights into 3D airflow dynamics within the rotor spinning chamber were provided by Lin et al. [9] and Xiao et al. [10], who examined how geometric and rotational parameters impact airflow patterns, offering valuable guidelines for optimizing rotor design and spinning settings.

In addition to simulations, experimental studies have also been conducted to explore how airflow affects fibers and yarns. Zeng and Yu [11], Guo and Hu [12], and Pei et al. [13] employed high-speed photography to analyze fiber movement in different air-jet spinning environments. Seyedi et al. [14] investigated fiber migration in a new rotor-jet spinning system with varying parameters, while Seyed et al. [15] and Lin et al. [16] compared yarn quality to assess how optimizing the baffle airflow area impacts yarn properties. Akankwasa et al. [17] examined blended yarn quality to validate simulated airflow characteristics in both conventional and two-feed rotor spinning machines. Despite these efforts, there remains a gap in visual experimental data on airflow within rotor-spinning devices under industrial conditions.

The airflow area in the confusor is critical because it significantly affects the fiber's configuration and the yarn's properties. Geometrical parameters are important in influencing the properties of airflow in yarn. To evaluate the influence of the geometric parameters of the confusor on the airflow characteristics and the cotton fiber's direct resistance coefficient, the confusor tube's calculations with a conical shape were adopted [18-25].

Methods. The relationship between the resistance of a flat plate deflected by an incompressible fluid flow and the Reynolds number *Re* of the incoming flow is known:

- for laminar flow

$$C_w = \frac{1.328}{Re^{0.5}}$$

- for turbulent flow

$$C_w = \frac{0.073}{Re^{0.2}}$$

Where: *Re*- Reynolds number

S_w- direct resistance coefficient.

Works [20-21] are also characterized by the dependence of $S_x(V)$ characteristic of small numbers of textile yarns, that is, for the case of laminar flow. The proof of this fact or, in general, the method of determining the nature of the flow around the results of the experiment can be processed experimental data in such a way that the desired relationship is expressed in the following form and is determined by the values of A and α, which are constant for the given speed range. - for laminar flow

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- for turbulent flow

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$$C_x = \frac{A}{U^{\alpha}} \quad (1)$$

if the indicator α is close to 0.5, then the flow can be considered laminar.

Results and Discussion. The nature of the deviation depends on the Reynolds number *Re* of the boundary layer, which may differ from the Re number of the incoming flow.

In contrast to [19-20], where the least squares method was used, we use the logarithm method to describe the curves close to the degree.

$$lgC_x=lgA-\alpha lgU \tag{2}$$

We determine the expression of the dependence of the resistance coefficient on the air speed in the pipe.

We present the equation for $C_x(\sigma)$.

We logarithmize both sides of the equation $C_x = \frac{A}{\vartheta^\alpha}$

As a result

$$lgC_x = lg\frac{A}{\vartheta^\alpha}$$
$$lgC_x = lgA - lg\vartheta^\alpha$$
$$lgC_x = lgA - \alpha lg\vartheta$$
$$C(\vartheta) = \frac{A}{\vartheta^\alpha}$$
$$lgC = lgA - 2lg\vartheta$$

Using the above equation (3.23), we form the expression of the dependence of the resistance coefficient on the exit surface using the dependence of the airspeed on the exit surface.

$$lgC = lg\frac{A}{\vartheta^\alpha}$$
$$C(\vartheta) = \frac{A}{\left(\vartheta_o \cdot e^{\frac{k}{m}\cdot t\sqrt{1-\frac{\left(2\sqrt{\frac{S_1}{\pi}}-2\sqrt{\frac{S_0}{\pi}}\right)^2}{4l^2}}}\right)^\alpha} \tag{3}$$

Using the expression (3.26), we get graphs using the Maple program.

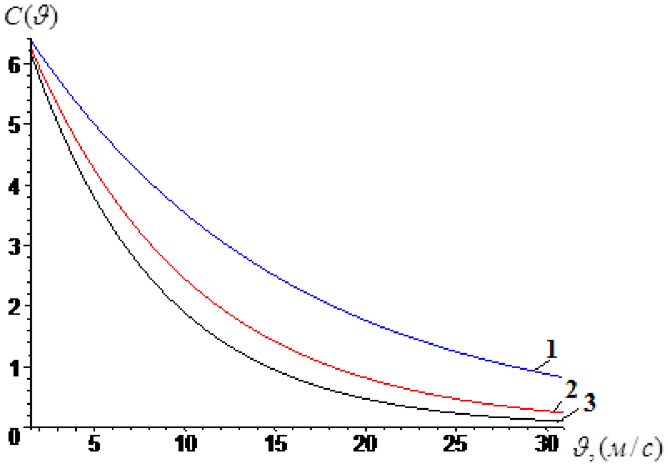

Figure 1. The graph of fiber resistance coefficient dependence on different surfaces S_{01}, S_{02}, S_{03}, and airspeed.

Fibers in a conical tube along the axis OX of the outlet of the tube to the surface value $S_{01} = 14.51mm^2$, $S_{02} = 12.56mm^2$, $S_{03} = 10{,}75mm^2$ values Graph of dependence on airspeed (Figure 1) was obtained. It can be seen from the graph that the air resistance decreases as the speed increases.

According to experience, it is assumed that S_x and ϑ are known. The *nn*-line (Fig. 2) is constructed using points lgC_x and $lg\vartheta$. By measuring the slope angle g, we determine the constant $\alpha = tg\gamma$ and calculate the value of γ.

There may be several intersecting straight lines in the studied speed range (for one experiment). In this case, the formula is copied for each pair of values of A and α, that is, for each subrange.

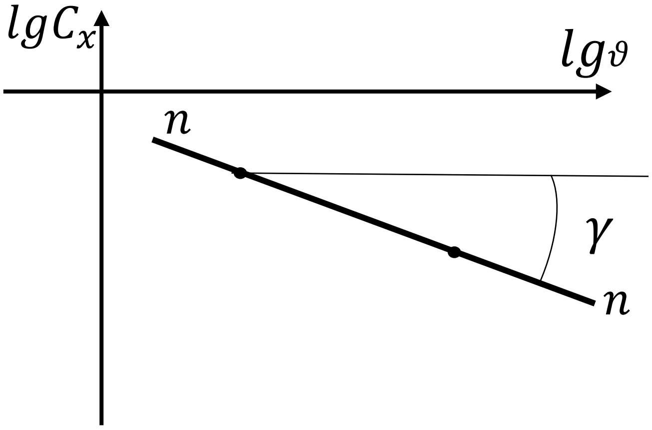

Figure 2. The working diagram of determining the indicator of the angle of inclination of the confusor pipe.

The results of experimental data processing show that the coefficient of resistance when spinning cotton fibers in a square channel is expressed in the form (1), its coefficients have the following values: A=4,000; $\alpha = 0{,}7 \div 1{,}3$; ϑ- air speed, m/s.

This means that when $\alpha \leq 1.0$, the flow in the layer is laminar, at high airspeeds and with the presence of fibrous components in the flow, $\alpha \geq 1.1$ or more (up to $\alpha \leq 1.30$), laminar flow is disturbed exists, turbulent diffusion phenomena are formed in the boundary layers of the fibers, which can change the direction of the fibers in the cavity [21].

The cotton fibers in the narrowing channel showed that the shrinkage coefficient is $\alpha = 0{,}8 \div 1{,}15$, which means that the *Re* numbers are very small, which means that the viscous force's role in the thin fiber's boundary layers is extremely important. So, unlike a rectangular channel, the airflow here is regulated to a certain extent and moves with relatively less distortion, that is, more laminar.

Conclusion. The analysis of the direct resistance coefficient of cotton fibers in a conical confusor tube reveals that airflow characteristics significantly influence fiber behavior and yarn quality. The mathematical models and experimental data indicate that increasing airflow velocity reduces the resistance coefficient, demonstrating that airflow dynamics play a crucial role in fiber transport and yarn formation. The study confirms that at lower velocities, laminar flow conditions prevail, whereas higher velocities introduce turbulence, affecting fiber alignment and yarn properties. These findings underscore the importance of optimizing confusor design and airflow parameters to enhance rotor spinning performance. The insights gained can be applied to refine spinning technologies, improve yarn quality, and increase production efficiency in textile manufacturing.

REFERENCES

1. Gooch JW., Rotor spinning. In: Gooch JW (ed.) Encyclopedic dictionary of polymers. New York: Springer New York, 2011, p 639.
2. Kwasniak J. An investigation of a new method to producefancy yarns by rotor spinning. J Text Inst Proc Abstr 1996; 87: 321–334.
3. Matsumoto YI, Fushimi S, Saito H, et al. Twisting mechanisms of open-end rotor spun hybrid yarns. Text Res J 2002; 72: 735–740.
4. Cheng KB and Murray R. Effects of spinning conditionson structure and properties of open-end cover-spun yarns. Text Res J 2000; 70: 690–695.
5. Das A and Alagirusamy R. 3-Fundamental principles ofopen end yarn spinning. In: Lawrence CA (ed.) Advances in yarn spinning technology. Cambridge, UK: Woodhead Publishing, 2010, pp.79–101.
6. Akankwasa NT, Lin H, Zhang Y, et al. Numerical simulation of three-dimensional airflow in a novel dual-feed rotor spinning box. Text Res J 2018; 88: 237–253.
7. Kong LX and Platfoot RA. Two-dimensional simulationof air flow in the transfer channel of open-end rotor spinning machines. Text Res J 1996; 66: 641–650.
8. Yang XW, Chen HL, Wu ZY, et al. Numerical simulation of 3D flow in rotation cup of rotor spinning. Appl Mech Mater 2011; 80-81: 1145–1149.
9. Lin H, Zeng Y and Wang J. Computational simulation ofair flow in the rotor spinning unit. Text Res J 2016; 86: 115–126.
10. Xiao M, Dou H, Chuanyu WU, et al. Numerical simulations of air flow behavior in spinning rotor. J Text Res 2014; 35: 136–141.
11. Zeng YC and Yu CW. Numerical simulation of fibermotion in the nozzle of an air-jet spinning machine. Text Res J 2004; 74: 117–122.
12. Guo HF and Xu BG. A 3D numerical model for a flexible fiber motion in compressible swirling airflow. Comput Model Eng Sci 2010; 61: 201–222.
13. Pei Z, Chen G, Liu C, et al. Experimental study on thefiber motion in the nozzle of vortex spinning via highspeed photography. J Nat Fiber 2012; 9: 117–135.
14. Seyedi R, Shaikhzadeh Najar S and Hoseinpour AR.Investigation of fiber migration in rotor-jet spun yarn. J Text Inst 2017; 108: 1794–1799.
15. Seyed S, Eskandarnejad S and Emamzadeh A. Effect ofgeometry of end of the fibre transport channel with slotted exit on rotor spun yarn quality. J Text Inst Proc Abstr 2015; 106: 564–570.

16. Lin H, Akankwasa NT, Bergada` JM, et al. Effect of rotor spinning transfer channel modification on fiber orientation and yarn properties. J Text Inst 2019; 110: 652–659.

17. Akankwasa NT, Lin H and Wang J. Evaluation of thedual-feed rotor spinning unit based on airflow dynamics and blended yarn properties. J Text Inst 2017; 108: 1985–1996.

18. Lin H, Bergada` JM, Zeng Y, et al. Rotor spinning transfer channel design optimization via computational fluid dynamics. Text Res J 2018; 88: 1244–1262.

19. Lin H, Akankwasa NT, Wang J, Zhang Ch. Simulation of the Effect of Geometric Parameters of the Fibre Transport Channel in Open-End Rotor Spinning. FIBRES & TEXTILES in Eastern Europe 2019; 27, 2(134): 52-57. DOI: 10.5604/01.3001.0012.9987

20. Р.В. Корабельников, Д.А. Лебедев, Е.И. Громова. Экспериментальное определение коэффициента аэродинамического сопротивления для натурального волокна. // Технология текстильной промышленности - 2008, № 2 (306). С 22-26.

21. Попов С.Г. О продольной тяге нити воздушной струей / Текстильная промышленность. - 1961. - №10.-с48-49.

22. S.L. Matismailov, Sh.R. Aripova, Kamol Akhmedov, Sherzod Korabayev, Sh.F. Makhkamova and Z.F. Valieva; Investigating the effect of guide construction on yarn tension. E3S Web Conf., 538 (2024) 04017. DOI: https://doi.org/10.1051/e3sconf/202453804017

23. Sherzod Korabayev, Jakhongir Soloxiddinov, Nafisa Odilkhonova, R. Rakhimov, Anvar Jabborov and Ahtam A. Qosimov; A study of cotton fiber movement in pneumomechanical spinning machine adapter. E3S Web Conf., 538 (2024) 04009. DOI: https://doi.org/10.1051/e3sconf/202453804009

24. Sherzod Korabayev, Kamol Akhmedov, Husanhon Bobojanov, Saypila Matismailov; A method for researching the aerodynamic properties of cotton fiber in a rotor spinning machine separator. *AIP Conf. Proc.* 11 March 2024; 3045 (1): 050010. https://doi.org/10.1063/5.0197299

Sherzod Korabayev, Kamol Akhmedov, Saypila Matismailov, Alisher Yuldashev; Analysis of forces affecting fiber breakage of opening roller saw teeth of rotor spinning machine. *AIP Conf. Proc.* 11 March 2024; 3045 (1): 030018. https://doi.org/10.1063/5.0197289

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