Influence of D - Type Slot Compact System on Migration Properties of the Carded Compact Yarn

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ABSTRACT

The compact spinning systems are mostly used for spinning of combed yarns. However, many attempts have been made to use the compact system for spinning carded yarns. Recently SUESSEN has introduced D–Type slot compact system for producing carded compact yarn. In this research work, an attempt has been made to analyze the migration properties of D–Type slot carded compact yarn. Three different twist factors have been selected and compared with regular carded compact yarn and regular carded ring yarn. In this work, the migration parameters such as Mean Fiber Position, Root Mean Squared (RMS) Deviation, Migration Intensity and Yarn Diameter have been measured using the Charge-Coupled Device (CCD) camera attached on a projection microscope. D–Type slot carded compact yarn, regular compact and regular ring yarn structures have been critically analyzed using Scanning Electron Microscope. The test results clearly indicate that the fiber migration in D–Type slot compact yarn is far better than both regular compact and regular ring yarns.

Key words: Regular carded ring yarn, Regular carded compact yarn, D-type slot carded compact yarn, CCD camera, Mean Fiber Position, RMS Deviation and Migration Intensity.

INTRODUCTION

Regular compact spinning is recognized as a revolution of ring spinning in the recent years. This technology is claimed for the superior quality and better raw material utilization [1,2,3].The regular compact spinning system produces a different yarn structure when compared to regular ring yarn structure. Even though there are many research work have been done on the properties and appearance of compact yarn, only few research work have been done to study the inner structure of the compact yarn [4,5]. The effect of twist on fiber migration for ring and rotor yarns has been investigated by many research workers [6, 7, 8, 9 and 10].

The effect of twist on fiber migration for regular compact spun yarns has been studied and it was found that the rate of fiber migration is higher when compared to regular ring yarn [4].

In ring spinning, the main source of the fiber migration is due to the tension differences between fibers during the yarn formation. When a thin ribbon-like fiber bundle is transformed into a roughly circular shape by twist insertion, fibers at the edges of bundle are faced with tension where as fibers in the middle are subjected to compression. To release the stress, fibers which are subjected to tension will try to shorten their path during the yarn formation whereas fibers which are under compression will try to lengthen its path. As a result of this, fibers leave their perfect helical path and migrate between layers of the yarn [11].

In regular compact spinning, tension differences between fibers during the twist insertion is smaller than those in ring spinning due to the elimination of the spinning triangle. Therefore fiber migration in compact yarns could be lesser than that in conventional ring spun yarns.

If any modification or changes done in compacting zone, there will be possibilities of change in the migration of fibers and it will change properties of the yarn. With this aim only, an attempt has been made through this research work by analyzing the migration properties using Suessen D–Type slot compact system. Recently Suessen introduced a novel concept of D–Type slot specially designed for the carded compact yarn [12]. The influence of twist on D–Type slot compact yarn and the effect of inter fiber migration are the main objectives of this research work. The inter fiber migration characteristics are viz., Mean Fiber Position, RMS Deviation, Migration Intensity and Yarn Diameter which have been analyzed under the Charge-Coupled Device camera attached in projection microscope.

MATERIALS

Carded 40 Ne yarn was produced using three systems viz., conventional ring spinning, SUESSEN conventional Slot and D–Type slot compact spinning system. Three different twist levels of 3.8, 4.2 and 4.6 have been selected and yarns were produced using Shanker 6 Indian variety of cotton. The properties of cotton have been studied using High Volume Instruments (HVI) and Advanced Fiber Information System (AFIS) are shown in *Table I* and *II*.

TABLE I: FIBER CHARACTERISTICS MEASURED USING HVI

S.No	Fiber characteristics	Min	Max	Avg
1	Micronaire	3.4	4.2	3.8
2	Upper Half Mean length(mm)	24.2	31.0	26.8
3	Length Uniformity (%)	72.1	82.1	75.2
4	Strength (g/tex)	18.8	21.6	19.1
5	Elongation (%)	4.5	8.2	6.5

TABLE II: FIBER CHARACTERISTICS TESTED USING AFIS

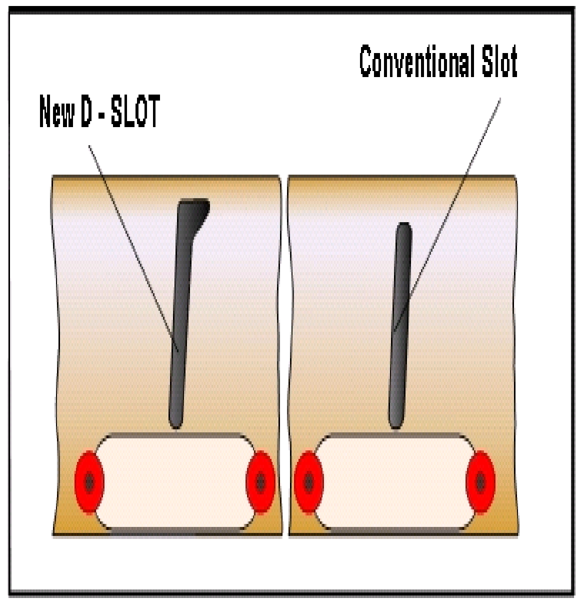
S.No	Fiber characteristics	Min	Max	Avg
1	Short fiber content counting technique (%)	19.2	35.4	25.8
2	Mean Length by weight (mm)	20.5	26.5	23.5
3	Upper Quartile length weighing technique (mm)	24.2	31.2	27.5
4	Maturity Ratio	0.81	0.93	0.84
5	Seed coat Neps /g	65	95	72

The migration properties are directly influenced by the fiber properties. Hence, the same raw materials with the above characteristics have been maintained to spin yarns in all the three experimental systems to avoid variation due to raw material.

YARN PRODUCTION METHODS

Tracer fiber technique has been used to study the migration properties. Hence 0.5% of black dyed fiber was used as tracer fibers and blended at the carding stage. Carded slivers of 0.14 Ne was processed through breaker and finisher draw frames. The Roving hanks of 1.61 Ne bobbins were produced.
40 Ne regular ring yarn, regular compact yarn and D–Type slot compact yarns have been produced with 3.8, 4.2 and 4.6 twist levels. Plate I shows the photographs of D–Type slot and conventional slot used for this research work [12].

PLATE I: NEW D – SLOT AND CONVENTIONAL SLOT



The photograph clearly indicates that the D slot has more length than conventional slot with Delta shape entry point which helps the shorter fiber to compact in a better manner that results in good short fiber utilization.

FIBER MIGRATION STUDY METHOD

0.19 meter lengths of yarn have been selected at random which were fixed on a glass trough under a standard tension of one cN. Then it was immersed in a liquid medium of Methyl Salicylate which has the same refractive index as that of tracer fibers. While examining under a microscope, the tracer fiber was shown against the faint background of yarn body, as a wavy line which representing the projection in one plane of helix. Using CCD Camera, around 1.9

millimeter of yarn was photographed at a time and the images were stored using a personnel computer. The structure of yarn has been critically analyzed using the position of tracer fiber from yarn boundary to yarn axis. The tracer fiber has been analyzed at ten different positions per sample. The number of trough / peak points measured per fiber is between 35 and 50 and the corresponding yarn length is between 19 millimeter and 26 millimeter.

CONFIGURATION OF TRACER FIBER IN YARN STRUCTURE

Parameters such as Mean Fiber Position ($\overline{Y}$), Root Mean Squared Deviation (D), Mean Migration Intensity (I), Equivalent Migration Frequency are as defined by Hearle[13]and Prementas[14]and the Migration Factor is as defined by You Huh[15]were used for characterizing migration behavior of the tracer fiber.

Mean Fiber Position

Mean fiber position ($\overline{Y}$) is defined as the tracer fiber position either near the yarn boundary or near the yarn axis. It is calculated from the following equation.

$$\overline{Y} = 1/L \int_{O}^{L} Y dZ = 1/n \sum_{i=0}^{n-1} Y_i$$

Where $Y_i = (r_i / R_i)^2$;

I = 0, 1, 2…,n-1, (the sequence number of observation)

R_i = The yarn radius;

r_i = The helix radius for the i^{th} observation;

Z = The length co-ordinate along the yarn;

L = The total yarn length (observed); and

n = The total number of observation.

Amplitude of Migration

Amplitude of Migration is the magnitude of deviations from mean position represented by Root Mean Squared Deviation (D). This is derived from the following equation:

$$D = \left[1/L \int_{O}^{L} (Y-\overline{Y})^2 dZ \right]^{1/2} = \left[1/n \sum_{i=0}^{n-1} (Y_i - \overline{Y}) \right]^{1/2}$$

Rate of Migration

Rate of migration is indicated by the mean rate of change of radial position, which is denoted as Mean Migration Intensity (I). This is derived from the following equations:

$$I = \left[1/L \int_{O}^{L} (dY/dZ)^2 dZ \right]^{1/2} = \left[1/n \sum_{i=0}^{n-1} (dY/dZ)^2 \right]^{1/2}$$

The modified equation to derive Mean Migration Intensity (I) is:

$$I = \left[1/n \sum_{i=0}^{n-1} (Y_{i+1} - Y_i / Z_{i+1}) \right]^{1/2}, \quad Z_i = Z_i - Z_{i-1}$$

Where $Z_1, Z_2, \ldots\ldots Z_{i+1}$ are the yarn axial distances between adjacent indications of peak and trough of tracer;

Z_1, $Z_2, \ldots\ldots. Z_{i+1}$, are the cumulative distances;

Y_i or Y_{i+1} are as defined earlier.

Equivalent Migration Frequency

Equivalent Migration Frequency is derived from the ideal migration cycle which is constructed from the calculated value of I and D as given below

$I = 1/4D\sqrt{3}$.

Migration Factor

Migration Factor (MF) is derived by multiplying RMS Deviation (D) and Migration Intensity (I) values.

MF = D X I

TRACER FIBERS MEASUREMENTS

Fig. 1 shows the various position of tracer fiber from the yarn boundary to yarn axis. The measurements of a, b, c and z were made at successive peak through tracer fiber image as shown in *Fig. 1*.

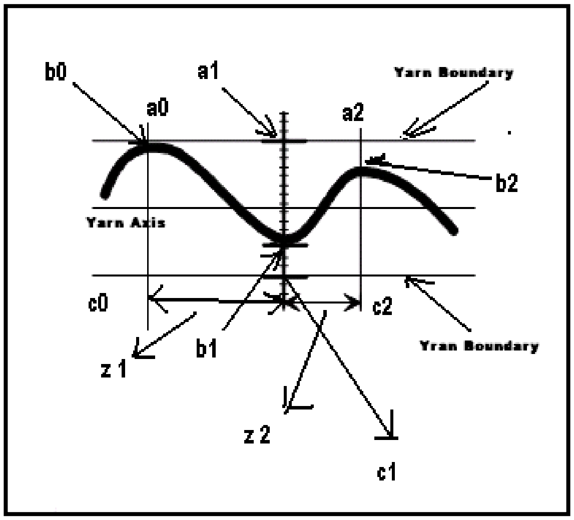


FIGURE 1: TRACER FIBER MEASUREMENT

Where c_0, c_1, $c_2 \ldots c_i$ and a_0, a_1, $a_2 \ldots . a_i$ points are located from start to end of the body.

i=0,1,2,…..,n-1 sequence number of observations, leaving aside the protruding and loosely held fiber at end portions.

The radius of yarn (R_i) for the i^{th} observation in scale units is {a_i - $c_{i\,/}$ 2}.

The helix radius (r_i) for that observation is given by {(a_i + c_i) / 2 - bi}, which is the offset of trough / peak from yarn axis.

The distance between adjacent trough and peak is Z_1, $Z_2 \ldots \ldots Z_i$. In order to avoid effects due to the change in yarn diameter and radial position of fibers is given by a ratio $r/R_{i,}$ which is derived from {(ai + ci) / 2 - bi}/{a_i -c_i / 2}.

Around 4 to5, trough/peak of tracer are appearing in a image of about 1.9 millimeter yarn length has been captured at a time and stored in the PC. Using software the images were sequentially merged to track the full length of tracer fiber and measurements were taken subsequent to applying appropriate scale and calibration check [5, 14].

RESULTS AND DISCUSSION

The influence twist factor on yarn diameter is shown in *Fig. 2* for the three spinning system. The yarn spun by D–Type slot compact system has the smaller yarn diameter followed by yarn spun by regular compact system and ring system. This is due to the better compaction done by the D–Type slot compact system in which short fibers were effectively brought to the yarn cross sectional area. Further, the D–Type slot pneumatic compaction starts earlier than the conventional slot compact system because of the increased slot length in the D–Type slot system when compared to conventional slot with Delta shape entry.

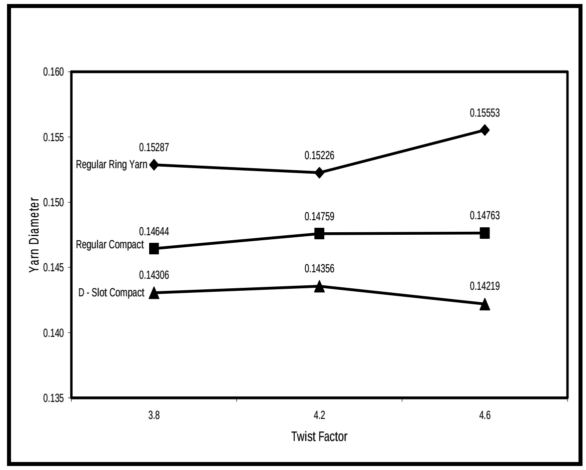


FIGURE 2: INFLUENCE OF TWIST ON YARN DIAMETER.

The influence of twist factor on Mean Fiber Position is shown in *Fig. 3* for the three spinning system. It is noticed that D–Type slot compact yarns have smaller mean fiber position values followed by regular compact yarn and regular ring yarn. The value of mean fiber position is 0.5 for both compact yarns which indicates that the density is greater at the center of the yarns axis. The mean fiber position in a ideal / uniform yarn with complete migration would be closer to 0.5, whereas in ring yarn, the value of the mean fiber position is more than 0.5 which shows lower migration. In all the three systems mean fiber position values is decreasing with increase of twist factor. It is also noticed that the mean fiber position value are minimum at twist factor of 4.6.

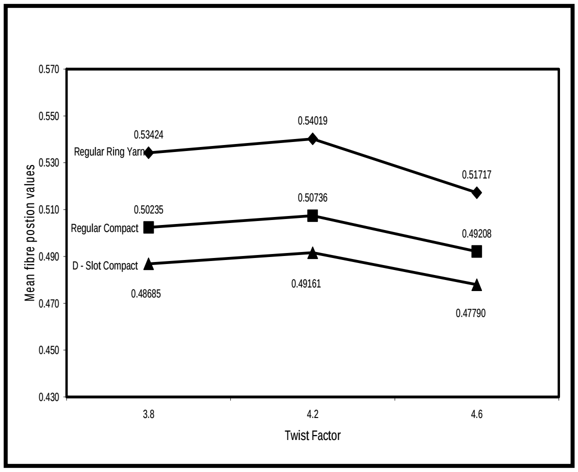


FIGURE 3: INFLUENCE OF TWIST ON MEAN FIBER POSITION

Fig.4 correlates very well with the findings of *Fig. 3*. The amplitude of migration has similar trend to that magnitude of deviation. In other words, mean fiber position is directly proportional to RMS deviation.

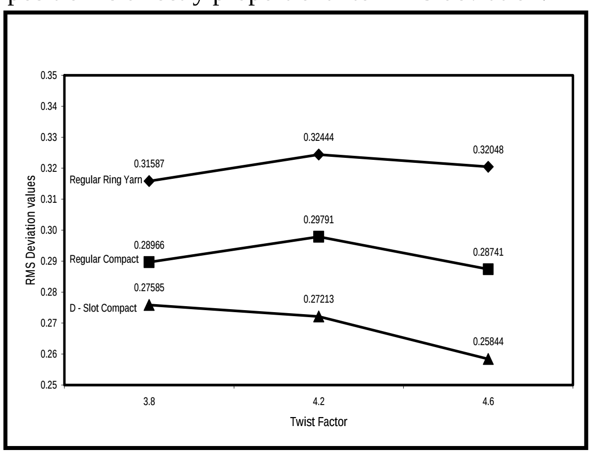


FIGURE 4: INFLUENCE OF TWIST ON RMS DEVIATION

In *Fig.4*, the D–Type slot compact yarn has lower value of mean fiber position and lower RMS values. Further it is observed that D–Type slot compact yarn has decreasing trend in RMS values which means it has less migration with better yarn compactness. The regular compact and regular ring yarn have maximum RMS value for the 4.2 twist level, and are decreasing with increased twist level of 4.6.

The influence of twist factor on migration intensity has shown in *Fig.5*. The result shows D–Type slot compact yarn has the minimum migration intensity values at all twist levels when compared other two systems. It is also observed there is no significant difference in migration intensity value at all three twist levels of D–Type slot compact system. In total the D–Type slot compact yarn has minimum value of yarn dia, mean fiber position, RMS deviation and migration intensity at all twists levels when compared other two systems. It is due to following reasons:

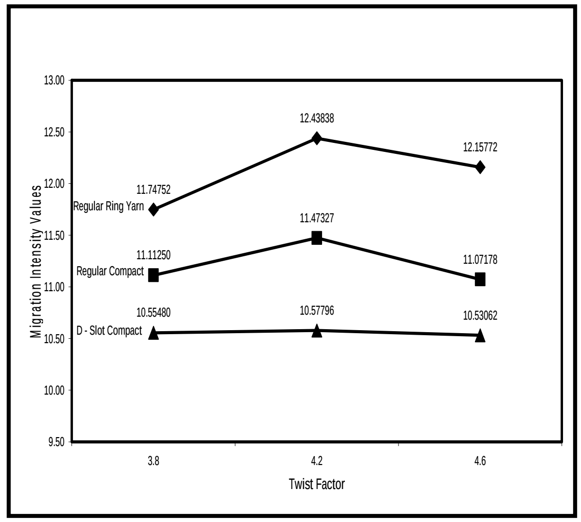


FIGURE 5: INFLUENCE OF TWIST ON MIGRATION INTENSITY

- All the short fibers in fiber strand are condensed properly and bundled effectively at the condensing zone without any fly in the case of D–Type slot compact system.
- Another important reason is Delta shaped entry in D–Type slot ensures better compactness when compared to other two systems.
- Moreover D–Type slot angle and slot width ensures better suction and compactness.
- The D–Type slot has better control on edge fibers due to higher suction slit and Delta shape at entry level of the compacting zone.
- The bundling effect in D–Type slot compact system is better due to diagonal positioning of the guiding edge.

SCANNING ELECTRON MICROSCOPE ANALYSIS

PLATE II: SEM – REGULAR CARDED RING YARN STRUCTURE IN 3 TWIST LEVELS

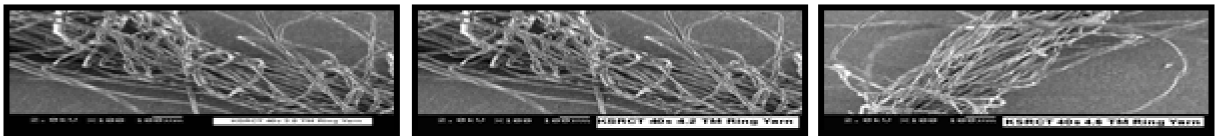


PLATE III: SEM – REGULAR CARDED COMPACT YARN STRUCTURE IN 3 TWIST LEVELS

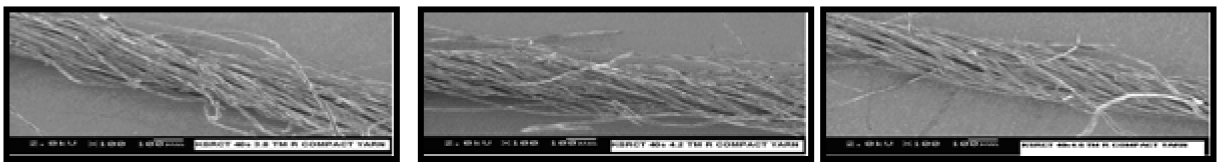


PLATE IV: SEM – D–TYPE SLOT CARDED COMPACT YARN STRUCTURE IN 3 TWIST LEVELS

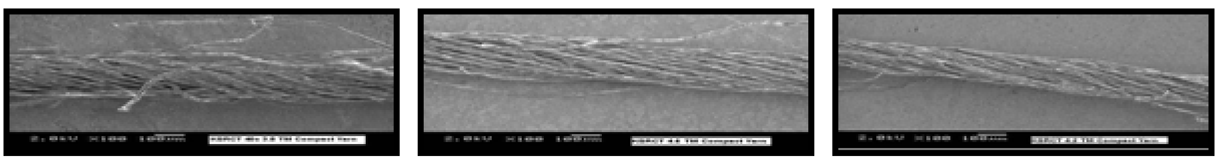


Plate II, III and IV shows that the yarn structures of three different systems such as regular carded ring yarn, regular carded compact yarn and D–Type slot carded compact yarns of three twist factors. From the above photographs the D–Type slot carded compact yarn has better aligned fiber with compacted and bundled fiber with minimum protruding fibers when compared other two systems such as regular carded ring yarn and regular cared compact yarns.

CONCLUSIONS

Through this research work three different systems such as Regular Carded Ring Spinning, Regular Carded Compact Spinning and D–Type slot Carded Compact Spinning have been selected to produce yarns of three different twist levels such as 3.8, 4.2 and 4.6.The tracer fiber technique has been adopted to study the influence of twist on Mean Fiber Position, Root Mean Squared (RMS) Deviation, Migration Intensity and Yarn Diameter for the above samples.

The influence of twist factor on yarn diameter shows that D slot carded compact yarns have lower yarn diameter then regular carded ring yarn and regular carded compact yarn. It ranges from 4 to 7 % reduction

in yarn diameter when compared other two systems. Whereas with in yarn samples from D–Type slot Compact System has no significant difference in yarn diameter at all three twist levels.

As far as Mean Fiber Position is concerned, D–Type slot carded compact yarns have the lower mean fiber position values at all three twist levels when compared to other two system such as regular ring and compact carded yarns. Within D–Type slot compact system samples have the minimum mean fiber position at 4.6 twist levels.

The influence of twist factor on RMS Deviation values and Migration Intensity of D–Type slot compact yarn has the minimum value for all 3 twist levels when compared with other two systems.

The photographs of Scanning Electron Microscope samples of three different spinning systems with three twist levels shows a clear picture of yarn structure. D–Type slot carded compact yarn has better aligned fiber with compacted , bundled fibers and also with minimum protruding fibers when compared other two systems such as regular carded ring yarn and regular cared compact yarns. The above study is focused only

on the influence of D–Type slot compacting system on fiber migration. However further studies are required to correlate with yarn quality characteristics.

ACKNOWLEDGMENT

The authors are thankful to the Management and General Manager of Arun Textile Mills, Gobi-Chetipalayam and the Chief Technical Officer of Lakshmi mills, Coimbatore India for their valuable help in the production of regular carded ring spun and regular carded compact-spun yarns and D Slot carded compact yarns.

REFERENCES

[1]. Kampen, W., Advantages of Condensed Spinning. *Melliand International* 6, 98 –100 (2000).

[2]. Meyer, U., Compact Yarns: Innovation as a Sector Driving Force. *Melliand International* 6, 2 (2000).

[3]. Stalder, H., Compact Spinning – A new Generation of Ring Spun Yarns. *Melliand Textilberichte* 76(3), E29– E31 (1995).

[4]. Guldemet Basal and William Oxenham, Comparison of Properties and Structures of Compact and conventional Spun Yarns:*Textile Res J* Vol 76(7) (2006): 567–575

[5]. Ganesan S., & Ramakrishna G.,Fiber migration in compact-spun yarns: Part-I-Pneumatic compact yarn, *Indian Journal of Fiber and Research*, Vol. 31, Sep 2006, pp.381-386.

[6].Morton W E, The arrangement of fibers in single yarns, Text Res J, 26 (1956) 325-331

[7]You Huh, Young Ryul Kim & Oxenham William, Analyzing structural and physical properties of ring, rotor and friction spun yarn, *Text Res J*, 72 (2002)156-163.

[8]. Hearle J W S, Gupta B S & Merchant V B, Migration of fibers in yarns, Part III: A Study of Migration in staple fiber Rayon yarn, Text Res J, 35 (1965) 788 - 795.

[9]. Salhotra K.R.,Dutta B.,and Sett S.K., Influence of Twist on Fiber Migration in Rotor-Spun Yarns Tex Res J, 51 *(*1981) 360 - 363.

[10]. Pillay K.P.R., Viswanathan N.,and. Parthasarathy M.S., The Structure and Properties of Open-End Yarns: Part I: A Study of Fiber Configurations and migration Textile Res J 45 (1975)366 - 372

[11]. Lord, P. R., The Structure of Open-end Spun Yarn. Textile Res.J. 41, 778–784 (1971).

[12]. Rainer Thum, Head Marketing, Magazine for spinning mills, *Spinnovation No 23*, 08 / Aug 2007, page no 37

[13]. Hearle J W S, Gupta B S & Merchant V B, Migration of fibers in yarns, Part I: Characterization and idealization of behavior, *Text Res J*, 35 (1965) 329-334

[14]. Primentas A & Iype C, The configuration of textile fibers in staple yarns, *JTATM*1 (4) (Summer 2001) 1-8

[15]. You Huh, Yound Ryul Kim & Woon Young Ryu, Three dimensional analysis of migration and staple yarn structure, *Text Res J*, 71 (2001) 81-90.

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