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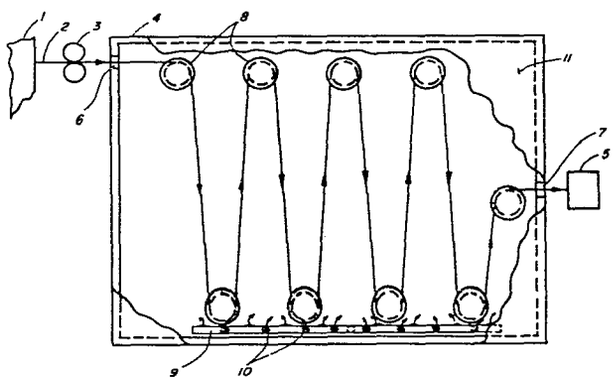
(54) Crimp angle modification process and apparatus.

(57) Process and apparatus for modifying the crimp angle memory of a crimped yarn are provided. The process comprises extending the crimp angle of the yarn by applying tension to the yarn, and heating the yarn while under that tension to at least the glass transition temperature, but below the melting point, of the yarn material. The apparatus comprises a pair of nip rolls, from which the yarn passes through a heated chamber to a cutter.



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CRIMP ANGLE MODIFICATION PROCESS AND APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a process and apparatus for modifying the crimp angle memory of a crimped yarn, preferably a textured, polyamide tow after it exits the crimper and prior to any other treatment. The tow stretching apparatus utilized in the front end of this process is shown in U.S. Patent 4 095 318 to Abbott et al., hereby incorporated by reference, and a typical crimper is shown by U.S. Patents 3 273 220 and 3 351 993 to Rosenstein et al., also incorporated by reference. See also U.S. Patents 3 266 082 to Brandi and 3 422 492 to Gorecki, pertinent portions of which are hereby incorporated by reference.

PRIOR ART

Crimped continuous filament yarn, preferably textured tow, is formed by, for example, forcing the continuous filament yarn through the nip of a pair of counter-rotating crimping rollers into a zone of restriction, such as a stuffing chamber or the like, in which the yarn accumulates by buckling and folding over itself continuously to form a multiplicity of V-shaped crimps while optionally being subjected to heat. Thereafter, the crimped yarn (textured tow) can be cut to form staple fiber which ultimately is formed into fabric such as tufted carpet. Intermediate to cutting and tufting, the staple fiber is carded, drafted and spun into yarn, which mechanically extends, i.e., opens or enlarges, the crimp angle of the fiber. When the fabric, e.g., tufted

carpet is heated, for instance during dyeing, the textured yarn tries to reassume the original crimp angle created during crimping. The effective tuft length of the fabric is thereby shortened. To avoid this total crimp redevelopment the present invention was made.

U.S. Patent 3 271 836 to Rosenstein, hereby incorporated by reference, teaches a method of distorting or modifying crimped synthetic thermoplastic yarn which comprises drawing the crimp over an edge while under tension to physically distort by wiping action the apices of the V-shaped crimp.

U.S. Patents 3 886 636 and 3 977 058 to Borenstein et al., hereby incorporated by reference, teach a method and apparatus for processing yarn wherein crimped and entangled yarn is heated while being exposed to relatively high tension and is thereafter packaged while still warm and under tension to produce a straightened yarn which, after cooling in the straightened form, will assume a crimped form upon subsequent heating in a relaxed state.

SUMMARY OF THE INVENTION

The present invention provides a process and apparatus for modifying the crimp angle memory of a crimped yarn.

The process comprises the steps of extending the crimp angle of the yarn by applying tension to the yarn, and heating the yarn while under that tension to at least the glass transition temperature, but below the melting point, of the yarn material.

This process is particularly useful in processing thermoplastic yarns including those of polyester and polyolefin (polypropylene), more preferably polyamide such as nylon 6,6 and nylon 6, most preferably the latter.

The tension applied when processing nylon yarns is preferably in a range of 0.01 to 0.04 gram per denier, more preferably 0.02 to 0.03 gram per denier, tensions of at least 0.01 gram per denier being required

to achieve a significant reduction in heat caused shrinkage of tufted fiber and tensions of greater than 0.04 gram per denier causing the crimp angle to be removed almost entirely when utilizing the apparatus of the present invention.

The glass transition temperature will vary depending on the particular yarn material. Further, the glass transition temperature of nylon 6 and nylon 6,6, respectively, are markedly affected by water content. See Buchanan and Walters, Glass-Transition Temperatures of Polyamide Textile Fibers, Part I, Textile Research Journal 398-406 (June 1977) and Kettle, Variation of the Glass Transition Temperature of Nylon-6 With Changing Water Content, 18 Polymer 742 (July 1977), both of which are hereby incorporated by reference. The effect of environment upon equilibrium water contents and glass transition temperature (dilatometric measurement technique) of samples of nylon-6 shown in the latter reference are:

R.H. (%)	Water Content (% W/W)	Tg (+ 1°C)
(a)	0.35	94
(b)	0.70	84
12	1.17	71
33	1.99	56
44	2.70	45
55	3.47	43
66	4.45	40
86	6.61	23
97	10.33	-6

(a) "dried" over silica gel;

(b) tested as received

It can be seen, then, that the temperature to which the yarn is heated (measured preferably by either a surface pyrometer such as the Digicon II by Alnor Instrument Company or a Raynger II by Raytek) may vary. It is only necessary that the temperature of the yarn be brought minimally to its glass transition temperature.

This will necessarily define the time and temperature exposure limits of the process. For nylon yarn, it is preferred that the yarn be heated to a temperature in the range of 40° to 100°C, more preferably 70° to 100°C. This is preferably accomplished by contacting the yarn with saturated steam at a temperature in the range of 100° to 180°C in a sealed environment or at a temperature in the range of 100° to 105°C at atmospheric conditions for a time of 2 to 4 seconds, more preferably 2.2 to 3.8 seconds.

The apparatus of the present invention comprises means for applying tension to the yarn to extend the crimp angle of the yarn, and means for heating the yarn while under this tension to at least the glass transition temperature, but below the melting point, of the yarn material.

The means for heating the yarn preferably comprises a chamber having a yarn inlet and a yarn outlet for passage of the yarn therethrough, a plurality of rolls for transporting the yarn therethrough, and means for supplying heat to the chamber. The preferred heat supply means is a steam header. The rolls in the heated chamber preferably are freewheeling; however, the speed of the first roll contacted in the chamber by the yarn may be ratioed to that of the roll last contacted by the yarn in the chamber to apply the required tension to the yarn. It is preferred, however, that the means for applying tension be independent of the heat application means, specifically, a pair of nip rolls from which the yarn passes to the means for heating, and withdrawal means, most preferably the cutter, to which the yarn passes from the means for heating. Tension bars could also be used in lieu of nip rolls.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a schematic side view, partially cut away, of the apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The tow stretching apparatus utilized in the front

end of this process is depicted in U.S. Patent 4 095 318 to Abbott et al., incorporated by reference herein. With reference to Figure 1, the apparatus of the present invention is provided to modify the crimp angle memory of the crimped yarn tow 2 exiting a crimper box or J box indicated by the numeral 1. Textured tow 2 is passed to a set of nip rolls 3, then into heating chamber 4 to be heated to its glass transition temperature, and finally to withdrawal means 5, which preferably is a cutter unit. Heating chamber 4, with swing-out front panel 11 for access thereto, has a yarn inlet 6 and yarn outlet 7, which are simply slots for passage of tow 2 therethrough. Sluices and seals can be provided, if desired, to prevent penetration of atmospheric air into heating chamber 4. A plurality of freewheeling, flanged rolls 8 for transporting tow 2 are attached to the rear panel of chamber 4, the particular number and arrangement being chosen to effect a given residence time for tow 2 in chamber 4. Saturated steam is introduced, preferably under atmospheric conditions, at the base of chamber 4 via steam header 9 having apertures 10. Nip rolls 3, operating on air pressure, apply tension to tow 2 which is maintained throughout heating chamber 4 by coordinating the speed of withdrawal means 5.

In lieu of applying and maintaining tension via nip rolls 3 and withdrawal means 5, tension may be applied and maintained by controlling the relative speeds of selected rolls 8, preferably the first and last to be contacted by tow 2 within chamber 4. Further, tension bars could be used in lieu of nip rolls 3 for applying tension to tow 2.

EXAMPLE 1 (CONTROL)

Nylon 6 polymer having, nominally, 50 carboxyl ends, milliequivalents per 10^6 grams polymer, 50 amine ends, milliequivalents per 10^6 grams polymer, a formic acid viscosity (ASTM D-789-59T) of 57, and having 0.13% titanium dioxide therein was produced in a continuous process, i.e., a process wherein subsequent to final

polymerization the molten polymer was pumped directly to spinning units via an extruder. The molten polymer having a temperature of about 267°C was melt-extruded under pressure of about 900 psig (6205 kPa) through a 300-orifice spinnerette at a rate of 187.5 pounds per hour (85.0 kg/hour) into a quench stack where crossflow of quenching fluid was air at a temperature of about 18°C and at a relative humidity of about 65%. The quenched filaments had a spin finish applied and were deposited in a tow can. The undrawn denier per filament was nominally 32, the modification ratio was targeted for 2.4, and the percent finish on yarn was about 0.9. Yarn made in accordance generally with this procedure and from several (16) tow cans was combined in a creel into a tow and stretched in a normal manner at a stretch ratio of about 3.3 to 1 in a tow stretcher. The tow was then fed through a stuffing box crimper using about 15 pounds (103 kPa) of steam to produce about 10.3 crimps per inch (4.1 crimps per cm), and was autoclaved at 127°C. Then, the tow was fed into a conventional cutter, was cut into staple yarn having a length of 8 inches (20.3 cm), and was baled.

A single ply bundle of 10 denier per filament staple fiber having a cotton count of 3.0 and a twist of 4.0 Z was formed. Some of this yarn was measured for crimp elongation before boil (percent), then boiled for thirty minutes in water, and measured again for crimp elongation after boil (percent). These values along with the differences (ΔS) are presented with some textured yarn physicals in Table 1.

EXAMPLES 2 THROUGH 7

The procedure of Example 1 was followed in each of Examples 2 through 7, respectively, except that the tow was fed through apparatus like that of Figure 1 prior to cutting in lieu of autoclaving. Steam was injected under 8 psig (55 kPa) into atmopsheric conditions at the base of chamber 4 to effect a saturated steam atmosphere of about 100°C. The tow passed through chamber 4 at a nominal rate

of 500 feet per minute (152 meters/minute) for a residence time of 3.8 seconds. Tension applied, crimp box steam pressure, crimp elongation before boil, crimp elongation after boil, and some textured yarn physicals are presented in Table 1.

EXAMPLES 8 THROUGH 14

In Examples 8 through 14, some of the yarn formed in Examples 1 through 7, respectively, was formed into tufted velour carpet having a target weight of 29.0 oz/yd^2 (983 g/m^2), target pile height of 0.5 inch (1.27 cm), POLY BAC FLW® primary backing and Action Back® secondary backing, both manufactured by Amoco Fabrics Co., Patchogue Plymouth Division. The carpets were beck dyed Salem Beige at a temperature of about 96°C prior to application of the secondary backing and shearing. The actual pile height of each carpet was then measured. Results are presented in Table 2.

DISCUSSION

With reference to Examples 2 through 7 and Table 1, it would be expected from the ΔS values that the pile height would be greater for carpets formed of these yarns (as opposed to control yarn) and dyed at a temperature which would redevelop latent crimp. Reference to Examples 8 through 14 and Table 2 shows this prediction to be accurate except in Example 6.

The crimp angle memory of the textured fiber was modified through use of the process and apparatus of the present invention to produce less tuft shrinkage via less crimp redevelopment, providing higher pile height, due to the extended crimp angle.

TABLE 1

	Control	Examples		
	1	2	3	4
Crimp Box Steam psig/kPa	15/103	4/27	4/27	4/27
Tension, g/d	-	0.02	0.02	0.02
Denier	10.4	10.7	10.7	11.0
U.E.[1], %	70	65	64	64
B.S.[2], g	50	51	49	48
Tenacity[3], g/d	4.8	4.8	4.6	4.4
Crimps/Inch (Crimps/cm)	10.3 (4.06)	9.7 (3.8)	10.6 (4.17)	11.7 (4.61)
Crimp Elongation, %				
Before Boiling	11.4	9.6	10.3	11.7
After Boiling	21.4	13.8	17.0	19.7
△ S	10.0	4.2	6.7	8.0

	Examples		
	5	6	7
Crimp Box Steam psig/kPa	10/69	23/158	4/27
Tension, g/d	0.02	0.02	0.03
Denier	11.8	11.7	12.0
U.E.[1], %	64	67	70
B.S.[2], g	50	49	52
Tenacity[3], g/d	4.3	4.2	4.3
Crimps/Inch (Crimps/cm)	9.7 (3.8)	10.7 (4.21)	9.9 (3.9)
Crimp Elongation, %			
Before Boiling	9.9	9.2	9.7
After Boiling	15.4	15.6	17.0
△ S	5.5	6.5	7.3

[1]Ultimate Elongation (ASTM D 2256-80).

[2]Breaking Strength (ASTM D 2256-80).

[3](ASTM D 2256-80).

TABLE 2

	Control	Examples		
	1	2	3	4
Stitch Rate				
Per Inch	11.1	11.6	11.5	10.7
Per cm	4.37	4.57	4.53	4.21
Pile Height				
Before Dyeing				
In/cm	0.5/1.3	0.5/1.3	0.5/1.3	0.5/1.3
After Dyeing				
In/cm	0.34/0.86	0.38/0.97	0.38/0.97	0.38/0.97
Weight				
oz/yd^2	29.5	29.5	29.0	29.0
g/m^2	1000	1000	983	983

	Examples		
	5	6	7
Stitch Rate			
Per Inch	10.7	11.6	10.6
Per cm	4.21	4.57	4.17
Pile Height			
Before Dyeing			
In/cm	0.5/1.3	0.5/1.3	0.5/1.3
After Dyeing			
In/cm	0.38/0.97	0.34/0.86	0.38/0.97
Weight			
oz/yd^2	29.1	29.5	29.0
g/m^2	987	1000	983

WE CLAIM:

1. A process for modifying the crimp angle memory of a crimped yarn, comprising the steps of:

extending the crimp angle of the yarn by applying tension to the yarn, and

heating the yarn while under said tension to at least the glass transition temperature, but below the melting point of the yarn material.

2. The process of claim 1 wherein the yarn is nylon.

3. The process of claim 2 wherein the tension applied is in the range 0.01 to 0.04 gram per denier.

4. The process of claim 2 wherein the yarn is heated to a temperature in the range of 40°C to 100°C.

5. The process of claim 2 wherein the yarn is heated by contact with saturated steam at a temperature of 100° to 180°C in a sealed environment.

6. The process of claim 2 wherein the yarn is heated by contact with saturated steam at a temperature of 100° to 105°C at atmospheric conditions for a time of 2 to 4 seconds.

7. Apparatus for modifying the crimp angle memory of a crimped yarn, comprising:

means for applying tension to the yarn to extend the crimp angle of the yarn, and

means for heating the yarn while under said tension to at least the glass transition temperature, but below the melting point, of the yarn material.

8. The apparatus of claim 7 wherein the means for heating the yarn comprises:

a chamber, having a yarn inlet and a yarn outlet,

a plurality of rolls in the chamber for transporting the yarn therethrough, and

means for supplying heat to the chamber.

9. The apparatus of claim 8 wherein the speed of the first roll contacted in the chamber by the yarn is ratioed to that of the roll last contacted by the yarn in the chamber to apply the required tension to the

yarn.

10. The apparatus of claim 8 wherein the means for applying tension to the yarn comprises a pair of nip rolls, from which the yarn passes to the yarn inlet of the chamber, and withdrawal means to which the yarn passes from the yarn outlet of the chamber, the rolls in the chamber being freewheeling.

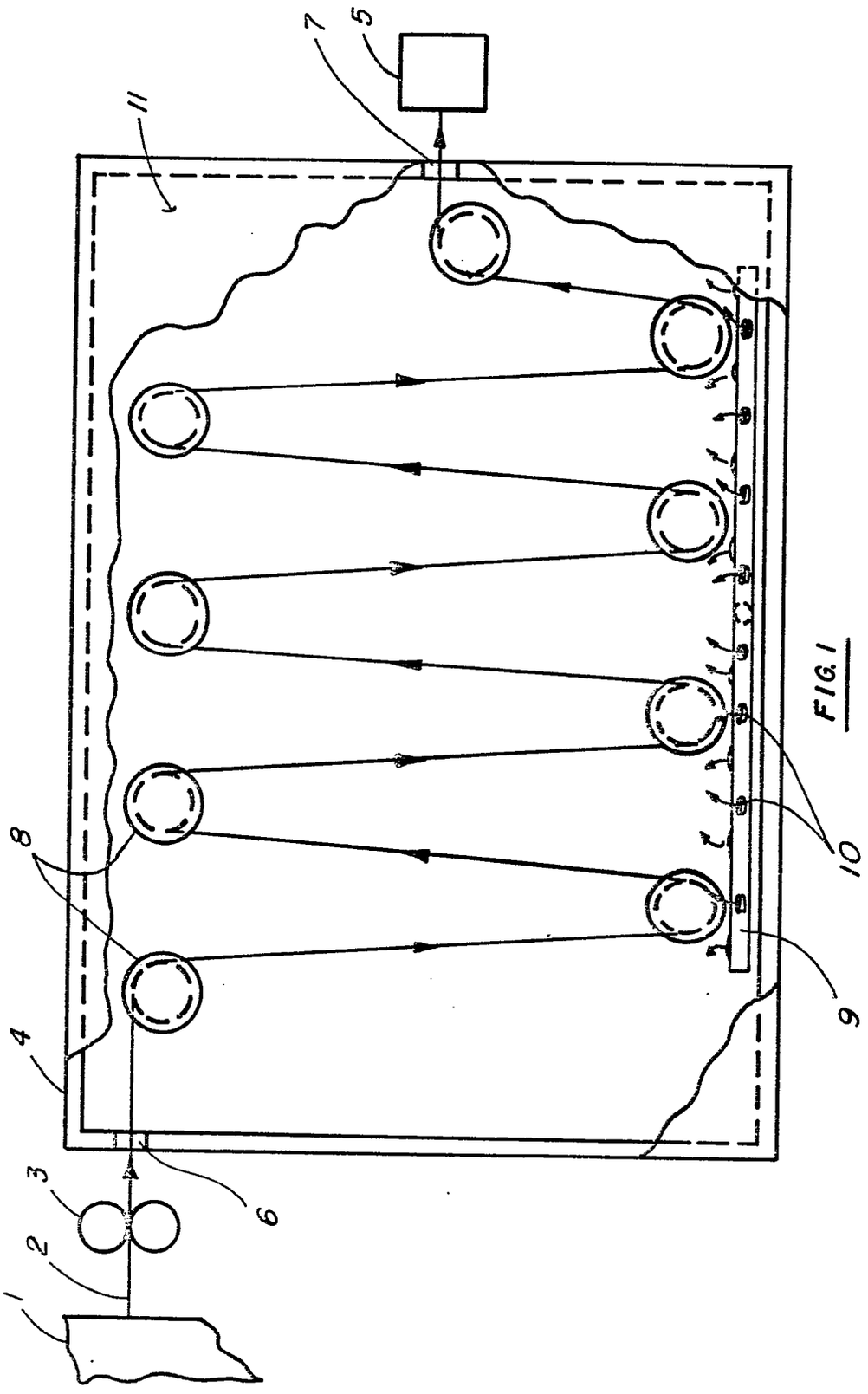

FIG. 1