STUDIES ON AIR-JET TEXTURING OF SPUN YARNS

by

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CERTIFICATE

This is to certify that the thesis entitled 'Studies on Air-Jet Texturing of Spun Yarns', submitted by Mr. J. Srinivasan to the Indian Institute of Technology, Delhi, for the award of Degree of Doctor of Philosophy is a record of the bonafide research work carried out by Mr. J. Srinivasan. He has worked under our guidance for the submission of this thesis, which to our 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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DEDICATED TO MY PARENTS

ABSTRACT

An attempt has been made to establish the suitability of the air-jet texturing process to bulk short staple spun yarns to improve their comfort related properties. It has been found that both the jet types namely the conically convergent-divergent and cylindrical jets are successful in opening up and texturing twisted yarns of both 'Z' and 'S' twist directions, and the direction of twist in the supply yarn has no influence on texturability. Further, a certain level of torque is needed in the twisted yarns to render them texturable as little bulk is developed in a twist set yarn. As the current theories of air-jet bulking do not envisage the rotation of the yarn in the air stream, which have been the basis of earlier hypotheses built around bulking of pre-twisted feeder yarns, it is pertinent to question how the modern jets are able to untwist and separate the filaments from the twisted bundle before they are individually bent into looped configurations. After re-examining all the theories, concerning the sequences of operations leading to bulking in the air-jet texturing process, an attempt has been made to outline the most probable mechanisms for bundle opening, loop formation and structural integration of the individually looped filaments. The suggested mechanism for bulking is universally applicable for zero twist and pre-twisted feeder yarns with either direction of twist and can be used to explain the mechanism of bulking for staple spun yarns.

After establishing that the new air-jet texturing nozzles can also texture twisted continuous filament yarns, the suitability of these jets to bulk short staple spun yarns is tried. At high levels of overfeed and air pressure conditions recurring thread breaks are observed and thus the process conditions are suitably modified to arrive at satisfactory performance levels. At relatively lower levels of overfeed and air pressure, encouraging results are obtained with cylindrical type of air-jet texturing nozzles and, thus, this type of nozzle is used for further studies. It is, however, observed that processing of spun yarns is much easier if a continuous filament yarn is introduced in the spun yarn structure at the spinning stage and therefore initial investigations are carried out using cotton/filament composite yarns where filament yarn forms about 10% of constituents by weight.

An investigation into texturing of spun yarns using the process of air-jet texturing, comparing the parent and textured composite yarn properties and the functional and comfort properties of both woven and knitted fabrics made described from parent as well as textured yarns is carried out. Fabrics made using air-jet textured yarns show considerably higher thermal insulation and reduced air permeability. Tensile and bursting strengths decrease with the use of air-jet textured yarns, but abrasion resistance improves. The results indicate that air-jet textured spun yarns have good potential for use where thermal comfort and softness of handle are of importance major requirements. Further, in order to ascertain whether the structural integrity of these yarns remain unimpaired in the fabrics after being subjected to repeated cycles of washing and drying - a useful requirement for their acceptability towards apparel end-uses - fabric properties are analysed after various numbers of laundering cycles. It is found that the tensile and bursting strength properties of the fabrics are not affected much by the laundering treatments. The textured yarn grey fabrics, in general, show higher relaxation by laundering, thereby resulting in increased thickness, thermal insulation, abrasion resistance with reduced air permeability and tear strength. The greater strain relief due to laundering of the bulkier textured yarn structure also helps in improving the crease recovery and wrinkling properties of fabrics made from these yarns. Fabrics made with textured yarns show higher wrinkle recovery than the parent yarn fabrics at various levels of strain applications. The extent of gain in whiteness of grey fabrics and loss in colour of dyed fabrics is almost the same in both the parent and textured yarn fabrics as a consequence of laundering treatments. The textured yarn fabrics, however show higher colour value than the parent yarn fabrics.

The ease of texturability of various spun yarn structures like carded spun, combed spun, siro spun, carded and combed composite spun, wrap spun and rotor spun yarns have been analysed. The yarn structures, after texturing, result in improved bulk, reduced modulus and flexural rigidity, thus rendering them suitable for improved comfort applications. Increased bulk of the different yarn structures after texturing is accompanied with a reduction in strength properties. It is observed, in general, that yarns with lesser fibre cohesion and interfibre friction, lesser packing and less homogeneous fibre arrangement in the yarn structure produce higher bulk during air-jet texturing. Carded spun yarn which has a low packing gives rise to high level of bulk during texturing. Rotor spun yarns result in a lower level of physical bulk as the constituent fibres do not easily separate due to the yarn's tripartite structure, twist angle variations and alternating twist in the fibre belts. Siro spun yarn which has little or no twist in the individual strands can be textured with relatively higher level of bulk. The structures which are capable of withstanding high air pressures due to higher structural reinforcements like composite spun, wrap spun and rotor spun yarns can be processed using higher overfeed and higher air pressures to improve their relative bulk levels. The effects of process variables viz. texturing overfeed, air pressure and feed material variable viz. yarn twist, on the important properties of air-jet textured yarns of different structural configurations have also been examined analysed. For this, a factorial design approach where factors are varied simultaneously in order to find the individual as well as interaction effects has been adopted. Using this experimental design, general relationships relating the properties with variables as also the significant terms in these relationships are computed, and the response surface designs are evolved graphically. In addition, yarn identity diagrams focussing the major quality parameters have been presented for the optimum processing conditions to compare the responses of different spun yarn structures towards bulking with the use of the air-jet texturing process.

The importance of yarn structural variants such as fibre packing density, fibre fineness and fibre length distribution, mean fibre extent and migration parameters in deciding the bulking potential of a spun yarn structure in air-jet texturing has also been studied. Three variants of carded yarns, combed yarns and yarns made from combed sliver which is again carded in both hundred percent spun and composite spun forms with three different twist levels show that the fibre to fibre distance and interfibre friction may have significant influence on the relative local velocities of the fibres in the turbulent air stream which would affect the texturing behaviour. It has been observed that spun yarns with uniform fibre length distribution, higher fibre extent and more fibre parallelisation such as combed yarns result in lesser bulk during texturing. Yarns with higher packing and migration result in higher interfibre friction with lesser fibre to fibre distance and are therefore subjected to reduced flow asymmetry, thus producing air-jet textured yarns with reduced bulk.

The effect of feeder yarn twist on the texturing performance of both filament and spun yarns has been studied. The air-jet textured yarns produced from twisted filament yarns show lower physical bulk than no-twist yarns but they give lower instability and higher tenacity than the air-jet textured yarns produced from no-twist feeder yarns. Yarns with higher twist level result in reduction in physical bulk and instability and higher tenacity after texturing. In the spun yarn structures also, higher twist results in reduction in physical bulk but enhances stability and tenacity. Thus, the twist in the feed yarns results in higher structural integrity of the textured yarns. Further, a comparison of properties of both yarns and fabrics of no-twist filament yarns (NT yarns) with equal level of physical bulk as that of the twisted filament yarns (both ZT and ST) has been presented. In general, the twisted textured yarns give rise to stronger and structurally more stable yarns and fabrics with higher tensile strength and crease recovery.

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