Direct determination of yarn snarliness

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The formation of snarls that take place in the yarns in post-spinning processes, such as winding, warping, weaving and knitting, has been studied. This defect is due to the excessive yarn twist liveliness (torsional buckling) and causes great trouble to the manufacturers of yarns and fabrics. Biased testing techniques are used for the measurement of this defect. A snarling testing apparatus PRIANIC and an unbiased testing technique have been developed and are reported. The investigation of factors such as yarn package form, yarn twist factor, time elapsed between production and processing stages of yarns and yarn conditioning show the significant role they play in the reduction of yarn snarliness.

Keywords: Knitting, Snarliness, Twist liveliness, Warping, Weaving, Winding, Yarn package, Yarn twist factor

1 Introduction

The twisted shape of the fibres forming a yarn brings to the fore two of their main physico-mechanical properties: torsional rigidity and torsional buckling. The higher the torsional rigidity, the stronger is the torsional buckling effect, also known as yarn twist liveliness. It is the tendency of a newly spun yarn to untwist spontaneously, a detrimental yarn characteristic having two representatives – the snarliness that occurs in the yarns and the spirality that appears in knitted fabrics. On the contrary, the crepe phenomenon, appears in special woven fabrics, is considered as a beneficial result of the yarn twist liveliness.

Yarn twist liveliness is affected by the twist factor, yarn fineness and retractive forces, which, in turn, are determined by the torsional and bending stresses in the fibres, and the torque generated during yarn twisting. The latter is constituted by three components, viz. torsion, bending and tension of the fibres, whereas its level depends on the degree of fibre migration that takes place. The twist liveliness of false-twisted and set yarns depends on their structure and, in particular, on the properties of the helical parts of their filaments.

1.1 Snarl

The snarl is due to yarn torque and takes place during the torsional buckling effect, where the yarn retires into itself and simultaneously is twisted in the opposite twist direction. Newly produced yarns exhibit a great tendency to untwist when freed from restraint. When such a yarn is prevented from untwisting, by being held at both ends approaching each other, it forms an arc. The nearer to U-shape this arc gradually comes, the easier is snarl formation (Fig. 1), whereas in highly twisted yarns, snarls are formed very fast before an arc appearance (Fig. 2). Recent research has shown that the torque required for a yarn to snarl is independent to the yarn twist level. Snarls appear in thinner yarn parts where twist accumulation occurs and/or in a likely part of the yarn when the numerical difference (yarn weight minus untwisted stress) has a negative value.

Many problems originate from the yarn snarliness and appear in post-spinning yarn processes. In yarn winding, a snarly yarn might be accumulated behind the finger guide (knife) of an electronic slub catcher, resulting in yarn breakage and worsening its quality.

Fig.1—Snarl formation of a normally twisted yarn
Due to lack of tension\textsuperscript{8}, the snarls are formed in single
yarns as they are withdrawn over the top of bobbins
during the folding-twisting processes and especially
in two-for-one twisting where this problem becomes
more serious. In weaving, snarls in weft yarns appear
when the shuttle returns to the shed from the box.
Some of these snarls are entrapped into the cloth and
do not open out even when the weft is subsequently
tensioned as picking proceeds, making necessary the
cloth mending for their removal. As the hanks made
from highly twisted yarns are removed from the reel
swift, they shrink and form numerous snarls, causing
great trouble during their positioning on the rods
(buttons) of the hank-dyeing machine. Moreover,
during the winding of these dyed yarn hanks to cones,
the formed snarls can cause snatching, tension peaks
and yarn breakage.

It is a virtue for a yarn, with its optimum twist
factor, to have the minimum snarliness level that can
be achieved by several ways such as storing\textsuperscript{9} at
adequately high temperature and relative humidity
(70-75\%) or by steaming\textsuperscript{10} that results in a fast yarn
relaxation.

1.2 Existing Methods for Testing Yarn Snarliness

Several workers\textsuperscript{3,11,14}, in an endeavour to measure
yarn snarliness, have described various methods that
are more or less based on the same principle. In these
methods, a light mass object is suspended from the
middle of a known length of yarn. As soon as the two
yarn ends are brought together, a loop (snarl) is
formed as rotated until reaching the immobility state.
The number of turns of the loop and/or the
measurement of the distance between the two yarn
ends\textsuperscript{15,16} give the yarn snarliness level. The drawback
of these methods is the constraint of the snarl
formation in a specific yarn place, a fact that does not
permit the drawing of true conclusions about the
objective snarling tendency of the yarns. Furthermore,
there is confusion about the mass of the hanged object
and the length of the yarn samples. Also, there is no
mention about yarn pretension.

All the above highlighted the necessity of using a
simple new method and an apparatus for the
measurement of snarliness, overcoming most of the
sources of errors and shortcomings of the earlier
methods. Therefore, in the present work, a snarling
testing apparatus PRIANIC and an unbiased testing
technique have been developed and are reported.

2 Materials and Methods

2.1 Snarling Testing Apparatus PRIANIC

The apparatus shown in Figs 3 and 4 consists of a
base where two stands are firmly fixed. A threaded
rod with two ball bearings is placed on the top of
these stands. A motor on the base drives the threaded
rod where beneath the latter there is a scale with
linear metre (100 cm). On the right side of the
apparatus, a movable part (1) with clamp jaw and a
pointer is in contact with the threaded rod, whereas a
stationary jaw (2) with a special yarn pretension
system exists on the left side. The pretension system
consists of an adjustable counterbalance and a
graduated rod (0-200 g) that is based on the TEX
system, with tension unit of tex/2 ± 10\% g.

2.1.1 Principle

The operation principle of the device is simple. A
yarn length of one metre is clamped on the two jaws
of the device. The movable part approaches the
stationary one as it is driven by the rotating threaded
rod. The yarn figures a U-shape loop and according to
its twist liveliness, a snarl is formed.

2.1.2 Testing Procedure

The device is set to its initial conditions. The
movable part (1) is returned to the right side of the
device, where the pointer indicates the value 100 on
the scale. As the linear density of the yarn is known,
the appropriate adjustment is made on the pretension
system. After discarding a substantial quantity of yarn
from a bobbin, one metre yarn specimen is fastened in the grip of the stationary jaw (2) while holding the other end of the yarn to prevent the loss of twist. The yarn is stretched until no contact of the graduated rod pointer of the pretension system can be detected and fastened in the grip of the movable part (1). By switching on the motor, the threaded rod rotates, forcing the movable part to move towards the stationary jaw. Thus, the yarn becomes loose and figures a U-shape loop. By the time the first snarl is formed, the operation of the device is suspended. The pointer of the stopped movable part indicates a value (e.g. 73.6 cm) that represents the snarliness value of the examined yarn specimen. The higher the value, the more snarly is the yarn.

Ten yarn specimens from each sample are considered as the most appropriate for testing. The atmospheric testing conditions must be 65 ± 2 % RH at 20 ± 2 °C under which the yarn samples must be kept for conditioning for 24 h.

2.1.3 Advantages of the Apparatus and the Method

The PRIANIC apparatus has the advantage of the standard operation speed. The movable jaw moves towards the stationary jaw at a constant speed of 0.5 cm/s, giving the total maximum time of 200 s for testing a dead yarn. In the existing various apparatus and methods, there is no reference about the speed of the movable jaw. Moreover, the testing time using the PRIANIC apparatus has been reduced remarkably in relation to the time of the other methods that ranged approximately between 10 min and 15 min. Furthermore, the apparatus is supplied with a proper yarn pretension system (tex/2 ±10% g) that is strongly recommended for testing yarn characteristics under dynamic conditions. The most important feature of the PRIANIC device and the accompanied method is that the yarn forms freely a snarl in the most likely part of it, confirming its unbiased testing principle. The snarliness value given by the measurement of the distance between the two yarn ends at the starting point of the snarl formation makes this method unrivalled.

2.2 Yarn Unwinding

The simple experiment shown in Fig. 5 was carried out to investigate the effect of the yarn unwinding manner on yarn twist and twist liveliness. Two parallel roving stripes were manually wound on a cop. The over-end unwinding added some twist in this assembly. The added number of turns per unit length of the unwound assembly with Z direction was equal to the figured spirals of that length on the cop (Fig. 5a). On the contrary, the under-end unwinding (Fig. 5c) showed exactly the same behaviour apart from that the twist direction was opposite, i.e. S direction. When the assembly was unwound sideways, no
The over-end unwinding of the yarns from their cop package adds most of the times some twist and probably increases slightly the twist liveliness of the yarns. It was shown that this twist increase was negligible when referred to yarn from cone packages and therefore did not affect the twist liveliness. Thus, it was decided for the various experiments to adopt the convenient, generally accepted and widely used over-end yarn unwinding.

2.3 Preparation of Yarn Samples and Testing of Snarliness

2.3.1 Long-Staple Yarns

Yarn samples of 32 tex were produced from 100% acrylic long-staple fibres with four different twist factors. Measurements of the yarn snarliness of these samples were made on the PRIANIC apparatus, with set pretension of 15 g, every two days for a period of 20 days. The obtained results are shown in Fig. 6, which clearly shows the significant role of the storage time on the relaxation of the twist liveliness.

2.3.2 Short-Staple Yarns

Experiments were carried out to examine any alterations of the snarliness level of short-staple yarns due to the possible effect of the following four factors:

(i) the shape of the yarn package (cop, cone);
(ii) the twist factor of the yarn samples;
(iii) the time elapsed from the yarn production up to the snarliness testing; and
(iv) the atmospheric conditions in which the yarn samples were stored.

Cotton singles ring-spun Z-twisted yarns of nominal linear densities 29 tex and 39 tex were produced and wound onto cops and cones. For both these yarn linear densities, three nominal twist factors (32, 34 and 39 turns.cm\(^{-1}\).tex\(^{1/3}\)) were chosen. Quantities of these six yarn samples were made up into two lots. One of these lots was kept in a standard testing laboratory environment of 20±2 °C and 65% RH and was referred to as conditioned lot. The other lot was kept in environment of non-standard conditions and was referred to as unconditioned.

After the yarn samples production, their linear densities and twist levels were tested and the means are presented in Table 1. The effect of the yarn package form of the unconditioned lot, the first day after the yarn production, on the yarn snarliness is presented in Fig. 7. Table 2 shows the readings of yarn snarliness, taken from all the yarn samples of both lots after one and one hundred days elapsed from the yarn production day.

3 Results and Discussion

From Fig. 6 it is obvious that the increased twist level of the long-staple yarn samples of both linear densities resulted in an increase of their snarliness. On the other hand, all the four yarn samples showed the dramatic decrease of the snarliness tendency on the very first two days after their production. This

<table>
<thead>
<tr>
<th>Yarn sample</th>
<th>Linear density tex</th>
<th>Twist, turns.cm(^{-1})</th>
<th>Actual twist factor turns.cm(^{-1}).tex(^{1/3})</th>
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<tbody>
<tr>
<td>S1</td>
<td>29.3</td>
<td>603.9</td>
<td>592.7</td>
</tr>
<tr>
<td>S2</td>
<td>29.3</td>
<td>656.5</td>
<td>631.2</td>
</tr>
<tr>
<td>S3</td>
<td>29.4</td>
<td>711.2</td>
<td>711.5</td>
</tr>
<tr>
<td>S4</td>
<td>39.4</td>
<td>522.3</td>
<td>505.5</td>
</tr>
<tr>
<td>S5</td>
<td>38.9</td>
<td>545.6</td>
<td>526.8</td>
</tr>
<tr>
<td>S6</td>
<td>39.5</td>
<td>632.0</td>
<td>625.6</td>
</tr>
</tbody>
</table>

A—Yarn on a cop package; B—Yarn on a cone package; and C—Average value of cop and cone yarn twist readings
PRIMENTAS: DIRECT DETERMINATION OF YARN SNARLINESS

Table 2 — Effect of yarn package, conditioning and conditioning time on short-staple yarn snarliness

<table>
<thead>
<tr>
<th>Yarn sample</th>
<th>Linear density, tex</th>
<th>Twist factor, cm⁻¹tex⁻¹</th>
<th>Yarn package</th>
<th>Yarn snarliness, cm</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>100⁺</td>
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<tr>
<td>S₁</td>
<td>29.3</td>
<td>32.4</td>
<td>A</td>
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<td>S₂</td>
<td>29.3</td>
<td>34.9</td>
<td>A</td>
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<tr>
<td>S₃</td>
<td>29.4</td>
<td>38.6</td>
<td>A</td>
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</tr>
<tr>
<td>S₄</td>
<td>39.4</td>
<td>32.3</td>
<td>A</td>
<td>55.7</td>
</tr>
<tr>
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<td>38.9</td>
<td>33.4</td>
<td>A</td>
<td>88.1</td>
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<tr>
<td>S₆</td>
<td>39.5</td>
<td>39.5</td>
<td>A</td>
<td>76.1</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>39.4</td>
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<td></td>
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<td>79.9</td>
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<td></td>
<td></td>
<td></td>
<td>B</td>
<td>77.2</td>
</tr>
</tbody>
</table>

A — Yarn on a cop package; B — Yarn on a cone package; C — Unconditioned yarn; and D — Conditioned yarn.

* Number of days intervened between yarn production and testing.

With an intervened time of 100 days from the production day, the yarns from conditioned cones showed, in most of the cases, smaller tendency to form snarls. This may be due to the combination of various factors such as the more efficient conditioning of the yarn during the winding stage where the most important factor was likely to be the wind, and the application of longitudinal tensile stress on the yarn. Furthermore, a cross-wound cone had a much more open structure. The better conditioning of the yarn in the cone form might also be due to lower tension existing in the yarn forming coils around the yarn package, resulting in a softer package when compared with the cop form of the yarn package. Furthermore, on comparing the readings obtained by measuring the yarn snarliness after a period of 100 days with those obtained one day after the yarn production, it can be seen that the time factor contributed slightly to the snarliness reduction of unconditioned yarns. On the other hand, following the appropriate statistical analysis that was based on the factorial design analysis of variance of these data, it could be stated that, in some cases, apart the great significance of the factor yarn package form, the factors conditioning and time were of noticeable importance for yarn relaxation with a significance level above 95%.

4 Conclusions

Twist liveliness remains a great problem, manifesting itself as snarls in the yarns and spirality in

Reduction in snarliness became smoother as the time from the production day was steadily elapsed. It could be also stated that yarn snarliness followed an almost linear trend.

The data in Tables 1 and 2 and Fig. 7 show that although the differences in twist amount were very small between cops and cones of the same yarn samples, the yarns from the cones in all the cases exhibited a relatively high reduction (20-40%) in snarliness. This was probably due to the tension applied to the yarn resulting from the winding speed and tensioning devices on the winding machine. This tension seemed to extend slightly the yarn, resulting in a rearrangement of the structure of the yarn cross-section. Moreover, the same tension may be responsible for the significant reduction in torque produced by the twist insertion during the spinning process.
knitted fabrics. The relative effectiveness of the various apparatus used for determining yarn snarliness and their disadvantages, concerning the adoption of the biased testing, led to the development of the snarling testing apparatus PRIANIC in an attempt to overcome most of the limitations of the earlier instruments. The validity of this instrument as well the adopted simple testing method was shown after testing a numerous series of yarns at different twist factors. Because this apparatus is still in the embryonic stage of development, many improvements need to be made. These could be: (i) an electronically adjusted pretension system that will be helpful mainly during the yarn stretching test. This test is considered as a sequential part of the snarl test. Except the presence of the advanced pretension system, the reverse movement of the movable bracket at various speeds is considered as essential; and (ii) the use of a counter with a rotating grip fixed on the movable bracket offers the opportunity for yarn twist testing. The twist alteration of the examined yarn will give the capability for examining the character of the new yarn status during the snarling test.

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