THE RELATIONSHIP BETWEEN THE BULK OF A RELAXED SKEIN AND THE TACTILE PROPERTIES OF THE RESULTANT WOVEN AND KNITTED FABRICS

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Abstract

This work is an attempt to develop some simple and realistic tools that can be applied by textile manufacturers to control the apparel quality of yarns produced at high production rates. The approach used in this work is based on the assumption that certain differences in the tactile behavior of woven and knitted fabrics made from rotor-spun yarns are reflected in the wet relaxation behavior of the yarns and fabrics. Differences in the wet relaxation behavior can be expected to arise as a result of the differences in spinning parameters such as yarn twist level, spinning tension, fiber disposition and yarn structure.

Results obtained on 100% cotton rotor yarns produced under two sets of spinning conditions revealed the differences in the apparel quality of these yarns. Results also revealed how the differences in yarn bulk and relaxation properties translate into fabric tactile behavior. Physical measurements made on relaxed skeins demonstrated how yarn manufacturers can readily monitor the apparel quality of yarns produced on high speed rotor spinning machines so as to maintain the tactile quality of the resultant woven and knitted fabrics within acceptable limits. Yarns produced with certain rotor and doffing tube combinations yielded relaxed skeins that were shorter and thicker than those produced with other rotor and doffing tube combinations. The yarns representing short and bulky skeins produced some what bulky and soft fabrics. The compression properties of the relaxed skein showed very good correspondence with the compression properties of the relaxed fabrics.

Introduction and Background

Many textile mills in the US currently produce 100% cotton and cotton/polyester yarns at very high rotor speeds of the order of 120,000 rpm, using a range of rotor diameters, groove shapes and doffing tube designs. This trend represents a wide variation in yarn structure - a new source of variation in yarn quality which exerts considerable influence on the tactile behavior of the resultant woven and knitted fabrics. Because of a general lack of understanding of some of the structure related yarn quality deficiencies and also because of the absence of a strong reaction from the consumers of apparel yarns and fabrics, staple yarn manufacturers have not so far paid adequate attention to the new source of variation in yarn and fabric quality. The problem, however, is quite serious because of the ever increasing trend toward higher twist insertion rates.

Over the past several years, innumerable studies of both fundamental and applied nature (1-4) have shown how differences in machine design and the process conditions influence the yarn quality and process performance in rotor spinning. It was well recognized by researchers that the characteristics of the doffing tube in conjunction with other parameters such as rotor speed, rotor diameter, groove shape, yarn count, twist factor, fiber physical properties, etc. play an important role in deciding the spinning performance and yarn quality. The shape, size and position of the doffing tube, among other things were found to influence the false-twist generated inside the rotor.

The false twist in turn, was found to have both positive and negative effects. It was shown that false twisting action enabled the production of yarn with low twist factors and reduced the end-breakage rate. Also moderate levels of false twist were found to result in an improvement in the uniformity of twist insertion and yarn strength and in a reduction of yarn extension and contraction. Too much false twist , however, extended the peripheral twist extent (twisted length of yarn in the rotor groove) too far and caused excessive wrapper fibers (loosely wrapped surface fibers) in the yarn. Studies also revealed that grooved doffing tubes enable lower yarn twists to be used but produce rougher and some what hairy yarns. It is thus clear that the structure and properties of the rotor yarn are heavily influenced by the spinning process parameters.

This study focused on the production and evaluation of yarns with and without the potential to assume bulk after relaxation. Simple methods were developed to characterize the inherent bulk of the yarn in wet and dry relaxed states. Attempts were also made to understand how the measured bulk properties of the yarns relate to the tactile performance of the resultant fabrics.

Experimental

Yarn Production : Two cotton yarns, one exhibiting a high contraction potential (hard yarn) and the other exhibiting low contraction potential (soft yarn) were produced on a Rieter open end spinning frame. The count of the hard yarn was Ne 5.6 while that of the soft yarn was Ne 6.2 and the yarns were made from cotton mixings that had very similar properties. The difference in the contraction potential of the yarns was achieved by manipulating the machine twist and

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the level of false twist generated in the rotor during the spinning process. Yarn properties are described in Table 1.

Fabric Production : The experimental yarns were used to produce a 12 ounce denim fabric and a 7.6 0z single jersey knit fabric. Two types of denim fabrics were made, one containing the soft yarn in both the warp and filling directions (soft yarn denim), and the other containing soft yarn in the warp direction and the hard yarn in the filling direction (hard yarn denim). Similarly, one of the knit fabrics was made with the soft yarn and the other with the hard yarn.

Evaluation of Yarns and Fabrics : To characterize the bulk of the experimental yarns in the relaxed state, the yarns were converted into 840 yard skeins on a motorized wrap reel. The skeins were then boiled in distilled water for 20 minutes, taking care to minimize twisting and yarn entanglement during the boil off. The boiled skeins were left exposed to standard atmosphere for one week during which the skeins assumed their relaxed dimensions. The diameter of the relaxed skein was measured by placing a collapsible ring around the skein. Because of the considerable variation in the diameter of the relaxed skeins, it was necessary to make at least 100 diameter measurements for each yarn type. The length of the relaxed skein was measured by suspending the skein across a vertically positioned ruler. A total of 25 skeins were used to compute the average length of the relaxed skein.

The relaxed skeins were also subjected to compressive deformation on the Kawabata compression tester. The compression properties of the relaxed skeins are given in Table 2. The woven and knitted fabrics representing the two yarns were also wet relaxed in a tumbling device which tumble rolled the fabrics in hot water for 30 minutes. The relaxed fabrics were then centrifuged and conditioned in standard atmosphere for 48 hours. The low stress mechanical behavior and thermal properties of the conditioned fabrics were measured using the Kawabata equipment. Measured fabric properties are listed in Table 3.

Table 1. Yarn properties

Yarn Property	Soft Yarn	Hard Yarn
Count (Ne)	6.2	5.6
Wrapper Fiber Percentage	High	Low
Appearance	Even	Uneven
Softness (Subjective)	Soft	Less Soft

Table 2. Measured properties of wet relaxed skein

Property	Skein of Soft Yarn	Skein of Hard Yarn
Relaxed Length (cm)	46.3	43.2
Relaxed Diameter (cm)	2.36	3.03
TO (Initial Thickness, mm)	22.1	29.6
TM (Thickness at 50 g/cm^2)	14.4	15.4
EMC%	39.2	48.0
RC%	32.0	28.0
WC (g/cm)	0.62	1.03

Table 3. Properties of wet relaxed fabrics

FABRIC	TENSILE				SHEAR		BENDING	
	LT	WT	RT	EMT	G	2HG	B	2HB
Soft Yarn Denim	0.2	17.4	35.9	7.9	4.5	8.0	0.87	0.87
Hard Yarn Denim	0.18	15.3	37.6	7.4	4.9	8.4	1.12	1.20
Soft Yarn Knit	---	---	---	---	0.9	2.9	.143	.178
Hard Yarn Knit	---	---	---	---	1.0	3.2	.169	.208

Table 3 . (continued)

COMPRESSION					SURFACE			THERMAL		
LC	WC	RC	EMC	TO	MIU	MMD	SMD	Q_{max}	W (dry)	W (wet)
.292	1.06	45.5	37.8	1.97	.190	.029	8.50	.096	1.03	2.74
.493	2.26	35.3	45.3	2.07	.191	.027	7.6	.085	1.02	2.74
.236	.463	42.3	22.8	1.72	---	----	----	.102	.96	2.88
.230	.476	40.9	23.8	1.75	----	----	----	.104	.99	2.63

Results and Discussion

Yarn Properties : The yarn produced with a moderate false twisting action gave a somewhat even appearance and a soft feel. The skein of this yarn, however, exhibited less contraction and less bulk on wet relaxation. Under compression, the relaxed skein representing the soft yarn showed a lower percentage thickness compression (EMC%), lower initial thickness (TO), lower compression energy (WC) and higher compressive resilience (RC%).

Fabric Properties : Table 3 shows that the property differences exhibited by the woven fabrics containing the two yarns are very similar to the differences exhibited by the corresponding knitted fabrics. Thus the two yarns produce a similar difference in properties in both woven and knitted fabrics. The hard yarn which assumed greater bulk after relaxation showed higher values in both woven and knitted fabrics for shear rigidity (G), shear hysteresis (2HG), bending rigidity (B), bending hysteresis (2HB), compression energy (WC), initial fabric thickness (TO), and percentage thickness compression (EMC%). The same yarn also showed lower compressive resilience in both woven and knitted fabrics. It is clear that the yarn that assumes greater bulk on relaxation produces a slightly less flexible but relatively softer fabric. The two yarns also gave a distinctly different appearance to the relaxed denim fabric. Thus the denim fabric containing the soft yarn in the warp direction and the hard yarn in the filling direction gave a much more ruffled and distorted surface appearance compared to the other denim fabric. Lack of compatibility in the wet contraction behavior of the warp and filling yarns appears to adversely affect the surface appearance of wet relaxed fabrics. It also appears that compatibility in yarn relaxation behavior is more important in coarse fabrics than in fine fabrics.

Conclusions

The two denim fabrics representing soft and hard yarns gave very similar surface appearance before washing. After washing, however, the denim fabric with the soft warp and hard filling yarn assumed very rough and uneven surface appearance. Excessive difference in the wet relaxation behavior of the warp and filling yarns therefore produced uneven fabric surface appearance. after washing.

Differences in yarn relaxation behavior can be captured by the differences in skein relaxation behavior. The skein relaxation behavior, in turn, can throw light on the compatibility of warp and filling yarns. A marked difference in the wet relaxation behavior of the warp and filling yarn skeins is an indication of rough surface appearance in densely woven fabrics.

Differences in yarn relaxation behavior affect the tactile properties of both woven and knitted fabrics.

The denim fabric made from soft warp and hard filling yarns showed lower tensile elongation, higher tensile resilience, higher shear and bending rigidities, higher compressibility and lower compressive resilience.

The two denim fabrics as well as the knitted fabrics showed exactly the same difference in compression properties as that shown by the two relaxed skeins.

Literature Cited

1. Nield, R., and Ali, A.R.A., J. Tex. Inst. 68, 110 (1977).
2. Text. Topics, 1976, 5, No.2.
3. Text. Praxis, 1977, 32, 1035.
4. Text. Praxis, 1977, 32, 251.