# Analysis of SIRO spun compact yarn made from 100% bamboo fibre

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## ABSTRACT

*Over the past 25 years, traditional twisting and folding techniques have evolved significantly. One method that continues to use the ring spindle is stage twisting, which, unlike many innovations aimed at cost reduction, is primarily focused on enhancing yarn quality. However, conventional processes involve separate spinning and two-folding steps, increasing production costs. To overcome this challenge, spinners have long sought a way to integrate spinning and twisting into a single process. SIRO Spinning Technology offers an effective solution.This study investigates the influence of strand spacing on SIRO yarn produced using a compact spinning system. Yarn samples were developed with five different strand spacing lengths and two levels of suction pressure. Various yarn properties were analyzed by optimizing the distance between roving strands and adjusting the negative pressure within the suction zone. The findings were then evaluated to determine the ideal parameters for achieving high-quality Eli-twist yarn.In the second phase, fabrics were produced using optimized yarn parameters in different combinations. Their properties were assessed to identify the best yarn configuration. Statistical tools and regression analysis were applied to refine and interpret the results effectively.*

**Keyword** : *Siro Yarn Strand Spacing, Suction pressure, Regression analysis*

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## 1.Introduction

Doubling is the process of combining two or more single yarns through twisting, resulting in what is known as ply or folded yarns. These yarns are essential for applications requiring enhanced strength or uniformity. However, for a given yarn quality, folded yarn is generally more expensive than a single yarn of the same linear density. EliTwist is a patented technology designed to economically produce compact spin-twisted yarn using the EliTe Compact Set directly on the ring spinning frame. In SIRO or DUOSPUN spinning, two rovings are drafted at a single spinning position but remain relatively far apart until they converge at a twisting point upon leaving the drafting system. The resulting large twisting triangle, formed due to the distance between the two rovings, causes the twist in both legs of the triangle to be only about 70% of the total twist in the final double-threaded yarn. These conditions have historically made such methods highly delicate, limiting their success in the short-staple sector despite their potential advantages.

## 2. Literature review

Wen-Yan Liu [1] studied various parameters in the Sirofil spinning system, including the angle in the "V" area, filament and roving tension, and torque under different feeding spacings. Based on these studies, optimal strand spacing recommendations were made for different spinning materials. Experimental analysis was conducted on yarn configuration, strength, elongation, hairiness, and evenness, with theoretical findings aligning closely with experimental results.P. Soltani and M. S. Johari [2] examined the effect of strand spacing and twist multiplier on the strength of Siro-spun yarns, focusing on structural parameters. Fiber migration, a key factor influencing yarn strength, was found to be significantly affected by strand spacing and twist multiplier. Their research involved producing lyocell yarns at five strand spacings and four different twist multipliers. Using a tracer fiber technique and image analysis, fiber migration parameters were studied. Uniaxial loading tests revealed that yarn tenacity increased with strand spacing up to 8 mm, after which it declined. The optimal tenacity at 8 mm was attributed to improved fiber position, higher migration factor, increased fiber breakage, and reduced hairiness.Sun & Cheng [3] produced Siro yarns with a 9 mm roving guide spacing and found that Siro yarns exhibited greater strength than single yarns at all twist multipliers, attributing this to strand twist. Su et al. [4] measured the drafting force in twin-spun yarns and observed that increasing roving spacing led to higher drafting force.Salhotra [5] studied Siro yarns made from 38 mm and 1.5 denier viscose and noted that reducing the draft led to a significant decrease in irregularity. With lower draft, the ribbon strand remained narrow, improving the yarn packing coefficient. Since Siro yarn strength is less dependent on fiber migration, finer yarns exhibited higher fiber rupture rates, enhancing tenacity.Cheng, V. Subramaniam, and K.S. Natarajan [6] found that increased spreading width improved blend uniformity, minimized color variation, and enhanced dyeing uniformity. Their study on Siro-spun yarns made from cotton, polyester/cotton, and viscose assessed frictional properties using Howell's method. The study showed that yarn-to-yarn and yarn-to-metal friction coefficients increased with greater strand spacing and twist due to changes in yarn surface characteristics. Gupte & Chiplunkar [7] observed that increasing roving spacing resulted in higher yarn strength and reduced hairiness. In some cases, Siro yarn strength surpassed that of doubled yarns of equivalent count. Saravanan [8] investigated blended cotton fibers with long-staple silk and poly-wool strands. He reported that Siro yarns could be spun at lower spindle speeds and found that adding short-staple cotton increased yarn hairiness, with tensile properties primarily influenced by the dominant fiber component. Beceren et al. [9] focused on the dimensional and physical properties of plain jersey fabrics made from viscose Siro yarns. Sawney et al. [10] and Dhawan [11] reported a 14% strength improvement in Siro yarns, with Dhawan & Salhotra stating that yarn quality improved with increased spacing, reaching an optimum before deteriorating beyond a certain point. Dhawan & Jai Prakas [12] noted that DRF yarns at optimal spacing were slightly superior to conventional doubled yarns.El Sayed, M.A.M., and Suzan H. Sanad [13] analyzed cotton fabrics made from Siro-spun and plied yarns. They highlighted that Siro-spun yarns eliminate two processing stages compared to two-fold yarn production, thereby reducing production costs while enhancing yarn and fabric quality. Armin Pourahmad and Majid Safar Johari [15] researched core-spun yarns with an acrylic sheath and a nylon flat core, produced using Ring, Siro, and Solo spinning systems, investigating the effects of various factors on yarn performance. N. Gokarneshan, N. Anbumani, and V. Subramaniam [6] explored the influence of strand spacing variations in Siro and double-rove yarns, conducting studies on cotton, polyester, and polyester-cotton yarns.

## 3. MATERIAL & METHODS

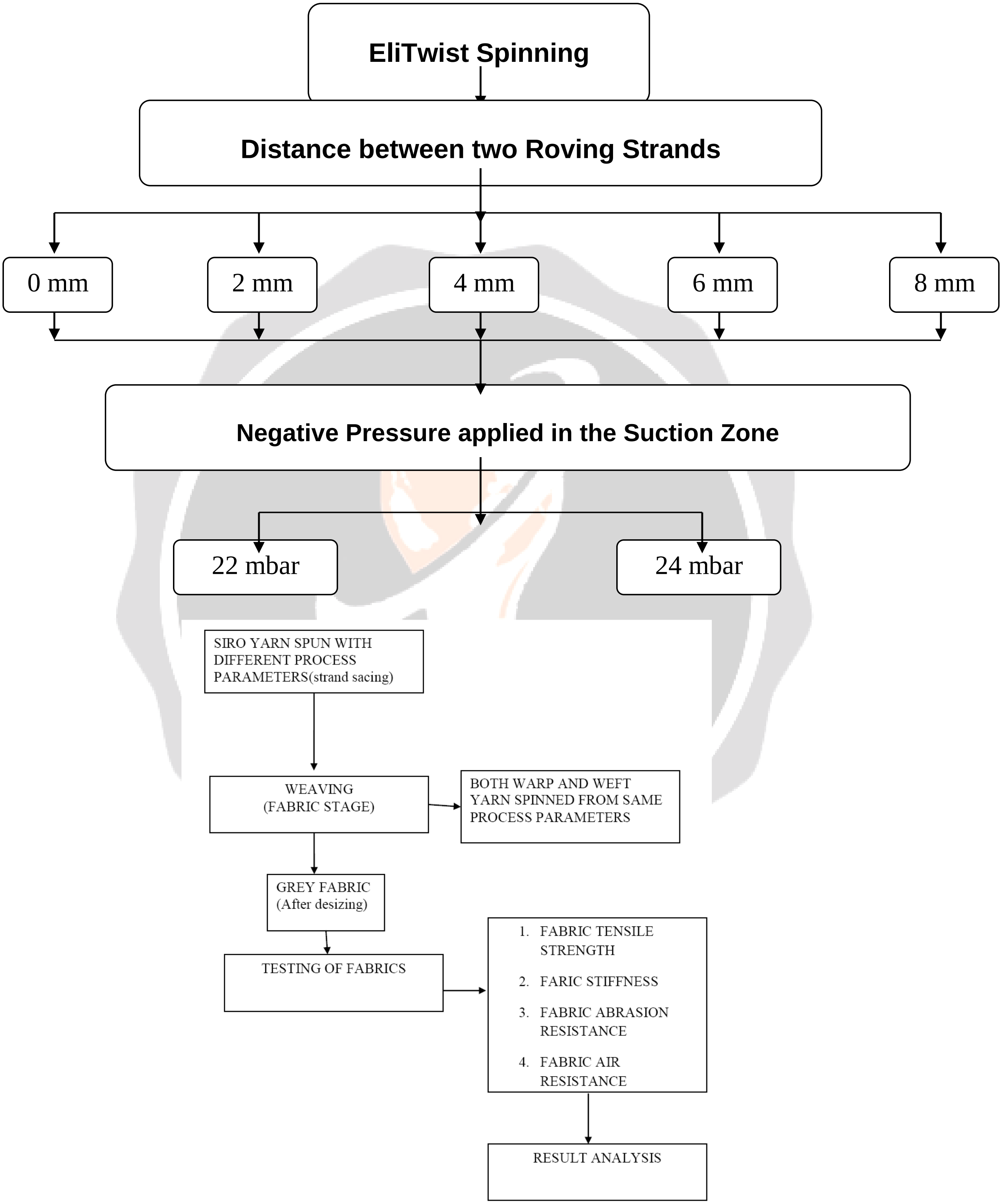
The material used in our trial consists of 100% bamboo fiber, which has been processed within the department up to the spinning stage. The process path and key process parameters are detailed below.

| **S.No** | **Parameters** | **Details** |
|---|---|---|
| **1** | **Carding** | **LC 300 A V3** |
| | a) Delivery Hank | 0.120 |
| | b) Delivery Speed in mpm | 120 |
| | c) Production Rate (Kg/hr) | 35.4 |

| | | |
|---|---|---|
| **2** | **Pre Comber Draw Frame** | **LD-2** |
| | a) No of Doubling | 5 |
| | b) Delivery Hank | 0.120 |
| | c) Delivery Speed in mpm | 600 |
| **3** | **Uni Lap** | **E-5** |
| | a) No of Doubling | 22 |
| | b) Lap Weight | 75gms/mt |
| **4** | **Comber** | **E-65** |
| | a) Delivery Hank | 0.120 |
| | b) Comber Speed (npm) | 450 |
| | c) Noil % | 18 |
| **5** | **Finisher Draw Frame** | **D-40** |
| | a) Delivery Hank | 0.120 |
| | b) No of Doublings | 8 |
| | c) Delivery Speed in mpm | 400 |
| **6** | **Simplex** | **LFS 1660 V** |
| | a) Delivery Hank | 0.9 |
| | b) Spindle Speed (rpm) | 980 |
| | c) TPI / TM | 1.40 / 1.48 |
| **7** | **Spinning** | **LR-6 AX – Elitwist Converted** |
| | a) No of Spindles | 1200 |
| | b) Spindle Speed (rpm) | 15500 |
| | c) Yarn Count | 40/2 |
| | d) Twist Direction | Unidirectional – S on S |
| | e) TPI | 18.1 |

**Table. 1 Spinning Preparatory process parameters**

The following flow chart will give the idea about the experimental status



| SAMPLES | WARP | WEFT | SAMPLE SPECIFICATION | Construction (Warp x Weft) (Ends/ inch x picks/inch) | WEAVE TYPE |
|---|---|---|---|---|---|
| 1 | D1S1 | D1S1 | A1 | 56 x 52 | PLAIN |
| 2 | D1S2 | D1S2 | A2 | 56 x 52 | PLAIN |
| 3 | D2S1 | D2S1 | A3 | 56 x 52 | PLAIN |
| 4 | D2S2 | D2S2 | A4 | 56 x 52 | PLAIN |
| 5 | D3S2 | D3S2 | A5 | 56 x 52 | PLAIN |

## 4. RESULTS & DISCUSSION

The test results from the trials conducted in our study are summarized in the table below. These results include data from both the ring frame cops stage and the final cone stage. In addition to laboratory test results, online data on autoconer breakage, Classimatt analysis, and lab evaluations have also been incorporated.

Equations have been formulated to predict yarn quality based on varying distances between the roving strands and the negative pressure applied in the suction zone. This predictive approach enables future yarn quality assessments without the need for additional trials, significantly saving time and reducing costs for the factory

U % = 7.78 - 0.0593 Dist between roving strands - 0.0210 Suction Pressure

Thick +50% = 9.40 - 0.700 Dist between roving strands - 0.100 Suction Pressure

Neps +200% = 15.5 - 0.125 Dist between roving strands - 0.400 Suction Pressure

Rkm = 27.0 + 0.0275 Dist between roving strands - 0.270 Suction Pressure

Elong % = - 10.4 - 0.0375 Dist between roving strands + 0.730 Suction Pressure

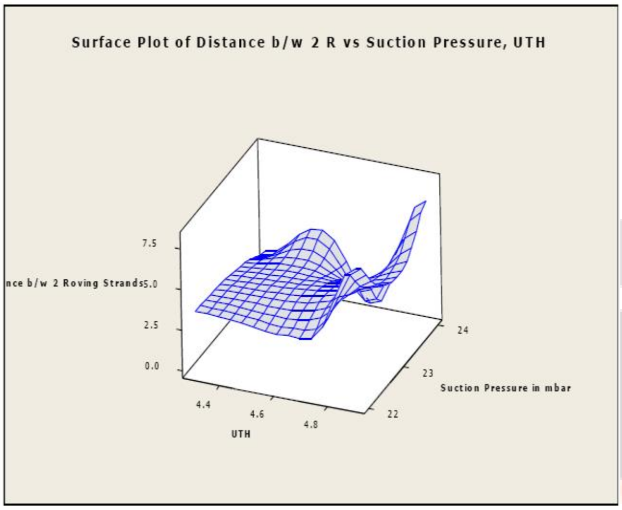
UTH = 4.99 + 0.0375 Dist between roving strands - 0.0200 Suction Pressure

S3 = 1940 - 38.0 Distance between roving strands - 45.5 Suction Pressure

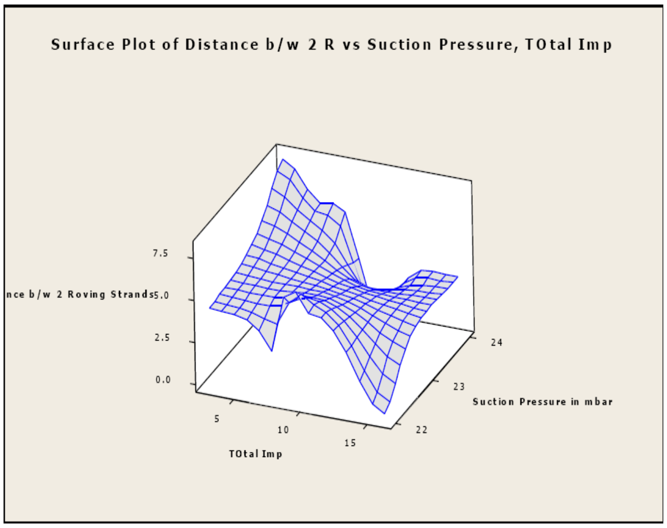
CMT = 49.0 + 0.75 Distance between roving strands - 0.80 Suction Pressure

**SURFACE PLOTS**

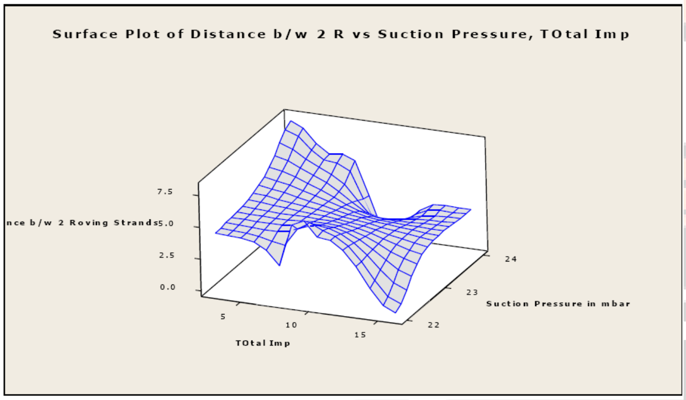
Hairiness Vs Suction Pressure Vs Distance



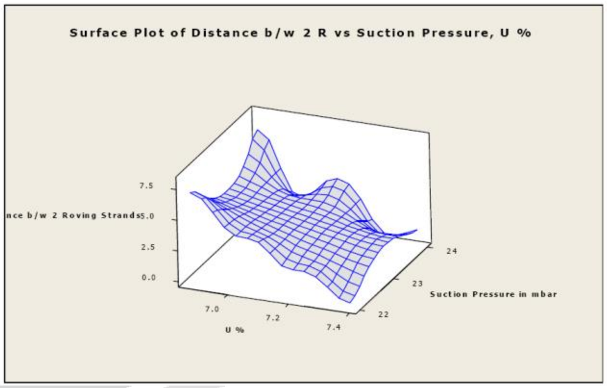
Rkm Vs Suction Pressure Vs Distance



Imperfection Vs Suction Pressure Vs Distance

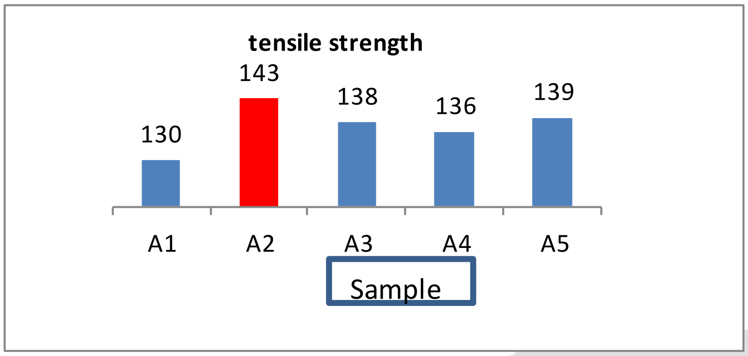


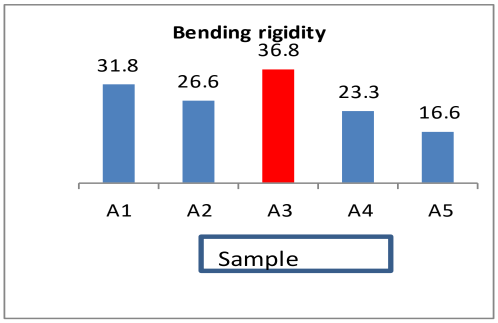
U% Vs Suction Pressure Vs Distance

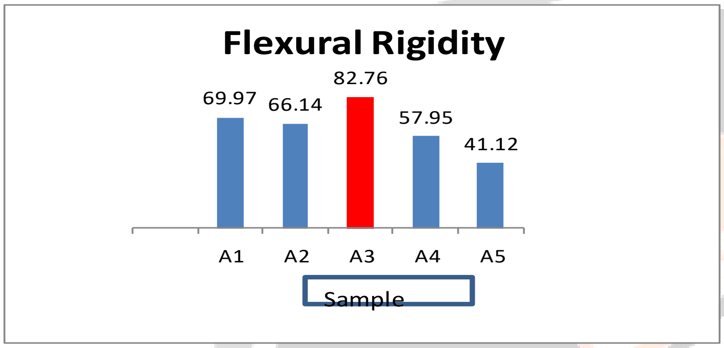


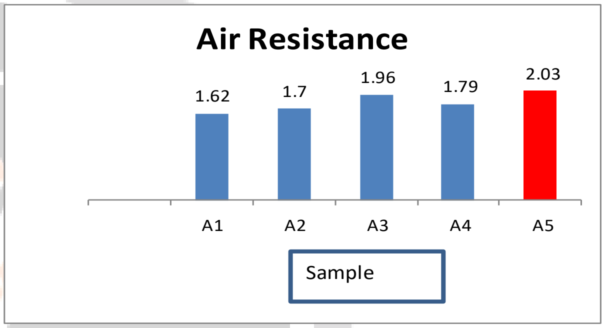
**Effect of Siro Yarn properties on Tensile Strength of the Fabric ( grey stage)**

| Fabric Spec | Distance | Pressure | Tensile Strength | Bending Rigidity | Flexural Rigidity | Air Resistance |
|---|---|---|---|---|---|---|
| A1 | 4 | 22 | 130.0 | 31.8 | 69.97 | 1.62 |
| A2 | 4 | 24 | 143.0 | 26.6 | 66.14 | 1.7 |
| A3 | 8 | 22 | 138.0 | 36.8 | 82.76 | 1.96 |
| A4 | 8 | 24 | 136.0 | 23.3 | 57.95 | 1.79 |
| A5 | 6 | 24 | 139.0 | 16.6 | 41.12 | 2.03 |









From the table value using MINITB, the following regression equations are derived.

Tensile Strength(Grey stage) = 321 + 27.5 U% - 15.7 Rkm - 0.69 Total Imp (Norm. Sens) - 0.952

Bending Rigidity - Grey = 466 - 92.4 U% + 4.98 Rkm - 0.030 Total Imp (Norm. Sens) + 2.32 Total Imp (Higher. Sens)

**Air Resistance - Grey = 3.1 + 0.50 U% - 0.174 Rkm + 0.0003 Total Imp (Norm. Sens) - 0.0276 Total Imp (Higher. Sens)**

Flexural Rigidity - Grey = 813 - 142 U% + 3.63 Rkm - 0.965 Total Imp (Norm. Sens) + 3.90 Total Imp (Higher. Sens)

## CONCLUSION

Yarn quality is evaluated based on various parameters, including unevenness percentage, imperfection levels, single yarn strength, elongation, and Classimat performance during further processing.

Our analysis indicates that the optimal yarn quality is achieved with an 8mm distance between the roving strands and a 24 mbar negative pressure. The derived equations are highly beneficial for predicting the quality of Eli-Twist yarn in future production.

Beyond identifying the optimal parameters, this approach allows us to determine the most suitable settings for different end uses of yarn. As yarn applications evolve, we can adjust the weightage assigned to each parameter, enabling us to fine-tune and identify the optimal configuration for specific end-use requirements.

While it is well established that raw material properties significantly impact fabric specifications and performance, our findings consistently show that a suction pressure of 22 mbar and a roving strand spacing of 8mm yield superior fabric results.

The regression equations we have developed provide a valuable tool for predicting fabric quality based on yarn specifications. This predictive capability helps reduce both the time and cost associated with conducting extensive trials..

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