TWIST STRUCTURE AND QUALITY ASPECTS OF FRICTION SPUN YARNS IN RELATION TO FIBRE AND PROCESS PARAMETERS

by

SUDERSHAN DHAMIJA
Department of Textile Technology

Submitted
in fulfilment of the requirements of the degree of
DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

July, 1999

DEDICATED TO

MY PARENTS,

AND TO

MY WIFE SUNITA

AND SWEET KIDS

EKTA, RITIKA AND KSHITIJ

FOR THEIR AFFECTION, UNDERSTANDING

AND PATIENCE

CERTIFICATE

This is to certified that the thesis entitled *"Twist Structure and Quality Aspects of Friction Spun Yarns in Relation to Fibre and Process Parameters"*, being submitted by Mr Sudershan Dhamija to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by him. Mr Sudershan Dhamija has worked under our joint guidance and supervision and fulfilled the requirements for submission of the thesis.

The results contained in this thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

Prof K R Salhotra

Professor
Department of Textile Technology
Indian Institute of Technology, Delhi,
New Delhi - 110 016, India

Dr R Chattopadhyay

Associate Professor
Department of Textile Technology
Indian Institute of Technology, Delhi,
New Delhi - 110 016, India

Prof R C D Kaushik

Professor and Director
The Technological Institute of Textile & Sciences,
Bhiwani -127 021, India

ACKNOWLEDGEMENTS

With the culmination of the proposed work and compilation in this form, I have an opportunity to express my deep regards and profound sense of gratitude to my learned and most respectable supervisors Prof K R Salhotra and Dr R Chattopadhyay, Department of Textile Technology, Indian Institute of Technology, Delhi and Prof R C D Kaushik, Director, The Technological Institute of Textile & Sciences, Bhiwani for their invaluable guidance and inspiring advice throughout the course of this research work. But for their generous help and lasting encouragement, it would have not been possible for me to accomplish this task.

Sincere gratitude is extended to all the faculty members of Indian Institute of Technology, Delhi and The Technological Institute of Textile & Sciences, Bhiwani who not only encouraged and inspired but also put every effort to help me out.

I am indebted to the staff members of various laboratories at Indian Institute of Technology, Delhi and The Technological Institute of Textile & Sciences, Bhiwani especially Sh. O.P. Thukral, Mr. Partap Singh and Mr. Fakir Chand who have helped me directly or indirectly during the course of work. Thanks are also due to the library staff of The Technological Institute of Textile & Sciences, Bhiwani for providing me the necessary assistance during survey of literature for this work.

My sincere thanks are due to all the staff members of T I T S Mills, Bhiwani who have strained their every nerve to spare their productive preparatory machines for my experimental work.

I shall be failing in my duty if I do not mention about my friends especially Mr Ashish Garg, Mr R V Mahendra Gowda, Mr D K Shakyawar, and other research scholars who have extended their whole-hearted cooperation in different ways at different stages of this work.

It will be unpardonable act if I do not acknowledge my parents who have been a constant source of inspiration and motivation to me. It is privilege, in deed, to express my immense sense of gratitude to them.

Words elude me to express my indebtedness to my wife Sunita who has never boggled to extend her helping hand at every moment of need. I especially thank her for her patience, understanding and cooperation.

Finally, sincere thanks from the core of my heart are due to my little kids, Ekta, Ritika and Kshitij who have missed some wonderful moments they should have enjoyed with me.

Sudershan Dhamija

ABSTRACT

The process of yarn formation in friction spinning is such that the structural weaknesses (poor fibre orientation, inadequate packing, less migration and lack of binding between successive layers in DREF-II structures and the variability in core wrappings by the sheath fibres for DREF-III yarns) reported to be responsible for lower yarn strength, can hardly be overcome. An enhancement in yarn strength is expected through the manipulation of twist as there exists a good correlation between the two. However, adjustment of twist is a difficult task in friction spinning as the fibrous assembly is negatively driven by the friction drums. Friction ratio (the ratio of friction drum surface speed to yarn delivery rate) is an important twist-influencing parameter in both types of friction spinning i.e. DREF-II and DREF-III and can easily be adjusted through a change in drum speed or delivery rate or both. This was varied in a wide range from 1.7 to 7.1 to investigate its influence on strength and other yarn characteristics.

It has been seen that for DREF-II yarns, the plot of tenacity versus friction ratio is similar to that of tenacity versus twist for ring yarns. There is an optimum level of friction ratio at which the tenacity is found to be maximum. The breaking extension of these yarns is found to increase with increase in friction ratio. However, for DREF-III yarns both these parameters attain a more or less constant level after an initial rise with increase in friction ratio. Higher combination of drum speed and delivery rate for a constant friction ratio results in lower values of yarn tenacity and breaking extension for DREF-II yarns. On the other hand, for DREF-III yarns, the tenacity increases with increase in delivery rate and corresponding drum speed while

breaking extension stays constant after an initial increase. Further, irrespective of friction ratio, the DREF-II yarns spun at lower delivery rates are found to be more uniform whereas it is just the reverse for DREF-III yarns. In regard to abrasion resistance, DREF-III yarns are found to be superior to DREF-II yarns at all the friction ratios.

The mechanism of twist insertion in friction spinning is quite complex. To add this complexity is the measurement of yarn twist. Most of the established twist-testing methods have been found to be inaccurate for these yarns. A detailed study was undertaken to investigate the twist structure of Open-End friction spun yarns. The study is divided into two phases. The first phase concentrates on an accurate method of twist measurement and the second on the influence of some fibre and process parameters on the amount of twist inserted in these yarns.

It has been observed that for a given yarn, different twist-testing methods yield different twist values. Optical method, based on the measurement of fibre helix angle and helix diameter through the well known tracer fibre technique gives highest twist values. It can be considered to be the most accurate technique for measuring twist as it gives direct measure by observing the fibres in the yarn structure. Interestingly, these twist values have been found to correlate well with those given by other methods of twist testing. Corresponding correlation coefficients and the regression equations have also been derived.

Both the helix angle and the helix diameter have been found to vary for the fibres fed at different positions along the length of the fibre assembly zone. The fibres fed from a sliver position nearest to the yarn delivery and expected to integrate last on to the fibre assemblage assume the highest values. However, the yarn twist (i. e. turns/ unit length) is found to be the same from the core to the yarn surface. The twist level is observed to fall with increase in fibre length from 25 to 44 mm. The coarser yarns show lower twist than the finer ones. The use of coarser fibres results in lower amount of twist in the yarn while an increase in suction pressure increases it.

In respect of fibre frictional properties, it is seen that a 75:25 LV40/2152P combination for the added fibre finish that shows highest fibre frictional coefficients viz. fibre-fibre (μ_{FF}) and fibre-metal (μ_{FM}) amongst the three different types of compositions used, yields maximum yarn twist. There is an optimum level of fibre finish and opening roller speed at which maximum twist is inserted into the yarn.

The DREF-III yarn has a core-sheath structure. For such structure, it is not possible to measure twist by the traditional methods of detwist or detwist-retwist. Twist structure has therefore been investigated by optical method only. It has been observed that the twist received by the sheath fibres remains more or less the same irrespective of their position during assembling along the yarn formation zone at the nip of friction drums, an observation similar to that made for DREF-II yarns. However, the use of coarser fibres reduces the twist. Core fibres, instead of being straight and parallel to the yarn axis as generally expected, were seen to be twisted. Both the core and the sheath fibres twist have been found to increase with the increase in suction pressure. A decrease in core content increases the core twist while sheath twist drops after an initial increase.

In DREF-III spinning system, beside continuous filament, staple fibres can be introduced in the core as parallel fibres. This may produce better structural reinforcement at the interface of core and sheath fibres. In order to investigate the changes occurring in yarn characteristics with changes in the form of core i. e. filament and staple fibres in parallel as well as twisted form, DREF-III friction spun core yarns have been produced by wrapping a fibrous sheath of viscose rayon fibres around three different forms of polyester core viz. drafted fibre band, twisted yarn in Z- & S-direction and continuous multifilament yarn at varying levels of core/sheath ratio. It has been observed that the yarn tenacity, breaking extension and the resistance to abrasion increase with an increase in the proportion of core upto 70% irrespective of the form of core but the sheath-slipping resistance (resistance required to dislodge the sheath fibres from the core), in general, improves with an increase in sheath content. Further, Z-twist yarn core produces strongest yarn with comparable sheath slipping resistance while yarns spun with multifilament core exhibit highest breaking extension & resistance to abrasion (cycles to rupture). The introduction of drafted fibres as core shows an increased sheath-slipping resistance for DREF-III friction spun core yarns. Core content as well as form of core do not show any relationship with yarn unevenness.

In core-sheath structures, the coverage of core by the sheath fibres is an important aspect as it influences the yarn surface characteristics like feel, comfort and appearance. To study the appearance of DREF-III friction spun yarns in this respect, polyester (in three different forms viz. staple fibres, spun yarn and multifilament) and viscose (in the form of staple fibres) dyed in different colours were used for producing the core yarns. Core/sheath ratio was varied in the range of 15/85 to 80/20. The coverage of the core (purple colour) by the sheath fibres (golden colour) was judged subjectively by the presence of golden/purple colour on the surface of the yarn. The visual examination showed that it is not possible to hide the core completely even with a high sheath content of 85%. There was a general consensus on this point among the twelve judges who assigned the ranks to various yarn samples. The coefficient of concordance was 0.65.

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