ULTRA-FINE HIGH-STRENGTH POLYAMIDE MULTIFILAMENT, AND COVERING YARN, STOCKING, AND FABRIC USING SAME

A polyamide multifilament, characterized in having a total fineness of 4.0-6.0 dtex, a single yarn fineness of 1.2 dtex or below, a strength-elongation product of 9.1 or above, and an elongation degree of 40-50%. Provided is a polyamide fiber having a small total fineness and single fiber fineness while having a high strength-elongation product and exhibiting a low unevenness (U%) in the longitudinal direction. Also provided are: a stocking exhibiting an excellent higher-order process passability and productivity and exhibiting an excellent softness, durability, and transparent feel; and a fabric exhibiting an excellent softness and durability.
The present invention relates to an ultrafine, high strength polyamide multifilament. It relates to an ultrafine, high strength polyamide multifilament such that stockings with excellent softness, durability, and transparent appearance can be obtained when the ultrafine, high strength polyamide multifilament according to the present invention is applied to stockings while woven fabrics with excellent softness, durability, and lightweightness can be obtained when it is applied to woven fabrics.

Polyamide fibers and polyester fibers, which are synthetic fibers, are widely used in the fields of clothing and industrial materials because they have excellent characteristics including mechanical and chemical properties. In particular, polyamide fibers are used widely in the field of general clothing applications such as stockings, undergarment, and sportswear because they have excellent characteristics in terms of their unique softness, high strength, color development in dyeing, heat resistance, hygroscopicity, etc.

Consumers of stockings have been calling for products having high softness and transparent appearance while maintaining the conventional-level durability to ensure comfortableness and a bare skin feeling.

To solve these problems, Patent document 1, for example, proposes to produce ultrafine, high strength polyamide fibers by heating and additionally stretching commercially available high strength nylon yarns having an elongation degree of 38% to 40% and apply them to production of stockings with a pleasant texture, good transparent appearance, and high durability. In addition, Patent document 2 proposes to produce ultrafine high strength polyamide fibers by heating and additionally stretching nylon 6 yarns having an elongation degree of 40% to 45% and apply them to production of stockings with high durability, transparency, and good texture.

On the other hand, with the spread of outdoor sports in recent years, demand for fabrics for sports clothing has been increasing year by year while latest fabrics have been decreasing in weight and thickness, resulting in demands for products having increased softness and lightweightness while maintaining the conventional-level durability.

The present invention aims to solve the above problems, and its main object is to provide a polyamide multifilament having a large strength-elongation product and an appropriate elongation degree while being extremely fine in terms of both the total fineness and single fiber fineness. More specifically, the present invention aims to provide stockings having high order process passage capability and product quality as well as excellent softness, durability, and transparent appearance and woven fabrics having excellent softness, durability, and lightweightness, by using polyamide multifila-
ment having a large strength-elongation product and an appropriate elongation degree while being extremely fine in terms of both the total fineness and single fiber fineness.

Means of Solving the Problems

[0010] The present invention adopts the following constitution to solve the problems described above.

[0011]

1. An ultrafine, high strength polyamide multifilament having a total fineness of 4.0 dtex to 6.0 dtex, a single fiber fineness of 1.2 dtex or less, a strength-elongation product of 9.1 or more, and an elongation degree of 40 to 50%.
2. An ultrafine, high strength polyamide multifilament as set forth in (1) further having a yarn unevenness (U%) of 1.2 or less.
3. An ultrafine, high strength polyamide multifilament as set forth in either (1) or (2) further having a sulfuric acid relative viscosity of 2.5 to 3.5.
4. A covering yarn produced by coating an ultrafine, high strength polyamide multifilament as set forth in any one of (1) to (3).
5. Stockings partly including a covering yarn produced by coating an ultrafine, high strength polyamide multifilament as set forth in (4).
6. A woven fabric including an ultrafine, high strength polyamide multifilament as set forth in any one of (1) to (3) used as warp and/or weft.

Advantageous Effect of the Invention

[0012] The ultrafine, high strength polyamide multifilament according to the present invention is a polyamide multifilament that has a large strength-elongation product and an appropriate elongation degree while being extremely fine in terms of both the total fineness and single fiber fineness. Furthermore, the use of the ultrafine, high strength polyamide multifilament according to the present invention serves for producing stockings having high order process passage capability and product quality as well as excellent softness, durability, and transparent appearance and woven fabrics having excellent softness, durability, and lightweightness.

Description of Preferred Embodiments

[0013] The invention is described in more detail below.

[0014] The polyamide that forms the ultrafine, high strength polyamide multifilament according to the present invention is a resin of a high molecular weight substance in which a so-called hydrocarbon group is connected to the backbone chain via an amide bond, and this polyamide should have high yarn making performance and good mechanical characteristics and preferably be mainly a polycaproamide (nylon 6) or polyhexamethylene adipamide (nylon 66), of which polycaproamide (nylon 6) is the more preferable because it does not gelate easily and has high yarn making performance. The term "mainly" as used above suggests that the ε-caprolactam units present in the polycaproamide account for 80 mol% or more, preferably 90 mol% or more, of the total monomer units. There are no specific limitations on the other components and useful ones include, for example, such units as aminocarboxylic acid, dicarboxylic acid, and diamine that serve as monomers constituting polydodecanamide, polyhexamethylene adipamide, polyhexamethylene azelamide, polyhexamethylene sebacamide, polyhexamethylene dodecanamide, polymetaxylylene adipamide, polyhexamethylene terephthalamide, polyhexamethylene isophthalamide, etc.

[0015] For the advantageous effects of the invention to be developed efficiently, the polyamide is preferably free of various additives including delustering agent such as titanium oxide, but may contain appropriate additives such as heat resistant agent unless they impair the effects. Their contents may be in the range of 0.001 to 0.1 wt% as necessary.

[0016] It is necessary for the ultrafine, high strength polyamide multifilament according to the present invention to have a total fineness of 4.0 to 6.0 dtex. If in range, it enables the production of stockings having high softness and good transparent appearance or woven fabrics having high softness and high lightweightness. If the total fineness is less than 4.0 dtex, softness yarns may be obtained, but they will be low in strength, leading to stockings and woven fabrics with poor durability. If the total fineness is more than 6.0 dtex, it will result in stockings with deteriorated transparent appearance or woven fabrics with deteriorated lightweightness. It is more preferable for the ultrafine, high strength polyamide multifilament according to the present invention to have a total fineness of 4.5 to 6.0 dtex.

[0017] It is necessary for the ultrafine, high strength polyamide multifilament according to the present invention to have a single fiber fineness of 1.2 dtex or less. If in this range, it enables the production of stockings and woven fabrics with high softness. If the single fiber fineness is more than 1.2 dtex, it leads to a stiff texture and low softness. The single fiber fineness should be as low as possible, but for the present invention, its lower limit is about 0.7 dtex.
It is preferable for the ultrafine, high strength polyamide multifilament according to the present invention to have a strength-elongation product of 9.1 or more. If in this range, it enables the production of stockings and woven fabrics having a durability at practical level. If the strength-elongation product is less than 9.1, the resulting stockings and woven fabrics will fail to have a durability at practical level and the yarns will suffer frequent yarn breakage in higher order processing steps, leading to poor high order process passage capability. It is preferable for the ultrafine, high strength polyamide multifilament according to the present invention to have a strength-elongation product of 9.5 or more. The strength-elongation product should be as large as possible, but for the present invention, its upper limit is about 10.0.

It is necessary for the ultrafine, high strength polyamide multifilament according to the present invention to have an elongation degree of 40% to 50%. If in this range, it ensures a low yarn breakage frequency in high order processing steps, leading to high order process passage capability and good product quality. In particular, it ensures enhanced high order process passage capability in high speed knitting and weaving steps. If the elongation degree is less than 40%, yarn breakage frequency will increase in high order processing steps in a stocking production process (covering yarn production step and stocking knitting step) and in a woven fabric production process (warping step and weaving step), leading to deterioration in high order process passage capability. Furthermore, the resulting stockings and woven fabrics will suffer frequent breakage in high order processing steps, leading to a decrease in high order process passage capability and deterioration in product quality.

For the ultrafine, high strength polyamide multifilament according to the present invention, the total fineness, single fiber fineness, strength-elongation product, and elongation degree should all be in the ranges specified above. Specifically, as the total fineness and single fiber fineness are reduced, durability will deteriorate although it is possible to ensure softness, transparent appearance, and lightweightness. On the other hand, durability is in proportion to the total fineness and single fiber fineness, and therefore, the strength-elongation product has to be increased in order to ensure high softness, transparent appearance, lightweightness, and durability. In addition, an appropriate level of elongation degree is necessary to maintain required high order process passage capability and product quality. Thus, as a result of intensive studies, the inventors identified suitable ranges in which the total fineness, single fiber fineness, high strength-elongation product, and elongation degree should all stay to provide stockings having high order process passage capability and product quality as well as excellent softness, durability, and transparent appearance and woven fabrics having excellent softness, durability, and lightweightness.

It is preferable for the ultrafine, high strength polyamide multifilament according to the present invention to have a yarn unevenness (U%) of 1.2 or less. If the value of U% is 1.2 or less, deep dyeing of thick portions of yarns will not occur when dyeing stockings and woven fabrics, thus ensuring good appearance and good product quality free of generation of streaks. It is more preferably 1.0 or less for production of stockings and 0.8 or less for production of woven fabrics. The value of U% should be as small as possible, but for the present invention, its lower limit is about 0.4.

It is preferable for the ultrafine, high strength polyamide multifilament according to the present invention to have a sulfuric acid relative viscosity of 2.5 to 3.5. It is more preferably 3.1 to 3.5. If the sulfuric acid relative viscosity is 2.5 to 3.5, it enables the production of stockings and woven fabrics having a durability at practical level. Good product quality can also be ensured.

There are no specific limitations on the cross-sectional shape of the ultrafine, high strength polyamide multifilament according to the present invention and it may have, for example, a circular cross section, flattened cross section, lens shape cross section, trilobite cross section, multilobar cross section, irregular cross section containing 3 to 8 convex portions and the same number of concave portions, hollow cross section, or other generally known irregular cross section.

Described below is the production method for the ultrafine, high strength polyamide multifilament according to the present invention.

The ultrafine, high strength polyamide multifilament according to the present invention can be produced by using a generally known melt-spinning apparatus. In a typical generally known melt-spinning process, polyamide material is melted, weighed and transported by a gear pump, and discharged from a spinneret to produce fibers, which are then cooled to room temperature by applying cooling air from a cooling apparatus such as chimney, bundled while supplying oil from an oil feeding apparatus, interlaced by a fluid interlacing nozzle apparatus, and transported on a take-up roller and a stretching roller where the yarn is stretched as a result of the difference in circumferential speed between the take-up roller and the stretching roller. Subsequently, the yarn is heat-treated by the heat of the stretching roller and wound up by a winder (winding-up apparatus) to provide a polyamide multifilament.

The ultrafine, high strength polyamide multifilament according to the present invention can be spun by adjusting the sulfuric acid relative viscosity of the polyamide polymer used for melt-spinning to 2.5 to 3.5, controlling the melting temperature in the melt-spinning step at a temperature higher by 20°C or more and 85°C or less than the melting point of the polyamide, controlling the steam seal heater temperature at 200°C or more to maintain a high atmospheric temperature below the spinneret, subjected to cooling that starts at a point 70 to 150 mm below the discharge holes under the spinneret to ensure slow cooling of the polyamide polymer, and taken up at a take-up roller speed of 1,300...
to 2,000 m/min, a draw ratio of 1.7 to 3.0, and wind-up speed of 3,000 m/min or more and 4,500 m/min or less.

[0027] The adoption of the direct spinning and stretching technique performed under such conditions enables the production of an ultrafine, high strength polyamide multifilament with a strength-elongation product of 9.1 or more and an elongation degree of 40% to 50%. In addition, adjusting the sulfuric acid relative viscosity to 2.5 to 3.5 makes it possible to obtain a polyamide polymer having a larger strength-elongation product.

[0028] Furthermore, controlling the take-up roller in a low speed region (1,300 to 1,800 m/min) while controlling the wind-up speed in a high speed region (3,500 to 4,000 m/min) was found to serve to depress uneven drafting and achieve uniform yarn cooling, resulting in a small U% value of 1.2 or less.

[0029] It is preferable to perform heat treatment by using the stretching roller as heating roller, and the heat treatment temperature is preferably 120°C to 180°C. This heat treatment is adopted because it enables the designing of heat shrinkage of the multifilament.

[0030] The rollers such as take-up roller and stretching roller may be selected from Nelson roller, drive roller provided with follower type separate roller, and single end support type roller.

[0031] The ultrafine, high strength polyamide multifilament according to the present invention is used as clad yarns for covering yarns. Such covering yarns may be a single covering yarn consisting of an elastic yarn as core covered with a single layer of clad yarns or a double covering yarn covered with two layers of clad yarns.

[0032] The material of the elastic yarn may be any one of various fibers including polyurethane based elastic fiber, polyamide based elastomer elastic fiber, polyester based elastomer elastic fiber, natural rubber based fiber, synthetic rubber based fiber, and butadiene based fiber, of which an appropriate one may be selected taking into consideration the elastic characteristics, heat-setting property, durability, etc. Particularly preferable are polyurethane based elastic fiber and polyamide based elastomer elastic fiber.

[0033] The thickness of the elastic yarn depends on the type of stockings and tightening pressure settings, but it is generally in the range of about 8 to 40 dtex to ensure a required durability, transparent appearance, and softness simultaneously. In particular, it is preferably 14 to 25 dtex. If it is less than 8 dtex, the yarn strength will not be sufficiently high and troubles such as core yarn breakage will occur frequently in the covering and knitting steps, easily leading to low stretchability and durability that are insufficient for stockings. If it is more than 40 dtex, on the other hand, the tightening force will be too large and the texture will be coarse, leading not only to a decrease in softness, but also deterioration in transparent appearance.

[0034] An appropriate covering twist count may be identified taking into consideration the fineness of the clad yarn, shrinkage rate, product texture, transparent appearance, and durability. If the covering twist count is large, the apparent thickness will decrease and the transparent appearance will improve, whereas if it is too high, the elastic yarn will be tightened too strongly, easily leading to a decrease in durability or a decrease in productivity in the covering step. If the covering twist count is too small, furthermore, the cladding property will decrease, easily leading to deterioration in durability, transparent appearance, and softness. Accordingly, when a clad yarn of 6 dtex is used as single covering yarn, for example, it is preferably designed in the range of 2,000 to 2,600 T/m as standard. In the case of a double covering yarn, furthermore, the standard range is generally 0.7 to 0.95 times the lower twist count. With respect to the twist direction, the lower twist and the upper twist may be either in the same direction or the opposite direction, but covering in the opposite direction is preferable to depress the torque. With respect to the draft ratio, an appropriate value may be adopted taking into account the intended pressure and it may be preferable, for example, to set it to 2.5 to 3.5 times.

[0035] A covering yarn can be produced by using an ordinary covering processing method. For example, processing may be performed as described in "Senti No Hyakkajiten (Encyclopedia of Fiber)" (Maruzen Inc., published Mar. 25, 2002, p. 439). In a typical process, an elastic yarn is pulled out at a constant rate, and while it is drafted at an appropriate ratio between two rollers, a clad yarn wound off from an H bobbin is wound on the elastic yarn at a constant covering twist count, followed by taking up the resulting covering yarn into a cheese.

[0036] The ultrafine, high strength polyamide multifilament according to the present invention is used to produce stockings partly formed of the covering yarn described above. In particular, it is favorably used in the leg part of stockings for making the most of its transparent appearance, bare leg-like appearance, and shadow effect. Here, the "stockings" include such stocking products as pantyhose, long stockings, and short stockings, and in the case of pantyhose, for example, the leg part refers to the portion between the garter part and the toes.

[0037] When stockings are produced by knitting, there are no specific limitations on the machine to be adopted and a common hosiery machine may be operated by a common knitting method that uses a two-feeder type or four-feeder type knitting machine to feed and knit a covering yarn according to the present invention. When using a single covering yarn, it is favorable to arrange an S-direction covering type single covering yarn and a Z-direction covering type single covering yarn alternately. Others include interknitting of a single covering yarn and a gray yarn, interknitting of a double covering yarn and a gray yarn, and Zokki knitting of a double covering yarn. A knitting machine with about 360 to 474 needles is generally used. The transparency increases though the durability decreases with a decreasing number of needles whereas the durability increases though the transparency decreases with an increasing number of needles. Therefore, an appropriate number can be adopted taking into consideration the clad yarn to be used and the fineness...
of the elastic yarn as well as the intended durability, transparent appearance, and softness. In typical cases, it is preferable to use a clad yarn of 6 dtex and a machine with 400 to 440 needles.

[0038] After the knitting, the subsequent steps for dyeing, post-processing, and final setting can be performed by generally known methods. Dyeing may be performed with an acidic dye or a reactive dye and, needless to say, there are no specific limitations on colors.

[0039] The ultrafine, high strength polyamide multifilament according to the present invention may be used as warp and/or weft for woven fabric production. To produce them, generally known weaving methods can be used. In a typical process, multifilament yarns for warp are warped by arranging them on a creel and wound on a beam, and the multifilament yarns around the beam are starched and dried to prepare warp. Then, the warp yarns are passed through the reed in the weaving machine and weft multifilament yarns are threaded to form a woven fabric. Various weaving machines are available including shuttle weaving machine, air jet loom weaving machine, water jet loom weaving machine, rapier weaving machine, and gripper-shuttle weaving machine and any weaving machine thereof can be used for manufacturing. In addition, some different weaves are available including plain weave, twill weave, and satin weave, of which an appropriate one may be adopted to suite particular objectives.

[0040] Then, dyeing is performed by a generally known dyeing method. In general, refining, intermediate setting, dyeing, and finish setting are performed to provide a final product. Available dyeing machines include the jet dyeing machine, jigger dyeing machine, beam dyeing machine, and wince dyeing machine, of which any dyeing machine may be used for dyeing. Dyeing may be performed with an acidic dye or a metal complex dye that is generally used for polyamide fiber and it is implemented at a temperature of 90°C or more for about 30 to 90 minutes. When a deep color dye is used, the woven fabric may be subjected to fixing treatment with a synthetic tannin, tannin/tartar emetic to prevent color loss.

[0041] The dyeing step may be followed by functional processing to impart additional functions. When used as base cloth for down jackets, for example, additional functions may be imparted by calendaring and water repellent treatment. Calendering may be performed either on one side or on both sides at any stage in the dyeing processing step, though it is preferably performed after the dyeing processing. For water repellent treatment, resin processing etc. is performed by padding, coating, dust attraction, lamination, etc., using a water repellent agent of paraffin based, fluorine resin based, or silicone based resin etc.

[0042] Being thin, lightweight, and moderate in air permeability, the thin, lightweight fabrics produced from the ultrafine, high strength polyamide multifilament according to the present invention can be widely useful in the field of sports clothing such as wind breakers and down jackets, and when used in wind breakers, for example, they will be comfortable because of being thin and lightweight and having sufficient strength and moderate air permeability.

Examples

[0043] The present invention is described in more detail below with reference to Examples.

A. Strength, elongation degree, and strength-elongation product

[0044] Measurements were taken from fiber specimens subjected to the tensile strength and degree of elongation tests specified in JIS L 1013-2010. With respect to the test conditions, a constant traverse rate type testing machine was used with a clamp interval of 50 cm and a tension speed of 50 cm/min. In the case where the strength at the time of breakage was smaller than the maximum strength, the maximum strength and the elongation at that moment were adopted.

[0045] The strength, elongation degree, and strength-elongation product were determined by the equations given below.

\[
\text{strength} = \frac{\text{strength at break (cN)}}{\text{fineness (dtex)}}
\]

\[
\text{elongation degree} = \frac{\text{elongation at break (cm) or elongation at maximum load (cm)}}{\text{clamp interval (cm)} \times 100}
\]

\[
\text{strength-elongation product} = \left\{\frac{\text{strength (cN/dtex)}}{\text{elongation degree (\%) + 100}}\right\} / 100
\]
B. Fineness

[0046] A fiber specimen was set on a sizing reel with a circumference of 1.125 m and rotated 500 times to prepare a loop like hank, and then the hank was dried in a hot air drier (105°C for 60 minutes) and weighed in a balance, followed by multiplying the weight by an official moisture regain and calculating the fineness from it. The official moisture regain was assumed to be 4.5%.

C. Sulfuric acid relative viscosity ($\eta$)

[0047] First, 0.25 g of a polyamide chip specimen or a fiber specimen was dissolved in sulfuric acid with a concentration of 98 mass% in such a manner that it would account for 1 g in 100 ml, and the efflux time (T1) through an Ostwald type viscometer was measured at 25°C. Subsequently, the efflux time (T2) of the sulfuric acid with a concentration of 98 mass% alone was measured. The ratio of T1 to T2, i.e., T1/T2, was adopted as sulfuric acid relative viscosity.

D. Yarn unevenness (U%)

[0048] Using a USTER TESTER IV tester manufactured by Zellweger Uster, measurements were taken from fiber specimens under the conditions of a specimen length of 500 m, yarn measuring speed V of 100 m/min, twister type S at 30,000/min, and 1/2 Inert.

E. Evaluation of leg part of stocking product

(a) Softness

[0049] A stocking product was put on a human leg form and its relative softness was evaluated by (five) testers experienced in texture evaluation. The ratings given by the testers were averaged and products having average ratings of 4 to 5, 3 to 4, 2 to 3, and 1 to 2 were ranked as S, A, B, and C, respectively.

Rating 5: very good
Rating 4: slightly good
Rating 3: fair
Rating 2: slightly inferior
Rating 1: inferior

Products ranked as S or A were judged to be acceptable in terms of softness.

(b) Durability

[0050] A stocking product was put on a human leg form normally "outside out" in such a manner that the garter part came to a position 60 cm from the heel toward the thigh. A circular mark that suited the size of the measuring frame was made on the back side of the thigh of the leg form, centering on a position 52.5 cm from the heel toward the thigh. When fixing a product to the measuring frame, the use of the circular mark for positioning of the product allows simulation of being worn by a human in determining the bursting strength, which was assumed to represent the durability.

[0051] The bursting strength of stocking products was measured according to the Muhlen Type Bursting Strength Testing Method (Method A) specified in JIS L 1096 (2010). Based on the measured bursting strength (average of three measurements), evaluation was performed according to the following four stage criterion:

S: 1.2 kg/cm² or more,
A: 1.0 kg/cm² or more and less than 1.2 kg/cm²,
B: 0.9 kg/cm² or more and less than 1.0 kg/cm²,
C: less than 0.9 kg/cm².

[0052] Products ranked as S or A were judged to be acceptable in terms of durability.

(c) Transparent appearance

[0053] A stocking product was put on a human leg form normally "outside out" in such a manner that the toe-side boundary of the garter part came to a position 60 cm from the heel toward the thigh. An embroidery frame (outside diameter of frame 15 cm, thickness of frame 1 cm) was used to fix the product so that the state of being worn would be
fixed in that portion. Specifically, to fix the state of being worn, the inner member of the embroidery frame was attached in such a manner that the top and bottom of the embroidery frame would be located at positions 60 and 45 cm from the heel, followed by attaching the outer member. The product fixed on the embroidery frame was removed from the leg form and placed in such a manner that the outer surface of the product faced the measuring apparatus and that the center of the embroidery frame came to the measuring position. A white color standard plate (L value 88.29) was put on top of the product (i.e., on the inner surface of the product), followed by measuring the L value (Lw) of the knitted fabric with a color difference meter (SM-T, manufactured by Suga Test Instruments Co., Ltd.), and then a black color standard plate (L value 7.74) was put on it, followed by measuring the L value (Lb) of the knitted fabric. The degree of transparency was calculated from the L values (Lw, Lb) by the following equation. A higher resulting value means better transparent appearance.

\[
\text{Degree of transparency} = \frac{\text{Lw} - \text{Lb}}{\text{W} - \text{B}}
\]

(Here, W is the L value of the white color standard plate, and B is the L value of the black color standard plate.)

The degree of transparency was measured three times, and based on the average, evaluation was performed according to the following four stage criterion.

S: 70% or more,
A: 65% or more and less than 70%,
B: 60% or more and less than 65%,
C: less than 60%.

Products ranked as S or A were judged to be acceptable in terms of transparent appearance.

(d) Appearance quality

The degree of uneven dyeing of a stocking product was evaluated based on relative ratings made by (five) testers. The ratings given by the testers were averaged and products having average ratings of 4 to 5, 3 to 4, 2 to 3, and 1 to 2 were ranked as S, A, B, and C, respectively.

Rating 5: very good
Rating 4: slightly good
Rating 3: fair
Rating 2: slightly inferior
Rating 1: inferior

Products ranked as S or A were judged to be acceptable in terms of appearance quality.

(e) Process passage capability

Stockings were knitted by a hosiery knitting machine continuously for one hour at a rotating speed of 400 rpm and evaluation was performed according to the following criterion based on the number of times of yarn breakage that occurred during the knitting operation.

S: less than 2 times of yarn breakage,
A: 2 or more times and less than 4 times of yarn breakage,
B: 4 or more times and less than 6 times of yarn breakage,
C: 6 or more times of yarn breakage.

Products ranked as S or A were judged to be acceptable in terms of process passage capability.

F. Evaluation of woven fabric products

(a) Softness

The relative bending softness of woven fabric products was evaluated by (five) testers experienced in texture
evaluation. The ratings given by the testers were averaged and products having average ratings of 4 to 5, 3 to 4, 2 to 3, and 1 to 2 were ranked as S, A, B, and C, respectively.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
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<tbody>
<tr>
<td>5</td>
<td>very good</td>
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<tr>
<td>4</td>
<td>slightly good</td>
</tr>
<tr>
<td>3</td>
<td>fair</td>
</tr>
<tr>
<td>2</td>
<td>slightly inferior</td>
</tr>
<tr>
<td>1</td>
<td>inferior</td>
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[0062] Products ranked as S or A were judged to be acceptable in terms of softness.

(b) Durability

[0063] Tear strength was measured to represent the durability. The tear strength of woven products was measured according to the Single Tongue Testing Method (Method A) specified in JIS L 1096 (2010). The tear strength in the warp direction was measured three times, and based on the average, evaluation was performed according to the following four stage criterion.

- S: 11.0 N or more,
- A: 10.0 N or more and less than 11.0 N,
- B: 9.0 N or more and less than 10.0 N,
- C: less than 9.0 N.

[0064] Products ranked as S or A were judged to be acceptable in terms of durability.

(c) Lightweightness

[0065] Mass per unit area was measured to represent the lightweightness. Mass per unit area of woven fabrics were determined as the mass per unit area in a standard state according to Method A specified in JIS L 1096 (2010). Three measurements were taken, and based on the average, evaluation was performed according to the following four stage criterion.

<table>
<thead>
<tr>
<th>Mass per unit area</th>
<th>Description</th>
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<tbody>
<tr>
<td>less than 19 g/m²</td>
<td>S</td>
</tr>
<tr>
<td>19 g/m² or more and less than 22 g/m²</td>
<td>A</td>
</tr>
<tr>
<td>22 g/m² or more and less than 25 g/m²</td>
<td>B</td>
</tr>
<tr>
<td>25 g/m² or more</td>
<td>C</td>
</tr>
</tbody>
</table>

[0066] Products ranked as S or A were judged to be acceptable in terms of lightweightness.

(d) Appearance quality

[0068] The degree of uneven dyeing of dyed woven fabrics was evaluated by (five) testers according to a four stage criterion. The ratings given by the testers were averaged and products having average ratings of 4 to 5, 3 to 4, 2 to 3, and 1 to 2 were ranked as S, A, B, and C, respectively.

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<tr>
<td>3</td>
<td>fair</td>
</tr>
<tr>
<td>2</td>
<td>slightly inferior</td>
</tr>
<tr>
<td>1</td>
<td>inferior</td>
</tr>
</tbody>
</table>

[0069] Products ranked as S or A were judged to be acceptable in terms of appearance quality.

(e) Process passage capability

[0070] Ten rolls (1,000 m/roll) of plain weave fabric were produced by a water jet loom weaving machine under the conditions of a weaving machine rotating speed of 750 rpm and a weft length of 1620 mm, and evaluation was performed
according to the following criterion based on the number of times of yarn breakage that occurred in the weaving machine.

- **S:** less than 2 times,
- **A:** 2 or more times and less than 4 times,
- **B:** 4 or more times and less than 6 times,
- **C:** 6 or more times.

[0071] Products ranked as S or A were judged to be acceptable in terms of process passage capability.

[Example 1]

(Production of polyamide multifilament)

[0072] As polyamide, chips of nylon 6 with a sulfuric acid relative viscosity ($\eta_r$) of 3.3 and a melting point of 225°C were dried by an ordinary method to a moisture content of 0.03 mass% or less. The resulting chips of nylon 6 were melted at a spinning temperature (melting temperature) of 285°C and discharged from a spinneret (discharge rate 11.673 g/min). The spinneret had 30 holes having a circular shape and a hole diameter of 0.15 to produce 6 threads/spinneret.

[0073] After being discharged from the spinneret, the threads were passed through cool air at 18°C in a cooling apparatus to achieve cooling to room temperature for solidification, bundled while receiving oil from an oil feed apparatus, entangled by a fluid entangling nozzle apparatus, stretched 2.1 times while travelling at a speed of 1,747 m/min on a take-up roller (first godet roll: 1 GD) and a stretching roller (second godet roll: 2GD) heated at 155°C, and wound up at a wind-up speed of 3,500 m/min to provide a 5.9-dtex, 5-filament nylon 6 multifilament.

[0074] Evaluation results of the resulting nylon 6 multifilament are given in Table 1.

(Production of stockings)

[0075] Using the resulting multifilament as clad yarn for covering yarn while using a 18-denier polyurethane elastic yarn (Mobilon K-L22T, manufactured by Nisshinbo Chemical Industries, Inc.) as core yarn, a double covering elastic yarn (DCY) was produced by carrying out double covering under the conditions of a draft ratio of 2.6, a lower twist count of 2,200 T/m (Z direction), and an upper twist count of 2,090 T/m (S direction).

[0076] The resulting DCY was fed to the feeder of a Super 4 knitting machine (number of needles 400) manufactured by Nagata Seiki Co., Ltd. to produce a leg part by knitting the DCY alone. Then, it was refined with a soaping agent (New Sunlex E, 2 g/L (manufactured by Nicca Chemical Co., Ltd.) at 60°C for 30 minutes, dyed in beige, a typical color of pantyhose, with an acidic half-milling dye (Telon Red A2R: 0.14% owf, Telon Yellow A2R: 0.16% owf, Telon Blue A2R: 0.12% owf (manufactured by DyStar)), an level dyeing agent (SeraGalN-FS; 0.5% owf (manufactured by DyStar)), and a pH sliding agent (ammonium sulfate; 4.0% owf) at 100°C for 60 minutes at a bath ratio of 1:50, subjected to fixing treatment at 90°C for 45 with a fixing agent (High Fix SW-A; 5% owf (manufactured by Dainippon Pharmaceuticals Co., Ltd.)), a scum removing agent (NWH201; 1% owf (manufactured by Senka Corporation)), and sodium carbonate, and subjected to final setting at 120°C for 30 seconds to provide a pantyhose product. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1.

[0077] The process passage capability for stocking production was found to be very high. The stockings also had good characteristics including very high softness, durability, transparent appearance, and appearance quality.

(Production of woven fabric)

[0078] First, 1,000 pieces of the resulting multifilament were warped and wound on a beam, and the threads on the beam were starched and dried to prepare warp. Then, after passing it through the reed in a water jet weaving machine, the resulting multifilament was threaded through weft to form a woven fabric. The resulting woven fabric was refined and heat-set at 180°C for 1 minute (intermediate setting). Subsequently, using a jet dyeing machine, the fabric was subjected to dyeing treatment with an acidic dye (Nylosan Blue-GFL 167%, manufactured by Sandoz, 1.0% owf) at 98°C for 60 minutes and fixation treatment with a synthetic tannin (Nylonfix 501 manufactured by Senka Corporation, 3 g/l) at 80°C for 20 minutes. Then, the back surface was subjected to calendaring at 190°C. Evaluation results of the resulting woven fabric are given in Table 1.

[0079] The process passage capability for woven fabric production was found to be very high. The woven fabric also had good characteristics including very high softness, lightweightness, and durability. It had good appearance quality though the U% value was slightly high.
Except for setting the 1GD speed to 1,503 m/min and the draw ratio to 2.4, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. The U% value improved when changing the conditions to decrease the 1GD speed and increase the draw ratio.

Using the resulting nylon 6 multifilament, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be very high. The stockings also had good characteristics including very high softness, durability, transparent appearance, and appearance quality.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be very high. The woven fabric also had good characteristics including very high softness, durability, lightweightness, and appearance quality.

Except for setting the 1GD speed to 1,386 m/min and the draw ratio to 2.6, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. The U% value and the strength-elongation product improved when changing the conditions to decrease the 1GD speed and increase the draw ratio.

Using the resulting nylon 6 multifilament, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be very high. The stockings also had good characteristics including very high softness, durability, transparent appearance, and appearance quality.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be very high. The woven fabric also had good characteristics including very high softness, durability, lightweightness, and appearance quality.

Except for setting the spinning temperature to 295°C, the 1GD speed to 1,577 m/min and the draw ratio to 2.3, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. The strength-elongation product and the U% value improved when changing the conditions to increase the spinning temperature for decreasing the yarn's thinning point to ensure more uniform cooling and, in addition, decrease the 1GD speed for increasing the draw ratio.

Using the resulting nylon 6 multifilament, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be very high. The stockings also had good characteristics including very high softness, durability, transparent appearance, and appearance quality.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be very high. The woven fabric also had good characteristics including very high softness, durability, lightweightness, and appearance quality.

Except for setting the discharge rate to 8.112 g/min, the same procedure as in Example 1 was carried out to produce a 4.1-dtex, 5-filament nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. Good results were obtained though the U% value slightly increased as a result of reducing the total fineness and the single fiber fineness.

Using the resulting nylon 6 multifilament, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be high. The stockings also had good characteristics including very high softness and transparent appearance. It had good appearance quality though the U% value was slightly high.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be high. The woven fabric also had good characteristics.
including very high softness and lightweightness. It had good appearance quality though the U% value was slightly high.

[Example 6]

[0092] Except for setting the discharge rate to 10.005 g/min, the 1 GD speed to 1,497 m/min, and the wind-up speed to 3,000 m/min, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. The U% value extremely improved when changing the conditions to decrease the 1 GD speed to control the uneven drafting between the spinneret and 1 GD while maintaining the same draw ratio as in Example 1.

[0093] Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be high. The stockings also had good characteristics including very high softness, transparent appearance, and appearance quality.

[0094] Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be high. The woven fabric also had good characteristics including very high softness, lightweightness, and appearance quality.

[Example 7]

[0095] Except for setting the discharge rate to 13.341 g/min, the 1 GD speed to 2,000 m/min, and the wind-up speed to 4,000 m/min, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. Though the U% slightly increased, good results were obtained when changing the conditions to increase the 1 GD speed to control the uneven drafting between the spinneret and 1 GD while maintaining the same draw ratio as in Example 1.

[0096] Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be very high. The stockings also had good characteristics including very high softness, durability, and transparent appearance. It had good appearance quality though the U% value was slightly high.

[0097] Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be very high. The woven fabric also had good characteristics including very high softness, durability, and lightweightness. It had good appearance quality though the U% value was slightly high.

[Example 8]

[0098] As polyamide, chips of nylon 6 with a sulfuric acid relative viscosity of 2.7 were dried by an ordinary method to a moisture content of 0.03 mass% or less. Except for melting the resulting nylon chips at a spinning temperature of 270°C and setting the discharge rate to 13.341 g/min, the 1 GD speed to 1,718 m/min, the draw ratio to 2.4, and the wind-up speed to 4,000 m/min, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1. The U% value improved when changing the conditions to increase the wind-up speed for decreasing the yarn’s thinning point to ensure more uniform cooling and, in addition, decrease the 1 GD speed for increasing the draw ratio. The U% value improved while maintaining a high strength-elongation product when using chips with a lower sulfuric acid relative viscosity than in Example 1 to depress the uneven drafting though it can work to reduce the strength-elongation product.

[0099] Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be high. The stockings also had good characteristics including very high softness, transparent appearance, and appearance quality.

[0100] Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be high. The woven fabric also had good characteristics including very high softness, lightweightness, and appearance quality.

[Example 9]

[0101] Except for using a spinneret with 36 holes having a circular shape and a hole diameter of 0.15 to produce 6
threads/spinneret, the same procedure as in Example 1 was carried out to provide a 5.9-dtex, 6-filament nylon 6 multi-filament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1.

[0102] Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be high. The stockings also had good characteristics including very high softness, transparent appearance, and appearance quality.

[0103] Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be high. The woven fabric also had good characteristics including very high softness and lightweightness. It had good appearance quality though the U% value was slightly high.

[Example 10]

[0104] As polyamide, chips of nylon 6 with a sulfuric acid relative viscosity of 2.7 were dried by an ordinary method to a moisture content of 0.03 mass% or less. Except for melting the resulting nylon chips at a spinning temperature of 270°C, the same procedure as in Example 1 was carried out to provide a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 1.

[0105] Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be high. The stockings also had good characteristics including very high softness, transparent appearance, and appearance quality.

[0106] Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be high. The woven fabric also had good characteristics including very high softness, lightweight, and appearance quality.

[Example 11]

[0107] As polyamide, chips of nylon 66 with a sulfuric acid relative viscosity of 2.8 were dried by an ordinary method to a moisture content of 0.03 mass% or less. Except for melting the resulting nylon 66 chips at a spinning temperature of 290°C, the same procedure as in Example 1 was carried out to provide a 5.9-dtex, 5-filament nylon 66 multifilament. Evaluation results of the resulting nylon 66 multifilament are given in Table 1.

[0108] Using the resulting nylon 66 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 1. The process passage capability for stocking production was found to be very high. The stockings also had good characteristics including very high softness, durability, transparent appearance, and appearance quality.

[0109] Using the resulting nylon 66 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 1. The process passage capability for woven fabric production was found to be very high. The woven fabric also had good characteristics including very high softness, durability, lightweight, and appearance quality.

[Comparative Example 1]

[0110] Except for setting the 1GD speed to 1,263 m/min and the draw ratio to 2.8, the same procedure as in Example 1 was carried out to provide a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 2. The U% value improved, though the elongation degree decreased, when changing the conditions to decrease the 1 GD speed and increase the draw ratio.

[0111] Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 2. Yarn breakage occurred frequently during stocking production, resulting in a largely inferior process passage capability. Evaluation of stocking characteristics showed a very high durability, transparent appearance, and appearance quality, but the product was slightly inferior in softness due to a slightly stiff texture.

[0112] Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 2. Yarn breakage occurred frequently during woven fabric production, resulting in a largely inferior process passage capability. Evaluation of woven fabric characteristics showed a very high durability, lightweight, and appearance quality, but the product was slightly inferior in softness due to a slightly stiff texture.
Except for setting the 1 GD speed to 2,293 m/min and the draw ratio to 1.6, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 2. Changing the conditions to increase the 1 GD speed and decrease the draw ratio resulted in a large elongation degree, a small strength-elongation product, and a very large U% value.

Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 2. Yarn breakage occurred during stocking production, resulting in an inferior process passage capability. Evaluation of stocking characteristics showed a largely inferior durability and appearance quality in spite of a very high softness and transparent appearance.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 2. Yarn breakage occurred during woven fabric production, resulting in an inferior process passage capability. Evaluation of woven fabric characteristics showed a largely inferior durability and appearance quality in spite of a very high lightweightness.

Except for setting the discharge rate to 15.828 g/min, the 1 GD speed to 1,503 m/min, and the draw ratio to 2.4, the same procedure as in Example 1 was carried out to produce a 8.0-dtex, 5-filament nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 2.

Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 2. The process passage capability for stocking production was found to be very high. However, as a result of an increase in the total fineness, evaluation of stocking characteristics showed a largely inferior softness and transparent appearance in spite of a very high durability.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 2. The process passage capability for woven fabric production was found to be very high. However, as a result of an increase in the total fineness, evaluation of woven fabric characteristics showed a largely inferior durability and appearance quality in spite of a very high softness and lightweightness.

As polyamide, chips of nylon 6 with a sulfuric acid relative viscosity of 2.7 were dried by an ordinary method to a moisture content of 0.03 mass% or less. Except for melting the resulting nylon chips at a spinning temperature of 270°C and setting the 1 GD speed to 2,179 m/min and the draw ratio to 1.7, the same procedure as in Example 1 was carried out to produce a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 2. Changing the conditions to increase the 1 GD speed and decrease the draw ratio resulted in a small strength-elongation product and a very large U% value.

Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 2. Yarn breakage occurred during stocking production, resulting in an inferior process passage capability. Evaluation of stocking characteristics showed an inferior durability and appearance quality in spite of a very high softness and transparency.

Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 2. Yarn breakage occurred during woven fabric production, resulting in an inferior process passage capability. Evaluation of woven fabric characteristics showed an inferior durability and appearance quality in spite of a very high softness and lightweightness.

Except for using a spinneret with 24 holes having a circular shape and a hole diameter of 0.15 to produce 6 threads/spinneret and setting the 1 GD speed to 1,442 m/min and the draw ratio to 2.5, the same procedure as in Example 1 was carried out to provide a 5.9-dtex, 4-filament nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 2.

Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 2. The process passage capability for stocking production was found to be very high. However, as a result of an increase in the single fiber fineness, evaluation of stocking characteristics showed a largely inferior softness in spite of a very high durability, transparency, and appearance quality.
Using the resulting nylon 6 multifilament, a woven fabric was produced by carrying out weaving, dyeing treatment, and calendering as in Example 1. Evaluation results of the resulting woven fabric are given in Table 2. The process passage capability for woven fabric production was found to be very high. However, as a result of an increase in the single fiber fineness, evaluation of woven fabric characteristics showed a largely inferior softness in spite of a very high durability, lightweightness, and appearance quality.

[Comparative Example 6]

As polyamide, chips of nylon 6 with a sulfuric acid relative viscosity of 2.2 were dried by a normal method to a moisture content of 0.03 mass% or less. Except for melting the resulting nylon chips at a spinning temperature of 270°C, the same procedure as in Example 1 was carried out to provide a nylon 6 multifilament. Evaluation results of the resulting nylon 6 multifilament are given in Table 2. The use of nylon 6 chips with a low sulfuric acid relative viscosity resulted in a small strength-elongation product.

Using the resulting nylon 6 multifilament, furthermore, stockings were produced as in Example 1. Evaluation results of the leg part of the resulting pantyhose product are given in Table 2. Yarn breakage occurred during stocking production, resulting in an inferior process passage capability. Evaluation of stocking characteristics showed a largely inferior durability in spite of a very high softness, transparency, and appearance quality.

[Comparative Example 7]

Except for setting the discharge rate to 6.925 g/min, the same procedure as in Example 1 was carried out in an attempt to produce a 3.5-dtex, 5-filament nylon 6 multifilament, but yarn breakage occurred frequently to make spinning difficult, failing to obtain an intended multifilament.

[Table 1]
<table>
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<tr>
<th></th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
<th>Example 4</th>
<th>Example 5</th>
<th>Example 6</th>
<th>Example 7</th>
<th>Example 8</th>
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[Table 2]
### Table 2

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(continued)
Claims

1. An ultrafine, high strength polyamide multifilament having a total fineness of 4.0 dtex to 6.0 dtex, a single fiber fineness of 1.2 dtex or less, a strength-elongation product of 9.1 or more, and an elongation degree of 40% to 50%.

2. An ultrafine, high strength polyamide multifilament as set forth in claim 1 further having a yarn unevenness (U%) of 1.2 or less.

3. An ultrafine, high strength polyamide multifilament as set forth in either claim 1 or 2 further having a sulfuric acid relative viscosity of 2.5 to 3.5.

4. A covering yarn produced by cladding an ultrafine, high strength polyamide multifilament as set forth in any one of claims 1 to 3.

5. Stockings partly comprising a covering yarn produced by cladding an ultrafine, high strength polyamide multifilament as set forth in claim 4.

6. A woven fabric comprising an ultrafine, high strength polyamide multifilament as set forth in any one of claims 1 to 3 used as warp and/or weft.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
D01F6/60(2006.01)i, A41B11/00(2006.01)i, A41B11/14(2006.01)i, D02G3/36 (2006.01)i, D03D15/00(2006.01)i

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)
A41B11/00-11/14, D01F1/00-6/96, D01F9/00-9/04, D02G1/00-3/48, D02J1/00-13/00, D03D1/00-27/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 01 February 2016 (01.02.16)
Date of mailing of the international search report: 09 February 2016 (09.02.16)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer
Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

• JP HEI10212601 B [0006]
• JP HEI11279884 B [0006]

Non-patent literature cited in the description