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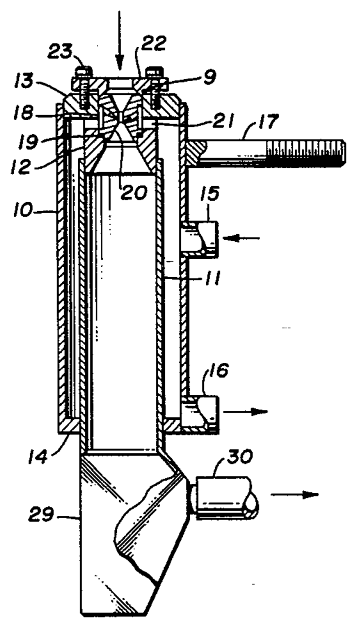
(54) **Heatset plied yarns and process for producing same.**

(57) A process for heatsetting plied carpet yarns is described in which a plied yarn is passed through a device wherein its fibers are entangled in a first zone (9) and the yarn is then heatset in a second zone (11). The resulting heat set yarns resist untwisting and are particularly useful in providing cut pile carpets.



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HEATSET PLIED YARNS AND PROCESS FOR PRODUCING SAME

BACKGROUND OF THE INVENTION

A. Field of the Invention

This invention relates to a novel heatset, plied yarn useful as pile in cut pile carpets and to a process for producing such yarn.

As used herein the term "plied yarn" means a yarn composed of two or more singles yarns which are plied together and includes yarns formed with conventional twisters or so called "cablers" as well as cabled yarns formed by cabling two or more plied yarns with cable twist. Each singles yarn is either a spun yarn or continuous filament yarn which in turn may be either a flat yarn or a textured yarn. Usually, for cut pile applications each singles yarn is textured and has a total denier ranging from about 500 to about 5000 (e.g. 1230-2640) and each fiber thereof has a denier ranging from about 6 to about 24. The term "textured yarn" as used herein means a yarn having latent (undeveloped) or actual (developed) bulk. The term "fiber" as used herein includes both a fiber of continuous length (filament) and a fiber of staple length (e.g. filament cut into short lengths).

B. Description of the Prior Art

Heatset, bulked, continuous filament yarns (BCF) and spun yarns (staple) are conventionally used as pile in cut pile carpet constructions (e.g. shag, saxony, frieze and pin point plush). Cut pile is obtained by cutting the loops of yarn in a tufted carpet. The cut pile consists of individual short lengths of plied yarn (hereinafter referred to as a tuft) each of which projects upwardly from the surface of the carpet backing and terminates as a cut end. The twist in cut pile tufts provides a rope-like contrast between the individual tufts and, thereby, establishes an identity between neighboring tufts, that is, the end of each tuft is distinguishable from the ends of neighboring tufts. This identity is commonly referred to as "endpoint definition". Twist also preserves endpoint definition by preventing neighboring tufts from becoming entangled which gives a carpet an undesirable matted appearance. Additionally, twist tends to make the tufts stand perpendicular to the carpet backing. Twist is heatset (fixed) in the plied yarn so that the tufts produced therefrom resist untwisting during the construction and life of the carpet, i.e., retain good endpoint definition.

In the typical batch autoclave heatsetting operation, which represents a majority of the commercial heatsetting operations, a plied yarn having a latent bulk is treated with steam at elevated temperatures while the yarn is under low tension to develop bulk and set twist in the yarn. The heatsetting operation relieves inherent torque in the plied yarn which would otherwise cause it to untwist and also fixes the shape of the singles yarns, that is, causes the singles yarns to develop a permanent helical (coiled) shape that locks them into their twisted configuration. Traditionally, the first step of the heatsetting operation is to make skeins from the plied yarn. The skeins are normally tumbled in a tumbler where live steam is circulated while the skeins are tumbled for approximately 5 minutes. The skeins are then removed from the tumbler, turned inside out, returned to the tumbler and processed a second time through the steam tumbling operation. The tumbling operation develops bulk in the yarn and relaxes the yarn prior to the actual twist setting steps. The tumbled skeins containing uniform moisture are then carefully loaded on to a metal basket which in turn is rolled into an autoclave. The autoclave is an extremely large (and expensive) pressure vessel which is automatically programmed to go through the heatsetting cycle. A typical such cycle for setting textured plied nylon yarn involves numerous steam treatments (e.g. five) of the skeins under varying conditions of temperature, pressure and time during which the autoclave is vacuum extracted between each steam treatment. After the autoclave operation, the skeins are normally tumbled dry and then allowed to come to equilibrium with atmospheric (ambient) conditions. The skeins are then rewound into packages on bobbins for tufting.

Recently, techniques have been developed for continuously heatsetting plied yarns. According to one such technique the yarn is slowly passed through a chamber by means of a conveyor-type belt wherein the yarn is exposed to a heated fluid (steam or air). According to another technique the yarn is continuously passed through two heated tubes wherein the bulk is developed in the first tube and the yarn is heatset and a false twist is imparted thereto in the second tube. Such a technique is described in U.S. 3,971,200.

The above-described prior art heatsetting operations have several drawbacks. One drawback is that the operations require considerable processing space. Another drawback is that carpet tufts cut from the resulting heatset yarns tend to untwist with time and normal wear. The batch autoclave operation has additional drawbacks such as not being capable of being run inline with other operations and being time consuming and labor intensified.

It is an object of the present invention to provide a simple and relatively inexpensive process for continuously heatsetting plied yarns which avoids the above-mentioned drawbacks of the prior art heatsetting operations.

Another object of the invention is to provide cut-pile, the tufts of which are more resistant to untwisting (i.e. have superior end point definition).

SUMMARY OF THE INVENTION

The foregoing objects are accomplished by the heatsetting process of the present invention, comprising:

(1) passing a plied yarn at an overfeed of from 10% to 40% into a first zone where at least one jet of heated fluid is directed laterally against the yarn at a velocity sufficient to cause fibers of each singles yarn to entangle with fibers of the other singles yarn(s) at intervals along the entire length of the yarn,

(2) passing said yarn from said first zone through a second zone where the yarn is in contact with a heated fluid, wherein the residence time of the yarn and the temperature of said heated fluid in said second zone are correlated to set the twist in said plied yarn, and

(3) thereafter cooling the resulting heatset plied yarn.

Preferably, the process is carried out by continuously passing a plied yarn through a single device wherein the fibers of each singles yarn are first entangled with fibers of the other singles yarn(s) (first zone) and then the yarn is heatset (second zone) using superheated steam as the heated fluid. The yarn passes from the device into ambient air where it is cooled. While tangling devices which are commercially available and/or described in the literature may be suitably used in carrying out the process of this invention, slight modification of such tangling devices may be required, for example, lengthening of the device may be required in order to provide for sufficient residence time of the yarn in the second zone (i.e. the heatsetting zone). While it is preferred to use steam and particularly superheated steam as the heated fluid in carrying out the process, heated air or some other heated fluid such as heated nitrogen or carbon dioxide can also be effectively used. If desired, the process of this invention may be conveniently coupled inline with other yarn processing operations, such as downstream from a twister or cabler.

The resulting heatset plied yarn is characterized in that fibers of each of its singles yarns are entangled with fibers of the other single yarn(s) at intervals along the entire length of the yarn thereby enhancing the resistance of the yarn to untwist. The entanglements act as mechanical bonds which lock the singles yarns together and help prevent them from untwisting during the construction and life of cut pile carpet. While the entanglements are not generally visible or noticeable by merely viewing the heatset yarn, they may be seen by untwisting the plied yarn. When compared to corresponding yarns heatset by the conventional batch autoclave heatsetting process, the resulting heatset plied yarn also has improved dyeing characteristics and, in particular, improved dye uniformity and resistant to color fading in the presence of ozone. It is believed that the improvements are due at least in part to the fact that in the process of this invention the yarn is subjected to steam for a relatively short period of time (e.g. less than a second) as compared to the batch autoclave process where the yarn is subjected to steam for much longer periods of time.

Cut pile carpets constructed from plied yarns heatset by the process of this invention have improved endpoint definition and improved tuft rigidity. Tuft rigidity is the ability of the tufts to stand perpendicular to the carpet backing after repeated cycles of compressive forces (load/no load), such as those encountered in the normal traffic patterns of a carpet.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a schematic representation of a preferred embodiment of a device suitable for use in carrying out the heatsetting process of this invention.

FIGURE 2 represents an enlarged lateral section taken along line 2-2 in FIGURE 1 and shows internal structural features of one embodiment of a device.

FIGURE 3 is a quarter section in perspective of a preferred embodiment of a forwarding jet suitable for use in the process of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The process of this invention is particularly useful in heatsetting plied yarns that are intended for use in the construction of cut pile carpets. Typically, such yarns are plied yarns composed of two or three singles yarns (usually two) which may be composed of polymeric fibers of materials such as polyamides, polyesters, polyolefins and polyacrylonitrile copolymers. The denier of the singles yarns is normally in the range of 1230 to 2460 with the fibers thereof each having a denier ranging from about 6 to about 24, although deniers outside these denier ranges could also be used. For most cut pile applications BCF singles yarns should each have a latent bulk of at least 15% and preferably in the range of 18 to 35%. The term "% Bulk" as used herein is determined by the formula:

$$\% \text{ Bulk} = \frac{L_1 - L_2}{L_1} \times 100$$

where L_1 is the length of a sample of yarn before development of its latent bulk and L_2 is the length of the same sample of yarn after being subjected to 180°C. dry heat for five (5) minutes followed by cooling at ambient temperature for one minute. The yarn sample lengths (L_1 and L_2) are measured with the sample being maintained in a vertical position by means of a clamp attached to the upper end of the yarn and a suitable support and a weight of 0.0009 grams per denier (gpd) attached to the lower end of the yarn, with the measurements being made 90 seconds after being subjected to 180°C. dry heat. The thermal shrinkage (TS) of the bulked yarn can be calculated by the formula

$\% \text{ TS} = \frac{L_1 - L_3}{L_1} \times 100$ where L_1 has the same meaning as above and L_3 is the length of the yarn (L_2) after it has been additionally stressed at 0.8 gpd. The latent bulk is developed under the heatsetting conditions used in carrying out the process of this invention.

The manner in which latent bulk is imparted to the singles yarns is not a critical part of this invention. Accordingly, latent bulk may be imparted to the singles yarns by any suitable means, for example, by spinning techniques or mechanical texturing techniques, such as, by gear crimping, jet crimping or stuffer-box crimping.

Two or more singles yarns are plied to provide the plied feed yarn. The singles yarns may be plied by means of commercially available apparatus specifically designed for this purpose. From the standpoint of economics recently developed apparatus referred to in the industry as "cablers" are preferred. To achieve a plied yarn of good appearance, the same physical conditions should be applied to each of the singles yarns, otherwise, a cork-screw effect will result, for example, the singles yarns should be of the same count and twist, the direction of twist should be the same for each and the tension in the yarns should be equal.

In a preferred embodiment of the process of the invention, disclosed in FIGURE 1, a plied yarn having latent bulk (i.e. feed yarn 1) is taken from a suitable supply source (e.g. from a cabler) and passed between driven roll 2 and its associated idler cot roll 3, through forwarding jet/heat chamber device 4, between driven roll 5 and its associated idler cot roll 6 and, finally, is wound up on bobbin 7 (by means of a winder, not shown) to form a package 8 of heatset, bulked, plied yarn. Roll 2 is driven at a higher peripheral speed than roll 5 to provide a 10 to 40% overfeed. The length of device 4 normally will range from

10 cm to 25 cm although the device may be of a longer or shorter length, if desired. For any given device the residence time of the plied feed yarn in the device and the temperature of the steam are correlated to sufficiently set the twist in the yarn. Under such conditions any latent bulk in the yarn will also be developed. It is desirable to use superheated steam so as to avoid unnecessary wetting of the yarn which can lead to handling difficulties.

It will be appreciated that, if desired, the entire embodiment shown in FIGURE 1 could be inverted so that yarn instead of traveling in a downward direction would travel in an upward direction, in which case, rolls 2 and 3 would be at the bottom, bobbin 7 (and rolls 5 and 6) would be at the top, and device 4 would be inverted and between rolls 2 and 3 and rolls 5 and 6.

The structure and function of the forwarding jet/heat chamber device 4 can be better understood by reference to FIGURE 2 which represents a longitudinal section along line 2-2 of FIGURE 1. The device is comprised of a body assembly and a replaceable jet nozzle 9 defining a first zone. The body has an outer shell 10 than can be cylindrical or have a square, rectangular or other cross section for convenience in fitting into existing equipment. Disposed coaxially with the axis of outer shell 10 is an inner cylinder 11 defining a second zone that is open at its yarn outlet end which projects beyond the end of the shell and is closed at its yarn inlet end by the cylindrical end piece 12 that is integral with inlet end shell closure 13. The outlet end of the shell is closed by end piece 14 that mates against the outside of inner cylinder 11. All junctions or contact surfaces between end closures and the shell and tube are welded or otherwise sealed to form strong leak-proof joints. In analogy with shell-and-tube heat exchangers, the open annular volume formed between the outer wall of the inner cylinder and the inner wall of the shell may be referred to as the "shell side," and the interior volume of the inner cylinder may be designated "tube side." Nipple or half coupling 15 opens into the shell side to provide an inlet for steam. Optionally, nipple or half coupling 16 opens into the shell side to provide a condensate drain connected to a steam trap (not shown). An externally threaded rod 17 welded to the shell provides convenient means for attaching the device 4 to a supporting bracket or to a machine frame.

Cylindrical opening 18 concentric with the axis of the inner cylinder is formed through the inlet end closure 13. The diameter of the central opening is abruptly reduced about half way along the axis of the end closure to provide an annular shoulder 19 that supports jet nozzle 9. The central opening flares to form a diverging frusto-conical surface 20 into the tube side. A plurality of radial ports 21 pass through the wall of the end piece, forming passages for steam from the shell side to the tube side. Removable jet nozzle 9 makes a snug fit into the end piece opening and bears against a sealing-ring gasket of soft metal, such as aluminum, supported by shoulder 19. A sealing-ring gasket of similar material is placed at the upper end of the nozzle, the two gaskets and nozzle being compressed into tight engagement by a follower ring or gland 22 held firmly in place by cap screws 23.

The structure of a typical jet nozzle 9 is shown in the perspective view of FIGURE 3 which shows that the axial passage for receiving the yarn undergoing treatment is comprised of a converging frusto-conical inlet 24 that joins a short cylindrical bore 25 which at its lower end joins a diverging frusto-conical outlet section 26. Along a major portion of the length of the nozzle its outside diameter is reduced to provide a circumferential channel 27 that registers with radial ports 21 of the body assembly shown in FIGURE 2. The outer edge of the upper end of the nozzle forms an external conical surface to aid in the centering and sealing of the upper ring gasket.

At least one conduit 28 through which a heated fluid (e.g. steam) passes connects circumferential channel 27 with inner bore 25. Preferably, a plurality of conduits 28 spaced apart along the axis of the jet and spaced circumferentially about the axis, connect circumferential channel 27 with the inner bore 25. As indicated, for ease of fabrication, the conduits may have an enlarged entrance counterbore which converges to a small exit through the wall of the central bore. The axis of the conduits 28 may be normal to the axis of the central bore of the jet but preferably are angled such that an appreciable component of the steam velocity is directed along the axis of the central bore. If the direction of movement of the yarn is taken as the positive direction of the central axis of the bore, then the axis of the conduits are preferably at an obtuse angle of 100°-175° with respect to the central axis of the bore. The actual diameter of the central bore depends, of course, upon the size of the yarn being treated. The cone angles or angles of convergence and divergence of the frusto-conical inlet and outlet sections, respectively, of the jet nozzle can be equal or unequal. However, to avoid undesirable turbulence, the divergence angle of the outlet section is made equal to or less than the divergence angle of the upper end closure of the device (surface 20 in FIGURE 2). The cone angles for both converging and diverging sections should be within the range of about 15°-95°.

A particularly preferred jet nozzle 9 is that described in U.S. Patent 3,609,834 to Lamb et al. The jet nozzle described in this patent differs from that shown in FIGURE 3 mainly in that it has removable parts (waffers) which fit together to provide yarn passage 24, 25, upper portion of 26 and conduits 28. This permits for easily and quickly changing the number size and angle of conduits 28 and also simplifies the manufacture of jet nozzle.

As indicated by numeral 29 in FIGURES 1 and 2, a metal duct having an open front is mounted directly to or beyond the outlet end of device 4. Suction line 30 (FIGURE 2) is connected to the duct so that volatile components or moisture escaping from the outlet of the device are drawn away from the operating area. When superheated steam is used, the steam is withdrawn from the yarn through line 30 before any substantial amount thereof is cooled and converted from superheated (i.e. dry steam) to saturated (i.e. wet) steam. Wet steam if in contact with the yarn will cause the yarn to become damp which in turn causes processing difficulties. The suction or vacuum source connected to line 30 can be the inlet side of a common air blower with a condenser and condensate trap upstream of the blower. A water-actuated aspirator or a low efficiency steam-jet squelched with water are very useful suction sources, particularly when steam is the active fluid in the device.

While any inert heated fluid may be used in practicing the present invention, superheated steam is preferred. Steam temperatures and pressures which may be used in providing superheated steam are published in the literature, such as, in the "Handbook of Chemistry and Physics". Although the temperature of the steam has some influence on the tangling of the fibers, its influence is insignificant in comparison to that of the pressure of the steam.

Superheated steam or other suitable heated fluid is directed through conduit(s) 28 against the plied yarn at a velocity sufficient to cause fibers of each singles yarn to entangle with fibers of the other singles yarn(s) at intervals along the entire length of the yarn. It will be appreciated that the frequency of the intervals and the strength of the entanglements imparted to the yarn increases as the velocity at which the heated fluid strikes the yarn increases. It will also be appreciated that as the frequency of the intervals and the strength of the entanglements increase, the resulting yarn becomes more resistant to untwisting. The following test is used to measure the yarns resistance to untwisting:

> The plies of a sample of yarn measuring at least 12.5 inches (31.75 cm) in length are separated from one another at one end thereof for a distance of 0.5 inch (1.27 cm). With the length of the yarn sample in a vertical position and the separated ply ends entending upwardly, a clamp is attached to each separated ply end. A pulling tension is then exerted on each clamp (i.e. ply end) sufficient to move it away from the vertical yarn length at a constant rate of 1.25 inches (3.175 cm) per second in a direction that is perpendicular to the vertical yarn length and that produces no lateral movement of the vertical yarn length at the point where the plies are being separated from one another (i.e. the clamps are moved in opposing directions and the angles defined by adjacent ply ends

are equal -- two ply ends define two angles each of 180°, three ply ends define three angles each of 120°, etc.). The same pulling tension will be exerted in each ply end. As the ply ends are moved away from the vertical yarn length, the yarn length is decreasing in length at the rate of 1.25 inches per second and is rotating about its length. The pulling tension required to move each clamp (i.e. ply end) away from the vertical yarn length at the rate of 1.25 inches per second is continually recorded on a chart. However, in carrying out the test, the clamps and means for moving same are adjusted so that the pulling tension exerted on each ply end will not exceed 40 grams. In the event that during the test movement of the clamps stops (i.e. a pulling tension of 40 grams fails to separate the ply ends from one another due to the presence of entangled fibers), the entanglements holding the plies together are cut (such as with scissors) one at a time while maintaining a pulling tension of 40 grams until the clamps are once again in motion (i.e. once again moving away from the vertical yarn length at a rate of 1.25 inches per second with a pulling tension of 40 grams or less). Such an event is referred to as a "stop". Care should be taken to keep the yarn sample from snarling at the point where the plies are separated from one another, such as, by gently holding the sample between the thumb and index finger just below the point where the ply ends are being separated from one another. However, the yarn length must not be held so tightly that the yarn is no longer free to rotate. Each time the clamps stop (i.e. a stop occurs) the foregoing procedure is repeated until the yarn sample is pulled apart. The number of stops is recorded and expressed in terms of stops per foot (30.48 cm) of yarn sample length. The average pulling tension between stops is determined from the above-mentioned chart.

Preferably, the heated fluid is directed through conduit(s) 28 against the yarn at a velocity sufficient to provide a plied yarn having on the average at least one stop per foot of yarn length and an average pulling tension of at least 10 grams and preferably at least 20 grams. Most preferably for carpet pile applications, the velocity of the heated fluid is sufficient to provide a plied yarn having from 4 to 20 stops per foot of yarn length with 7-15 being particularly preferred and an average pulling tension of at least 10 grams with 20 grams being particularly preferred. (As the stops per foot of yarn length increase, the yarn becomes increasingly harsh to the touch, decreases in diameter, and increases in its resistance to untwisting.)

For purposes of comparison a two-ply 1850 denier nylon 66 BCF yarn when heatset by the conventional batch autoclave process contains no stops and has an average pulling tension of from 3 to 5 grams. A corresponding plied yarn formed from spun singles yarns (staple) contains an occasional stop and also has an average pulling tension of 3-5 grams. It will be appreciated that in the case of yarns heatset by the process of this invention the pulling tension will vary along the yarn length since the strength and frequency of the entanglements varies. On the other hand, in the case of a plied yarn heatset by the conventional autoclave process, there is very little variation in the pulling tension along the length of the yarn since the yarn does not have entanglements.

The following examples are given to further illustrate the invention. In the examples a forwarding jet/heat chamber device substantially as shown in FIGURES 1 and 2 and a jet nozzle substantially as shown in FIGURE 5 of U.S. Patent 3,609,834 were used.

The device had an outer shell comprised of standard 2.5 inch (6.3 cm) pipe that projected 0.5 inch (1.27 cm) beyond the outlet end of the shell. The inlet end piece, integral with inner cylinder end closure was bored to a diameter of 0.75 inch (1.9 cm) with shoulder spaced 0.671 inch (1.7 cm) from the top; the portion of this bore below the shoulder diverge at a 90° cone angle with the length of the shoulder being 0.656 inch (1.66 cm).

The overall outside diameter of the jet nozzle was 0.75 inch and the overall length was 1.327 inch (3.37 cm). The nozzle contained 3 removable waffers as shown in FIGURE 5 of U.S. Patent 3,609,834. The converging inlet of the nozzle had a 50° cone angle and converged to a bore diameter of 0.078 inch (2 mm). The bore then diverged at a 15° cone angle and joined the diverging outlet having a 90° cone angle. The center waffer had one slot and the top waffer two slots (conduits) each drilled through the wall of the bore at an angle of 140° with respect to the axis of the bore. The slots in the top waffer were spaced 0.050 inch (1.3 mm) on center and the slot in the center waffer was spaced opposite and equidistant from the slots in the top waffer. The slots in the top waffer each had a depth of 0.040 inch (1.02 mm) and a width of 0.012 inch (0.30 mm). The slot in the center waffer each had a depth of 0.030 inch (0.76 mm) and a width of 0.020 inch (0.51 mm). The nozzle was locked into the body assembly by means of the follower ring and two aluminum ring gaskets as shown in FIGURE 2.

The device was mounted about 12 inches (30.48 cm) from a driven feed roll-cot roll combination on a vertical frame in a position inverted from that shown in FIGURE 1. A similar roll combination was located about 10 inches (25.4 cm) above the device and a winder was located below this roll combination. The lower coupling of the device was connected to a supply of superheated steam by means of pipe with a pressure gauge and steam pressure regulator immediately upstream. The upper coupling was plugged. The device was thermally insulated with standard-thickness magnesia pipe covering and wrapped with seamed asbestos cloth. The follower ring was left uninsulated and exposed so that the jet nozzle could be easily removed and replaced. Two funnel-mouthed aluminum ducts, one below and one above the device, were each connected to a vacuum source to draw away fumes from the operating area.

EXAMPLES 1-9

Two bulked continuous filament (BCF) nylon 66 (polyhexamethylene adipamide) singles yarns each having 95 filaments and a total denier of about 1850 were plied on a commercial cabling apparatus to provide a 3888 denier, 2 ply S-twist, BCF nylon 66 yarn with zero twist inserted in the singles yarns and 2.5 turns per inch (tpi) or 9.8 turns per decimeter (tpd) S-twist inserted in the ply. Samples of the yarn were processed under various sets of conditions. In processing the yarn samples, the yarn was threaded through the apparatus as shown in FIGURE 1 and collected onto a bobbin. The denier, % bulk, thermal shrinkage, and tangle between plies were measured on each processed yarn sample and are given in the following table along with the conditions under which each yarn sample was processed.

TABLE I

Sample Number	Steam Pressure Psig (Kg/cm^2 gauge)	Steam Temp. °C.	Roll Speed, ft/min(m/min) Feed	Roll Speed, ft/min(m/min) Take-off	Overfeed %	Denier	Bulk %	Thermal Shrinkage,%	Tangle Stops Per Foot (m)	Average Pulling Tension, grams
1	65 (4.6)	250	150 (45.7)	120 (36.6)	20	4404	12.7	1.4	8 (26.2)	≥20
2	" "	"	" "	130 (36.6)	13	4282	10.0	"	6 (19.7)	≥20
3	" "	"	" "	109 (33.2)	27	4572	14.5	0.9	11 (36.1)	≥20
4	" "	"	110 (33.5)	89 (26.8)	20	4368	9.5	"	8 (26.2)	≥20
5	" "	"	300 (91.4)	240 (73.2)	"	4208	13.6	1.4	3 (9.8)	≥10
6	40 (2.8)	"	150 (45.7)	120 (36.6)	"	4118	14.5	1.8	2 (6.6)	≥10
7	100 (7.0)	"	" "	"	"	4572	9.5	0.5	13 (42.7)	≥20
8	65 (4.6)	150	" "	"	"	4332	12.7	0.9	8 (26.2)	≥20
9	" "	300	" "	"	"	4564	10.9	0.5	7 (23.0)	≥20
Supply	- -	-	- -	-	-	3888	17.6	2,7	0	3-5

EXAMPLE 10

This example illustrates the exceptional appearance and performance characteristics of carpets constructed from heatset plied yarns of the present invention.

1300 denier, 68 filament, 2 ply S-twist bulked, continuous filament (BCF) nylon 66 yarn having 3.0 turns per inch (tpi) or 11.8 turns per decimeter (tpd) Z-twist inserted in the singles yarns and 3.0 tpi S-twist inserted in the ply was heatset using the procedure described in Example 1 and a steam pressure of 58 psig (17.58 Kg/cm^2), a steam temperature of 250°C. and an overfeed of 20%. The resulting heatset yarn (Test yarn) was tufted into a saxony construction (Test carpet) at 30 oz/yd^2 (1.02 kg/m^2) pile weight, 7/8 inch (2.2 cm) pile height in Typar[R] primary backing.

A 1230 denier, 68 filament, 2 ply S-twist BCF nylon 66 yarn (Control yarn) with 3.0 tpi Z-twist inserted in the singles yarns and 2.75 tpi (10.8 tpd) S-twist inserted in the ply was heatset and its bulk developed by the conventional batch autoclave heatsetting process (i.e. steam tumbled in skein form and then heatset in an autoclave). This yarn was tufted into a saxony construction (Control carpet) identical to that of the Test carpet.

Each carpet was beck dyed to a gold shade using disperse dyes. A secondary backing of polypropylene was then applied to each carpet. Each carpet was then tip sheared.

As compared to the Control carpet, the Test carpet was of a cleaner and clearer appearance and had noticeably better tuft erection, endpoint definition and tuft definition. Each tuft of the Test carpet was individually visible.

The performance of samples of both carpets (Test and Control carpets) was assessed under identical conditions. A sample of each carpet was subjected to the "Tetrapod Walker Carpet Test". This test is designed to predict wear performance of carpets in terms of change in appearance due to tuft or pile compaction. In the test a drum is lined with carpet sample with the pile facing inward. The sample measures 8.75 inches (22.23 cm) by 24.75 inches (62.87 cm) cut the long dimension parallel to the tufted rolls and is conditioned at least 12 hours at 21° ± 1°C. and 65% relative humidity ± 2%. The inside surface of the drum corresponds to that of the sample surface. An equiangular tetrapod having rubber feet and weighing 1.1 kg is placed inside the drum. The drum is rotated at the rate of 60 rpm about its cyrindrical axis, thereby causing the tetrapod to tumble or walk on the carpet pile. The carpet samples were examined after being exposed to 10,000; 25,000 and 50,000 revolutions of the drum. Even after 50,000 revolutions, the Test carpet sample had a good appearance and good color retention; no traffic lane was evident and the carpet had good body. On the other hand, the Control carpet sample had a matted appearance after 10,000 revolutions. Also, the Test carpet exhibited better retention of endpoint definition and tuft rigidity than did the Control carpet.

In another test a sample of each carpet was placed on a floor in a high school in Decatur, Alabama. After 20,000 traffics on each sample, each sample was steamed cleaned. Again, the Test carpet exhibited better retention of endpoint definition and tuft rigidity after the traffics and after the steam cleaning than did the Control carpet. The Control carpet appeared matted. In this test a traffic is one person walking across the carpet sample. Even after 50,000 traffics, a sample of the Test carpet appeared almost like new and still possessed good endpoint definition and tuft rigidity.

EXAMPLE 11

This example demonstrates that heatset plied yarns of the present invention, when dyed, have improved resistance to color fading in the presence of ozone as compared to corresponding yarns which have been heatset by the conventional batch autoclave process.

1230 denier, 68 filament, 2 ply S-twist BCF nylon 66 yarn with 3.5 tpi of Z-twist inserted in the singles and 3.5 tpi of S-twist inserted in the ply was heatset in the same manner as the test yarn described in Example 2. This yarn was tufted into a tip sheared, saxony construction (Test carpet) at 27.6 oz/yd^2 (0.937 kg/m^2) pile weight, 7/8 inch (2.2 cm) pile height in Typar ^{R} primary backing.

A 1230, 68 filament, 2 ply S-twist BCF nylon 66 yarn with 2.5 tpi (8.8 tpd) Z-twist inserted in the singles and 2.75 tpi (10.8 tpd) S-twist inserted in the ply was heatset and its bulk developed by the conventional batch autoclave heatsetting process (i.e. steam tumbled in skein form in an autoclave at 132.2°C.). This yarn was tufted into a saxony construction (Control carpet) identical to that of the above Test carpet.

A sample of each carpet was beck dyed with one of six commercially used disperse dye shades. After a secondary backing of polypropylene was then applied to the dyed carpet samples with latex, the pile was tip sheared. The color fading of each dyed carpet sample was measured after three ozone cycles by AATCC Test Method 129-1968 which expresses fading as a relative Gray Scale value ranging from 1 to 5 with 5 being the least faded and 1 being the most faded. The results of the testing are given in the following table.

TABLE II

Carpet Sample	Gray Scale Number
1. Light Blue	
Test	3 1/2
Control	3
2. Beige	
Test	3
Control	2 1/2
3. Spring Green	
Test	2 1/2
Control	2
4. Kentucky Green	
Test	3
Control	2 1/2
5. Rust	
Test	2 1/2
Control	2

The results in Table II show that disperse dyed carpets prepared from heatset yarns of the present invention have improved resistance against fading in the presence of ozone. A difference of 1/2 Grade Scale is generally recognized in the trade as being significant.

EXAMPLE 12

A 2.5 cotton count, 2 ply S-twist nylon 66 spun yarn with 4.5 tpi (17.7 tpd) of Z-twist inserted in the singles and 3 tpi (11.8 tpd) of S-twist inserted in the ply was heatset according to the present invention using the same procedure and conditions that were used in heat-setting the yarn described in Example 1 and a steam pressure of 120 psig (17.58 kg/m^2), a steam temperature of 250°C. and an overfeed of 20%. The individual singles yarns were composed of fibers having a staple length of 7.5 inches (19.05 cm) each of which contained 8-10 crimps per inch (3.15-3.94 crimps per cm). The resulting heatset yarn was tufted into a plush construction of acceptable appearance.

CLAIMS

1. A process for heatsetting a plied yarn characterized by:

(a) passing a plied yarn at an overfeed of from 10% to 40% into a first zone where at least one jet of heated fluid is directed laterally against the yarn at a velocity sufficient to cause fibers of each singles yarn to entangle with fibers of the other singles yarn(s) at intervals along the entire length of the yarn,

(b) passing said yarn from said first zone through a second zone where the yarn is contacted with a heated fluid, wherein the residence time of the yarn and the temperature of said heated fluid in said second zone are correlated to set the twist in said plied yarn, and

(c) thereafter cooling the resulting heatset plied yarn.

2. The process of claim 1 characterized in that the heated fluid in said first and second zones is steam.

3. The process of claim 1 characterized in that said velocity is sufficient to provide a yarn having on the average at least one stop per foot of yarn length and an average pulling tension between stops of at least 10 grams.

4. The process of claim 1 characterized in that said velocity is sufficient to provide a yarn having on the average from 4 to 20 stops per foot of yarn length and an average pulling tension between stops of at least 20 grams.

5. The process of claim 1 characterized in that said heated fluid is superheated steam.

6. The process of claim 1 characterized in that each of the singles yarns of said plied yarn is composed of bulked continuous filaments.

7. The process of claim 1 characterized in that each of the singles yarns of said plied yarn is composed of staple fibers.

8. The process of claim 1 characterized in that three jets of heated fluid are directed laterally against said yarn in said first zone.

9. A heatset plied yarn characterized in that fibers of each of its singles yarns are entangled with fibers of the other singles yarn(s) at intervals along the entire length of the yarn.

10. The yarn of claim 9 further characterized in having on the average at least 1 stop per foot of yarn length.

11. The yarn of claim 10 further characterized in having an average pulling tension of at least 10 grams.

12. The yarn of claim 11 having on the average 4 to 20 stops per foot of yarn length.

13. The yarn of claim 12 having an average pulling tension of at least 20 grams.

14. The yarn of claim 13 having on the average from 7 to 15 stops per foot of yarn length.

15. The yarn of claim 9 wherein each singles yarn is composed of bulked continuous filaments.

16. The yarn of claim 9 wherein each singles yarn is composed of staple fibers.

17. The yarn of claim 9 wherein the singles yarns are of substantially the same denier and have substantially the same denier per fiber.

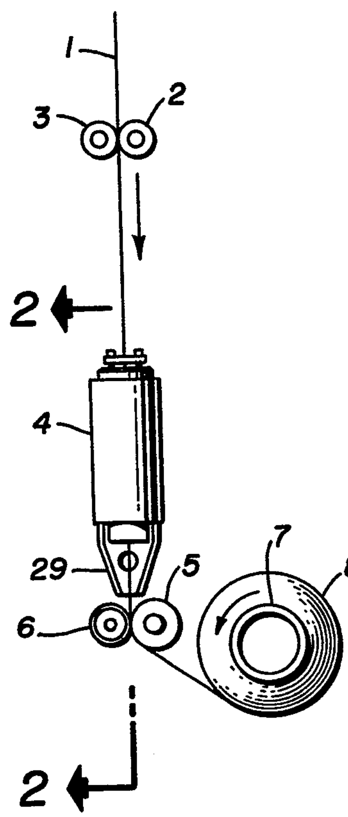
18. The yarn of claim 17 wherein each singles yarn has a denier between 1230 and 2460.

19. The plied yarn of claim 18 wherein each singles yarn has a denier per fiber between 6 and 24.

20. The plied yarn of claim 9 wherein said plied yarn is composed of two singles yarns.

21. The plied yarn of claim 9 wherein the fibers thereof are made of polyhexamethylene adipamide.

FIG. 1.



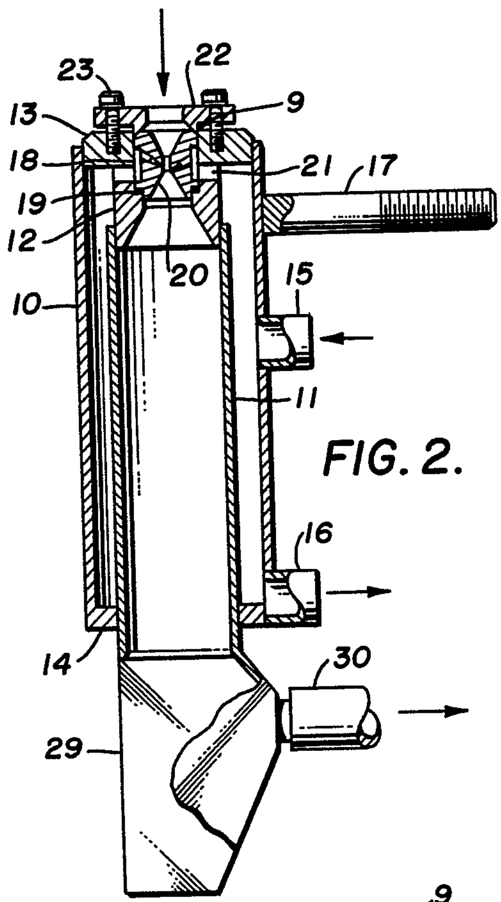


FIG. 2.

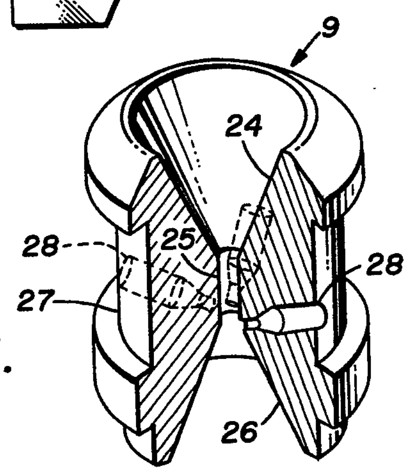


FIG. 3.

0013829

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 79 30 3025

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - A1 - 2 558 481 (BASF FARBEN + FASERN) * claim 1; page 4, last paragraph *	1,2, 5,9
	DE - A1 - 2 632 384 (BASF FARBEN + FASERN) * complete document *	1
	GB - A - 1 422 615 (MONSANTO) * page 2, lines 74 to 76 *	1
D	US - A - 3 971 200 (LEESONA CORP.) * claim 1 *	1
A	US - A - 3 483 691 (MONSANTO)	
D	US - A - 3 609 834 (MONSANTO)	
A	US - A - 3 688 358 (ASAHI KASEI KOGYO)	
A	DE - A - 1 435 599 (C. NUISSL)	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

D 02 G 1/16
D 02 G 3/34

TECHNICAL FIELDS SEARCHED (Int.Cl.³)

D 02 G 1/16
D 02 G 3/34

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	27-03-1980	KLITSCH

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