FIBRE MIGRATION IN COMPACT SPUN YARNS

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1. Introduction

The mechanical properties of staple yarns depend not only on physical properties of constituent fibres but also the yarn structure characterized by geometrical arrangement of fibres in yarn. Of the various structural properties for staple yarn, the relative fibre movement at the point of yarn formation and the resultant position of fibres in the yarn structure has a decisive influence on yarn properties such as, Strength, C.V. of Strength, Elongation, Hairiness and Running Performance. The relative fibre movement has been termed as 'Fibre Migration' by Morton [1]. 'Fibre Migration' characteristic in staple yarns is to a great extent influenced by the factors such as spinning system adopted or fibre accumulation mechanism and the relative tension of fibres at the point of yarn formation apart from fibre characteristic such as length, fineness, crimp, cross section shape. Of the widely used system in the production of staple yarns such as Ring, Rotor and Friction Ring yarn exhibits highest fibre migration followed by Rotor and Friction spun yarns the least, based on spinning tension and its variation. The "Compact Yarn" is spun with a significantly reduced spinning triangle to less than 20%of Ring Yarn (Base of the triangle from 2-3mm to less than 0.5 mm) and hence a less variation in path distance among fibres of drafted stand. This results in less variation in tension among the fibres than Ring Yarn and hence the migratory characteristic of it is expected to be less and it will lie some where between Ring and Rotor yarns. But the strength obtained in Compact Yarn is more. This necessitated a study of Migration, Packing Density and other related factors on Compact Yarn so as to explain the physical properties of it. In this study, fibre migration behaviour in 'Short Staple Compact Spun Yarn from Cotton' is attempted.

2. Review of Literature

There has been many structural analysis study of yarn since early 1950. Tracer fibre technique used by Morten [1] in 1949 is still being followed by many researchers. Morten [1] introduced the term 'Fibre Migration' to denote the change in position of single fibre along the length of yarn. The study of Morton [2] revealed that 'Migration' was due to tension differences resulting from different path length of fibres. Morton found that interval of helix profiles decreased as the twist increases. Riding [3] observed that fibre migration using a new measurement method in which he simultaneously viewed yarn from two perpendicular directions.

In 1965, Hearle and Co-workers [4] established the theoretical basis for fibre migration and characterized migration behaviour of an ideal yarn by considering ribbon-twist model and suggested various migration parameters such as Mean Fibre Position, RMS Deviation, Mean Migration Intensity, Equivalent Migration Frequency. Hearle [5] also studied the occurrence of Geometric Mechanism in addition to Tension Mechanism to influence fibre migration during yarn formation and explained existence of irregular short-term variations and regular long-term variations along yarn length. In the same year, Hearle and Gupta [6] said if analysis is carried for large no of tracers sample then there is no need to go in for observing in two different planes. They demonstrated the migration behaviour in 'Staple Fibre Rayon Yarn' and concluded that frequency of migration is shown to be roughly constant in relation to frequency of twist.

In 1969, Gupta and Hamby [7] work emphasized that the migration behaviour of staple yarns is to a large extent dependent on their mean fibre position. They also concluded that spindle speed and spinning tension influence rate of fibre migration, but to a lesser extent. In 1970, Gupta [8] discussed the work on Geometric Mechanism of fibre migration and the influence of roving and drafting variables in detail. In 1971, Lord [9] has done a work on structure of open-end spun yarn and in 1972, Hearle and Co-workers [10] also carried out research work on fibre migration in OE yarns. They concluded that low strength of rotor spun yarns could be attributed to poor fibre alignment, inferior and shallower fibre migration with in yarn body, fairly large no of folded fibres. In 1994, Alagha *et all* [11] and his associates concluded that difference in migration characteristic of yarn on different spinning system were due to different twisting methods and different levels of tension developed during yarn formation. They also developed an image analysis system to assess the structural characteristics of friction spun yarns, mainly fibre migration. In 2001, a three dimensional analysis of migration of staple yarn structure by You Huh *et all*[12] reveals the efficacy of 3-dennsional visualization with image analyzer for structural analysis of staple yarns. In 2002 You Huh *et all* [13] analyzes structural-physical property of Ring, Rotor and Friction spun yarn. The finding of them is that Ring yarn has highest migration followed by Rotor and Friction being the least.

With regard to 'Short Staple Compact Spun Yarn', so far no work has been published as this technology has been very recently has come to the commercial existence. This necessitates carrying out a research work on 'Fibre Migration' on Compact Spun Yarn.

Literature reveals that instrumentation such as CCD Camera or Trinocular Microscope with CCD Camera could be used to magnify and capture the image of the tracer fibre in a computer and using software the trajectory of tracer fibre is being analyzed three- dimensionally.

3. Materials & Methods for the study

3.1 Materials for the study

The Cotton variety H-4 with a 2.5 % Span Length of 29/30 mm and fineness 4.0 was used for the production of combed Roving of 1.37 Ne. A small proportion i.e. 1.0% by weight of above fibres were black dyed & used as tracer fibres, which were introduced in the Carding stage with the remaining un-dyed material.. The yarn counts 40^s Ne & 52^s Ne run by the mills on Elite Compacting system was selected for the study. The tracer fibre incorporated roving was used in two spindles to produce Compact Yarn in a commercial machine. For the production of equivalent count Ring Yarn the same spindles with out compacting attachment was used, while keeping the process parameters such as Spindle Speed, Twist Factor and Traveler Weight identical for both yarns.

3.2. Techniques & Instrumentation adopted for migration study

The standard Tracer-fibre technique has been used for the study .The yarn thus produced using tracer fibres is immersed in liquid medium (Methyl Salicylate) having substantially the same refractive index as that of fibres concerned. The yarn being examined under a microscope, the un-coloured fibres disappear from view leaving the path of each tracer-coloured fibre to be clearly visible. The tracer is seen against the faint background of yarn body as the wavy line representing the projection in one plane of helix.

The present study is confined to the use of Projection Microscope (Projectina-40x) fitted with CCD Camera and unidirectional analysis of projection.

3.3 Configuration of Tracer fibre

Parameters such as Mean Fibre Position (Y), RMS Deviation (D), Migration Intensity (I), Equivalent Migration Frequency defined by Hearle [4] and Migration Factor [12] defined by You Huh are used for Characterizing Migration Behaviour of the tracer fibre under Microscope

4. Results and Discussion

The Table1&2 gives the Migration Charaterization Data Summary obtained from measurements taken each on tracer fibres of Ring and Compact yarn of 40s & 52s Combed Cotton.

4.1 Mean Fibre Position (Y), RMS Deviation (D) and Mean Migration Intensity (I)

There are reduction in Mean Fibre Position (Y), RMS Deviation (D) and Mean Migration Intensity (I) to the tune of 10.7 %, 11.0 % & 9.8 % respectively for the 40^s Ne Compact Yarn compared to Ring yarn. Similarly, there are reduction in Mean Fibre Position (Y), RMS Deviation (D) and Mean Migration Intensity (I) to the tune of 29.3%, 17.6% & 9.64 % respectively for 52^s Ne Compact Yarn. T' -test values reveals that the quantum of reduction is significant at 95% Confidence level for Y and D. The reason for the reduction is best explained by proper understanding of "Tension variation as mechanism of Migration" and due to elimination of spinning triangle in the Compact Yarn Spinning.

4.2 Tension variation as mechanism of Migration

Morton [1] proposes that fibres twisting round a long path on the outside of a yarn would develop a high tension, while the fibres following the shorter straight path in the centre would be under low tension. Similarly in Ring Spinning due to formation of spinning triangle, the corner fibre of the drafted strand that emerges from the front roller has to travel longer path than the one at the centre before it reaches the point of yarn formation resulting in higher tension.

Table 1 : Migration Characterization data for Compact and Ring yarn (40^s Ne)

Parameters	Yarn Dia.-mm		Mean Fibre Position		RMS Devia. (D)		Migration Intensity(I) cm^{-1}	
	COMPACT	RING	COMPACT	RING	COMPACT	RING	COMPACT	RING
Overall Mean	0.13384	0.14995	0.48030	0.53772	0.26225	0.29479	10.46379	11.60218
S.D of Mean	0.00577	0.00601	0.10067	0.06808	0.03597	0.03253	1.79399	2.61815
c.v % of Mean	4.31471	4.00798	20.95972	12.66148	13.71671	11.03559	17.14478	22.56598
$T_{95\%}/F_{95\%}$ & T_{Act}/F_{Act}	T=2.262	6.115	T=2.262	1.494	F=1.22	1.264	T=2.262	1.134
S.D. of Individl.			0.26859	0.29983				
C.V. % Individl.	8.55680	7.66796	55.92123	55.75908				
$T_{95\%}$ & T_{Act} of Individl.	T=1.96	14.033	T=1.96	2.017				
Equi. Mig. Freq. cm^{-1}							5.7590	5.6808
Mig. Factor-cm^{-1}							2.7441	3.4202

Table 2 : Migration Characterization data for Compact and Ring yarn (52^s Ne)

Parameters	Yarn Dia.-mm		Mean Fibre Position		RMS Devia. (D)		Migration Intensity(I) cm^{-1}	
	COMPACT	RING	COMPACT	RING	COMPACT	RING	COMPACT	RING
Overall Mean	0.12394	0.14382	0.41532	0.58730	0.30918	0.37529	11.42825	12.68512
S.D of Mean	0.01100	0.00964	0.12519	0.14940	0.07991	0.10394	4.13975	3.80938
c.v % of Mean	8.87818	6.70028	30.14259	25.43917	25.84597	27.69494	36.22382	30.03028
$T_{95\%}/F_{95\%}$ & T_{Act}/F_{Act}	T=2.262	4.298	T=2.262	2.790	F=1.22	1.301	T=2.262	0.706
S.D. of Individl.	0.01218	0.01691	0.30695	0.37992				
C.V. % Individl.	9.82905	11.75694	75.89716	64.68918				
$T_{95\%}$ & T_{Ac} of Individl.	T=1.96	19.078	T=1.96	6.985				
Equi. Mig. Freq. cm^{-1}							5.3352	4.8788
Mig. Factor-cm^{-1}							3.5334	4.7605

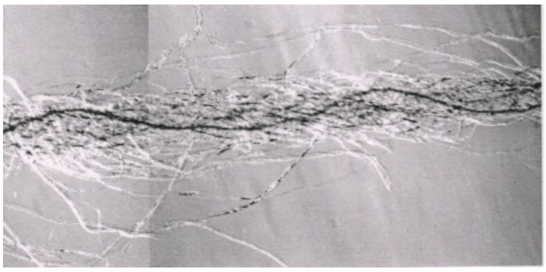
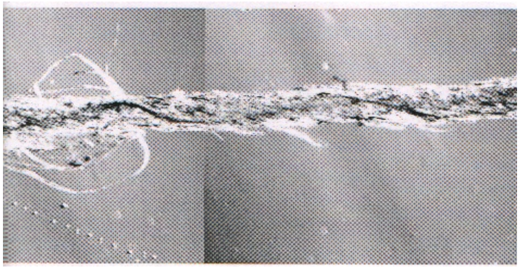
The difference in tension among the fibres would cause an interchange of position of fibres and thus lead to a more or less regular migration. This is apart from the Geometric Mechanism that Contribute to long term migration based roving twist and ring frame draft. The difference in fibre path distance of spinning triangle with 3mm base is 05mm only, where as the difference in fibre path distance for the fibres located at core and surface is 2.6 mm for a 25 mm length of 40^s Ne yarn.

From this one can under stand that difference in path experienced in spinning triangle, which gets eliminated in compact yarn, is much lesser than that of the difference in path followed by fibres at different radial position (20%only). This is the reason for the lesser differences of around 10 %-25 % in the Migration Character (Y, D, I) of Compact Yarn compared to Ring Yarn.

4.3 Yarn Diameter and Packing density

From the data given in Table 1 and from the testing of yarn in Uster 4–SX-OM Module, one can see that there is an overall reduction of yarn diameter to the tune of 10. % for 40^s Ne and 15 % in 52^s Ne for the Compact yarn compared to Ring Yarn of same count, which shows that there is an equivalent increase in Overall Packing Density. This is due to pneumatic compaction that is involved in the production of

Compact yarn, which is mainly responsible for increase in Strength apart from better integration of fibre. This can be visualized from in the CCD Camera photograph given below for the Compact and Ring Spun yarn

Ring Spun Yarn	**Compact Spun Yarn**
	

5. Conclusion

The following conclusion one can derive from the study of migration on Compact Spun and Ring Spun yarn:

- The elimination of spinning triangle in Compact Spinning Technology has reduced the migration parameters such as Mean Fibre Position, RMS Deviation and Mean Migration Intensity to the tune of 10 %- 25 % only. This is due the lesser differential path distance experienced by fibre in spinning triangle than due to differential path distance experienced by fibres at different radial position (20 %).
- Differential path experienced by fibres at different radial position is a major factor for the contribution of migration based on Tension Mechanism, which is apart from Geometric Mechanism Contribution to long term migration.
- The increase in strength of compact yarn in spite of lesser migration of fibres shall be attributed to the factors such as higher packing density and better integration of fibre to yarn body.

6. References

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