

PINEAPPLE FIBERS BASED HYBRID YARN FOR FASHION FABRIC

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ABSTRACT

The impact of cotton–pineapple fiber blend ratios on the mechanical and physical characteristics of yarns is examined in this study. Pineapple long fibers were cut to staple lengths suitable for spinning, and blends of cotton–pineapple and cotton tencel. Fiber properties were characterized using the High-Volume Instrument (HVI) and Advanced Fiber Information System (AFIS). The 70:30 cotton–pineapple blended yarn (20 Ne) was analyzed using a single yarn strength tester, evenness tester, and blackboard tester, while all blend ratios were evaluated using a lea strength tester. The results revealed that pineapple-blended yarns exhibited lower tenacity, RKM, and elongation compared to 100% cotton yarns, while the cotton–pineapple–Tencel blend (40:20:40) exhibited higher tenacity due to the superior strength and flexibility of Tencel fibers. Evenness and imperfection indices increased with pineapple content, but Tencel inclusion improved uniformity and reduced hairiness. Increasing pineapple fiber content enhanced comfort and aesthetic characteristics, indicating potential for sustainable high-end fashion fabrics.

KEYWORDS: Cotton–pineapple blend, Tencel fiber, Yarn properties, Sustainable textiles, Fashion fabric.

1. INTRODUCTION

The study investigates the development and performance characteristics of a sustainable textile blend comprising pineapple leaf fiber (PALF), cotton, and Tencel.

Cotton is a natural fiber harvested from the fluffy boll of the cotton plant. It is one of the most widely used textiles in the world because of its comfort, versatility, breathability, absorbent, durable and biodegradable.

Lycell is a type of fabric made from wood pulp, usually derived from sustainably sourced trees like eucalyptus, beech, or spruce. It falls under the category of regenerated fibers, which means it is produced through a chemical process but is made from natural materials.

The wood pulp is dissolved in a non-toxic solvent (like N-methylmorpholine N-oxide) to create a slurry, which is then extruded into fibers and spun into thread. The process is considered more eco-friendly than traditional fibers like cotton or polyester because it uses less water, produces fewer chemicals, and the solvent can be recycled, minimizing waste.

Pineapple leaf fiber (PALF) is a remarkable natural fiber with high cellulose content, significant tensile strength, and a relatively low micro fibrillary angle, which contributes to its superior mechanical properties [5]. On its own, pineapple yarn has been used to produce mats, bags, tablecloths, and lightweight embroidered fabrics due to its strength and sheen [1].

Several studies have investigated the effect of fiber loading and chemical treatment on PALF composites. For example, PALF-reinforced polyester composites (PALF/PE) treated with 1N NaOH or KOH showed enhanced tensile strength and flexural modulus, particularly at 45 wt.% fiber loading [2]. Similarly, PALF/cotton yarns were developed in various weight ratios (50:50, 40:60, 30:70), demonstrating that changes in PALF composition can significantly affect yarn physical and mechanical properties [3]. The rule of mixtures also shows that tensile modulus and strength of composites increase with fiber volume fraction [4].

Hybridization of PALF with other fibers has been explored to create bio composites from discarded 174 GSM pineapple fabric, emphasizing the potential of this agricultural by-product for sustainable industrial applications [6]. Spinning studies have reported that 100% PALF yarn produced on apron draft ring and flyer jute spinning frames achieved counts of 121 tex

and 138 tex, respectively, while cotton–PALF blended yarns (90:10 and 80:20) produced on cotton spinning systems demonstrated the effect of twist factors on yarn quality [7].

In addition to the economic benefits, pineapple by-products such as residual pulp, peels, stems, and leaves can be valorized for industrial applications, reducing environmental pollution and generating higher-value products [8]. Recent studies on cotton–pineapple blended yarns highlight the high tensile strength and Young’s modulus of pineapple fibers, reinforcing the potential of these blends for fashion fabrics [9].

However, when blended with cotton and Tencel, it becomes even more versatile, comfortable, and durable. The combination of pineapple fiber’s strength and shine with cotton’s softness and breathability allows the production of blended yarns suitable for fashion fabrics and sustainable apparel applications [1]. Cotton–pineapple yarn blends are more cost-effective than pure pineapple yarns while maintaining desirable mechanical and aesthetic properties. Such blends can be used to produce a wide range of products, including clothing, shoes, and accessories [1].

The main objective of the present work is to analyze cotton–pineapple–Tencel blended yarns by producing yarns in different blend ratios and counts to evaluate their physical, mechanical, and evenness properties. By systematically studying the effect of fiber composition and spinning parameters, this study aims to provide insights into creating high-performance, sustainable fashion yarns.

2. EXPERIMENTAL

2.1 MATERIALS

The cotton fiber used is cameroon which is west african cotton. The length and strength of this cotton are good, so when blended with pineapple, the desired results are obtained.



Figure 1: Long staple pineapple fiber.

2.1.1 RAW COTTON PROPERTIES

Table 1: Properties of Cameroon raw cotton.

Description	Value
Spinning consistency index	130
Micronaire	4.89
Maturity	.88
Length (mm)	30.29
Uniformity index (%)	82.2
Short fiber (%)	8.3
Strength (g/tex)	29.2
Elongation	6.9
Reflectance	72.6
Yellowness	10.4
Color grade	32-1
Trash count	14
Trash area (%)	0.16
Trash identification	2
Neps count/g	213
Seed coat neps count/g	9
Upper quartile length (mm)	31.60
Finess (mtex)	163
Immature fiber content (%)	5.5
Maturity ratio	0.92

2.1.2 TENCEL FIBER

Table 2: Properties of tencel fiber.

Description	Value
Denier	1.2
Length	32mm
Color	Bright
Origin	Austria

In this study, a synthetic staple fiber with a denier of 1.2 and a staple length of 32 mm was used. The fiber was of bright grade, indicating high luster and a clean surface appearance suitable for producing fine-quality yarns. The selected fiber properties align with standard requirements for short-staple spinning and ensure consistency in processing performance and yarn quality evaluation. The combination of pineapple fiber with fine-denier synthetic fiber aims to achieve an optimal balance of strength, softness, and sustainability. The bright synthetic component improves yarn smoothness and spin ability, while the pineapple fiber contributes to biodegradability, moisture management, and structural reinforcement. This blended material is suitable for developing eco-friendly textile applications with improved functional and aesthetic properties.

2.1.3 PINEAPPLE LEAF FIBER (PALF)

Pineapple fiber, known for its high tensile strength, lustrous appearance, and biodegradability, was blended with cotton to enhance comfort and breathability, while Tencel was incorporated to improve softness, moisture management, and overall fabric drape.

The blend demonstrates a synergistic effect, where the mechanical strength and natural sheen of pineapple fiber are complemented by the softness of cotton and the smooth, uniform structure of Tencel. Experimental results show that the pineapple-containing yarns possess satisfactory spin ability and improved dimensional stability. The inclusion of Tencel further enhances yarn evenness, reduces hairiness, and contributes to a more refined fabric hand feel. Mechanically

extracted from pineapple leaves (by-product of pineapple processing) Preparation: Washed, chemically treated (NaOH or KOH), and cut to 28–30 mm staple length.

Fiber properties:

High cellulose content: 82–85%

Young's modulus: 2.76 GPa

Tensile strength: 80.2 MPa (for 30% fibre weight fraction) [1]

Fineness: 7–10 μm (coarser than cotton)

Mixing ratio of cotton, pineapple and tencel:

Table 3: Mixing ratio of cotton, pineapple and tencel.

Sample	Mixing ratio of cotton, pineapple and tencel
A	70:30:0
B	80:20:0
C	40:20:40
D	100:0:0
E	0:0:100

2.2 METHODS

The samples used in this study included out of total number of data five different mixing ratios.

Pineapple fibres were obtained from our country and all fibres are initially long and then crushed into smaller pieces. Pineapple blended with cotton is then subjected to the spinning process, subsequently processed by weaving and dyeing.

First, pineapple fibre is converted into a short staple fibre after shredding. After blending cotton and pineapple fibre, the process is carried out hand mixing according to different ratios for different count in each section Blow room, Carding, Drawing, Simplex, Ring, and Winding. Finally, cotton, cotton pineapple, cotton pineapple tencel blended yarn and 100% tencel yarn is produced based on sample A (70:30:0), sample B (80:20:0), sample C (40:20:40) for 20 Ne and sample D (100:0:0) for 100% cotton and sample E (0:0:100) for 100% tencel. Blow room hand mixing preferred because of virgin pineapple is not possible to separately run in the process for the machine design limitations.



Figure 2: Shredding pineapple fiber.



Figure 3: After chemical conditioning fiber.

2.2.1 CHEMICAL CONDITIONING PROCEDURE

First Treatment:

0.25% Selbena and 5.5% water of total weight of Flax.

Second Treatment:

0.15% Selbena and 4.5% water, calculated on the total weight of the cotton flax.

After conditioning mix up with cotton to prepare further process in ring spinning. [Fig 3]

2.2.2 AFTER SHREDDING



Figure 4: Cutter blade.

The mentioned cutter blade [Fig 5] & [Fig 6] shredded the long staple fiber into a staple length of almost 23-25 mm.

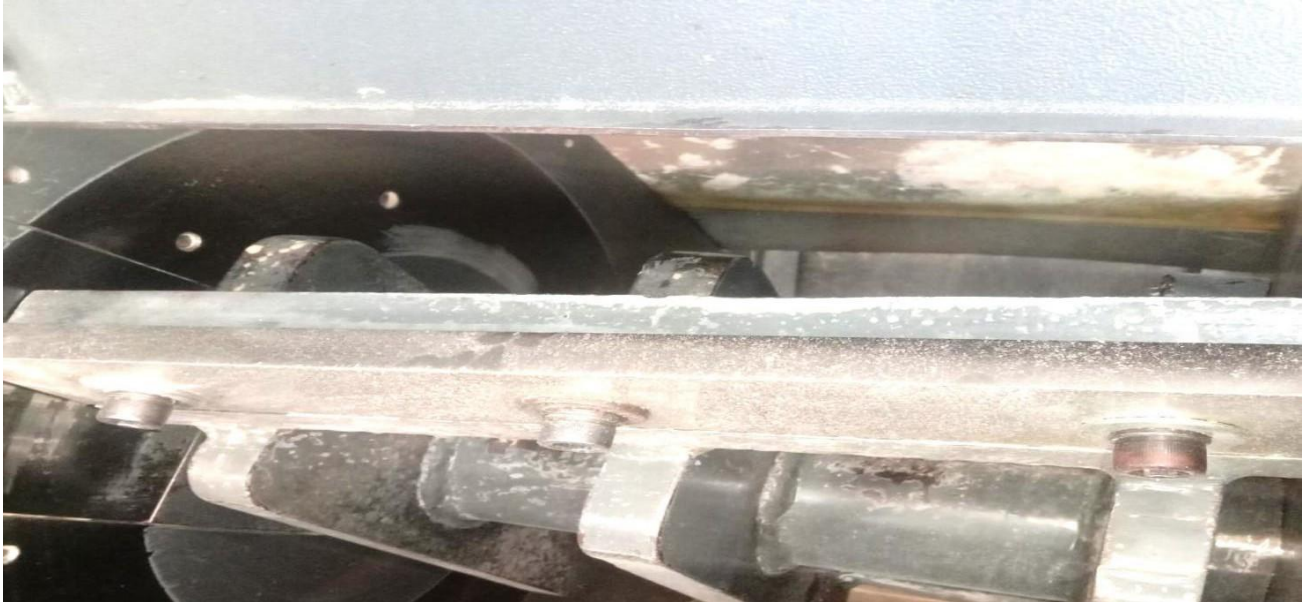


Figure 5: Cutter blade (single).

Herewith shows that the single cutter blade is used to cut the long staple fiber at an optimum set distance of 1 inch or 25.4-mm. After shredding, long staple length is converted into short staple length, which are almost 1 inch in fibre length.

2.2.3 AFTER CRUSHED PINEAPPLE LEAF FIBER



Figure 6: After crushed pineapple leaf fibre.

After shredding the pineapple, fibre is made into bale formation. After that, the bales are mixed with cotton by hand.

Raw cotton is collected accordingly follow the Bale Management where numbering, grading, sorting and open the cover of compressed bales. After those bales are arranged or feed to the Blendomat line by following according to lay down chart. Chronologically feed to the Blow room line, Carding, Breaker draw frame, Finisher draw frame, Roving frame, Ring frame. Testing machines have been tested the material.

2.3 PROCESS PARAMETER

Hand mixing have been done based on ratio 70% cotton and 30% pineapple. After hand mixing completed properly then it will be prepared by blow room section for the next process in carding section.

2.3.1 CARDING SECTION

Carding is shortly described as the reduction of entangled mass of fibers to filmy wave by working them between too closely spaced relatively moving surfaces closed with sharp points.

Table 4: Process parameter of sliver process.

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Production Speed	135m/min	150m/min	140m/min	230m/min	160m/min
Sliver weight	70 grain/yds.	70 grain/yds.	70 grain/yds.	70 grain/yds.	70 grain/yds.
Hank	0.119 Ne	0.119 Ne	0.119 Ne	0.119 Ne	0.119 Ne
Draft	110	110	110	110	110
Flat Speed	150 mm/min	180 mm/min	140 mm/min	320 mm/min	250 mm/min
Cyclinder Speed	560 rpm	560 rpm	560 rpm	850 rpm	650 rpm
Licker in Speed 1, 2, 3	850, 1350, 1750 rpm	900,1400, 1800 rpm	850,1350, 1750 rpm	900,1400, 1800 rpm	900, 1400, 1800 rpm
Licker in Angle	1 degree	2 degree	1 degree	4 degree	3 degree
Cyclinder to Flat	11, 11, 11, 12, 12 Thou	10, 10, 10, 12, 12 Thou	12, 12, 12, 14, 14 Thou	9, 9, 9, 11, 11, 11 Thou	11, 11, 11, 13, 13, 13 Thou

Table 4 shows that the different speed, setting & gauging at the different process ratios.

2.3.2 BREAKER DRAW FRAME SECTION

This is the first stage or passage to regular the sliver.

Table 5: Process parameter of sliver process.

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Production Speed	500 m/min	550 m/min	500 m/min	600 m/min	500 m/min
Sliver weight	69.44 grain/yds.	69.44 grain/yds.	69.44 grain/yds.	69.44 grain/yds.	69.44 grain/yds.
Hank	0.120 Ne	0.120 Ne	0.120 Ne	0.120 Ne	0.120 Ne
Roller gauge	Front to middle 38 mm Back to Middle 42 mm	Front to middle 38 mm Back to Middle 42 mm	Front to middle 40 mm Back to Middle 44 mm	Front to middle 38 mm Back to Middle 42 mm	Front to middle 39 mm Back to Middle 43 mm

Table 5 shows that the different speed, setting & gauging at the different process ratios.

2.3.3 FINISHER DRAW FRAME SECTION

The second passage, which significantly raises quality standards in spinning mills at minimal capital cost.

Table 6: Process parameter of sliver process

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Production Speed	500 m/min	550 m/min	500 m/min	650 m/min	500 m/min
Sliver weight	69.44 grain/yds.	69.44 grain/yds.	69.44 grain/yds.	69.44 grain/yds.	69.44 grain/yds.
Hank	0.120 Ne	0.120 Ne	0.120 Ne	0.120 Ne	0.120 Ne
Roller gauge	Front to middle 40 mm Back to Middle 44 mm	Front to middle 40 mm Back to Middle 44 mm	Front to middle 42 mm Back to Middle 46 mm	Front to middle 40 mm Back to Middle 44 mm	Front to middle 44 mm Back to Middle 48 mm

Table 6 shows that the different speed, setting & gauging at the different process ratios.

2.3.4 SIMPLEX SECTION

The sliver has to be reduced sufficiently in diameter to form a roving.

Table 7: Process parameter of roving process.

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Production Speed	900 rpm	950 rpm	900 rpm	950 rpm	900 rpm
Hank	0.70 Ne	0.70 Ne	0.70 Ne	0.70 Ne	0.70 Ne
TPI	1.07	1.05	0.84	1.02	0.74

Table 7 shows that the different speed, setting & gauging at the different process ratios.

2.3.5 RING FRAME SECTION

Ring Spinning is the final process for cotton to yarn. The ring spinning frame developed the yarn through the process parameter.

Table 8: Process parameter of yarn process.

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Production Speed	10000 rpm	10500 rpm	10000 rpm	12000 rpm	11000 rpm
TPI	20.26	22.09	20.97	20.15	17.88

Table 8 shows that the different speed and TPI (Twist per inch) at the different process ratios.

3. RESULTS AND DISCUSSION

3.1 EVENNESS PROPERTIES

Table 9: Experimental design

Sample	Mixing ratio of cotton, pineapple and tencel	Mixing stage	Manufactured yarn count (Ne)
A	70:30:0	Before blow room	20
B	80:20:0	Before blow room	20
C	40:20:40	Before blow room	20
D	100:0:0	Before blow room	20
E	0:0:100	Before blow room	20

Table 10: Evenness properties of pineapple based hybrid yarn.

Sample	Um (%)	Cvm (%)	Thin (-50%)	Thick (+50%)	Neps (+200%)	Hairiness (-)
A	19.11±0.27	24.91±0.37	541.5±126	2361±160	4005±72	6.0±0.34
B	15.17±0.21	19.86±0.32	59±15	1216±117	1972±183	5.8±0.32
C	13.92±0.14	18.78±0.24	4±3	1225±64	2274±152	5.5±0.30
D	10.12±0.20	12.80±0.24	1±1	56±16	64±16	5.98±0.10
E	8.40±0.24	10.6±0.31	0.3±0.85	6.3±5.56	9.1±3.27	4.37±0.21

Evenness properties of pineapple based hybrid 20 Ne yarn with standard deviation on different ratios **70:30**, **80:20**, **40:40:20**, **100:0:0** and **0:0:100** of cotton, pineapple and tencel.

3.2 TENSILE PROPERTIES

Table 11: CSP of pineapple based hybrid yarn.

Sample	CSP		
	Mean	SD	CV%
A	1846	108	5.85
B	2428	105	4.32
C	2792	92	3.29
D	3055	95	3.10
E	4864	99	2.03

It is evident that in the bundle strength test, due to the use of 30% pineapple, its count strength product is less on the other hand; the count strength product is more when 20% pineapple is used for 20 Ne. The count strength to use tencel 40% in sample C is increased because tencel strength is higher than that of cotton and pineapple. 100% tencel count strength product is more than cotton.

3.3 COTTON BLENDED YARN

3.3.1 BLACKBOARD OF COTTON PINEAPPLE BLENDED

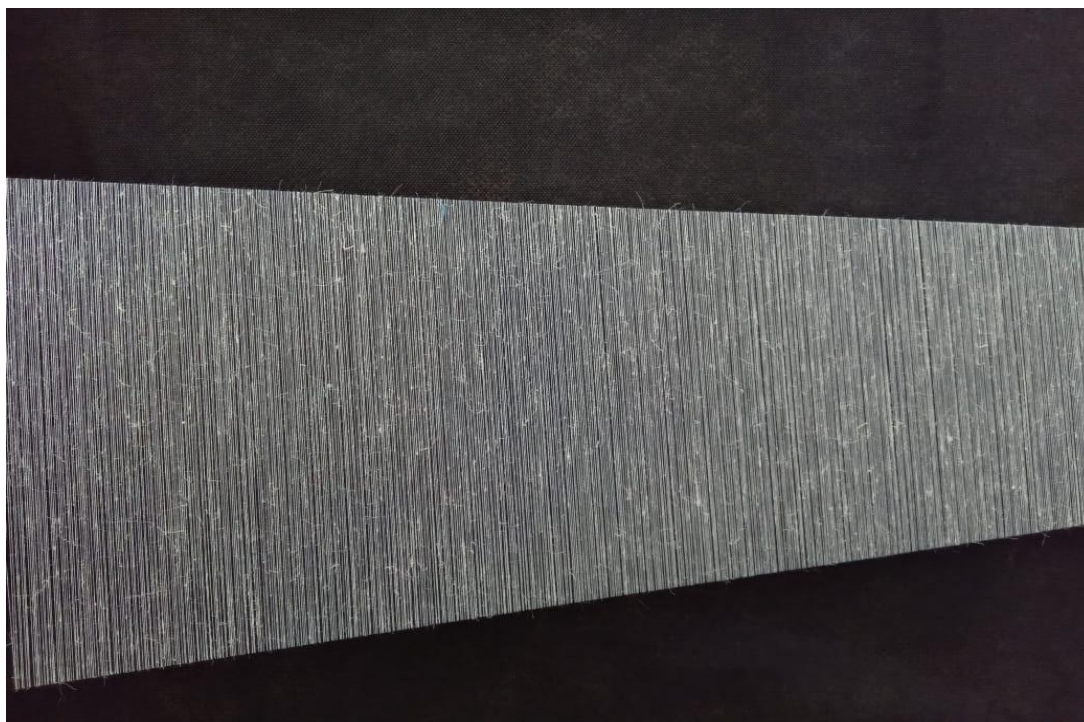


Figure 7: 20 Ne, of 70:30 Cotton Pineapple blended.

20 Ne, of 70:30 Cotton Pineapple blended, showing that more protruding fiber hairiness, thick places, neps etc in Black Board. [Fig 8]

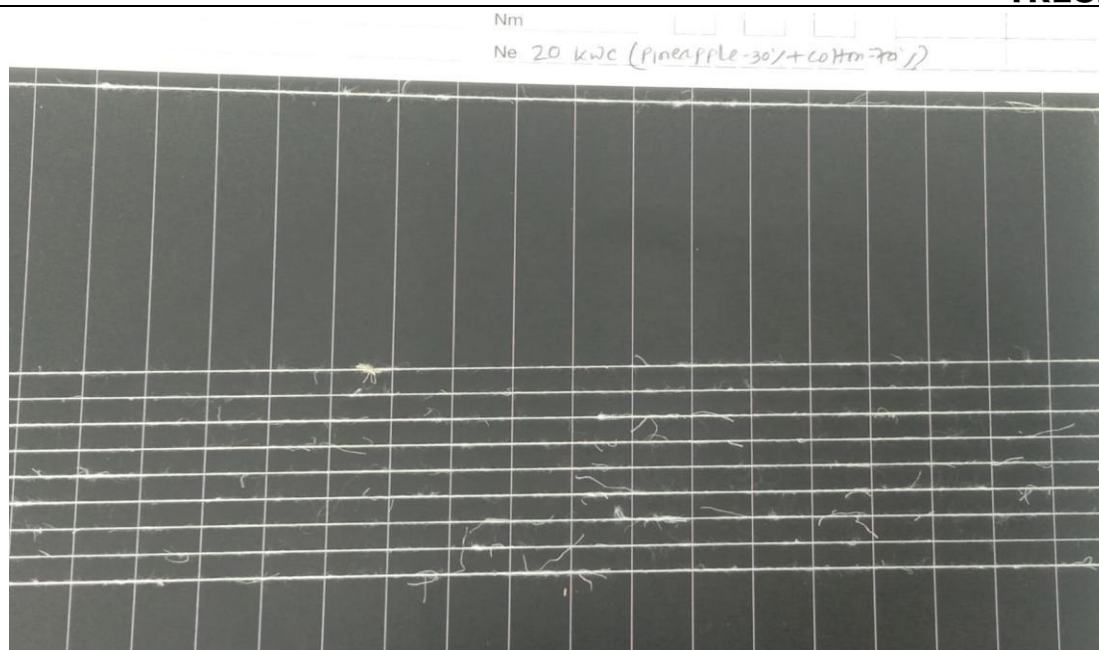


Figure 8: Blackboard of Cotton Pineapple Blended (70:30).

3.3.2 BLACKBOARD OF COTTON PINEAPPLE BLENDED (SINGLE YARN)

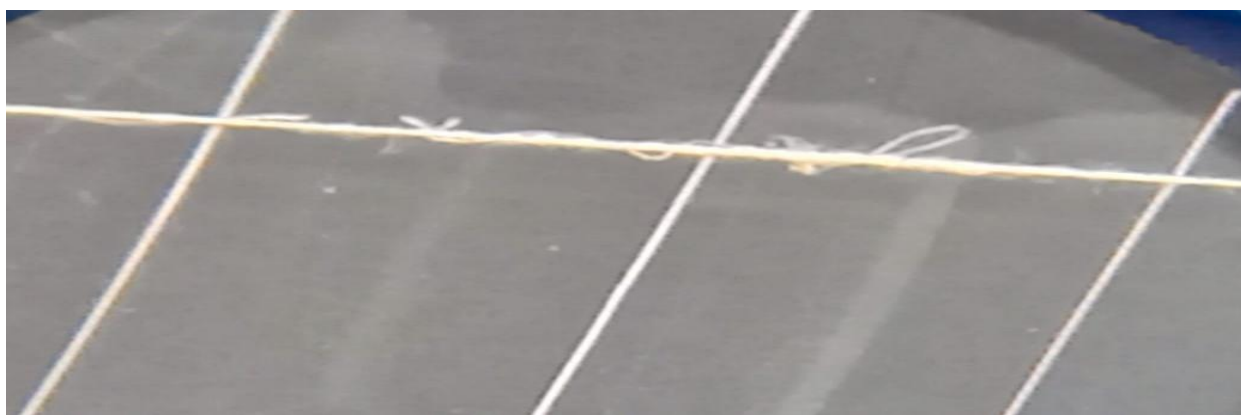
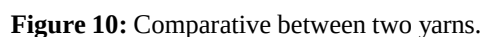


Figure 9: Blackboard of PALF Cotton blended.

The blackboard of cotton pineapple blended single yarn shows the pineapple fibers to be disordered and frayed.

The blackboard of cotton pineapple blended yarn shows the pineapple fibers to be ordered and uniform comparatively cotton pineapple blended yarn.



3.3.3 EFFECT ON WINDING SYSTEM COTTON BLENDED (70:30)

Figure 11: Yarn clearer setting of NSLT, PF, C/CC, Jp Splice, Jm Splice.

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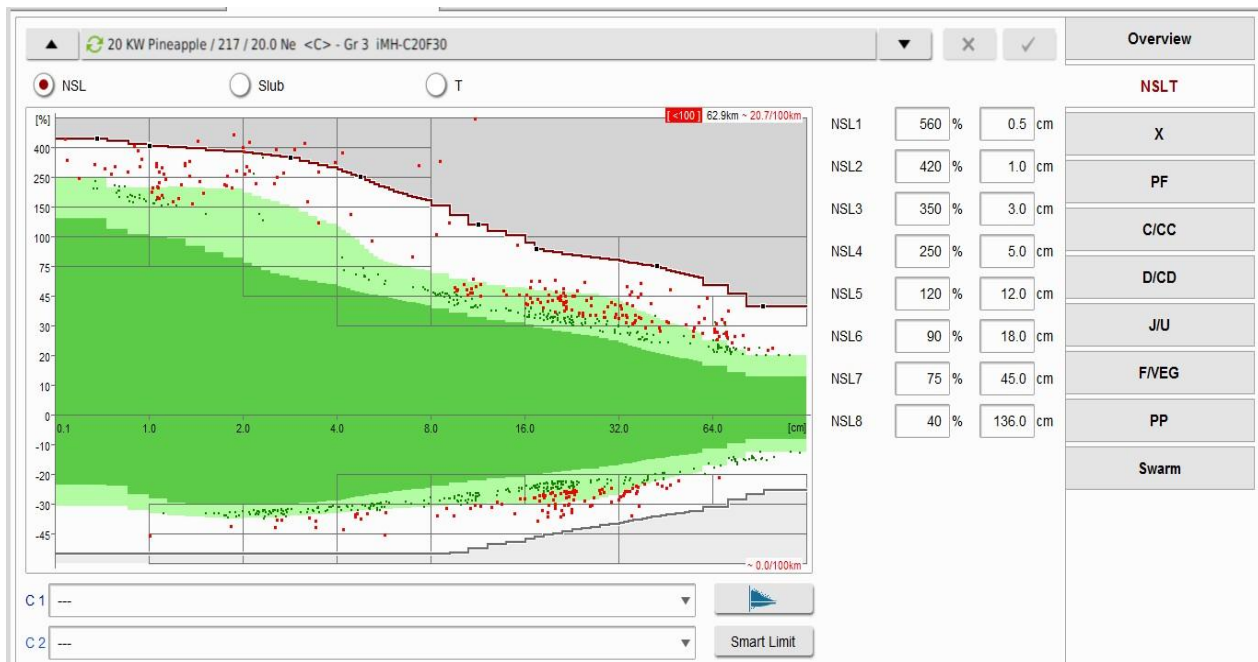


Figure 12: Cotton Pineapple blended Clearing Limits (NSL) with body yarn.

Cotton pineapple blended clearing limits NSL thin setting showing that the wide comparatively with body yarn.

	abs	/100km		abs	/100km		abs	/100km		abs	/100km
YF	55	119.6	Cp	1	2.2	FD	5	10.9	MC		
YJ	77	167.4	Cm	2	4.3	FL	0	0.0	CMC		
YB	26	56.5	CCp	1	2.2	PP	2	4.3	OC		
			CCm	0	0.0				COC		
									CY		
N	6	13.0	Dp	0	0.0	SVD			BMp		
S	18	39.1	Dm	0	0.0	SVL			BMm		
L	11	23.9	CDp	0	0.0	CSVD					
T	4	8.7	CDm	0	0.0	CSVL					
X	2	4.3							Jp	0	0.0
			swNSL	0	0.0	swFD	0	0.0	Jm	0	0.0
PF	3	6.5	swT	0	0.0	swFL	0	0.0	JR %		0.2

Figure 13: Yarn Fault.

Cotton pineapple blended yarn fault showing that the 119.6 in 100 km.0

Here, Neps 13, Short Thick Place 39.1, Long Thick Place 23.9, Thin 8.7, Count Plus 2.2, Count minus 4.3, Continues Count Plus 2.2, Continues Count Minus 0.0, Periodic Fault 6.5, Joint plus 0.0, Joint Minus 0.0 in 100 km observations. Long thick Place more due to hank variation more in back process.

3.3.4 CLASSMATE FAULT

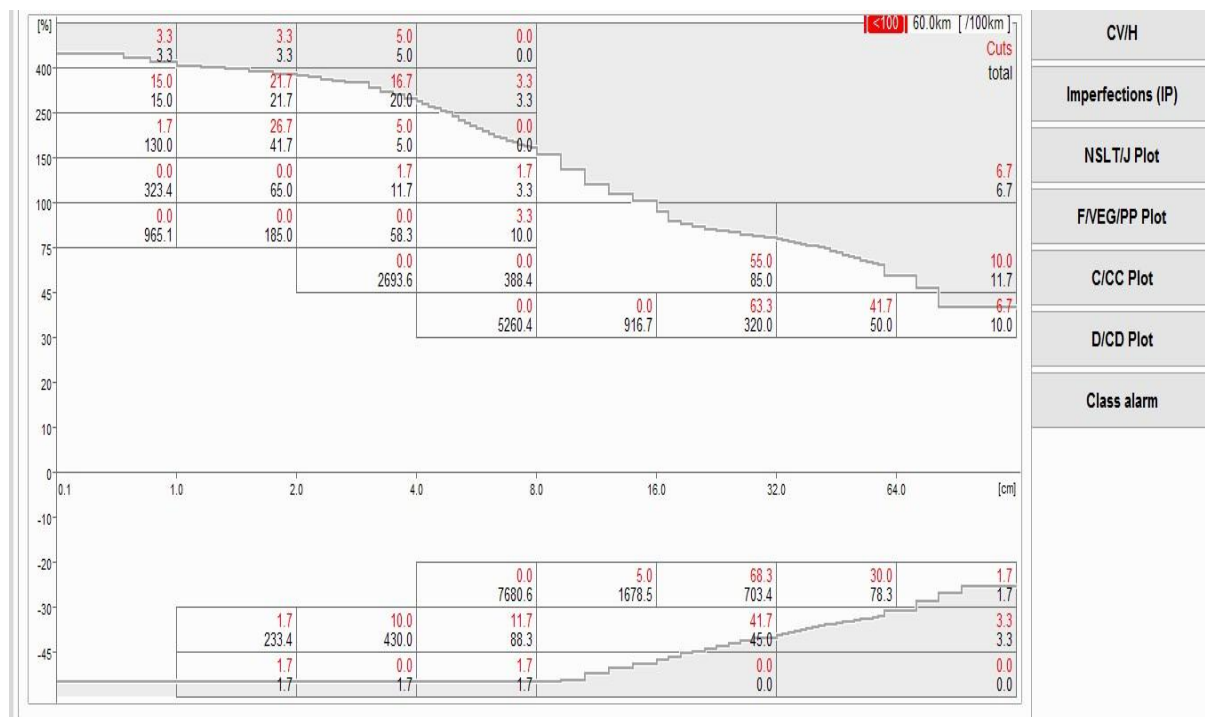


Figure 14: Pineapple Blended NSLT/J Classes

Table 12: Uster classimat fault analysis.

Description	Category	Total
Raw material faults	A1+A2+B1+B2+C1+D1	1608.5
Objectionable faults	A3+A4+B3+B4+C2+C3+C4+D2+D3+D4	251.7
Long thick	E+F+G	103.4
Long thin	H1+H2+I1+I2	45

Classmate fault showing, that in different classes which has showed in total yarn fault in different classes between the raw material and process fault. Objectionable fault has been cuts and total faults/100 km counted as total fault.

3.4 EFFECT ON WINDING SYSTEM OF 100% COTTON

Page 1		Page 2		Smart Limit		NSLT	
NSL	T	X	PF	C/CC	D/CD	X	
NSL1 300% 0.5cm	T1 -45% 1.0cm	X open	PF Sensitivity 28%	Cp +8.0% 10.0m	Dp +20.0% 10.0m		
NSL2 220% 1.2cm	T2 -45% 2.2cm		PF Number of periods 30	Cm -8.0%	Dm -20.0%		
NSL3 130% 3.5cm	T3 -40% 4.0cm			CCp1 +23.0% 2.0m	CDp1 +35.0% 2.0m		
NSL4 65% 8.0cm	T4 -35% 8.0cm			CCp2 +9.5% 12.0m	CDp2 +20.0% 12.0m		
NSL5 40% 16.0cm	T5 -28% 16.0cm			CCm1 -20.0% 2.0m	CDm1 -35.0% 2.0m		
NSL6 25% 32.0cm	T6 -23% 32.0cm			CCm2 -9.5% 12.0m	CDm2 -20.0% 12.0m		
NSL7 22% 64.0cm	T7 -20% 64.0cm						
NSL8 20% 120.0cm	T8 -18% 136.0cm						
Jp	Jm	FD/VEG	FL	PP	Swarm NSLT	J/U	
Jp adjust to NSL close 1%	Jm adjust to T close 2%	FD1 21.0% 0.5cm	FL1 20.0% 0.5cm	PP1 20.0% 0.5cm	NSL Max. events 0		
		FD2 16.0% 1.0cm	FL2 14.0% 1.0cm	PP2 14.0% 1.5cm	T Max. events 0		
		FD3 6.0% 2.5cm	FL3 11.0% 1.5cm	PP3 9.0% 2.5cm			
		FD4 5.0% 3.2cm	FL4 9.0% 2.0cm	PP4 6.0% 3.8cm			
		FD5 0.0% 0.0cm	FL5 6.0% 3.0cm	PP5 5.5% 5.0cm			
F clearing active		VEG as FD	FL6 5.0% 4.0cm	PP6 0.0% 0.0cm			
PP clearing active			FL7 0.0% 0.0cm				
U 80.0%							
						PP	
						Swarm	

Figure 15: 100% Cotton clearer setting.

Cotton pineapple blended clearing limits setting NSL Thick places, Thin places, Periodic fault, count plus, count minus, continuous count plus, continuous count minus, joint plus splice, joint minus splice setting showing that the standard comparatively with the body yarn.

	abs	/100km		abs	/100km		abs	/100km		abs	/100km
YF	153	143.7	Cp	1	0.9	FD	30	28.2	MC		
YJ	230	216.1	Cm	0	0.0	FL	0	0.0	CMC		
YB	79	74.2	CCp	1	0.9	PP	7	6.6	OC		
			CCm	3	2.8				COC		
N	7	6.6	Dp	0	0.0	SVD			CY		
S	31	29.1	Dm	0	0.0	SVL			BMp		
L	18	16.9	CDp	0	0.0	CSVD			BMm		
T	38	35.7	CDm	0	0.0	CSVL					
X	3	2.8							Jp	5	4.7
PF	14	13.2	swNSL	0	0.0	swFD	0	0.0	Jm	11	10.3
			swT	0	0.0	swFL	0	0.0	JR %		4.3

Figure 16: Yarn fault

Cotton pineapple blended yarn fault showing that the **143.7** in **100 km**.

Here, Neps **6.6**, Short Thick Place **29.1**, Long Thick Place **16.9**, Thin **35.7**, Count Plus **0.9**, Count minus **0.0**, Continues Count Plus **0.9**, Continues Count minus **2.8**, Periodic Fault **13.2**, Joint plus **4.7**, Joint minus **10.3** in **100 km** observations.

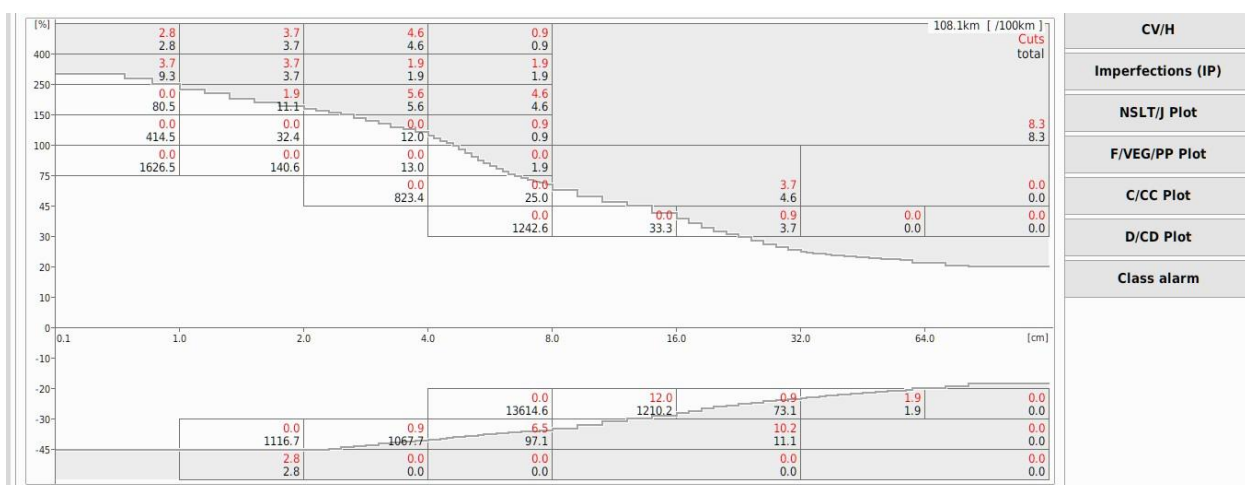


Figure 17: Classmate fault

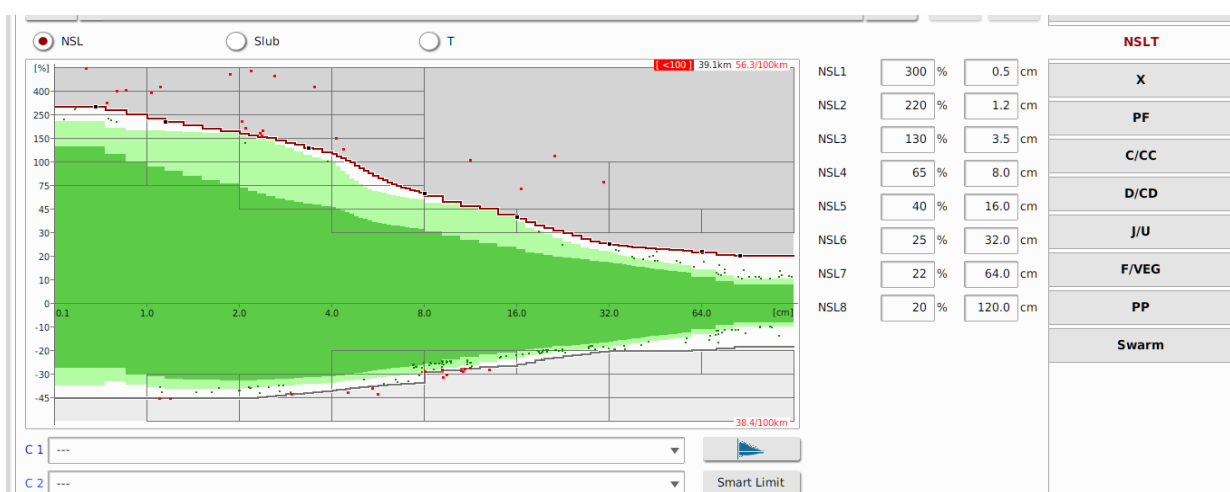


Figure 18: 100% Cotton clearing limits (NSL) with body yarn.

Cotton pineapple blended clearing limits NSL thin setting showing that the standard comparatively with body yarn.

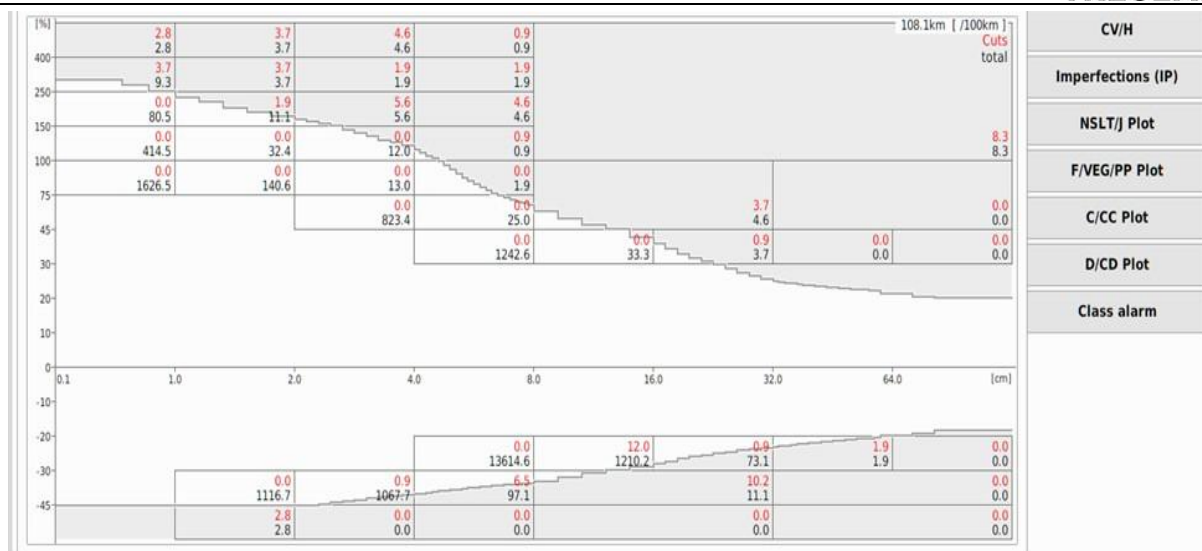


Figure 19: 100% cotton classmate

Table 13: Uster classmat fault analysis of 100% cotton yarn

Description	Category	Total
Raw material faults	A1+A2+B1+B2+C1+D1	2239
Objectionable faults	A3+A4+B3+B4+C2+C3+C4+D2+D3+D4	51
Long thick	E+F+G	12.9
Long thin	H1+H2+I1+I2	11.1

Classmate fault showing, that in different classes which has showed in total yarn fault in different classes between the raw material and process fault. Objectionable fault has been cuts and total faults/100 km counted as total fault.

3.5 MULTIPLE HISTOGRAM MASS COTTON PINEAPPLE BLENDED (70:30) YARN

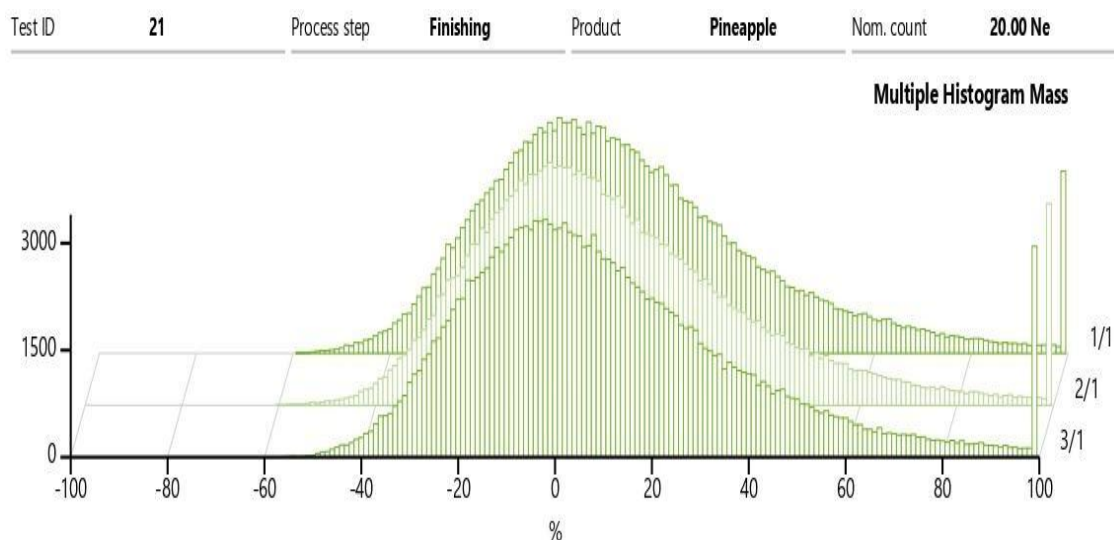


Figure 20: Multiple Histogram Mass cotton pineapple blended yarn

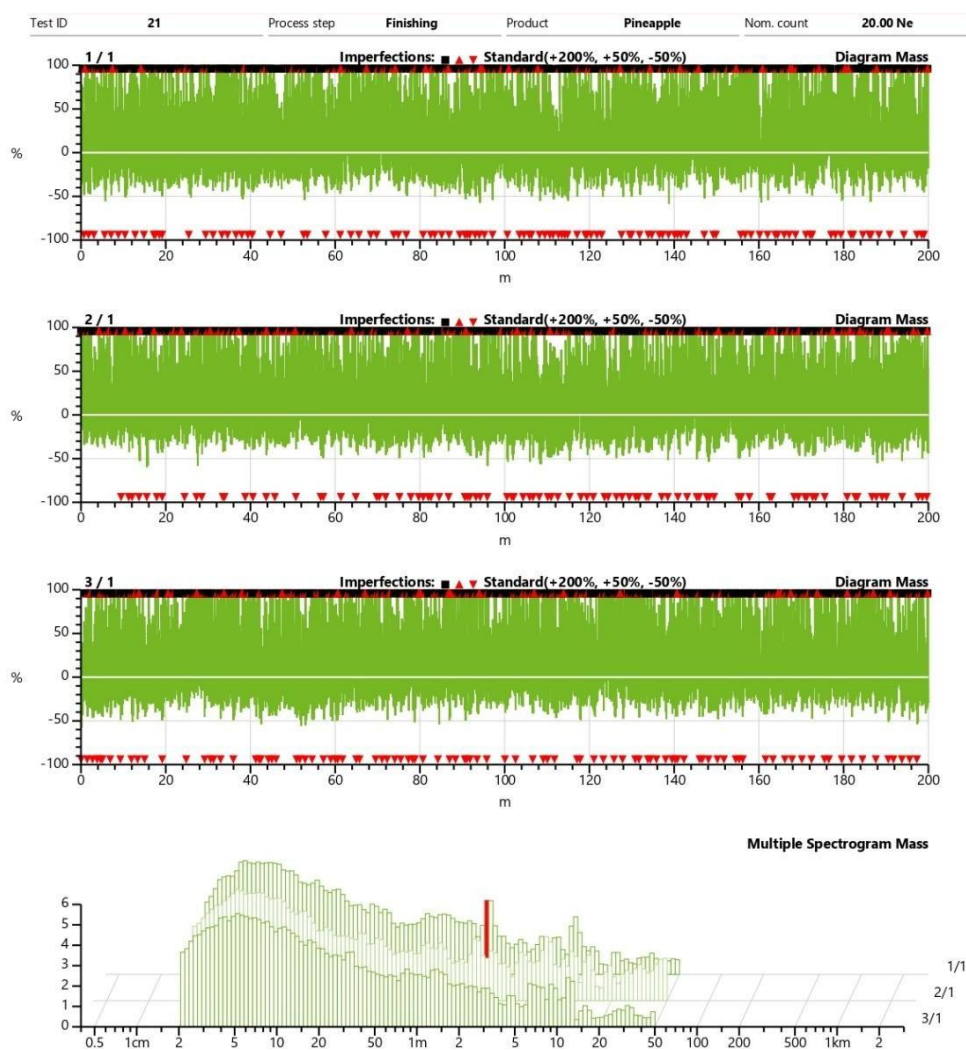


Figure 21: Diagram Mass and Multiple Spectrogram Mass cotton pineapple blended yarn.

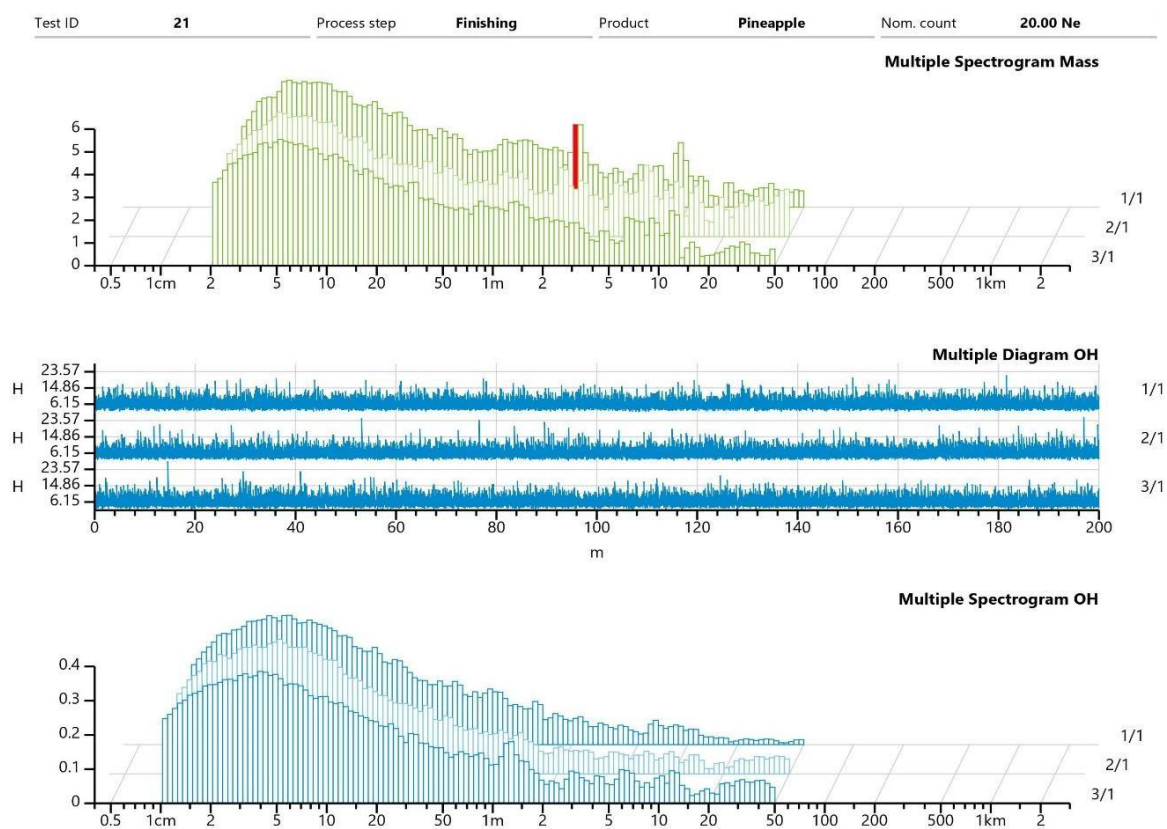


Figure 22: Multiple Spectrogram Mass, Multiple Diagram OH, Multiple Spectrogram OH.

3.6 TENSILE PROPERTIES

Table 14: Tensile Properties of Cotton Pineapple Blended Yarn.

Mixing ratio (Cotton: Pineapple)	Force in Max. [cN]	Elongation[%]	Tenacity [RKM]
70: 30	383	5.50	13.21
CV%	15.80	12.33	15.80

In the cotton pineapple blended yarn, the values are of single count strength product **13.21** and tenacity is breaking load in own weight **383**.

The tensile test results for the Cotton: Pineapple (70:30) blended yarn are summarized in terms of maximum force, elongation, tenacity, and work done during stretching.

The yarn exhibited a maximum breaking force of 383 cN, indicating a moderate strength level relative to pure cotton and other blends. The elongation at break was 5.50 %, suggesting limited extensibility and moderate flexibility of the yarn. The tenacity value of 13.21 RKM represents the yarn's strength per unit linear density, which is suitable for medium-strength textile applications.

In terms of variability, the Coefficient of Variation (CV %) values for each property show the degree of uniformity in yarn performance:

Force (15.80%) and Tenacity (15.80%) indicate moderate variation, reflecting some inconsistency in fiber strength distribution. Elongation (12.33%) has the lowest variation, suggesting relatively uniform stretch behavior across samples. Overall, the Cotton: Pineapple (70:30) yarn demonstrates a balanced combination of strength and flexibility, though improvements in blending or processing could enhance its uniformity and energy absorption consistency.

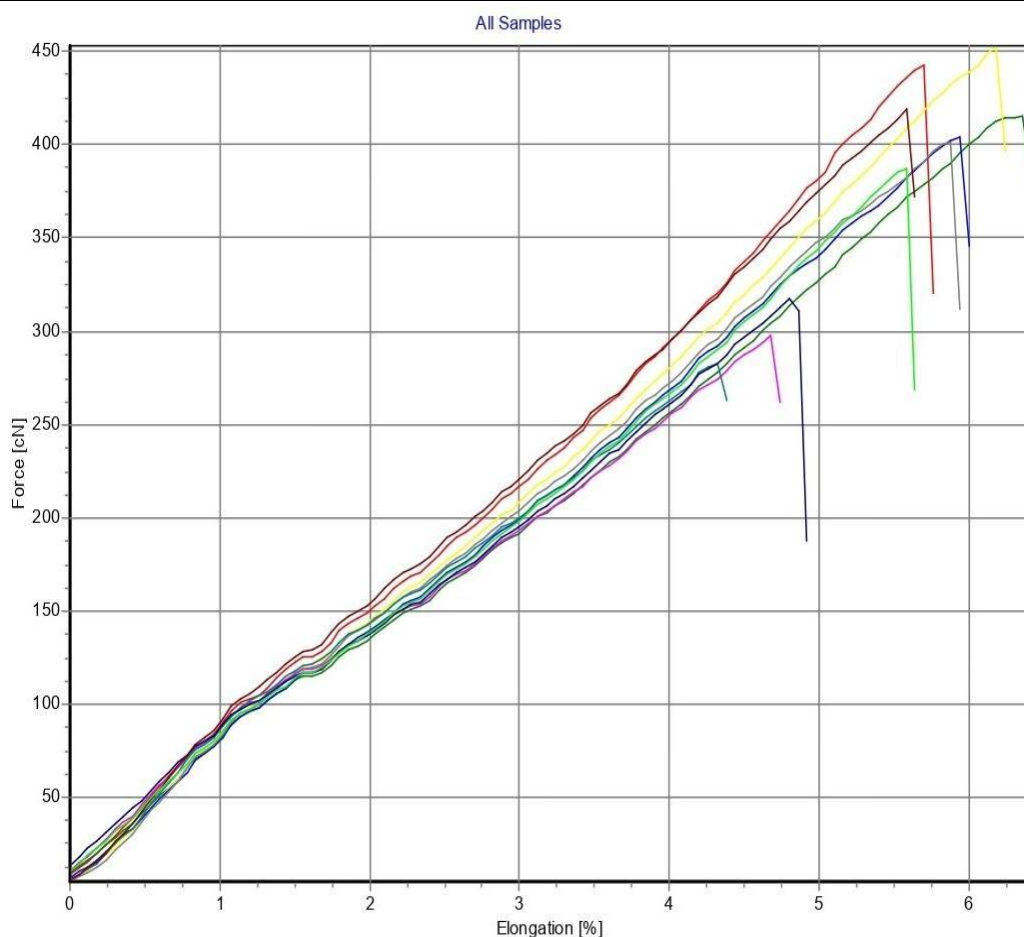


Figure 23: Forces [cN] Vs. elongation curve of cotton pineapple blended.

Above figure, showing that elongation [percentage] curve of 10 samples with Force [cN] of cotton pineapple blended. It has shown the average curve for every sample. It can occasionally be split into two sections: a first, red section that contains all test samples, and a second, green section that contains some missing or broken samples. In this case, the average value no longer represents all samples, but rather only those that are present at that particular point, which may make it less representative.

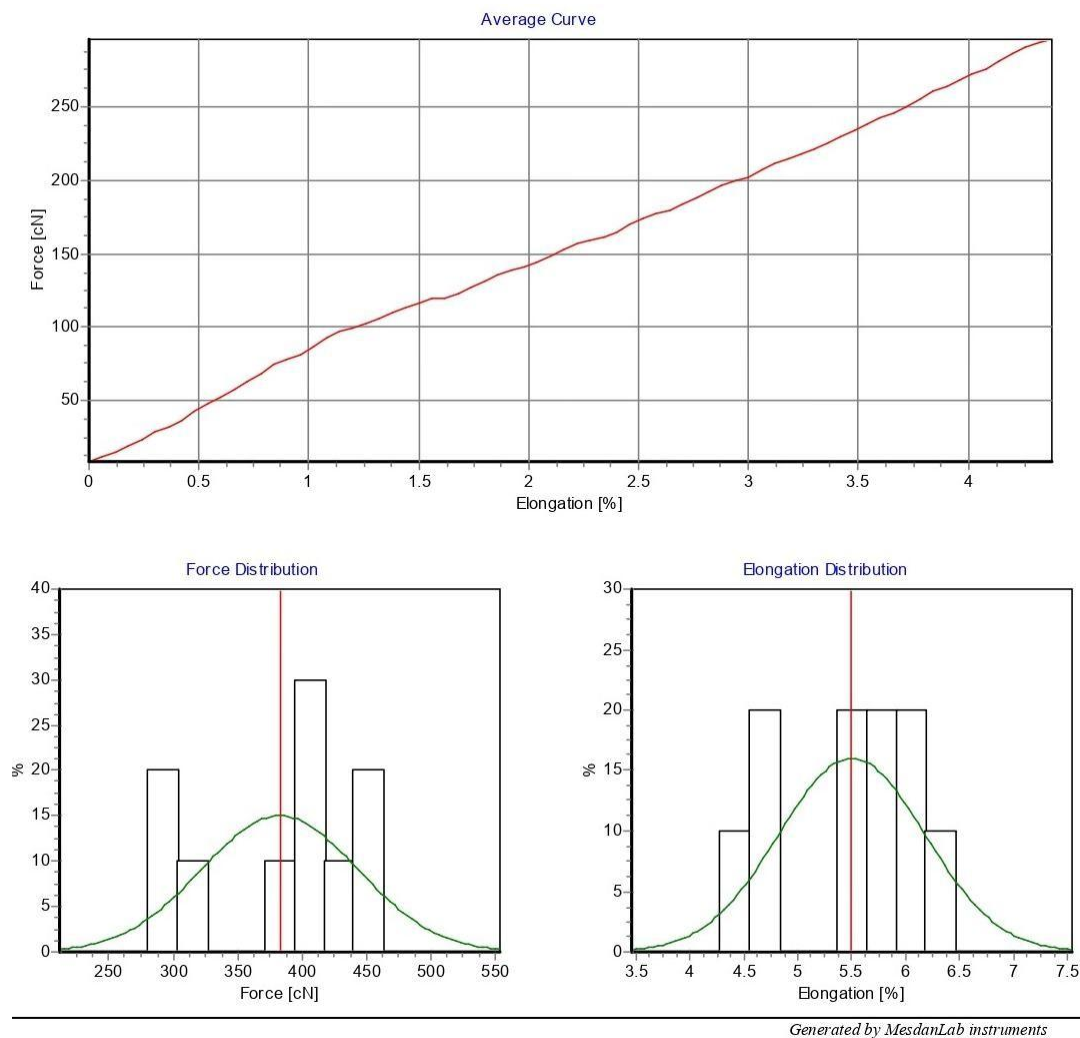


Figure 24: Force distribution and elongation distribution curve of cotton pineapple blended.

Above figure showing that force distribution and elongation distribution curve of cotton pineapple blended. Here, mentioned that displays the Gauss curve and the force distribution graph by dividing tests into 10 classes them in relation to the average value vertical red line, mentioned that force distribution **380** and elongation distribution **5.5**.

This chart represents tensile test results of a Cotton–Pineapple blended yarn (70:30 ratio) — meaning 70% cotton fiber and 30% pineapple fiber. It shows how the yarn behaves under stretching force, describing its strength (force) and elongation (stretching ability).

Here is the breakdown:

Elongation (%) — how much the yarn stretches before breaking. Force (cN) — the load required to break the yarn.

The red curve shows a gradual and almost linear increase in force with elongation. Indicates the yarn has steady strength build-up, showing good bonding between cotton and pineapple fibers. Force Distribution (Bottom Left) shows how tensile strength (force in cN) varies across tested samples. Average breaking force, 380–400 cN.

The histogram bars show sample distribution, and the green line is a normal distribution curve.

Indicates moderate strength variation — meaning the yarn is uniform in tensile strength. Elongation Distribution (Bottom Right) shows how elongation (%) is distributed among samples.

Average elongation, 5.5–6.0%. Indicates moderate flexibility enough stretch without breaking easily. Cotton provides softness, flexibility, and comfort.

Pineapple fiber adds strength, sheen, and durability due to its lingo cellulosic structure.

The blend (70% cotton + 30% pineapple) creates a yarn with improved strength compared to pure cotton, good elongation, ensuring workable flexibility, enhanced sustainability and eco-friendliness, a slightly stiffer but glossy texture, suitable for both apparel and home-textile applications.

Statistical results of all bobbin samples

	F.Max [cN]	E@MF [%]	Ten. [RKM]	Work [cN*mm]	YM [cN/tex]
Mean value	383	5.50	13.21	5381	195.95
Maximum	453 (3)	6.36 (2)	15.65 (3)	6893 (3)	243.55 (8)
Minimum	282 (7)	4.32 (7)	9.75 (7)	3255 (7)	160.52 (5)
Range	44.604 [%]	37.086 [%]	44.604 [%]	67.601 [%]	42.373 [%]
CV	15.805 [%]	12.338 [%]	15.805 [%]	23.991 [%]	12.717 [%]
Deviation	60	0.68	2.09	1291	24.92
IC 95%	37	0.42	1.29	800	15.44
IC 99%	49	0.55	1.70	1052	20.30

Statistical results of bobbin: 1

	F.Max [cN]	E@MF [%]	Ten. [RKM]	Work [cN*mm]	YM [cN/tex]
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IC 95%	37	0.42	1.29	800	15.44
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Figure 25: Statistical result of cotton pineapple blended Yarn.

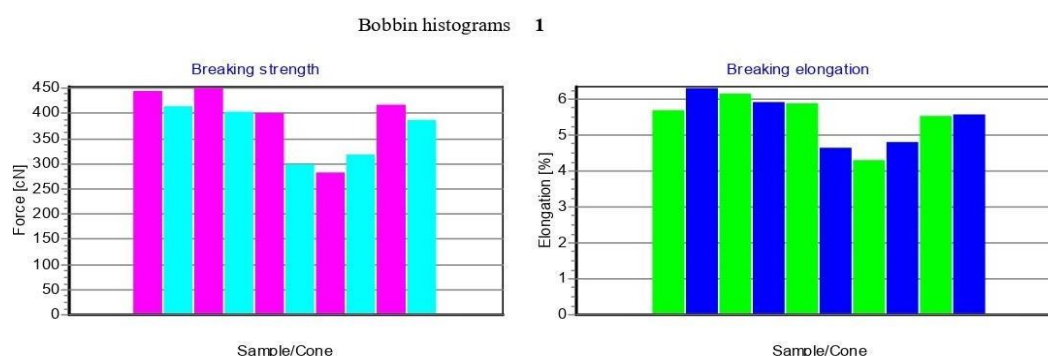


Figure 26: Yarn traction of cotton pineapple blended yarn.

Above figure shows the yarn traction phenomena of cotton pineapple blended yarn where Force expressed in cN, mean value **383**, maximum **453**, and minimum **253**. In the elongation, mean value **5.50**, Maximum **6.36**, minimum **4.32** that is expressed in Percentage.

This image presents bobbin-wise tensile property histograms for a Cotton–Pineapple (70:30) blended yarn, showing the variation of breaking strength and breaking elongation across different yarn samples or cones. Each pair of bars represents two test sets or readings from different cones. The observations are breaking strength values range roughly between 280 cN and 450 cN. Some bobbins (first two) show high strength (≈ 440 – 450 cN), indicating good fiber alignment and twist balance. Other bobbins (middle samples) have lower values (≈ 300 cN), likely due to minor variations in blend ratio, fiber cohesion, or uneven drafting. The overall variation is moderate, showing consistent spinning quality with slight unevenness between cones.

3.7 TENSILE PROPERTIES OF 100% COTTON

Table 15: Tensile properties of 100% cotton yarn.

Mixing ratio	Force in Max. [cN]	Elongation[%]	Tenacity [RKM]
	1.05	6.0	16.14
100% Cotton	3.94	10.2	3.94

3.7.1 FORCE VS. ELONGATION CURVE OF 100% COTTON YARN:

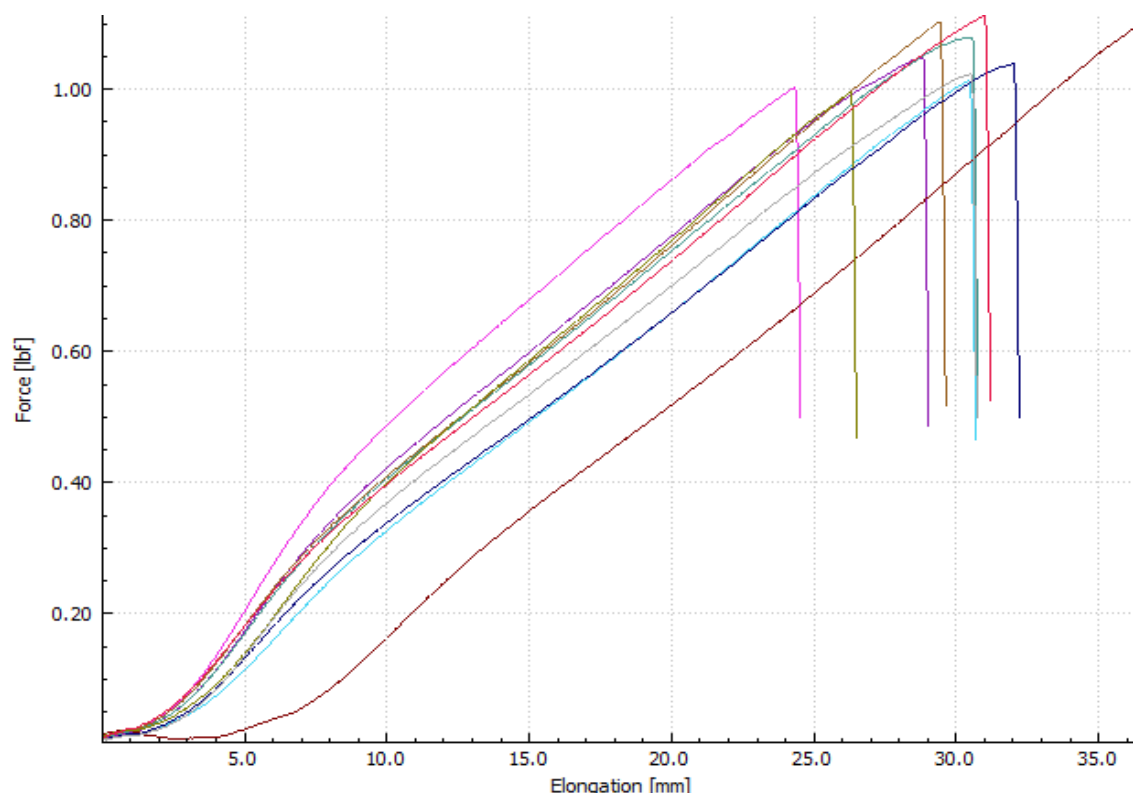


Figure 27: Forces [lbf] Vs. elongation curve of 100% cotton yarn

The graph represents the **tensile behavior** of **100% cotton yarn**, showing the relationship between the applied force and elongation during stretching until breakage. Each colored line corresponds to an individual test sample. In the initial region (0–5 mm elongation), the curves show a **gradual slope**, attributed to the straightening and alignment of fiber crimp within the yarn structure. This is followed by a **near-linear elastic region**, where force increases proportionally with elongation, reflecting the inherent stiffness and uniform fiber packing of cotton. The curves reach a **peak force of approximately 1.0–1.2 lbf**, followed by an abrupt drop, signifying yarn rupture. The **elongation at break** occurs around 25–30 mm, indicating moderate extensibility typical of ring-spun cotton yarns. Overall, the **100% cotton yarn** demonstrates **stable and predictable tensile performance**, characterized by **high strength, moderate elongation**, and **excellent structural uniformity**, making it suitable for applications requiring durability and dimensional stability.

3.7.2 BREAKING FORCE AND ELONGATION OF 100% COTTON YARN

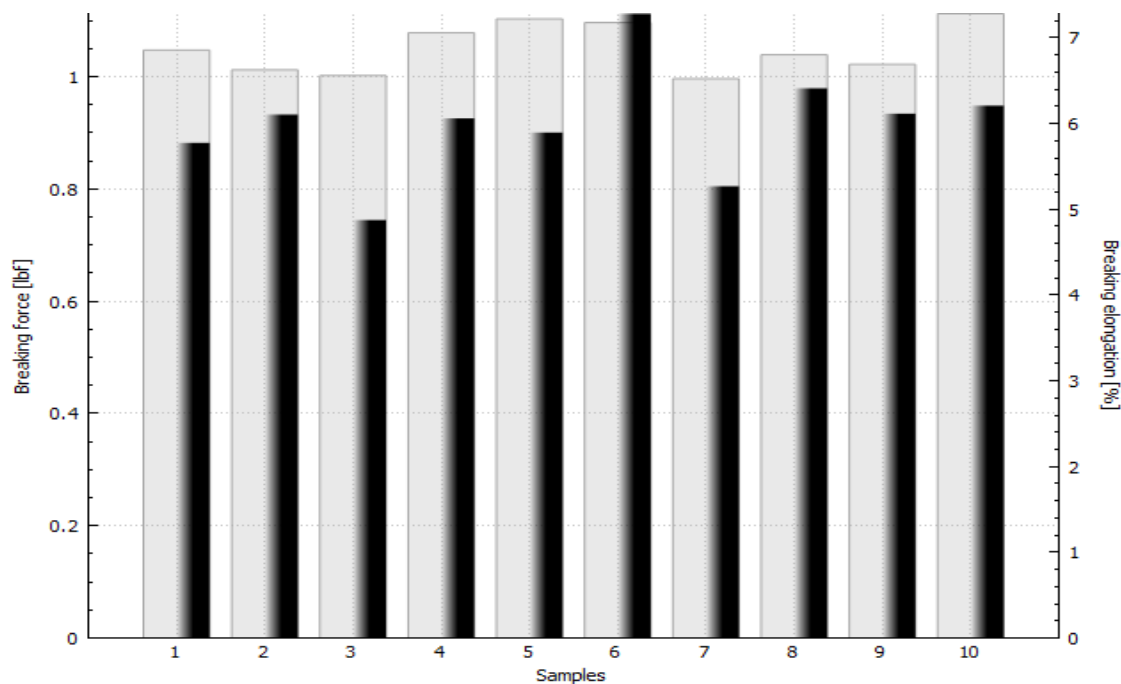


Figure 28: Yarn traction of cotton yarn

The graph illustrates the **breaking force** and **breaking elongation** of ten individual **100% cotton yarn samples**. The black bars represent the **breaking force (lbf)**, while the light gray bars indicate the corresponding **elongation (%)** at break. The results show that the **breaking force** values generally range between **0.8 and 1.1 lbf**, demonstrating good tensile strength across samples. The **elongation values** vary between approximately **5% and 7%**, indicating moderate extensibility typical of cotton yarns. Minor fluctuations among samples reflect natural fiber variation and spinning irregularities, but the overall pattern indicates **consistent mechanical performance**.

4. CONCLUSION

The Using both yarn strength and unevenness metrics, the thorough assessment of yarn performance throughout all samples shows a distinct and steady advance toward superior yarn qualities. The least refined yarn, with significant structural irregularity and low reliability in downstream processing, is represented by Sample A, which has the lowest CSP and the highest degrees of unevenness and imperfection.

Significant improvements are seen when the samples move from sample A to D. While Um%, CVm%, thin places, thick places, and neps drastically decrease, CSP continuously rises, suggesting better drafting efficiency, more controlled fiber alignment, and fewer structural flaws. This concurrent increase in strength and consistency demonstrates that improved fiber preparation and ideal processing conditions have a direct impact on yarn cleanliness and mechanical performance.

The most sophisticated and optimal yarn is clearly Sample E. It has the lowest values for unevenness, mass variation, imperfection, and hairiness, as well as the greatest CSP (4864). These qualities emphasize its improved surface quality, increased durability, and higher consistency, which make it ideal for high-end and performance-sensitive textile applications.

Overall, the combined findings from define outcome confirm that methodical improvements in spinning parameters and raw material selection result in significant gains in yarn strength, homogeneity, and cleanliness. Sample E demonstrates the success of the gradual optimization mirrored across the sample set by representing the ideal balance between mechanical and structural performance.

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