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Studies on fiber migration in wet spun cotton compact yarns and the relationship between migration parameters and properties

Dr.V.Krishnakumar
Principal, Vivekanandha Institute of Engineering & Technology, Tiruchengode.
kitcha27@yahoo.com

Dr.V.Subramaniam
Department of Textile Technology, Jaya Engineering College, Thiruninravur, Chennai - 624 101

Dr.B.S.Dasaradan
Department of Textile Technology, PSG College of Technology, Coimbatore - 641 004

An investigation on the characterization of wet spun cotton yarns in terms of its migration parameters has been carried out by using the tracer fibre technique. The relationship between the migration properties and the properties of wet spun cotton yarns has been examined. Wet spun cotton yarns exhibit higher migration than those of regular spun yarns.

1. Introduction

A considerable amount of work has been carried out on the migration of spun and filament yarns in order to correlate the migration parameters with their physical properties. Spun yarns produced from regular and compact spinning have been examined for their migration Basal (2003), Ganesan and Ramakrishnan (2006) have studied fibre migration in spun yarns using the parameters suggested by Hearle (1969).

Kothari Chattopadhyay and Agarawal (1996) have reported on filament migration in air-jet textured yarns and their relationship with yarn properties which is quite useful. It was found that migration had influenced physical bulk loop frequency and initial modulus. Alagha et al. (1994) have studied fibre migration in friction spun yarns using image analysis. This paper reports the effect of wetting on the migration of cotton yarns and its effect on the properties.

If the position, which is occupied by a fibre or a filament in yarn, is traced out point by point along its length it will be seen to traverse back and forth across imaginary cylindrical zones of the yarn badly being in part at or near the core, and in part at or, near the surface. This behaviour is termed as migration by morton and morton and yen (1952).

In an investigation, which was concerned with spirality of weft knitted fabrics, it was found that the use of wet spun yarns had led to a significant reduction in spirality. Since wet spun yarns also can be regarded as compact yarns, in view of their reduction in hairiness and improvement in strength, it was thought that a study of its structure in terms of its migration parameters would be able to improve our understanding.

Ganesan & Ramakrishnan (2006) and Basal (2003) have carried out studies on fibre migration of compact yarns.

Further, questions such as whether or not the effects noticed in wet spun yarns are temporary or permanent remain unanswered. An attempt therefore has been made to establish the relationship between the migration parameters and the properties of wet spun yarns using cotton. The image analysis technique, which was used by Alagha Oxenham and Iype (1994) for studying the structural parameters of friction spun yarns, was employed in the study.

2. Experimental

2.1. Materials

The yarns produced from cotton with a linear density of 14.76 tex (40 Ne.) were used for the study.

Wet spinning

In the ring frame, a burette filled with water was fixed at the top of the front roller and water was allowed to trickle down to wet the fibres (Fig 1).

Wet spinning of cotton fibres was attempted by ATIRA, Subramanian (1975) and by Lord and Nicholas (1974).

The latter workers have wetted rotor spun yarns and were successful in producing a yarn which was free from hairiness. The wet spun yarn can also be regarded as a compact yarn since it is devoid of hairiness. It will be introducing to study fibre migration in these yarns with a view to ascertaining the effect of it on yarn strength. This will be also useful to find out if the effect is temporary or permanent.

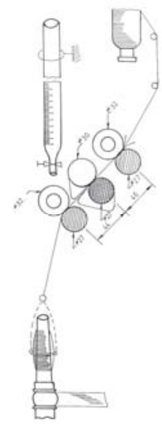


Fig-1

Tracer fibre technique

The tracer fibre technique was employed for studying the migration behaviour.A small quantity of black dyed fibres (1.0 % by weight of fibres) was used as tracer fibres which were introduced in the carding stage with the reminded being grey material. The roving containing that tracer fibre was used for the production of yarns. These roving was converted to 40 Ne (14.76 tex) with a twist factor of 34 tpcm tex$^{0.5}$. The yarns were dipped in a methyl solicylate (refractive index). The coloured tracer fibres were distinctly visible on the screen. The configuration of each tracer fibre can now be clearly discerned. The tracer fibre is seen as wavy line representing the projection in the plane of the helix. Each wave correspondence to one turn of twist.The image analysis technique was used for measuring migration.

A digital image is a representation of a real image or an object such as a fabric sample. The image is regarded as a two dimensional array with elements known as pixels and it can be described by a function f (x,y), where the value of the function at any pair of coordinates x and y is the intensity of the light detected at that point.

A charge coupled device (CCD) camera can be used to generate an electrical signal that represents the intensities of the input image source. These electrical signals are digitized by an analogue to digital converter to form a digital image. The image of the yarn with the tracer fibre can be noticed on the PC screen,(Fig-2) and measurements, can be taken.

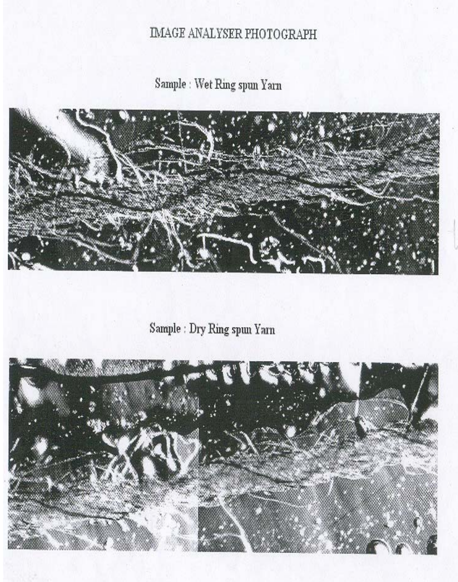


Fig - 2

Determination of migration parameters

The parameters suggested by Hearle *et al* (1969) were determined as follows: Mean fibre position representing the tendency of a fibre to be near the yarn centre or yarn surface

$$\bar{Y} = \frac{1}{z}\int_0^z Y dz = \frac{\sum Y}{n}$$

where $Y = \left(\frac{r}{R}\right)^2$ r = helix radius, R = radius, z = length along the yarn, n = number of observations.

Amplitude of migration representing the deviation from mean fibre position.

$$D = \left[\frac{1}{z}\int_0^z (Y - \bar{Y})^2 dz\right]^{1/2} = 3\left[\frac{\sum (Y - \bar{Y})^2}{n}\right]^{1/2}$$

(2)

Frequency of migration (cm^{-1})

$$\left(\frac{1}{4\sqrt{3D}} = \frac{1}{4A}\right)$$

where I = mean migration intensity representing the rate of radial change of the fibre.

$$I = \left[\frac{1}{z}\int_0^z \left(\frac{dY}{dz}\right)^2 dz\right]^{1/2}$$

A = Amplitude of migration

Z = Length of yarn taken for measurement (cm)
n = Number of observations

Migration intensity - This is the rate of change of radial position. For this the mean migration intensity is used

$$I = \left[\frac{1}{z} \int_0^z \left(\frac{dY}{dz} \right)^2 dz \right]^{1/2} = \left[\sum \left(\frac{dY}{dz} \right)^2 \Big/ n \right]^{1/2}$$

Yarn diameter, the vertical distance between the upper and lower yarn boundaries was also obtained.

Migration factor

Kim, Hug and Ryu (1999) have suggested another measure known as migration factor for characterizing fibre migration in yarns.

Migration factor = r.m.s. deviation x migration intensity

The higher the value of migration factor, the greater the migration.

Measurements

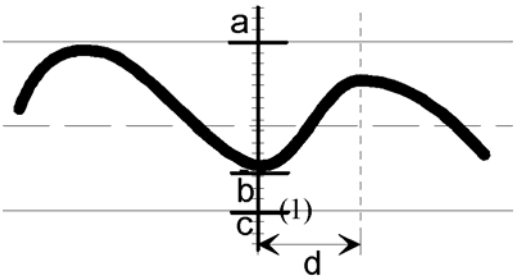
Measurements a,b,c & z were made at successive peak and trough of a traced fibre image have been made and diameter of yarn which is (c-a).

The number of observations was determined form the equation

$$n = \frac{t^2_{95\%} v^2}{E}$$

Where $t_{95\%} = 1.96$,
V = Coefficient of variation in percentage of observed samples, and
E = the error of estimation.

The number of tests was found to be 200, and the mean was found.



$$\frac{r}{R} = \frac{\left(\frac{a+c}{2} \right) - b}{\left(\frac{a-c}{2} \right)}$$

Testing of wet spun and regular yarns

Tensile tests on both regular and wet spun cotton yarns were performed on tensorapid. The wet spun yarns were dried and conditioned for weeks before taking for testing.

Results and Discussion

Table 1 lists the migration parameters obtained from 20 measurements taken each on 10 tracer fibres of dry and wet spun yarns.

The magnitude of migration in wet spun yarns is higher than those of dry spun yarns. This may be ascribed to the higher tension between the fibres and this will lead to a higher migration of fibres in the wet spun cotton yarns.

A higher value of mean fibre position would imply that the fibres move towards the surface. For ideal migration, the value of mean fibre position should be 0.5. The highest value of MFP (mean fibre position) is due to ribbon like twisting which takes place with the formation of spinning triangle, immediately after the front hip where high tensioned fibres on the edges of the spinning triangle immediately try to ease their tension by migrating towards the yarn core by displacing the relatively low tension fibres towards the yarn surface. Hence, fibre migration in wet spun yarns is from surface to the core and core to surface and thus fibres are crossing more concentric cycles and thus following a longer path which gives rise to higher value of MFP in yarn.

It is clear that the yarn diameter of wet spun yarn is lower than that of drying spun yarn due to greater packing of fibres(Table-2). The packing density of wet spun compact yarn is 0.4 as against 0.6 for the dry yarn.

Overall, the migration ratio(**Table-1)** shows a higher value for wet spun yarn (2.8561) as against the value of dry yarn (2.0331) which explains the increase in yarn tenacity given in (**Table-2)**

Table-1 Migration analysis summary of dry and wet spun yarn
(Count Ne40)

Parameters	Yarn Dia. Mm		Mean fibre position (Y)		RMS Devia. (D)		Migration intensity (I) cm-)		Equivalent migration frequency (cm-1)		Migration factor (cm-1)	
	Dry	Wet*	Dry	Wet*	Dry	Wet*	Dry	Wet*	Dry	Wet*	Dry	Wet*
Overall Mean	0.13761	0.12864	0.51789	0.54286	0.26223	0.29836	7.75326	9.73596	4.2676	4.71001	2.03314	2.8561
S.D. of Mean	0.01023	0.01289	0.16439	0.15994	0.04765	0.08074	2.19021	1.76916	-	-	-	-
C.V. % of Mean	7.43677	10.01944	31.74171	29.46210	18.16991	27.06099	28.24885	18.17138	-	-	-	-

Table- 2 Yarn characteristics

Yarn type	**U%**	**Thin places – 50% /km**	**Thick places +50% /km**	**Neps +200% /km**	**H index**	**Packing density g/cm3**	**Tenacity gf/tex**
Dry	18.67	915	2200	1795	5.97	0.39	13.82
Wet	18.45	945	2005	2020	2.68	0.60	16.04

Also the yarn hairiness Index–Zweigle (Wet yarn 2.68 and dry 5.97) shows that wet spun yarn was produced with less hairiness **(Table-3)**

Table-3 Hairness of dry and wet spun yarns (Zweigle)

Yarn	**1 mm**	**2 mm**	**3 mm**	**4 mm**	**5 mm**	**8 mm**	**10 mm**	**12 mm**	**15 mm**	**18 mm**	**21 mm**	**25 mm**	**S3 mm**	**Index mm**
Dry	11902	899.5	924.5	757.5	191.00	59.00	2.50	0.00	0.00	0.00	0.00	0.00	1934.50	243.00
CV	4	1.34	6.04	21.19	50.35	64.72	141.42	0.00	0.00	0.00	0.00	0.00	18.31	56.45
Wet	3283	352	133	50	8	1	0.00	0.00	0.00	0.00	0.00	0.00	192	6.5
CV	28.88	50.35	66.99	79.20	88.39	141.42	0.00	0.00	0.00	0.00	0.00	0.00	71.45	141.42

Conclusion

The wet spun cotton yarn is characterized by higher migration compared to dry yarns, and thus adequately explains the increase in strength and reduction in hairiness.

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