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Effect of Stretch on Frequency Distribution of Breaking Elongation of Sized Yarns and Their Weavability

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The effect of stretch during sizing on the frequency distribution of breaking elongation of sized yarn at break and its impact on warp breakage rate was studied. The frequency of low-elongation yarns increased out of proportion with increase in stretch, which in turn increased the warp breakage rate. The beam sized at high stretch level also behaved erratically in terms of warp breakage rate in the loomshed. A linear relationship between the warp stretch and the loss in yarn elongation during sizing was established.

Keywords: Breaking elongation, Frequency distribution, Sizing, Stretch, Warp breakage rate, Weavability, Yarn

1 Introduction

During sizing the warp sheet has to be kept under a certain minimum tension for ensuring proper contact of yarn with the drying cylinders, for easy splitting of the warp sheet at the lease rods and for preparing beams of the required density. A certain amount of stretch—percentage increase in length—of the warp sheet is, therefore, inevitable. The yarn is dried in the stretched condition. The presence of size inside the yarn precludes the recovery of the dry sized yarn to its original length. Thus, in the process of sizing, there is a permanent loss in the elongation of yarn.

Much work[1-4] has been done to ascertain the effect of stretch during sizing on the yarn elongation and its uniformity and on the weavability of these yarns. However, the effect of stretch on the frequency distribution of elongation of sized yarn and the relationship between the stretch and the loss in yarn elongation during sizing has not been so well documented. An attempt was made in this study to ascertain the effect of stretch during sizing on the frequency distribution of elongation of sized yarn at break and the way in which it affects the performance of the yarn in weaving. An attempt was also made to correlate the stretch in sizing and the loss in yarn elongation during sizing.

2 Materials and Methods

The experiments were conducted on a sizing machine equipped with a positive dry nip mechanism. The stretch during sizing was measured by using both electronic stretch indicator and mechanical length counters.

In each experiment, for cotton as well as blend yarns, a sufficient number of beams at different stretch levels was prepared from the same creel after adjusting the stretch before the start of each beam. The other sizing variables which could influence the weavability of yarns, e.g. size liquor concentration, its viscosity and temperature, size add-on, and machine speed, were kept constant as far as possible. Sized yarn samples were collected at the end of each beam, and the samples were tested for tensile properties on a Uster tensile strength tester.

3 Results and Discussion

3.1 Relationship between Warp Stretch and Loss in Yarn Elongation during Sizing

For establishing the relationship between warp stretch and loss in yarn elongation during sizing, data collected in earlier studies conducted in the ATIRA's pilot mill[4] were also made use of.

The loss in yarn elongation during sizing was calculated by substracting the sized yarn breaking elongation (E_S) from the grey yarn breaking elongation (E_G). The values of loss in yarn elongation (E_G-E_S) thus obtained were plotted against the stretch (S) during sizing (Fig.1). The figure shows a linear relationship between the two as:

$$E_G - E_S = 0.30 + 0.82\ S$$
$$\text{or } E_S = E_G - (0.30 + 0.82\ S) \quad \ldots (1)$$

A very high value (0.97) of the coefficient of correlation shows that there is a very good agreement between the loss in yarn elongation and stretch during sizing. The positive intercept indicates that even in the absence of stretch, $S=0$, the mere presence of size reduces the yarn elongation by 0.30%. A slope of less than one (0.82) indicates a lower loss in elongation for a

given stretch. This can be attributed to inter-fibre friction at low stretch and to permanent deformation of fibre at relatively higher stretch.

3.2 Effect of Stretch on Frequency Distribution of Elongation and Weavability of Sized Yarns

To study the effect of stretch on the frequency distribution of elongation of sized yarns, three warp beams were prepared from the same creel of 40s polyester/polynosic/cotton (PPnC) yarn, each beam at a different level of stretch varying from 0.4 to 2.2%. The histograms of elongation at break of the sized yarns, taken from each of the above three beams, ar shown in Fig.2. The figure shows that at a stretch level of 0.4% most of the yarns (91%) have elongation between 4 and 7%, and only a few yarns (9%) show a breaking elongation of less than 4%. On the other hand, the beam sized at 2.2% stretch contains a significant number of yarns (41%) with a breaking elongation of less than 4%.

To ascertain the effect of this increase in the frequency of low elongation threads on warp breakage rate, a similar experiment was carried out by using 50s P/C (48:52) blend yarn. The data (Table 1) show that in this case also, a high level of stretch introduces into the warp sheet a high frequency of threads of low breaking elongation (< 5%). Consequently, at such high levels of stretch the CV% of breaking elongation of the sized yarn is very high. Furthermore, the proportion of low-elongation threads has a striking effect on the warp-breakage rate during weaving: a beam containing 22% of yarns with a breaking elongation of less than 5% has an average warp-breakage rate of 0.8 per 3,000 ends × 10,000 picks, whereas the beam containing 60% of such threads registers a warp-breakage rate of 1.9. Thus this study establishes that a high level of stretch during sizing influences the warp-breakage rate during weaving through the incidence of a high frequency of warp threads of low elongation rather than through the average level of breaking elongation.

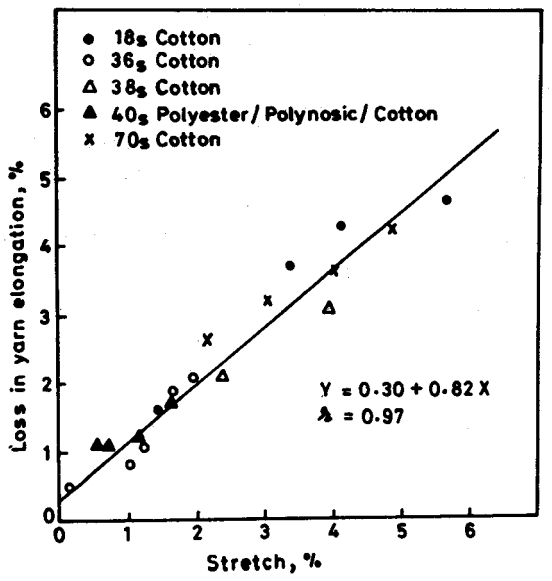

Fig. 1— Relationship between stretch and loss in yarn elongation during sizing

3.3 Uneven Stretch as a Cause of Erratic Variation in the Warp-Breakage Rate within a Weaver's Beam

Mill experience shows that occasionally the hourly warp-breakage data register erratic variation even

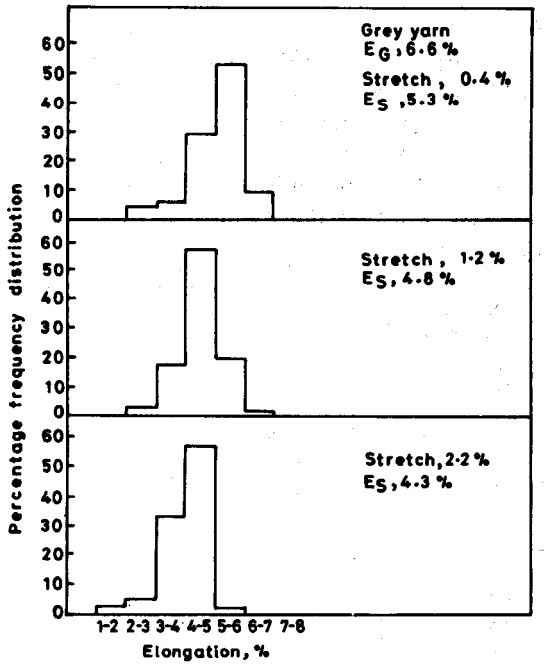

Fig. 2— Effect of stretch on the frequency distribution of breaking elongation of sized yarn (40s polyester/polynosic/cotton yarn)

Table 1— Effect of Stretch on Frequency Distribution of Breaking Elongation and Weavability of Sized Yarn

[50s Polyester/Cotton (48:52) Yarn]

Parameter	Grey Yarn	Yarn beams sized at different stretch levels		
		Beam 1	Beam 2	Beam 3
Av. elongation, %	7.5	5.4	5.3	4.8
Frequency distribution				
Up to 4%	0	0	4	14
4-5%	0	22	22	46
5-6%	6	60	60	38
6-7%	12	18	14	2
Above 7%	82	0	0	0
Total	100	100	100	100
Frequency of yarns below 5% elongation	0	22	26	60
CV% of elongation	11.5	10.5	12.5	14.9
Warp breaks per 3,000 ends × 10,000 picks	—	0.8	1.1	1.9
Av. yarn strength, g	208	244	238	223

within a weaver's beam: there are abnormally high values which lie far outside the 3-sigma limits on the basis of a Poisson distribution. Experiments were therefore conducted to understand whether such high readings are related to the presence, in the warp sheet, of threads of abnormally low breaking-elongation.

A 36s combed cotton yarn was sized at different levels of stretch varying from 0.15 to 2%. Fig.3 shows the histograms of elongation at break of yarns sized at different levels of stretch. Once again the data in Table 2 show that the beam sized at 0.15% stretch level contains only 1% of threads with a breaking elongation of less than 4%, whereas the beam sized at 2%-stretch level contains 27% of such threads. As a result, the average warp-breakage rate for the 0.15%-stretch beam is 0.63 per 3,000 ends × 10,000 picks, whereas the average warp-breakage rate for the 2%-stretch beam is 0.94.

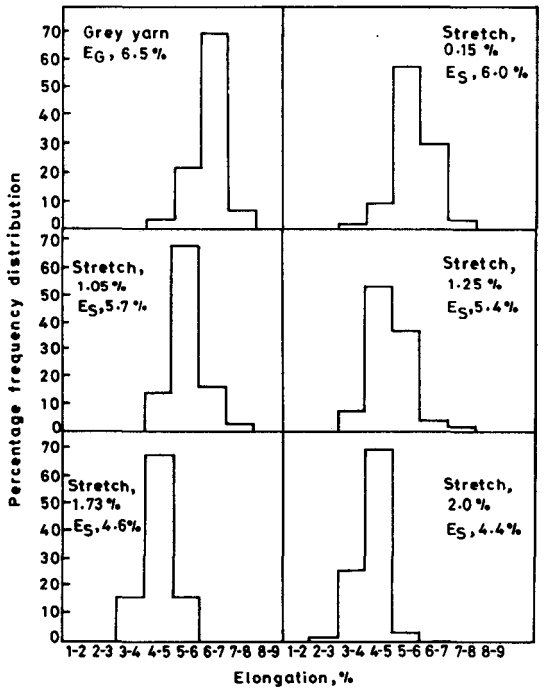

Fig. 3— Effect of stretch on the frequency distribution of breaking elongation of sized yarn (36s combed cotton yarn)

Table 2— Effect of Stretch on Breaking Elongation and Weavability of Sized Yarn

[36s Combed Cotton Yarn]

	Grey yarn	Stretch level, %			
		0.15	1.25	1.75	2.0
Av.elongation, %	6.5	6.0	5.7	4.6	4.4
Percentage number of ends below 4% elongation	0	1	7	16	27
Warp breaks per 3,000 ends × 10,000 picks	—	0.63	0.80	0.74	0.94
Av. yarn strength, g	260	310	320	310	325

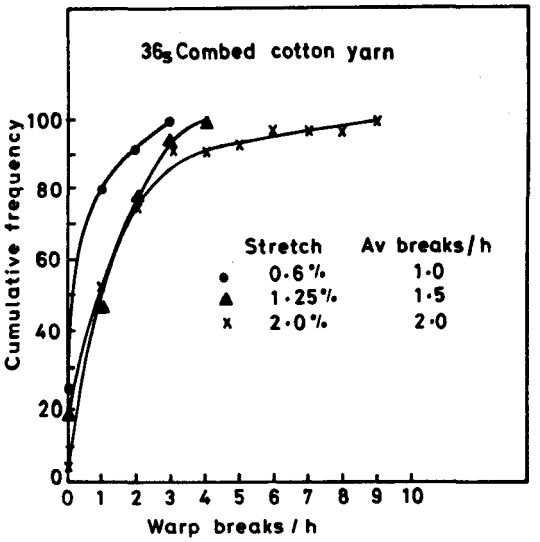

Fig. 4— Effect of stretch on the cumulative frequency distribution of hourly warp breakage rate in loomshed

What is more important is that the 2%-stretch beam registers some hourly readings of very high level that are not encountered in the case of the 0.15%-stretch beam. This can be seen from Fig.4, where the cumulative frequency of hourly warp breaks has been plotted for the beams sized at different stretch levels. The figure shows that in the case of the 2%-stretch beam, the frequency distribution extends right up to 9 warp breaks per hour, whereas in the case of the 0.6%-stretch beam the maximum of hourly warp breaks is only 3. A high level of stretch in sizing therefore introduces in the warp sheet threads of breaking elongation well below a critical minimum, and that these threads in turn render the weaving performance of the beam highly erratic. Such a behaviour of the beam would obviously increase the workload of the weaver, and consequently would reduce the loom efficiency through increased interference.

4 Summary and Conclusions

It is known that, beyond a certain level, warp stretch during sizing adds substantially to the warp breakage rate in weaving. This increase in breakage rate has been attributed to an excessive loss in elongation resulting from excessive stretch.

This study has made available some additional information of value in interpreting this phenomenon. A high level of stretch during sizing not only reduces the average level of the elongation of the warp yarn, but also renders the individual threads to be more non-uniform in terms of breaking elongation. This increase in the non-uniformity is the result of an abrupt increase in the frequency of threads with elongation below a certain critical level. Such low-elongation threads would appear to be a cause for the excessive warp-breakage rate resulting from excessive stretch in sizing.

One cause of the occasionally observed intervals of very high warp breakage in a given weaver's beam could be the presence in the beam of threads of very low elongation.

The study also establishes a linear relationship between warp stretch and loss in elongation of sized yarn during sizing.

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