PROCESS FOR MAKING A BULKY, MULTIFILAMENT, SUBSTANTIALLY TWISTLESS SYNTHETIC YARN AND PRODUCT THEREOF

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ABSTRACT OF THE DISCLOSURE

A bulked twist-free coherent yarn consisting of polyamide filaments having a set crimp and being intermingled is obtained by subjecting the as-spun filaments, whilst still plastic to the action of a high velocity fluid jet to attenuate and molecularly orient the filaments as well as imparting a random irregular crimp thereto and causing the filaments to intermingle. A proportion of the filaments may be of the conjugate filaments composed of at least two dissimilar components.

This invention relates to synthetic filament yarns, particularly to yarns produced from high molecular weight synthetic polymers, and to processes for their preparation.

Bulky continuous multifilament yarns of high molecular weight synthetic polymers such as polyamides, characterised in that the individual filaments have coils, loops or whorls at random intervals along their length, are well known to the art. In such yarns the coils and loops are held in place by the twist usually imparted to the yarn. A convenient process for producing this yarn involves subjecting a drawn multifilament yarn to the action of a turbulent compressible fluid.

We have now discovered a useful bulk multifilament polyamide yarn in which substantially all of the filaments are characterised in that they have a random irregular crimp, which crimp persists in the individual filaments when they are pulled out from the yarn, and are intermingled to provide a twist free coherent structure.

Accordingly, therefore, from one aspect, the present invention provides a bulky multifilament yarn comprising oriented polyamide filaments having a random irregular crimp along their length, which crimp persists in the individual filaments when they are pulled out from the yarn, the filaments in the yarn being intermingled to provide a twist free coherent structure.

By intermingling is meant that substantially all of the individual filaments in the yarn are axially displaced relatively to each other so that the paths of two or more filaments cross and re-cross each other at random intervals along the length of the yarn.

According to another aspect the present invention provides a process for the manufacture of a bulky coherent yarn wherein molten polymers consisting of at least a major proportion of polyamide are extruded into filaments which, whilst they are in a substantially amorphous plastic state, are subjected to the action of a fluid jet at a high velocity to provide drawing tension in the filaments above the point of application of the said fluid jet to attenuate, and molecularly orient them and at an angle to the filament path to impart a random irregular crimp thereto and cause the filaments to intermingle to form a coherent yarn structure, the said yarn being forwarded to a yarn winding device and formed into a package and at least the polyamide filaments therein caused to crystallise.

Crystallisation of the filaments in the yarn may be induced before the yarn reaches the wind-up device, e.g. by treatment with steam before the winding device, or the filaments may be allowed to crystallise after being formed into a package either under ambient conditions or the rate of crystallisation may be accelerated by subjecting the package to a steam or heat treatment for example.

While the polyamide filaments are in the substantially amorphous plastic condition referred to above they lack, although oriented, elastic recovery and hence retain the "shape" into which they are formed. On subsequent crystallisation this "shape" is permanently set into the filaments. Thus in the process of this invention, the filaments are cramped and formed into an intermingled coherent structure by the action of the fluid jet whilst in this plastic state, subsequent crystallisation of the filaments then sets the filaments in this form.

In the normal production of polyamide yarns, e.g. form polyhexamethylene adipamide, the filaments are normally caused to crystallise immediately after extrusion, and before being substantially oriented, by passing them through a known as a steam conditioner tube. If such a device is used in the present process in an analogous manner, e.g. by placing the tube above the fluid jet, then a non-coherent yarn of uncrimped filaments is obtained.

It is thought that the angle of incidence of the fluid jet and the filaments must be sufficiently large to cause the...
fluid flow around the filaments to be turbulent. This turbulence may be due to the formation, within the jet, of toroidal fluid vortices which have their axes perpendicu­lar to the mean filament axes and which break up to give a random turbulent fluid flow. Whenever the reason for the turbulent flow its effect is to cause the filaments to be whipped about and their paths to be made to cross and re­cross each other at random intervals and thus yield an interfaced and coherent yarn. If a small stream of inci­dence flow is too small streamline flow will result which, whilst drawing the filaments, may not pro­vide the necessary turbulence for interlacing; if the angle is too great then an excessive amount of turbulence may result and the forwarding velocity of the fluid may not be great enough to attenuate and thus orient the filaments.

The velocity of the fluid jet required to attenuate and orient the filaments to the desired amount, which velocity is a function of the air consumption (i.e. air pressure) and aspirating jet design, will vary depending upon the polymer being spun and the process conditions including the emergent viscosity of the polymer, i.e., the melt viscosity, at the time of extrusion, the spineret design, the filament/fluid contact distance which provides the drag on the filaments, and the angle of incidence between the fluid jet and the filaments.

In general the velocity of the fluid jet must be suf­ficiently high to provide a resultant tension in the filaments, above the point of action of the jet on the filaments, which will attenuate and orient the said filaments to the required extent.

The resultant tension is the algebraic sum of the tension applied to the filaments by the fluid jet acting to attenuate the filaments, and the tension caused by the melt viscosity of the polymer, surface tension effects and air drag above the point of action of the fluid jet, which act to resist attenuation of the filaments.

Since the rate of production of yarn by this process is high, in the order of 15.000 feet per minute, normal methods of winding onto yarn packages can be used only with great difficulty and the use of centrifugal and other wind-up systems are preferred. There is the added difficulty that during the crystallisation process the filaments spontaneously elongate, and if this is allowed to occur on the yarn package it will result in sloughing if normal yarn packages are wound.

The invention will now be fully explained by reference to the accompanying drawings.

In the drawings:

FIGURE I is a schematic representation of an apparatus assembly useful for forming the yarns of this invention.

FIGURE II is a cross-section of an aspirating jet suitable for use with the assembly of FIGURE I.

Referring to FIGURE I freshly formed filaments 1 are spun through spineret 2 and are converged into a bundle at the throat of the aspirating jet 3. Within and downstream of the aspirating jet the filaments are acted upon by high velocity air which is supplied through the intake 4. Toroidal vortices, having their axes substantially perpendicu­lar to the mean axes of the filaments, are thought to be formed within the jet and to create a turbulent zone around the filaments causing them to be whipped from side to side and to intermingle with each other. The inter­mingled yarn obtained is forwarded by the blast of air issue­ing from the jet to the centrifugal wind up system 5.

In FIGURE II, the aspirating jets comprises a hollow body portion 10 which is externally threaded at either end and has an intake pipe 11 attached thereto. A cover 12 containing a yarn inlet guide 13 is screwed onto the top of the body portion 10. A second cover 14 containing a yarn exhaust guide 15 is screwed onto the bottom of the body portion 10. The bottom and top ends of the inlet and exhaust guides respectively are chamfered to provide an annular air injector passageway 16. The angle of cham­ber on the guides is referred to as the injector half angle

and is denoted by FIGURE II. The annular air injector passageway is arranged to direct the air downwards, i.e. in the direction of filament flow.

In operation the aspirating jet may conveniently be placed at some point above the solidification point of the freshly spun filaments. The filaments are con­verged together at the throat of the aspirating jet through which they are passed. In the aspirating jet the filaments are contacted by a jet of high velocity fluid which quenches the filaments, causing them to crimp in an irregular ran­dom manner. The turbulence resulting from the fluid ver­tices formed within the jet then cause the filaments to intermingle, and form a coherent yarn. As the yarn issued from the mouth of the jet, the high velocity fluid issuing with it forwards the yarn at substantially greater speed than the extrusion speed i.e. it exerts a drag effect on the yarn, thus causing the filaments in the yarn to be at­tenuated and oriented. The attenuation and orientation does not, however, take place within the jet but at some point between the spineret and the throat of the jet, i.e. the semi-molten filaments are attenuated. The drag effect of the fluid on the yarn continues for some distance be­low the mouth of the jet, and it is therefore important that the wind up system for the yarn is placed below the point at which the drag becomes insiginificant in order to achieve maximum attenuating efficiency. Owing to the high speeds of production of the yarn, in the order of 15.000 ft./min, the usual wind up techniques are not available and the yarn has to be packaged by a high speed wind up system. Thus, for example, a centrifugal device such as a modified Topham box, or a device such as that described in British Patent 930,546, may be used to wind up the yarn into a package.

Acceleration of crystallisation of the yarn in the pack­age may conveniently be achieved by dripping water into the aspirating gun, the effect of the high velocity fluid atomises the water so distributing uniformly throughout the yarn and allowing more rapid and uniform crystal­lisation of the yarn in the package than would take place if the yarn were merely allowed to crys­talise under ambient conditions.

Air is the preferred fluid for the production of yarns of this invention although other gaseous fluids, may be employed. The temperature of the air may beneficially be raised above ambient temperature, care being taken how­ever, to ensure that its temperature is low enough to have a quenching action on the yarn at its point of contact with the yarn. Increasing the temperature of the air will, of course, accelerate the crystallisation of the yarn, and if the yarn consists of or contains heterofilaments having a potential crimp, at least part of this crimp may also be developed.

The following examples illustrate convenient process for obtaining the yarn of the invention.

EXAMPLES 1 AND 2

In these examples the polymer used was polyhexamethylene adipamide having a relative viscosity of 32.6 and a melt viscosity of 475 poises at 290° C. (the spinning temperature). The polymer was spun through a 34 hole spineret and the filaments converged into a bundle at the throat of an aspirating jet of type described with reference to FIGURE II and located at a fixed dis­tance below the spineret and having the following di­mensions.

Inlet bore: internal diameter 3/4", length 2".
Exhaust bore: internal diameter 3/8", length 6".
 Injector half angle (α): 10°.

Air at ambient temperature was used as the fluid. The velocity of the air, measured in terms of air consump­tion, was fixed at the required level by adjusting the size of the air injector passage, i.e. the distance apart of the inlet and exhaust bores. The coherent yarns of inter­mingled filaments which was obtained was collected in
the amorphous state by a device located 4 ft. below the aspirating jet and allowed to crystallise under ambient conditions. The crystalline yarn had a similar appearance to that shown. Other experimental details and yarn properties are given in Table I below.

| TABLE I |
|-----------------|-----------------|
| Dist. of jet below spinneret, ft. | Example 1 | Example 2 |
| Air consumption, cu. ft./min. | 15 | 2 |
| Polymer throughput, lb./hr. | 4.75 | 6.1 |
| Yarn velocity, ft./min. | 38,100 | 18,900 |
| Yarn denier. | 37.2 | 73.0 |
| Tensile strength | 2.31 | 3.11 |
| Elongation at break | 6.848% | 6.948% |
| Initial modulus g.4/.1000% ext. | 41.4 | 85.9 |

What we claim is:

1. A process for the manufacture of a bulky, multi-filament, substantially twistless yarn comprising extruding molten polymers consisting of at least a major proportion of a polyamide into filaments, impinging fluid from a high velocity fluid jet upon said filaments, whilst they are in a substantially amorphous, plastic condition, to provide sufficient tension in the filaments above the point of application of said fluid jet to attenuate and molecularly orient them, said fluid being impinged upon said filaments at an angle to the filament path to impart a random irregular crimp thereto and to cause said filaments to intermingle to form a coherent yarn structure, forwarding said yarn to a yarn winding device and forming it into a package, and causing at least the polyamide containing filaments to crystallise.

2. A process according to claim 1 wherein the molten polymers are wholly polyamides.

3. A process according to claim 2 wherein the molten polyamides consist of polyhexamethylene adipamide only.

4. A process according to claim 1 wherein at least some of the molten polymers are extruded as heterofilaments.

5. A process according to claim 4 wherein the molten polymers consist solely of polyamides.

6. A process according to claim 5 wherein the molten polymers consist of at least two polyamides selected from the group consisting of polyhexamethylene adipamide, polyethylene adipamide, polyamidoneadecanoic acid and an 80/20 polyhexamethylene adipamide/polyethylene adipamide/polyethylene adipamide copolymer.

7. A process according to claim 4 wherein a minor component of the heterofilaments is a polyester.

8. A process according to claim 7 wherein the polyester is polyethylene terephthalate.

9. A process according to claim 1 wherein at least the polyamide filaments are caused to crystallise before the yarn reaches the winding device.

10. A process according to claim 9 wherein the yarn is subjected to a steam treatment to cause the polyamide filaments to crystallise.

11. A process according to claim 4 wherein the yarn is subjected to a heat treatment to develop any potential crimp therein and to cause the polyamide containing filaments to crystallise.

12. The product produced by the process of claim 1.

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