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(54) Fine denier two component corespun yarn for fire resistant safety apparel and method.

(57) The fine denier corespun yarn (10) is formed on an air jet spinning apparatus and comprises two components, including a core (11) of high temperature resistant fibers, and a core wrapper (12) of low temperature resistant fibers surrounding and covering the core (11). The high temperature resistant fibers of the core (11) are selected from the group consisting essentially of aramid fibers (Kevlar and Nomex), polybenzimidazole fibers (PBI) and heat stabilized/oxidized polyacrylonitrile fibers. The low temperature resistant fibers of the core wrapper (12) are natural fibers, such as cotton. The corespun yarn (10) is fabricated into a fabric and subjected to a high temperature flame environment, the low temperature resistant fibers of the core wrapper (12) are charred but do not melt, drip or exhibit afterflame or afterglow, and the charred portion remains in position around the core (11) and maintains the same type of flexibility and integrity as the unburned fabric.

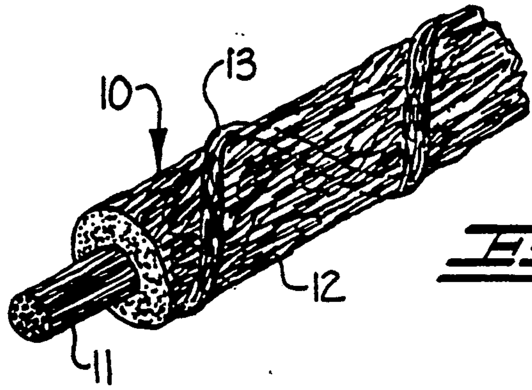

FIG-1

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Field of the Invention

This invention relates generally to fine denier two component corespun yarn for forming fabric useful in the production of fire resistant safety apparel and to the method of forming the corespun yarn, and more particularly to such a corespun yarn which includes a core of high temperature resistant fibers and a core wrapper of low temperature resistant fibers surrounding and covering the core.

Background of the Invention

It is generally known to form heat resistant fabrics of various types of yarns. For example, hazardous industrial work uniforms, firefighter uniforms, and military protective uniforms have been formed of fabrics fabricated of yarns formed of non-synthetic fibers, such as cotton or wool. These fabrics are then topically treated with conventional halogen-based and/or phosphorous-based fire retarding chemicals. However, uniforms formed of this type of fabric have a limited wear life, and are heavier in weight than non-flame retardant uniform fabrics, the chemical treatment typically adding about 15% to 20% to the weight of the fabric. When this type of fabric is burned, it forms brittle chars which break away with movement of the fabric.

Also, it is known to form fire resistant safety apparel of fabrics fabricated of yarns formed entirely of nonburning or high temperature resistant fibers or blends of nonburning fibers, such as Nomex, Kevlar or PBI. These fabrics do exhibit thermal stability but are very expensive to produce, and do not have the comfort, moisture absorbancy, and dyeability characteristics of fabrics formed of natural fiber yarns.

U.S. Patent Nos. 4,381,639; 4,500,593; and 4,670,327 disclose yarns for forming heat resistant fabrics which include a core of continuous glass filaments covered by a layer of heat-resisting aramid fibers. However, the yarns and fabrics disclosed in these patents are very expensive to produce because of the high cost of the fibers required to produce these yarns and fabrics. Also, the yarns and fabrics disclosed in these patents have the surface characteristics of the aramid fibers so that these fabrics do not have the desirable surface characteristics of dyeability and comfort of fabrics formed of conventional natural fibers, such as cotton, wool or the like.

U.S. Patent No. 4,331,729 discloses a heat resistant fabric formed of a yarn including a core of carbon filaments and a cover of aramid fibers. The yarn and heat resistant fabric disclosed in this patent also includes the same type of disadvantages as pointed out in the above discussion of prior art patents.

We have already proposed a three component corespun yarn for forming fabric useful in the production of fire resistant safety apparel. The three component corespun yarn includes a core of high temperature resistant fibers, a core wrapper of low temperature resistant fibers, and an outer sheath of low temperature resistant fibers. This three component corespun yarn is spun on a DREF friction spinning apparatus and the finest yarn counts obtained using this apparatus have been 14/1 cotton count (equivalent to 380 denier). While this three component corespun yarn provides excellent fire resistance, dyeability and comfort to fabrics formed therefrom, there are times when it is desirable to produce fine textured fabrics of corespun yarns having finer yarn counts.

Summary of the Invention

With the foregoing in mind, it is an object of the present invention to provide a fine denier two component corespun yarn for forming a fine textured fabric useful in the production of fire resistant safety apparel having the appearance, feel, dyeability, and comfort characteristics of conventional types of fabrics formed of conventional natural fibers and not including fire resistant characteristics.

The fine denier two component corespun yarn of the present invention includes a core of high temperature resistant fibers, and a core wrapper or outer sheath of low temperature resistant fibers surrounding and covering the core. The high temperature resistant fibers forming the core are aramid fibers, such as Kevlar or Nomex, or polybenzimidazole fibers, such as PBI, or heat stabilized/oxidized polyacrylonitrile fibers, such as Panox® by RK Textiles, Ltd., and Lastan® by Asahi Chemical Co. The low temperature resistant fibers of the core wrapper may be either natural or synthetic, such as cotton, wool, polyester, modacrylic, or blends of these fibers. Fine denier corespun yarns of the present invention have been produced in cotton count sizes of 22/1 (242 denier), 20/1 (266 denier), and 18/1 (295 denier).

The core of high temperature resistant fibers constitutes about 20% to 25% of the total weight of the corespun yarn, and the core wrapper of low temperature resistant fibers constitutes about 80% to 75% of the total weight of the corespun yarn. It is preferred that the high temperature resistant fibers of the core constitute about 20% of the total weight while the core wrapper of low temperature resistant fibers constitute about 80% of the total weight.

The corespun yarn is preferably formed on a MURATA air jet spinning apparatus (MJS) in which the high temperature resistant fibers of the core and the low temperature resistant fibers of the core wrapper are fed together through the entrance end of a feed trumpet. The fibers then pass through a drafting section, through oppositely directed air jet nozzles, and then wound onto a take-up package. The air jet nozzles cause the core wrapper of low temperature resistant fibers to surround and cover the core so that the yarn and the fabric produced therefrom have the surface characteristics of the low temperature resistant fibers forming the core wrapper while the yarn has very little, if any, twist, torque and liveliness.

When fabrics formed of the fine denier corespun yarn of the present invention are exposed to flame and high heat, the core sheath of low temperature resistant staple fibers surrounding and covering the core are charred and burned but remain in position around the fiberglass core to provide a thermal insulation barrier. The core of high temperature resistant fibers remains intact after the core wrapper of organic low temperature resistant fibers has burned away and the core forms a lattice upon which the char remains to block flow of oxygen and other gases while the survival of the supporting lattice provides a structure which maintains the integrity of the fabric after the core wrapper of organic low temperature resistant fibers have been burned and charred.

Since the corespun yarn of the present invention contains a small percentage by weight of the expensive high temperature resistant fibers, preferably about 20%, the corespun yarn of the present invention can be produced at a much more economical cost than fire resistant fabrics formed of yarns including large percentages by weight of expensive high temperature resistant fibers. For example, the high temperature resistant fibers of the core cost about 9 to 10 dollars per pound while the cotton fibers of the core wrapper cost about 60 to 80 cents per pound. Thus, by using about 80% cotton fibers, a substantial savings is realized in the cost of producing the corespun yarn of the present invention.

When fabrics formed of the corespun yarn of the present invention are exposed to high heat and flame, the core wrapper fibers are charred but remain in position around the high temperature resistant core to provide a thermal insulation barrier. This provides an insulating air layer between the skin and the fabric. This characteristic is important in a fire situation in which a firefighter wearing a shirt or a hood made from this fabric would continue to be thermally protected by the insulating air layer between his clothing and skin, which remains intact even though the core wrapper fibers will become charred.

Fabrics woven or knit from the corespun yarns of the present invention may be dyed, printed and topically treated with conventional flame retardant chemicals in a manner similar to the flame retardant treatment applied to fabrics produced of 100% cotton fibers. However, the weight added to the fabric by the flame retardant treatment is substantially reduced, to about 10% to 12%, because the core of high temperature resistant fibers does not absorb the flame retardant chemicals. The fabric formed of the corespun yarn of the present invention does not melt, drip, or exhibit afterflame or afterglow when burned. The charred outer portion of the fabric maintains the flexibility and integrity of the unburned portion of the fabric.

Brief Description of the Drawings

Other objects and advantages will appear as the description proceeds when taken in connection with the accompanying drawings, in which --

Figure 1 is a greatly enlarged view of a fragment of the corespun yarn of the present invention with portions of the core wrapper being removed at one end portion thereof;

Figure 2 is a fragmentary schematic isometric view of a portion of a Murata air jet spinning apparatus of the type utilized in forming the fine denier corespun yarn of the present invention; and

Figure 3 is a greatly enlarged isometric view of a fragmentary portion of a fabric knit of the corespun yarn of Figure 1.

Description of the Preferred Embodiment

The fine denier corespun yarn of the present invention, broadly indicated at 10 in Figure 1, includes a core 11 of high temperature resistant fibers, and a core wrapper 12 of low temperature resistant fibers surrounding and covering the core 11. As illustrated in Figure 1, the high temperature resistant fibers of the core 11 extend generally in an axial direction and longitudinally of the corespun yarn 10 while the majority of the low temperature resistant fibers of the core wrapper 12 extend in a spiral direction around the core 11. A minor portion of the low temperature resistant fibers of the core wrapper 12 are separated and form a binding wrapper spirally wrapped around the majority of the fibers, as indicated at 13. Since the core wrapper 12 of low temperature resistant staple fibers surrounds and covers the core 11, the outer surface of the yarn has the appearance and general characteristics of the low temperature resistant staple fibers forming the core sheath 12.

The high temperature resistant fibers of the core 11 are selected from the group consisting essentially of aramid fibers, such as Kevlar and Nomex, and polybenzimidazole fibers, such as PBI, or heat stabilized/oxidized polyacrylonitrile fibers, such as Panox® by RK Textiles, Ltd., and Lastan® by Asahi Chemical Co., or a mixture or blend of these fibers. The low temperature resistant fibers of the core wrapper 12 may be either natural or synthetic, such as cotton, wool, polyester, modacrylic, rayon, or blends of these fibers.

The core 11 of high temperature resistant fibers constitutes about 20% to 25% of the total weight of the corespun yarn 10 and the core wrapper 12 of low temperature resistant fibers constitutes about 80% to 75% of the total weight of the corespun yarn 10. It is preferred that the high temperature resistant fibers of the core 11 constitute about 20% of the total weight and the core wrapper 12 of low temperature resistant fibers constitute about 80% of the total weight. The core 11 may be formed entirely of aramid fibers or may be formed of a blend of these fibers with polybenzimidazole fibers. The core wrapper 12 surrounds and covers the core 11 so that the fibers forming the core 11 are completely hidden from view in the fabric produced of this yarn.

As pointed out above, the corespun yarn 10 of the present invention is preferably produced on a Murata air jet spinning apparatus of the type illustrated schematically in Figure 2. The Murata air jet spinning apparatus is disclosed in numerous patents, including U.S. Patent Nos. 4,718,225; 4,551,887; and 4,497,167. As schematically illustrated in Figure 2, the air jet spinning apparatus includes an entrance trumpet 15 into which the high temperature resistant core 11 is fed along with a sliver of low temperature resistant staple fibers 12 to form a core wrapper surrounding and covering the core. The fibers are then passed through a set of drafting rolls 16, a first fluid swirling air jet nozzle 17, and a second fluid swirling air jet nozzle 18. The spun yarn is then drawn from the second fluid swirling nozzle 18 by a delivery roll assembly 19 and is wound onto a take-up package, not shown. The first and second fluid swirling nozzles or air jets 17, 18 are constructed to produce swirling fluid flows in opposite directions, as schematically illustrated in Figure 2. The action of the oppositely operating air jets 17, 18 causes a minor portion of the staple fibers to separate and wind around the unseparated staple fibers and the wound staple fibers maintain the core sheath 12 in close contact surrounding and covering the core 11.

The following nonlimiting example is set forth to demonstrate one of the types of corespun yarns which have been produced in accordance with the present invention.

One end of .50 hank roving of high temperature resistant Kevlar fibers 11, providing a weight necessary to achieve 20% in overall yarn weight, is fed into the entrance end of the entrance trumpet 15. At the same time, one end of 100% carded cotton sliver, providing a weight necessary to achieve 80% in overall yarn weight, is also fed into the entrance end of the trumpet 15. The core 11 is fed onto the top of the cotton sliver 12 so that the cotton fibers are spun around the core. The fine denier corespun yarn achieved by this air jet spinning process is then knit in a plain jersey construction fabric 20, as illustrated in Figure 3. The corespun yarn 10 forms successive courses of stitch loops in the fabric 20.

This knit fabric 20 is particularly suitable for use in forming a protective hood or undergarments for firefighters and may be dyed, subjected to a topical fire resistant chemical treatment, and then subjected to a conventional durable press resin finish, if desired. This knit fabric has the feel and surface characteristics of a similar type of knit fabric formed of 100% cotton fibers while having the desirable fire resistant characteristics not present in knit fabric formed entirely of cotton fibers.

When this fire resistant knit fabric is subjected to a National Fire Prevention Association Test Method (NFPA 701), which involves a vertical burn of 12 second duration to a Bunsen burner flame, the fabric exhibits char lengths of less than 1.5 inches with no afterflame or afterglow. In accordance with Federal Test Method 5905, a vertical burn of two 12 second exposures to a high heat flux butane flame shows 22% consumption with 0 seconds afterflame, as compared with 45% consumption and 6 seconds afterglow for a similar type of knit fabric of similar weight and construction formed entirely of cotton fibers and having a fire resistant chemical treatment. Throughout all burn tests, the areas of the fabric char remain flexible and intact, exhibiting no brittleness, melting, or fabric shrinkage. While the core wrapper of cotton fibers is burned and charred, the charred portions remain in position surrounding the core of high temperature resistant Kevlar fibers to provide a thermal insulation barrier and the Kevlar core provides a matrix or lattice which prevents destruction of the fabric. The insulation barrier prevents penetration of the flame through the fabric to the skin of the wearer of this hood.

In the fabric used for forming fire resistant safety apparel, as disclosed in the present application, the corespun yarn 10 includes two components, namely, a core 11 of high temperature resistant fibers with the fibers extending primarily in an axial or longitudinal direction of the yarn, and a core wrapper 12 of low temperature resistant fibers surrounding and covering the core 11 and with the fibers extending primarily in a spiraled direction around the core 11. The high temperature resistant fibers of the core 11 are selected from the group consisting essentially of aramid fibers, polybenzimidazole fibers and heat stabilized/oxidized polyacrylonitrile fibers and the core 11 remains intact even when the fabric formed of this yarn is subjected to a high temperature flame. The fibers of the core wrapper 12 surround and cover the core 11. The fibers of the core wrapper 12 provide the desired surface characteristics to the fabric formed of these corespun yarns. When a fabric formed of the present corespun yarn is subjected to high temperature flame environment, the fibers of the core wrapper 12 are burned and become charred but remain in position around the core 11 and maintain substantially the same flexibility and integrity as the unburned fabric.

In the drawings and specification there has been set forth the best mode presently contemplated for the practice of the present invention, and although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being defined in the claims.

Claims

1. A fine denier corespun yarn (10) for forming fire resistant safety apparel characterized by a core (11) of high temperature resistant fibers selected from the group consisting essentially of aramid fibers, polybenzimidazole fibers, and heat stabilized/oxidized polyacrylonitrile fibers, and a core wrapper (12) of low temperature resistant fibers surrounding and covering said core (11).

2. A fine denier corespun yarn according to Claim 1, characterized in that said core (11) of high temperature resistant fibers constitutes about 20% to 25% of the total weight of said corespun yarn (10) and wherein said core wrapper (12) of low temperature resistant fibers constitutes about 80% to 75% of the total weight of said corespun yarn (10).

3. A fine denier corespun yarn according to Claim 2 characterized in said core (11) of high temperature resistant fibers constitutes about 20% of the total weight of said corespun yarn (10), and wherein said core wrapper (12) of low temperature resistant fibers constitutes about 80% of the total weight of said corespun yarn (10).

4. A fine denier corespun yarn according to Claim 1, characterized in that said core (11) comprises aramid fibers.

5. A fine denier corespun yarn according to Claim 1, characterized in that said core wrapper (12) comprises cotton fibers.

6. A fine denier corespun yarn according to Claim 4, characterized in that said core (11) comprises Kevlar fibers.

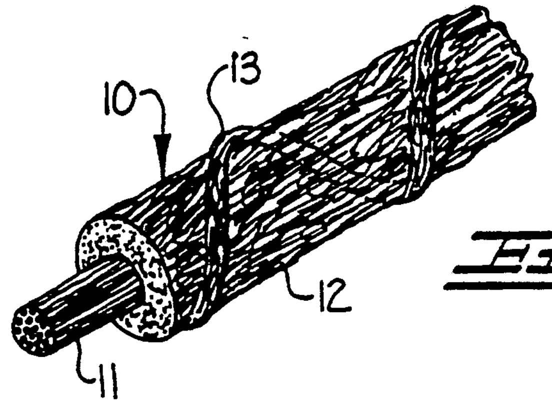
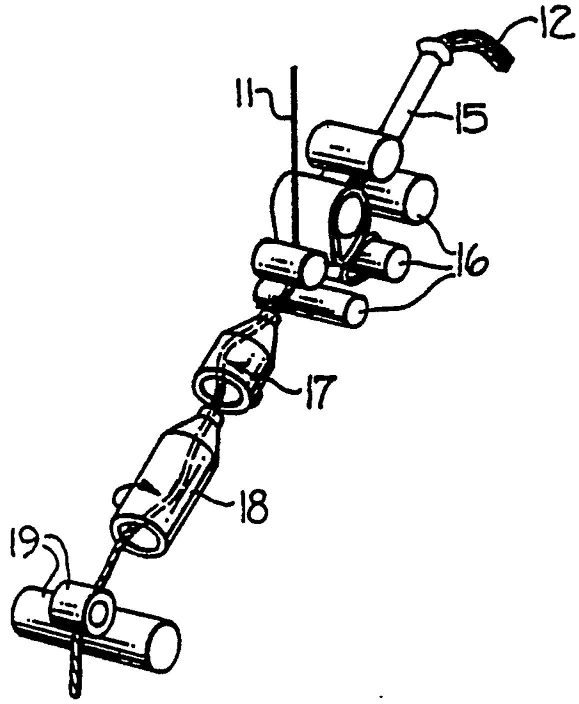


Fig-1

Fig-2



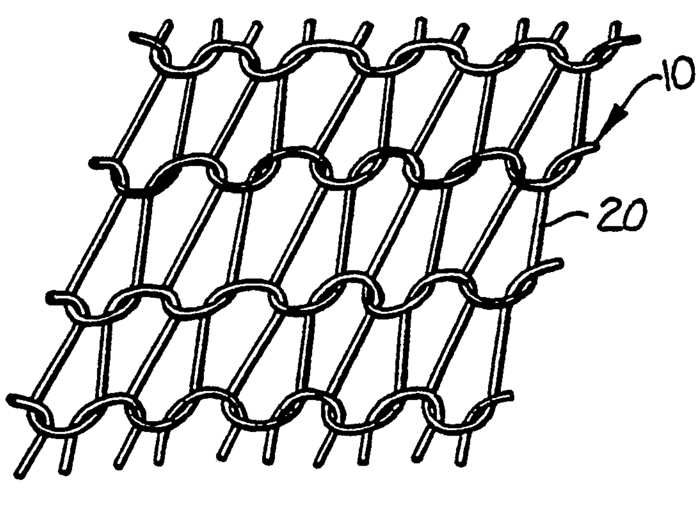


Fig-3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 30 9151

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	NL-A-8603023 (WISSELINK'S TEXTIELFABRIEKEN B.V.) * page 1, line 29 - page 2, line 37 * ---	1-6 1	D02G3/04 D02G3/44
Y	Dr.Otto-Albrecht Neumüller: "Römpp Chemie-Lexikon" Franch'sche Verlagshandlung, Stuttgart * pages 3274 - 3275 *catchword"Polyacrylnitril" * page 3279 *catchword "Polybenzimidazol" ---	1	
X	WO-A-8701140 (TEN CATE OVER-ALL_FABRICS BV) * claims 1, 5, 11, 13 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			D02G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 JUNE 1990	HOEFER W.D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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