

Studies on Simultaneously Draw-Textured Polyethylene Terephthalate Slit Film Yarn

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Received 2 November 1981; accepted 18 December 1981

Polyethylene terephthalate slit film yarn, which was crystalline and partially oriented, was simultaneously draw-textured on a spindle false-twist texturing machine under standard conditions of texturing at three different draw ratios. The textured samples were heat-set in hot water. The extent of stretch imparted to the yarn during texturing has a considerable influence on the crimp retraction characteristics; higher stretch results in lower crimp retraction, but improved crimp stability. The strength of the textured yarn with higher stretch is also higher. A stretch of 100% results in a textured yarn with acceptable characteristics.

Yarns produced from slit films can have certain advantages, particularly in terms of economics, over the conventional multifilament yarns produced by spinning and drawing or high speed spinning. It was, therefore, considered worthwhile to explore the possibility of producing textured yarns from these coarse yarns. Since the yarn was crystalline and partially oriented, both the possible routes for the production of textured yarn were used. One set of textured yarns was prepared by first stretching the slit film yarn by 100% (draw ratio, 2) at different temperatures and then texturing the drawn yarn on a spindle false-twist texturing machine. The results of this study, which are mainly concerned with the effect of the drawing temperature of the feeder yarn on the characteristics of the textured yarn, will be published elsewhere¹. The second set of samples was prepared by stretching the parent yarn by 50, 75 and 100% respectively while simultaneously texturing it under standard conditions. The results of this study, which are mainly concerned with the effect of the stretch imparted during texturing on the characteristics of the textured yarn, are presented in this paper.

Weinsdoerfer and Egbers² studied the simultaneous draw-texturing of conventional polyethylene terephthalate (PET) yarn (circular cross-section) and concluded that the stretch imparted during texturing has an important effect on the characteristics of the textured yarn. The present studies show that the draw ratio is also important in the case of slit film yarns (rectangular cross-section). However, the textured yarns produced by this method as well as by the conventional false-twist method have a harsh feel, apparently due to the rectangular cross-sectional

geometry of the filaments which have sharp edges. Since this aspect has not been studied, no comments are made on it.

Experimental Procedure

Sample preparation—PET slit film yarn 580/10/2/12 (580 denier, 10 filaments, a twist of 2 turns per inch and 12 μ m thickness) was used. It was manufactured and supplied by Garware Nylons, Bombay. The yarn was crystalline, but had low orientation. It was simultaneously draw-textured on Scragg CS-12 minibulk stretch yarn machine, which has one heater, by modifying the feed unit drive to reduce its speed in relation to that of the take-up roller, so that the required draw could be achieved. The yarn was simultaneously draw-textured at three draw ratios, viz. 1.50, 1.75 and 2, under the following conditions: heater temperature, 185°C; heater contact period (calculated), 1.77 sec; spindle speed, 60,000 rpm; twist level, 45 tpi; cooling period (calculated), 0.46 sec; and overfeed in winding zone, 1%.

The as-textured samples were relaxed in water to overcome the temporary set and release the latent crimp at 90-95°C for 20 min under free conditions. The measured deniers of the textured yarns were 408, 390 and 310 for draw ratios 1.50, 1.75 and 2 respectively.

Structural studies—Scanning electron micrographs of the cross-sections of the textured yarns were taken on a Cambridge Stereoscan S4-10. Shadowgraphs of the longitudinal sections of the textured yarns were taken with the help of a photographic enlarger on which the yarn was mounted under a load of 0.002 gpd.

The X-ray crystallinity of the samples was determined using Farrow and Preston's method³. The

crystallite orientation was measured from the azimuthal intensity scan of the (100) reflection by expressing its half width as a reciprocal.

Measurement of crimp retraction and crimp stability—The crimp retraction was measured by a method based on the HATRA method⁴. The test involved measurement of hank lengths in air at room temperature at tensions of 0.002 and 0.1 gpd.

The crimp stability was measured by subjecting the samples to (i) a cyclic loading test to their respective decrimping loads (25-30 g) on an Instron tester and expressing the percentage crimp stability as the ratio of the areas of hysteresis loop for the tenth to the second cycle multiplied by 100, and (ii) to dead loads of 1 gpd for 8 hr followed by relaxation for 40 hr. The retention of percentage crimp retraction was taken as a measure of crimp stability. All the measurements were made in a temperature- and humidity-controlled laboratory.

Measurement of tensile characteristics—Load-elongation curves of the multifilament yarn samples were obtained on an Instron universal testing instrument Model 1112. Samples of 5 cm gauge length were mounted under a tension of 0.002 gpd and extended at 100% per min. Load was converted to stress using the measured values of yarn deniers. From the stress-strain curves, the decrimping extension, initial modulus, tenacity and the elongation at first break were computed using the usual procedures⁵. The sonic modulus was determined on the pulse propagation metre PPM-5R at 5 kHz.

Results and Discussion

The cross-sections of the parent and the textured yarns are shown in Fig.1. It is clear from these micrographs that the initial flat filaments in the yarn are distorted considerably on texturing. Fig.2 is a shadowgraph of the water-relaxed, textured slit film yarn (draw ratio, 2) and has been included to illustrate the crimp geometry.

The X-ray crystallinity increased on texturing from about 39% for the parent yarn to around 44% for the textured samples; the effect of draw ratio on crystallinity was rather small. The crystallite orientation (reciprocal of half width) also increased on texturing and it registered an increase with increase in draw ratio (Fig.3). The sonic modulus shows a considerable increase with increase in draw ratio (Fig.4). Since sonic modulus is related to orientation^{6,7}, it may be concluded that during texturing, as the stretch applied increases, the tension increases and

the molecules, which have considerable mobility at the texturing temperature, get progressively more aligned.

The crimp retraction and decrimping extension data show a decrease in crimp retraction with increase in draw ratio (Fig.5). The crimp stability data, on the other hand, show an increase in crimp stability with increase in draw ratio (Fig. 6).

To explain these results, it may be recalled that as the draw ratio increases, the orientation of the molecules

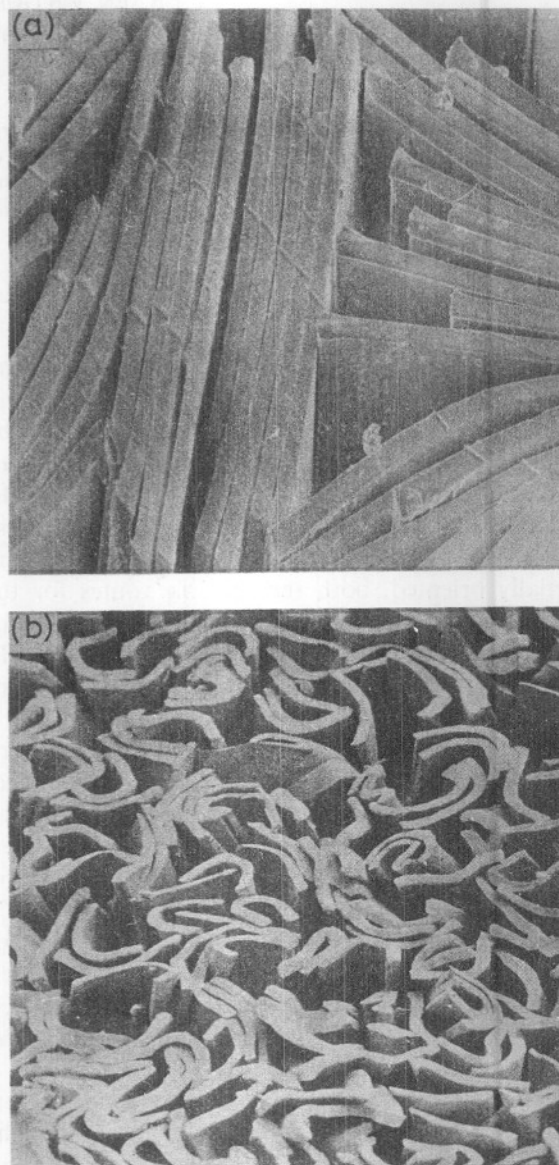


Fig. 1—Scanning electron micrograph of the cross-section of (a) parent yarn, and (b) simultaneously draw-textured yarn (draw ratio, 2)

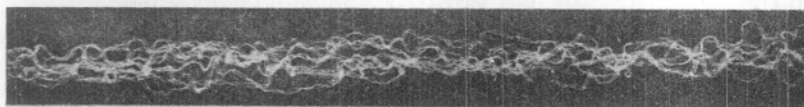


Fig. 2 Shadowgraph of the simultaneously draw-textured yarn (draw ratio, 2)

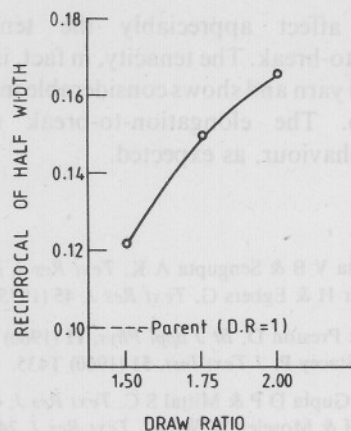


Fig. 3—Crystallite orientation (reciprocal of half width) of the simultaneously draw-textured yarn as a function of draw ratio

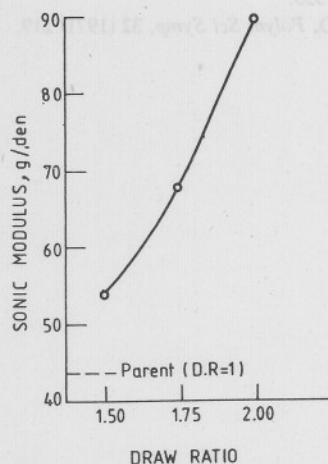


Fig. 4—Sonic modulus of simultaneously draw-textured yarn as a function of draw ratio

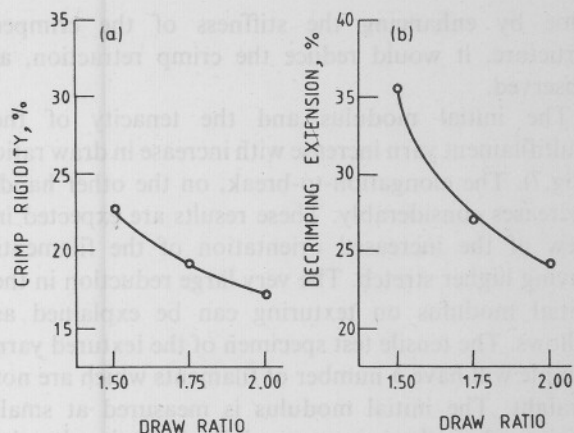


Fig. 5—Crimp retraction characteristics of simultaneously draw-textured yarn (a) crimp rigidity, and (b) decrimping extension

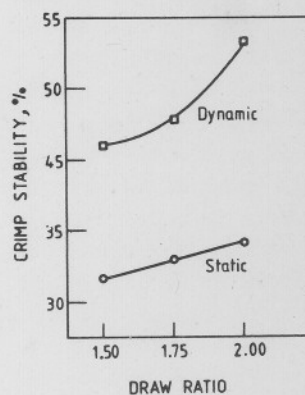


Fig. 6—Crimp stability characteristics of simultaneously draw-textured yarn

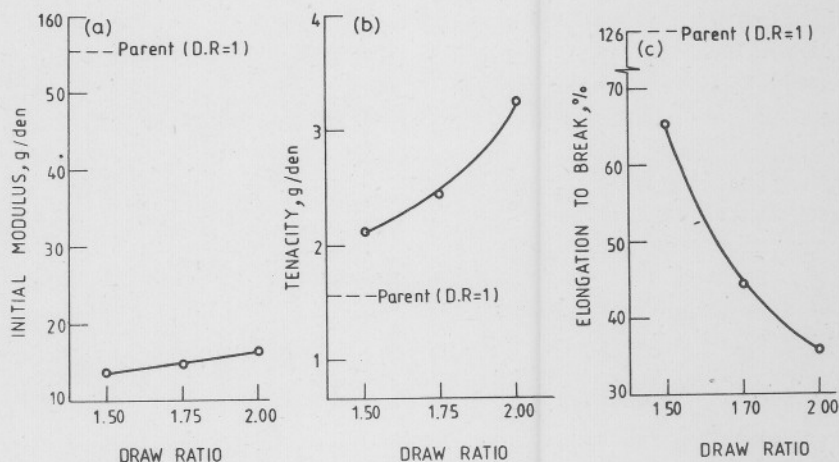


Fig. 7—Mechanical properties of the simultaneously draw-textured yarn (a) initial modulus, (b) tenacity, and (c) elongation-to-break

registers a considerable increase, though crystallinity does not show any appreciable change. Increase in molecular orientation promotes crystallization⁸. However, the high tension prevailing in the texturing zone impedes crystallization⁹. At higher draw ratios,

the tension can be very large². The net effect may be that crystallinity does not change, though considerable changes, e.g. in crystal size and their distribution, will be expected. Increased molecular orientation results in more cohesion. This improves stability, but at the same

time by enhancing the stiffness of the crimped structure, it would reduce the crimp retraction, as observed.

The initial modulus and the tenacity of the multifilament yarn increase with increase in draw ratio (Fig. 7). The elongation-to-break, on the other hand, decreases considerably. These results are expected in view of the increased orientation of the filaments having higher stretch. The very large reduction in the initial modulus on texturing can be explained as follows. The tensile test specimen of the textured yarn sample will have a number of filaments which are not straight. The initial modulus is measured at small strains when there is unequal load sharing by the filaments. This point has been explained in detail elsewhere⁵ for conventional textured yarns. At larger strains, the load sharing is more uniform and hence

does not affect appreciably the tenacity and elongation-to-break. The tenacity, in fact, is higher for the textured yarn and shows considerable increase with draw ratio. The elongation-to-break shows the opposite behaviour, as expected.

References

- 1 Sen A, Gupta V B & Sengupta A K, *Text Res J*, in press.
- 2 Weinsdoerfer H & Egbers G, *Text Res J*, **45** (1975) 654.
- 3 Farrow G & Preston D, *Br J appl Phys*, **11** (1960) 353.
- 4 Fitton S & Stacey P, *J Text Inst*, **51** (1960) T435.
- 5 Gupta V B, Gupta D P & Mittal S C, *Text Res J*, **48** (1978) 446.
- 6 Charch W H & Moseley W W (Jr), *Text Res J*, **24** (1959) 525.
- 7 Moseley W W (Jr), *J appl Polym Sci*, **3** (1960) 266.
- 8 Spruiell J E, McCord D E & Beuerlein R A, *Trans Soc Rheol*, **16** (1972) 535.
- 9 Statton W O, *Polym Sci Symp*, **32** (1971) 219.