Abstract: A method for producing a fire resistant thread comprising the steps of: unwinding a first yarn being a fire resistant polymer from a first spool onto a first pirn; unwinding a second yarn being a synthetic and/or natural yarn from a second spool onto a second pirn; unwinding a third yarn being a synthetic and/or natural yarn from a third spool onto a third pirn; unwinding the first yarn, the second yarn and the third yarn from the first pirn, the second pirn and the third pirn; twisting the first yarn, the second yarn and the third yarn each in a first direction; twisting the first yarn, the second yarn and the third yarn together in a second direction to form a three-ply thread; coating the three-ply thread with a bonding agent in order to form the fire resistant thread; and collecting the fire resistant thread.
PROCESS OF MAKING A FIRE RESISTANT THREAD

Field of the Invention

The present invention relates to a process for producing a fire resistant thread.

Background of the Invention

It has long been a problem in the textile industry to create an inexpensive, sewable fire resistant thread. The sewing thread should allow easy movement when tension is applied and ease in needle threading; should resist friction during sewing; should have sufficient elasticity to avoid the breaking of stitches; and should have sufficient strength to hold seams during laundering or dry cleaning and in use. Threads for special uses may require appropriate treatment. Garments made of fire-resistant fabrics, for example, may be sewn with thread that has also been made fire-resistant.

Such a thread would have a variety of uses including, but not limited to: sewing mattress parts together, sewing fire fighting gear and clothing together, and sewing upholstery together. Additional uses for such a sewable thread include, but are not limited to, seat belts, air bags, cargo nets, cargo straps, and carpeting. A sewable fire resistant thread must meet the federal requirements of 16 CFR 1632 and Cal 129 in order to be used to sew the various components of a mattress together.
A variety of methods and steps have been used in order to fabricate a fire resistant thread. The various factors which must be taken into account when developing a thread are numerous. There are a wide variety of both synthetic and natural yarns to choose from. Among the yarns, there are a wide range of thicknesses and finishes to choose from. One must then determine the proper and optimum number of yarns to combine in order to form a thread as well as determining the proper and optimum number of twists and the direction of those twists required to obtain a thread having the physical and functional characteristics both required and desired.

Hence, there exists an unsatisfied need for a method of making a fire resistant thread.

**Summary of The Invention**

A method for producing a fire resistant thread comprising the steps of: unwinding a first yarn being a fire resistant polymer from a first spool onto a first pirn; unwinding a second yarn being a synthetic and/or natural yarn from a second spool onto a second pirn; unwinding a third yarn being a synthetic and/or natural yarn from a third spool onto a third pirn; unwinding the first yarn, the second yarn and the third yarn from the first pirn, the second pirn and the third pirn; twisting the first yarn, the second yarn and the third yarn each in a first direction; twisting the first yarn, the second yarn and the third yarn together in a second direction to form a three-ply thread; coating the three-ply thread with a bonding agent in order to form the fire resistant thread; and collecting the fire resistant thread.
Brief Description of the Drawings

For the purpose of illustrating the invention, there is shown in the figures a form that is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

Figure 1 illustrates an embodiment of a method for producing a fire resistant thread.

Figure 2 illustrates an embodiment of a fire resistant thread.

Figure 3 illustrates an embodiment of a method for producing a fire resistant thread.

Detailed Description of The Invention

Referring to the drawings, wherein like numerals indicate like elements, there is shown in Figure 1 an embodiment of a method for producing a fire resistant thread 10. In this embodiment, the present invention may be summarized in five major steps: The first step includes pirn winding 1 which involves the unwinding of each yarn 20 from a spool followed by winding each yarn 20 on a pirn. The second step includes a first twisting process 2 during which each yarn 20 is tensioned and then given a twist in a first direction. The third step includes a second twisting process 3 during which each of the yarns are combined together, the yarns are tensioned and then given a twist in a
second direction. The forth step includes a coating process 4 during which the combined yarns are coated with a bonding agent resulting in a fire resistant thread 10. The fifth step includes a spooling process 5 during which the fire resistant thread 10 is collected and spooled. In one embodiment of the present invention, the five steps described above may be accomplished on five separate machines. In another embodiment of the present invention, the five steps described above may be accomplished on one or more machines.

Pirn winding 1, as used herein, is the process of taking a larger supply package of raw material and making it into smaller packages that will run approximately the same duration. In one embodiment of the present invention, the pirn is run with a bi-conical taper with a sharper edge (shoulder). In another embodiment of the present invention, the taper on the pirn is a cocoon shape with a more dull edge (shoulder). In another embodiment of the present invention, the smoother shoulder, the normally coarse para-aramid fiber would make a more evenly distributed delivery to the first twisting process and allow for the yarn to run completely without breaking or tangling. In one embodiment of the present invention, the pirn winding may take place using a machine made by LEMA LEZZENI (Cossato, Italy) such as machine type CLV/C 200 or a similar machine.

First twist process 2 twists the input (pirns) yarns in a first direction with a certain amount of turns per inch (t.p.i.) and winds them in a parallel manner preparing these yarns for the second twist process 3. In the first twist process 2, each yarn 20 may
have its own individual tension setting. That is to say that a first yarn 22 is tensioned at one setting, a second yarn, 24 is tensioned at the same or a different setting, and a third yarn, 26 is tensioned at the same or a different setting as the first yarn 22 and/or the second yarn 24. In one embodiment of the present invention, the first twist process may take place using a machine made by Thema Systems S.r.l. (Moglia, Italy), such as the DT/140 N Spindle or a similar machine. In one embodiment of the present invention the amount of tension on the thread is adjusted as is the percentage of difference between the drive spindles and the overfeed roll. This adjustment allows for the processing of a high tenacity, low elongation fiber (e.g. a fire resistant polymer) and a mid tenacity, high elongation fiber (e.g. a synthetic or natural fiber) to be run together without bunching or knotting. This adjustment prevents the creation of loops in the yarns which would make it unlikely that the fire resistant thread would function as a sewing thread without binding up or breaking in the needle.

Second twist process 3 twists the yarns in a second direction (the opposite direction of the first direction) with a certain amount of turns per inch (t.p.i.) to create a smooth, even multiple-ply thread. In one embodiment of the present invention, much like the first twist process 2, the amount of tension is maintained in a consistent manner allowing for the full length run of the yarn. Knots or uneven wind at this point would prohibit the even application of the coating and make proper stitch formation impossible. In one embodiment of the present invention, the second twist process 3 may take place using a machine made by Thema Systems S.r.l. (Moglia, Italy), such as the R 325N DT/100 CE or a similar machine.
The coating process 4 coats the combined yarns with a bonding agent resulting in a fire resistant thread 10. Looking to Figure 3, in one embodiment of the present invention, the coating process 4 is accomplished by running the thread from a supply creel 200, through a first set of stretch rollers 210, a dipping tank 220, a squeegee 230, a first oven 240, a second oven 250, a third oven 260, a second set of stretch rollers 270, over a lick roll lubrication applicator 280 and on to a final spool 290. In one embodiment of the present invention the coating process 4 is accomplished on an M&P coating range. In another embodiment the coating process 4 is modified to allow for the even stretching of the fire resistant thread 10 without any damage to the individual fibers. At the same time the process preserves the smoothness required to make the fire resistant thread sewable. Without these tensioning adjustments to the coating range, knots would result that would make the fire resistant thread unusable in any needle application. In one embodiment of the present invention the coating process may be carried out on a TAF 52 Bonding machine manufactured by MP s.r.l. (Urgnano, Italy) or a similar machine.

The spooling process 5 is the fifth step during which the fire resistant thread 10 is collected and spooled. Spooling is the act of placing the fire resistant thread 10 on a serving package designated by the customer. In one embodiment of the present invention, a final level of lubrication is applied to the fire resistant thread for optimum performance. In another embodiment of the present invention the coating process may
be carried out on a spooling machine manufactured by Texilmesa s.r.l. (Lecco, Italy) or a similar machine.

Referring again to the drawings, wherein like numerals indicate like elements, there is shown in Figure 2 an embodiment of a fire resistant thread 10. The present invention provides a fire resistant thread. The fire resistant thread may be comprised of three or more yarns 20 which may be referred to as a first yarn 22, a second yarn 24 and a third yarn 26. In one embodiment, the first yarn 22 is a filament yarn comprised of a fire resistant polymer. The second yarn 24 and the third yarn 26 are each comprised of a synthetic and/or natural yarn. The first yarn 22, the second yarn 24 and the third yarn 26 individually have a first twist in the same direction. The first 22, second 24 and third yarns 26 are then combined using a second twist which is in the opposite direction of the first twist resulting in a 3-ply thread 50. In one embodiment, the fire resistant thread is a sewing thread. Sewing thread, as used herein, refers to a thread which may be used to sew two or more fabrics together.

The present invention discloses a method for producing a fire resistant thread 10 comprising the steps of: unwinding a first yarn 22 being a fire resistant polymer from a first spool 100 onto a first pirn 105; unwinding a second yarn 24 being a synthetic and/or natural yarn from a second spool 110 onto a second pirn 115; unwinding a third yarn 26 being a synthetic and/or natural yarn from a third spool 120 onto a third pirn 125; unwinding the first yarn 22, the second yarn 24 and the third yarn 26 from the first pirn 105, the second pirn 115 and the third pirn 125; twisting the first yarn 22, the second
yarn 24 and the third yarn 26 each in a first direction; twisting the first yarn 22, the second yarn 24 and the third yarn 26 together in a second direction to form a three-ply thread 50; coating the three-ply thread with a bonding agent in order to form the fire resistant thread; and collecting the fire resistant thread.

Unwinding, as used herein, refers to the process of removing a yarn or thread from a spool or pirn, preferably without breaking or damaging the yarn or thread.

Yarn 20, as used herein, refers to a strand comprised of fibers, filaments 30, or combinations thereof, natural or synthetic, suitable for use in sewing threads. In one embodiment, the yarn may be comprised of a number of fibers twisted together. In another embodiment, the yarn 20 may be comprised of a number of filaments 30 grouped together but not twisted. In yet another embodiment, the yarn 20 may be comprised of a number of filaments 30 twisted together. In still another embodiment, the yarn 20 may be comprised of a single filament 30, called a monofilament, either with or without twist. In still another embodiment, the yarn 20 may be comprised of a combination of natural and synthetic fibers. In still another embodiment, the yarn may be comprised of a combination of natural and synthetic filaments.

Fiber, as used herein, refers to units of matter having length at least 100 times their diameter or width. Typically textile fibers are units that can be spun into a yarn by various methods including twisting. Fibers suitable for textile use possess adequate length, fineness, strength, and flexibility for yarn formation and for withstanding the
intended use of the completed yarn. Other properties affecting fiber performance include, but are not limited to, elasticity, durability, uniformity, luster, crimp (waviness), moisture absorption, reaction to heat and sunlight, reaction to the various chemicals applied during processing and in the dry cleaning or laundering of the completed fabric, and resistance to insects and microorganisms. The wide variation of such properties among textile fibers determines their suitability for various uses. In one embodiment, fiber may refer to staple. In another embodiment, fiber may refer to continuous filament and/or tow.

Filament 30, as used herein, refers to a fiber of an indefinite or extreme length such as found naturally in silk. Synthetic strands are extruded into filaments that are converted into filament yarn, staple, or tow.

Yarns may be categorized into different types which include single, ply, or cord. Single, or one-ply, yarns may refer to single strands composed of fibers and or filaments held together by at least a small amount of twist. In one embodiment of the present invention, the first, second, third, or additional yarns may be filaments grouped together either with or without twist. In yet another embodiment, the first, second, third, or additional yarns may be synthetic filaments extruded in sufficient thickness for use alone as yarn (monofilaments). In yet another embodiment, the first, second, third, or additional yarns may be continuous multifilament yarns. Single yarns of the spun type, composed of many short fibers, may be held together with a twist in either S-twist 40 or Z-twist direction 35.
Ply, plied, or folded, yarns may be composed of two or more single yarns twisted together. In one embodiment, the fire resistant thread may be a three-ply thread 50 may be comprised of three single yarns. In yet another embodiment, the first, second, third or additional yarns are each twisted in one direction (e.g., the "S" direction 40) and are then combined and twisted in the opposite direction (e.g., the "Z" direction 35) to make a ply thread. In one embodiment, the fire resistant thread 10 may be comprised of single yarns 20 twisted in the "S" direction 40 which are then combined and twisted in the "Z" direction 35. In another embodiment, the fire resistant thread 10 may be comprised of single yarns 20 twisted in the "Z" direction 35 which are then combined and twisted in the "S" direction 40.

Cord yarns may be produced by twisting ply yarns together, with the final twist usually applied in the opposite direction of the ply twist. In one embodiment, a fire resistant thread may be a cord yarn having an SZS form, with S-twisted singles made into Z-twisted plies that are then combined with an S-twist. In another embodiment, a fire resistant thread may be a cord yarn having a ZSZ form. In yet another embodiment, a fire resistant thread may be a cord yarn having an SSZ or a ZZS pattern.

First yarn 22, as used herein, refers to a yarn, as described above, which is a filament yarn. Filament yarn, as used herein, refers to a yarn composed of one or more continuous filaments assembled with or without a twist. In one embodiment of the present invention, the first yarn 22 may be comprised of filaments 30 having a first twist.
in either the "S" 40 or "Z" 60 direction, made of a fire resistant polymer. In another embodiment, the first yarn 22 may be comprised of fibers having a first twist in either the "S" 40 or "Z" 60 direction, made of a fire resistant polymer. In still another embodiment, the first yarn 22 may be a monofilament yarn. In still another embodiment, the first yarn 22 may be a continuous multifilament yarn.

Fire resistant polymer, as used herein, refers to a polymer that does not burn at all, burns slowly, or is self-extinguishing after removal of an external source of ignition. A yarn 20 may be fire resistant because of the innate properties of the fiber/filament, the twist level of the yarn, the presence of flame retardants, or a combination thereof. In one embodiment of the present invention, the first yarn 22 may be comprised of filaments 30 made of a fire resistant polymer including, but not limited to, an aramid, a polyester polyarylate, a PBO, a melamine formaldehyde, or combinations thereof. In another embodiment of the present invention, the first yarn 22 may be comprised of fibers made of a fire resistant polymer including, but not limited to, an aramid, a polyester polyarylate, a PBO, a melamine formaldehyde, or combinations thereof. In still another embodiment, the first yarn 22 may be an aramid yarn. In still another embodiment, the first yarn 22 may be an aramid (e.g., Kevlar made by DuPont Corp. of Wilmington, Delaware, USA) continuous multifilament yarn.

Spool, as used herein, refers to a device used to provide either temporary or permanent storage for a yarn 20. First spool 100, as used herein, refers to a spool used to provide either temporary or permanent storage for a first yarn 22. Second spool
110, as used herein, refers to a spool used to provide either temporary or permanent storage for a second yarn 24. Third spool 120, as used herein, refers to a spool used to provide either temporary or permanent storage for a third yarn 26.

Pirn, as used herein, refers to a device used to provide either temporary or permanent storage for a yarn 20. First pirn 105, as used herein, refers to a pirn used to provide either temporary or permanent storage for a first yarn 22. Second pirn 115, as used herein, refers to a pirn used to provide either temporary or permanent storage for a second yarn 24. Third pirn 125, as used herein, refers to a pirn used to provide either temporary or permanent storage for a third yarn 26. In one embodiment of the present invention, a yarn 20 is unwound from a spool and then wound onto a pirn in order to ensure snag-free delivery of the yarn. In another embodiment of the present invention, a yarn is wound onto a pirn into a cocoon shape (Fig. 3) in order to ensure snag-free delivery of the yarn.

Second yarn 24, as used herein, refers to a yarn, as described above, that is either a synthetic yarn, a natural yarn or a combination thereof. In one embodiment of the present invention, the second yarn 24 may be comprised of filaments 30 having a first twist in either the "S" 40 or "Z" 35 direction. In another embodiment, the second yarn 24 may be comprised of fibers having a first twist in either the "S" 40 or "Z" 35 direction. The second yarn 24 may be comprised of materials including, but not limited to, cotton, linen, alpaca, angora, mohair, llama, cashmere, silk, camel, yak, possum, qiviut, cat, dog, wolf, rabbit, buffalo hair, polyamides, polyolefins, polyesters, acrylics,
cellulosics, or combinations thereof. In one embodiment of the present invention, the second yarn 24 may be a continuous multifilament yarn. In another embodiment, the second yarn 24 may be a nylon continuous multifilament yarn.

Synthetic yarn, as used herein, refers to a yarn comprised of synthetic fibers and/or filaments obtained from man-made sources. Synthetic fibers/filaments, as used herein, refers to fibers/filaments made of polymers that do not occur naturally but instead are produced from by-products of petroleum or natural gas. Synthetic fibers/filaments may be produced from fiber-forming substances including, but not limited to, (1) polymers synthesized from chemical compounds; (2) modified or transformed natural polymers; and (3). Synthetic fibers/filaments include, but are not limited to, polyamides, polyolefins, polyesters, acrylics, cellulosics, acetates, rayons, fiberglass, or combinations thereof.

Natural yarn, as used herein, refers to a yarn comprised of natural fibers and/or filaments obtained from non-man made sources. Natural fibers, as used herein, refer to any hair-like raw material directly obtainable from an animal, vegetable or mineral source which may be spun into a yarn. The only filament that is produced in nature is silk. Most textile fibers are slender, flexible, and relatively strong. They are elastic in that they stretch when put under tension and then partially or completely return to their original length when the tension is removed. Natural fibers include, but are not limited to, cotton, linen, alpaca, angora, mohair, llama, cashmere, camel, yak, possum, qiviut, cat, dog, wolf, rabbit, buffalo hair, or asbestos. Natural filaments include silk.
Third yarn 26, as used herein, refers to a yarn 20, as described above, that is either a synthetic yarn, a natural yarn, or a combination thereof. In one embodiment of the present invention, the third yarn 26 may be comprised of filaments 30 having a first twist in either the "S" 40 or "Z" 35 direction. In another embodiment, the third yarn 26 may be comprised of fibers having a first twist in either the "S" 40 or "Z" 35 direction. The third yarn 26 may be comprised of materials including, but not limited to, cotton, linen, alpaca, angora, mohair, llama, cashmere, silk, camel, yak, possum, qiviut, cat, dog, wolf, rabbit, buffalo hair, polyamides, polyolefins, polyesters, acrylics, cellulosics, or combinations thereof. In one embodiment of the present invention, the third yarn 26 may be a continuous multifilament yarn. In another embodiment, the third yarn 26 may be a nylon continuous multifilament yarn.

Twist, as used herein, refers to the spiral arrangement of the filament(s) and/or fibers around the axis of the yarn. Twist may be produced by revolving one of a filament/fiber strand while the other end is held stationary. The twist binds the filaments/fibers together and enhances the strength of the yarn. The direction of the twist is described as S-twist 40 and Z-twist 35. A yarn has S-twist 40 if, when held in a vertical position, the spirals conform to the direction of slope of the central portion of the letter "S." A yarn has Z-twist 35 if, when held in a vertical position, the direction of spirals conforms to the slope of the central portion of the letter "Z." In one embodiment, the twist may refer to a first twist which may be in either the "S" 40 or "Z" 35 direction. In another embodiment, the twist may refer to a second twist which may be a twist in the
opposite direction as the first twist. In still another embodiment, the twist may refer to a third twist which may be a twist in either the same or the opposite direction as the first twist.

In one embodiment of the present invention, the first yarn 22, the second yarn 24 and the third yarn 26 each have a twist in a first direction in the range of 8.0 to 12.0 turns per inch. In another embodiment, the first yarn 22, the second yarn 24 and the third yarn 26 each have a twist in a first direction in the range of 9.0 to 10.5 turns per inch. In still another embodiment, the first yarn 22, the second yarn 24 and the third yarn 26 each have a twist in a first direction of 9.2 turns per inch.

In one embodiment, the first yarn 22, the second yarn 24 and the third yarn 26 are combined together with a twist in a second direction in the range of 4.0 to 8.0 turns per inch to form a three-ply thread 50. In another embodiment, the first yarn 22, the second yarn 24 and the third yarn 26 are combined together with a twist in a second direction in the range of 4.5 to 7.0 turns per inch to form a three-ply thread. In yet another embodiment, the first yarn 22, the second yarn 24 and the third yarn 26 are combined together with a twist in a second direction of 5.0 turns per inch to form a three-ply thread 50.

Bonding agent, as used herein, refers to a material, such as an adhesive, used to bond filaments and or fibers to one another. Bonding agents may include, but are not
limited to, polyurethanes, polyethylene terephthalates, polyacrylics, nylons and other conventional fiber bonding compositions.

Multifilament yarn, as used herein, refers to a filament yarn, as described above, comprised of two or more filaments assembled with or without a twist. In one embodiment of the present invention, the first yarn 22, second yarn 24 and third yarn 26 are continuous multifilament yarns.

Dyeable, as used herein, refers to the ability of a fiber, filament, thread, yarn, or combination thereof to be colored with either natural or synthetic dyes. Dyeing processes include, but are not limited to, batik, chain dyeing, cross dyeing, high-temperature dying, ingrain, jet dyeing, mass-colored, muff dyeing, package dyeing, pad dyeing, piece dyeing, pressure dyeing, reserve dyeing, short-liquor dyeing, skein dyeing, solution dyeing, solvent dyeing, space dyeing, spin-dyeing, stock dyeing, thermal fixation, union dyeing, yam dyeing, or combinations thereof. In one embodiment of the present invention, the fire resistant thread 10 is dyeable.

Denier, as used herein, refers to the weight in grams of 9,000 meters of filament or filament yarn. For example, if 9,000 meters of a yarn weigh 15 grams, it is a 15-denier yarn; if 9,000 meters of a yarn weigh 100 grams, it is a 100-denier yarn, and much coarser than the 15-denier yarn. Thus a smaller number indicates a finer yarn. In one embodiment of the present invention, the deniers of the first and second yarns are roughly equal to one another. In another embodiment, the deniers of the first, second,
and third yarns are roughly equal to one another. In another embodiment, the denier for
the first yarn 22, second yarn 24 and third yarn 26 is between 50 and 450. In still
another embodiment, the denier for the first yarn 22, second yarn 24 and third yarn 26 is
between 125 and 250. In still another embodiment, the denier for the first yarn 22,
second yarn 24 and third yarn 26 is between 175 and 225. In still another embodiment, the
denier for the first yarn 22, second yarn 24 and third yarn 26 is 80. In still another
embodiment, the denier for the first yarn 22, second yarn 24 and third yarn 26 is 200. In
still another embodiment, the denier for the first yarn 22, second yarn 24 and third yarn
26 is 400.

Filament count, as used herein, refers to the number of individual filaments that
make up a thread or yarn. In one embodiment of the present invention, the filament
count for the first yarn 22, second yarn 24 and third yarn 26 is between 30 and 75. In
another embodiment, the filament count for the first yarn 22, second yarn 24 and third
yarn 26 is between 40 and 65. In yet another embodiment, the filament count for the
first yarn 22, the second yarn 24 and the third yarn 26 is 40. In still another
embodiment, the filament counts of the second 24 and third yarns 26 are roughly equal
to one another. In still another embodiment, the filament count of the first yarn 22 is
substantially different to the filament counts of the second 24 and third yarns 26. In still
another embodiment, the filament count of the first yarn 22 is roughly equal to the
filament count of the second 24 and third yarns 26.
The present invention may be realized in the form of numerous embodiments. One embodiment of the present invention discloses a method for producing a fire resistant thread comprising the steps of: unwinding a first yarn 22 being a fire resistant polymer from a first spool 100; winding the first yarn 22 onto a first pirn 105; unwinding a second yarn 24 being a synthetic and/or natural yarn from a second spool 110; winding the second yarn 24 onto a second pirn 115; unwinding a third yarn 26 being a synthetic and/or natural yarn from a third spool 120; winding the third yarn 26 onto a third pirn 125; unwinding the first yarn 22, the second yarn 24, and the third yarn 26 from the first pirn 105, the second pirn 115 and the third pirn 125; tensioning and then twisting the first yarn 22, the second yarn 24 and the third yarn 26 each in a first direction; tensioning and then twisting the first yarn 22, the second yarn 24 and the third yarn 26 together in a second direction to form a three-ply thread 50; coating the three-ply thread 50 with a bonding agent in order to form the fire resistant thread 10; and collecting the fire resistant thread 10.

In one embodiment of the above method (illustrated in Figure 3), the first yarn 22 is wound onto the first pirn 105 in a cocoon shape, the second yarn 24 is wound onto the second pirn 115 in a cocoon shape and the third yarn 26 is wound onto the third pirn 125 in a cocoon shape. In another embodiment of the above method, the fire resistant polymer is selected from the group comprising: an aramid, a polyester polyarylate, PBO, melamine formaldehyde, or combinations thereof. In still another embodiment of the above method, the second yarn 24 and the third yarn 26 are selected from the group comprising: cotton, linen, polyamides, polyolefins, polyesters, acrylics,
cellulosics, or combinations thereof. In yet another embodiment of the above method, the first 22, second 24 and third 26 yarns are continuous multifilament yarns. In still another embodiment of the above method, the fire resistant thread 10 is dyeable.

In one embodiment of the above method for producing a fire resistant thread 10, the first 22 and second 24 yarns each have a denier in the range of 50 to 450 and have a filament count in the range of 30 to 75; the first yarn 22, the second yarn 24 and the third yarn 26 each are tensioned to prevent any loops or breaks in the yarn and having a twist in a first direction being an "S" direction in the range of 8.0 to 12.0 turns per inch; and the first yarn 22, the second yarn 24 and the third yarn 26 are tensioned together to prevent any loops or breaks in the yarns and then combined together with a twist in a second direction being a "Z" direction in the range of 4.0 to 8.0 turns per inch to form the three-ply thread 50.

In another embodiment of the above method for producing a fire resistant thread 10, the first 22, second 24 and third 26 yarns each have a denier in the range of 125 to 250 and have a filament count in the range of 40 to 65; the first yarn 22, the second yarn 24 and the third yarn 26 each are tensioned to prevent any loops or breaks in the yarn and having a twist in a first direction being an "S" direction in the range of 9.0 to 10.5 turns per inch; and the first yarn 22, the second yarn 24 and the third yarn 26 are tensioned together to prevent any loops or breaks in the yarns and then combined together with a twist in a second direction being a "Z" direction in the range of 4.5 to 7.0 turns per inch to form the three-ply thread 50.
In another embodiment of the above method for producing a fire resistant thread 10, the first yarn 22 is a aramid continuous multifilament yarn with a denier of 200 and a filament count of 40; the second 24 and third yarns 26 each being a nylon continuous multifilament yarn with a denier of 200 and a filament count of 40; the first yarn 22, the second yarn 24 and the third yarn 26 each are tensioned to prevent any loops or breaks in the yarns and have a twist in a first direction being an "S" direction of 9.2 turns per inch; the first yarn 22, the second yarn 24 and the third yarn 26 are tensioned together at to prevent any loops or breaks in the yarns and then combined together with a twist in a second direction being a "Z" direction of 5.0 turns per inch to form the three-ply thread 50.

In one embodiment of the above method for producing a fire resistant thread, the first yarn 22 is an aramid continuous multifilament yarn and the second yarn 24 and the third yarn 26 each being a nylon continuous multifilament yarn.

In one embodiment of the above method for producing a fire resistant thread 10, the coating step 4 may be comprised of the following steps: running the three-ply thread 50 from a supply creel 200; passing the three-ply thread 50 through a first set of stretch rollers 210; passing the three-ply thread 50 through a dipping tank 220 which contains a bonding agent; passing the three-ply thread 50 through a squeegee roller 230 to remove excess bonding agent; passing the three-ply thread 50 through a first oven 240 to dry the three-ply thread; passing the three-ply thread 50 through a second
oven 250 to dry the three-ply thread; passing the three-ply thread 50 through a third
oven 260 to dry the three-ply thread; passing the three-ply thread 50 through a second
set of stretch rollers 270; applying a lubricant 280 to the three-ply thread 50 resulting in
the fire resistant thread; and collecting the fire resistant thread 10 on a spool 290. In
another embodiment of the above methods for producing a fire resistant thread 10, the
first oven 240 has a temperature in the range of 132°C to 143°C, the second oven 250
has a temperature in the range of 143°C to 154°C and the third oven 260 has a
temperature in the range of 154°C to 166°C. In still another embodiment of the above
methods for producing a fire resistant thread 10, the first oven 240 has a temperature in
the range of 135°C to 140°C, the second oven 250 has a temperature in the range of
140°C to 150°C and the third oven 260 has a temperature in the range of 150°C to
162°C. In still another embodiment of the above methods for producing a fire resistant
thread 10, the first oven 240 has a temperature in the range of 138°C to 142°C, the
second oven 250 has a temperature in the range of 142°C to 150°C and the third oven
260 has a temperature in the range of 150°C to 158°C.

One embodiment of the present invention discloses a method for producing a fire
resistant thread comprising the steps of: providing a first yarn 22 being a fire resistant
polymer yarn; providing a second yarn 24 being a synthetic and/or natural yarn; twisting
the first yarn 22 and the second yarn 24 each in a first direction; twisting the first yarn 22
and the second yarn 24 together in a second direction to form a two-ply thread; coating
the two-ply thread with a bonding agent in order to form the fire resistant thread;
collecting the fire resistant thread. In one embodiment of the present invention the fire
resistant polymer yarn is selected from the group comprising: an aramid, a polyester polyarylate, PBO, melamine formaldehyde, or combinations thereof. In another embodiment, the second yarn 24 is selected from the group comprising: cotton, linen, polyamides, polyolefins, polyesters, acrylics, cellulosics, or combinations thereof. In still another embodiment, the first 22 and second yarns 24 are continuous multifilament yarns. In yet another embodiment, the fire resistant thread 10 is dyeable. In still another embodiment, the first 22 and second yarns 24 each have a denier in the range of 50 to 450 and have a filament count in the range of 30 to 75. In yet another embodiment, the first yarn 22 is an aramid continuous multifilament yarn; and the second yarn 24 is a nylon continuous multifilament yarn.

In one embodiment of the present invention, the first twist process may take place using a machine made by Thema Systems S.r.l. (Moglia, Italy), such as the DT/140 N Spindle or a similar machine. In another embodiment of the present invention, each yarn may be tensioned using a ball yarn tensioner, varying the spindle speed (onto which a yarn is wound), the type of shape the yarn is wound into on a spindle, or a combination thereof. In another embodiment, the ball yarn tensioner uses ball bearings to increase or decrease the amount of tension on one or more yarns. The ball yarn tensioner is used to regulate the yarn reserve and compensate for variations in tension. The yarn reserve, as used herein, has the function of keeping the tension of the yarn constant by absorbing any irregularities during the unwinding. The yarn reserve is governed by the number and diameter of ball bearings placed within the ball yarn tensioner. The fewer the number of ball bearings placed within the ball tensioner,
the longer the reserve. The greater the number of ball bearings placed within the ball tensioner, the shorter the reserve. In one embodiment, the ball bearings may be the ones supplied by the machine manufacturer such as Thema Systems S.r.l. (Moglia, Italy), for the DT/140 N Spindle or the R 325N DT/100 CE. In another embodiment of the present invention, the ball bearings may be made of any material, including, but not limited to, an aramid or a polyamide. In another embodiment, the ball bearings may range in diameter from 2-12mm. In another embodiment, the ball bearings may range in diameter from 4-8mm. In another embodiment, the ball bearings may be made of an aramid and have a diameter of 5mm or 10mm. In still another embodiment, the ball bearings may be made of a polyamide and have a diameter of 5mm or 10mm. In another embodiment of the present invention, the number of ball bearings placed within the ball yarn tensioner is sufficient enough to prevent loops in a yarn 20 and at the same time insufficient enough to cause the yarn 20 to break. In one embodiment of the present invention, the number of ball bearings placed within the ball yarn tensioner is adjusted to compensate for factors selected from the group comprising: temperature, humidity, yarn type, yarn speed, or a combination thereof. In another embodiment, between 2 and 8 ball bearings are used to tension each yarn during the first twist process 2. In still another embodiment, between 2 and 8 ball bearings are used to tension the yarns during the second twist process 3. In another embodiment of the present invention, the number of ball bearings placed within the ball yarn tensioner is sufficient enough to prevent loops in the three yarns 22, 24 and 26 and at the same time insufficient enough to cause the yarns to break during the second twist process 3. In one embodiment of the present invention, the number of ball bearings placed within the
ball yarn tensioner is adjusted to compensate for factors selected from the group comprising: temperature, humidity, yarn type, yarn speed, or a combination thereof during the second twist process 3.

In one embodiment of the present invention, the second twist process 3 requires two separate tension settings: the first tension setting is on the three yarns as they pass through a ball yarn tensioner (much like the individual yarns in the first twist process 2 described above) and the second tension setting is after the second twist process is completed and the 3-ply yarn is being wound on a pirn or spindle. In another embodiment, the second tension setting is achieved by adding weights to a flyer placed on top of the supply yarns. In still another embodiment, the weight placed on top of the flyer ranges from 20 to 60 grams. In yet another embodiment, the weight placed on top of the flyer ranges from 20 to 40 grams. In still another embodiment, the weight placed on top of the flyer is 20 grams. In yet another embodiment, the weight placed on top of the flyer ranges is 40 grams. In still another embodiment, the weight placed on top of the flyer is 60 grams.

In one embodiment of the present invention, the second twist process 3 may take place using a machine made by Ratti - Thema Systems S.r.l., such as the R 325N DT/100 CE. In another embodiment, the second twist process 3 requires two separate tension settings: the first tension setting is on the three yarns as they pass through a ball yarn tensioner (much like the individual yarns in the first twist process 2) and the
second tension setting is after the second twist process is completed and the 3-ply yarn is being wound on a pirn or spindle.

In one embodiment, the above method may further comprise the steps of providing one or more additional yarns selected from the group comprising: a fire resistant polymer, a synthetic yarn, a natural yarn, or a combination thereof; twisting the additional yarn or yarns each in a first direction; twisting the first yarn, the second yarn, and the additional yarn(s) together in a second direction to form a multiple-ply thread; coating the multiple-ply thread with a bonding agent in order to form the fire resistant thread; and collecting the fire resistant thread.
CLAIMS

1. A method for producing a fire resistant thread comprising the steps of:
   unwinding a first yarn being a fire resistant polymer from a first spool onto
   a first pirn;
   unwinding a second yarn being a synthetic and/or natural yarn from a
   second spool onto a second pirn;
   unwinding a third yarn being a synthetic and/or natural yarn from a third
   spool onto a third pirn;
   unwinding said first yarn, said second yarn and said third yarn from said
   first pirn, said second pirn and said third pirn;
   twisting said first yarn, said second yarn and said third yarn each in a first
   direction;
   twisting said first yarn, said second yarn and said third yarn together in a
   second direction to form a three-ply thread;
   coating said three-ply thread with a bonding agent in order to form said fire
   resistant thread; and
   collecting said fire resistant thread.

2. The method for producing a fire resistant thread of claim 1 wherein said
   fire resistant polymer being selected from the group comprising:
   an aramid, a polyester polyarylate, PBO, melamine formaldehyde, or
   combinations thereof.
3. The method for producing a fire resistant thread of claim 1 wherein said second and third yarns being selected from the group comprising:
cotton, linen, polyamides, polyolefins, polyesters, acrylics, cellulosics, or combinations thereof.

4. The method for producing a fire resistant thread of claim 1 wherein said first, second and third yarns being continuous multifilament yarns.

5. The method for producing a fire resistant thread of claim 1 wherein said fire resistant thread being dyeable.

6. The method for producing a fire resistant thread of claim 1 wherein said first, second, and third yarns each having a denier in the range of 50 to 450 and having a filament count in the range of 30 to 75;
said first yarn, said second yarn and said third yarn each having a twist in a first direction being an "S" direction in the range of 8.0 to 12.0 turns per inch;
said first yarn, said second yarn and said third yarn being combined together with a twist in a second direction being a "Z" direction in the range of 4.0 to 8.0 turns per inch to form said three-ply thread.

7. The method for producing a fire resistant thread of claim 6 wherein said first, second, and third yarns each having a denier in the range of 125 to 250 and having a filament count in the range of 40 to 65;
said first yarn, said second yarn and said third yarn each having a twist in a first direction being an "S" direction in the range of 9.0 to 10.5 turns per inch;
said first yarn, said second yarn and said third yarn being combined together with a twist in a second direction being a "Z" direction in the range of 4.5 to 7.0 turns per inch to form said three-ply thread.

8. The method for producing a fire resistant thread of claim 7 wherein said first yarn being an aramid continuous multifilament yarn with a denier of 200 and a filament count of 40; and

said second and third yarns each being a nylon continuous multifilament yarn with a denier of 200 and a filament count of 40;
said first yarn, said second yarn and said third yarn each having a twist in a first direction being an "S" direction of 9.2 turns per inch;
said first yarn, said second yarn and said third yarn being combined together with a twist in a second direction being a "Z" direction of 5.0 turns per inch to form said three-ply thread.

9. A method for producing a fire resistant thread comprising the steps of:
unwinding a first yarn being a fire resistant polymer from a first spool;
winding said first yarn onto a first pirn;
unwinding a second yarn being a synthetic and/or natural yarn from a second spool;
winding said second yarn onto a second pirn;
unwinding a third yarn being a synthetic and/or natural yarn from a third spool;

winding said third yarn onto a third pirn;

unwinding said first yarn, said second yarn, and said third yarn from said first pirn, said second pirn and said third pirn;

... tensioning and then twisting said first yarn, said second yarn and said third yarn each in a first direction;

... tensioning and then twisting said first yarn, said second yarn and said third yarn together in a second direction to form a three-ply thread;

... coating said three-ply thread with a bonding agent in order to form said fire resistant thread; and

... collecting said fire resistant thread.

10. The method for producing a fire resistant thread of claim 9 wherein said first yarn being wound onto said first pirn in a cocoon shape;

... said second yarn being wound onto said second pirn in a cocoon shape;

... and

... said third yarn being wound onto said third pirn in a cocoon shape.

11. The method for producing a fire resistant thread of claim 9 wherein said fire resistant polymer being selected from the group comprising:

... an aramid, a polyester polyarylate, PBO, melamine formaldehyde, or combinations thereof.
12. The method for producing a fire resistant thread of claim 9 wherein said second yarn and said third yarn being selected from the group comprising:
cotton, linen, polyamides, polyolefins, polyesters, acrylics, cellulosics, or combinations thereof.

13. The method for producing a fire resistant thread of claim 9 wherein said first, second and third yarns being continuous multifilament yarns.

14. The method for producing a fire resistant thread of claim 9 wherein said fire resistant thread being dyeable.

15. The method for producing a fire resistant thread of claim 9 wherein said first and second yarns each having a denier in the range of 50 to 450 and having a filament count in the range of 30 to 75;
said first yarn, said second yarn and said third yarn each being tensioned to prevent any loops or breaks in the yarn and having a twist in a first direction being an "S" direction in the range of 8.0 to 12.0 turns per inch; and
said first yarn, said second yarn and said third yarn being tensioned together to prevent any loops or breaks in the yarns and then combined together with a twist in a second direction being a "Z" direction in the range of 4.0 to 8.0 turns per inch to form said three-ply thread.
16. The method for producing a fire resistant thread of claim 15 wherein said first, second, and third yarns each having a denier in the range of 125 to 250 and having a filament count in the range of 40 to 65;

said first yarn, said second yarn and said third yarn each being tensioned to prevent any loops or breaks in the yarns and having a twist in a first direction being an "S" direction in the range of 9.0 to 10.5 turns per inch; and

said first yarn, said second yarn and said third yarn being tensioned together to prevent any loops or breaks in the yarns and then combined together with a twist in a second direction being a "Z" direction in the range of 4.5 to 7.0 turns per inch to form said three-ply thread.

17. The method for producing a fire resistant thread of claim 16 wherein said first yarn being an aramid continuous multifilament yarn with a denier of 200 and a filament count of 40;

said second and third yarns each being a nylon continuous multifilament yarn with a denier of 200 and a filament count of 40;

said first yarn, said second yarn and said third yarn each being tensioned to prevent any loops or breaks in the yarns and having a twist in a first direction being an "S" direction of 9.2 turns per inch; and

said first yarn, said second yarn and said third yarn being tensioned together to prevent any loops or breaks in the yarns and then combined together with a twist in a second direction being a "Z" direction of 5.0 turns per inch to form said three-ply thread.
18. The method for producing a fire resistant thread of claim 9 wherein said first yarn being an aramid continuous multifilament yarn; and

    said second yarn and said third yarn each being a nylon continuous multifilament yarn.

19. The method for producing a fire resistant thread of claim 9 wherein said coating step being comprised of the following steps:

    running said three-ply thread from a supply creel;
    passing said three-ply thread through a first set of stretch rollers;
    passing said three-ply thread through a dipping tank which contains a bonding agent;
    passing said three-ply thread through a squeegee roller to remove excess bonding agent;
    passing said three-ply thread through a first oven to dry said three-ply thread;
    passing said three-ply thread through a second oven to dry said three-ply thread;
    passing said three-ply thread through a third oven to dry said three-ply thread;
    passing said three-ply thread through a second set of stretch rollers;
    applying a lubricant to said three-ply thread resulting in said fire resistant thread; and
collecting said fire resistant thread on a spool.

20. The method for producing a fire resistant thread of claim 19 wherein said first oven having a temperature in the range of 132°C to 143°C;

said second oven having a temperature in the range of 143°C to 154°C;

and

said third oven having a temperature in the range of 154°C to 166°C.
Fig. 3
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B05D 3/02 (2011.01)
USPC - 428/85; 427/372.2; 427/393.3

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8)- B05D 3/02 (2011.01);
USPC- 428/85; 427/372.2; 427/393.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Patents and NPL (classification, keyword; search terms below)

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
PubWest (US Pat, PgPub, EPO, IFO), GoogleScholar (PL, NPL), FreePatentsOnline (US Pat, PgPub, EPO, IFO, WIPO, NPL);
Search terms used: fire, flame, heat, temperature, sew, thread, filament, multifilament, yar, twist ply, plied, spool, pirn, package, unwind, unwound, synthetic, polymer, inorganic, natural, cellulose, cotton, dye, twist, tension

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  "O" document referring to oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  "&" document member of the same patent family

Date of the actual completion of the international search: 23 March 2011 (23.03.2011)
Date of mailing of the international search report: 12 APR 2011

Authorized officer: Lee W. Young
PCT T08/024, K-371-272-4300
PCT OSP: 371-272-7734

Form PCT/A/10 (second sheet) (July 2009)