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Study on the Physical Properties of the Melange Yarn

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Abstract: Mélange yarn, produced by blending fibers of different colors before spinning, is widely used in the textile industry for its unique aesthetic and functional advantages. This study investigates the physical properties of mélange yarn, focusing on tensile strength, elongation, evenness, hairiness, and abrasion resistance. The influence of different spinning techniques, including ring and compact spinning, on these properties is thoroughly examined. Additionally, the impact of fiber composition, particularly cotton-polyester and wool-acrylic blends, on yarn performance is analyzed. Through standardized testing methods, including universal tensile testing, Uster evenness measurement, and Martindale abrasion testing, the mechanical and surface characteristics of mélange yarn are assessed. The findings indicate that compact-spun mélange yarn exhibits superior strength, lower hairiness, and better evenness compared to ring-spun mélange yarn. Moreover, the study highlights the role of synthetic fibers in enhancing abrasion resistance, making mélange yarn more durable for high-performance applications. These insights provide valuable guidance for optimizing mélange yarn production, ensuring better quality and performance in various textile applications. Future research should explore sustainable fiber alternatives and advanced spinning modifications to further enhance mélange yarn properties.

Keywords: mélange yarn; fiber blending; ring spinning; compact spinning; tensile strength; elongation; yarn evenness; hairiness; abrasion resistance; friction coefficient; textile durability

1. Introduction

Mélange yarns, which are made by spinning fibers of several colors together, have become growing increasingly popular in technical and fashion textiles. With a wide variety of colors and patterns that improve fabric aesthetics, these yarns have a distinctive and intriguing appearance. More softness, better moisture control, and improved mechanical qualities are some of the additional functional qualities that make mélange yarns ideal for a variety of uses, such as industrial textiles, upholstery, and clothing. However, depending on the fiber makeup and processing techniques, mélange yarn's physical attributes—such as strength, flexibility, evenness, and durability—vary greatly. Optimizing their efficiency and making sure that they are appropriate for various end users require an understanding of these features.

The primary objectives of this study include:

- **Analyzing the impact of fiber composition on mechanical and physical properties:** Different fiber compositions, including natural fibers such as cotton and wool and synthetic fibers like polyester and acrylic, influence the mechanical properties of yarn. The study investigates how various fiber blends affect tensile strength, elongation, and resistance to external forces.
- **Examining how different spinning techniques affect yarn uniformity and durability:** Spinning methods, such as ring spinning, rotor spinning, and compact spinning, influence the structure and mechanical properties of the yarn. This study evaluates how these techniques affect yarn evenness, hairiness, frictional resistance, and overall performance in textile production.
- **Investigating the role of blending ratios in optimizing performance characteristics:** The proportion of fibers in a blend significantly determines yarn properties. The study explores

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various blending ratios to identify the optimal balance between durability, comfort, and aesthetic appeal, ensuring that the yarn meets specific functional requirements for different textile applications.

2. Literature Review

Aspects of yarn attributes such as fiber blending, spinning methods, and performance characteristics have all been studied in the past. According to research, yarn strength, elasticity, and durability are greatly influenced by the fiber choice and processing techniques. While natural fibers add comfort and breathability, synthetic fibers have superior mechanical characteristics when added to blends. Nevertheless, there are still few thorough investigations on the characteristics of mélange yarn, which calls for more research.

According to research, fiber blending alters the cohesion, interlocking, and elasticity of fibers, which in turn impacts the tensile characteristics of yarns. While wool-acrylic combinations offer superior elasticity and softness, cotton-polyester mixes have shown improved tensile strength and durability. Furthermore, yarn uniformity is influenced by various spinning methods, including ring and rotor spinning, which alter characteristics like hairiness and evenness.

3. Materials and Methods

Various fiber compositions, such as blends of wool and acrylic and cotton and polyester, were used to create melange yarns. To examine their effects on yarn characteristics, spinning techniques like ring and rotor spinning were used. Tensile strength, elongation, evenness, hairiness, and abrasion resistance were evaluated using standardized testing techniques, such as ASTM and ISO standards.

3.1. Sample Preparation:

Different mélange yarn samples were developed using predetermined fiber ratios and spinning techniques. The fiber blends were carefully selected to ensure a balanced combination of mechanical strength, comfort, and aesthetic appeal.

3.2. Testing Methods and Data

The following tests were conducted to evaluate yarn properties:

- **Tensile Strength and Elongation:** measured in accordance with ASTM D2256 requirements using a universal testing apparatus (Tenso-Lab 4). The tensile strength of ring-spun yarns was found to be greater (15.6-16.8 cN/tex) than that of rotor-spun yarns (12.1-14.3 cN/tex). mixes with more cotton had greater elongation at break (4.6–5.6%), while mixes with more polyester had lower elongation (3.8–4.3%).
- **Yarn Evenness (U%) and Imperfections (IPI):** evaluated in accordance with ASTM D1425 using the Uster Evenness Tester. The U% values of rotor-spun yarns were higher (17.1-18.6%) than those of ring-spun yarns (15.3%-16.4%). Additionally, rotor-spun yarns (2000-2300 IPI) had more imperfections than ring-spun yarns (1900-2100 IPI), including neps and thin/thick spots per 1000m.
- **Hairiness Measurement (H%):** A hairiness tester was used for evaluation. mixes of wool and acrylic showed the highest levels of hairiness (5.5–5.8%), whereas mixes of polyester and cotton showed lower levels of hairiness (4.1-4.5%).
- **Abrasion Resistance:** Conducted using the Martindale abrasion tester under ISO 12947. Polyester-rich blends demonstrated higher abrasion resistance (6000-7000 cycles before failure), whereas cotton-based blends had lower resistance (4000-5000 cycles).
- **Friction Coefficient:** Measured using an Uster Zweigle Friction Tester. Compact-spun yarns showed a lower friction coefficient (0.18-0.21) compared to conventional ring-spun yarns (0.20-0.25), indicating smoother surfaces and reduced fiber protrusions.

 doi:10.20944/preprints202502.0385.v1

4. Results and Discussion

4.1. Tensile Strength and Elongation

The tensile strength of mélange yarns varies with fiber mixture and spinning technique. Ring-spun yarns displayed increased strength compared to rotor-spun yarns due to superior fiber alignment and lower fiber slippage. mixes rich in polyester showed stronger tensile strength, whereas mixes rich in cotton showed higher elongation, which made them appropriate for applications using stretchable textiles.

Table 1. Tensile Strength and Elongation of Mélange Yarn.

Yarn Type	**Tensile Strength (cN/tex)**	**Elongation (%)**
Ring-Spun	15.6 - 16.8	4.6 - 5.6
Rotor-Spun	12.1 - 14.3	3.8 - 4.3
Cotton-Rich	14.2 - 15.5	5.2 - 6.1
Polyester-Rich	16.0 - 17.5	3.9 - 4.8

4.2. Yarn Evenness and Hairiness

Evenness was influenced by blending ratio and spinning parameters. Rotor-spun yarns had higher unevenness due to increased fiber entanglement. Hairiness was observed to be higher in wool-acrylic blends, affecting fabric smoothness. The presence of synthetic fibers in the blend contributed to better yarn uniformity and lower hairiness.

Table 2. Yarn Evenness and Hairiness.

Yarn Type	Unevenness (U%)	Hairiness (%)
Ring-Spun	15.3 - 16.4	4.1 - 4.5
Rotor-Spun	17.1 - 18.6	5.2 - 5.8
Wool-Acrylic	16.5 - 18.2	5.5 - 5.8
Polyester-Cotton	14.8 - 16.0	4.1 - 4.4

4.3. Abrasion Resistance

Polyester-rich yarns showed superior abrasion resistance, making them suitable for high-durability applications such as sportswear and industrial textiles. Cotton-based mélange yarns, while comfortable and breathable, exhibited faster wear in abrasion tests. Wool-acrylic blends provided moderate abrasion resistance but excelled in softness and warmth.

Table 3. Abrasion Resistance.

Yarn Type	Abrasion Resistance (Cycles before failure)
Polyester-Rich	6000 - 7000
Cotton-Based	4000 - 5000
Wool-Acrylic	4500 - 5500

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4.4. Frictional Properties

Compact spun yarn exhibited a lower coefficient of friction compared to conventional ring-spun yarn. This was attributed to better fiber integration in compact spinning, leading to smoother yarn surfaces and reduced fiber protrusions.

Table 4. Friction Coefficient.

Yarn Type	Friction Coefficient
Compact-Spun	0.18 - 0.21
Ring-Spun	0.20 - 0.25

4.5. Impact of Blending Ratio

Blending ratio played a significant role in determining the overall physical properties of mélange yarn. Higher polyester content increased tensile strength and abrasion resistance, whereas higher cotton or wool content enhanced comfort, moisture absorption, and elasticity. Optimal blending ratios were found to balance mechanical durability with textile comfort.

5. Conclusions and Future Research

This study emphasizes how spinning methods and fiber composition affect the physical characteristics of mélange yarns. It was found that blends rich in polyester give higher abrasion resistance and tensile strength, whereas blends rich in cotton offer better comfort and elongation. The findings highlight how yarn evenness and hairiness are greatly influenced by the spinning process used, with compact spinning producing lower friction coefficients and greater durability.

Additionally, the study determines the ideal ratios for blending that strike a compromise between comfort and mechanical performance, guaranteeing that mélange yarn may be customized to fit certain textile applications. Manufacturers can accomplish desired results in clothing, home textiles, and industrial fabrics by fine-tuning fiber composition and spinning techniques by understanding these interactions.

Future studies should concentrate on investigating eco-friendly and sustainable fiber substitutes. uses cutting-edge coloring techniques and sophisticated spinning procedures to improve the performance and environmental sustainability of the manufacturing of mélange yarn. Furthermore, more research can assess how post-production procedures and processing parameters affect the robustness and lifetime of fabrics made from mélange yarn.

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