

**INTERNAL AND SURFACE STRUCTURE
OF
ROTOR - SPUN YARN**

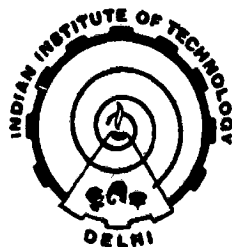
by

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submitted

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



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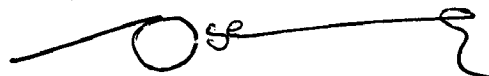
INDIAN INSTITUTE OF TECHNOLOGY, DELHI

JULY, 1991

CERTIFICATE

This is to certify that the thesis entitled "INTERNAL AND SURFACE STRUCTURE OF ROTOR SPUN YARN" submitted by Mr. Ajay Kumar Saxena 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. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard.

This thesis or any part thereof, has not been submitted, to any other University or Institution for the award of any degree or diploma.



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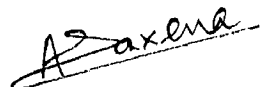
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(AJAY KUMAR SAXENA)

DEDICATED TO
MY
PARENTS

ABSTRACT

Man has come a long way from the early hand spindle, operating at 1000 - 2000 rpm to the rotor operating more than 100,000 rpm today. After 1828, a major breakthrough was made with the introduction of ring spinning system by John Thorps. The progress in the technology of spinning staple yarn remained more or less stagnant till the inception of rotor open end spinning system. However, after a relatively brief acceptance phase, it is now quite clear that rotor spinning has become an inseparable part of spinning technology. Among all fibres the one which seems to be gaining more and more popularity not only because of its novelty but for overall acceptance by consumers, is polyester. Therefore, many research workers have engaged themselves in a task of carrying out modifications in rotor spinning to make it suitable to be used for polyester fibre successfully. The problem of lower strength of polyester rotor spun yarn in comparison to that of ring spun yarn is still unresolved.

Moreover any change in machine parameters causes the change in fibre configuration inside the rotor groove and ultimately in the yarn structure. This change in configuration of fibre is finally responsible for yarn properties. As the fibre configuration at different stages of rotor spinning is the function of machine variables, it becomes necessary to study the fibre behaviour inside the rotor groove as well as in the yarn affected by machine variables.

For a systematic and self-explanatory study of fibre behaviour at different stages of spinning and yarn

characteristics, the present work is divided into twelve chapters. The objectives, methodology adopted and the important findings of each chapter are discussed. In the present work, polyester staple fibre of 38 mm length and 1.2 denier is used for experimental work.

Chapter 1 describes the general introduction of the problems carried out in the present research work.

Chapter 2 deals with the effect of sliver preparation on fibre disorder at rotor groove. Here, slivers of three different stages i.e. carded, first drawn and second drawn were used. Finally, 24 tex count were made. Modified Lindsley technique has been used to study the fibre orientation at rotor groove. On the basis of studies carried out, it is observed that fibre orientation at rotor groove is inferior to that in the feed slivers. Proportion of curved fibre ends in corresponding sliver and rotor groove ring decreases, while the coefficient of relative fibre parallelisation increases with the increase of drawframe passages.

In chapter 3, the approach for preparation of samples is discussed. Rotor speed, rotor diameter and opening roller speed have been taken as machine variables. Three levels of each variable have been considered for experimental work. In the present research work a 3-variables factorial design developed by Box and Behnken has been used.

Chapter 4 deals with the effect of machine variables on yarn characteristics. It is observed that an increase in the rotor speed, rotor diameter and opening roller speed reduces the yarn tenacity but the reduction is higher at higher rotor speed.

Breaking elongation decreases with an increase either in rotor speed or in rotor diameter but opening roller speed does not show any effect on it. Yarn uniformity improves with the increase in the rotor diameter but decreases with an increase in the rotor speed and opening roller speed. Number of thick places increases with the increase in the rotor speed and opening roller speed while it first increases then decreases with the increase in the rotor diameter. Number of neps increases with an increase in rotor speed, while an increase in rotor diameter first increases then decreases the number of neps. Thin places do not show any change with the change in machine variables.

Chapter 5 deals with the effect of machine variables on fibre orientation at rotor groove. To study the fibre orientation at rotor groove, modified Lindsley technique has been used and results are characterised on the basis of the values of proportion of the curved fibre ends (ϱ) and coefficient of relative fibre parallelisation (K_{rp}). It is observed that ϱ and K_{rp} have significant effect of rotor machine variables. The value of ϱ in forward and reverse direction increases with an increase in opening roller speed, rotor speed and rotor diameter; but the value of ϱ is more in forward direction. It is seen that the value of K_{rp} reduces with the increase in the rotor speed but with the increase in the opening roller speed, it first decreases and then increases. This trend is valid for both forward and reverse direction. The effect of rotor diameter on K_{rp} is more prominent from 36mm to 46mm rotor diameter in comparison to that from 46mm to 56mm rotor diameter.

Chapter 6 describes the effect of machine variables on fibre breakages and loss in fibre bundle strength at rotor groove. The rings were collected from the rotor groove and the mean fibre length and fibre bundle strength were measured. It is observed that an increase in opening roller speed increases the reduction in mean fibre length and loss in fibre bundle strength. The increase in the rotor speed does not show any effect on reduction in mean fibre length upto 60,000 rpm but onward the reduction is very much marked. The fibre bundle strength reduces with the increase in the rotor speed. The rotor diameter has not shown any significant effect on reduction in mean fibre length and fibre bundle strength.

Chapter 7 presents the effect of machine variables on the fibre reversal at rotor groove and in yarn. In order to study the fibre reversal, modified tracer fibre technique has been used. Fibres were dyed with their one half in red colour and other one in black colour using disperse dyes. The reversal of fibre at rotor groove was studied by taking out the ring from the rotor groove and it was observed under ultraviolet light; but in case of yarn, the tracer fibres were observed in an immersion liquid (67% α -bromo naphthalene and 33 % liquid paraffin).

It is observed that percentage of reversed fibres at rotor groove first increases then decreases with an increase in rotor speed; while on increasing the opening roller speed it increases. For higher rotor speed and higher opening roller speed, the increase in the percentage of reversed fibre is more. It is noticeable that opening roller speed is more responsible for fibre reversal. The reversal of fibres is reducing with the

increase in the rotor diameter from 36mm to 46mm; while it is almost constant for the change from 46mm to 56mm rotor diameter.

In case of yarn, it is observed that percentage of reversed fibres increases with the increase in the rotor speed, while the increase in opening roller speed and rotor diameter do not show any much effect. On comparing the fibre reversal at rotor groove and in yarn, it is observed that fibre reversal is more from rotor groove to yarn in comparison to that from feed sliver to the rotor groove; which indicates fibre peeling-off from rotor groove is more responsible for fibre reversal. It is also observed that opening roller speed and rotor diameter have a significant effect on contribution of broken fibres towards the fibre reversal. Results show that with the increase in the opening roller speed and rotor diameter, the fibre reversal of broken fibres increases while rotor speed does not show any effect on it.

Chapter 8 deals with the effect of machine variables on fibre-extent (spinning-in-coefficient) and type of hooks in yarn. The tracer fibre technique has been used for measurement. It is observed that an increase in the rotor speed, rotor diameter and opening roller speed reduces the value of the spinning-in-coefficient in yarn. An increase in opening roller speed reduces the percentage of straight fibres and leading hooks, but middle leading hooks increase. On the other side, increase in the rotor speed, reduces the percentage of straight fibres and leading hooks but middle leading hooks initially increases. Both end hooks first increase then decrease with the increase in the rotor speed and opening roller speed.

Chapter 9 deals with the effect of machine variables on twist efficiency. For measuring the twist, widely accepted untwist-retwist method has been used. It is observed that twist efficiency decreases with an increase in rotor speed and increases with the increase in the opening roller speed and rotor diameter. It is also observed that the twist efficiency increases at higher rotor speed and opening roller speed.

In chapter 10, the effect of machine variables on fibre packing in the yarn is discussed. It is observed that yarn diameter and packing coefficient have reciprocal relationship with the rotor machine variables. At a particular rotor speed and rotor diameter, packing coefficient initially decreases and then increases with the increase in opening roller speed. It is also observed that at a particular opening roller speed, upto 60000 rpm rotor speed, packing coefficient first decreases then increases with an increase of rotor diameter. But on further increase in rotor speed, packing coefficient increases continuously with rotor diameter.

Chapter 11 deals with the effect of machine variables on the configuration of neps and thick places. First of all, we collected the neps and thick places on Uster Evenness tester by using the selectors as neps and thick places respectively. Then we examined these under the projection microscope and putting them under different groups, according to their configuration. Neps are just classified into 6 groups as - Abraded neps, Unopened neps, Fused-fibre neps, Loose-belt neps, Tight-belt neps and Abraded-belt neps. On the other hand, thick places were put into 4 groups as Surface-clustered, Abraded, Unopened and Belt.

It is observed that an increase in opening roller speed increases the number of abraded neps, loose-belt neps, abraded-belt neps, surface-clustered thick places, unopened and abraded thick places, while unopened and fused-fibre neps decrease. Tight-belt neps and belt thick places do not show any influence of opening roller speed. At the same time, the number of abraded-belt neps, unopened neps, fused-fibre neps, loose-belt neps, belt thick places, unopened and abraded thick places increase by an increase in rotor speed. But abraded neps, tight-belt neps and surface-clustered thick places are not influenced by rotor speed. It is also seen that the increase in rotor diameter increases the abraded thick places, while the number of unopened and fused-fibre neps and unopened thick places decrease with larger rotor diameter. On the other hand, abraded neps, loose-belt neps, tight-belt neps, abraded-belt neps, belt and surface-clustered thick places do not show any noticeable effect of rotor diameter.

Finally, the chapter 12 deals with the simultaneous effect of various structural parameters on yarn tenacity and unevenness. It is concluded that yarn tenacity and unevenness are greatly influenced by spinning-in-coefficient and percentage of straight fibres in yarn. The value of correlation coefficient shows a sound reasonable agreement between the actual and calculated values of yarn tenacity and unevenness and thus confirmed the reliability of the regression equations developed based on least square method.

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