



(11) **EP 3 786 348 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
03.03.2021 Bulletin 2021/09

(21) Application number: **19792622.3**

(22) Date of filing: **19.04.2019**

(51) Int Cl.:
D06M 13/02 ^(2006.01) **D01F 6/60** ^(2006.01)
D06M 13/224 ^(2006.01) **D06M 101/34** ^(2006.01)

(86) International application number:
PCT/JP2019/016728

(87) International publication number:
WO 2019/208404 (31.10.2019 Gazette 2019/44)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **25.04.2018 JP 2018084176**

(71) Applicant: **Toray Industries, Inc.**
Tokyo, 103-8666 (JP)

(72) Inventors:
• **SATO, Kirita**
Mishima-shi, Shizuoka 411-8652 (JP)
• **YAMAGUCHI, Sumio**
Nagoya-shi, Aichi 451-8666 (JP)

(74) Representative: **Kador & Partner PartG mbB**
Corneliusstraße 15
80469 München (DE)

(54) **POLYAMIDE MONOFILAMENT**

(57) Provided is a polyamide monofilament which prevents thread shedding in a weaving process and provides excellent weaving properties and fabric quality. This polyamide filament is characterized in that the amount of oil deposition is 0.1-1.5% by weight, and com-

ponents comprising hydrocarbons and fatty acid alkyl esters having a weight average molecular weight of 500 or less in the deposited oil account for 40% by weight or less of the total components of the oil.

EP 3 786 348 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a polyamide monofilament that gives a fabric having excellent quality and requiring high precision, such as a mesh fabric and a filter without yarn cast-off or loom stop and with good weaving properties.

BACKGROUND ART

[0002] Polyamide fibers represented by polycapramide and polyhexamethylene adipamide are widely used in applications such as clothing and industrial materials because of their excellent mechanical properties, chemical resistance, and heat resistance. In the application to the industrial materials, in particular, the application to the filter made of a monofilament fabric (a screen gauze fabric) is widely developed, and the filter has a wide range of applications such as a medical treatment, filtration of drinking water, a bag filter for an automobile, and acoustics.

[0003] In recent years, since high filter performance is required in various applications, weight reduction, thinning, and densification of the screen gauze fabric are advanced, and demands for fabric quality also increase. The fabric quality deteriorates due to defects such as a tight pick and a vertical line, and examples of causes of these defects include a thickness unevenness of the monofilament yarn, a deposited unevenness of an oil on the yarn surface, an unevenness of shrinkage due to heat, and an unevenness of tension when the yarn is unwound. Many techniques are proposed to improve the quality of these monofilaments.

[0004] For example, Patent Document 1 proposes a production method in which a pair of oil supply guides sandwiches the monofilament yarn and is arranged with a phase shifted in a running direction to uniformly supply an oil in a circumferential direction of the yarn, stabilizes deposition of the oil in a longitudinal direction of the yarn, and provides the monofilament having stable quality.

[0005] Patent Document 2 proposes, in a drum-shaped package formed of a polyamide monofilament, a package of the polyamide monofilament yarn in which the yarn-to-yarn dynamic friction coefficient and the drum winding width are defined, thus there is no yarn drop on an end surface of a drum, and an instantaneous tension fluctuation is suppressed when the yarn is unwound to suppress an occurrence of the tight pick.

[0006] Patent Document 3 proposes a polyamide monofilament and a fiber package of the polyamide monofilament in which tension of a yarn when the yarn passes through a yarn guide during warping is low and the generation of static electricity is suppressed by defining rubbing tension of the monofilament and the amount of static electricity generated.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0007]

Patent Document 1: Japanese Patent Laid-open Publication No. 2008-57085

Patent Document 2: Japanese Patent Laid-open Publication No. 2012-222112

Patent Document 3: International Publication No. 2016-052287

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0008] However, the number of insertions of a weft yarn in a weaving process increases with weight reduction, thinning and densification of the screen gauze fabric. A screen gauze fabric is woven mainly by a projectile loom, and as for the monofilaments described in Patent Documents 1, 2, and 3, as the number of insertions of the weft yarn increases, there is a problem that the yarn comes off a cap of the projectile, the loom stops, and the relevant part becomes a defect when the weft yarn is inserted.

[0009] Therefore, the present invention is intended to solve the above problem, and an object of the present invention is to provide a polyamide monofilament that suppresses the yarn cast-off in the weaving process and can provide excellent weaving properties and fabric quality.

SOLUTIONS TO THE PROBLEM

[0010] The above problem can be solved by the following configuration.

(1) A polyamide monofilament containing a deposited oil, an amount of the deposited oil being 0.1 to 1.5% by weight, the deposited oil containing a component containing a hydrocarbon having a weight average molecular weight of 500 or less and a fatty acid alkyl ester having a weight average molecular weight of 500 or less, a rate of the component being 40% by weight or less based on a total weight of the deposited oil.

(2) The polyamide monofilament according to (1), wherein a fluctuation rate of the amount of the deposited oil in a longitudinal direction of a yarn is 20% or less.

EFFECTS OF THE INVENTION

[0011] According to the present invention, it is possible to provide a polyamide monofilament that suppresses yarn cast-off in a weaving process and can provide excellent weaving properties and fabric quality.

BRIEF DESCRIPTION OF THE DRAWING

[0012] Fig. 1 is a schematic view showing an example of a process for producing a polyamide monofilament according to the present invention.

EMBODIMENTS OF THE INVENTION

[0013] Hereinafter, a polyamide monofilament of the present invention is described in detail.

[0014] A polyamide used in the polyamide monofilament of the present invention is a so-called high molecular weight product in which a hydrocarbon group is linked to a main chain by an amide bond, and may be produced by a polycondensation reaction using an aminocarboxylic acid and a cyclic amide as raw materials, or may be produced by a polycondensation reaction using a dicarboxylic acid and a diamine as raw materials. Hereinafter, these raw materials are collectively referred to as a monomer. Examples of the monomer include petroleum-derived monomers, biomass-derived monomers, and mixtures of the petroleum-derived monomers and the biomass-derived monomers, and are not limited to these. Such a polyamide is not particularly limited, and examples of the polyamide include polycaprolactam, polyundecanolactam, polylauryllactam, polyhexamethylene adipamide, polyhexamethylene sebacamide, and polyhexamethylene dodecanediamide. Among these, polyhexamethylene adipamide is preferable because of excellent spinnability and mechanical properties.

[0015] The polyamide of the present invention may be copolymerized or mixed with a second component and a third component in addition to a main component within a range in which the object of the present invention is not impaired. Examples of a copolymerization component can include a structural unit derived from an aliphatic dicarboxylic acid, an alicyclic dicarboxylic acid, an aromatic dicarboxylic acid, an aliphatic diamine, an alicyclic diamine, and an aromatic diamine, and the amount of the copolymerization is preferably 10 mol% or less, more preferably 5 mol% or less, as the amount of monomers of the copolymerization component to the total amount of monomers.

[0016] The viscosity of the polyamide in the present invention may be selected within a common range for producing an industrial fiber, and it is preferable to use a polymer having a 98% sulfuric acid relative viscosity of 2.0 or more and 4.0 or less. It is preferable that the polyamide has a 98% sulfuric acid relative viscosity of 2.0 or more because sufficient strength can be obtained when the polyamide is used as a fiber, and it is preferable that the polyamide has a 98% sulfuric acid relative viscosity of 4.0 or less because the extrusion pressure of the molten polymer at the time of spinning and the increase rate with time can be suppressed, an excessive load on production equipment can be reduced, a replacement cycle of a die can be extended, and productivity can be ensured. When a woven fabric is produced by using the fiber obtained by controlling in such a range, it is possible to obtain a woven fabric in which the product strength of the woven fabric, for example, tear strength is strength sufficient for practical use.

[0017] As long as the amount and the kind are within a range in which the object of the present invention is not impaired, an additive for improving productivity such as heat resistance may be blended, and an additive having functions such as matting, moisture absorption, antimicrobe, ultraviolet shielding, and heat retention may be blended. The content of these additives is preferably 1.0% by weight or less to the polyamide from the viewpoint of physical properties of the monofilament.

[0018] A spinning oil used in the polyamide monofilament of the present invention mainly contains a solvent, a smoothing component, and an antistatic component.

[0019] The solvent is used to dissolve and disperse active components such as the smoothing component and the antistatic component in the spinning oil, and the solvent volatilizes from a yarn surface by heat treatment of the yarn in

a process for producing the yarn. Since the amount of the active components per the oil component on the yarn surface increases as the solvent volatilizes, it is preferable to use a solvent that easily volatilizes.

[0020] The antistatic component is used to suppress static electricity generated on the yarn surface, and known ionic surfactants such as anionic surfactants, cationic surfactants and amphoteric surfactants are used.

[0021] The smoothing component is used to improve lubricating ability of the yarn surface, and to suppress a tension fluctuation and yarn breakage and stabilize process passability when the yarn is unwound, when the yarn passes through a yarn guide, and when the yarn passes between warps in a weaving process. In general, as the smoothing component, an ester-based component, a hydrocarbon-based component, an ether ester-based component, an ether nonionic surface active agent having a polyoxyalkylene group in the molecule, a polyhydric alcohol partial ester type nonionic surface active agent, and a polyoxyalkylene polyhydric alcohol fatty acid ester type nonionic surface active agent are used.

[0022] The screen gauze fabric is mainly woven by a projectile loom, and the projectile loom inserts a weft yarn by striking a metal part called a projectile that holds a yarn with a polyurethane resin cap. In the present invention, as a result of examining factors that cause the weft yarn to come off the cap of the projectile when the weft yarn is inserted during weaving, it was found that a specific component in the oil deposited on the yarn surface penetrates into the projectile cap, and deformation of the projectile cap due to the penetration of the specific component causes a holding force of the yarn to decrease.

[0023] The specific component is a component containing a hydrocarbon and a fatty acid alkyl ester in the oil, and the penetration tends to occur when the weight average molecular weight of the component is 500 or less. That is, since the hydrocarbon and the fatty acid alkyl ester have few polar groups in the molecule and have a high affinity with a polyurethane similarly having few polar groups in the molecule, these components easily penetrate into the projectile cap made of a polyurethane. When these components penetrate into the projectile cap, these components enter between polyurethane molecular chains forming the projectile cap and spread the molecular chains to cause deformation of the projectile cap. Moreover, the structure of the polyurethane molecular chain is changed to cause embrittlement of the projectile cap, and thus it is presumed that the holding area between the yarn and the projectile cap decreases, friction between the yarn and the cap decreases, the yarn slips on the cap, the holding force decreases, and the yarn cast-off occurs.

[0024] Therefore, in the present invention, in order to provide stable process passability and to prevent the yarn from coming off the cap of the projectile when the weft yarn is inserted in the weaving process, it was found that it is important to control the rate of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the oil deposited on the yarn based on the total weight of the deposited oil.

[0025] The polyamide monofilament of the present invention contains a deposited oil, the deposited oil contains a component containing a hydrocarbon having a weight average molecular weight of 500 or less and a fatty acid alkyl ester having a weight average molecular weight of 500 or less, and the rate of the component is 40% by weight or less based on the total weight of the deposited oil. Since it is difficult for the component to penetrate into the above-mentioned projectile cap by controlling the rate in such a range, the deformation of the cap can be suppressed, and the yarn cast-off during weaving can be suppressed. Since the number of times the loom stops is reduced by suppressing the yarn cast-off, productivity is improved. Furthermore, fabric defects such as a line and a tight pick can be reduced, and a fabric having excellent quality can be obtained by suppressing the yarn cast-off and reducing the number of times the loom stops. The rate of the component is more preferably 30% by weight or less. When the rate of the component exceeds 40% by weight, the penetration of the component into the projectile cap occurs during weaving, the yarn cast-off from the projectile occurs as described above, and the fabric defects increase. The component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the oil also functions as the smoothing component for imparting smoothness to the yarn, and the smoothing component exists on the yarn surface in a film or other shape to bring about a smoothing effect such as reducing the friction of the yarn. In general, as the weight average molecular weight of the smoothing component increases, a film forming ability is improved and the smoothing component tends to remain on the yarn surface. Since the friction occurs due to the viscous resistance of the smoothing component itself, as the weight average molecular weight of the smoothing component increases, the smoothness tends to decrease due to viscous resistance. On the other hand, as the weight average molecular weight decreases, the decrease of the smoothness due to the viscous resistance does not occur, but the smoothing component tends not to remain on the yarn surface. From the above, since the weight average molecular weight of the smoothing component used is preferably from 200 to 500, the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the oil deposited on the yarn surface is preferably deposited in an amount of 5% by weight or more. When the amount of the component is 5% by weight or more, the smoothness of the yarn is sufficient, the running properties of the yarn on the loom are good, and there are not the tight pick and the line in the fabric.

[0026] As for the polyamide monofilament of the present invention, the amount of the deposited oil is 0.1 to 1.5% by

weight based on the weight of the yarn. When the amount of the deposited oil exceeds 1.5% by weight, the process passability deteriorates such that an oil drop occurs due to excessive deposition of the oil when the yarn passes through the yarn guide in the weaving process, and yarn breakage occurs due to the oil drop. Furthermore, when the amount of the deposited oil is less than 0.1% by weight, the yarn surface is scraped when the yarn passes through the yarn guide in the weaving process due to lack of the oil component on the yarn surface, and a monomer-like precipitate (generally called a scum) occurs. When the scum accumulates on the guide, yarn breakage occurs and the process passability deteriorates. Furthermore, since the tension of the running yarn fluctuates due to the accumulated scum, tight pick or a line occurs in the relevant part, or the scum is picked up by the yarn and enter the fabric, and then the relevant part turns into a defect. Therefore, the amount of the deposited oil is preferably 0.1 to 0.5% by weight based on the weight of the yarn.

[0027] As for the polyamide monofilament of the present invention, it is preferable that the fluctuation rate of the amount of the deposited oil in a longitudinal direction of the yarn is 20% or less. By controlling the fluctuation rate in such a range, the amount of the deposited oil does not increase locally in the longitudinal direction of the yarn, and since it is possible to suppress excessive deposition of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less due to local excess of the oil, the cap can be prevented from being deformed and the yarn cast-off during weaving can be suppressed. Since the number of times the loom stops is reduced by suppressing the yarn cast-off, productivity is improved. Furthermore, fabric defects such as a line and a tight pick can be reduced, and a fabric having excellent quality can be obtained by suppressing the yarn cast-off and reducing the number of times the loom stops. Besides, since there is no difference in the deposition of the oil in a longitudinal direction of a yarn, the tension fluctuation can be suppressed when the yarn is unwound. Furthermore, there is no occurrence of the scum due to the scrape of the yarn surface caused by insufficient deposition of the oil, and a woven fabric without defects can be obtained. More preferably, the fluctuation rate of the amount of the deposited oil is 15% or less.

[0028] In the present invention, the molecular structure of the deposited component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less is not limited except the molecular weight.

[0029] In the present invention, the hydrocarbon is used as a solvent in preparing the oil, in addition to being used as the above-mentioned smoothing component. As described above, it is important that the solvent of the oil is easy to volatilize in order to increase the amount of the active component per the oil component on the yarn surface, and since the solvent easily volatilizes, the hydrocarbon that penetrates into the projectile cap tends not to remain on the yarn surface. It is known that the ease of volatilization of the hydrocarbon correlates with the viscosity, that is, the lower the viscosity, the easier the volatilization. A known method for measuring the viscosity of the hydrocarbon is a method using a Saybolt Universal viscometer. The viscosity measured using the Saybolt Universal viscometer is expressed in the unit of Saybolt Universal second (SUS), and the smaller the SUS, the smaller the viscosity. The upper limit of the viscosity of the hydrocarbon used as the solvent of the spinning oil used in the polyamide monofilament of the present invention is not limited, but the viscosity is preferably 100 SUS or less from the above-mentioned viewpoint of ease of volatilization. The lower limit of the viscosity is also not limited, but the viscosity is preferably 30 SUS or more from the viewpoint of managing the spinning oil.

[0030] Examples of the fatty acid alkyl ester used in the present invention mainly include a polyhydric alcohol fatty acid ester, a polyhydric carboxylic acid aliphatic alcohol ester, and an ester compound having a structure in which an aliphatic monohydric alcohol and a fatty acid form an ester bond.

[0031] The polyhydric alcohol fatty acid ester is an ester made of an aliphatic dihydric alcohol having 2 to 6 carbon atoms or an aliphatic trihydric alcohol having 3 or 4 carbon atoms and an aliphatic monovalent carboxylic acid having 4 to 24 carbon atoms. The polyhydric alcohol fatty acid ester is also a compound having no polyoxyalkylene group in the molecule. The polyhydric carboxylic acid aliphatic alcohol ester is an ester made of an aliphatic divalent carboxylic acid having 2 to 6 carbon atoms and an aliphatic monohydric alcohol having 4 to 24 carbon atoms, and is also a compound having no polyoxyalkylene group in the molecule. The ester compound having a structure in which an aliphatic monohydric alcohol and a fatty acid form an ester bond is an ester of an aliphatic monovalent carboxylic acid having 4 to 24 carbon atoms and an aliphatic monohydric alcohol having 4 to 24 carbon atoms.

[0032] The alcohol and the fatty acid that constitute the fatty acid alkyl ester are as follows. Examples of the aliphatic dihydric alcohol having 2 to 6 carbon atoms include ethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, dipropylene glycol, tripropylene glycol, 1,2-butanediol, 1,3-butanediol, 1,4-butanediol, 2-methyl-1,3-propanediol, 1,5-pentanediol, and 1,6-hexanediol. Examples of the aliphatic trihydric alcohol having 3 or 4 carbon atoms include glycerin and trimethylolpropane.

[0033] The aliphatic monohydric alcohol having 4 to 24 carbon atoms may be saturated or unsaturated, and the number of unsaturated bonds is not particularly limited. One kind or two or more kinds of aliphatic monohydric alcohols may be used, and a saturated aliphatic alcohol and an unsaturated aliphatic alcohol may be used in combination. Examples of the aliphatic monohydric alcohol include butyl alcohol, pentanol, hexanol, heptanol, octyl alcohol, iso-octyl alcohol, lauryl alcohol, myristyl alcohol, myristoleyl alcohol, cetyl alcohol, isocetyl alcohol, palmitoleyl alcohol, stearyl alcohol, isostearyl

alcohol, oleyl alcohol, elaidyl alcohol, vaccenyl alcohol, gadoleyl alcohol, arachidyl alcohol, isoicosanyl alcohol, eicosenoyl alcohol, behenyl alcohol, isodocosanyl alcohol, ercanyl alcohol, lignoceranyl alcohol, isotetracosanyl alcohol, nervonyl alcohol, cerotyl alcohol, montanyl alcohol, and mercinyl alcohol.

[0034] The aliphatic monovalent carboxylic acid having 4 to 24 carbon atoms may be saturated or unsaturated, and the number of unsaturated bonds is not particularly limited. One kind or two or more kinds of aliphatic monovalent carboxylic acids may be used, and a saturated fatty acid and an unsaturated fatty acid may be used in combination. Examples of the aliphatic monovalent carboxylic acid include butyric acid, crotonic acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, lauric acid, myristic acid, myristoleic acid, pentadecanoic acid, palmitic acid, palmitoleic acid, isocetyl acid, margaric acid, stearic acid, isostearic acid, oleic acid, elaidic acid, vaccenic acid, linoleic acid, linolenic acid, tuberculostearic acid, arachidic acid, isoeicosic acid, gadoleic acid, eicosenoic acid, docosanoic acid, isodocosanoic acid, erucic acid, tetracosanoic acid, isotetracosanoic acid, nervonic acid, cerotic acid, montanic acid, and melissic acid.

[0035] The aliphatic divalent carboxylic acid having 2 to 6 carbon atoms is not particularly limited as long as it has a valence of 2 or more, and one kind or two or more kinds may be used. Examples of the aliphatic divalent carboxylic acid include citric acid, isocitric acid, malic acid, aconitic acid, oxaloacetic acid, oxalosuccinic acid, succinic acid, fumaric acid, maleic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, and sebacic acid.

[0036] The alcohol and the fatty acid that constitute the ester compound having a structure in which the aliphatic monohydric alcohol and the fatty acid form an ester bond are the ester compound of the aliphatic monovalent carboxylic acid having 4 to 24 carbon atoms and the aliphatic monohydric alcohol having 4 to 24 carbon atoms.

[0037] As for these esters, an ester obtained by synthesis according to a known method using an alcohol and a fatty acid that are generally commercially available may be used. Furthermore, among naturally occurring esters such as natural fruits, seeds, and flowers, a natural ester satisfying the constitution of the above-mentioned ester may be used as it is, a natural ester may be purified by a known method to obtain a purified ester, and an ester obtained by separating and re-purifying the purified ester by a known method utilizing the melting point difference may be used as necessary.

[0038] The polyamide monofilament of the present invention is preferably reduced in the fluctuation rate of dry heat shrinkage stress in the longitudinal direction of the yarn in order to obtain a fabric having excellent quality. When the fluctuation rate of the dry heat shrinkage stress is large, an unevenness occurs in shrinkage of the yarn, and the woven fabric has a defect called a tight pick, when the woven fabric is heat-treated in the weaving process. The fluctuation rate of the dry heat shrinkage stress is preferably 15% or less, more preferably 12% or less.

[0039] Next, a preferred embodiment for satisfying the above-mentioned amount of the deposited oil, the rate of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the deposited oil, and the fluctuation rate of the amount of the deposited oil in the longitudinal direction of the yarn is described.

[0040] An example of the method for producing the polyamide monofilament of the present invention is specifically described with reference to Fig. 1. Fig. 1 is a schematic view showing the example of a process for producing the polyamide monofilament according to the present invention.

[0041] A melted polyamide chip is weighed and transported by a gear pump and discharged from a spinneret 1 to form a yarn, the yarn is passed through steam jetting devices 2 in which steam is jetted toward a spinneret surface provided directly below the spinneret, and an area that is provided on a downstream side of the steam jetting devices 2 and in which cooling air is blown from a cooling device 3 to cool and solidify the yarn to room temperature, and then the oil is supplied by an oil supply device 4. The yarn is wound around take-up rollers 5 a plurality of times, and further wound around drawing rollers 6 a plurality of times to allow the yarn to pass through the rollers. In this process, the yarn is drawn in accordance with the ratio of the peripheral speed of the take-up rollers 5 to the peripheral speed of the drawing rollers 6. Finally, the yarn is heat-treated by heating the drawing rollers 6, and wound with a winder (wind-up device) 7.

[0042] In order to obtain the polyamide monofilament of the present invention, it is important to keep the heat treatment temperature at the time of heat treatment using the drawing roller 6 and the length to wind the yarn around the drawing roller 6, that is, the heat treatment length within appropriate ranges in the production process shown in Fig. 1, and to keep the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the oil deposited on the yarn by the oil supply device 4 within an appropriate range.

[0043] When the polyamide monofilament of the present invention is heat-treated by the drawing rollers 6, the heat treatment temperature is 180°C or higher. As described above, in the polyamide monofilament of the present invention containing the deposited oil containing the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less, it is important to control the rate of the component in the oil deposited on the yarn based on the total weight of the deposited oil. Since the component has a low boiling point and is easily decomposed by heat, the component volatilizes or is decomposed by the heat treatment using the drawing rollers 6, and the amount of the component remaining on the yarn surface is

reduced. When the heat treatment temperature with the drawing rollers 6 is within such a range, it is possible to control the rate of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the deposited oil to 40% by weight or less based on the total weight of the deposited oil. It is also possible to control the fluctuation rate of the amount of the deposited oil in the longitudinal direction of the yarn to 20% or less. It is also possible to control the fluctuation rate of the heat shrinkage stress to 15% or less. Furthermore, since a monomer and an oligomer remaining on the yarn surface and in the yarn can volatilize to reduce the remaining amount, it is possible to suppress the deposition of the monomer or the oligomer as the scum in the weaving process. When the heat treatment temperature is less than 180°C, the heat treatment is insufficient, the rate of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less is more than 40% by weight based on the total weight of the deposited oil, and the fluctuation rate of the amount of the deposited oil in the longitudinal direction of the yarn exceeds 20%, or the fluctuation rate of the heat shrinkage stress exceeds 15%, and thus the fabric quality deteriorates. Furthermore, the scum derived from the remaining monomer and oligomer is generated, and deterioration of productivity in the weaving process and deterioration of the fabric quality occur. On the other hand, the upper limit of the heat treatment temperature is not particularly limited in terms of the yarn quality, but is preferably 200°C or less from the viewpoint of preventing the productivity of the yarn from deteriorating when the surface of the heated drawing rollers 6 gets dirty with the oil component. The heat treatment temperature is more preferably 185°C to 190°C.

[0044] When the polyamide monofilament of the present invention is heat-treated by the drawing rollers 6, the length to wind the yarn around the drawing rollers 6, that is, the heat treatment length is 3.0 m or more. When the heat treatment length is within such a range, the heat treatment of the yarn on the drawing rollers 6 is sufficiently performed to control the rate of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the oil deposited on the yarn to 40% by weight or less based on the total weight of the deposited oil. It is also possible to control the fluctuation rate of the amount of the deposited oil in the longitudinal direction of the yarn to 20% or less. It is also possible to control the fluctuation rate of the heat shrinkage stress to 15% or less. When the heat treatment length is less than 3.0 m, the heat treatment is insufficient, the rate of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less is more than 40% by weight based on the total weight of the deposited oil, or the fluctuation rate of the amount of the deposited oil in the longitudinal direction of the yarn exceeds 20%, and thus the fabric quality deteriorates. Furthermore, the fluctuation rate of the heat shrinkage stress exceeds 15%, and the fabric quality deteriorates. The heat treatment length is more preferably 3.5 m or more. The upper limit of the heat treatment length is not particularly limited in terms of the yarn quality, and may be set appropriately so that handling of production equipment may not be difficult.

[0045] As for the spinning oil used in the polyamide monofilament of the present invention, it is preferable to control the rate of the amount of the component containing the hydrocarbon having a weight average molecular weight of 500 or less and the fatty acid alkyl ester having a weight average molecular weight of 500 or less in the deposited oil to 90% by weight or less based on the total weight of the deposited oil. When the amount of the component is within such a range, the above-mentioned good smoothness can be obtained, the penetration of the component into the projectile cap can be suppressed, and a woven fabric having excellent product quality can be obtained. Furthermore, the amount of the solvent is not too small when the oil is prepared, the oil in which the components are uniformly dissolved can be obtained, and the variability in the amount of the deposited oil can be reduced when the oil is deposited on the yarn.

[0046] The elongation of the polyamide monofilament of the present invention may be appropriately set according to the application, and is preferably 25 to 50% from the viewpoint of processability when the polyamide monofilament is processed into the woven fabric.

[0047] Furthermore, the strength is preferably 4.0 cN/dtex or more from the viewpoint that the woven fabric is used in the application to a filter requiring a high degree of precision, and the woven fabric having a strength of 4.0 cN/dtex or less can be used without problem depending on the application of the woven fabric.

[0048] The fineness may be appropriately set according to the application, and a fineness of 4 to 60 dtex is practically preferable in the application to the filter.

[0049] The cross-sectional shape of the polyamide monofilament of the present invention is not limited to a round cross section, and various cross-sectional shapes such as flat shape, Y-shape, T-shape, hollow shape, four-square shape, and tick-tack-toe shape can be adopted.

EXAMPLES

[0050] The present invention is described in detail with reference to examples. The following methods were used as measuring methods in the examples.

A. Sulfuric acid relative viscosity

[0051] In order to obtain a sample concentration of 1 g/l, 0.25 g of a sample was dissolved in 100 ml of 98 wt% sulfuric acid, and a flow time (T1) at 25°C was measured using an Ostwald viscometer. Subsequently, a flow time (T2) of 98 wt% sulfuric acid alone was measured. The ratio of T1 to T2, that is, T1/T2 was defined as the sulfuric acid relative viscosity.

B. Melting point (Tm)

[0052] Using a differential scanning calorimeter DSC-7 type manufactured by PerkinElmer Co., Ltd., 20 mg of the sample polymer was heated from 20°C to 280°C at a heating rate of 20°C/min as 1st RUN, held at 280°C for 5 minutes, then cooled from 280°C to 20°C at a cooling rate of 20°C/min, held at 20°C for 1 minute, and again, the temperature was raised from 20°C to 280°C at a heating rate of 20°C/min as 2nd RUN. The temperature of the endothermic peak observed during the 2nd RUN was defined as the melting point.

C. Fineness

[0053] A hank was made by winding the sample yarn 200 times using a wrap reel with a frame circumference of 1.125 m, the hank was dried with a hot-air dryer ($105 \pm 2^\circ\text{C} \times 60$ minutes), and then the hank was weighed with a balance and the fineness was calculated from a value obtained by multiplying the weight by official moisture regain. The measurement was performed 4 times, and the average was defined as the fineness.

D. Tensile strength and elongation

[0054] The measurement was performed under a constant rate of extension conditions shown in JIS L1013 (chemical fiber filament yarn test method, 2010) using "TENSILON" (registered trademark) UCT-100 manufactured by ORIENTEC CORPORATION as a measuring instrument. The elongation was calculated from the elongation at the point showing maximum strength in the tensile strength-elongation curve. The tensile strength was defined as the value obtained by dividing the maximum strength by the fineness. The measurement was performed 10 times, and the average was defined as the tensile strength and the elongation.

E. Boiling water shrinkage percentage

[0055] A hank was made by winding the polyamide monofilament 20 times using a wrap reel with a peripheral length of 1.125 m, and an initial length L_0 was obtained under a load of 0.09 cN/dtex. Then, the hank is treated in boiling water under no load for 30 minutes, and then air-dried. Next, a length L_1 after treatment under a load of 0.09 cN/dtex is obtained and the boiling water shrinkage percentage is calculated by the following formula.

$$\text{Boiling water shrinkage percentage (\%)} = [(L_0 - L_1) / L_0] \times 100$$

F. Fluctuation rate of dry heat shrinkage stress

[0056] Using an FTA measuring machine (FTA-500 manufactured by Toray Engineering Co., Ltd.), the yarn was passed through a dry heat treatment device (a length of 15.5 cm) heated to 100°C and installed in the measuring machine under the conditions of a monofilament supply speed of 10 m/min and a running yarn stress of 0.03 cN/dtex, and the fluctuation rate of the dry heat shrinkage stress was obtained by measurement for 10 minutes. A fluctuation rate of the dry heat shrinkage stress of 20% or less was regarded as acceptable. The smaller the fluctuation, the better.

G. Amount of deposited oil and fluctuation rate thereof

[0057] The amount of the deposited oil was calculated from the weight difference of the container before and after the extraction by accurately weighing 10 g of the sample (the polyamide monofilament), immersing the sample in normal hexane at 15°C, extracting the oil over 10 minutes, removing the normal hexane and drying the sample after the extraction, and measuring the weight of the container. The measurement was performed 10 times, the average and the standard deviation of the measured values were obtained, and the fluctuation rate was calculated.

H. Identification of oil component on yarn surface

[0058] The polyamide monofilament was put into a Soxhlet extractor, cyclohexane was then added, the mixture was heated under reflux for about 4 hours, and then cyclohexane was recovered to extract the oil component on the yarn surface. The obtained extract was measured by a known $^1\text{H-NMR}$ method, and the structure of the oil component was identified from spectrum data. The sample was injected into a separation column KF-402HQ and KF-403HQ manufactured by Showa Denko K.K. at a concentration of 3 mg/cc using a high-speed gel permeation chromatography device HLC-8220GPC manufactured by Tosoh Corporation, and the weight average molecular weight of the oil component in the extract was calculated from a peak measured with a differential refractometer.

I. Yarn cast-off property

[0059] The polyamide monofilament was used as a weft yarn, and when a fabric was produced with a weft yarn driving speed of 750 m/min in a projectile loom, the number of times the yarn cast-off from the projectile cap occurs per 10 million m of the weft yarn was recorded, and an occurrence number of times of less than 5 times was regarded as acceptable. The smaller the number of times, the better.

J. Number of times loom stops

[0060] The polyamide monofilament was used as a weft yarn, and when a fabric was produced with a weft yarn driving speed of 750 m/min in a projectile loom, the number of times the loom stopped per 10 million m of the yarn was recorded, and a number of times the loom stopped of less than 5 times was regarded as acceptable. The smaller the number of times, the better.

K. Fabric quality

[0061] The polyamide monofilament was used as a weft yarn to produce a woven fabric, the woven fabric was visually evaluated by the following three grades according to the occurrence state of the unevenness and the line per 50 m of the woven fabric, and an evaluation result of o or better was regarded as acceptable.

S: The woven fabric has excellent quality without line or unevenness.

A: The woven fabric has slight line or unevenness, but has no problem in use as a product.

B: The woven fabric has line or unevenness and cannot be used as a product.

(Example 1)

[0062] As the base polymer, polyhexamethylene adipamide (a sulfuric acid relative viscosity of 2.80, a melting point of 262°C) having a titanium oxide content of 0.02% by weight was adjusted so that the moisture percentage was 0.135% by weight. The chip of the base polymer was put into a spinning machine shown in Fig. 1 and melted at a spinning temperature of 289°C , and spun out from a spinneret 1 having 4 round holes with a discharge hole diameter of 0.55 mm and a hole length of 9.5 mm to obtain a yarn. The yarn was cooled and solidified by blowing with cool air using a cooling device 3, an oil in which the amount of a component containing a hydrocarbon having a weight average molecular weight of 500 or less and a fatty acid alkyl ester having a weight average molecular weight of 500 or less was adjusted to 70% by weight based on the weight of the oil was applied to the yarn using an oil supply device 4 with an oiling roller system, and then the yarn was taken up at a peripheral speed (take-up speed) of 774 m/min (set value) with take-up rollers 5. Subsequently, the yarn was wound 3.5 times around the take-up rollers 5, and then taken up by drawing rollers 6 having a surface temperature of 190°C to draw the yarn between the rollers at a draw ratio of 4.03 times. The yarn was wound 5.5 times around the drawing rollers 6 (3.8 m in terms of yarn length), heat-treated, and then wound with a winder 7 having a winding speed of 3000 m/min (set value) to obtain a polyhexamethylene adipamide monofilament having a fineness of 8dtex. A fabric was produced from the obtained monofilament. Table 1 shows the evaluation results of the monofilament and the fabric.

(Example 2)

[0063] A monofilament was obtained under the same conditions as in Example 1 except that the surface temperature of the drawing rollers 6 was changed to 185°C . Table 1 shows the evaluation results of the obtained monofilament.

(Example 3)

[0064] A monofilament was obtained under the same conditions as in Example 1 except that the oil in which the amount of the component containing the hydrocarbon having a weight average molecular weight of 500 or less or the fatty acid alkyl ester having a weight average molecular weight of 500 or less was adjusted to 88% by weight based on the weight of the oil was applied to the yarn using the oil supply device 4, and the number of turns during the heat treatment with the drawing rollers 6 was changed to 4.5 times (3.1 m in terms of yarn length). Table 1 shows the evaluation results of the obtained monofilament.

(Example 4)

[0065] A monofilament was obtained under the same conditions as in Example 1 except that the roller rotation speed of the oil supply device 4 with the oiling roller system was adjusted so that the amount of the deposited oil on the yarn was 1.0% by weight, and the number of turns during the heat treatment with the drawing rollers 6 was changed to 4.5 times (3.1 m in terms of yarn length). Table 1 shows the evaluation results of the obtained monofilament.

(Comparative Example 1)

[0066] A monofilament was obtained under the same conditions as in Example 1 except that the roller rotation speed of the oil supply device 4 with the oiling roller system was adjusted so that the amount of the deposited oil on the yarn was 1.65% by weight, and the number of turns during the heat treatment with the drawing rollers 6 was changed to 4.5 times (3.1 m in terms of yarn length). Table 1 shows the evaluation results of the obtained monofilament.

(Example 5)

[0067] A monofilament was obtained under the same conditions as in Example 1 except that the surface temperature of the drawing rollers 6 was changed to 180°C, and the number of turns during the heat treatment with the drawing rollers 6 was changed to 4.5 times (3.1 m in terms of yarn length). Table 1 shows the evaluation results of the obtained monofilament.

(Comparative Example 2)

[0068] A monofilament was obtained under the same conditions as in Example 1 except that the surface temperature of the drawing rollers 6 was changed to 175°C, and the number of turns during the heat treatment with the drawing rollers 6 was changed to 4.5 times (3.1 m in terms of yarn length). Table 2 shows the evaluation results of the obtained monofilament.

(Example 6)

[0069] A monofilament was obtained under the same conditions as in Example 1 except that the oil adjusted by changing the weight average molecular weight of the hydrocarbon used as a smoothing component in the oil supply device 4 as shown in Table 1 was applied to the yarn. Table 2 shows the evaluation results of the obtained monofilament.

(Comparative Example 3)

[0070] A monofilament was obtained under the same conditions as in Example 1 except that the number of turns during the heat treatment with the drawing rollers 6 was changed to 3.5 times (2.4 m in terms of yarn length). Table 2 shows the evaluation results of the obtained monofilament.

(Examples 7 and 8)

[0071] A monofilament was obtained under the same conditions as in Example 1 except that the oil adjusted by changing the viscosity of a solvent used as the solvent in the oil supply device 4 as shown in Table 1 was applied to the yarn. Table 2 shows the evaluation results of the obtained monofilament.

[Table 1]

		Unit	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Example 5
Raw material polymer	Polyamide type		N66	N66	N66	N66	N66	N66
	Sulfuric acid relative viscosity		2.80	2.80	2.80	2.80	2.80	2.80
	Melting point	°C	262	262	262	262	262	262
Production method	Viscosity of solvent	-	30SUS	30SUS	30SUS	30SUS	30SUS	30SUS
	Weight average molecular weight of hydrocarbon	-	280	280	360	360	360	360
	Proportion of hydrocarbon (A)	wt%	50	50	72	50	50	50
	Weight average molecular weight of fatty acid alkyl ester	-	400	400	470	400	400	400
	Proportion of fatty acid alkyl ester (B)	wt%	20	20	16	20	20	20
	Rate of (A) + (B)	wt%	70	70	88	70	70	70
	Heat treatment temperature	°C	190	185	190	190	190	180
Fiber	Heat treatment length	m	3.8	3.8	3.1	3.1	3.1	3.1
	Deposited amount	wt%	0.35	0.45	0.35	1.00	1.65	0.45
	Rate of hydrocarbon having weight average molecular weight of 500 or less and fatty acid alkyl ester having weight average molecular weight of 500 or less	wt%	25	30	28	30	30	35
	Fluctuation rate of deposited amount	%	14	15	14	18	15	18
	Tensile elongation	%	40	39	38	39	39	38
	Tensile strength	cN/dtex	6.0	6.0	6.2	6.1	6.1	6.2
	Boiling water shrinkage percentage	%	9.0	9.3	9.0	9.4	9.4	9.8
High order evaluation	Fluctuation rate of dry heat shrinkage stress	%	12	15	15	15	15	15
	Yarn cast-off property	Times	1	1	0	2	5	3
	Number of times loom stops	Times	1	1	1	4	7	4
	Fabric quality	-	S	S	S	A	A	A

[Table 2]

		Unit	Comparative Example 2	Example 6	Comparative Example 3	Example 7	Example B
Raw material polymer	Polyamide type		N66	N66	N66	N66	N66
	Sulfuric acid relative viscosity		2.80	2.80	2.80	2.80	2.80
	Melting point	°C	262	262	262	262	262
Production method	Viscosity of solvent	-	30SUS	30SUS	30SUS	100SUS	45SUS
	Weight average molecular weight of hydrocarbon	-	360	150	360	280	280
	Proportion of hydrocarbon (A)	wt%	50	50	50	50	50
	Weight average molecular weight of fatty acid alkyl ester	-	400	400	400	400	340
	Proportion of fatty acid alkyl ester (B)	wt%	20	20	20	20	20
	Rate of (A) + (B)	wt%	70	70	70	70	70
	Heat treatment temperature	°C	175	190	190	190	190
	Heat treatment length	m	3.1	3.8	2.4	3.8	3.8
Fiber	Deposited amount	wt%	0.45	0.35	0.35	0.46	0.46
	Rate of hydrocarbon having weight average molecular weight of 500 or less and fatty acid alkyl ester having weight average molecular weight of 500 or less	wt%	54	26	45	15	14
	Fluctuation rate of deposited amount	%	22	12	25	18	14
	Tensile elongation	%	38	40	38	40	40
	Tensile strength	cN/dtex	6.2	6.1	6.1	6.0	6.0
	Boiling water shrinkage percentage	%	11.0	9.0	13.5	9.0	9.0
	Fluctuation rate of dry heat shrinkage stress	%	17	15	25	15	15
	Yarn cast-off property	Times	7	1	8	3	1
High order evaluation	Number of times loom stops	Times	11	3	14	4	1
	Fabric quality	-	B	A	B	A	S

DESCRIPTION OF REFERENCE SIGNS

[0072]

- 5 1: Spinneret
- 2: Steam jetting device
- 3: Cooling device
- 10 4: Oil supply device
- 5: Take-up roller
- 15 6: Drawing roller
- 7: Winder (wind-up device)

20 **Claims**

1. A polyamide monofilament comprising a deposited oil, an amount of the deposited oil being 0.1 to 1.5% by weight, the deposited oil containing a component containing a hydrocarbon having a weight average molecular weight of 500 or less and a fatty acid alkyl ester having a weight average molecular weight of 500 or less, a rate of the component being 40% by weight or less based on a total weight of the deposited oil.
- 25 2. The polyamide monofilament according to claim 1, wherein a fluctuation rate of the amount of the deposited oil in a longitudinal direction of a yarn is 20% or less.

30

35

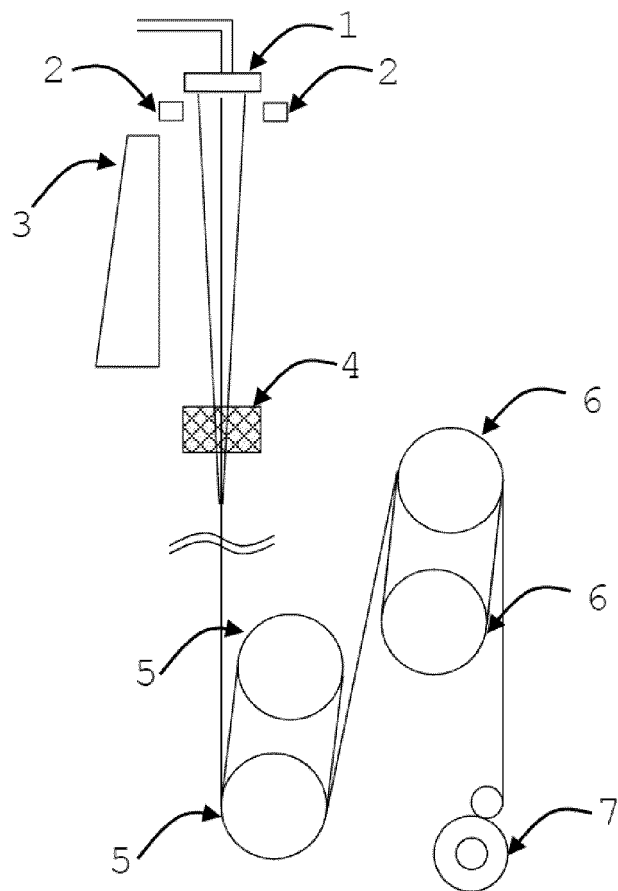
40

45

50

55

FIG. 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/016728

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. D06M13/02 (2006.01) i, D01F6/60 (2006.01) i, D06M13/224 (2006.01) i,
D06M101/34 (2006.01) n

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)

Int.Cl. D06M13/02, D01F6/60, D06M13/224, D06M101/34

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 46-7637 B1 (KANEBO BOSEKI KK) 25 February 1971, claims, examples, page 3, lines 32-35, page 3, right column, lines 2-7 (Family: none)	1-2
A	JP 3-143341 A (TORAY MONOFILAMENT CO., LTD.) 18 June 1991, examples 1-3, claims (Family: none)	1-2
A	JP 63-42912 A (KANEBO KABUSHIKI KAISHA) 24 February 1988, example 1, claim 1 (Family: none)	1-2
A	JP 2007-270363 A (TORAY MONOFILAMENT CO., LTD.) 18 October 2007, example 12 (Family: none)	1-2
A	JP 2004-250840 A (TORAY INDUSTRIES, INC.) 09 September 2004, example 5 (Family: none)	1-2

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
25 June 2019 (25.06.2019)

Date of mailing of the international search report
09 July 2019 (09.07.2019)

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

Authorized officer

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2008057085 A [0007]
- JP 2012222112 A [0007]
- WO 2016052287 A [0007]