Effect of Filament Characteristics and Processing Variables on the Characteristics of Air Textured Nylon 6 Filament Yarn

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Nylon 6 multifilament yarns were air textured in a laboratory scale air texturing unit. Parameters like pre-twist, overfeed and air pressure were varied and their effects on yarn characteristics, such as percentage increase in linear density, loop size and frequency, percentage physical bulk, percentage instability and tenacity were evaluated. The data were statistically analysed for the effect of variables on yarn characteristics. Percentage increase in linear density, loop frequency, percentage physical bulk and percentage instability increase with increase in air pressure, while loop size and tenacity decrease. With increase in pre-twist level, percentage increase in linear density, loop frequency and percentage physical bulk increase, while loop size and tenacity decrease. Percentage instability decreases first and then increases with increase in pre-twist.

Commonly, textured yarns are classified into the following three groups based on their physical characteristics: (1) Stretch yarns, (2) modified stretch yarns, and (3) bulk yarns. Bulk yarns combine greatly increased mass or bulk in the limited stretch and impart to fabric and garments soft, full hand and ability to adequately recover from extension. There are many distinct types of bulk yarn processes in practice such as stuffer box bulking, turboduo-twist bulking, air jet bulking, etc. Air jet bulking is basically a mechanical method involving overfeeding of the filament yarn through a turbulent air stream which transforms the excess length into a series of random loops along each filament. On emerging from the air jet, the yarn bundle collapses and the looped filaments become locked in place by inter-filament friction. The stable structure so formed resembles a spun yarn and is characterized by greater bulk, better covering power, a more subdued lustre and a warmer hand compared to a continuous filament yarn in its untextured form.

Even though the air jet bulking technique has been in use since 1955, there are very few published reports on it. The effect of processing variables on air textured continuous filament yarn was studied by Wray and Price. The effect of false twisting in the air bulking process was reported by Wray and Entwistle. Physico-mechanical tests were carried out for both air textured yarns and the corresponding parent filament yarns by Rozmarynowska and Godek who reported that the air bulking operation does not cause permanent deformation of the filament. The inclined yarn guide needle jet was used to air texture the filament in the above mentioned studies.

In the present investigation, yarn texturing jet of the type having an elongated housing with a venturi supported in one end having conical opening on both the entrance and exit and a yarn guide needle positioned in the other end, was used.

The following feed material and processing variables influence the characteristics of air textured yarns: (1) Frictional coefficient of filaments, (2) filament denier, (3) total denier, (4) pre-twist level, (5) texturing speed, (6) percentage overfeed, (7) feed tension, (8) delivery tension, (9) air pressure, and (10) air flow rate.

The present investigation is an attempt to study the effect of pre-twist level, percentage overfeed and air pressure on air textured yarn.

Nylon 6 filament yarns with different twist levels were used as feed material. For this purpose, a laboratory scale air texturing unit was fabricated and the experiments were carried out at the texturing speed of 60 m/min.

The air textured samples were tested for the following yarn characteristics: (i) Linear density, (ii) loop size, (iii) loop frequency, (iv) percentage physical bulk, (v) percentage loop instability, and (vi) tenacity.

Materials and Methods

Materials—Semi-dull Nylon 6 filament yarn of 100 denier 24 filaments was used. The yarns were twisted to the levels of 10, 15 and 20 per in, Z direction; steaming treatment was given for 45 min to set the twist.
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Results and Discussion

The data are presented in Figs 2-7. The results of statistical analysis for F test are given in Table 1.

Equipment—The equipment used (Fig. 1) had the following components: (1) Bobbin holder, (2) tensioner, (3) feed roller, (4) air jet, (5) delivery roller, and (6) take-up system.

Method—The twist set filament yarns from the bobbin were fed through the tensioner and the overfeed roller to the air jet. The textured yarn was taken out at right angles to the air stream by delivery rollers and wound on the cheese under tension. The overfeed was varied from 20 to 30% and the air pressure from 45 to 75 psi.

Testing procedures—Linear density was calculated by weighing 90 m yarn. The loop size in mm and loop frequency per in were measured using the projection microscope with the magnification of 20. The loop size was calculated as follows:

\[
\text{Loop size, mm} = \frac{\text{Overall diameter - Yarn core diameter}}{2}
\]

For determining physical bulk, 200 g of the textured yarn and the same weight of the corresponding untextured filament yarn were wound on two different cheeses under the same winding tension. The thickness of the material on both the cheeses was measured and the percentage increase in physical bulk was calculated as follows:

\[
\text{Physical bulk, } \% = \frac{\text{Diam. of textured yarn package} - \text{Diam. of empty cheese}}{\text{Diam. of the parent yarn package} - \text{Diam. of empty cheese}} \times 100
\]

For determining instability, a simple instability tester consisting of a vertical stand with a yarn toggle clamp at the top, and a marking notch at a distance of 1 m below, with a small centimetre scale beneath it was used. Provision was made for hanging weights on the specimen to be tested by means of a hook and a weight holder. This arrangement was set up as stated by Wray. A 100 cm length of yarn was subjected to a load of 0.33 g/den of the textured yarn for 30 sec and the instability was recorded as the percentage permanent increase in length after the load had been removed.

Tensile strength was tested in the Good brand single thread strength tester. The rate of traverse was 12 in/min. The 12 in gauge was used. Tenacity (gpd) was calculated from the single thread strength.

Fig. 1—Air texturing unit [(1) Bobbin holder; (2) tensioner; (3) feed roller; (4) air jet; (5) delivery roller; and (6) take-up system]
**Linear density**—It is evident from Fig. 2 that the percentage increase in linear density varies with pre-twist, overfeed and air pressure. This is contradictory to the findings of Wray who reported that the effect of overfeed on the percentage increase in linear density was linear and that pre-twist and air pressure had little effect. The results of the present study show that the linear density increases with increase in pre-twist level and air pressure for a particular percentage overfeed. This confirms the findings of Rozmarynowska and Godek who reported that the overfeed effect was not...
higher pressure for a low pretwisted yarn, the loop size increases with increase in percentage overfeed. This would result in a marked influence on the number of loops formed and bringing more of them to the surface of the yarn. But in the case of low percentage overfeed, higher air pressure is needed to form more loops. (At 10 tpi, 70 lb frequency value may be experimental error.) When the pressure and the percentage overfeed are increased, the number of loops formed and the increased number of buried loops due to high filament deflection. The saturation point for increased loop formation and the burying in the yarn core varies with pre-twist, overfeed and air pressure.

Physical bulk—It is clear from Fig. 5 that the physical bulk increases with increase in percentage overfeed, pre-twist level and pressure. Wray\(^1\) reported that overfeed is the greatest single factor affecting physical bulk, since it causes higher loop size and loop frequency. But at a particular percentage overfeed, the higher pressure helps in the formation of greater number of loops and also in accommodating all the available length of filaments due to overfeed. When the twist increases, yarn contraction increases. Hence, the yarn density decreases and the loop formation increases. These contribute to higher bulk even after balancing the loss in bulk due to reduction in loop size. The F test analysis (Table I) also reveals that the overfeed, pre-twist and pressure influence the physical bulk. Even at low pressure, if the overfeed is more, the yarn gets bulked due to the formation of a large number of loops.
number of loops and their higher size. The above effect is accelerated in the case of material of very high twist due to the higher twist contraction. In the case of high percentage overfeed and high twisted yarn, the effect of air pressure is not pronounced, which may be due to the balancing of the increased number of loops by the reduction in loop size.

**Instability**—The data presented in Fig. 6 show that the instability increases with air pressure and percentage overfeed. In the case of pre-twist, percentage instability increases with decrease in pre-twist at low pressure, but beyond a certain air pressure, when the pre-twist increases, the percentage instability decreases first and then increases. The binding twist secures the looped structure, but the complex entanglement of loops due to air drag forces and the compactness of the structure due to the delivery tension also contribute to yarn stability. For a particular pre-twisted yarn at a particular percentage overfeed, the higher air pressure forms greater number of loops than at lower pressure and this results in fewer unlooped filaments in any cross-section to take the strain and consequently some of them break. The neighbouring loops are pulled out, resulting in higher instability. More yarn is available for loop formation at higher percentage overfeeds, but the increased number of loops will be loose in binding and could be easily removed under low loads, thus causing high instability. (The point of 45 lb pressure at 30% overfeed may be experimental error.) At low twist, the yarn was observed to be stringy, loose and easily extensible, since it is composed of long floats of ballooned filaments rather than coils. Yarn of higher twist processed at low pressure possesses high stability, while yarn of higher twist processed at high pressure is slightly less stable, since there are more of small loops and fewer tensioned filaments in any cross-section to take the strain. For this reason, the 20 ti p curve crosses the 15 tpi curve at the point of 60 lb air pressure and goes to the higher percentage instability side, as the air pressure increases further.

**Tenacity**—It is seen from Fig. 7 that the tenacity (gpd) decreases with increase in pressure, twist level and percentage overfeed. At higher twist levels, the yarn gets entangled and the loops are bound by high reasserted twist in the yarn bundle. These loops take little strain, so that the other load bearing elements break more easily, resulting in low tenacity values. At the higher air pressure, a larger number of loops are formed than at lower pressure. Consequently, the yarns processed at higher pressure have fewer straight filaments to take the strain and these lead to a low tenacity. When the percentage overfeed is increased, keeping the twist and pressure constant, the loop size is greater and the loops are loose in binding compared to low overfeed and thus higher overfeed yarn possesses low tenacity.

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**References**

4. Rozmarynowska K & Godek J, Bulk, stretch and texture (The Textile Institute, Manchester) 1966.