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Effect of process parameters and blend percentage on physical properties of polyester/viscose blended air-jet textured yarns

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The effect of air pressure, overfeed and varying blend percentage on the properties of the polyester/viscose blended air-jet textured yarns has been studied. It is observed that at lower air pressure and overfeed levels, the increasing texturing speed reduces physical bulk and at higher texturing speed the increasing overfeed increases physical bulk. Physical bulk increases with the simultaneous increase in overfeed and air pressure and it reduces with a combination of low overfeed and high texturing speed. A combination of high texturing speed and low air pressure generates lower instability in the textured yarn.

Keywords: Air-jet texturing, Blending, Overfeed, Physical bulk, Polyester/viscose blend

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1 Introduction

Air-jet texturing is one of the several processes which is used to convert continuous filament yarns to textured yarns and is the most versatile of all the known texturing methods. It is unique and purely a mechanical method which uses cold supersonic air stream to produce entangled filament bulked yarns of low extensibility. Being a purely mechanical method, it can be used for both thermoplastic and non thermoplastic filaments yarns. Air-jet texturing thus provides excellent potential for combining two or more multifilament yarns into a more or less intimately blended coherent structure. The effects of filament characteristics and processing variables on properties of air-jet textured polyester, polyamide or polypropylene filaments have been widely investigated. However, there are very few published reports on air-jet texturing of viscose and/ or blends of viscose. Hence, blends of polyester/viscose offer interesting possibilities for producing yarns suitable for suiting fabrics. This paper reports the production of polyester/viscose blended air-jet textured yarns.

2 Materials and Methods

2.1 Materials

Two types of fully oriented yarns (FOY), namely polyester of 72/75 denier having circular cross-section and viscose of 75/24 denier having serrated cross-section, were used for the study. Tenacity, modulus and breaking elongation of polyester yarn were 40.5 gf/tex, 1559 gf/tex and 18.9% respectively while for viscose yarn these properties were 15.8 gf/tex, 1432 gf/tex and 10.2% respectively. The yarns were textured on an Eltex AT/HS air-jet texturing machine with Hemajet using S325 core. Five different blends were used for texturing along with 100% polyester and 100% viscose yarns. For blending, required number of polyester yarn is fed along with required number of viscose yarn to make a total of six yarns being fed simultaneously for texturing. The polyester yarns and other blends were passed through the wetting device before being entered to the jet. Three different sets of process parameters A, B and C (Table 1) were used by varying the overfeed and air pressure, keeping the texturing speed constant at 400 m/min.

Table 1—Process parameters used for texturing

Process parameter code	Overfeed %	Air pressure bar	Texturing speed m/min
A	14.7	7	400
B	24	8.5	400
C	33.3	10	400

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Following air-jet texturing parameters were kept at constant level:

Water application : 1L/h at 1 bar water pressure
Winding underfeed : 0.7%
Mechanical stretch : 4.7%
Stabilizing temperature : 200°C

2.2 Methods

2.2.1 Yarn Denier

Skeins were prepared on a wrap reel of 1m girth. Five skeins of 100m each were prepared from each package and weighed on an electronic balance capable of measuring to an accuracy of 1 mg. The yarn denier was calculated as follows:

$$\text{Yarn denier} = \frac{\text{Weight of 100 m skein (g)}}{100} \times 9000$$

Linear density values of parent and textured yarns are shown in Table 2.

2.2.2 Physical Bulk

Physical bulk of air-jet textured yarns was measured using the package density method. Packages of equal diameter were wound using parent and air-jet textured yarns under constant tension of 3cN at a speed of 300m/min for 30 min in a spindle driven winder. Physical bulk was measured using the following relationships:

$$\text{Physical bulk (\%)} = \frac{\text{Density of parent yarn package (g/cm}^3)}{\text{Density of textured yarn package (g/cm}^3)} \times 100$$

$$\text{Package density (g/cm}^3) = \frac{M_{c+y} - M_c}{\pi L(R^2_{c+y} - R^2_c)}$$

Table 2—Linear densities of parent and textured yarns

Blend[a] (P/V)	Initial linear density den	Linear density (den) after texturing A	B	C
0/6	450	474	480	489
1/5	447	488	475	515
2/4	444	482	473	505
3/3	441	476	467	496
4/2	438	470	460	489
5/1	435	460	458	476
6/0	432	448	455	467

[a]In terms of no. of slivers.

Where M_{c+y} is the total weight of full package; M_c, the weight of empty package; L, the traverse length of the package; R_{c+y}, the overall radius of full package; and R_c, the radius of empty package.

2.2.3 Instability

The instability of the air-jet textured yarns was measured using Du Pont's weight hanging method. A basic load of 0.01 gf/den was applied to the yarn and a mark was made at 100 cm distance from the clamp. Yarn was then subjected to an additional load of 0.5 gf/den for 30 s. The permanent extension in the length of the yarn, measured 30 s after the heavy load has been removed, was taken as a measure of instability. Ten readings were taken from a sample package to estimate instability, and between each successive readings nearly 5 m yarn was unwound from the package and discarded.

2.2.4 Tensile Properties

Tensile properties of all textured yarns were measured according to ASTM test method D2256-95a using Instron tester (model 4411) with 500 mm gauge length, 300 mm/min cross-head speed and 0.055 gf/den pretension level. Thirty samples from each package were tested.

3 Results and Discussion

3.1 Physical Bulk

It is observed from Fig. 1 that the increase in polyester content in the yarn produces higher physical bulk and an increase in air pressure and overfeed also produces higher bulk. Polyester filaments having lower bending stiffness due to lesser diameter[1] facilitates loop formation giving higher physical bulk. Also, the polyester-rich blends possess more number of filaments because of lower denier per filament (1dpf) which provides more number of loop forming segments in the yarn due to greater drag forces operating on them because of greater surface area. When air pressure is increased, the difference between the forces acting on different filaments increases, giving increased relative longitudinal displacements. Also, the lower density of polyester as compared to viscose may contribute to the higher bulk of the polyester-rich blend. So, the loop frequency increases producing higher bulk.[2,3] Increased overfeed assists in blowing out longer length of filaments to be blown out at a given time interval producing larger loop sizes generating higher bulk.

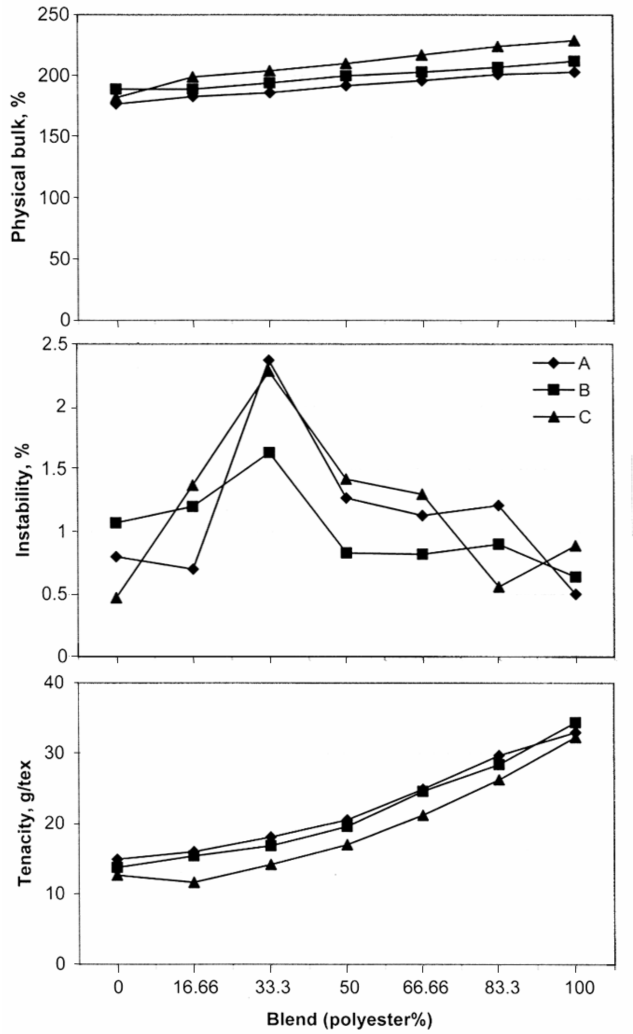

Fig. 1—Effect of blend proportion on yarn physical bulk, instability and tenacity at 400m/min texturing speed [(A) 14.7% overfeed, 7 bar air pressure, (B) 24% overfeed, 8.5 bar air pressure, and (C) 33.3% overfeed, 10 bar air pressure]

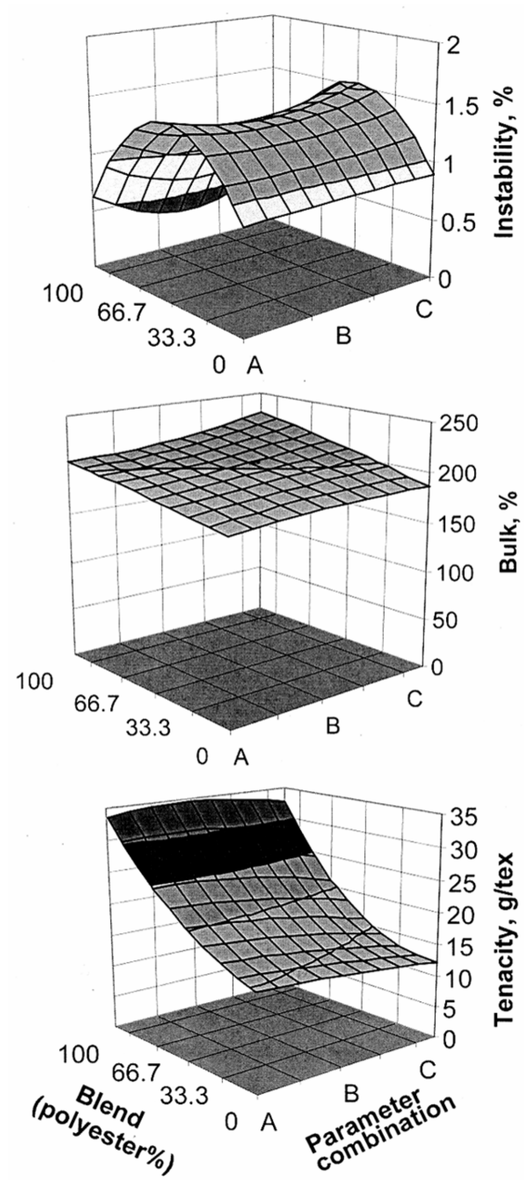

Fig. 2—Interaction effect of blend percentage and process parameters on yarn Instability, physical bulk and tenacity at constant texturing speed of 400 m/min

3.2 Instability

Figure 1 shows that an increase in polyester in the blend up to 33.3% increases the instability at all process conditions but beyond that an increase in polyester % reduces instability of the yarn. Initially, with the increase in polyester content in the blend the number of loops increases (Fig. 1), which increases the chance of more number of loops being opened up, thereby increasing the instability. But after the polyester content in the feed yarn increases sufficiently, the polyester-rich blend possessing greater number of filaments (due to lower dpf) increases both the interlacements and surface contact area, resulting in lower instability. When the overfeed is sufficiently high then there will be consequent reduction in yarn tension, resulting in lesser entanglements. Also, at higher air pressure and overfeed, greater number of entangled loops will be formed which increases the chances of these loops being pulled out when the yarn is being tensioned, thereby increasing the instability. When the overfeed and air pressure values are sufficiently low, the filaments will not be able to consume the total overfeed, resulting in lower tension and a consequent reduction in entanglements, thus increasing the instability.

When the air pressure and the overfeeds are matching with each other, the entanglements will be optimum for a particular type of nozzle, providing lowest instability. In other words, there is a range of overfeed beyond which the effective texturing can be achieved for a particular nozzle.

3.3 Tenacity

Figure 1 also shows that an increase in polyester % in the blend increases the tenacity of the yarn. The increase in tenacity is very slow initially, but with higher amount of polyester % the rate also increases. The tenacity of the yarn is contributed by two opposing factors, namely (i) the strength of the polyester filaments having a positive contribution and (ii) loops present in the yarn lowers the tenacity of the yarn. Initially, when small amount of polyester is present then lowering of tenacity due to increased bulk is dominant (2^{nd} factor). But when the amount of polyester is more than 33.3% in the blend then the contribution of stronger polyester filaments (1^{st} factor) is dominant which increases the yarn tenacity rapidly. For a particular blend, the tenacity of the yarn is found to decrease with increasing air pressure and overfeed which may be attributed to increasing bulk in the yarn. Sengupta *et al*.[4] reported that with the increase in air pressure, nep level increases and yarn tenacity reduces.

3.4 Interaction Effects

Figure 2 shows that the process parameters and blend percentage do not have a strong interaction effect on yarn instability. A combination of medium overfeed and air pressure along with lesser amount of polyester results in higher instability in the yarn. But a polyester-rich blend or a viscose-rich blend under the conditions of low or high overfeed and air pressure results in lower instability. Figure 2 shows that a combination of polyester-rich blend and higher process conditions results in higher physical bulk which means that the polyester filaments are more capable of consuming higher amount of air pressure and overfeed than viscose filaments. Figure 2 shows that the tenacity of the blended textured yarns does not depend on the interaction effect of the process conditions and blend percentage but solely depends on the percentage of polyester in the blend. Higher amount of polyester in the blend is responsible for higher tenacity.

4 Conclusions

4.1 Higher amount of polyester in the blend produces higher physical bulk in the yarn. Also, higher overfeed and air pressure conditions produce more physical bulk in the textured yarn.

4.2 Moderate air pressure and overfeed conditions produce low instability values in the yarn. Also, up to 33.3% of polyester in the blend increases the instability, whereas further increase in the amount of polyester in the blend reduces the instability in the yarn.

4.3 Higher amount of polyester in the blend results in higher yarn strength under any process conditions. Increasing air pressure and overfeed reduce tenacity of the yarn.

4.4 Blend percentage and process conditions have good positive interaction effect on yarn physical bulk, whereas they do not show sufficient interaction effect on instability and tenacity of the yarn.

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