INFLUENCE OF FEEDER YARN CHARACTERISTICS ON STRUCTURE AND PROPERTIES OF POLYPROPYLENE DRAW-TEXTURED YARN

by
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CERTIFICATE

This is to certify that the thesis entitled **"Influence of Feeder Yarn Characteristics on Structure and Properties of Polypropylene Draw-Textured Yarn"** being submitted by Mr. Ranjit Kumar Datta 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. Ranjit Kumar Datta has worked under our joint guidance and supervision and fulfilled the requirements for the submission of the thesis.

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

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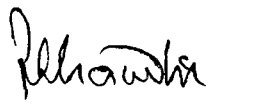

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ABSTRACT

Polypropylene has established itself as a very useful industrial and household fibre. However, it has not made any significant impact in the apparel sector mainly due to its waxy and clammy feel, hydrophobicity and the absence of dye sites. Textured polypropylene yarns, on the other hand, show a great deal of promise in the apparel end-use because of improved feel and increased water retention and comfort. Polypropylene has generally been considered a difficult fibre to texturize owing to its high crystallizing tendency. Most of the detailed work on texturing has, however, been carried out on fully drawn yarns which obviously have a fully developed crystalline structure.

In the present study, spin-draw technology, which hitherto has been used for producing high tenacity flat yarns, has been examined as an alternate route for producing feeder yarns for draw-texturing. In addition, the high speed spinning process has also been investigated. It has been established that by changing the spinning parameters, yarns with a wide range of mechanical properties can be produced which is a direct consequence of changes brought about in the morphology of yarns thus spun. In order to study the effect of the spinning process parameters, the nominal draw-down ratio in the spinning zone was kept constant for major part of this study.

The present work may be divided into three broad areas:

a) Production and characterization of polypropylene feeder yarns : The yarns have been produced by both spin-draw and high speed spinning processes. The effect of spinning speed and/or on-line draw ratio has been investigated in detail. The structures of these yarns have been characterized by WAXS, birefringence, crystallite and amorphous orientation, sonic modulus, DSC, density, etc., while the mechanical properties have been evaluated through tenacity, elongation, initial modulus, yield stress, etc. The effect of molecular weight of polypropylene on spinnability and subsequent yarn properties too, has been studied. It has been convincingly demonstrated that yarn properties can be engineered to a great extent through micro-structure control to suit the end-use requirements.

(b) Draw-texturing of polypropylene feeder yarn : Feeder yarns suitable to meet the requirements of friction draw-texturing have been produced by both the spinning processes. Draw-texturing process was optimized with respect to the following process parameters :

- o Heater temperature
- o Contact time (in the heater)
- o D/Y ratio
- o Draw-ratio (during texturing)

As a result of the differences in feeder yarn properties, the texturing parameters needed to be changed. For instance, residual draw of the parent yarn determines the texturing draw-ratio. Factorial design as well as the conventional techniques have been used for optimisation.

The textured yarns have been evaluated for crimp properties, namely, crimp rigidity, crimp contraction force, crimp stability, etc. Structural and mechanical properties have also been investigated. Molecular weight of the polymer has been found to affect the texturizability of the yarns. For instance, high speed spinning process is not conducive for producing POY from high molecular weight (MFI = 11) polypropylene and the yarn thus produced is not found suitable for draw-texturing. On the other hand, a high molecular weight polypropylene can be made through the spin-draw route to produce textured yarns of acceptable quality.

(c) Effect of colourants on spinnability and texturizability : Polypropylene cannot be dyed and hence, to-date mass colouration remains the only viable alternative. The colourants affect the rate of crystallization and change the morphology of the feeder yarns. In addition, as the colourants are generally used in the form of masterbatches which also contain low molecular

weight carrier polymer, the carrier is also expected to influence the morphological structure. In the present work, the effect of incorporation of colourant in the form of masterbatch has been investigated. The structural and mechanical properties show significant changes which consequently affect the texturizability; spinning and texturing parameters, therefore, need to be altered suitably.

In brief, this study also reveals that between the spin-draw and the high speed spinning processes the former is a more versatile technique and offers greater flexibility in terms of molecular weight of polypropylene, both in the presence and the absence of colourants. Feeder yarns, thus produced, are texturizable at speeds used in commercial practice.

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