ASSESSMENT OF INFLUENCE OF DIAGONAL PATH OFFSET IN SPINNING IN HAIRINESS CONTROL

(A JOURNAL PAPER)

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ABSTRACT

The spinning geometry of a ring frame plays an important role in affecting the yarn properties. This project examines the effect of diagonal yarn path in ring spinning on yarn properties. Both left diagonal and right diagonal yarn arrangements with three offsets are tried in ring spinning for two cotton counts 40^S C & $6O^S$ C. The various yarn results, especially hairiness from Zweigle hairiness tester, are compared with the results of yarn produced from conventional yarn path. The results shows that yarn hairiness values are significantly reduced with left diagonal path when compared to conventional straight path. It is also noticed that not only the hairiness value, but the total imperfections also found reduced in left diagonal path when compared to straight yarn path in 40^S C in all the three offsets.
In right diagonal path, the total imperfections found get reduced in 40^SC in all the three offsets. But hairiness has increased. In 60^SC, both hairiness and imperfections are increased compared to straight yarn path.
A modified ring spinning system was proposed to create diagonal yarn paths and offsets. The system was tested on yarn counts 20s, 40s, and 60s (100% cotton) under different diagonal offsets. The results showed that the modified system improved yarn hairiness without altering tensile and unevenness properties. The maximum reduction in hairiness was 42.6%, 28.5%, and 21.3%, with coarser yarns showing more significant improvement. The diagonal path was found to be the most important factor in determining yarn hairiness across all yarn counts.

INTRODUCTION

The quality of yarn is a critical determinant of the performance, durability, and aesthetic appeal of textile products. Among the various parameters that define yarn quality, yarn hairiness—a measure of the extent to which fibres protrude from the yarn surface— holds particular significance. Excessive hairiness can adversely affect downstream processing, such as weaving and knitting, leading to issues like breakage, pilling, and uneven dye uptake. Consequently, controlling yarn hairiness has become a key focus in modern spinning technologies. One of the less explored but potentially significant factors influencing yarn hairiness is the diagonal yarn path offset during the spinning process. This parameter affects the alignment, tension, and distribution of fibres within the yarn structure, thereby playing a role in hairiness control. The present study aims to assess the influence of diagonal yarn path offset on yarn hairiness by analysing its effects across different spinning conditions. Understanding this relationship can provide valuable insights for optimizing spinning processes, enabling the production of yarns with superior quality and consistency. This investigation contributes to the growing body of knowledge in textile manufacturing, paving the way for innovations that meet the increasing demand for high-performance and aesthetically appealing textile products.

1.1 Background context

This study aims to understand the impact of the diagonal yarn path offset on yarn hairiness in spinning processes. Despite advancements in spinning technology, the role of this offset remains underexplored. This offset determines the alignment of fibres, affecting tension distribution and fibre positioning within the yarn structure.
Understanding this aspect is crucial for optimizing spinning conditions and achieving superior yarn quality. The study aims to enhance process efficiency and product performance in the textile industry.

1.2 Problem Statement

Yarn hairiness, the protrusion of fibres from the yarn surface, is a significant quality issue in textile manufacturing. It can cause friction, thread breakage, and machine inefficiencies during downstream processes like weaving and knitting. High hairiness also affects the aesthetic and functional properties of textile products, such as smoothness, strength, durability, and uniform dyeing and finishing. Despite advancements in spinning technologies, the persistence of this issue highlights the need for deeper investigation into the factors influencing it. One such factor is the diagonal yarn path offset during spinning, which affects fibre alignment, tension, and distribution. However, the relationship between this offset and yarn hairiness is poorly understood, hindering manufacturers from fully utilizing this parameter to improve yarn quality.

1.3 Scope of project

The scope of this project is to systematically investigate the influence of diagonal yarn path offset on yarn hairiness during the spinning process. The study will focus on analysing how different degrees of offset in the yarn path affect fibre alignment, tension distribution, and the overall formation of the yarn, with particular attention given to its impact on hairiness levels. This research will be conducted using various yarn materials and spinning techniques to assess the relationship between path offset and hairiness under different operational conditions.
Specifically, the project will explore a range of variables such as the magnitude of the diagonal offset, spinning speed, and fibre types to understand how these factors interact in the context of yarn hairiness. The experiments will involve the use of advanced instrumentation to measure yarn properties such as fiber protrusion, tensile strength, and evenness. By manipulating the diagonal yarn path offset, the study aims to identify the optimal settings that reduce hairiness while maintaining or even enhancing other yarn qualities like strength and consistency.

2.Literature Review

2.1 The mechanism of hairiness reduction in offset ring spinning with a diagonal yarn path

C Singh, S Gordon, X Wang - Textile Research Journal, 2019 - journals.sagepub.com This study explores offset spinning, a technique that alters the spinning triangle geometry by diagonally offsetting the yarn path during spinning. The researchers found that the direction of offset, and twist direction can change yarn twist configuration, controlling hair generation during spinning. Based on imaging observations and hairiness parameter results, a mechanism for hairiness reduction and preferred offset direction are proposed.

2.2 Yarn hairiness on ring spinning with modified yarn path

X Liu, X Su - 2016 - nopr.niscpr.res.in

Yarn hairiness on a modified ring spinning system with a pair of offset devices which can change the horizontal offset of spinning triangle continuously has been discussed in this paper. It is observed that the selection of appropriate right horizontal offset of spinning triangle can help to reduce the spun yarn hairiness with "Z" twist, whereas the selection of appropriate left offset can help to reduce the spun yarn hairiness with "S" twist. The corresponding appropriate horizontal offsets are given by experiments for five types of yarn, namely 20s, 30s, 40s, 50s and 60s with "Z" twist respectively. Finally, the explanations of hairiness reduction are given according to the fibre tension distributions at spinning triangle.

2.3 An overview on the spinning triangle-based modifications of ring frame to reduce the staple yarn hairiness

MKR Khan, HA Begum, MR Sheikh - Journal of Textile Science and …, 2019 - scirp.org
The traditional ring spinning system has limitations, including yarn hairiness, which negatively impacts weaving, knitting, and dyeing processes. Researchers are exploring modified ring frames to reduce hairiness. The spinning triangle (ST) plays a crucial role in fiber tension distribution and shape. This paper discusses spinning triangle-based modifications and agent-aided ring spinning systems to reduce yarn hairiness and improve textile product quality.

2.4 Effects of the Horizontal offset of the Ring Spinning Triangle on Yarn

The spinning triangle is crucial in yarn spinning, affecting the distribution of fibre tension and yarn properties. The horizontal offset of the twisting point to the symmetric axis of the nip line is a critical factor influencing yarn quality. This paper investigates the effects of the horizontal offset on yarn qualities, providing a theoretical model and analysing relationships between fibre tension and the horizontal offset. The modified ring spinning system is simulated numerically and evaluated.

2.5 Recent research and developments on yarn hairiness

N Haleem, X Wang - Textile Research Journal, 2015 - journals.sagepub.com

Hairiness is an important quality parameter of spun yarns. It not only affects the quality of yarns, but also the weaving and knitting performance of yarns as well as the quality of the resultant fabrics. Various developments regarding yarn hairiness have been reported in the last decade. These cover aspects such as hairiness measurement, modeling, simulation, spinning modifications and post spinning treatments to reduce hairiness. This study is an attempt to critically review all significant recent developments regarding yarn hairiness. Further possibilities of research and future work are also briefly discussed.

3.METHOLOGY

The study investigates the impact of diagonal yarn path offset on yarn hairiness during the spinning process. It uses an experimental approach, selecting appropriate materials like cotton and polyester to ensure uniformity in fibre properties. An adjustable spinning machine is used to control the diagonal yarn path offset, maintaining consistent spinning conditions. Yarn samples are produced under varying path offset settings, and hairiness levels are measured using advanced tools. Additional quality parameters like strength, evenness, and elongation are also analysed. Data collected from these experiments is systematically recorded and statistically analysed to identify patterns and correlations between the diagonal yarn path offset and yarn hairiness.

The study is conducted in 40^s Ne and 60^s Ne. Fibers specification and machinery details along with process parameter are listed in the flow chart. Three offsets are selected namely 70mm, 50mm, and 30mm for each left and right diagonal path.

3.1 Properties of Cotton

Cotton, a popular natural fibre in the textile industry, is known for its softness, breathability, and versatility. Its physical properties, including staple length, strength, and fineness, determine its suitability for spinning processes and the quality of the resulting yarn. Longer staple cotton, like Egyptian or Pima cotton, produces finer, stronger yarns due to better fibre alignment and reduced ends. Cotton fibre strength, measured as the force required to break a bundle of fibres, directly impacts the durability and tensile properties of the yarn. Higher strength fibres are better suited for high-speed spinning and result in more robust fabrics. Fineness, the diameter or thickness of the fibre, affects the smoothness and evenness of the yarn, making cotton ideal for high-quality textiles.

COTTON		40^sc	60^sC
	variety	Bunny	Mcu 5
	2.5% span length	28.2mm	30.5 mm
	50% span length	13.8 mm	14.2mm
	Strength in g/ tex	21.5 g/ tex	22.8 g
	Fineness in mic	3.8 mic	3.4 mic

3.2 BLOWROOM

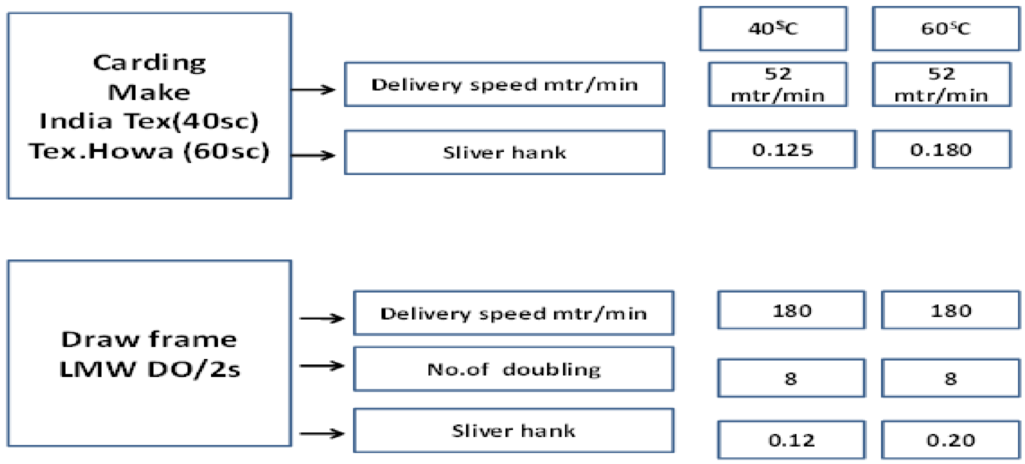
The blow room is the first stage in the spinning process, where raw cotton fibres are prepared for subsequent stages like carding and spinning. Its primary purpose is to open, clean, and blend the cotton fibres. The raw cotton, often in compressed bales, contains impurities such as seeds, leaves, dirt, and dust, which must be removed to ensure smooth processing and high-quality yarn production. The blow room achieves this by passing the cotton through a series of machines designed to break down large tufts into smaller ones, allowing for better cleaning and even distribution of fibres.

Blow room Make Ramaraj machine works		40^sC	60^sC
	variety	Bunny	Mcu 5
	Hopper bale breaker	do	do
	Step cleaner	do	do
	Hopper feeder with condensor	do	do
	Double beater scutcher with Two bladed beater and Kirschner beater	do	do
	Delivery speed meter/min	7.5 meter/min	7.5 meter/min
	Weight in grams/ meter	400 grm/mtr	350 grm/mtr
	Lap hank	0.001475	0.00169

3.3 CARDING, DRAWING

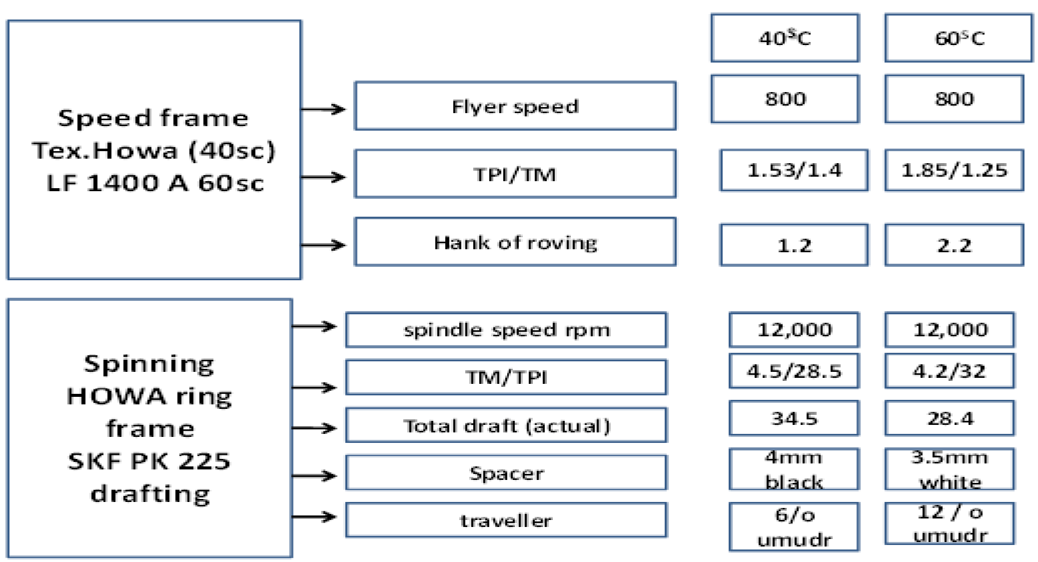
Carding and drawing are crucial in producing high-quality yarn, focusing on fibre preparation. Carding, often called the "heart of spinning," involves disentangled and cleaned fibres, converting them into a web and condensing them into slivers. This process enhances fibre quality and uniformity.

Drawing involves blending and straightening fibres to create a uniform sliver. It aligns fibres, reduces thickness, and ensures consistency. This process improves fibre alignment, strength, and evenness, ensuring uniformity in colour, texture, and properties. Both methods produce smooth, strong, and even yarns.



3.4 SPEED FRAME, RING FRAME

The speed frame, also known as the roving frame, is a crucial stage in the spinning process that prepares drawn slivers for final spinning. It attenuates and twists the slivers to form roving, a fine, lightly twisted fibre strand that can be easily fed into spinning machines. The speed frame's primary objectives are to reduce sliver thickness, impart strength, and prepare fibres for smooth drafting in the spinning stage.
The ring frame is a crucial machine in the spinning process, transforming roving into the final yarn through drafting, twisting, and winding. It is essential for producing strong, fine, and uniform yarns. The roving is fed into drafting rollers, which attenuate fibres to the desired thickness.



4.Experimental Procedure

To assess the influence of diagonal yarn path offset on hairiness control during spinning, a systematic experimental approach was adopted. The study began with the selection of cotton and synthetic fibres with uniform properties, such as staple length,

strength, and fineness, to ensure consistency across all samples. The fibres were conditioned in a controlled environment to standardize their moisture content and optimize them for spinning. A spinning machine equipped with adjustable components for controlling the diagonal yarn path offset was utilized. The machine was calibrated to maintain consistent spinning parameters, including spindle speed, twist density, and draft ratio, while varying the diagonal yarn path offset at predetermined angles (e.g., 0°, 10°, and 20°).
Yarn samples were produced under these varying offset conditions, ensuring consistent production to minimize errors. Hairiness levels of the spun yarns were measured using precise hairiness testers, complemented by measurements of other quality parameters such as yarn strength, evenness, and elongation. Data were systematically recorded and analysed using statistical tools to identify patterns and correlations between the diagonal yarn path offset and hairiness levels. The experiments were repeated for validation and extended across different fibre types and spinning speeds to ensure the reliability and applicability of the findings. This methodical approach enabled a comprehensive understanding of the role of diagonal yarn path offset in hairiness control, providing valuable insights for optimizing spinning processes.

4.1 Overview of Yarn Hairiness

Yarn hairiness is the protrusion of fibres from the yarn surface due to incomplete fibre alignment and inadequate cohesion during the spinning process. It is a critical quality parameter that affects both the manufacturing process and the final textile product. Excessive hairiness can lead to challenges in weaving and knitting, such as thread breakage, machine stoppages, reduced efficiency, lint and fly formation, and increased maintenance costs. It also affects the aesthetic and functional properties of the fabric, leading to rougher surfaces, uneven dye uptake, and reduced fabric durability. High hairiness in textiles can affect their visual appeal, performance, and abrasion resistance. It's crucial to control hairiness in yarn production to ensure high-quality fabrics. Addressing factors like diagonal yarn path offset can enhance processing efficiency and product quality. This ensures fabrics meet consumer expectations and industry standards, enhancing the overall quality of textiles.

5.Measurement of Properties

The precise measurement of yarn properties like hairiness, strength, and evenness is vital for evaluating and enhancing yarn quality, as these parameters directly impact the performance of downstream processes.

5.1 Hairiness Measurement

Yarn hairiness is quantified using specialized instruments like hairiness testers or optical systems. These devices measure the length and number of fibre protrusions on the yarn surface, providing precise measurements. The results are expressed as hairiness index values, allowing for comparisons across different yarn samples. Popular tools such as the Uster Tester or Zweigle Hairiness Tester provide precise measurements by capturing data on the extent and distribution of protruding fibers

5.2 Strength Measurement

Tensile testing machines measure yarn strength by measuring the maximum force it can withstand before breaking. This process, combined with controlled pulling force, ensures the durability and reliability of yarn in high-stress applications like weaving or sewing.

5.3 Evenness Measurement

Yarn evenness, a measure of yarn thickness and mass uniformity, is evaluated using testers like the Uster Evenness Tester. These devices detect variations in linear density and imperfections, often expressed as the coefficient of variation (CV%) or imperfection index, providing insights into yarn consistency.

6.Impact of Yarn Hairiness on Processing and Product

Yarn hairiness, caused by fibre protrusion from the yarn surface, impacts textile manufacturing processes and product quality. Excessive hairiness increases friction between yarn and machine components, leading to wear, tear, thread breakages, and machine stoppages. Loose fibres also contribute to lint and fly generation, contamination of machinery, and uneven tension during weaving or knitting, potentially causing fabric defects.

Hairiness in yarns can negatively impact the aesthetics of fabrics, causing uneven dye uptake, patchy or streaky finishes, abrasion, and pilling. It also affects the fabric's durability and tactile qualities, making it feel rough or uncomfortable to wear. Controlling yarn hairiness is crucial for efficient processing, cost-effectiveness, and the production of high-quality, durable, and visually appealing textiles.

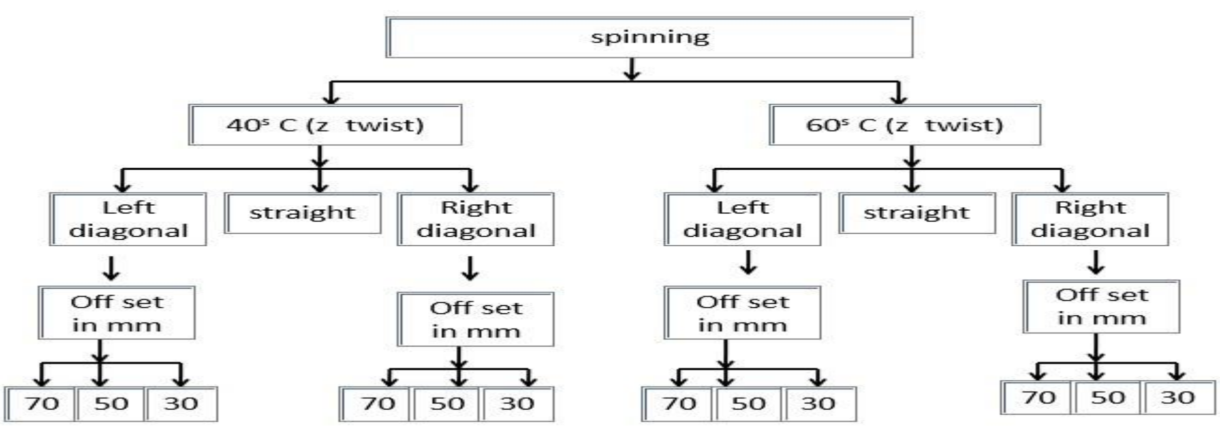
7. Material and Spinning Parameters

Yarn Count	Twist	Total draft	Roving Quality
20s	654.9	17.41	100% combed cotton, count 570 tex, micronnaire value 4.5, fibre length 28.1mm
40s	1024.3	38.74	100% combed cotton, count 445 tex, micronnaire 4.1, fire length 32mm
60s	1382.9	46.28	100% combed cotton, count 445 tex, micronanaire 4.1, fire length 32mm

7.1 Testing Method

All yarn samples were tested under standard conditions. Yarn hairiness tested by YG172A hairiness tester was the most concerned property. This hairiness measurement gave 3-9mm hairiness amount in 10m yarn. Yarn tenacity and breaking elongation were obtained by YG063 tensile tester. The imperfection test was done on YG135G.

7.2 Spinning



8.Result

To get the above offsets, three lines of fluted rollers are modified. The pneumatic broken end collecting orifice, bottom apron guiding positions, roving condensers also modified according to the offsets selected.

9.Conclusion

Yarn hairiness plays a critical role in determining the efficiency of textile manufacturing processes and the quality of finished products. Excessive hairiness can lead to operational challenges, including increased friction, thread breakages, lint generation, and uneven tension during weaving or knitting, which disrupt production and elevate costs. Additionally, it adversely impacts product aesthetics, durability, and performance, resulting in rough textures, uneven dye uptake, and pilling, which compromise consumer satisfaction. Controlling yarn hairiness is therefore essential not only for optimizing manufacturing efficiency but also for enhancing the visual and functional appeal of textiles. By understanding and managing the factors that influence hairiness, such as diagonal yarn path offset, the textile industry can achieve better process stability, reduced waste, and high-quality, durable fabrics that meet market demands.

10.References

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