Faculty of Engineering

Department of Textile engineering

Project (Thesis) on

Comparative Analysis of Cotton Covered Elastomeric Hybrid Yarns And Cotton Yarn Physical Properties In Splice And Without Splice Condition

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A thesis submitted in partial fulfilment of the requirements for the degree of

Bachelor of Science in Textile Engineering

Advance in Yarn Manufacturing Technology

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Mr. Alamgir Hossain**, Lecturer (Senior Scale), Department of Textile Engineering, Faculty of Engineering, Daffodil International University. We also declare that, neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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LETTER OF APPROVAL

This project report prepared by Md. Imrul Quies (ID: 073-23-642), is approved in Partial Fulfillment of the Requirement for the Degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING. The said student have completed their project work under my supervision. During the research period I found them sincere, hardworking and enthusiastic.

Alamgir Hossain

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ACKNOWLEDGEMENT

Firstly, I express my gratefulness to almighty Allah for his divine blessing makes us possible to complete this project successfully.

I am grateful to my supervisor **Alamgir Hossain,** Lecturer (Senior Scale), Department of Textile Engineering, Faculty of Engineering, Daffodil International University. Deep knowledge and keen interests of our supervisor in the field of Yarn manufacturing influenced me to carry out the project work. His endless patience, scholarly guidance, continual encouragement, energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting these at all stages have made it possible to complete this project.

Finally, I would like to express a sense of gratitude to my beloved parents and friends for their mental support, strength and assistance throughout writing the project report.

DEDICATION

This thesis report is dedicated to my mother

Abstract

This study pretends to assess the yarn breakage in ring machine in spinning process. The ring spinning process is a critical stage in textile manufacturing that significantly impacts the quality of the final product. Yarn breakage in ring spinning machines remains a persistent challenge, adversely affecting production efficiency, costs, and product consistency. This research report investigates the yarn breakage data analysis of several different yarn count. Special emphasis is placed on the comparison of cotton and elastane core-spun yarns, with and without splicing, to understand their respective performance in terms of strength, elasticity, and resistance to breakage. Comprehensive tensile testing and statistical analyses were conducted to explore the interplay between jaw separation distances during testing and the mechanical properties of yarn. Findings suggest that optimal machine settings and material selection can significantly mitigate yarn breakage, providing actionable insights for improving manufacturing efficiency and product quality. The study also considers the environmental implications of fiber shedding during production, contributing to a holistic understanding of the challenges and opportunities in the textile industry.

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CHAPTER 01
INTRODUCTION

Introduction:

Textile manufacturing is a multifaceted process where the properties of intermediate products, such as spun yarn, play a pivotal role in determining the performance of the final fabric. Studies, such as those by Smith et al. (2019) and Johnson (2020), have highlighted how intermediate products influence key attributes like durability, elasticity, and texture in the finished textiles. Among the many steps involved, the ring spinning process is critical as it transforms drafted fibers into twisted yarn. This stage is susceptible to numerous issues, with yarn breakage being a predominant concern. Breakages during spinning not only reduce production efficiency but also compromise the quality of the final product by increasing variability and downtime. [1] [2]

Yarn breakage is influenced by factors such as fiber characteristics, tension inconsistencies, and machine parameters. Studies, including those by [3] and [4], have demonstrated that variations in fiber maturity and drafting tension are primary contributors to yarn instability, while suboptimal spindle speeds exacerbate breakage rates. For example, the selection of fibers, such as cotton and elastane, and their interaction with spinning settings, like twist levels and drafting systems, can significantly impact yarn performance. Furthermore, the incorporation of splicing technologies introduces additional complexity, as the junctions created can weaken the yarn structure. Addressing these issues requires a systematic examination of the underlying causes and the development of optimized spinning strategies.

This study aims to bridge the knowledge gap by providing a comprehensive analysis of yarn breakage mechanisms in ring spinning machines, building upon prior research that highlights existing gaps in understanding the interplay between material properties and spinning parameters. Special focus is given to core-spun yarns, which are widely used for their enhanced functional properties, such as elasticity and strength. Through a series of tensile strength and elasticity tests, this research explores the effects of splicing, material composition, and machine settings. Additionally, the study examines the environmental implications of synthetic fiber shedding, highlighting the need for sustainable practices in textile production. By combining empirical data with theoretical insights, this report seeks to offer actionable recommendations for mitigating yarn breakage and enhancing the efficiency of the ring spinning process.

1.1 Objective of the study

The primary objective of this research is to analyze the factors contributing to yarn breakage in ring spinning machines and to identify solutions that enhance yarn performance and production efficiency. The study focuses on:

i. Investigating the mechanical properties of various yarn compositions, including core-spun and 100% cotton yarns, with-out splice condition.
ii. Finding the relations between Tenacity, Extension and yarn twist between Cotton and Cotton/Spun yarn.

1.1.1. Scope of the study: The scope of this research focuses on understanding and addressing the factors influencing yarn breakage in ring spinning machines in different count yarn, which is a critical issue in the textile industry. The study is designed to explore the mechanical properties of yarns and establish relationships between key parameters that impact yarn performance and production efficiency. The following aspects outline the boundaries and focus areas of this study:

Yarn Composition Analysis:

- The research examines the mechanical properties of various yarn compositions, including core-spun yarns and 100% cotton yarns.
- Special emphasis is given to the “Splice” and "without splice" condition, to identify the impact of yarn continuity on breakage rates.

Mechanical Properties Examination:

- Analysis of key mechanical properties such as tenacity (strength), extension (elongation), and yarn twist is conducted.
- Comparative studies between cotton yarns and cotton/spun blended yarns are performed to understand their performance under similar conditions.

Industrial Application:

While the research is conducted under controlled conditions, the findings will be contextualized for industrial applicability in ring spinning operations.

1.1.2, Limitations of the study:

- The study is confined to specific yarn types (core-spun and 100% cotton) and does not extend to synthetic or other blended yarns.
- The focus is on mechanical properties and does not include chemical treatments or external processing influences.
- This study aims to contribute valuable insights for textile manufacturers and researchers, enabling better understanding and control of yarn performance during the ring spinning process.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Core Spun Yarn and cotton yarn

Core spun yarn, a unique and versatile type of yarn, has gained significant attention in the textile industry due to its distinctive properties and wide-ranging applications. At its core, core spun yarn is composed of a central filament, typically made of a synthetic material like spandex, which is then enveloped by a sheath of natural or synthetic fibers. This integrated manufacturing process, known as spun bonding, eliminates intermediate steps and provides opportunities for increased production and cost reduction. [5] Beside in cotton yarn only cotton fibers are simulated together with a certain number of twist.

2.1.1 Structure of Core Spun Yarn and cotton yarn

The structure and performance of core spun yarn are heavily influenced by the selection of the core material and the spinning parameters employed. For instance, using a spandex filament as the core can impart elastic properties to the yarn, while the choice of the sheath fibers, such as cotton, can contribute to the yarn's overall appearance and feel. Studies have shown that adjusting the feed-in angle and draw ratio of the core material can significantly impact the yarn's cover effect and dynamic elastic recovery.

Furthermore, the integration of different yarn components, such as polyester, elastane, and cotton, can be leveraged to create core spun fabrics with enhanced moisture management and thermal regulation properties. The use of specialized fibers, like bamboo charcoal or quick-dry materials, in the sheath can also introduce additional functional benefits, such as improved water vapor transmission, far infrared emissivity, and air permeability.

The versatility of core spun yarn manufacturing allows for the production of a wide range of textile products, from apparel to technical textiles. By understanding the interplay between the core material, sheath fibers, and process parameters, manufacturers can optimize the performance and characteristics of core spun yarns to meet the evolving demands of the textile market. [6]

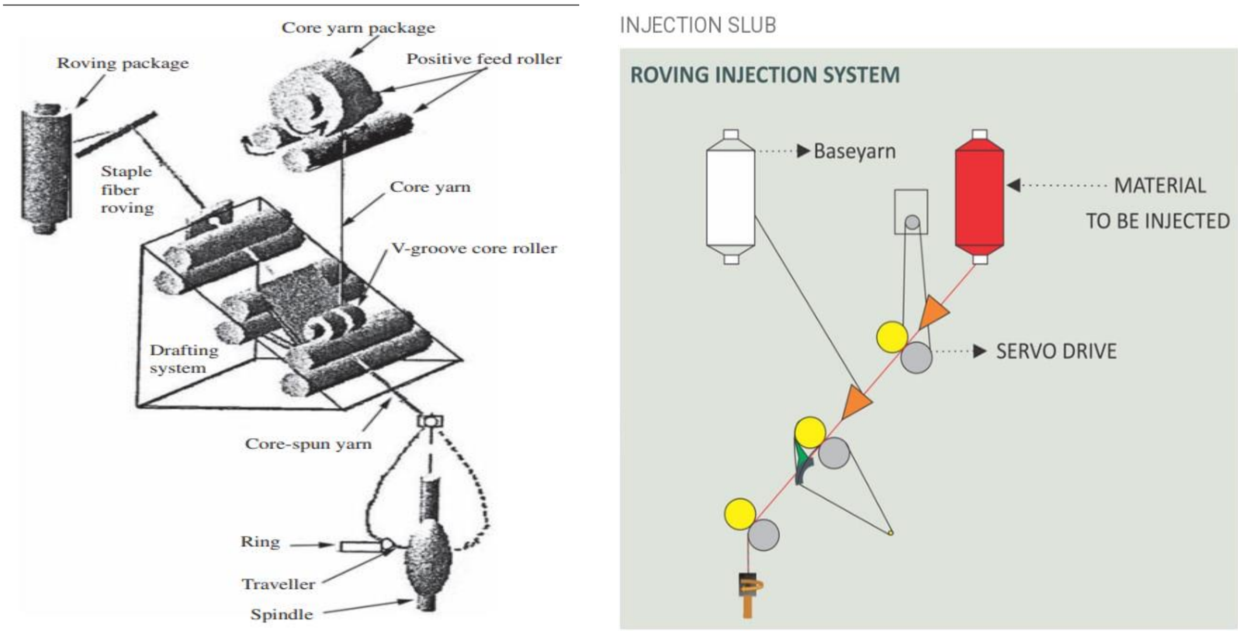


Figure 1 The schematic of core-spun yarn production method

The primary purpose of incorporating core-spun yarn in textiles is to leverage the unique characteristics of the continuous filament (such as elastomeric, crimped, or rigid filaments) combined with the staple fibers of either synthetic or natural origins. Core-spun yarns with filaments like nylon or polyester as the core material offer enhanced strength and functional benefits. In contrast, the use of various natural fibers (e.g., cotton, flax, silk, wool) as the outer sheath imparts the appearance and surface properties typical of natural fiber yarns. Figure 2 illustrates a typical core-spun hybrid yarn, where continuous filaments form the core, surrounded by staple fibers acting as a protective cover or sheath. [7]

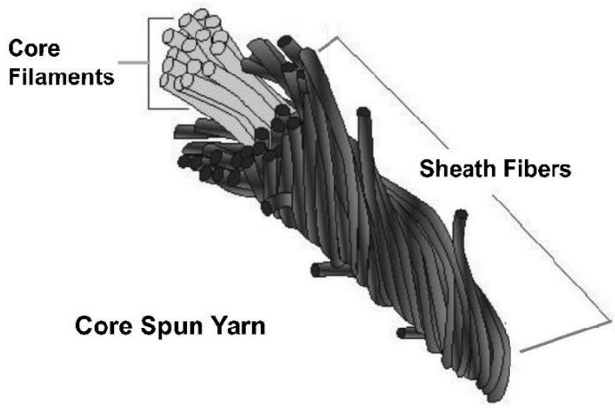


Figure 2 The schematic of core-spun yarn production method

For cotton yarn, the spinning process remains largely similar, with the exception of incorporating a filament yarn, which is inserted into the core of the cotton yarn. The schematic image below illustrates the structural configuration and appearance of the yarn. Multiple cotton staple fibers are twisted together cohesively to form the yarn, while the filament at the core enhances its functional properties.

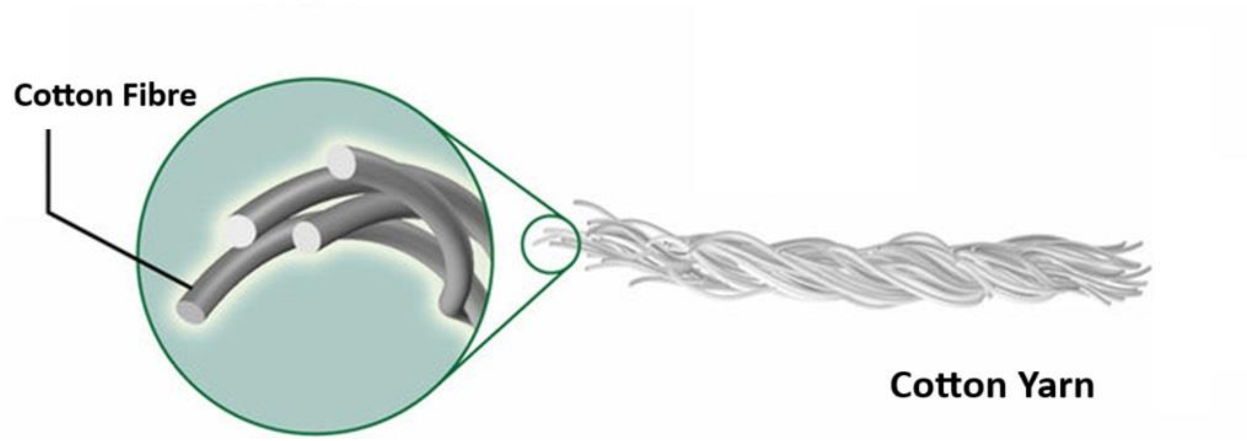


Figure 3 The schematic of cotton yarn production method

2.2 Factors Contributing to Yarn Breakage

Yarn irregularity, a common issue in textile manufacturing, has been identified as a significant contributor to yarn breakage in ring spinning machines. Uneven yarn characteristics, such as high unevenness percentages, can lead to increased tension and stress on the yarn, ultimately resulting in increased instances of yarn breakage. The formation of mechanical neps, caused by fiber buckling, is another factor that can compromise the structural integrity of the yarn, leading to breakage.

The maturity of the cotton fibers used in the spinning process has also been found to influence the likelihood of yarn breakage. Specifically, the coefficient of circularity, a measure of fiber maturity, has been shown to correlate with the minimal inertia radius of the fiber cross-section, which in turn impacts the yarn's resistance to breakage. [8]

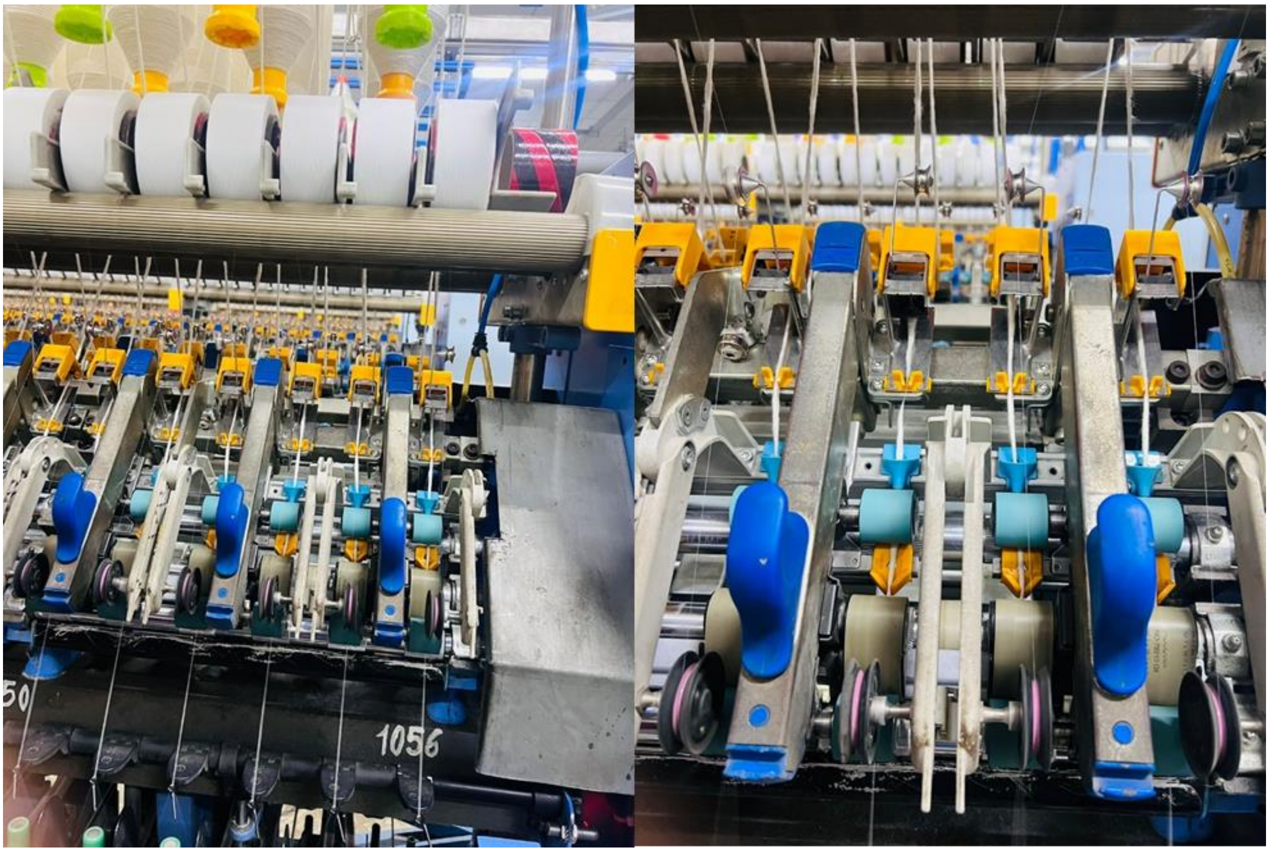


Figure 4 Yarn breakage in ring spinning machine

CHAPTER – 3

METHODOLOGY

3.1 Materials

For this research we took 03 types of grey yarn samples from ring spinning machine. Specification of these samples is mentioned in Table 1

Sample No	Sample	Count	Type
1	Cotton elastane	10 Ne + 40D	Splice
2	Cotton elastane	10 Ne + 40D	Without Splice
3	Cotton	10 Ne	Splice
4	Cotton	10 Ne	Without Splice
5	Cotton elastane	16 Ne + 70D	Splice
6	Cotton elastane	16 Ne + 70D	Without Splice
7	Cotton	16 Ne	Splice
8	Cotton	16 Ne	Without Splice
9	Cotton Elastane	30 Ne + 40D	Splice
10	Cotton Elastane	30 Ne + 40D	Without Splice
11	Cotton	30 Ne	Splice
12	Cotton	30 Ne	Without Splice

Table 1 Yarn Sample specification.

3.2 Process of manufacturing sample (yarn)

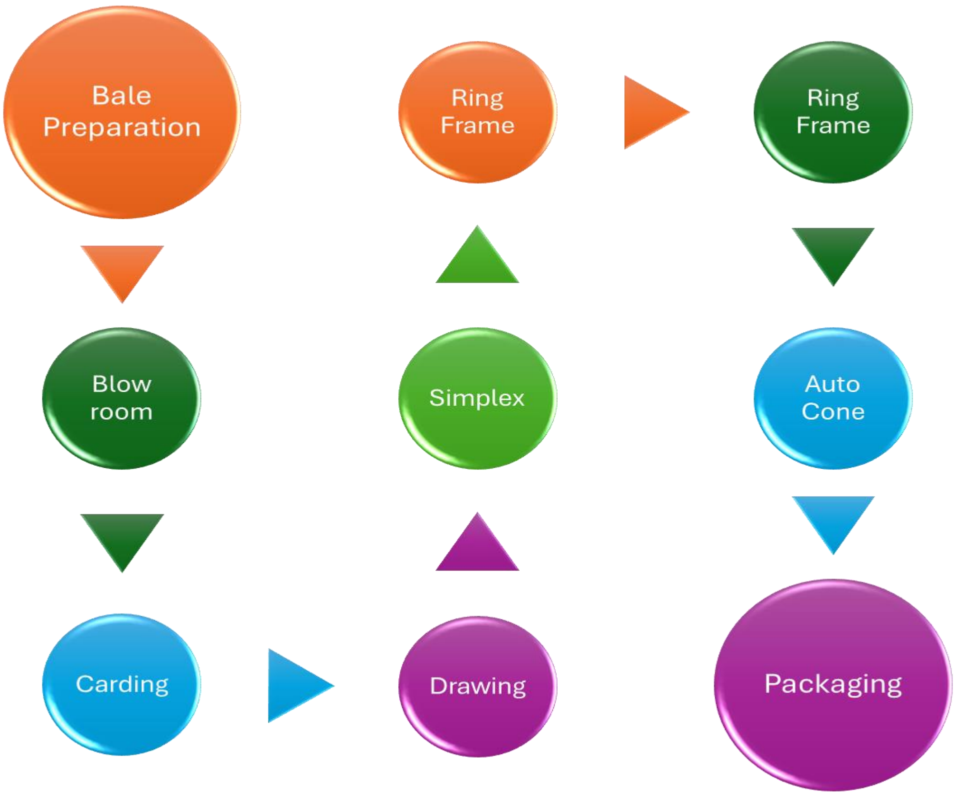


Figure 5 Process Flow chart of Yarn Manufacturing in spinning factory

The provided process flowchart illustrates the key steps involved in the yarn manufacturing process. Here's a description of the stages:

3.2.1. Bale Preparation:

- Raw cotton is processed into bales to prepare it for further stages.
- This step ensures the material is suitable for feeding into the next processes.

3.2.2. Blow Room:

- Cotton bales are opened and cleaned in the blow room to remove impurities.
- The fibers are loosened and prepared for carding.

Blow-room Machine setting	
Machine Brand	Rieter
Line	03
B12	CI – 0.4, RW – 05
B76	DOP – 0.3
B17	CI – 0.4, RW – 05
A79	CI – 0.4, RW - 05

Table 2 Blowroom Machine setting

3.2.3. Carding:

- Carding machines align the fibers into a thin web and remove short fibers or remaining impurities.
- The output is a sliver, a continuous strand of fibers.

Carding Machine setting	
Machine Brand	Rieter (C-70)
No of M/C	18-26, & 29
Sliver weight grains/6 yds	102
Delivery Hank	0.08
Can length	6000
Kg/Hour	88
Cylinder Speed	820
Flat Speed	330
Licker in Speed	1440
Licker in wing setting	57
Delivery Can Color	Can with double red elastic band

Table 3 Carding machine setting

3.2.4. Drawing:

- Multiple slivers are combined and drawn to improve uniformity.
- This process ensures consistent fiber blending and alignment.

Draw Frame Breaker Setting	
Machine Brand	Rieter (SB 22)
M/C no	07
Sliver weight grains/6 yds	85

Delivery Hank	0.098
Can length	7000
Doubling	6
Draft	6.87
Back Draft	1.3
Delivery Speed (M/Min)	670
Roller Gauge	39×43
Trumpet	4.6
Delivery Can Color	Can with double red elastic band

Table 4 Draw Frame Breaker setting

Draw Frame Finisher Machine Setting	
Machine Brand	Rieter (RSB D-24)
M/C no	07
Sliver weight grains/6 yds	85
Delivery Hank	0.098
Can length	4500
Doubling	7
Draft	6.46
Back Draft	1.15
Delivery Speed (M/Min)	650
Roller Gauge	39×43
Doubling	07
Trumpet	4.2
Delivery Can Color	Can with double red elastic band

Table 5Drawframe finisher machine setting

3.2.5. Simplex:

- The drawn sliver is further processed to add slight twists, creating a roving.
- This step prepares the material for spinning.

Simplex Machine setting	
Machine Brand	Jingwei (1436 B)
M/C No	13
Simplex Doff length	1800
Delivery Hank	0.66
Feed Hank	0.098
TPI	1.04
TPM	41
TM	1.28
Flyer Speed (RPM)	1075
Roller gauge	9×21×23
B. Draft	1.2
Spacer	Green (6.5 mm)
Simplex Bobbin Color	White

Table 6 Simplex machine setting

3.2.6. Ring Frame:

- The roving is spun into yarn on the ring frame, where the final twist and strength are added.
- This is a critical step in determining the quality of the yarn.

Ring Frame Machine Setting	
Machine Brand	Jingwei JWF1562
Count:	16 + 70D
Lot	2001V
TPI	17.25
TM	3.85
Break draft	1.75
Total Draft	32.60
Average Speed	13000
Spacer Color	White (3.0mm)
Ring Traveler	No.1
Aram Pressure	
Roller Gauge	44×55 mm
Shaddle Gauge	1.00 mm
Bottom Roller Diameter	27 mm
Top Apron	40×30×1.0
Bottom Apron	83×30×1.0
Cot Roller Diameter	28.0 mm
Ring Cup Diameter	38 mm
Tin Pulley Dia(mm)	250
Spindle Wharve Dia(mm)	19
Motor Rpm	1470
Motor Pulley(mm)	148
M/c pulley(mm)	176
M/c Speed(Rpm)	13000
SPL Tape Size	2620×10×0.6
Travers	0 mm
Jocky Pulley Diameter	70mm

Table 7 Ring Frame machine setting

3.2.7. Auto Cone:

- The spun yarn is wound onto cones in this automated step.
- It ensures the yarn is free from defects and prepared for packaging.

3.2.8. Packaging:

- The final yarn is packed according to customer requirements and is ready for distribution or further processing.

Each step contributes to transforming raw cotton into high-quality yarn suitable for textile applications.

3.3. Machine used for testing samples:

For this research we have been following physical test. About details of the machine used are mentioned in the Table 8.

Name of the machine	Brand & Model	Purpose	Photo
Yarn twist tester	MAG – EQ YTT 37	Twist test	
Universal yarn tester	JAMES HEAL - Titan	Strength & Elasticity test	

Table 8 Types of machines used in the research.

3.4. Methods:

3.4.1. Sample collection method:

The non-spliced yarn samples for each count were directly collected from the ring frame during the spinning process. In contrast, the spliced yarn samples were obtained after joining the broken yarn at the respective splice points. Each yarn count comprised two compositions—100% cotton and a Cotton / Lycra blend—resulting in four types of specimens for each count. Each specimen was prepared with a standard length of 1 meter to ensure uniformity and facilitate comparative analysis.

3.4.2. Test method:

To achieve precise and reliable results in this research, all tests were conducted on single yarn samples. The evaluation of tensile strength and elongation was performed in accordance with ISO 2062 standards. Additionally, the twist testing procedures adhered to ISO 2061:2015 standards, ensuring compliance with established international methodologies.

Testing Method of ISO 2062: Tensile Testing of Yarn

ISO 2062 specifies the method for determining the breaking force and elongation at break of yarns using a constant rate of extension (CRE) testing machine. The process involves the following steps:

3.4.2.1 Scope and Purpose

The method is applicable to single yarns, plied yarns, and cabled yarns to evaluate their tensile strength and elongation properties. It provides data essential for quality control and textile performance evaluation.

3.4.2.2. Apparatus

- **CRE Tester**: A tensile testing machine capable of applying a constant rate of extension.
- **Clamps**: Jaws to securely hold the yarn without slippage or damage.
- **Measuring System**: A system to record the breaking force and elongation at break.
- **Pretension Device**: For applying a specified pretension before testing.

3.4.2.3. Sampling

- Yarn samples must be conditioned at standard atmospheric conditions for testing textiles (20 ± 2°C and 65 ± 2% RH) for at least 24 hours.
- Specimens should be cut to a specified length suitable for the gauge length.

3.4.3.4. Test Parameters

- **Gauge Length**: The nominal distance between clamping points. Standard lengths are 500 mm or 250 mm (exceptionally).
- **Extension Rate**: A rate of 100% per minute based on the gauge length (e.g., 500 mm/min for 500 mm gauge length).

3.4.2.5. Procedure

1. **Preparation**: Mount the specimen on the tester, ensuring the clamps grip it securely without preloading.
2. **Application of Pretension**: Apply a specified pretension to align the yarn and remove slack.
3. **Testing**: Initiate the test by extending the specimen at the constant rate until rupture.
4. **Data Recording**: Record the breaking force (in centinewtons) and elongation at break (as a percentage of the initial length).

3.4.2.6. Number of Tests

- Conduct a minimum of 07 tests for each yarn sample to ensure statistical reliability.

3.4.2.7. Calculations

- **Breaking Force**: The maximum force applied to the specimen before rupture.
- **Elongation at Break**: The percentage increase in length corresponding to the breaking force.
- **Breaking Tenacity**: Calculated as the ratio of breaking force to linear density, expressed in centinewtons per tex.

3.4.2.8. Reporting

The test report should include:

- Yarn type, composition, and count.
- Gauge length and extension rate.
- Average breaking force (cN) and elongation at break (%).
- Standard deviation and coefficient of variation for the results.
- Test conditions (temperature and humidity).

This method ensures consistent evaluation of yarn tensile properties for manufacturing quality control and performance assessments. [9]

3.4.3. Testing method of ISO 2061:2015 Determination of twist in yarns — Direct counting method

3.4.3.1. Scope

This International Standard specifies a method for the determination of the direction of twist in yarns, the amount of twist, in terms of turns per unit length, and the change in length on untwisting, by the direct counting method. This International Standard is applicable to a) single yarns (spun and filament), b) plied yarns, and c) cabled yarns. Separate procedures are given for each type of yarn.

3.4.3.2. Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Twist number of turns about the axis of a yarn based on its nominal gauge length before untwisting Note 1 to entry: Twist should preferably be expressed as turns per meter (turns/m), but it may be expressed as turns per centimeter (turns/cm).

Gauge length distance between two effective clamping points of the test specimen mounted in the testing equipment

Initial length of a test specimen under a specified pretension at the beginning of a test.

3.4.3.3. Apparatus

Twist counter, consisting of a pair of clamps, one of which is rotatable in either direction and positively connected to a revolution counter. The position of one or both clamps shall be adjustable to permit testing yarn lengths from 10 mm to 500 mm. There shall be no play in the clamp which might affect the gauge length.

Note the number of twist and divide it by 39.37 and get the TPI (Twist per Inch). [10]

3.5 Sample collection:

All samples were obtained from various ring spinning machines, encompassing 02 types of yarn: **cotton** yarn and **cotton/spandex** yarn. The cotton/spandex yarn samples were collected under two specific conditions:

1. **Spliced Condition**: Samples were directly collected from the ring spinning machine in their spliced state.
2. **Unspliced Condition**: Samples were collected by standing in front of the ring spinning machine and waiting for a yarn breakage. After the breakage, the yarn was manually joined, and the sample was collected.

This approach ensured a comprehensive representation of the yarn conditions for further analysis.

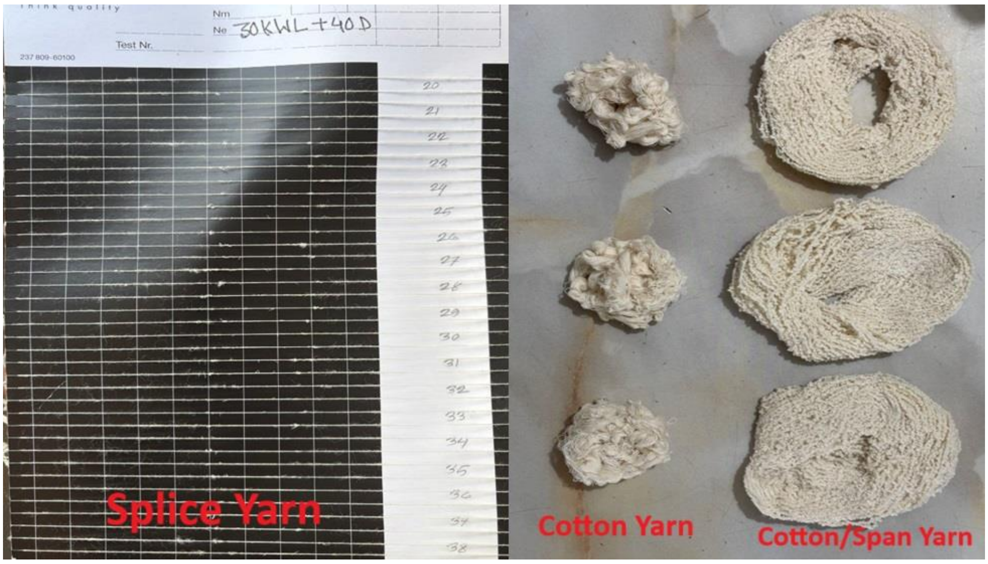


Figure 6 Test specimen collection

CHAPTER – 4

RESULT AND DISCUSSION

4.1. Twist test:

4.1.1 Test results and analysis on single count

Collected specimen of Splice yarn and without splice yarn of 100% Cotton and Cotton/Elastane of 10,16,24,30 Ne count from same machine and find the twist test.

Without Splice Condition TPI of 10 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
11	Count 10 Ne	12.96	12.86
13	Count 10 Ne	12.72	
15	Count 10 Ne	12.88	
16	Count 10 Ne	12.72	
18	Count 10 Ne	13.03	

Table 9 Twist test report of 10Ne cotton yarn without splice condition

Splice Condition TPI of 10 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
11	Count 10 Ne	12.23	12.03
13	Count 10 Ne	11.35	
15	Count 10 Ne	12.18	
16	Count 10 Ne	11.95	
18	Count 10 Ne	12.43	

Table 10 Twist test report of 10Ne cotton yarn splice condition

Without Splice Condition TPI of 10 Ne + 40 D			
Ring m/c	**Count**	**TPI**	**Average TPI**
11	Count 10 Ne + 40D	16.05	15.99
13	Count 10 Ne + 40D	16.35	
15	Count 10 Ne + 40D	15.87	
16	Count 10 Ne + 40D	15.74	
18	Count 10 Ne + 40D	15.96	

Table 11 Twist test report of 10Ne + 40D cotton yarn without splice condition

Splice Condition TPI of 10 Ne + 40 D			
Ring m/c	**Count**	**TPI**	**Average TPI**
11	Count 10 Ne + 40D	15.15	14.95
13	Count 10 Ne + 40D	14.58	
15	Count 10 Ne + 40D	15.00	
16	Count 10 Ne + 40D	14.80	
18	Count 10 Ne + 40D	15.23	

Table 12 Twist test report of 10Ne + 40D cotton yarn splice condition

4.1.2. TPI Comparison of 10Ne & 10Ne+40D in without Splice condition

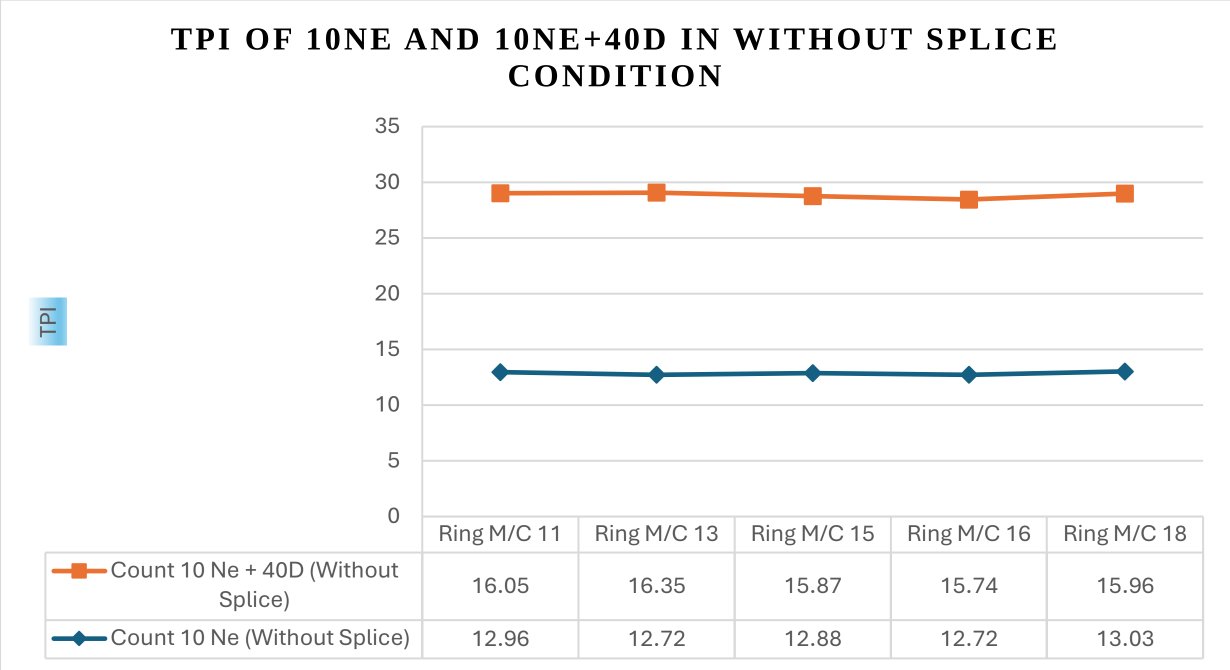


Chart 1 Line Chart of Comparison TPI of 10Ne & 10Ne+40D in without splice condition

4.1.2.1..Description of the Line Chart:

The line chart compares the TPI (Twist Per Inch) of two yarn types, **10 Ne** and **10 Ne + 40D**, under "Without Splice" conditions across different ring machines (M/C 11, M/C 13, M/C 15, M/C 16, and M/C 18).

- The **orange line** represents the TPI of **10 Ne + 40D (Without Splice)**.
- The **blue line** represents the TPI of **10 Ne (Without Splice)**.

4.1.2.2. Key Findings:

1. **TPI Trend Across Machines**:
    - **10 Ne + 40D**: The TPI values range from 15.74 to 16.35, showing slight fluctuations but remaining relatively consistent.
    - **10 Ne**: The TPI values range from 12.72 to 13.03, also displaying a stable trend with minor variations.
2. **Difference in TPI**:
    - For all machines, the TPI of **10 Ne + 40D** is consistently higher than that of **10 Ne** by approximately 3.0 to 3.5 units.
3. **TPI Values**:
    - Machine **M/C 13** shows the highest TPI for **10 Ne + 40D (16.35)**, while **M/C 16** has the lowest value (15.74).

- Machine **M/C 18** records the highest TPI for **10 Ne (13.03)**, while **M/C 13** and **M/C 16** show the lowest (12.72).

4.1.2.3. Overall:

- The **10 Ne + 40D** yarn exhibits consistently higher TPI compared to **10 Ne**, indicating that the addition of 40D likely enhances the twist strength in yarn.
- Both yarn types maintain relatively stable TPI values across different machines, suggesting uniformity in machine performance and processing conditions.
- The difference in TPI indicates that **10 Ne + 40D** may offer better mechanical or functional properties for specific textile applications requiring higher twist density.

Without Splice Condition TPI of 16 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
1	Count 16 Ne	16.68	16.75
3	Count 16 Ne	16.78	
5	Count 16 Ne	16.73	
8	Count 16 Ne	16.81	
10	Count 16 Ne	16.76	

Table 13 Twist test report of 16 Ne cotton yarn without splice condition

Splice Condition TPI of 16 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
1	Count 16 Ne	15.75	15.66
3	Count 16 Ne	14.97	
5	Count 16 Ne	15.81	
8	Count 16 Ne	15.80	
10	Count 16 Ne	15.99	

Table 14 Twist test report of 16 Ne cotton yarn splice condition

Without Splice Condition TPI of 16 Ne + 70D			
Ring m/c	**Count**	**TPI**	**Average TPI**
1	Count 16 Ne + 70D	20.66	20.83
3	Count 16 Ne + 70D	21.56	
5	Count 16 Ne + 70D	20.61	
8	Count 16 Ne + 70D	20.80	
10	Count 16 Ne + 70D	20.54	

Table 15 Twist test report of 16 Ne+70D cotton/Spun yarn without splice condition

Splice Condition TPI of 16 Ne + 70D			
Ring m/c	**Count**	**TPI**	**Average TPI**
1	Count 16 Ne + 70D	19.50	19.47
3	Count 16 Ne + 70D	19.24	
5	Count 16 Ne + 70D	19.47	
8	Count 16 Ne + 70D	19.55	
10	Count 16 Ne + 70D	19.60	

Table 16 Twist test report of 16 Ne+70D cotton/Spun yarn splice condition

4.1.3. TPI Comparison of 16Ne & 16Ne+70D in without Splice condition

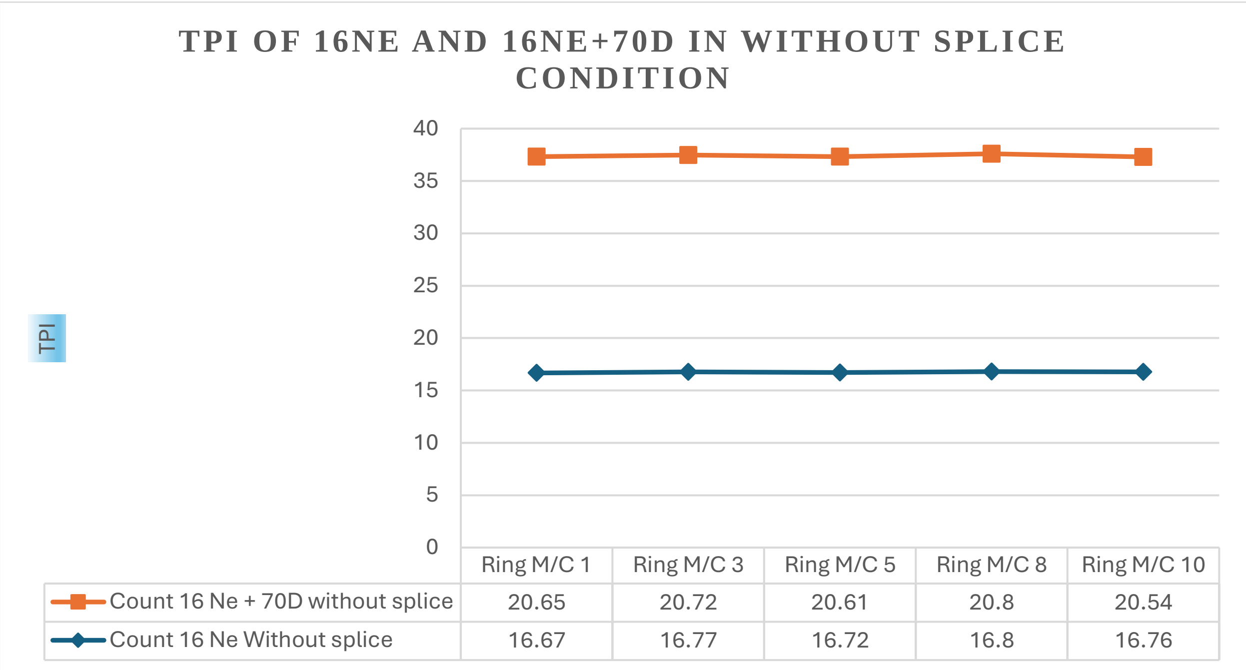


Chart 2 Line Chart of Comparison TPI of 16Ne & 16Ne+70D in without splice condition

4.1.3.1. Description of the Line Chart:

The line chart compares the TPI (Twist Per Inch) of two yarn types, **16 Ne** and **16 Ne + 70D**, under "Without Splice" conditions across five ring machines (M/C 1, M/C 3, M/C 5, M/C 8, and M/C 10).

- The **orange line** represents the TPI of **16 Ne + 70D (Without Splice)**.

- The **blue line** represents the TPI of **16 Ne (Without Splice)**.

4.1.3.2. Key Findings:

1. **TPI Trend Across Machines**:
    - **16 Ne + 70D**: The TPI values range between 20.54 and 20.80, showing a consistent trend with minimal variation.
    - **16 Ne**: The TPI values range between 16.72 and 16.80, also maintaining a stable trend across the machines.
2. **Difference in TPI**:
    - The TPI of **16 Ne + 70D** is consistently higher than that of **16 Ne** by approximately 3.8 to 4.1 units across all machines.
3. **TPI Values**:
    - **16 Ne + 70D** records the highest TPI on **M/C 3 (20.72)** and the lowest on **M/C 10 (20.54)**.
    - **16 Ne** records the highest TPI on **M/C 8 (16.80)** and the lowest on **M/C 5 (16.72)**.

4.1.3.3. Overall:

- The **16 Ne + 70D** yarn demonstrates significantly higher TPI compared to **16 Ne**, suggesting that the addition of 70D enhances the twist density in the yarn.
- Both yarn types exhibit stable performance across different machines, indicating consistent manufacturing conditions.
- The higher TPI values of **16 Ne + 70D** may imply better tensile strength or durability, making it suitable for applications requiring stronger and more twisted yarns.

Without Splice Condition TPI of 24 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
2	Count 24 Ne	19.00	19.50
4	Count 24 Ne	19.00	
6	Count 24 Ne	20.50	
8	Count 24 Ne	19.50	
9	Count 24 Ne	20.50	

Table 17 Twist test report of 24 Ne yarn without splice condition

Splice Condition TPI of 24 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
2	Count 24 Ne	17.94	18.43
4	Count 24 Ne	16.95	
6	Count 24 Ne	19.37	
8	Count 24 Ne	18.33	
9	Count 24 Ne	19.56	

Table 18 Twist test report of 24 Ne yarn splice condition

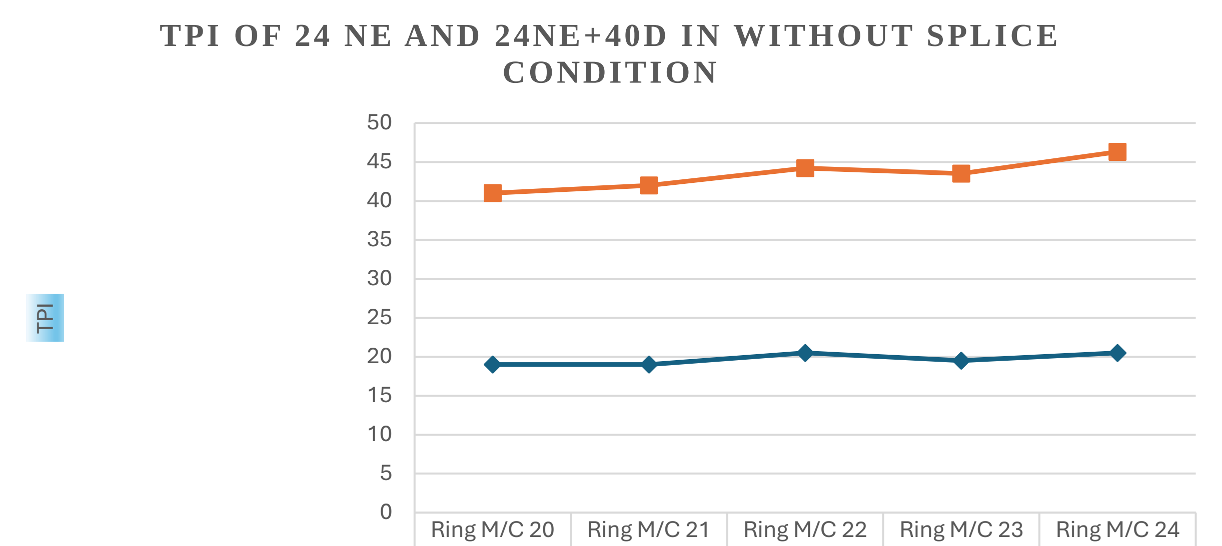
Without Splice Condition TPI of 24 Ne + 40 D			
Ring m/c	**Count**	**TPI**	**Average TPI**
2	Count 24Ne+40D	22.00	23.70
4	Count 24Ne+40D	23.00	
6	Count 24Ne+40D	23.70	
8	Count 24Ne+40D	24.00	
9	Count 24Ne+40D	25.80	

Table 19 Twist test report of 24 Ne + 40 D yarn without splice condition

Splice Condition TPI of 24 Ne + 40 D			
Ring m/c	**Count**	**TPI**	**Average TPI**
2	Count 24Ne+40D	20.77	22.17
4	Count 24Ne+40D	20.52	
6	Count 24Ne+40D	22.40	
8	Count 24Ne+40D	22.56	
9	Count 24Ne+40D	24.61	

Table 20 Twist test report of 24 Ne + 40 D yarn splice condition

4.1.4. TPI Comparison of 24Ne & 24Ne+40D in without Splice condition



	Ring M/C 20	Ring M/C 21	Ring M/C 22	Ring M/C 23	Ring M/C 24
Count 30 Ne + 40D (Without Splice)	22	23	23.7	24	25.8
Count 24 Ne (Without Splice)	19	19	20.5	19.5	20.5

Chart 3 Line Chart of Comparison TPI of 24 Ne & 24Ne+40D in without splice condition

4.1.4.1. Description of the Line Chart

The chart illustrates the TPI (Twist Per Inch) values for two different yarn types under "Without Splice" conditions across five ring machines (M/C 20 to M/C 24):

1. **Count 30 Ne + 40D (Without Splice):** Represented by an orange line with higher TPI values across all machines.
2. **Count 24 Ne (Without Splice):** Represented by a blue line with comparatively lower TPI values across all machines.

The data shows TPI values increasing progressively as the ring machine number advances from M/C 20 to M/C 24.

4.1.4.2. Key Findings

1. TPI of Count 30 Ne + 40D (Without Splice):
   - Starts at 22 on M/C 20 and steadily increases to 25.8 on M/C 24.
   - The TPI trend shows consistent growth across machines, with slight fluctuations.
2. TPI of Count 24 Ne (Without Splice):
   - Begins at 19 on M/C 20 and reaches 20.5 on M/C 24.
   - This yarn type exhibits a smaller range of TPI variation compared to the Count 30 Ne + 40D yarn.
3. Comparison Between Yarn Types:
   - Count 30 Ne + 40D consistently shows higher TPI than Count 24 Ne for all machines.

- The TPI difference between the two yarn types narrows slightly as the machine count increases.

4.1.4.3. Overall:

TPI Performance: The Count 30 Ne + 40D (Without Splice) demonstrates better twist consistency and higher TPI values, indicating superior twist behavior compared to the Count 24 Ne (Without Splice). Machine Impact: The ring machine type significantly influences TPI, with higher machine counts (M/C 24) producing greater TPI values. Application Insight: Count 30 Ne + 40D may be better suited for applications requiring stronger or more twisted yarns due to its higher TPI values, while Count 24 Ne offers consistent performance with less twist variation.

Without Splice Condition TPI of 30 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
20	Count 30 Ne	22.70	23.07
21	Count 30 Ne	22.49	
22	Count 30 Ne	23.22	
23	Count 30 Ne	23.32	
24	Count 30 Ne	23.62	

Table 21 Twist test report of 30 Ne yarn without splice condition

Splice Condition TPI of 30 Ne			
Ring m/c	**Count**	**TPI**	**Average TPI**
20	Count 30 Ne	21.42	21.58
21	Count 30 Ne	20.06	
22	Count 30 Ne	21.94	
23	Count 30 Ne	21.92	
24	Count 30 Ne	22.53	

Table 22 Twist test report of 30 Ne yarn in splice condition

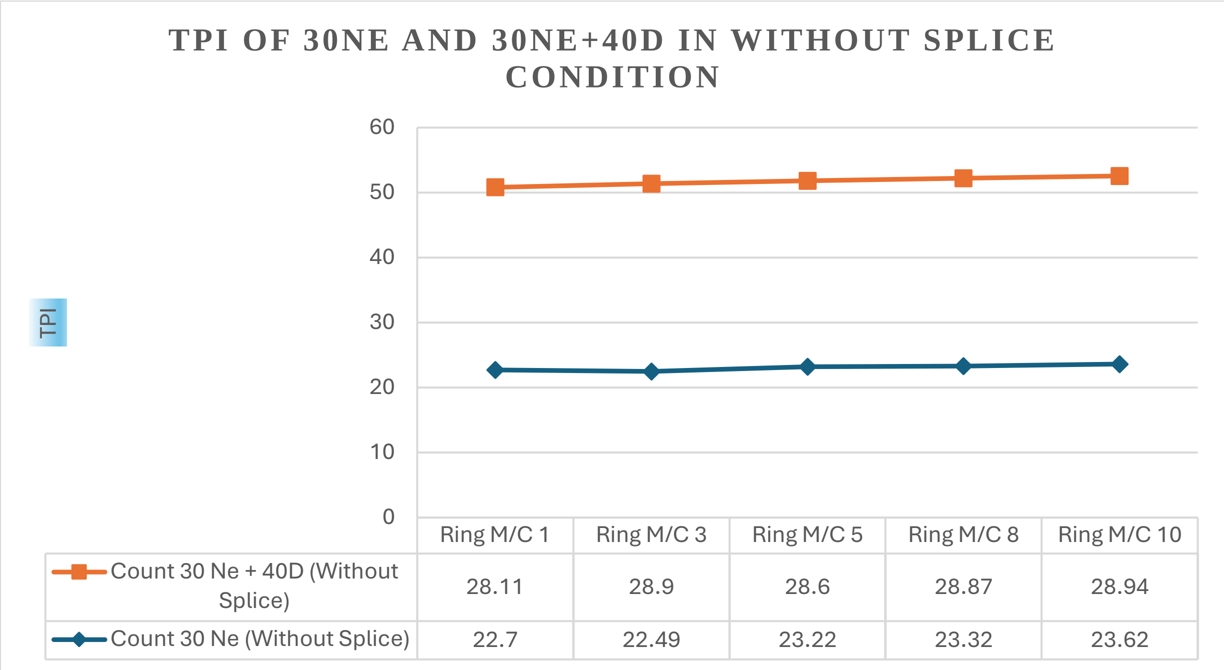
Without Splice Condition TPI of 30 Ne + 40 D			
Ring m/c	**Count**	**TPI**	**Average TPI**
20	Count 30 Ne + 40D	28.11	28.68
21	Count 30 Ne + 40D	28.90	
22	Count 30 Ne + 40D	28.60	
23	Count 30 Ne + 40D	28.87	
24	Count 30 Ne + 40D	28.94	

Table 23 Twist test report of 30 Ne + 40 D yarn without splice condition

Splice Condition TPI of 30 Ne + 40 D			
Ring m/c	**Count**	**TPI**	**Average TPI**
20	Count 30 Ne + 40D	26.54	26.82
21	Count 30 Ne + 40D	25.78	
22	Count 30 Ne + 40D	27.03	
23	Count 30 Ne + 40D	27.14	
24	Count 30 Ne + 40D	27.61	

Table 24 Twist test report of 30 Ne + 40 D yarn in splice condition

4.1.5. TPI Comparison of 30Ne & 30Ne+40D in without Splice condition



	Ring M/C 1	Ring M/C 3	Ring M/C 5	Ring M/C 8	Ring M/C 10
Count 30 Ne + 40D (Without Splice)	28.11	28.9	28.6	28.87	28.94
Count 30 Ne (Without Splice)	22.7	22.49	23.22	23.32	23.62

Chart 4 Line Chart of Comparison TPI of 30Ne & 30Ne+40D in without splice condition

4.1.5.1. Description of the Line Chart:

The chart shows the TPI (Twist Per Inch) comparison of two yarn types, **30 Ne** and **30 Ne + 40D**, in "Without Splice" conditions across five ring machines (M/C 1, M/C 3, M/C 5, M/C 8, and M/C 10).

- The **orange line** represents the TPI of **30 Ne + 40D (Without Splice)**.
- The **blue line** represents the TPI of **30 Ne (Without Splice)**.

4.1.5.2. Key Findings:

1. **TPI Trend Across Machines**:
   - **30 Ne + 40D**: The TPI values range from **28.11** to **28.94**, showing a slight upward trend across the machines.
   - **30 Ne**: The TPI values range from **22.49** to **23.62**, with a gradual increase across the machines.
2. **Difference in TPI**:
   - The TPI of **30 Ne + 40D** is consistently higher than that of **30 Ne** by approximately **5.5 to 6.0 units** across all machines.
3. **TPI Values**:
   - **30 Ne + 40D**: Records the highest TPI on **M/C 10 (28.94)** and the lowest on **M/C 1 (28.11)**.

- **30 Ne**: Records the highest TPI on **M/C 10 (23.62)** and the lowest on **M/C 3 (22.49)**.

4.1.5.3. Overall:

30 Ne + 40D exhibits significantly higher TPI compared to **30 Ne**, which indicates that the addition of 40D improves the twist density and possibly the yarn's strength or durability.Both yarn types show an increasing trend in TPI across machines, suggesting that machine efficiency or processing parameters are consistent. The higher TPI values of **30 Ne + 40D** may make it more suitable for applications that require higher twist and enhanced mechanical properties, such as durable fabrics or technical textiles.

4.1.6. TPI observation of 04 count in 08 composition

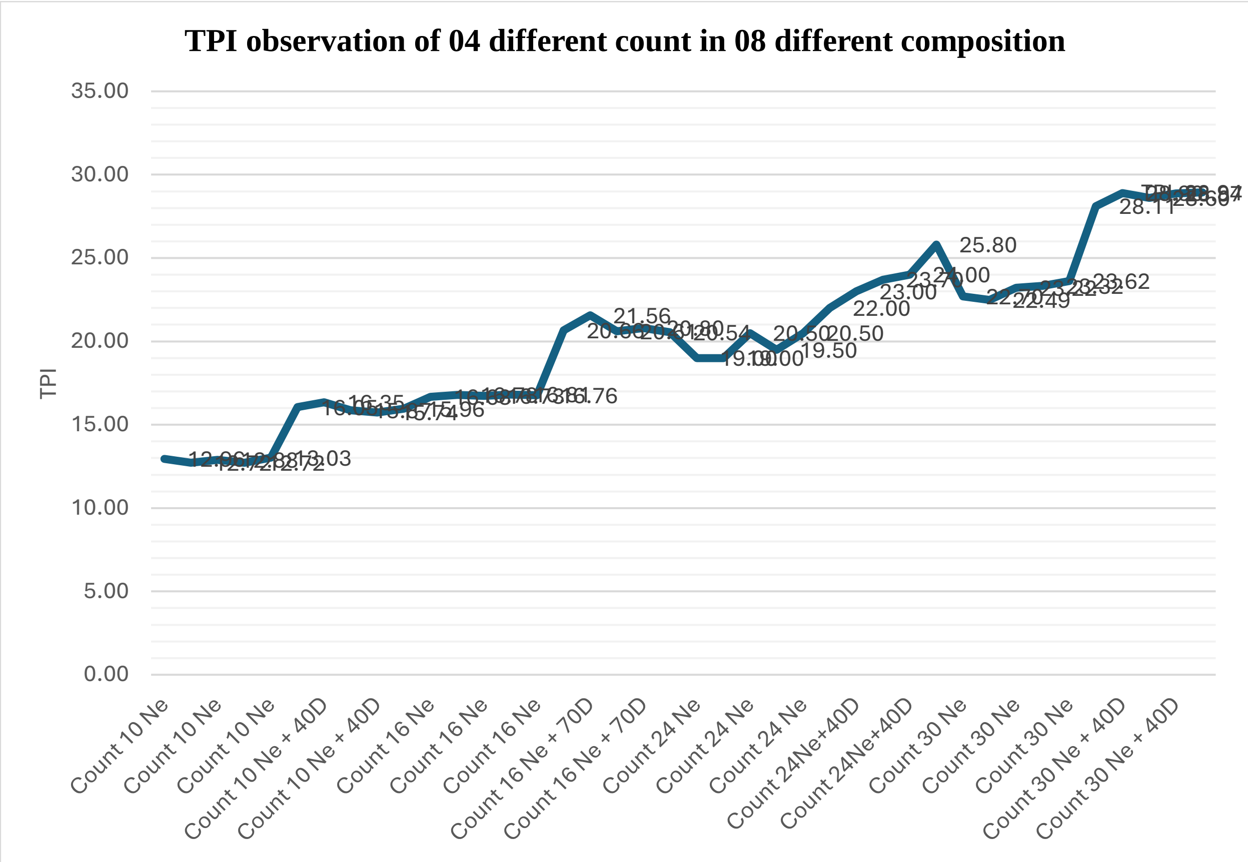


Chart 5 Line chart of TPI of 8 different count yarn in without splice condition

The chart illustrates the TPI (Twist Per Inch) observations across three different yarn counts (10 Ne, 16 Ne, 24 Ne and 30 Ne) and eight different compositions, highlighting the relationship between yarn fineness, composition, and TPI requirements.

4.1.6.1.Key Observations:

1. **Comparison of TPI Trends**:
   - Across all three yarn types (10 Ne, 16 Ne, 24 Ne and 30 Ne) and their respective blends with deniers (40D or 70D), the blended yarns consistently exhibit higher TPI values than their pure counterparts.
   - The TPI of the blended yarns is higher by approximately **3-6 units** depending on the yarn count and the denier of the blend, indicating that the addition of synthetic fibers (Deniers) enhances twist properties.

Coarser Yarns Require Lower TPI:

- The 10 Ne yarn count exhibits the lowest TPI values, consistently ranging between 12 and 13.03. This indicates that coarser yarns demand fewer twists per inch to maintain their structure.

Finer Yarns Require Higher TPI:

- As the yarn count increases (e.g., 30 Ne), the TPI values significantly rise, reaching up to 28.94. This demonstrates that finer yarns necessitate more twists per inch to ensure strength and cohesion.

2. **Impact of Blending**:
    - The addition of synthetic fibers (e.g., 40D or 70D) enhances the TPI in all cases, implying that blending contributes to improved twist density.
    - Higher deniers, such as 70D, result in even higher TPI (e.g., 16 Ne + 70D compared to 10 Ne + 40D or 30 Ne + 40D), suggesting that the denier size plays a role in increasing the twist capacity.

Yarn Composition Affects TPI:

- For the same yarn count, compositions containing spandex (e.g., cotton/spandex blends like 40D or 70D) require higher TPI compared to 100% cotton yarns. This is evident across all counts, where blended yarns consistently display elevated TPI values.

3. **Yarn Count and TPI Relationship**:
    - The TPI values are generally higher for finer yarn counts (e.g., 30 Ne has higher TPI compared to 10 Ne or 16 Ne). This aligns with the expected behavior where finer yarns require more twists to maintain strength and stability

4.1.6.2. Overall:

- **Blending Effect**: The addition of synthetic fibers (40D or 70D) significantly improves the TPI of yarns, making them more suitable for applications requiring higher twist density, strength, and durability.
- **Consistency in Manufacturing**: The stable TPI trends across ring machines demonstrate well-maintained manufacturing conditions, ensuring reliable production quality.

- **Suitability for Applications**: Blended yarns, due to their higher TPI, are better suited for technical and durable textiles, while pure yarns with lower TPI may be preferred for softer and more pliable fabrics.
- **Optimization Opportunities**: Higher deniers (like 70D) and finer yarn counts (e.g., 30 Ne) exhibit superior TPI, suggesting an opportunity for optimization depending on the intended application.

In summary, blending with deniers consistently enhances yarn properties, and stable machine performance supports the efficient production of high-quality yarns.

4.1.6. TPI comparison of cotton & cotton/spandex yarn in without splice condition

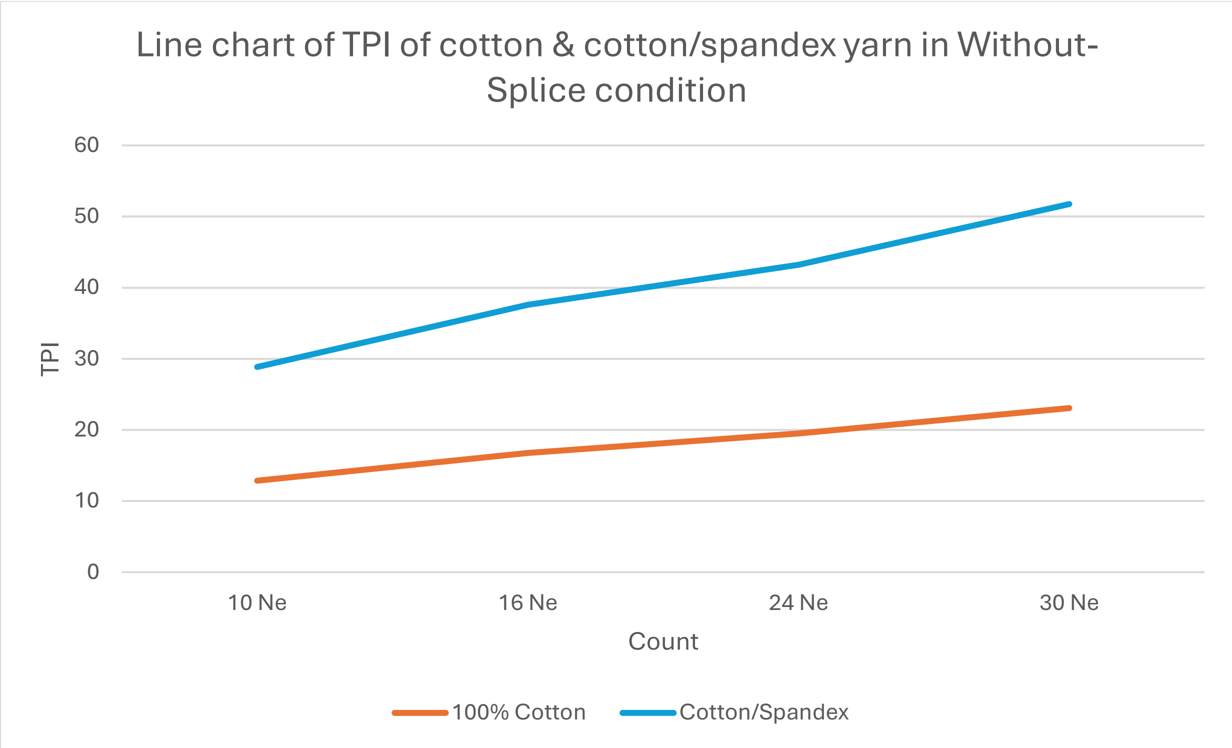


Chart 6 Line chart of comparison of TPI in without splice condition for 4 different count in two composition

4.1.6.1.Description

The chart represents the Twist Per Inch (TPI) values for two different yarn types—100% Cotton and Cotton/Spandex—under splice and without-splice conditions across four yarn counts: 10 Ne, 16 Ne, 24 Ne, and 30 Ne and 10 Ne+40D, 16 Ne+70D, 24 Ne+40D, and 30 Ne+40D

- The **blue line** represents TPI values for Cotton/Spandex, showing consistently higher values.

- The **orange line** represents TPI values for 100% Cotton, which are comparatively lower.
- Both lines display an increasing trend as the yarn count progresses from 10 Ne to 30 Ne.

4.1.6.2. Key Findings

1. **General TPI Trends:**
   - TPI values increase with higher yarn counts for both yarn types, indicating that finer yarns (higher counts) exhibit higher twist levels.

2. **Performance of Cotton/Spandex:**
   - Cotton/Spandex consistently outperforms 100% Cotton in terms of TPI.
   - The TPI values for Cotton/Spandex range from approximately 30 (10 Ne) to 50 (30 Ne), showing a steeper increase compared to 100% Cotton.

3. **Performance of 100% Cotton:**
   - TPI values for 100% Cotton range from approximately 10 (10 Ne) to 20 (30 Ne).
   - The TPI increases steadily but at a slower rate compared to Cotton/Spandex.

4. **Yarn Composition Impact:**
   - The presence of spandex significantly increases the TPI, which may be attributed to the elastic nature of spandex requiring additional twist for stability in the yarn structure.

4.1.6.3. Overall:

- Higher Twist Requirements for Blended Yarn: Cotton/Spandex yarn demonstrates higher TPI values due to its unique composition, which necessitates additional twist to integrate the elastic spandex fibers.
- Yarn Fineness Correlation: Both yarn types show that finer yarns (higher counts) require more twists per inch, likely due to their smaller cross-sectional area needing tighter cohesion.
- Application Insight: Cotton/Spandex yarns are likely better suited for applications requiring elasticity and strength, while 100% Cotton is more appropriate for applications prioritizing simplicity and breathability.

This analysis highlights the relationship between yarn count, composition, and TPI, providing valuable insights for optimizing spinning processes and yarn selection.

4.1.7. TPI comparison of cotton & cotton/spandex yarn in splice condition

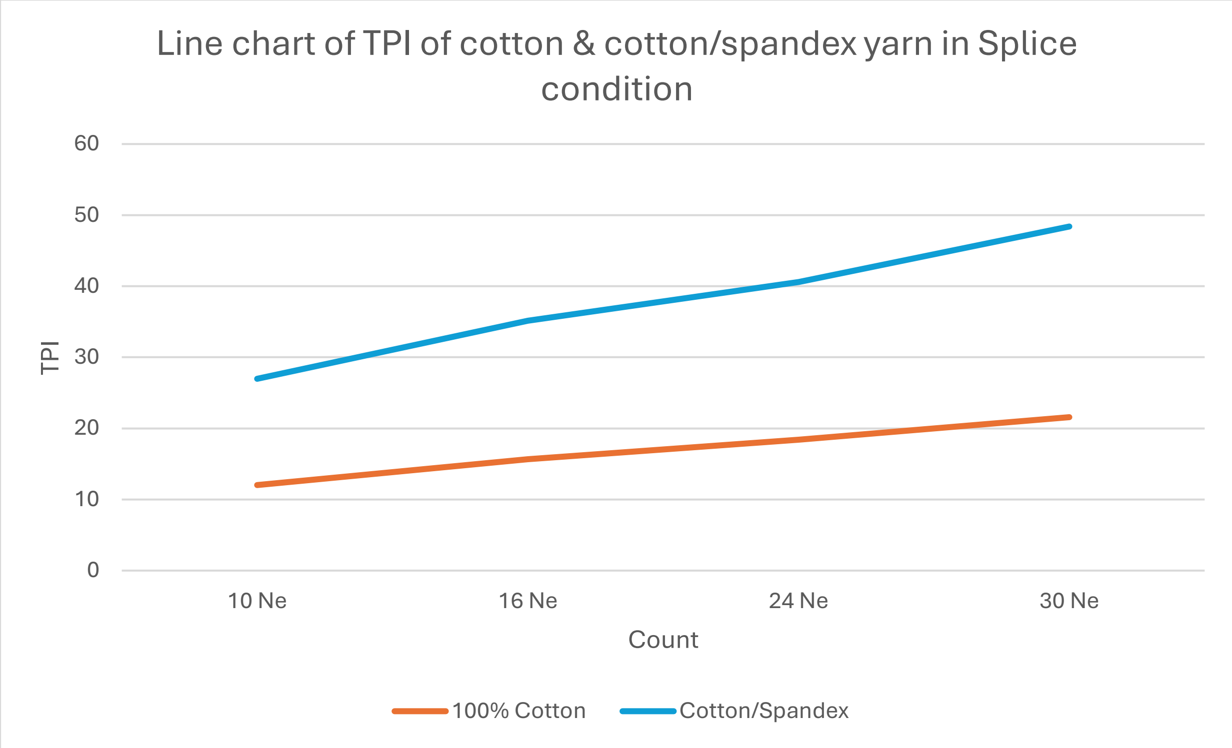


Chart 7 Line chart of comparison of TPI in splice condition for 4 different count in two composition

4.1.7.1. Description of the Line Chart

The line chart illustrates the **Twist Per Inch (TPI)** of two yarn types—**100% Cotton** and **Cotton/Spandex**—under **splice conditions** across four yarn counts: **10 Ne, 16 Ne, 24 Ne, and 30 Ne.**

- The **blue line** represents TPI for **Cotton/Spandex**, which consistently exhibits higher values across all yarn counts.
- The **orange line** represents TPI for **100% Cotton**, showing a lower range of TPI values.
- Both yarn types exhibit an increasing trend in TPI as the yarn count progresses from 10 Ne to 30 Ne.

4.1.7.2. Key Findings

1. **TPI for Cotton/Spandex:**
    - Starts at approximately **30 TPI** for 10 Ne and increases to nearly **50 TPI** for 30 Ne.
    - Displays a steeper growth rate in TPI compared to 100% Cotton.

2. **TPI for 100% Cotton:**
   - Starts at around **10 TPI** for 10 Ne and gradually increases to approximately **20 TPI** for 30 Ne.
   - The increase is steady but more gradual compared to Cotton/Spandex.
3. **Comparison Between Yarn Types:**
   - Cotton/Spandex demonstrates significantly higher TPI than 100% Cotton at all yarn counts.
   - The difference in TPI widens as the yarn count increases, highlighting the impact of spandex in the blend.
4. **Effect of Yarn Count:**
   - Both yarn types show a positive correlation between yarn count and TPI, where finer yarns (higher counts) require more twists per inch for structural stability.

4.1.7.3. Overall:

- **Impact of Fiber Composition:** Cotton/Spandex exhibits higher TPI due to the presence of spandex, which necessitates additional twist for cohesion and elasticity.
- **Correlation Between TPI and Yarn Count:** Higher yarn counts (finer yarns) require more twists for both yarn types, reflecting the structural demand of finer fibers.
- **Application Suitability:**
  - **Cotton/Spandex:** Best suited for applications requiring elasticity and durability, such as activewear or stretch fabrics.
  - **100% Cotton:** Suitable for applications where simplicity, breathability, and softness are prioritized, such as lightweight apparel or home textiles.

This chart provides insights into the mechanical properties of yarns in splice conditions, offering guidance for optimizing spinning processes and product development

4.1.8. TPI comparison of Splice and Without Splice yarn of cotton & Cotton/spandex yarn

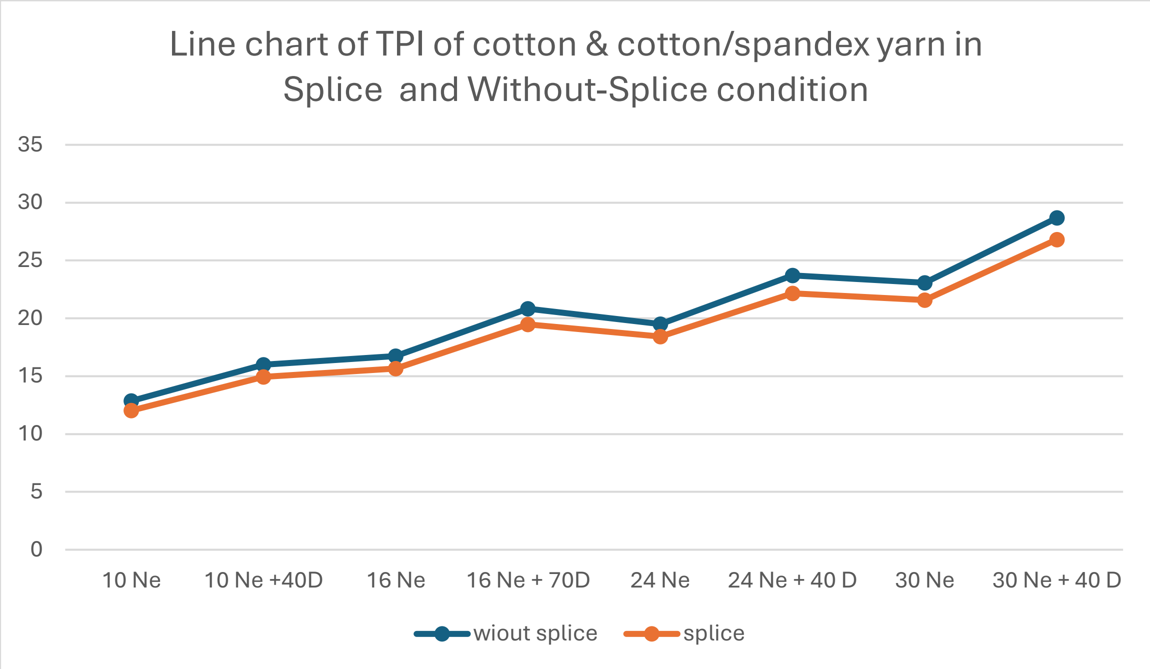


Chart 8 Line chart of comparison of TPI of 8 different count in two condition

4.1.8.1. Description of the Line Chart:

The chart compares the Turns Per Inch (TPI) of cotton and cotton/spandex yarn under two different conditions: "splice" and "without splice." The TPI values are plotted for various yarn counts, including 10 Ne, 10 Ne + 40D, 16 Ne, 16 Ne + 70D, 24 Ne, 24 Ne + 40D, 30 Ne, and 30 Ne + 40D.

- **X-axis**: Represents the yarn counts and types.
- **Y-axis**: Displays the TPI values, ranging from 0 to 35.
- **Data Lines**: Two lines:
  - Blue line: Represents the "without splice" condition.
  - Orange line: Represents the "splice" condition.

4.1.8.2. Key Findings:

1. **General Trend**:
   - The TPI increases with finer yarn counts (moving from 10 Ne to 30 Ne + 40D) for both splice and without splice conditions.

2. **Comparison between Splice and Without Splice**:
   - The TPI values for "without splice" are consistently higher than those for "splice" across all yarn counts.

- The difference between the two conditions is more pronounced at higher yarn counts.

3. **Notable Points**:
    - For coarser yarns like 10 Ne and 10 Ne + 40D, the difference in TPI between splice and without splice is minimal.
    - At finer yarns like 30 Ne and 30 Ne + 40D, the difference becomes more evident.

4.1.8.3. Overall:

The "without splice" condition produces higher TPI compared to the "splice" condition, particularly as the yarn count increases. This suggests that the splicing process may reduce the twist intensity in yarn, which becomes more apparent in finer yarns.

4.2. Strength and Elasticity Test

4.2.1. Machine parameter:

This test has done in Tensile strength tester following ISO 2062 method in 02 Jaw Separation 500 mm

Force Control Gain	25
Load Cell	200 N
Jaw Scheme	T15
Jaw Separation	500.00 mm
Break Detection	20%
Linear Density	36.91 tex
Pretension	0.50 cN/tex
Speed of Pull To Load Cell Max	500.00 mm/min

Table 25 Tensile Strength tester setting of ISO-2062 method

4.2.2. Test results:

10 Ne + 40 D without Splice yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	582.08	9.85	9.88
2	727.78	12.34	8.01
3	489.00	8.28	6.49
4	823.69	13.95	8.34
5	713.74	12.20	9.63
6	609.40	10.05	9.99
7	966.77	12.25	10.77
Mean	**701.78**	**11.27**	**9.01**

Table 26 Test report of 7 specimen of Count 10 Ne + 40D (Without Splice) , Cotton/Elastane

10 Ne + 40 D Splice yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	569.46	9.64	6.34
2	642.29	10.88	6.6
3	506.22	8.57	5.94
4	578.13	9.79	6.34
5	570.01	9.67	6.21
6	574.02	9.72	6.34
7	578.03	9.77	6.34
Mean	**574.02**	**9.72**	**6.30**

Chart 9 Test report of 7 specimen of Count 10 Ne + 40D (Splice) , Cotton/Elastane

10 Ne Without Splice			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	729.38	12.35	7.098
2	740.83	12.71	6.966
3	793.60	13.44	9.221
4	933.93	15.81	9.400
5	818.20	13.86	8.927
6	848.53	14.37	8.824
7	850.53	14.40	8.701
Mean	**817.86**	**13.85**	**8.448**

Table 27 Test report of 7 specimen of Count 10 Ne (Without Splice) , 100% Cotton

10 Ne Splice			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	713.57	10.89	6.54
2	653.81	13.16	6.56
3	821.54	9.43	9.97
4	655.50	12.54	9.40
5	653.43	13.40	7.27
6	799.26	11.46	8.01
7	508.53	11.49	7.10
Mean	**686.52**	**11.77**	**7.84**

Chart 10 Test report of 7 specimen of Count 10 Ne (Splice) , 100% Cotton

16 Ne + 70D (Without Splice)			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	240.5	10.4	8.2
2	245.2	10.6	8.5
3	235.8	10.2	7.9
4	250.7	10.8	8.7
5	242.4	10.5	8.3
6	238.9	10.3	8
7	247.1	10.7	8.6
Mean	**242.94**	**10.50**	**8.31**

Table 28 Test report of 7 specimen of Count 16 Ne + 70D (Without Splice), Cotton/Elastane

16 Ne + 70D Splice			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	235.29	10.18	7.55
2	114.95	4.97	5.27
3	244.10	10.56	9.58
4	175.96	7.58	8.70
5	193.59	8.33	6.76
6	225.03	9.96	7.26
7	147.74	8.54	7.02
Mean	**190.95**	**8.59**	**7.45**

Chart 11 Test report of 7 specimen of Count 16 Ne + 70D (Splice), Cotton/Elastane

16 Ne (Without Splice) Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	250.4	10.9	5.1
2	255.3	11.1	5.3
3	245.8	10.7	5
4	260.7	11.4	5.4
5	252.2	11	5.2
6	248.9	10.8	5.1
7	257.4	11.2	5.3
Mean	**252.96**	**11.01**	**5.20**

Table 29 Test report of 7 specimen of Count 16 Ne (Without Splice) , 100% Cotton

16 Ne Splice Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	244.97	10.67	4.70
2	119.68	5.20	3.29
3	254.45	11.08	6.06
4	182.98	8.00	5.40
5	201.41	8.72	4.23
6	234.45	10.44	4.63
7	153.90	8.94	4.32
Mean	**198.84**	**9.01**	**4.66**

Chart 12 Test report of 7 specimen of Count 16 Ne (Splice) , 100% Cotton

24 Ne Without Splice Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	165.2	10.9	4.9
2	160.4	10.6	4.7
3	170.8	11.3	5.1
4	158.9	10.5	4.6
5	162.3	10.7	4.8
6	168.5	11.1	5
7	164.7	10.85	4.9
Mean	**164.40**	**10.85**	**4.86**

Chart 13 Test report of 7 specimen of Count 24Ne (without Splice) , 100% Cotton

24 Ne Splice Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	161.62	10.67	4.51
2	75.19	4.97	2.92
3	176.81	11.70	6.18
4	111.53	7.37	4.60
5	129.62	8.48	3.91
6	158.72	10.73	4.54
7	98.47	8.66	4.00
Mean	130.28	8.94	4.38

Chart 14 Test report of 7 specimen of Count 24Ne (Splice) , 100% Cotton

24 Ne + 40 D without Splice Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	182	9.5	9.2
2	185.5	9.7	9.5
3	178.4	9.3	8.9
4	190	9.9	9.8
5	187.2	9.8	9.4
6	180.3	9.4	9.1
7	188.5	9.85	9.6
Mean	**184.56**	**9.64**	**9.36**

Chart 15 Test report of 7 specimen of Count 24Ne+40D (wihtout Splice) , Cotton /spandex

24 Ne + 40 D Splice Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	178.05	9.30	8.48
2	86.96	4.55	5.89
3	184.68	9.63	10.79
4	133.36	6.95	9.80
5	149.50	7.77	7.65
6	169.83	9.09	8.26
7	112.70	7.86	7.83
Mean	**145.01**	**7.88**	**8.39**

Chart 16 Test report of 7 specimen of Count 24Ne+40D (Splice) , Cotton /spandex

30 Ne + 40 D (Without Splice) Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	232.56	11.81	7.41
2	259.76	13.2	9.72
3	214.32	10.89	8.01
4	192.3	9.77	7.23
5	211.44	10.74	8.5
6	224.25	11.39	9.02
7	208.32	10.58	8.38
Mean	**220.42**	**11.2**	**8.32**

Table 30 Test report of 7 specimen of Count 30 + 40D (Without Splice) , Cotton/Elastane

30 Ne + 40 D (Splice) Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	181.71	9.23	6.66
2	172.27	8.75	5.81
3	148.25	7.53	4.5
4	231.13	11.74	7.17
5	185.12	9.45	6.1
6	180.76	9.22	6
7	184.14	9.3	5.99
Mean	**183.34**	**9.32**	**6.03**

Chart 17 Test report of 7 specimen of Count 30 + 40D (Splice) , Cotton/Elastane

30 Ne (Without Splice) Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	284.33	14.44	5.21
2	264.42	13.43	5.11
3	294.55	14.96	5.36
4	299.04	15.19	5.77
5	328.52	16.69	5.62
6	279.3	14.19	5.11
7	279.37	14.19	5.12
Mean	**289.93**	**14.73**	**5.33**

Table 31 Test report of 7 specimen of Count 30 Ne, 100% Cotton without splice

30 Ne (Splice) Yarn			
Specimen	**Max Force (cN)**	**Max. Tenacity (cN/tex)**	**Extension (%)**
1	222.16	11.29	4.68
2	175.36	8.90	3.05
3	203.75	10.34	3.01
4	359.42	18.25	5.72
5	287.63	14.69	4.03
6	225.13	11.49	3.40
7	246.94	12.47	3.66
Mean	**245.77**	**12.49**	**3.94**

Chart 18 Test report of 7 specimen of Count 30 Ne, 100% Cotton Splice

4.2.3.Analysis of Extension% on Cotton Yarn in Splice condition:

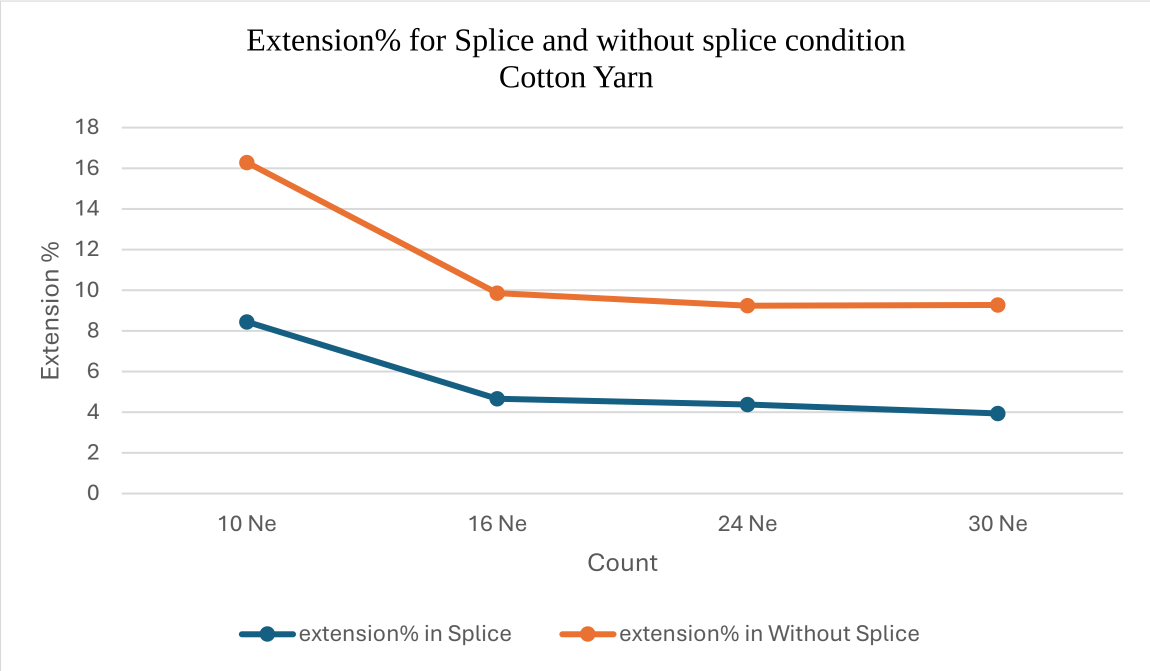


Figure 7 Extension% of Splice vs Without Splice of Cotton yarn

The line chart compares the **extension percentage** of cotton yarn under two conditions: **splice** and **without splice**, across different yarn counts (10 Ne, 16 Ne, 24 Ne, and 30 Ne). The blue line represents the extension percentage in the splice condition, while the orange line represents the extension percentage without the splice condition.

4.2.3.1. Description

1. **X-axis (horizontal):** Represents the yarn counts (10 Ne, 16 Ne, 24 Ne, 30 Ne).
2. **Y-axis (vertical):** Represents the extension percentage (%).
3. **Data Representation:**
   - For all counts, the splice condition shows consistently lower extension percentages than the without splice condition.
   - Both conditions exhibit a decreasing trend as the yarn count increases.

4.2.3.2. Key Findings

1. **Extension in Splice Condition:**
   - Starts at around 8% for 10 Ne.
   - Gradually decreases to slightly below 5% for 30 Ne.
2. **Extension in Without Splice Condition:**
   - Starts significantly higher at 16% for 10 Ne.
   - Steadily decreases to around 10% for 30 Ne.

3. The gap between the two lines narrows as the yarn count increases, indicating a decreasing difference in extension percentage between the splice and without splice conditions.

4.2.3.3. Reason

- The **splice condition** involves joining fibers more compactly, which likely enhances yarn cohesion and reduces elasticity, resulting in a lower extension percentage.
- In contrast, the **without splice condition** may retain more natural elasticity, leading to higher extension percentages.
- The diminishing gap in extension with higher yarn counts might be due to finer yarns inherently having less extensibility, reducing the relative impact of splicing.

4.2.3.4. Overall:

- The splice condition consistently results in a lower extension percentage compared to the without splice condition.
- As the yarn count increases (finer yarns), the difference in extension percentage between the two conditions diminishes.
- This suggests that splicing significantly affects extension properties, particularly in coarser yarns.

4.2.4. Analysis of Tenacity (cN/tex) on Cotton Yarn in Splice condition:

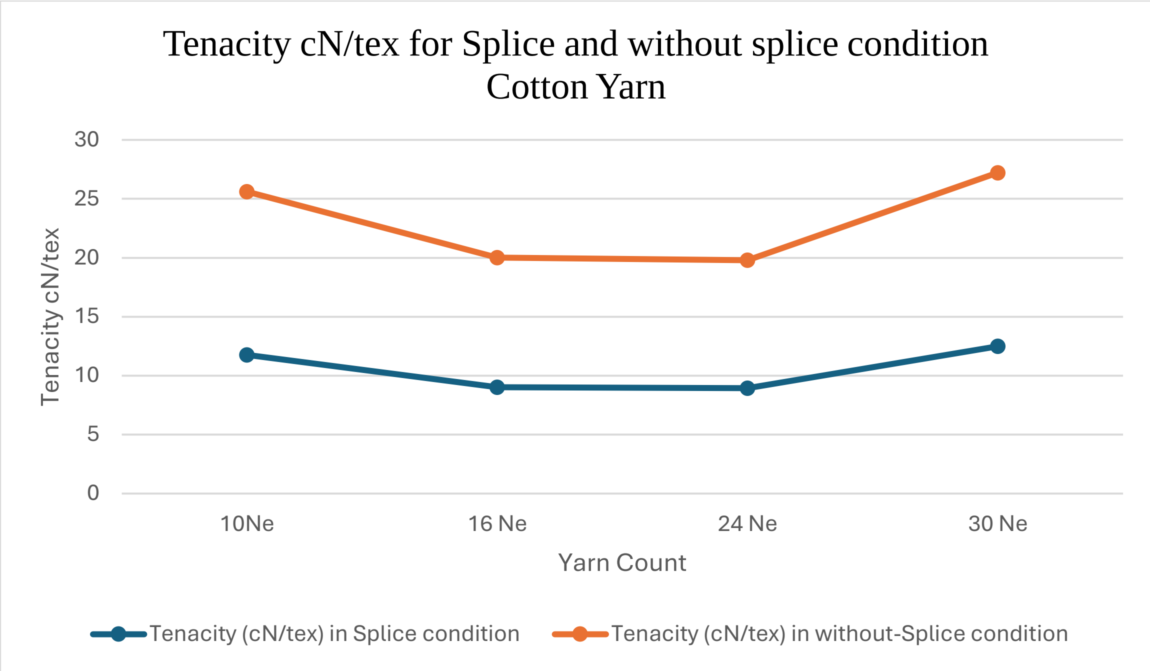


Figure 8 Tenacity cN/tex of Splice vs Without Splice of Cotton yarn

The line chart illustrates the **tenacity (cN/tex)** of cotton yarn in **splice** and **without splice conditions** across various yarn counts (10 Ne, 16 Ne, 24 Ne, and 30 Ne). The blue line represents tenacity under splice conditions, while the orange line represents tenacity without splice conditions.

4.2.4.1. Description

1. **X-axis (horizontal):** Indicates the yarn count (10 Ne, 16 Ne, 24 Ne, 30 Ne).
2. **Y-axis (vertical):** Represents tenacity in cN/tex (a measure of yarn strength).
3. **Data Representation:**
    - The splice condition exhibits consistently lower tenacity values compared to the without splice condition.
    - For the without splice condition, tenacity decreases from 10 Ne to 16 Ne, remains stable between 16 Ne and 24 Ne, and then rises sharply at 30 Ne.
    - For the splice condition, the tenacity values remain fairly stable, with a slight increase at 30 Ne.

4.2.4.2. Key Findings

1. **Tenacity in Splice Condition:**
    - Starts at approximately 12 cN/tex for 10 Ne.
    - Decreases slightly to around 10 cN/tex for 16 Ne and 24 Ne.
    - Increases slightly to 13 cN/tex for 30 Ne.
2. **Tenacity in Without Splice Condition:**
    - Starts significantly higher at 25 cN/tex for 10 Ne.
    - Gradually decreases to around 20 cN/tex at 16 Ne and remains steady at 24 Ne.
    - Increases sharply to 30 cN/tex for 30 Ne.
3. The gap between the splice and without splice conditions narrows slightly at finer yarn counts (higher Ne).

4.2.4.3. Reason

1. **Splice Condition:**
    - Splicing reduces tenacity due to the disruption of the continuous fiber structure, leading to a weaker yarn.
    - The relatively stable trend indicates that splicing has a consistent effect across different yarn counts.
2. **Without Splice Condition:**
    - Yarn without splicing retains its continuous fiber structure, resulting in higher tenacity.
    - The sharp increase in tenacity at 30 Ne could be attributed to better fiber alignment or optimized processing conditions for finer yarns.

4.2.4.4. Overall:

- The **without splice condition** consistently yields higher tenacity compared to the **splice condition**, confirming that splicing negatively affects yarn strength.
- The effect of splicing becomes less pronounced as the yarn count increases (finer yarns).
- For applications requiring high yarn strength, the without splice condition is preferable, especially at finer yarn counts. However, splicing may still be used where strength is less critical and operational efficiency is prioritized.

4.2.5. Analysis of Extension% on Cotton/spandex Yarn in Splice condition:

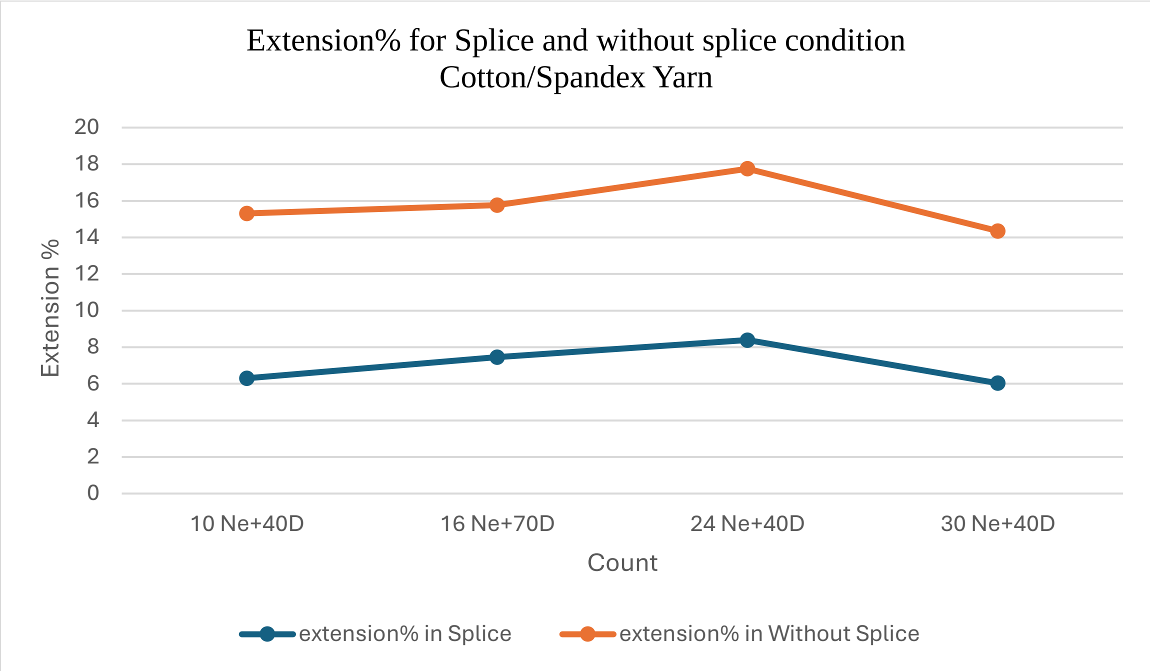


Figure 9 Extension% of Splice vs Without Splice of Cotton/spandex yarn

The line chart compares the **extension percentage** of **cotton/spandex yarn** under two conditions: **splice** and **without splice**, across different yarn counts (10 Ne+40D, 16 Ne+70D, 24 Ne+40D, and 30 Ne+40D). The blue line represents the splice condition, while the orange line represents the without splice condition.

4.2.5.1. Description

1. **X-axis (horizontal):** Represents the yarn count, combining Ne (cotton count) and D (denier for spandex).
2. **Y-axis (vertical):** Represents the extension percentage (%).
3. **Data Representation:**
    - The extension percentage is consistently higher in the without splice condition across all yarn counts.
    - In the splice condition, the extension percentage shows a slight increase initially and then decreases gradually.
    - In the without splice condition, the extension percentage increases to a peak at 24 Ne+40D before decreasing.

4.2.5.2. Key Findings

1. **Splice Condition:**
    - Extension percentage starts at around 6% for 10 Ne+40D.
    - Slightly increases to around 7% at 16 Ne+70D.
    - Gradually decreases to around 5% at 30 Ne+40D.
2. **Without Splice Condition:**
    - Extension percentage begins at approximately 14% for 10 Ne+40D.
    - Peaks at around 17% at 24 Ne+40D.
    - Declines to approximately 13% at 30 Ne+40D.
3. The difference between splice and without splice conditions is more pronounced at coarser yarn counts (10 Ne+40D and 16 Ne+70D) and narrows slightly as the yarn becomes finer (30 Ne+40D).

4.2.5.3. Reason

1. **Splice Condition:**
    - Splicing introduces a compact joint in the yarn, reducing its elasticity and extension percentage.
    - The relatively stable and gradual trend indicates that splicing has a consistent impact, irrespective of the yarn count.
2. **Without Splice Condition:**
    - The absence of splicing retains the natural elasticity contributed by the spandex, resulting in higher extension percentages.
    - The peak at 24 Ne+40D might be due to optimized fiber-to-spandex interaction at this specific count.

4.2.5.4. Overall:

- The **without splice condition** consistently exhibits a higher extension percentage than the **splice condition**, confirming that splicing limits the elasticity of cotton/spandex yarn.
- The impact of splicing is more significant at coarser yarn counts and diminishes slightly as the yarn becomes finer.
- For applications requiring higher elasticity, the **without splice condition** is preferable. However, splicing can still be used in contexts where elasticity is less critical or efficiency in yarn processing is prioritized.

4.2.6. Analysis of Tenacity (cN/tex) on Cotton Yarn in Splice condition:

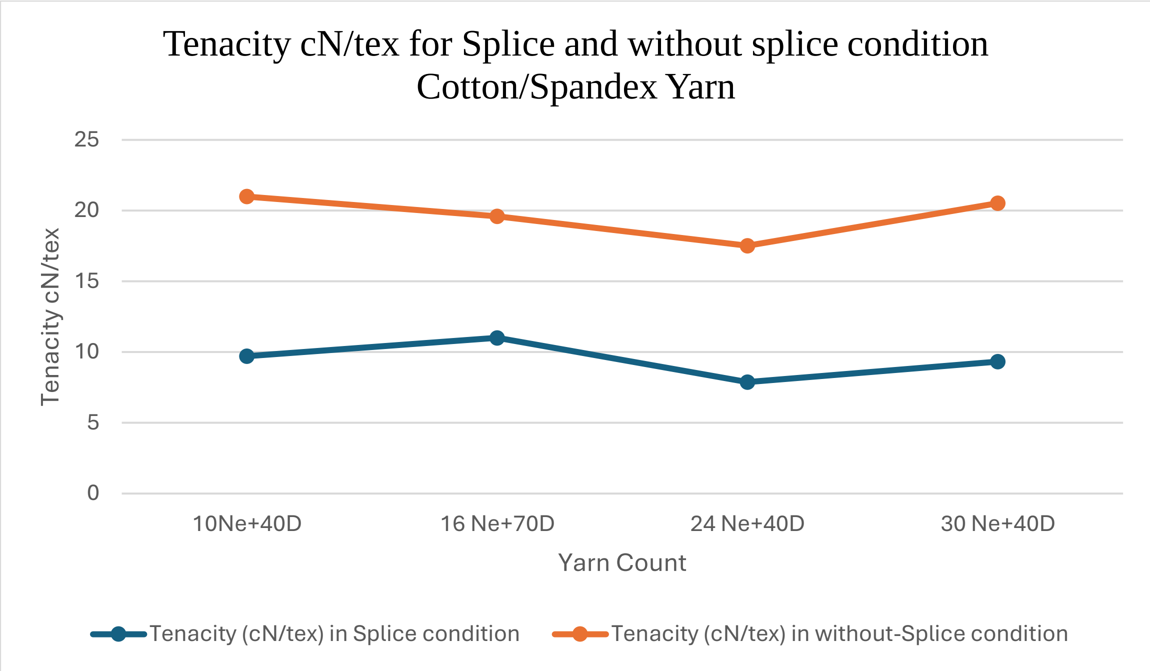


Figure 10 Tenacity cN/tex of Splice vs Without Splice of Cotton/spandex yarn

4.2.6.1. Description of the Line Chart:

The line chart illustrates the tenacity (cN/tex) of Cotton/Spandex yarn across different yarn counts (10 Ne, 16 Ne, 24 Ne, and 30 Ne) in two conditions:

1. **Splice condition** (represented by the blue line).
2. **Without-splice condition** (represented by the orange line).

4.2.6.2. Key Findings:

1. **Without-splice condition** consistently shows higher tenacity (cN/tex) than the splice condition for all yarn counts.
2. In the **splice condition**:
   - The tenacity gradually increases from 10 Ne to 30 Ne, except for a slight dip at 24 Ne.
   - The values are lower, peaking at around 11-12 cN/tex.
3. In the **without-splice condition**:
   - Tenacity starts higher and shows a gradual decline from 10 Ne to 24 Ne.
   - There is a notable recovery at 30 Ne, where tenacity reaches its highest at ~21 cN/tex.

4.2.6.3. Reason for Observed Trend:

1. The **splice condition** involves joining techniques, which likely introduce weak points in the yarn structure, reducing the overall tenacity.
2. The **without-splice condition** avoids such weak points, leading to stronger and more consistent yarn.
3. The variation across yarn counts could be attributed to differences in fiber density, structure, or the splicing process' efficiency for finer or coarser yarn counts.

4.2.6.4. Overall :

- **Without-splice condition** provides significantly higher yarn strength across all counts, making it more suitable for applications where strength is critical.
- However, the splice condition may still serve specific uses where flexibility, repairability, or process convenience are prioritized over maximum strength.

CHAPTER 5

CONCLUSION

5, CONCLUSION

This study provided a comprehensive comparative analysis of cotton and core-spun yarns under Splice and without Splice conditions, focusing on their mechanical properties, including **tenacity (cN/tex)**, **extension (%)**, **force (cN)**, and **yarn twist**. The findings offer critical insights into the performance characteristics of these yarn types, enabling better material selection for specific applications.

5.1. Final Summary:

The analysis of tenacity (cN/tex) in Cotton/Spandex yarn reveals that the **splice condition** significantly weakens yarn strength compared to the **without-splice condition** across all yarn counts (10 Ne, 16 Ne, 24 Ne, and 30 Ne). This reduction in strength is due to the splicing process, which introduces weak points in the yarn structure, making it less durable and more prone to breakage under tension.

5.2. Effect of Spliced Yarn in Garments:

1. **Reduced Fabric Strength**: Garments made with spliced yarn may have lower tensile strength, impacting durability.
2. **Increased Defects**: Weak splicing points can lead to fabric imperfections, such as broken threads during weaving, knitting, or usage.
3. **Lower Stretch Recovery**: In Cotton/Spandex blends, the weaker splicing areas might compromise the elasticity and stretch recovery of the garment.
4. **Reduced Wear Resistance**: Spliced yarn garments may exhibit reduced resistance to abrasion and stress, affecting their lifespan.

5.3. Strategies to Reduce the Effects of Spliced Yarn in Spinning:

1. **Improved Splicing Techniques**:
    - Use advanced splicing technology that ensures better fiber interlocking and minimizes weak points.
    - Adjust air pressure and splicing parameters to match yarn type and count.
2. **Fiber Quality Control**:
    - Use longer, more uniform fibers to improve splicing efficiency and reduce strength loss.
    - Maintain proper humidity during the splicing process to enhance fiber cohesion.
3. **Minimize Splicing Frequency**:
    - Optimize spinning machine settings to produce longer yarn lengths without the need for frequent splicing.
    - Regularly monitor and maintain spinning machines to avoid unnecessary breaks during yarn production.
4. **Blending Optimization**:
    - Ensure consistent blending of Cotton/Spandex to reduce irregularities that may impact the splicing process.
    - Experiment with different ratios of cotton to spandex to improve spliced yarn properties.

5.3. Conclusion:

While splicing is essential for continuous yarn production, it negatively impacts tenacity in Cotton/Spandex yarn. By optimizing the splicing process and employing better fiber control techniques, manufacturers can mitigate the strength reduction, resulting in higher-quality yarn for garments. Addressing these challenges will improve garment durability, performance, and consumer satisfaction.

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Annexation:

Sample before test

Sample after test

EN ISO 2062 (500mm 500mm/min)

Date: 2009

Yarns from packages - Determination of single-end breaking force and elongation at break

---

Test Details

Test Name:	Yarn Test	Print Date:	8/14/2024
Customer:	Cotton/Elastane	Force Control Gain:	25
3:	Witthout Nort	Load Cell:	200 N
Specimens:	7	Load Cell SN:	SERIAL NUMBER
Required Directions:	-	Version:	7.1.15.0
Test Time:	9:49 AM	Firmware:	V2.8
Test Date:	8/14/2024	Titan SN:	Not Licensed
Jaw Scheme:	T15	Tested by:	Administrator
Jaw Separation:	500.00 mm		

Procedure Settings

Break Detection:	20 %
Pretension (Linear Density)	
Linear Density:	36.91 tex
Pretension:	0.50 cN/tex
Pull To Load Cell Maximum	
Speed:	500.00 mm/min

Results

Specimen	Max Force (cN)	Max. Tenacity (cN/tex)	Extension (%)
1	428.1	11.6	4.83
2	476.5	12.91	4.19
3	385.46	10.44	3.53
4	475.27	12.88	4.19
5	488.44	13.23	5.17
6	425.75	11.54	4.43
7	401.39	10.88	4.18
Mean	440.13	11.92	4.36
Coeff Of Var	9.15%	9.15%	12.03%

EN ISO 2062 (500mm 500mm/min)

Date: 2009

Yarns from packages - Determination of single-end breaking force and elongation at break

---

Test Details

Test Name:	S. YARN	Print Date:	8/22/2024
Customer:	10NE	Force Control Gain:	25
Reference:	500M	Jaw Pressure:	100
Specimens:	7	Load Cell:	200 N
Required Directions:	-	Load Cell SN:	SERIAL NUMBER
Test Time:	4:46 PM	Version:	11.0.3.0
Test Date:	8/22/2024	Firmware:	V2.8
Jaw Scheme:	T5	Titan SN:	Not Licensed
Jaw Separation:	500.00 mm	Tested by:	Administrator

Procedure Settings

Break Detection: 20 %

Pretension (Linear Density)

Linear Density: 59.05 tex

Pretension: 0.50 cN/tex

Pull To Load Cell Maximum

Speed: 500.00 mm/min

Results

Specimen	Max Force (cN)	Max. Tenacity (cN/tex)	Extension (%)
1	729.38	12.35	7.098
2	750.83	12.71	6.966
3	793.60	13.44	9.221
4	933.93	15.81	9.400
5	818.20	13.86	8.927
6	848.53	14.37	8.824
7	850.53	14.40	8.701
Mean	817.86	13.85	8.448
Coeff Of Var	8.411%	8.411%	11.80%

EN ISO 2062 (500mm 500mm/min)

Date: 2009

Yarns from packages - Determination of single-end breaking force and elongation at break

---

Test Details

Test Name:	S.YARN	Print Date:	8/22/2024
Customer:	30NE	Force Control Gain:	25
3:	500MM	Load Cell:	200 N
Specimens:	7	Load Cell SN:	SERIAL NUMBER
Required Directions:	-	Version:	7.1.15.0
Test Time:	4:04 PM	Firmware:	V2.8
Test Date:	8/22/2024	Titan SN:	Not Licensed
Jaw Scheme:	T5	Tested by:	Administrator
Jaw Separation:	500.00 mm		

Procedure Settings

Break Detection:	20 %
Pretension (Linear Density)	
Linear Density:	19.68 tex
Pretension:	0.50 cN/tex
Pull To Load Cell Maximum	
Speed:	500.00 mm/min

Results

Specimen	Max Force (cN)	Max. Tenacity (cN/tex)	Extension (%)
1	284.33	14.44	5.21
2	264.42	13.43	5.11
3	294.55	14.96	5.36
4	299.04	15.19	5.77
5	328.52	16.69	5.62
6	279.3	14.19	5.11
7	279.37	14.19	5.12
Mean	289.93	14.73	5.33
Coeff Of Var	7.04%	7.04%	5.05%

EN ISO 2062 (500mm 500mm/min)

Date: 2009

Yarns from packages - Determination of single-end breaking force and elongation at break

---

Test Details

Test Name:	S. YARN	Print Date:	8/22/2024
Customer:	30NE+40D	Force Control Gain:	25
3:	500MM	Load Cell:	200 N
Specimens:	7	Load Cell SN:	SERIAL NUMBER
Required Directions:	-	Version:	7.1.15.0
Test Time:	3:35 PM	Firmware:	V2.8
Test Date:	8/22/2024	Titan SN:	Not Licensed
Jaw Scheme:	T5	Tested by:	Administrator
Jaw Separation:	500.00 mm		

Procedure Settings

Break Detection: 20 %

Pretension (Linear Density)

Linear Density: 19.68 tex

Pretension: 0.50 cN/tex

Pull To Load Cell Maximum

Speed: 500.00 mm/min

Results

Specimen	Max Force (cN)	Max. Tenacity (cN/tex)	Extension (%)
1	232.56	11.81	7.41
2	259.76	13.2	9.72
3	214.32	10.89	8.01
4	192.3	9.77	7.23
5	211.44	10.74	8.5
6	224.25	11.39	9.02
7	208.32	10.58	8.38
Mean	220.42	11.2	8.32
Coeff Of Var	9.74%	9.74%	10.51%

Comparative Analysis of Physical Properties of Cotton Covered Elastomeric Hybrid Yarns And Cotton Yarn In Splice And Without Splice Condition

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