

## Optimization of Process Parameters in Eli-Twist Yarn

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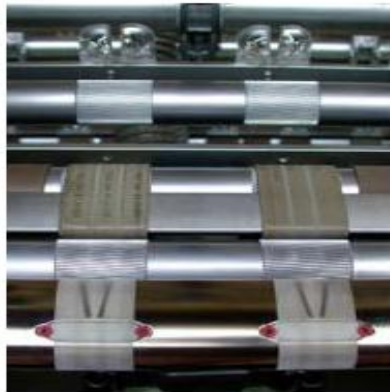
**Abstract**—Eli-Twist yarn, produced by Suessen Elite compact spinning technology has superior in technically and economically in the recent days compared to the two-ply yarns. The quality of this Eli-twist yarn is governed by many parameters. The distance between roving strands and the negative pressure applied in the suction has substantial effects on the quality aspect of this yarn. The feed roving distance and negative pressure were varied in such a way that ten different combinations are produced. The effects of these two parameters on yarns fineness, Rkm, Elongation %, U %, Hariness were studied. To assess the yarn quality the concept of Cpk (Process Capability Index) could be used effectively. An attempt has been made to implement the concept of Cpk in the analysis of the properties of Eli-twist yarn.

**Keywords:** Eli-Twist, Compact, Hariness, U%, Cpk,

### I. INTRODUCTION

Eli-Twist is a patented process which produces economically a compact spin-twisted yarn with the EliTe Compact Set directly on the ring spinning frame. The Eli-Twist Process permits to reduce the twisting triangle to a degree that it has practically no influence on spinning stability. In this process, two rovings pass through the twin condensers at the entrance of the drafting system and they are drafted separately at a certain distance. Further the drafted roving leaves the front roller pair of the drafting system and passes through the compacting zone. In the condensing zone, the distance between the drafted fibre strands is reduced to about 5 mm by means of two suction slots in V-shaped arrangement in the compacting zone. This close distance is possible, as the two yarn components when leaving the delivery roller pair does not produce any fibre ends sticking out and overlapping each other. On the other hand, this close distance enables the twisting point to come closer to the delivery clamping line.

The Eli-Twist Process allows reduction in the twisting triangle to a degree that the restrictions mentioned above are eliminated. During condensing, both components get closer and reach a minimum distance by means of two suction slots in the condensing zone in a V shaped arrangement.



*Figure 1 - Drafting Zone of Eli-Twist Spinning*

Owing to condensation, the two components after leaving the condensing zone do not form a spinning triangle. Consequently, no fibres are found to be sticking out, spreading up to the other yarn component or not being embedded in the yarn. The twist, running into the two yarn legs from the twisting points, need not overcome any resistance and hence easily reaches the clamping line. As a result, the two fibre strands can be led very closely and the twisting point has a very small distance from the clamping line of the front roller pair.

The Eli-twist process yarn has a novel structure combining all advantages of condensing and doubling. Yarn surface and appearance of Eli-twist are comparable to a single compact yarn.

### II. MATERIALS AND METHODS

Materials used in the trial are 100% Indian Cotton (Variety: Shankar 6), which is processed under control up to spinning department. Table 1 shows the details of process path and important process parameters.

**Table 1 - Spinning Preparatory process parameters**

Parameters	Details
<b><u>Carding</u></b>	<b>LC 300 A V3</b>
a) Delivery Hank	0.120
b) Delivery Speed in mpm	120
c) Production Rate (Kg/hr)	35.4
<b><u>Pre Comber Draw Frame</u></b>	<b>LD-2</b>
a) No of Doubling	5
b) Delivery Hank	0.120
c) Delivery Speed in mpm	600
<b><u>Uni Lap</u></b>	<b>E-5</b>
a) No of Doubling	22
b) Lap Weight	75
<b><u>Comber</u></b>	<b>E-65</b>
a) Delivery Hank	0.120
b) Comber Speed (npm)	450
<b><u>Finisher Draw Frame</u></b>	<b>D-40</b>
a) Delivery Hank	0.120
b) No of Doublings	8
c) Delivery Speed in mpm	400
<b><u>Simplex</u></b>	<b>LFS 1660 V</b>
a) Delivery Hank	0.9
b) Spindle Speed (rpm)	980
c) TPI / TM	1.40 / 1.48
<b><u>Ring spinning</u></b>	<b>LR-6 AX – Elitwist Converted 1660 V</b>
a) Yarn Count	40/2
b) Avg. Spindle Speed (rpm)	15500
c) TPI	18.0

The process details and parameters given above are common for all the trial samples, whereas the changes have been made only in the spinning parameters. Levels have been decided for the two factors by considering the raw material, atmospheric conditions, economic viability, work methods & possibility of the mills.

**Table 2 - Factors & Levels**

Factors	Levels
Distance between the 2 roving strands	5 (0mm, 2mm,4mm,6mm,8mm)
Negative pressure applied in the suction zone	2 (22mbar & 24mbar)

The material from Speed frames have been taken for the trials. All the trials have been run in the identical spindles in the ring frame at a constant speed. The distance between the roving strands is optimized by means of specially designed roving guides and the measurement of the distance was taken by using a normal measuring scale. Fig.1 represents both the normal roving guide and the specially designed roving guide present in the drafting zone.

Table 3 - Design of experiments

Trial	Distance b/w 2 roving strands in mm	Suction pressure applied (mbar)
Trial 1	0	22
Trial 2	0	24
Trial 3	2	22
Trial 4	2	24
Trial 5	4	22
Trial 6	4	24
Trial 7	6	22
Trial 8	6	24
Trial 9	8	22
Trial 10	8	24



Figure 2 - Specially designed roving guide



Figure 3 - Measurement of Negative Pressure

### III. TESTING PARAMETERS

The trial samples have been tested for their count, variation in count, Lea strength, Single yarn strength, Elongation %, number of imperfections, Hairiness and Classimat faults respectively. All the testing has been done by using the latest testing instruments under the standard atmospheric conditions. Testing procedures have been followed as per the testing instrument recommendations.

Table 4 - Testing Process Parameters

Test Type	Testing Instruments	No of Samples Tested	Testing Speed (mpm)
Count	Cascade	30 / Trial	NA
Lea Strength	Statex	30 / Trial	25 m/min
Evenness	Uster Tester 5	30 / Trial	800 m/min
Tensile Properties	Uster Tenso Jet 4	30 / Trial	400 m/min
Hairiness	Zweigle	30 / Trial	500 m/min
Classimat	Loepfe Zenit	100% samples	1500 mpm (i.e., winding speed)

Test results of the samples, both at ring frame cops stage and the final cone stage were tabulated. Apart from the laboratory test results, the online data on the autoconer breakage, online Classimat and the lab data were also included. Laboratory testing has been conducted in the recently developed Uster testing instruments.

All the testing has been conducted at standard atmospheric conditions i.e. at 65% relative humidity with dry temperature of 74°F and wet temperature of 66°F respectively.

Test Results have been analysed statistically by means of using the concept of CpK (Process Capability Index). The quality of yarn has been assessed by comparing the test results with the specifications/variations. Each parameter has been given certain amount of weightage and the CpK values have been calculated for each trial.

#### IV. RESULTS & DISCUSSION

Table 6 - Test results of trail 1, 2, 3, 4, 5

Process Parameters	Requirement		Trial 1		Trial 2		Trial 3		Trial 4		Trial 5	
	Mean	Cvb	Mean	Cvb	Mean	Cvb	Mean	Cvb	Mean	Cvb	Mean	Cvb
Count			40/2		40/2		40/2		40/2		40/2	
Set TPI / TM			18.2 / 4.06		18.2 / 4.06		18.2 / 4.06		18.2 / 4.06		18.2 / 4.06	
Twist Direction			S		S		S		S		S	
Package Tested			Cone		Cone		Cone		Cone		Cone	
Distance b/w 2 Roving Strands mm			0		2		4		6		8	
Negative Pressure applied in Suction Zone (m bar)			22		22		22		22		22	
<b>Test Results</b>	<b>Mean</b>	<b>Cvb</b>	<b>Mean</b>	<b>Cvb</b>	<b>Mean</b>	<b>Cvb</b>	<b>Mean</b>	<b>Cvb</b>	<b>Mean</b>	<b>Cvb</b>	<b>Mean</b>	<b>Cvb</b>
Avg Count	20.0	1.3	20.7	0.5	20.6	0.7	20.5	0.6	20.5	0.8	20.5	0.7
Avg Rkm	20.5	7.5	21.9	6.5	21.0	5.3	21.0	5.5	20.7	5.5	21.2	5.4
Elongation %	5.4	7.5	5.5	6.8	5.4	6.0	5.9	6.0	5.7	7.1	5.7	5.5
U%	6.8	2.5	7.4	3.9	7.0	2	7.0	2.8	6.9	1.2	6.9	2.0
Thin -50%			0	4.0	0	0	1	316.0	0	0.0	0	0.0
Thick +50%	5	35.0	8	57.0	4	85	5	65.0	3	84.0	2	77.0
Neps +200%	8	35.0	8	44.0	4	96	5	85.0	4	58.0	5	63.0
Total Imp / Km	13		16		8		11		7		7	
Thin -30%			71	30.0	49	34	45	38.0	24	22.0	27	33.0
Thick +35%	25	35.0	31	30.0	29	31	25	46.0	18	31.0	20	46.0
Neps +140%	25	35.0	29	22.0	26	34	24	34.0	21	36.0	20	35.0
Total Imp / Km	50		131		104		94		63		67	
Hairiness	4.8	4.0	4.7	12.1	4.6	4.7	4.6	5.2	4.7	3.9	4.9	3.9
S3	750	35.0	1457.0	7.3	570.0	14.7	543.0	7.3	710.0	7.3	652.0	7.3
Total CMT Faults	20.0	1.5	38.0	1.5	13.0	1.5	20.0	1.5	33.0	1.5	33.0	1.5
<b>Over all Cpk</b>			<b>0.813</b>		<b>1.106</b>		<b>1.099</b>		<b>1.345</b>		<b>1.261</b>	

Table 7 - Test results of trail 6,7,8,9,10

Process Parameters	Requirement		Trial 6		Trial 7		Trial 8		Trial 9		Trial 10	
Count			40/2		40/2		40/2		40/2		40/2	
Set TPI / TM			18.2 / 4.06		18.2 / 4.06		18.2 / 4.06		18.2 / 4.06		18.2 / 4.06	
Twist Direction			S		S		S		S		S	
Package Tested			Cone		Cone		Cone		Cone		Cone	
Distance b/w 2 Roving Strands mm			0		2		4		6		8	
Negative Pressure applied in Suction Zone (m bar)			24		24		24		24		24	
Test Results	Mean	Cv b	Mean	Cv b	Mean	Cvb	Mean	Cvb	Mean	Cv b	Mean	Cvb
Avg Count	20.0	1.3	20.7	1.2	20.3	0.5	20.7	1.3	20.7	1.2	20.4	0.5
Avg Rkm	20.5	7.5	20.3	7.1	20.5	7.1	19.7	7.2	21.3	5.3	21.3	5.5
Elongation %	5.4	7.5	6.0	7.7	5.7	7.0	5.6	7.5	5.6	6.4	5.5	6.4
U%	6.8	2.5	7.3	2.3	7.0	2.3	7.1	1.0	6.7	1.3	6.9	1.3
Thin -50%			0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Thick +50%	5	35.0	6	52.0	7	84.0	5	103.0	2	89.0	1	137.0
Neps +200%	8	35.0	4	80.0	7	59.0	9	71.0	5	52.0	2	37.0
Total Imp / Km	13		10		14		14		7		3	
Thin -30%			67	23.0	41	26.0	45	16.0	12	27.0	23	37.0
Thick +35%	25	35.0	26	23.0	22	55.0	29	31.0	9	46.0	17	22.0
Neps +140%	25	35.0	25	34.0	27	39.0	28	16.0	17	9.0	20	23.0
Total Imp / Km	50		118		90		102		38		60	
Hairiness	4.8	4.0	4.7	8.9	4.3	4.7	4.5	8.6	4.9	3.9	4.9	5.3
S3	750	35.0	819.0	7.3	718.0	7.3	454.0	7.3	667.0	7.3	819.0	7.3
Total CMT Faults	20.0	1.5	26.0	1.5	24.0	1.5	25.0	1.5	38.0	1.5	16.0	1.5
<b>Over all Cpk</b>			<b>0.944</b>		<b>0.930</b>		<b>0.813</b>		<b>1.410</b>		<b>1.620</b>	

**V. EFFECT ON HAIRINESS**

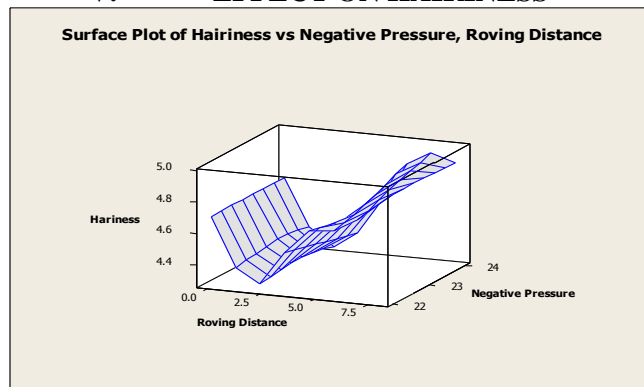


Figure 4 - Surface plot of distance between two roving strands & Suction Pressure on Uster Hairiness index

In both the levels of the suction pressure, the distance between two roving stands of 2 mm and 4 mm give less hairiness whereas too higher and lower distances leads to higher hairiness. From the surface plot figure 4, we can understand that the effect of Roving distance and Negative Pressure on Hairiness is very linear. In very low distance, the fibre web cannot spread out evenly during drafting, also in higher distances the protruding end cannot be controlled effectively by the suction pressure. This may be the main reason for higher hairiness in both extremes.

**VI. EFFECT ON RKM**

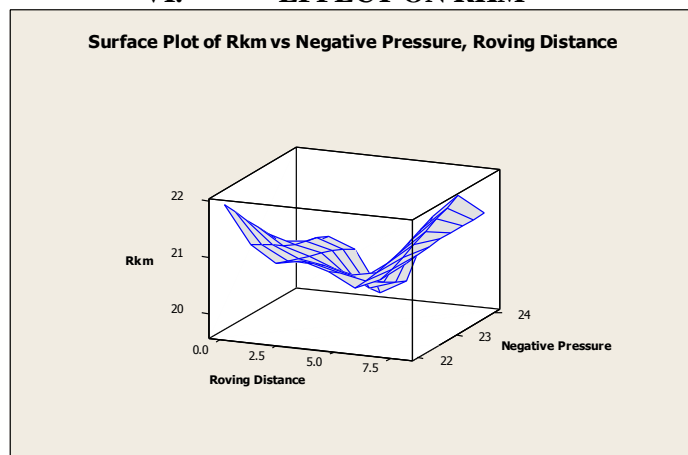


Figure 5 - Surface plot of distance between two roving strands & suction pressure on Rkm (Single yarn strength)

Rkm value does not change much for the distance between roving strand and negative pressure applied. But the coefficient of variation between values are higher for higher negative pressure in all the distance between roving stands and the 8 mm distance, gives comparatively lesser co-efficient of variation in both the negative pressures applied.

The surface plot shows that at 8 mm distance and 24 mbar negative pressures, the Rkm values are higher. The low negative pressure (22 mbar) does not change the Rkm values much in all the roving distances. This may be due the low compaction effect by low pressure.

**VII. EFFECT ON TOTAL IMPERFECTIONS**

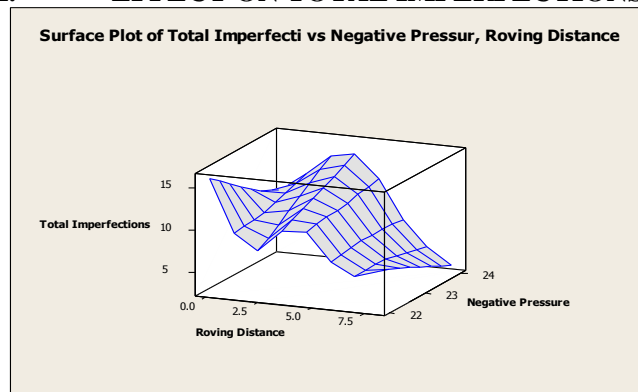


Figure 6 - Surface plot of distance between two roving strand & suction pressure on Total imperfections

The surface plot clearly indicates that total imperfections get reduced while increasing the suction pressure and distance between the roving strands. The roving distance plays a major role on total imperfections than the suction pressure. The defects like Thin -50%, Thick +50%, Neps +200% increase for higher suction pressure, whereas minor defects like Thin -30%, Thick +35%, Neps +140% reduce for higher negative pressure. The co-efficient of variation increases for higher roving distances. This phenomena obeys the single yarn compact principle, as the roving distance increases the spinning triangle also gets increased, the effective control over the edge fibres by drafting roller gets reduced. The higher negative pressure may not effectively utilise for control over the edge fibres.

**VIII. EFFECT ON YARN UNEVENNESS**

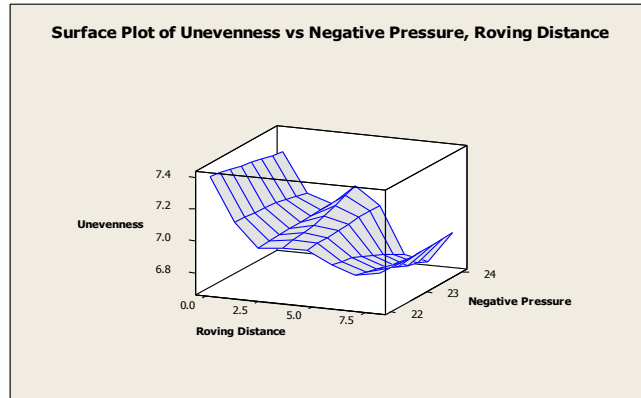


Figure 7 - Surface plot of distance between two roving strands & suction pressure on yarn unevenness

Yarn Unevenness gets reduced for higher distances between roving and suction pressure. The Unevenness gets reduced upto a roving distance of 6 mm drastically and no further significant reduction is realized after 6 mm. There is no significant effect of negative pressure on the Yarn Unevenness.

The surface plot graph shows the linear relationship between yarn unevenness and distance between two roving strands. As the distance between two roving strands increases, the Unevenness gets reduced for upto 6 mm distance and after 8 mm distance the Unevenness gets increased. This may be because higher distance leads to poor control over the individual fibre by drafting roller. Also when distance becomes very close, there is not sufficient space to spread out the fibre web.

**IX. IMPORTANCE GIVEN TO EACH PARAMETER IN CpK**

The table given below shows the weightage of each parameter taken for the calculation of CpK. Apart from the average value variation, each parameter has also been considered for calculating the CpK. Weightage of each parameter will vary according to the end use of the product.

Table 5 - Weightage given to each test parameter

Avg Count	5.0
Avg Rkm	20.0
Elongation %	15.0
U%	5.0
Thick +50%	5.0
Neps +200%	15.0
Thin -30%	2.5
Thick +35%	10.00
Neps +140%	10.00
Hairiness	5.0
S3	2.5
Total CMT Faults	5.0

A model has been developed for predicting the yarn quality at various distances between the roving strands and the negative pressure applied in the suction zone. With this the yarn quality results can be predicted in future without conducting any trials. This in turn will result in saving a lot of time and money involved in conducting such trials.

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

## X. CONCLUSION

As the quality of yarn is predicted by means of various parameters such as Unevenness %, Imperfection level, Single yarn strength, Elongation, Classimat faults, performance of the yarn downstream process etc, CpK is found to be the right tool for identifying the right process in spinning mills by considering all the yarn quality parameters based on its end use.

The aforesaid analysis proves that the overall yarn quality is better in 8mm strand spacing with 24-mbar negative pressure. Also the model developed is very useful in future for predicting the yarn quality of Eli-twist yarn.

Based on the end user the weightage given to each yarn quality parameter will be fine tuned and as a result, the optimum process parameter can be easily identified.

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