Quality characteristics of tasar (tussah) silk yarn

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Four commercially available tasar silk yarns have been characterized on the basis of physical and mechanical properties. Machine-reeled and organzine (double-twisted) yarns show the highest and lowest value of evenness respectively. Neps contribute maximum towards imperfections in comparison to thick and thin places. Though the tenacity values of brin are almost similar for all the yarns, the changes occur when the brins are converted into yarn. The yarns are more extensible than brins. The moduli of the brins are always higher than those of the corresponding yarns. All tasar yarns show rectangular cross-section of brin.

Keywords: Antheraea mylitta D., Brin, Organzine, Tasar silk, Tram

1 Introduction

Among the non-mulberry varieties of silk, the tasar silk produced by Antheraea mylitta D. predominates in India. A variety of products, such as saris, shirting and furnishing fabrics, appeal to the people due to their specific texture which may be characterized as rough in appearance and harsh in handle. The reason behind such a texture lies in the structure of the yarn. Hence, the characterization of tasar yarn has to be done scientifically so that a specific product of desired texture and appeal can be easily made. This is an area which has not received due attention of researchers and technologists working in tasar trades. Generally, the raw silk yarn is evaluated visually by laying the yarn parallel on a panel of seriplane. The appearance grade is determined using the standard photographs prepared by the Silk Conditioning House of Yokohama and Kobe, Japan, in 1962. The judgement based on visual examination by expert assessor is liable to human subjectivity as the perception may vary from person to person. In the present study, an attempt has been made to characterize four varieties of commercially available tasar silk yarns on the basis of objective test methods as followed for cotton, worsted and blended yarns. The characterization has been carried out in terms of its physical and mechanical properties.

2 Materials and Methods

2.1 Materials

Thigh-reeled, machine-reeled, single-twisted (tram) and double-twisted (organzine) tasar silk yarns, commercially available in the form of leas, were used. The linear density (count), twist and the number of brins in the cross-sections of these yarns are given in Table 1.

<table>
<thead>
<tr>
<th>Type of yarn</th>
<th>Linear density</th>
<th>No. of plies</th>
<th>Twist</th>
<th>No. of brins in the cross-section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thigh-reeled</td>
<td>76.18</td>
<td>Single</td>
<td>1.5-4(S)</td>
<td>12</td>
</tr>
<tr>
<td>Machine-reeled</td>
<td>90.99</td>
<td>Single</td>
<td>nil</td>
<td>14</td>
</tr>
<tr>
<td>Single-twisted (tram)</td>
<td>71.16</td>
<td>Single</td>
<td>9.57(Z)</td>
<td>12</td>
</tr>
<tr>
<td>Double-twisted (organzine)</td>
<td>115.92</td>
<td>Two</td>
<td>12.35(Z)</td>
<td>22</td>
</tr>
</tbody>
</table>

Z and S indicate the direction of twist

2.2 Methods

2.2.1 Determination of Mass Irregularity (Evenness)

Mass irregularity was determined on Uster I at 25 m/min running speed and 5 min duration of test. At least thirty samples of each type of yarn were tested and the mean and CV values of mass irregularity were calculated. While taking the mass irregularity profile, the chart speed was kept at 5 cm/min so that every centimetre of trace represents 0.5 m of yarn. The distribution patterns of mass irregularity values were also plotted.

2.2.2 Evaluation of Imperfection

Imperfections, such as thick places, thin places and neps as defined by Furter, in the yarns were...
evaluated on Uster I using the following sensitivity settings:

- Thick place + 50%
- Thin place - 50%
- Neps + 200%

At least, thirty readings were taken for each sample containing 125 m yarn. The distribution of faults in these sections of yarn was also determined.

2.2.3 Determination of Cross-sectional Shape

Yarns were pulled through soft corks and then thin cross-sections were cut by a sharp blade. The cross-sections were viewed under scanning electron microscope and photographed.

2.2.4 Evaluation of Mechanical Properties

Yarns were evaluated for their mechanical properties on Instron 4201 interfaced with a computer using 20 cm gauge length and 15 cm/min cross-head speed. The yarns were threaded between the jaws at a tension level of 0.01 N/tex. A minimum of thirty tests were carried out per sample and the average and CV values were calculated. Some typical traces of stress-strain behaviour were recorded. Similar test was also carried out on the individual brins after isolating them from yarns.

3 Results and Discussion

3.1 Physical Properties

Table 2 shows the evenness and imperfection values of yarns studied. It is observed that the evenness ranges from 16 to 23% and it is highest (23-73%) for machine-reeled yarn and lowest (16.22) for organzine yarn. The CV% of evenness varies between 27 and 38%, indicating a high variation in evenness.

The distribution patterns of evenness values (Fig. 1) show that the evenness (CV%) varies from 5 to 35% for thigh-reeled yarn, 13 to 37% for machine-reeled yarn, 11 to 31% for single-twisted yarn (tram) and 11 to 35% for double-twisted (organzine) yarn. This shows that certain sections of these yarns are reasonably uniform; the evenness (CV%) values less than 12.9 are indicative of these regions. Some typical mass irregularity profiles, as detected on Uster, are shown in Fig. 2. The peaks indicate the presence of thick places or neps. The sudden fall in average values is indicative of thin region of yarn.

3.2 Imperfections

The total imperfections (Table 2) vary from 42.59 to 71.66 per 125 m of yarn and are maximum for

![Evenness values of tasar yarns: (a) thigh-reeled, (b) machine-reeled, (c) single-twisted, and (d) double-twisted](image)

**Table 2—Evenness and imperfection values of yarn**

<table>
<thead>
<tr>
<th>Type of yarn</th>
<th>Linear density den</th>
<th>Evenness/125 m %</th>
<th>Thick places/125 m</th>
<th>Thin places/125 m</th>
<th>Neps/125 m</th>
<th>Total imperfections/125 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thigh-reeled</td>
<td>76.18</td>
<td>18.99</td>
<td>16.83</td>
<td>8.13</td>
<td>33.03</td>
<td>57.99</td>
</tr>
<tr>
<td>Machine-reeled</td>
<td>90.99</td>
<td>(35.82)</td>
<td>(48.56)</td>
<td>(160.98)</td>
<td>(47.72)</td>
<td>(71.66)</td>
</tr>
<tr>
<td>Single-twisted</td>
<td>71.16</td>
<td>18.97</td>
<td>11.50</td>
<td>6.56</td>
<td>24.53</td>
<td>42.59</td>
</tr>
<tr>
<td>(tram)</td>
<td>(30.15)</td>
<td>(66.30)</td>
<td>(156.23)</td>
<td>(61.64)</td>
<td>(48.37)</td>
<td>(44.92)</td>
</tr>
<tr>
<td>Double-twisted</td>
<td>115.92</td>
<td>16.22</td>
<td>12.30</td>
<td>3.06</td>
<td>29.56</td>
<td>44.92</td>
</tr>
<tr>
<td>(organzine)</td>
<td>(38.08)</td>
<td>(55.72)</td>
<td>(324.27)</td>
<td>(48.37)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values in parenthesis indicate CV%
Fig. 2: Mass irregularity profile of tasar yarns: (a) thigh-reeled, (b) machine-reeled, (c) single-twisted, and (d) double-twisted.
machine-reeled yarn. Neps contribute maximum (around 60%) towards the imperfections while the thick and thin places contribute around 30% and 10% respectively. Hence, reduction in neps will improve substantially the quality of these yarns.

All types of imperfection, especially the thin places, vary over a wide range. Thin places are more or less similar in thigh-reeled, machine-reeled and single-twisted (tram) yarns and significantly lower in case of organzine yarn. The lowest thin places in organzine are probably due to the doubling effect of this yarn which is also reflected in its evenness value. The distribution patterns of thin places (Fig.3) are similar for all the yarns. The exponential decrease in the frequency of thin places shows that there are certain sections in yarn which contain lot of thin places. Incidence of high number of thin places may be reduced substantially if one understands the mechanism of generation of these faults.

Thick places vary from 11.5 to 21.9 per 125 m of yarn. Tram and organzine yarns contain minimum number of thick places (Table 2). The distribution patterns of thick places are shown in Fig.4.

Neps vary from 24.53 to 43.43 per 125 m of yarn and have high CV% values. The distribution patterns of neps are shown in Fig.5.

### 3.3 Mechanical Properties

The mechanical properties of yarns are given in Table 3. It is observed that the double-twisted yarn shows highest tenacity followed by single-twisted, thigh-reeled and machine-reeled yarns. In order to know how far the strength of brin gets translated into the tenacity of yarn, the strength translation efficiency values were also calculated. The tenacity values of brin are almost similar for all the yarns. However, when the brins are converted into yarns, the tenacity values no longer remain same. The

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**Fig. 3**—Thin places of tasar yarns: (a) thigh-reeled, (b) machine-reeled, (c) single-twisted, and (d) double-twisted

**Fig. 4**—Thick places of tasar yarns: (a) thigh-reeled, (b) machine-reeled, (c) single-twisted, and (d) double-twisted

**Fig. 5**—Neps of tasar yarns: (a) thigh-reeled, (b) machine-reeled, (c) single-twisted, and (d) double-twisted
Table 3—Mechanical properties of yarns

<table>
<thead>
<tr>
<th>Type of yarn</th>
<th>Maximum tenacity N/tex</th>
<th>Tenacity translation efficiency</th>
<th>Strain at maximum tenacity, %</th>
<th>Young's modulus N/tex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yarn</td>
<td>Brin</td>
<td>Yarn Brin</td>
<td>Yarn Brin</td>
</tr>
<tr>
<td>Thigh-reeled</td>
<td>0.16</td>
<td>0.18</td>
<td>22.83</td>
<td>18.59</td>
</tr>
<tr>
<td></td>
<td>(17.30)</td>
<td>(24.77)</td>
<td>(15.55)</td>
<td>(33.67)</td>
</tr>
<tr>
<td>Machine-reeled</td>
<td>0.16</td>
<td>0.20</td>
<td>18.47</td>
<td>18.15</td>
</tr>
<tr>
<td></td>
<td>(28.60)</td>
<td>(20.76)</td>
<td>(29.41)</td>
<td>(30.04)</td>
</tr>
<tr>
<td>Single-twisted</td>
<td>0.17</td>
<td>0.19</td>
<td>22.75</td>
<td>18.89</td>
</tr>
<tr>
<td>(Tram)</td>
<td>(18.13)</td>
<td>(20.14)</td>
<td>(10.06)</td>
<td>(28.13)</td>
</tr>
<tr>
<td>Double-twisted</td>
<td>0.18</td>
<td>0.20</td>
<td>22.04</td>
<td>16.28</td>
</tr>
<tr>
<td>(Organzine)</td>
<td>(10.68)</td>
<td>(17.24)</td>
<td>(8.55)</td>
<td>(17.24)</td>
</tr>
</tbody>
</table>

Values in parenthesis indicate CV%.

strength translation efficiency varies between 80 and 90%. Double-twisted yarn shows the highest translation efficiency, whereas the machine-reeled yarn shows the lowest. The lowest translation efficiency for machine-reeled yarn may be ascribed to its high unevenness and absence of twist.

The high value of translation efficiency for thigh-reeled yarn is attributed to the presence of twist and gum which gives the yarn a coherent structure. The twist was found to be around 1.5-4.0 turns/in in S direction. The presence of twist gets also indirectly manifested in the smooth round shape of the yield region in the stress-strain diagram of thigh-reeled yarns as shown in Fig.6.

The modulii of the brins are always higher than those of the corresponding yarns. The asymmetric build up of stress in the individual brins due to its inherent variability is expected to cause the modulus to be lower.

The % strain at maximum tenacity is always higher for the yarn than the brin. The individual CV% values of strain at maximum tenacity vary from 28 to 33% for brins and from 8 to 29% for yarns. The higher yarn elongation in comparison to that of brins for all the yarns, except the machine-reeled yarn, can be ascribed to the presence of twist. Absence of twist shows hardly any change in elongation values for machine-reeled yarn.

3.4 Stress-strain Diagrams for Yarns and Brins

The stress-strain diagrams of brins and yarns are shown in Fig.6. The nature of the diagrams is similar in all cases and typical of any silk. Except for the machine-reeled yarn, in all the cases the yield region can be characterized by smooth rounded off curve which indirectly shows the influence of twist. In a twisted yarn as the central filament reaches the yield point the outer filaments remain at lower extension. As a result, the sharp bend in fibre stress-strain curve gets spread out over a range of yarn extension as proposed by Hearle et al.2.

The existence of step breaks is observed mainly in the case of thigh-reeled yarn at higher strain level. Machine-reeled yarn also shows a tendency for step breaks. This is because in machine-reeled yarn the brins may behave independently, causing break to occur in staggered fashion during straining process due to its non-coherent structure as a result of the absence of twist and inadequate gum content. In the case of thigh-reeled yarn, the bonds existing between the brins and gum break down at high strain level. This causes inhomogeneous stress distribution
between the brins since they start behaving independently. The low level of winding tension, expected during such reeling operation, may also cause the filament length to be unequal in a given section of the yarn. This would further increase the asymmetry of stress distribution, causing the brins to break individually in a staggered fashion.

3.5 Cross-sectional Shape

The cross-sectional shapes of different varieties of tasar, as viewed on scanning electron microscope, are shown in Fig. 7. It is clear that cross-sectional shapes of tasar are more or less rectangular in nature and hence differ from that of mulberry variety which is triangular. The shapes were further characterized in terms of their length, width and length-to-width ratio and the results are presented in Table 4. It is observed that while the length varies from 38 to 47 μm, the width varies from 10 to 14 μm and the length-to-width ratio varies from 3 to 4. Such a cross-section will hinder the close packing of the brins in the yarn.

The bending rigidity will also be high, especially when brins are bent in a plane parallel to the width of the cross-section. The projecting edges of the cross-sections of the brins at the yarn surface may also be a source of harsh feeling which is generally observed in such types of yarn.
4 Conclusions

Evenness varies from 16 to 23% for the four commercially available tasar yarns studied. The total imperfections varies from 42.60 to 71.60 per 125 m of yarn. The contributions of neps and thick places to total imperfections are 60% and 30% respectively. Double twisted yarn shows the highest tenacity. Tenacity translation efficiency ranges from 80 to 90% and it is highest for double-twisted yarn. Yarns are more extensible than brins. The CV% values of strain at maximum tenacity vary from 28 to 33% for brins and from 8 to 29% for yarns. The cross-sectional shapes of all varieties of tasar are more or less rectangular in nature wherein the length-to-width ratio varies from 3 to 4.

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References