FUNCTIONALLY SUPERIOR FABRICS OF PREDOMINANTLY COTTON CONTENT

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Abstract

A few special fabrics of predominantly cotton content made with different core yarns are discussed. Based on the ASTM and other standard test methods for cotton textiles, some of these fabrics containing only 10 to 30% (by weight) core material exhibit remarkable improvements in certain function-specific properties. For example, a 17% glass core content provides an excellent fire barrier character to the fabric, and only 10% content of high-performance polyethylene significantly improves the fabric tear resistance and, hence, durability. On the other hand, a 40% polyester-core content in a fabric provides satisfactory levels of dimensional stability and easy-care properties after the fabric has been appropriately heat set. A 50% polyester content may provide extra strength to an almost 100%-cotton-surface fabric/substrate for certain heavy-duty, industrial abrasive drills. These fabrics have been developed for marketing to explore possible commercial applications of the USDA-patented* core-spinning technologies.

Introduction

For many years, scientists at SRRC have been trying to help promote the use, competitiveness and, hence, profitability of American cotton through research and development of new technologies and value-added products. In the last few years, some of these scientists have focused their efforts in developing certain function-oriented, cotton-rich fabrics of improved performance, using the so-called bicomponent yarns produced by the USDA-developed and -patented core-spinning technologies. These bi-component core yarns of mostly cotton content and almost 100% cotton surface are comprised of a core component usually consisting of a strong, function-specific synthetic fiber and a wrap or sheath component of generally 100% cotton. Thus, a properly engineered fabric made with these yarns exhibits the good and desirable properties and suppresses the undesirable characteristics of constituent fibers. Four specific-application fabrics, viz., a duck for a military tent, a twill for fire-barrier/fire-safe institutional uniform, a bottom-weight for denim, and a drill for an industrial abrasive cloth, are briefly discussed separately.

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1. Polyethylene-Core Duck Fabric for a Military Tent

The U.S. Army needs a strong, durable and flame-retardant duck fabric of predominantly cotton content for tents. The fabric must meet a rather stringent tear strength requirement of at least 2.7 kg in both warp and filling directions. By using a premium quality combed cotton such as Pima, Acala, or an intimate blend thereof, it is possible to produce a fabric which, in its greige stage, meets the required tear strength specification. However, when the fabric is chemically finished with a special finish for the required fire retardancy, it loses about 50% of its tear strength and, thus, becomes unacceptable.

One of our research approaches to developing the required fabric for the army was to strategically combine an ordinary, run-of-the-mill carded cotton with as little as only 10% Dyneema - a gel-spun, high performance polyethylene fiber (PE) - the world's strongest fiber available. Incidentally, Dyneema was developed and is now commercially marketed by DSM High Performance Fibers, The Netherlands, who are our CRADA cooperators and have sponsored and partially funded this research. Using the USDA-patented staple-core spinning technology, Figure 1, we have been able to produce a 90:10 cotton/PE-core yarn with an almost 100% cotton surface - which is very desirable for the subsequent fabric "FR" finishing. Table I shows the important function-specific properties of the FR-finished fabric made with these yarns. As seen, the fabric not only meets but in some case even exceeds the required specifications for the two most critical properties, viz., the tear strength and the fire retardancy.

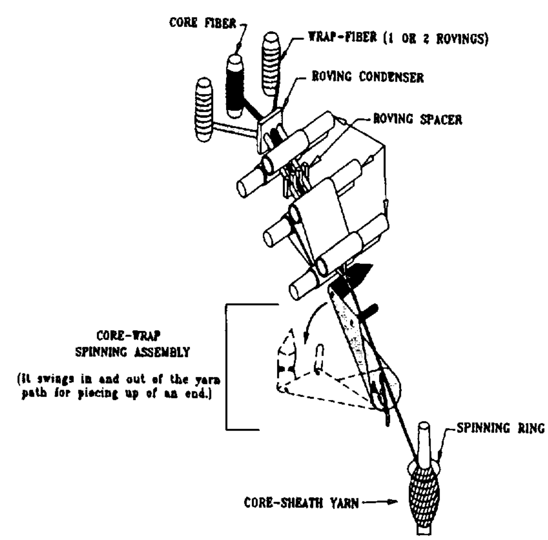

Figure 1. A schematic of the USDA-patented staple-core spinning system

2. Glass-Core Fabric For Fire-protective Uniforms

Because of increased awareness and emphasis on the safety of the people and their material possessions, firesafe textiles, especially for institutional and industrial applications such as drapes, curtains, mattress tickings, and work uniforms, are in great demand, and the demand is growing rapidly. Although cotton is an excellent textile fiber, it burns quickly and,hence, in its untreated form, is not suitable for fire-safe or fire-barrier applications. Even a chemically treated, i.e., FR- finished cotton fabric may not provide an adequate fire barrier, which is critical in many end-use applications. A fire-barrier fabric inhibits a flame from propagating to any adjacent combustible material such as foam (used in furnitures, mattresses, and aircraft seats) and flesh (in case of a utility worker or a steel worker who accidentally catches an electric or fire sark).

By applying the USDA-patented filament-core spinning process, Figure 2, and using an electrical (E)-type glass filament core, it has been possible to produce a predominantly-cotton yarn of almost 100% cotton surface. The fabric produced with this yarn and later FR finished prevents a primary flame on its one face to migrate or cross over to the other face or side, which provides a relatively inexpensive fire barrier. Table II only shows the important, function-specific properties of the FR-finished fabric. As seen in Figure 3 and table II, the glass-core fabric in a flammability test leaves a woven glass structure intact, which may provide an excellent fire barrier (the most desirable property) in a fire-sensitive/fire-protective textile application.

*The ARS-USDA patented core-spinning technologies based on the ring spinning system have been exclusively licensed to Firesafe Products Corporation/High Technology Textiles-International, Irvington, NJ, who must be contacted for any commercial use of the technologies.

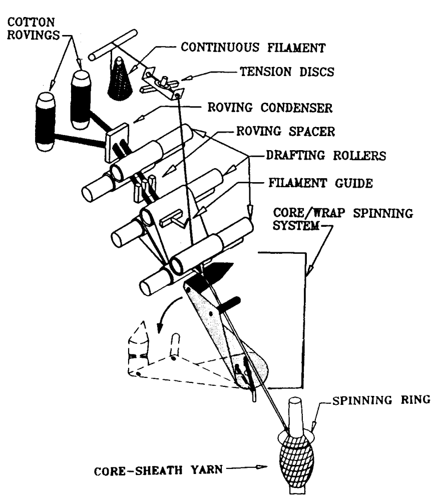

Figure 2. A schematic of the USDA-patented filament-core spinning system

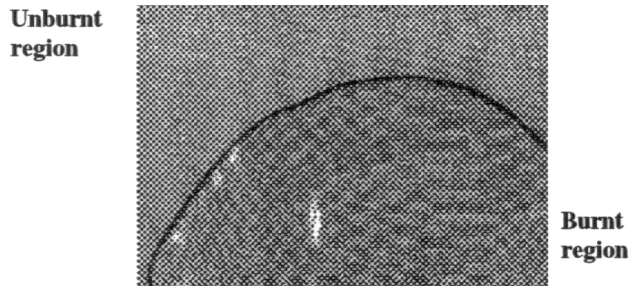

Figure 3. A glass-core fabric after being exposed to a flame.

3. <u>Polyester-Core Fabric Made With Tandem-spun Yarns</u>

Although cotton is an excellent textile fiber, it has certain deficient and hence undesirable characteristics. For example, it is relatively weak. In its natural state, it burns quickly. It wrinkles and shrinks on laundering. It requires special chemical finishes to modify some of its undesirable properties, which, in turn, adversely affect considerably its other desirable properties. Furthermore, most of these special chemical finishes now are considered to be environmentally sensitive, if not toxic. Also, cotton quality, supply and, hence, price are somewhat inconsistent and unpredictable. Last, but not least, cotton is naturally trashy and requires a substantial amount of opening and cleaning in fiber preparatory processes. Obviously, some of these cotton deficiencies must be profitably and safely addressed in the fiber utilization processes to promote use of the fiber and maintain its competitive market share. One of the cotton research objectives at SRRC has been to develop new, value-added, cotton-rich, environment-friendly textile products of improved functional performance. To economically improve dimensional stability (shrinkage resistance), wrinkle resistance, and durability of predominantly cotton fabrics, while still preserving all the desirable characteristics or advantages of 100% cotton, scientists at SRRC have developed a totally new concept of Integrated Tandem Spinning for producing a polyester staple-core, cotton-wrapped yarn of good quality and coverage at an extremely high production speed. Basically, the Tandem Spinning system, Figure 4, integrates two entirely dissimilar spinning technologies into a new, high-speed spinning system that produces a unique core-wrap yarn which is significantly and characteristically superior to the one produced by any of the two constituent spinning technologies separately. A fabric produced with these so-called bicomponent yarns, once appropriately heat set, provides excellent cotton handle and aesthetics and also exhibits satisfactory levels of permanent dimensional-stability and wrinkle-resistance and of tensile and tear strengths and, hence, durability (mainly due to presence of the high tenacity polyester that has been permanently heat set without any environmentally-sensitive, chemical finish or treatment).

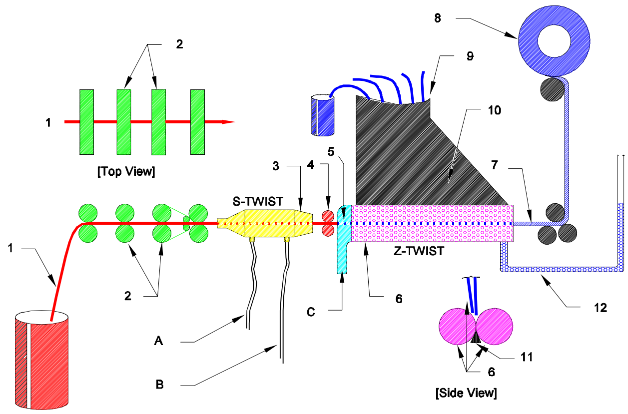

Figure 4. A new high-speed, integrated tandem spinning system.

Table III shows some performance-specific properties of a 60:40 cotton: polyester staple-core, bottom-weight fabric which has only been heat set permanently, i.e., the fabric underwent no chemical treatment of any environmental consequence. As seen, the fabric (which, incidentally, has an almost 100% cotton surface) provides acceptable levels of shrinkage and durable press after 5 household laundering cycles. Needless to mention, a traditional 100% cotton fabric of similar structure simply could not provide these desirable features. On the other hand, an equivalent fabric made with the conventional intimate-blend yarns of cotton and high tenacity polyester would not only lack the desirable 100% cotton surface but also be pruned to a highly objectionable "pilling" characteristic of the 40% polyester on the fabric surface. Thus, one can easily understand the potential of the SRRC core-spinning technologies and of the cotton-rich fabrics produced thereof.

4. Polyester-Reinforced Cotton Drill For Industrial Abrasive Cloth

The foundation fabric for industrial abrasives or sandpapers must be sufficiently strong and durable to match or survive the life span of the abrasive material. Also, the foundation cloth must be a good substrate to allow an adequate adhesion of the abrasives to the cloth. Cotton undoubtedly is an excellent substrate, but it is not as strong and durable as, for example, polyester, which is very strong but is not a good substrate for chemical or adhesive finishing. Depending on the application and its requirements, a fabric of 100% cotton or an appropriate intimate blend of cotton and polyester staple may be adequate. However, in case of some heavy-duty industrial applications, a fabric made with high-tenacity polyester staple-core yarns of suitable core-wrap ratio (which yields an almost 100% cotton surface for excellent absorbency) may be even better. In a very preliminary study, two existing abrasive drills (i.e., two commercial drill fabrics that were being used as foundation cloths for producing industrial abrasives) made with 100% cotton and 50:50 poly/cotton intimate blend, respectively, have been compared with an experimental drill fabric made with a common warp and 50:50 cotton/polyester-staple-core yarn filling produced by the method shown under fabric # 1 above.

Table IV shows certain properties (in the filling direction) of the three fabrics made with the polyester-core yarn, the 100% cotton yarn, and the polyester/cotton intimate-blend yarn. Although, because of the different kinds and types of yarns involved in these fabrics, a true comparison of the fabric properties is not possible, the data in the table at least indicate that the core-yarn fabrics are strong and have an almost total (>95%) cotton surface, which may be very useful in the production of some heavy-duty abrasives. A bicomponent core-wrap yarn, while preserving the desirable all-cotton surface for superior absorbancy and adhesion, is generally stronger and more durable than a 100% cotton yarn. However, it is fair to mention here that there are many other factors including the fabric cost and quality which, though not within the scope of this paper, must be fully considered and evaluated for any new product.

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Table I. Properties of FR-finished fabrics made with cotton and with cotton-polyethylene blend

	100% cotton (A)	90:10 cotton/ PE-core (B)
Weight (gf/m^2)	319	325
Construction (ends/cm and picks/cm)	19 & 13	19 & 13
Tensile strength (kgf) Warp & Fill	74 & 62	114 & 78
Percent improvement of "B" and "A"		55 & 26
Tearing strength (kgf)	2.1 & 1.8	4.6 & 3.3
Percent improvement of "B" over "A"		124 & 85

*gf = gram force

Table II. Properties of FR-finished fabric made with fiberglass-core/cotton-wrap yarn

Weight (gf/m^2)	260
Construction (ends/cm x picks/cm)	36 x 22
Tensile bkg. strength (kgf)	43
Tensile bkg. strain (%)	8.5
Tearing strength (kgf)	3.4
Fire resistance (char length in cm.)	5.5
Oxygen index to sustain combustion (%)	32
Residuee after exposure to flame	A solid barrier of glass fabric

Table III: Properties of differently finished cotton/polyester staple-core fabrics made with SRRC tandem-spun yarns

Sample A: (heat-set, union-dyed, and finished with a softener only)

Sample B: (heat-set, union-dyed, and finished with 5% DP-resin plus the softener)

DP Rating after 5 HLTD		
A 3.4		
B 3.2		
Shrinkage (%) after 5 HLTD		
Warp	3.4 (A)	1.1 (B)
Filling	3.3	0.4
Tensile breaking strength (kg)		
Warp	51.5 (A)	47.3 (B)
Filling	25.02	22.4
Tensile breaking elongation (%)		
Warp	27.0 (A)	21.0 (B)
Filling	20.4	18.2
Tearing Strength (kg)		
Warp	6.3 (A)	5.2 (B)
Filling	4.1	3.6

Table IV. Properties of different drill cloths

	PET-Core Cotton-Wrap	IntimateBlend*	100% Cotton *
Weight (g/m^2)	264.5	262.8	261.7
Construction (ends/cm x picks/cm)	30.3x18.9	30.3x18.9	30.3x1.9
Tensile Bkg. Strength (kgf)			
2.54 cm Ravel Strip	39.6	29.1	20.9
ASTM Grab	59.1	42.3	29.1
Tensile Bkg. Elongations (%)			
Ravel Strip	20.4	16.7	11.9
ASTM Grab	24.2	19.9	13.2
Tongue Tear Strength (Kgf)	4.32	3.23	1.54
Bulk rating (air permeability ranking)	0.688	1.00	0.896

*Open-end spun yarns for existing products