HIGH PERFORMANCE COTTON/DYNEEMA® BLEND TENT FABRICS

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Abstract

Although cotton has many natural advantages, its use for military tent fabrics has declined, primarily because of the heaviness of the fabrics, which is dictated by the strength requirements. Indeed, many 100% cotton fabrics treated with modern flame-resistant finishes fail to meet the high performance standards required by the military. In this work we produced stronger, more durable fabrics from predominantly-cotton yarns containing extra high strength Dyneema® polyethylene fibers. Fabrics woven from these intimately blended yarns were treated with a flame resistant finish. Because the fabrics contained mostly cotton, softness, absorbency, breathability, and other desirable properties of all cotton were preserved.

Introduction

Cotton fabrics have some good properties such as high wet strength, natural water resistance, and good breathability that make them ideally suitable for military uses. The fabric breathability property is especially important in tarpaulin and tentage end-uses, where condensation on the underside of the fabric is undesirable. The cotton fabrics when dry have the necessary porosity to allow the passage of moisture or water vapor, and when wet become highly water resistant, because of the unique swelling property of the cotton fiber.

Despite these advantages of cotton, its use in these products has declined, largely because the cotton fabrics must be excessively heavy in order to meet the high strength requirement. In addition, flame retardant (FR) finishes required for most military tents usually result in a substantial weight add-on, which causes fabric stiffening and a substantial loss in tearing strength.

One approach to improving the strength properties of the cotton fabrics is to blend cotton with high tenacity manmade fibers. The strongest fiber available for blending with cotton is Dyneema®. Dyneema is a high density polyethylene fiber produced by a gel spinning process. Ultradrawing of this gel causes molecular chain alignment which results in an extra-high strength, high modulus fiber. Other advantages of the Dyneema fiber include excellent light resistance, good abrasion and flex resistance, and good chemical resistance. On the negative side, the fiber has a relatively low melting point (about 295°F), and is flammable (1).

Experimental

The Cotton used in the blends was an Acala variety with a 1⅛ inch staple length. The Dyneema fiber was made available to SRRC on an experimental basis under a research collaboration with DSM High Performance Fibers, The Netherlands (the developer and producer of Dyneema). To be suitable for blending with cotton, the fiber was produced with a 1.5 denier finaness and a 1.5 inch staple length. Dyneema has a tenacity of over 35 g/denier and is almost 15 times stronger than cotton. Breaking elongation of the Dyneema is about 3.0%.

The cotton was processed through superior and fine cleaners at the SRRC pilot plant, using standard cotton processing equipment and conditions. Weigh-pan blenders were used to produce blends containing 10%, 20%, and 30% Dyneema with cotton. The blends were processed on a Hollingworth card into 60 grain/yard sliver at about 60 lbs./hr. The card sliver from each blend was drawn twice on a Versamatic DF, producing a 55 grain/yard sliver at about 400 ft./min. A 0.75 hank roving was produced from each of the blends on a Saco Lowell Rovematic. A twist multiplier of 4.0 was used to spin 14/1 and 15/1 (Ne) yarns on a conventional ring spinning frame. For comparison purposes, 100% cotton yarns were produced under similar conditions. All the yarns were two-plied with a 4.0 TM, and then prepared for weaving. No major problems were encountered at any stages of processing.

A duck-type fabric weighing approximately 9.00 oz./sq.yd. (griege state) was woven from each set of yarns on a Draper X-P loom. The fabrics were woven from 14/2 warp and 15/2 filling yarns with a thread count of 52 ends x 34 picks per inch. The griege fabrics were boiled-off and scoured by conventional procedures. The scoured fabrics were treated for flame retardancy with a 50% solution of Apex Flameproof #344-HC. Apex #344-HC is produced by the Apex Chemical Corporation and is an aqueous dispersion of a 2:1 ratio of decabromodiphenyl oxide and antimony trioxide with an active ingredients content of 67.5%. The fabric was padded with the solution to a wet pick-up of approximately 70%, dried at 225°F for 3.5 min., and cured at 275°F for 4.0 min.

Results and Discussion

Single-strand and skein yarn strengths of the cotton/Dyneema intimate blends are compared with those of 100% cotton yarns in Table I. The yarns showed dramatic increases in strength as the percentage of Dyneema was increased. Based on single-strand strength, only 10% Dyneema improved yarn strength over 50%, and 30%

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:802-803 (1998)
National Cotton Council, Memphis TN

Dyneema increased yarn strength about 130%. Skein strength data also showed similar trends.

Table II compares the properties of the FR treated cotton/Dyneema blend fabrics with those of 100% cotton fabrics. Breaking and tearing strengths of the blend fabrics were much greater than those of the 100% cotton fabric. Breaking strength was increased over 100% with the addition of 30% Dyneema. Tearing strength also showed much larger increases. Warp tearing strength of the fabric containing 30% Dyneema was about five times greater than that of the 100% cotton fabric. The Dyneema/cotton blends also had much better abrasion resistance. This probably was because of the excellent inherent abrasion resistance of the Dyneema fiber. All the fabrics easily passed flammability resistance tests. A char length of less than five inches and an oxygen index of over 30% are considered acceptable.

Conclusion

Cotton/Dyneema intimate blends containing up to 30% Dyneema were processed on the cotton ring spinning system with no major problems. Fabrics produced from the blends were much stronger and more durable than comparable 100% cotton fabrics. The blend fabrics also had much better abrasion resistance. The FR treated blend fabrics had acceptable flammability resistance. The results of this research have been presented to personnel at the U.S. Army Natick Research, Development, and Engineering Corp, Natick, MA, who have expressed interest in continuing the research to develop additional "more difficult" fabrics.

Acknowledgment

We would like to thank Ingrs. Van Gorp, Director of Research, and Jan Kriele, Research and Marketing, DSM High Performance Fibers, the Netherlands, for the CRADA and related funding for this week. We also wish to express our appreciation to co-workers of the Textile Engineering and Textile Finishing Chemistry Research Units for their contributions in processing, finishing and testing the yarns and fabrics.

Literature Cited

DSM High Performance Fibers, The Netherlands, Properties of Dyneema HPPE Fiber, technical brochure, 1994

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Table I. Properties of cotton/Dyneema intimate blend yarns compared with 100% cotton yarns.

	Fiber content (cotton/Dyneema)			
Property	100c	90c/10d	80c/20d	70c/30d
Yarn strength[1]				
Single-strand (g/tex)				
14/1	15	23	28	35
15/1	15	24	28	37
Skein (csp)[2]				
14/1	2258	3481	4291	4705
15/1	2346	3383	4080	4776

[1]Yarns for fabric were 2-plied (i.e., 14/2 warp, 15/2 filling).
[2]Cotton count X lbs.

Table II. Properties of FR treated cotton/Dyneema intimate blend fabrics compared with 100% cotton fabrics.

	Fiber content (cotton/Dyneema)			
Fabric Property	100c	90c/10d	80c/20d	70c/30d
Weight (oz./sq. yd.)	10.99	11.46	12.04	11.72
Thread Count (W x F)	50 x 32	50 x 32	50 x 32	50 x 32
Breaking Strength (lbs.)				
Warp	175	266	323	371
Filling	109	192	260	297
Tearing Strength (lbs.)				
Warp	6.1	13.1	17.3	30.0
Filling	5.7	8.9	13.5	21.9
Flex Abrasion (cycles)				
Warp	944	2722	3752	6844
Filling	1275	3851	5386	7981
Char Length (in)				
Warp	3.50	3.94	3.81	3.82
Filling	3.38	3.75	3.88	3.75
Oxygen Index %				
Warp	55.2	45.3	41.3	39.3
Filling	54.7	46.0	41.2	38.3