EFFECT OF CONSTRUCTION ON FELTING SHRINKAGE OF WOOL KNIT FABRIC*

Tightness Of Knit Found To Have Marked Effect On Felting Behavior

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WITH chemical shrink resistance now a requirement in many military specifications for wool and part-wool knit items, attention has been focused by the Quartermaster laboratories on the role of constructional factors in shrinkage. Previous work** had shown that parameters such as wales and courses per inch and yarn size had a profound effect on mechanical or relaxation shrinkage, and it was desired to determine the effect of these factors on the so-called "chemical" or felting shrinkage of wool—that normally is controlled by the chlorination treatment.

TABLE 3

Fabric	Yarn Count	Fabric Texture Wales	Fabric Texture Courses	Shrinkage in 5 Launderings (%) Length	Shrinkage in 5 Launderings (%) Width
Rib knit	15/2	12	18	14	0
tubing	26/2	12	20	29	16
	15/1	15	17	30	19

It had been observed, for example, that a loose, sleazy construction would felt more than a tight knit even though identical treated wool was used in the manufacture of both. Determination of the principles involved in this behavior might permit the utilization of milder chemical treatments and thus extend the useful wear life of the wool garment. The mechanism of felting shrinkage is known to depend upon the differential migration of fibers within the yarn or fabric structure. It is reasonable to assume that the fibers will migrate more freely if they are not restricted by high twist of the yarns or compacted by excessive tightness of the fabric.

An experiment was set up to analyze these constructional factors and also to determine the relative effect of structure and chemical treatment on felting shrinkage. A lot of 64's grade Australian wool top was treated by a commercial, continuous top-treating process employing alkaline wet chlorination. Three different intensities of treatment designated as mild, optimum and severe chlorination were used. These lots of wool were top dyed with chrome colors and then spun into the following yarns: 15/1 and 15/2 on the Bradford system using normal and higher then normal knitting twist, 26/1 and 26/2 on the Bradford and French systems using normal knitting twist, and 36/1 and 36/2 on the French system using normal knitting twist. The yarns were fabricated into socks or tubing using either flat or 1 x 1 rib stitches. With each knitting machine, that number of courses was used which would produce a commercially acceptable fabric with a given type of yarn. The courses were then varied above and below this value to give a tight and a loose or sleazy construction, in addition to the "normal" texture.

The knit fabrics were relaxed by submerging them in water at 90 degrees F. for two hours, followed by hydroextraction and tumble drying. The laundering procedure used was the Army wool mobile laundering, except that the load was increased from 20 to 23½ pounds, in order to accommodate all of the specimens in a single run. The wash cycle comprised two 5-minute suds, using Igepon T as detergent, followed by three 3-minute rinses, extraction, and tumble drying; water temperature was maintained at 100 degrees F. Five wash cycles was the maximum used, since it resulted in severe felting of most of the untreated fabrics. Since all of the relaxation shrinkage was removed during the two-hour soaking and tumbling, the dimensional changes obtained from the five launderings consisted almost entirely of felting shrinkage.

EFFECT OF TEXTURE—In a short review such as this it is possible to present only the major effects noted and the most important conclusions reached in this study. It was found that the most important construction variable from the standpoint of its effect on felting shrinkage is the tightness of knit or knitting stiffness. For example, in the case of a flat knit tubing made from a 26/2 untreated yarn, the length shrinkage was decreased from 46 to 35 percent and the width shrinkage from 38 to 26 percent by increasing the wales from 11 to 14 and the courses from 13 to 20 per inch. In the case of fabrics made from treated wool, where the potential felting has been decreased considerably by the chlorination treatment, the amount of improvement that can take place by tightening the structure decreases. The possibility for reducing felting shrinkage of fabrics made from optimum and severely treated yarn by increasing the knitting stiffness is illustrated by the data in Table 1.

It would appear that making a satisfactory shrink resistant garment depends upon a judicious combination of proper level of treatment with a sufficiently firm construction. It is conceivable that an untreated structure can be knitted sufficiently dense to be called shrink resistant, but only at the expense of softness and suppleness which are the chief virtues of knit garments. On the other hand, a sleazy construction can be over-chlorinated to produce adequate control of shrinkage but only with loss of hand and wearing qualities.

EFFECT OF YARN TWIST, PLY AND SPINNING SYSTEM—Study of the effect of twist indicates a small but consistent trend toward lower shrinkages as the amount of twist in the singles yarn is increased. Examples of this effect are shown in Table 2.

The role of plying in felting behavior was determined by laundering fabrics made from 15/1 yarn and those made with 26/2 yarn which were substantially the same in weight. It was found that plying produced no significant effect on the laundering shrinkage of the fabrics. Small differences that were noted in some instances could be attributed to differences in yarn twist. Comparison of the felting rate of untreated fabrics made from yarns spun on the French and on the Bradford systems indicated that type of spinning has a negligible effect on the felting behavior.

EFFECT OF YARN COUNT—Of considerable significance in its effect on the felting behavior of these fabrics was that of yarn number or count. It was found, as shown in Table 3, that the heavier fabrics made with yarns of lower yarn number are relatively less feltable:

COVER FACTOR—Considering that the knitting stiffness (as measured by the wales and courses per inch) and the yarn count had the most profound effect on the felt-

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TABLE 1

Fabric	Yarn Count	Level of Treatment	Fabric Texture Wales	Fabric Texture Courses	Felting Shrinkage in 5 Launderings (%) Length	Felting Shrinkage in 5 Launderings (%) Width
Flat knit	26/2	optimum	10	12	19	6
tubing			14	17	10	1
Flat knit	26/2	severe	10	13	10	—1
tubing			14	18	4	2

TABLE 2

Fabric	Yarn Count	Fabric Texture Wales	Fabric Texture Courses	Yarn Twist Single	Yarn Twist Ply	Shrinkage in 5 Launderings (%) Length	Shrinkage in 5 Launderings (%) Width
Flat knit	15/1	19	24	6.7		23	13
tubing	15/1	19	24	8.1		20	11
Flat knit	15/2	14	17	3.9	7.0	26	17
tubing	15/2	14	17	7.7	5.1	23	13

*Data presented in this report are taken from Textile Series Report #66 by Herman Bogaty, Arnold Sookne and Milton Harris of the Harris Research Laboratories and Louis I. Weiner of the Quartermaster Research & Development Laboratories.

**Textile Series Report #57—"Factors affecting the relaxation shrinkage of knit underwear tubing" — Louis I. Weiner.

Influence Of Stitch Construction On Felting Shrinkage Surveyed By QM

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ing shrinkage of the fabrics, it was suggested that these two factors could be considered together as a measure of denseness or cover to predict the felting tendencies of a given knit wool fabric. In the case of woven fabrics the measure known as the cover factor is frequently used as an index of the tightness or density of structure of the material. Cover factor, K, is defined as:

$$K = \frac{T.P.I.}{\sqrt{N}}$$

where T. P. I. stands for the number of ends or picks per inch and N stands for the count of the warp or filling yarns. It is understood from this relationship that by either increasing the number of threads per inch or by increasing the size of the yarn (decreasing yarn count) the tightness or cover factor increases. It was felt that a relationship similar to this could be used to describe the tightness of a knit structure. A suitable formula for cover factor of knit fabrics was determined to be:

$$K = \frac{W \cdot C}{\sqrt{N}}$$

where W and C represent the wales per inch and the courses per inch respectively and N the yarn count expressed as the singles equivalent. It was found that cover factors so calculated gave a good indication of the density of the knit structure. Cover factors calculated from this formula were plotted against the felting shrinkage of the fabrics and excellent correlations were obtained. These relationships furnish a simple method for determining whether a given knit fabric is sufficiently firm for shrink resistant applications. Cover factors of approximately ten are quite satisfactory for most shrink resistant materials. Cover factors of five are indicative of rather loose construction and even with a severe shrink resistant treatment might not be suitable for many end use requirements.

It may be concluded that the most effective way of controlling the felting shrinkage of knit wool items is through the use of a chlorination treatment. However, factors of construction, especially yarn count and knitting stiffness, do contribute appreciably to the felting behavior and should be considered in the design of shrink resistant treated woolens.

Fortunately, the constructions procured by the Quartermaster Corps are sufficiently dense (high cover factor) that the application of a normal chlorination treatment results in an item that can be laundered many times under severe field laundering conditions and still maintain its size and shape. However, many commercial items which have been well treated and are offered as shrink resistant, are not sufficiently dense in structure to withstand home washing, particularly in a washing machine. Based on the data presented in this report it is suggested that all producers of shrink resistant knit woolens compute the cover factors of their items to determine whether they are sufficiently high to warrant treatment and promotion as being shrink resistant. It is likely that a simple test of this nature will lead to increased consumer acceptance of shrink resistance and will protect the knitter from excessive returns of items that failed in laundering.

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Great Care Major Requirement In Cashmere Dyeing

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hand kettles for thorough scouring to the newest high pressure stock drying machine.

Cashmere Corp. is constantly seeking means of stepping up production time, but not at the expense of the finished product. It employs a permanent staff of five men in its laboratory. It is possible, said Mr. Adler, that through higher temperatures under high pressure, a method of speeding up production might be realized."

"We must achieve level dyeing but many of the dyes we have to use are difficult to dye level." Mr. Adler stated. "The reasons for this," he added, "are: (a) the high degree of wash-and fastlightness required by the expensive yarns and (b) the fact that the principal high quality dyes meeting these requirements give a characteristically unlevel dyeing. These factors make the dyeing of cashmere yarn just about the most difficult assignment a dyer can undertake."

At Erie Dyeing, a "daylight matching' light" is used which also shows "shade under artificial light so that colors will match.