Tensile Behaviour of Multifilament Yarns at High Twist Levels

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The twist tenacity curves for twisted multifilament yarns, predicted by the analytical model, depart substantially from the theoretical plot due to the melding (merging) of the filaments under high twist levels. On the occurrence of melding the load-sharing property of individual filaments is improved. At points of melding, the load tends to be shared by the concerned filaments jointly.

Keywords: Melding, Multifilament yarn, Tensile behaviour, Yarn tenacity, Yarn twist

Twist in multifilament yarns causes radial forces which bind the filaments together. However, under stress the filaments, which have followed a longer path, are strained more than those which have followed a shorter path. Thus, the load shared by the different filaments is not equal. But, had the load been shared by the filaments jointly, the tensile strength of the yarn would have been more, leading to the maximum filament strength utilization at the point of rupture which would have been catastrophic. However, if the filaments had been melded (merged or combined) together, the problem of load sharing would have been dramatically improved upon.

A multifilament polyester yarn of 76 den/36 filaments/0 twist was chosen for the experiment. The yarn was twisted on a doubling frame (Textool). Five twist multipliers (tex/2 × turns/cm) of 11.97, 12.78, 15.34, 16.68 and 19.17 were chosen for the test. The tensile strength of the yarn samples was measured on an Instron universal testing machine at a gauge length of 5 cm and cross-head speed of 10 cm/min. Twenty-five readings were taken for each twist multiplier. The observed values of tenacity were plotted against the twist multiplier. The theoretical values of tenacity, calculated using the equations developed by Hearle et al., were also plotted against twist values. Fig. 1 shows that the theoretical values of tenacity are marginally higher than the experimental values up to an optimum level of twist after which the gap between theoretical and experimental values increases, the latter being higher. It is possible that at higher TM the melding of filaments occurs, causing better load sharing due to reduced slippage over surfaces.

The melding of filaments is substantiated by another significant observation. In zero twist multifilament yarn, the breakage occurs in steps whereas in low twist yarns, the individual filaments behave independently and interface slippage occurs but at high twist levels, a sharp break is noted. There is a departure from the stepped to the catastrophic simulating, the character of a continuum of ‘fused monofilaments’. Because of melding the filaments act as one strand and the load-sharing property is im-

Fig. 1—Effect of twist on tenacity of multifilament yarns

Fig. 2—Rupture phenomena in multifilament yarns as a function of twist
proved. At 12.78, 15.34 and 16.68 TM, some filaments can still slip (the stepped break points) just before breakage (Fig. 2). However, in the case of high twist multiplier yarns (19.17 TM), the breakage is like that of a single filament.

References