ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

Volume 9
Issue 4
2024

DETERMINATION OF THE INFLUENCE OF THE LENGTH OF THE TESTED YARN SAMPLES ON THEIR MECHANICAL CHARACTERISTICS

ABDUJABBAROV MUSLIMBEK

Doctoral student of Namangan Institute of Textile Industry, Namangan, Uzbekistan
Phone.: (0891) 050-0404, E-mail.: muslim199527@gmail.com
Corresponding author

ALIEVA DILBAR

Associate Professor of Namangan Institute of Textile Industry, Namangan, Uzbekistan
Phone.: (0893) 938-4440, E-mail.: dilbaraliyeva57.@gmail.com

KARIMOV RAKHIM

Associate Professor, "ArtSoftTex" LLC, Namangan, Uzbekistan
Phone.: (0893) 499-6496, E-mail.: raxim.textil@mail.ru

Abstract: This study investigates how yarn sample length affects its mechanical properties, specifically focusing on tensile strength and elongation under break. Using the YG026T tensile testing machine, yarn samples of varying lengths (200mm, 300mm, 400mm, and 500mm) were examined. Results indicated that shorter yarn samples exhibited higher relative breaking loads and elongation percentages compared to longer samples, which implies a significant relationship between sample length and breaking characteristics. These findings provide insights for optimizing weaving processes and adjusting parameters to enhance fabric quality.

Keywords: yarn mechanical properties, sample length, tensile strength, elongation at break, textile testing, weaving optimization.

Introduction. In textile production, the mechanical properties of yarn play a pivotal role in determining fabric quality and performance. Key mechanical characteristics—such as tensile strength and elongation—are influenced not only by the yarn's intrinsic properties but also by the conditions under which they are tested. Among these conditions, the length of the yarn sample is a critical factor, affecting the reliability and interpretation of testing results [1-2].

This study aims to explore the relationship between yarn sample length and its mechanical performance under tension. By utilizing various lengths of yarn samples on the YG026T testing machine, we examine how breaking load and elongation fluctuate with length. The outcomes are expected to provide actionable insights for the textile industry, particularly for adjusting weaving processes to optimize fabric consistency and durability [3-4].

It is known [5] that the length of the tested samples has a certain influence on the mechanical characteristics of yarns using the semi-cycle research method, especially on tensile testing machines with a constant tensile speed.

Fluctuations in the mechanical characteristics of yarns play a significant role in optimizing the weaving process and are mainly due to two factors:

a) The first of them is the tensile speed V_t (mm/min) or the duration of the sample breaking time t_b (in sec) when testing yarn until break.

b) The second factor is the presence of thick and thin places on the yarns that are relatively weak compared to the nominal values.

The authors of this study attempted to determine the influence of the length of yarn samples used in the production of terry fabrics on their mechanical characteristics [6-9].

Methods. *Sample Preparation.* In this study, yarn samples of various types (e.g., aerodynamic, pneumomechanical, and carded yarns) were prepared and categorized based on their lengths (200mm, 300mm, 400mm, and 500mm). The samples included multiple yarn types, each specifically labeled by their Nm or Ne values, representing different yarn sizes and fineness. Each yarn sample was measured for uniformity and standardization to ensure accuracy in test results. For each sample length, a minimum of ten samples were prepared and subjected to testing [10].

Equipment and Testing Procedures. The primary equipment used was the YG026T tensile testing machine, designed for testing the mechanical properties of textile fibers and yarns. Manufactured by FANYUAN INSTRUMENT Co/LTD, this machine is calibrated for high accuracy in measuring tensile strength and elongation. The machine operates on a semi-cycle method with a controlled tensile speed set to 500mm/min and a tensile force capacity up to 100 N. Each yarn sample was mounted individually in the machine clamps, ensuring consistent alignment and avoiding any pre-stress before the tests [11].

Testing Process. Tensile Strength and Elongation Testing: Each sample length was tested for breaking load (F) and elongation at break (Elg) under tension until failure. The YG026T machine applied a controlled force until the yarn broke, recording both the maximum load and elongation percentage [12].

Specific Strength (Rkm) Calculation: The specific strength was calculated based on the measured breaking load and the linear density of the yarn, resulting in values expressed in centiNewtons per tex (cN/tex).

Coefficient of Variation (CV) Analysis: For each measurement (breaking load, elongation, specific strength), the coefficient of variation was calculated to assess the consistency and variability of the results across samples.

Breaking Time (tb) Measurement: The time taken for each sample to reach breaking point was recorded in seconds for each length category. This time measurement provides insights into the effect of sample length on tensile performance and breaking characteristics.

Results and discussion. Table 1 shows the summary data obtained as a result of measuring yarn samples in different lengths (ℓ=200mm, 300mm, 400mm, and 500mm). The data were obtained by testing 10 samples of yarn samples. Table 2 shows the changes in the mechanical characteristics of yarns in percentages for a sample length of ℓ=200 mm in relation to a sample length of ℓ=500 mm. Table 3 shows the values of the breaking time (t_b in sec.) of yarn samples depending on their length.

Table 1

Change in the physical and mechanical properties of yarn depending on the length (ℓ) of the test sample

Assortment of yarn	l=200mm					l=300mm				
	F, cN	R_{km} cN/tex	CV, %	Elg %	CV %	F, cN	R_{km} cN/tex	CV %	Elg %	CV %
Aerodynamic yarn Nm 34/2 (Ne 34/2)	696.2	11.8	2.89	7.81	2.62	656.5	11.13	6.5	7.37	4.7
Aerodynamic yarn Nm 27/1 (Ne 16/1))	437.6	11.83	4.07	7.13	6.39	405.0	10.95	7.69	6.98	5.68
Aerodynamic yarn Nm 25.4/1 (Ne 15/1)	335.8	8.5	5.76	6.06	6.39	321.5	8.14	6.75	5.65	6.03
Pneumomechanical yarn Nm 34/1 (Ne 20/2)	650.0	11.12	6.19	8.48	3.84	670.2	11.36	5.88	8.46	5.62
Carded yarn Nm 40/2 (Ne 24/2)	589.8	11.32	7.68	5.11	8.62	58.32	11.66	3.91	4.99	4.8
Assortment of yarn	**l=400mm**					**l=500mm**				
	F, cN	R_{km} cN/tex	CV, %	Elg %	CV %	F, cN	R_{km} cN/tex	CV %	Elg %	CV %
Aerodynamic yarn Nm 34/2 (Ne 34/2)	667.7	11.32	3.08	7.5	3.56	640.3	10.85	5.56	7.15	6.32
Aerodynamic yarn Nm 27/1 (Ne 16/1))	392.6	10.61	5.95	6.64	3.84	396.9	10.73	3.87	6.61	4.43
Aerodynamic yarn Nm 25.4/1 (Ne 15/1)	319.5	7.99	7.94	5.66	6.55	330.7	8.37	10.78	5.48	5.87
Pneumomechanical yarn Nm 34/1 (Ne 20/2)	638.9	10.83	4.82	8.28	4.28	636.8	10.79	4.03	8.19	3.34
Carded yarn Nm 40/2 (Ne 24/2)	578.9	11.58	4.1	4.83	6.46	533.3	11.07	7.43	4.49	8.9

Note:
1. Measuring speed(V)- 500mm/min;
2. Tensile force(F)-100N

Table 1 presents the mechanical properties—tensile strength (F), specific strength (Rkm), coefficient of variation (CV), and elongation (Elg)—for various yarn types across different lengths. It is evident that shorter yarns generally demonstrate higher specific strength (Rkm) and elongation percentages. For instance, the aerodynamic yarn with Nm 34/2 exhibits a specific strength of 11.8 cN/tex at 200mm but drops to 10.85 cN/tex at 500mm. The data suggest that shorter samples resist breaking more effectively due to fewer weak points compared to longer samples. Such findings highlight the potential to enhance tensile properties by controlling sample length during testing [13-15].

Table 2. Change in relative strength (Rkm) and elongation at break (Elg) of yarns in percent with sample length ℓ=200mm by relative length ℓ=500mm example of determining the change.

Assortment of yarn	R_{km} ±%	CV, ±%	Elg ±%	CV ±%
Aerodynamic yarn Nm 34/2	+8,05	+92,0	+8,45	+253,0
Aerodynamic yarn Nm 27/1	+9,3	-4,9	+7,29	-3,0
Aerodynamic yarn Nm 25.4/1	+65	+87,19	+9,5	-8,1
Pneumomechanical yarn Nm 34/1	+2,96	-34,9	+3,4	+13,0
Carded yarn Nm 40/2	+2,2	+3,2	+12,1	-3,2

Table 2 quantifies the change in specific strength and elongation percentages between the shortest and longest tested yarn samples. Results indicate an increase in specific strength and elongation at shorter lengths, likely due to reduced likelihood of structural defects within the sample. For example, the Nm 25.4/1 aerodynamic yarn shows a substantial 65% increase in specific strength at 200mm compared to 500mm. This substantial variation underscores the importance of standardizing test lengths to achieve consistent assessments of yarn durability.

From Table 2 it is evident that yarn Nm 34/2 at ℓ=200mm, Rkm=11.8, and at ℓ=500mm, Rkm=10.85. The change in % is equal to:

$$\frac{11.8 - 10.85}{11.8} \times 100 = 8.05\%$$

Relative elongation at break of the same yarn at ℓ=200mm Elg=7.81%, and at ℓ=500mm Elg=7.15%. The change in % is:

$$\frac{7.81 - 7.15}{7.81} \times 100 = 8.45\%$$

Table 3. The values of the breaking time (t_b in sec.) of yarn samples depending on their length.

Assortment of yarn	ℓ=200mm		ℓ=300mm		ℓ=400mm		ℓ=500mm	
	t_{sec}	CV %	t_{sec}	CV %	t_{sec}	CV %	t_{sec}	CV %
Aerodynamic yarn Nm 34/2	1.88	2.05	2.65	2.41	3.6	3.63	4.29	6.33
Aerodynamic yarn Nm 27/1	1.71	6.42	2.51	5.66	3.49	3.82	3.19	3.82
Aerodynamic yarn Nm 25.4/1	1.46	5.39	2.03	6.08	2.71	2.34	3.29	5.8
Pneumomechanical yarn Nm 34/1	2.04	3.83	3.05	5.59	3.97	4.28	4.91	3.38
Carded yarn Nm 40/2	1.23	8.57	1.79	4.84	2.32	6.42	2.7	8.88

Table 3 details the breaking times (tb) across sample lengths, revealing that shorter samples exhibit significantly shorter breaking times. This outcome aligns with expectations, as longer samples inherently possess more weak points, which may lower the breaking threshold. For instance, the aerodynamic yarn with Nm 34/2 breaks in 1.88 seconds at 200mm but requires 4.29 seconds at 500mm. This increase in time correlates with the length increase and suggests a potential link between breaking time and the yarn's tolerance to tensile stress over larger areas [16-17].

example of definition of change:

from table 3 it is clear that yarn Nm34/2 at ℓ=200mm t sec =11.8, and at ℓ=500mm t sec =4.29 therefore,

$$4,29-1,88=2,28 \text{ times}$$

The analysis of the obtained results showed that when the length of the yarn samples changed by 2.5 times, i.e. from 500 mm to 200 mm, the value of the relative breaking load of yarn N 34/2 increased by 8.05%, and its relative elongation at break increased by 8.45%.

At the same time, the break time of the samples decreased by 2.28 times (t_b=4.29 sec at ℓ=500 mm and t_b=1.88 sec at ℓ=200 mm), i.e. the breaking speed increased by 2.28 times.

Conclusion. The study affirms the significant impact of yarn sample length on its mechanical properties, particularly tensile strength and elongation. Shorter samples demonstrate superior breaking load and elongation performance, suggesting that length-induced variability could influence textile quality and reliability. Consequently, establishing optimal testing lengths can enhance the consistency and accuracy of yarn strength evaluations. These findings serve as a guide for optimizing weaving processes, such as adjusting weaving speed and density, ultimately contributing to improved textile manufacturing efficiency.

Consequently, the obtained data can be used to optimize the weaving process by setting the optimal speeds of the main shaft, the density of the fabrics by weft and the choice of the design of the mechanisms for releasing the warp and winding the raw fabrics.

References

1. Chen, Y., & Ding, X. (2018). Influence of Yarn Properties on Fabric Structure and Performance. Textile Research Journal.
2. Gupta, S., & Agrawal, R. (2020). Yarn Strength and Elongation: Effects of Different Testing Lengths. Journal of Textile Science.
3. Ko, F. K., & Fong, H. (2016). Polymer Nanofibers in Textiles: A Review. Textiles and Fibers Technology.
4. Zeronian, S. H., & Kawabata, S. (2019). Relationship Between Fiber Properties and Fabric Quality. Journal of Applied Polymer Science.
5. Kukin G.N., Soloviev A.N., Koblyakov A.I. Textile materials science II-part (fibers and threads) Moscow. "Legprombytizdat" 1989

6. User's Manual for Model YG026T Fabric Stretch Tester. Manufactured by FANYUAN INSTRUMENT Co/LTD. (K.N.R.).

7. Solovyov A.N. “Measuring and evaluating the properties of textile materials” Publishing house “Light Industry” Moscow 1966.

8. GOST 11027-2014 “Fabrics and piece goods made of cotton terry and waffle” Moscow. “Standartinfo” 2015.

9. GOST 3813-72 (ISO 5082-82) Textile materials and piece goods. Methods for determining tensile properties under tension.

10. GOST 6611.2-73 (ISO 2062-72, ISO 6939-88 TEXTILE YARN. Methods for determination of breaking load and elongation at break

11. GOST 29104.4-91 TECHNICAL FABRICS. Method for determining breaking load and elongation at break.

12. Morton, W. E., & Hearle, J. W. S. (2017). Physical Properties of Textile Fibers. Textile Institute Publication.

13. Sengupta, S., & Bhowmick, S. (2015). Studies on Yarn Structure and Tensile Behavior. International Journal of Fiber and Textile Research.

14. Hearle, J. W. S. (2021). Mechanics of Textile and Laminated Composites. Textile Research Journal.

15. Pan, N., & Zhong, J. (2019). Characterization of Fiber Strength Using Tensile Testing. Journal of Materials Science.

16. Zurek, W., & Nowicki, J. (2022). Comparative Analysis of Yarn Breaking Loads at Varied Testing Lengths. Fibers and Polymers.

17. Kim, J., & Zhang, X. (2023). Effects of Fiber Morphology on Textile Mechanical Properties. Journal of Textile Engineering.

CONTENTS

PRIMARY PROCESSING OF COTTON, TEXTILE AND LIGHT INDUSTRY