OPTIMAL BLENDING RATIO FOR COTTON/RAMIE YARNS AND THE RESULTING FABRIC QUALITY

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Abstract

Producing cotton/ramie blended yarns and fabrics is an ideal way to integrate the best properties of both cotton and ramie fibers into a single textile product. However, the processing of cotton/ramie blends using a cotton system usually requires extra care. The spinning of cotton yarns blended with long stable ramie fiber requires special adjustment of the drawing frame so that adequate sliver and roving can be prepared prior to actual spinning. In this study, direct blending of cotton with ramie staple fiber was carried out prior to carding and drawing with the aim of minimizing equipment adjustment. Experimental cotton/ramie yarns of 20 Ne and 30 Ne, having a series of ramie blending ratios between 10% to 50%, were spun and then knitted into fabrics. Primary properties of the cotton/ramie blended fiber and yarns evaluated using the HVI and Uster tester. The Kawabata data were used to compare bending and compressive properties of the cotton/ramie blended fabrics with those of a pure cotton fabric of similar construction. The effect of the ramie blending ratio on blended yarn and fabric performance was analyzed and the optimal ramie blending ratio was determined.

Introduction

Ramie is a high quality, expensive natural fiber. It is widely used for making apparel fabrics because of its silky luster, strong wet strength, excellent dimensional stability and absorbency. It is fast drying, and easy to dye [Frederick, 1990]. Its resistance to deterioration due to wear, mildew, rot, laundering, and perspiration is more attractive to today's consumers who are looking for high performance antibacterial textiles. Ramie has been cultivated in the Far East for many centuries. It was used in apparel long before cotton. In today's global market, China, Brazil, and the Philippines are the three major suppliers of raw ramie fiber, accounting for approximately 75%, 20%, and 5% of the world's supply [Hester and Yuen, 1989].

Ramie production in the U.S. has been very limited. Ramie began to have a major impact on the U.S. market in the early 1980's. Because it was not included in the Multi-Fiber Arrangement (MFA-3), its imports, ranging from raw ramie fiber to ramie blended fabrics and apparels, increased dramatically and reached a peak in 1985. Ramie/cotton blends, particularly 60/40 ramie/cotton sweaters, were very popular because of economical and technical factors. They were cost-effective compared to linen and silk, and blended easily with cotton. Since ramie imports were controlled under the MFA-4 that became effective in 1986, ramie was no longer ranked as a highly traded fiber [Hester and Yuen, 1989]. However, it is believed that new markets for ramie applications in the U.S. still exist. China is paving the way for entering the World Trade Organization (WTO). Research on the processing of ramie fiber is, therefore, necessary and beneficial to domestic textile manufacturers in understanding ramie properties and gaining hands-on experience of ramie production.

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This paper presents a study on the spinnability of ramie/cotton blends, in particular, the spinning of ramie/cotton blended yarn having cotton-fiber content of 50% or more. The emphasis is on the determination of the optimal blending ratio of ramie with cotton. In the production of ramie/cotton blend yarns, the procedure of mixing ramie and cotton fibers is very important. Two blending methods are commonly used [Yu et al., 1997]. One method is to blend ramie sliver with cotton sliver during the drawing process. The other method is to blend ramie fiber with cotton fiber in opening and carding. This method is widely used in spinning many cotton blended yarns, and is used in this study to determine whether this method of fiber blending is suitable for mixing ramie stable fiber with cotton.

Experiment

The ramie fiber used for this study was staple fiber supplied by Filter Media Specification. Length of the ramie stable was 3.75 inch (95.25 mm). Cotton fiber (Acala) was provided by the USDA Southern Regional Research Center.

Fiber processing and spinning was executed in the Mini Spinning Laboratory at the USDA Southern Regional Research Center. Ramie and Acala cotton were opened and blended using a Spinlab 338 opener/blender. Ramie blending ratios of 10%, 15%, 20%, 25%, 30%, 40%, and 50% were used for mixing with cotton fiber. After opening, the fibers were carded and then drawn to form sliver. The sliver was fed into a Shirley spinning frame for yarn spinning. Yarns of 20 Ne and 30 Ne with the above blending ratio were made. These spun yarns were knitted into single knitted fabrics using a FAK knitter with a 10-inch cylinder.

To evaluate fiber dimensions and strength, the Spinlab High Volume Instrument (HVI) System was used to test pure cotton and ramie/cotton blends. Yarn strength and evenness were tested using the Scott Tester, Uster Tensorapid 3, and Evenness tester. A pure ramie yarn (20 Ne) was also tested for comparison purpose. Mechanical properties of the knitted fabrics of pure cotton, pure ramie and ramie/cotton blended were evaluated using the Kawabata KES-FB Instruments [Kawabata and Niwa, 1989].

Results and Discussion

Fiber Dimensions and Strength

The HVI data of fiber length and fineness of the ramie/cotton blend are listed in Table 1. As shown Figure 1, an increase in the ramie blending ratio results in an increase in the average fiber length of the blend and a decrease in length uniformity. The length-ratio and uniformity-ratio can be expressed using a 2nd degree polynomial function (see Table 2). The micronaire fineness and its CV% are also proportional to the ramie blending ratio as illustrated in Figure 2. Two 2nd degree polynomial functions are listed in Table 2 and both can be used to describe this relationship.

The HVI data on the tensile strength of ramie/cotton blended fiber are listed in Table 1 and illustrated in Figure 3. There is a minimum value at the ramie blend ratio of 20%. This phenomenon is due to the difference in the breaking elongation of the two kinds of fibers. As the blending ratio exceeds 20%, the fiber strength increases significantly. This indicates that the mean fiber tenacity of the ramie/cotton fiber bundle will be improved markedly with the presence of ramie fiber. A 3rd degree polynomial function can be used for illustrating this relationship (Table 2).

Yarn Strength and Evenness

Single strand yarn breaking strengths of the ramie blended yarns tested by the Uster Tensorapid are listed in Table 3. Compared to the pure cotton and ramie blended yarns, the pure ramie yarn has the greatest yarn strength. As the ramie blending ratio approaches 50%, yarn strength trends to be minimum (Figure 4). The tested results of yarn strength using the skein test reveal a similar trend to that from the Uster Tensorapid, as shown in Figure 5.

Both the pure cotton and pure ramie yarns have good yarn evenness (Table 3). As the ramie blending ratio increases, the yarn evenness becomes worse and tends to reach a minimum when the ramie blending ratio approaches 50% (Figure 6).

Fabric Bending and Compressive Properties

The present work evaluates bending and compressive properties of the cotton/ramie fabrics in comparison with those of pure cotton fabrics having the same structure. As shown in Figures 7 and 8, the presence of ramie has little effect on fabric bending rigidity and bending hysteresis. However, the increase of ramie blending ratio trends to elevate the compressive energy and to decrease the compressive resilience (Figures 9 and 10). This means there will be an increase of fabric toughness and weakening of elastic recovery.

Optimal Ramie Blending Ratio

Although the mixing of ramie fiber with cotton increases the mean length of the blended fiber bundle, it also increases irregularities in fiber length and fineness. Yarn strength and evenness will also be adversely affected by increasing ramie blending ratio. A small ramie blending ratio should be used for cotton mix. Considering the range of ramie blending ratio from 10% to 50% investigated in the present work, a ramie blending ratio between 10% to 30% is an optimal choice.

Summary

The spinnability of ramie/cotton blends was investigated using a mini spinning system for cotton. Ramie/cotton blended yarns of 20 Ne and 30 Ne were produced with a series of ramie blending ratios between 10% and 50%. These yarns were then knitted into fabric. The properties of the ramie/cotton blended fibers and ramie/cotton yarns were tested using the HVI system and the Uster tester, respectively. The main mechanical properties of the ramie/cotton fabric were evaluated using the Kawabata instruments. The experimental data indicated that direct blending of ramie staple fiber with cotton fiber was practical and necessary prior to carding, drawing, and spinning, but the present ramie stable length was not suitable for spinning with cotton because of large length irregularity and relatively low yarn quality. To obtain the best processability and spun yarn quality of the blends, the optimal ramie blending ratio should be controlled between 10% and 30%, or conversely, a smaller cotton blending ratio within 10% to 30% should be considered. In this range, the ratio of 20% should be avoided due to a potential of producing lower fiber strength, mean length, and uniformity. A further investigation on determination of optimal ramie length for blending with cotton is needed.

Acknowledgements

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References

Hester, S. B. and M. L. Yuen. 1989. Ramie: Patterns of World Production and Trade. J. Text. Inst., **80**(4), 493-505.

Frederick, E. R. 1990. Ramie: A New U.S. Industry. INDA Journal of Nonwovens Research. **2**(2), 44-45.

Yu, C. W., Y. M. Zhang, and F. C. Jiang. 1997. Ramie Yarn Manufacturing and Quality Control. China Textile University Press, Shanghai, China.

Kawabata, S. and M. Niwa. 1989. Fabric Performance in Clothing and Clothing Manufacture, J. Text. Inst., 80(1), 19-50.

Table 1. HVI Data of Fiber Fineness, Length, and Strength of Ramie/Cotton Blend.

Blending Ratio (%)	Micronaire	Mic. CV (%)	Mean Length (inch)	Uniformity Index (%)	Strength (gf/tex)
0	4.19	0.64	0.967	83.70	32.25
10	4.39	0.57	0.978	82.50	30.50
15	4.52	0.73	0.985	82.00	29.86
20	4.66	0.74	0.977	80.90	28.33
25	4.86	0.73	0.998	81.30	29.65
30	4.98	0.92	1.003	80.30	31.68
40	5.35	0.93	1.006	79.60	37.05
50	5.73	1.11	1.014	79.30	38.88
100	8.46	3.10	1.018	76.90	64.80

Table 2. Relationships between Fiber Properties and Ramie Blending Ratio.

Parameter	Polynomial Equation*	R^2
Mean Length	$0.96+0.14k-0.09k^2$	0.9279
Uniformity Index	$83.57-11.72k+5.09k^2$	0.9820
Micronaire Fineness	$4.18+1.98k+2.30k^2$	0.9998
Micronaire CV	$0.66-0.33k+2.76k^2$	0.9935
Strength	$32.42-40.87k+150k^2-3.44k^3$	0.9927

* k = ramie blending ratio.

Table 3. Ramie/Cotton Blended Yarn Strength and Evenness.

	20 Ne			30 Ne		
Blending Ratio (%)	Skein Strength (lb)	Single End (cN/tex)	Evenness (%CV)	Skein Strength (lb)	Single End (cN/tex)	Skein Strength (lb)
0	81.00	11.46	23.37	67.50	14.90	25.08
10	88.00	13.92	24.09	58.00	12.23	28.33
15	76.50	12.02	27.72	49.50	10.88	27.55
20	93.00	10.35	26.07	59.00	11.97	29.65
25	78.50	11.58	26.33	40.00	9.60	32.08
30	80.00	8.50	29.27	40.00	9.34	27.39
40	62.50	8.86	30.61	49.00	9.58	26.87
50	49.00	8.80	32.85	40.00	7.84	38.64
100	–	19.84	22.50	–	–	21.00

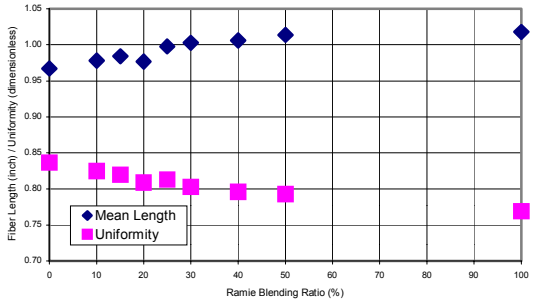

Figure 1. Mean Length and Uniformity of Ramie Blended Fiber.

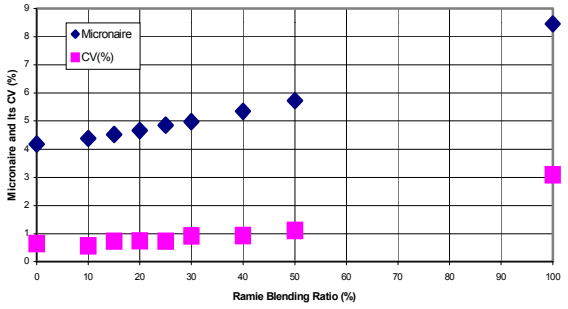

Figure 2. Fineness and Irregularity of Ramie Blended Fiber.

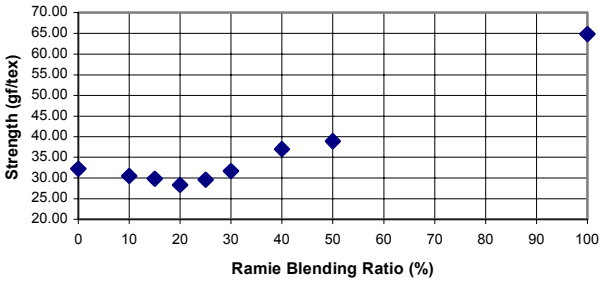

Figure 3. Tensile Strength of Ramie Blended Fiber (HVI).

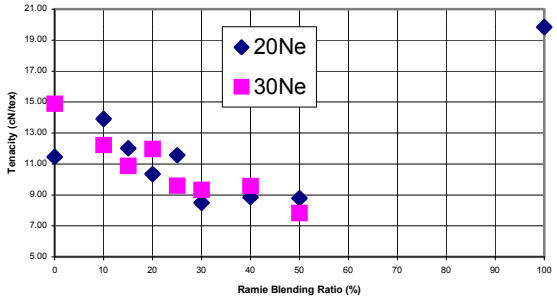

Figure 4. Single Strand Yarn Strength.

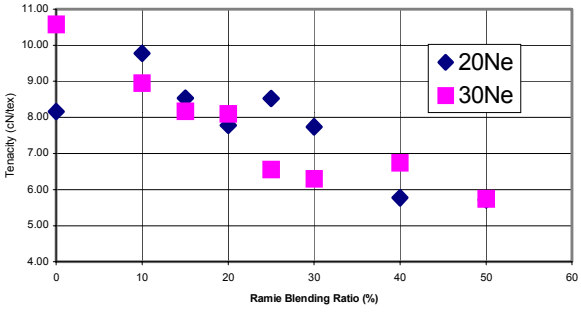

Figure 5. Ramie Blended Yarn Strength by Skein Test.

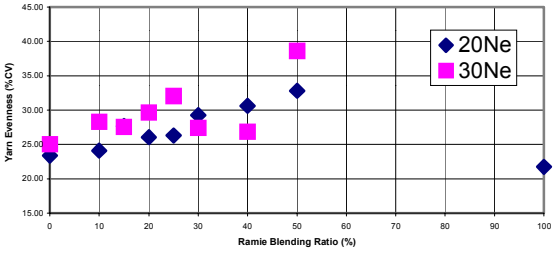

Figure 6. Ramie Blended Yarn Evenness.

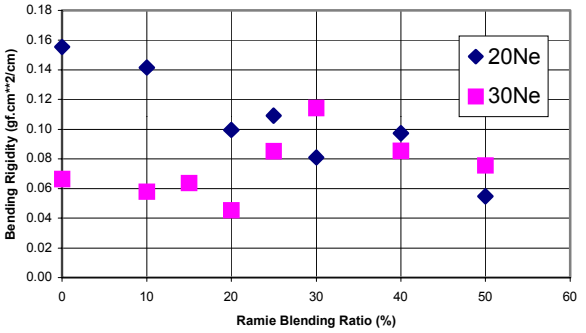

Figure 7. Bending Rigidity of Cotton/Ramie Knitted Fabric.

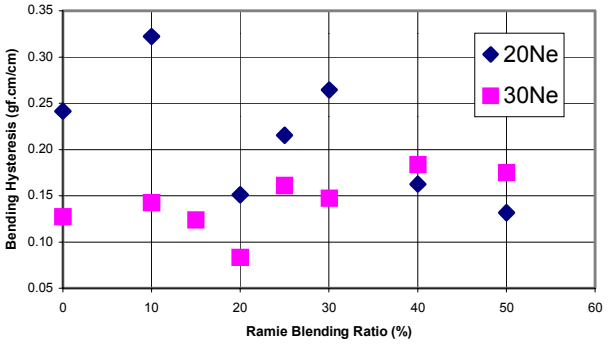

Figure 8. Bending Hysteresis of Cotton/Ramie Knitted Fabric.

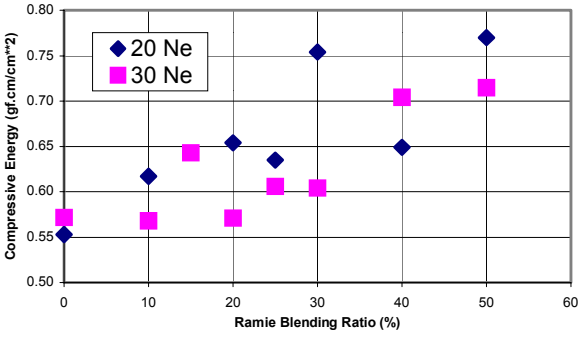

Figure 9. Compressive Energy (WC) of Cotton/Ramie Knitted Fabric.

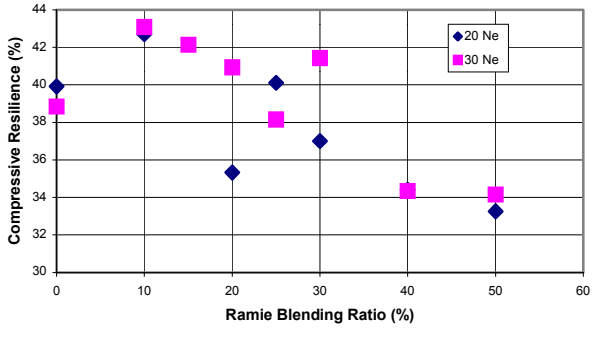

Figure 10. Compressive Resilience (RC) of Cotton/Ramie Knitted Fabric.