Elastic recovery properties of polyester jet-spun yarns

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The relationship between magnitudes of the instrumental measurement of the elastic recovery properties and some yarn parameters has been studied. In general, the coarse yarns have low immediate elastic recovery, high delayed elastic recovery, and a large permanent set than the fine yarns prepared under the identical processing conditions. The use of higher first nozzle pressure and main draft produces high immediate elastic recovery but low delayed elastic recovery and permanent set. Both amplitude and rate of extension produce a large variation in the elastic recovery properties, the magnitude being dependent mainly on processing factors.

Keywords: Air-jet spinning, Elastic recovery, First nozzle pressure, MJS yarn

1 Introduction

The increasing popularity of air-jet spinning technology and its ability to produce fine yarns for certain substrates has created a need to expend its range. This new technology offers significant advantages in respect of processing speed, production cost, and some potential benefits in weaving. When air-jet spun yarn is used¹, the improvement in warp and filling stops can be up to 25.5% and 55% respectively. A comprehensive bibliography of the literature in this field is available in a recent publication². Much of this literature is focused on the dependency of yarn properties on important fibre and process parameters³. However, there is no report on the elastic recovery properties of air-jet spun yarns. A better understanding of the elastic parameter would help in engineering yarns for specific end uses. This is because the manufacturing of textile material involves a long process of transformation in which the textile substrate is subjected to different kinds of stress which give rise to internal tensions that ease with the time. This increases the variation in dimensions, resulting in the rejection of the substrate for the application for which it is destined. This paper reports the findings of an exploratory study of the elastic recovery characteristics of polyester jet-spun yarns produced by varying first nozzle pressure and main draft.

2 Materials and Methods

2.1 Preparation of Yarn Samples

Polyester staple fibre of the length 51 mm, fineness 1.67 dtex, tenacity 31.75 cN/tex and breaking extension 30.8% was processed on a Lakshmi Rieters' blow room line and carded on a MMC card. The card sliver was given three passages on a Lakshmi Rieters drawframe DO/2S to produce finisher sliver of 2.7 ktx. This sliver was spun into 11.8 and 18.5 tex yarns on a Murata air-jet spinner (Model MJS 802) with total draft of 229 and 145 respectively using a machine speed of 200 m/min and a feed ratio of 0.98. First nozzle pressures of 2.0, 2.5 and 3.0 k gf/cm² and main drafts of 30.91, 35.77 and 41.55 were used for producing nine samples for each yarn count.

2.2 Tests

The elastic recovery parameters of the yarns were determined using Instron tensile tester (Model 4411) as per the ASTM standard, 500 mm test specimens being elongated at extension rates of 50, 100 and 500 mm/min. The immediate elastic recovery (IER), delayed elastic recovery (DR) and permanent set (PS) were obtained for initial extension levels of 2, 4 and 6%. For each selected level of extension, the yarns were allowed to fully retract and then relaxed for 3 min, and the variations in extension were observed. Fig. 1 shows the typical load vs. extension in an elastic recovery measurement⁴. OA is a load extension curve obtained as a consequence of the initial extension of the specimen up to a pre-determined level (OL). The cross-head of the Instron is then

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Immediate elastic recovery (IER), % = [BL/OL] x 100
Delayed elastic recovery (DR), % = [BC/OL] x 100
Permanent set (PS), % = [OC/OL] x 100

3 Results and Discussion

The influence of experimental variables, viz. first nozzle pressure, main draft and amplitude and rate of extension, on elastic recovery properties was assessed using the analysis of variance (Table 1) at 1% level of significance. Only the first order interactions were considered.

3.1 Influence of Amplitude and Rate of Extension on Immediate Elastic Recovery

Figs 2-7 show the recovery responses of the polyester MJS yarns produced with different first nozzle pressure and main draft. In air-jet spinning, the yarn linear density is a highly significant factor for immediate elastic recovery, delayed elastic recovery and permanent set, as has been observed using the statistical analysis ANOVA (Table 1). Fig. 2 shows that the highest immediate elastic recovery is 83.4% for 11.8 tex yarn at 41.55 main draft and 3.0 kgf/cm² first nozzle pressure. The lower immediate elastic recovery of 45.1% belongs to 18.5 tex at 30.91 main draft and 2.0 kgf/cm² first nozzle pressure. The first nozzle pressure is an another highly significant factor for immediate elastic recovery because it increases the incidence of wrapper fibres which exerts more radial pressure on the core fibres, resulting in a compact packing. It is noteworthy that the change in main draft offers significant advantage in respect of immediate elastic recovery; the lower immediate elastic recovery corresponds to lower main draft and increases consistently with the increase in main draft.

It can be seen from Fig. 2 that the choice of extension rate significantly affects the immediate elastic recovery. The immediate elastic recovery, in general, registers lower values with decreasing extension rate. Such a behaviour of immediate elastic recovery could be ascribed to the unique structural features of MJS yarns. At low extension rate, the phenomenon of stress-relaxation predominates during the actual stretching time which impairs the recovery characteristics. The immediate elastic recovery of MJS yarns is also influenced by the amplitude of extension. It is evident from Fig. 3 that the immediate elastic recovery significantly decreases with the increase in amplitude of extension. However, the decrease in immediate elastic recovery with the increase in amplitude of extension is less marked in
Fig. 2—Influence of extension rate on immediate elastic recovery

Fig. 3—Influence of amplitude of extension on immediate elastic recovery
Fig. 4—Influence of extension rate on delayed elastic recovery

Fig. 5—Influence of amplitude of extension on delayed elastic recovery
Fig. 6—Influence of extension rate on permanent set

Fig. 7—Influence of amplitude of extension on permanent set
the yarns produced with higher first nozzle pressure. This is expected due to the higher incidence of wrapper fibres which restrict the process of disintegration of the yarn structure during stretching.

3.2 Influence of Amplitude and Rate of Extension on Delayed Elastic Recovery

Figs 4 and 5 depict the delayed elastic recovery of different MJS yarns. In general, the yarns produced with lower main draft exhibit higher delayed elastic recovery, followed by the yarns produced with higher main draft. According to the ANOVA results, first nozzle pressure is a highly significant factor affecting delayed elastic recovery. The delayed elastic recovery has a tendency to decrease with the increase in first nozzle pressure (Figs 4 and 5). This suggests that the yarns should be spun with high first nozzle pressure to keep the delayed elastic recovery low. The increase in extension rate further reduces delayed elastic recovery, the latter however reflects no consistent trend in respect of yarn linear density and amplitude of extension.

3.3 Influence of Amplitude and Rate of Extension on Permanent Set

Permanent deformation (Figs 6 and 7) generally seems to be larger for coarse yarns but it tends to decrease when the extension rate increases and, at the same time, when amplitude of extension decreases. This is quite understandable in the light of the fact that these parameters result in increased immediate elastic recovery. The use of lower first nozzle pressure and main draft leads to a larger permanent deformation. The increased permanent deformation with lower values of first nozzle pressure and main draft can be attributed to the lack of sufficient transverse forces as a result of improper formation of wrappers, causing more core fibres to slip than to break.

4 Conclusions

Both extension rate and amplitude of extension exert significant influence on immediate elastic recovery, which tends to increase when the extension rate increases and decreases when the amplitude of extension increases. The immediate elastic recovery increases markedly with the increase in both first nozzle pressure and main draft.

Lowest delayed elastic recovery and permanent deformation are observed at a first nozzle pressure of 3.0 kgf/cm². However, the delayed elastic recovery and permanent deformation increase when the yarn linear density increases and, at the same time, when main draft and extension rate decrease. The increase in amplitude of extension increases permanent deformation of the structures, but its effect on the delayed elastic recovery is not clear.

References