Effect of Wet Processing Parameters and Type of Weave on the Shrinkage of Polyester/Viscose Blend Fabrics

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The dependence of fibre shrinkage on wet processing parameters, viz. dry setting temperature, pH of the bath, conditions of hot water treatment and repeated wetting-drying treatments, has been studied in the case of three common polyester/viscose blend (15/85, 30/70 and 48/52) compositions adopting different weaves—plain, twill, hopsack and satin. Blends with higher viscose contents showed greater combined swelling and relaxation shrinkages on treatment with distilled water and alkaline solutions. On the other hand, blends with higher polyester contents exhibited greater combined relaxation and swelling shrinkages on being subjected to dry heat. Weaves with longer floats and fewer interlacements showed greater shrinkage compared to other weaves.

Fabrics show dimensional changes at various stages of processing and tailoring. In wet processing, the stability of fabrics is one of the main factors with which the manufacturers are concerned. Different fabrics undergo shrinkage to different extents. A residual shrinkage of 1-2% for a finished fabric is permissible, and is tolerable; any shrinkage beyond this level is liable to cause problems, the type of the problem depending on the end use of the fabric. The dimensional changes resulting in a fabric should be predictable, and if possible they should be controllable by any of the methods available to the satisfaction of the consumer. Shrinkage is the linear contraction of fabric expressed as percentage of the original dimensions. Relaxation shrinkage results from the release of latent strains and swelling shrinkage is caused by fibre swelling for which complex fabric interactions are responsible. Thermal shrinkage is synonymous with relaxation shrinkage.

The objective of this study was to ascertain the manner in which dimensional changes occur in a wide range of fabrics, including slack weaves like satin and twill and the more compact ones like hopsack and plain. The shrinkage occurring in the fabrics after wet treatments was noted. Various blends of polyester and viscose, viz. 15/85, 30/70 and 48/52, in the above-mentioned four weaves were taken and their shrinkage behaviour was studied under different conditions in respect of pH, temperature, dry heat and duration and number of treatments. The fabric samples were not subjected to agitation during treatment. This made their evaluation easier.

Materials and Methods
Preparation of the samples—Polyester fibre (15 kg) of 1.5 denier, length 51 mm and tenacity 4.5 g/denier, and viscose (22 kg) of the same denier, but of length 54 mm and tenacity 2.5 g/denier were taken. Three mixings with different percentages of polyester and viscose, viz. 48/52, 30/70 and 15/85, were made. From these mixings, yarn was prepared through the sequential stages of scutching, carding, draw frame (two passages) simplex and ring spinning. For preparing suittings, the yarn was doubled through cone winding, parallel cheese winding, twisting on the doubler and then cone winding again. This yarn, with the help of a sectional warping machine, was converted into three beams of warp, woven in three stages, for the three blends on a plain loom, with negative let-off.

Fabric samples were prepared from the different polyester/viscose blends in different weaves—plain, twill, hopsack and satin. The other parameters which otherwise normally affect shrinkage were kept constant as in a simple control experiment.

(i) All the three fabric samples were prepared on the same sequence of machines to eliminate the machine to machine variation.
(ii) All the yarns produced had the same number of turns per inch.
(iii) The nominal count for all the three yarns was kept the same (single 48-Z doubled 48/2-s).
(iv) Reed-pick in all the fabric samples and also within a sample was the same throughout (72 x 72 nominal).

It is well established that weaves with longer floats and fewer interlacements are not much disturbed by fibre and yarn swelling. To have an idea of the magnitude of this effect of weaves upon fabric shrinkage, the following four weaves were adopted:
plain, twill-2/2, 4-thread satin and 2 x 2 hopsack. The fabrics were subjected to the following tests:

1. The samples were dipped in distilled water for different time intervals (5, 10, 30 or 45 min).
2. The samples were immersed in water at different temperatures (40, 60, 80 or 95°C) for a fixed period of 40 min.
3. The samples were subjected to dry heat at 100, 200 or 220°C in a conditioning oven for 4 sec to produce thermal shrinkage in the loose condition.
4. The samples were dipped in alkaline and acidic solutions of pH 4, 6, 8 or 9 for 20 min. Alkaline solutions were made with caustic soda, while acidic solutions were made with acetic acid.
5. The samples were given repeated wetting treatments in distilled water, the duration of each treatment being 5 min; the progressive shrinkage was measured. The conditions chosen match the ones in commercial practice.

The specimens were produced as per the standards laid down in the BS Handbook. The fabric was woven in 91 cm width, leaving 10 cm from each selvedge. Samples of 25 x 25 cm size were cut and then marked with the help of a template of 20 x 20 cm. Care was taken to mark along the threads, warp and weft way, with a microtip pen using unwashable ink. Prior to marking, the samples were allowed to attain equilibrium in standard atmosphere (RH 65%, and temperature 27 ± 2°C) for 24 hr. All measurements were made under atmospheric conditions.

Results and Discussion

Effect of dry heat—It is seen from Fig. 1 (A-D) that blends with a higher proportion of polyester undergo greater shrinkage. This is possibly related to the thermoplastic nature of the polyester fibre. According to Hearle1, at elevated temperature, the bonds between the molecular chains get weakened and the originally strained molecules on processing settle down to the position of least strain; this results in shrinkage. This does not happen with viscose, which is not thermoplastic. Consequently, blends containing more of polyester show higher resultant shrinkage. Increase in temperature from 200° to 220°C causes an unusual increase in the extent of shrinkage. The softening temperature of polyester is 210°C and, the softening occurring when this temperature is crossed adds to the magnitude of shrinkage caused. Among the various weaves, hopsack undergoes maximum shrinkage and plain weave, the minimum. Satin and twill weaves lie in between these two, satin exhibiting slightly higher shrinkage. Thus, weaves with longer floats and fewer interlacements suffer higher shrinkage.

Effect of pH—Cellulosic fibres, viscose for example, swell more in alkaline media. Harwood2 investigated this behaviour in detail. At higher alkalinity, the swelling is more and hence the shrinkage is more in the case of blends containing more of viscose. Alkalinity has negligible effect on the shrinkage behaviour of polyester. Acidic pH has little effect on any of the blends. In the alkaline range, the magnitude of shrinkage increases continuously with increase in alkalinity. The 48/52 blend shows minimum shrinkage and the 15/85 blend, the maximum shrinkage (Fig. 2). As for the weaves, here too, hopsack shows the maximum shrinkage, and plain weave the least, with satin and twill lying in between. In other words, weaves with longer floats and fewer interlacements undergo greater shrinkage.

Effect of temperature of washing—During wet processing, the fabric is repeatedly dipped in hot solutions and this causes shrinkage. The tests conducted in the present study simulate this treatment. It is seen from Fig. 3 that the 48/52 blend exhibits minimum shrinkage initially at temperatures of 40° and 60°C, but there is a marked increase in the extent of shrinkage at higher temperatures (80° and 95°C). The curves for the 30/70 blend lie haphazardly in between the curves for the 48/52 and 15/85 blends. The 15/85 blend undergoes the maximum shrinkage. This is obviously due to the swelling shrinkage of viscose present in high proportion in this blend. At higher temperatures, the polyester as well as the strains in the viscose get relaxed, whereby the extent of relaxation shrinkage is the same. The two add up in a complex manner to increase the net shrinkage. The relaxation and swelling shrinkages exhibited by the 48/52 blend are by no means greater than those exhibited by the 15/85 blend. Among the different weaves tried, those with longer floats are more free to get compact due to their loose structure, and hence they shrink more. This tallies with the observation of Collins3. On the other hand, weaves with more interlacements like plain weave are already compact and tend to undergo lesser shrinkage. The combined effect of these two behaviours results in greater shrinkage in hopsack and lesser shrinkage in satin and twill weaves, while the least shrinkage is exhibited by fabrics in plain weave.

Effect of soaking in distilled water at room temperature—It is seen from Fig. 4 that with increase in the duration of soaking, there is negligible increase in shrinkage in the case of the 48/52 blend. On the other hand, the 15/85 blend shows steep rise in shrinkage. This can be attributed to the high viscose content of the 15/85 blend, which is responsible for its extensive swelling through moisture regain. Polyester with very low moisture regain undergoes very little shrinkage. This is in conformity with the explanation given by Snowden and Wagh4. Relaxation shrinkage in all the
Fig. 1—Area shrinkage on dry heat treatment [(A) Plain weave, (B) Hopsack weave, (C) Twill weave, and (D) Satin weave]

Fig. 2—Area shrinkage on treatment with solution of different pH [(A) Plain weave, (B) Hopsack weave, (C) Twill weave, and (D) Satin weave]
Fig. 3: Area shrinkage on treatment with hot distilled water for different time intervals. 
(A) Plain weave, (B) Hopsack weave, (C) Twill weave, and (D) Satin weave.

Fig. 4: Area shrinkage on treatment with distilled water for different time intervals. 
(A) Plain weave, (B) Hopsack weave, (C) Twill weave, and (D) Satin weave.
three blends is of approximately the same magnitude and hence the 15/85 blend which undergoes large swelling shows the maximum shrinkage and 48/52, the minimum shrinkage; the 30/70 blend lies in between the two.

As for the weaves the same trend as in the earlier experiments is observed here too.

**Effect of repeated treatments**—Fabrics are often subjected to repeated washing during manufacture and end use. In the first washing-drying treatment, there is considerable swelling followed by shrinkage and local strains get locked in the structure. These disappear in the subsequent drying-washing cycles. These strains are prominent at places in the yarn where sticking has occurred. When the yarn dries, free spaces develop, allowing for accommodation between fibres; a less strained and more shrunk structure results when the cloth is wetted again. Agitation again helps overcome these local strains, promoting shrinkage. This explanation is due to Collins, later confirmed by Cryer.

It is seen from Fig. 5 that the shrinkage is minimum in the case of the 48/52 blend and maximum in the case of the 15/85 blend. The reason for this is the greater swelling undergone by viscose. It is also observed that shrinkage is more in the first four cycles; thereafter, the rate of increase in shrinkage due to repeated treatments seems to become constant or starts decreasing. The different weaves show the same trend as in the preceding tests.

**Conclusions**

1. In acidic and alkaline baths, blends with a higher content of viscose undergo greater shrinkage compared to the ones with higher polyester content.
2. Heat treatment causes greater shrinkage in blends with higher polyester content.
3. Weaves with longer floats and fewer interlacements exhibit greater shrinkage for a given fabric.

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**Fig. 5**—Area shrinkage on repeated treatments in distilled water [(A) Plain weave, (B) Hopsack weave, (C) Twill weave, and (D) Satin]
(4) Most of the shrinkage occurs in the first four dippings; there is negligible or no shrinkage beyond the sixth dipping.

(5) With increase in the temperature of the dipping bath, the extent of shrinkage increases for all the blends; the increase is more prominent in blends with higher viscose content.

(6) On soaking the fabrics in distilled water, bulk of the shrinkage occurs in the first 45 min.

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References