



(11) **EP 3 859 057 A1**

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

(43) Date of publication:
04.08.2021 Bulletin 2021/31

(51) Int Cl.:
D01F 6/62 (2006.01) **B41N 1/24** (2006.01)

(21) Application number: **19865767.8**

(86) International application number:
PCT/JP2019/037722

(22) Date of filing: **25.09.2019**

(87) International publication number:
WO 2020/067224 (02.04.2020 Gazette 2020/14)

(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

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(54) **POLYESTER MONOFILAMENT FOR SCREEN CLOTH AND WOVEN MESH FABRIC FOR DIRECT DIGITAL PLATEMAKING**

(57) The present invention provides a polyester monofilament for screen mesh cloths, which needs no dyeing step and is suitable for use in direct digital plate-making in which no positive film is used. The polyester monofilament makes it possible to attain a reduction in emulsion curing time and to thereby conduct highly precise screen printing in a short time period, has excellent

laser-light transmission, and has excellent higher-order passability in weaving. The polyester monofilament for screen mesh cloths of the present invention has a transmittance, in irradiation with light having a wavelength of 405 nm, of 30% or greater and has a breaking tenacity of 4.3-9.0 cN/dtex, an elongation at rupture of 11.0-50.0%, and a 10% modulus of 2.5-9.0 cN/dtex.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a polyester monofilament suitable for high-mesh woven fabrics for screen mesh cloth applications. More specifically, the present invention relates to a polyester monofilament for a screen mesh cloth suitable for direct digital platemaking, which is a novel high-definition printing technique which performs direct platemaking and printing by digital processing using a computer and in which a positive film is not used and a dyeing process is not required.

BACKGROUND ART

[0002] Conventionally, as a fabric for screen printing, a woven mesh fabric made of natural fibers or inorganic fibers has been widely used. However, in recent years, synthetic meshes which are excellent in flexibility, durability, and cost performance, particularly woven mesh fabrics made of polyester among those are widely used, and are used in a wide range of applications, such as textile printing, identification printing, high accuracy printing of graphic designs such as label printing of compact discs, electronic substrate circuit printing, and the like. With improvements of functionality and compactness of electronic devices accelerated in recent years, the substrate circuit have also become more precise and compact, and it is strongly required that the screen mesh cloth has high printing accuracy.

[0003] In order to satisfy the required characteristics such as the improvement in printing accuracy, the strength and the modulus of the monofilament as the constituent elements have been increased. On the other hand, the technical revolution is advanced also in the platemaking process. In a common screen printing, a gray fabric obtained by warping and weaving is dyed in yellow to inhibit halation, and a processed cloth is produced by heat setting. This processed cloth is applied to a plate frame with high tension, and a photosensitive emulsion mainly composed of diazo-based compounds is applied, and then the positive film and the plate are pressed to be bonded in an exposure process, and the photosensitive emulsion is solidified by ultraviolet irradiation. After that, an unsolidified portion of the photosensitive emulsion is removed and a negative is prepared, and the plate frame is filled with the coating material and then the coating agent is applied to the object by squeezing to perform printing. In the platemaking/printing process, the most important process from the viewpoint of printing accuracy is an alignment process of the positive film and the printing plate. While the alignment of the positive film and the printing plate directly influences the printing accuracy, the alignment operation is largely dependent on the experience, knowledge, and sensation of the operator, and a large number of artificial factors tend to cause variations.

[0004] In order to solve this problem, a new platemaking and printing technique called direct digital platemaking has been developed. Direct digital platemaking is a platemaking/printing technique in which a printing pattern is digitized by a computer, a photosensitive emulsion on a platemaking surface is treated with a laser based on optical output, and a pattern is formed on a printing plate by direct exposure. Since the printing pattern is directly formed by the computer, a positive film is not necessary and thus the cost of the positive film can be reduced, and the alignment with the positive film is eliminated so that the printing accuracy is improved as compared with the conventional screen printing method.

[0005] In addition, in a common screen printing method, since halation occurs in the exposure process and the photosensitive emulsion curing process so that the printing accuracy is lowered, a treatment for preventing halation has been indispensable. For example, in Patent Literatures 1 and 2, which disclose typical monofilaments for a screen mesh cloth, titanium oxide, which is also known as a matting agent, is contained, and the screen mesh cloth is dyed in yellow in the dyeing process to prevent halation. On the other hand, in addition to titanium oxide, there are cases in which a chemical substance for preventing halation is contained in the polymer itself. In Patent Literature 3, a spun-dyed monofilament in which an organic compound-based yellow pigment is contained in a polymer has been proposed, and in addition to the effect of preventing halation, a dyeing process is not required, so that the environmental load can be reduced. In addition, in Patent Literature 4, an ultraviolet absorbent is contained in the polymer, the screen mesh cloth is dyed in yellow, and the exposure and the photosensitive emulsion curing are performed to improve the effect of preventing halation.

[0006] In this manner, in the common screen printing method, it is necessary to contain titanium oxide and to make the screen mesh cloth yellow in order to prevent halation. On the other hand, this is not the case with a multifilament for clothing. As disclosed in Patent Literature 5, for example, a woven fabric for clothing having high transparency and excellent esthetics by reducing the content of titanium oxide has been proposed.

CITATION LIST

PATENT LITERATURE

5 **[0007]**

Patent Literature 1: JP-A-2009-228175

Patent Literature 2: WO 2011/086954

Patent Literature 3: JP-A-2009-221620

10 Patent Literature 4: JP-A-2011-16279

Patent Literature 5: JP-A-2016-41859

SUMMARY OF INVENTION

15 TECHNICAL PROBLEM

[0008] As described above, in the common screen printing, a treatment for preventing halation during exposure and photosensitive emulsion curing is indispensable. On the other hand, in direct digital platemaking, there is no restriction on the content of titanium oxide and the color of the screen mesh cloth since the influence of halation is small. As a result, the curing time of the photosensitive emulsion can be significantly shortened by using the transparent raw yarn excellent in transparency for a laser to be used during exposure for the screen mesh cloth. By shortening the curing time of the photosensitive emulsion, the platemaking process can be made more efficient, and high accuracy printing can be performed in a short time. From this viewpoint, as a monofilament for a screen mesh cloth used in direct digital platemaking, a transparent bright monofilament having excellent laser transparency is preferable.

25 **[0009]** In the monofilaments described in Patent Literatures 1 and 2, titanium oxide is contained as described above, and the screen mesh cloth is dyed in yellow in the dyeing process. In this case, since titanium oxide and the dye hinder the laser transmission, it is difficult to say that the monofilaments are suitable for direct digital platemaking. In Patent Literature 3, in addition to titanium oxide, an organic compound-based pigment is contained, but it is difficult to say that it is suitable for direct digital platemaking from the viewpoint of inhibiting the laser transmission. In Patent Literature 4, 30 in addition to the fact that the yellow dye hinders the laser transmission, the strength and modulus of the screen mesh cloth are reduced due to shrinkage during dyeing, so that the dimensional stability and the printing accuracy of the screen mesh cloth are reduced. Therefore, it is also difficult to say that it is suitable for the direct digital platemaking, in which there is no restriction on the color of the screen mesh cloth.

35 **[0010]** Although the multifilament for clothing disclosed in Patent Literature 5 has a reduced titanium oxide content in order to improve transparency and esthetics, a screen mesh cloth has a higher quality requirement than a woven fabric for clothing, and even if the technique described in Patent Literature 5 is applied to a monofilament for a screen mesh cloth, the monofilament cannot withstand the abrasion resistance with the reed in weaving. That is, since the content of metal particles to form fine unevenness on the surface of the fiber, such as titanium oxide, is small, the friction coefficient between the raw yarn and the metal is high, and it is obvious that printing defects such as fluffing, scum or the like are caused in weaving. In addition, since a multifilament has poor uniformity of the fiber diameter compared with a monofilament, it is not preferable as a raw yarn for the screen mesh cloth.

40 **[0011]** In order to obtain a bright monofilament which is suitable for direct digital platemaking, it is important to impart excellent transparency to the raw yarn and at the same time to reduce fluffing and scum defects in the weaving.

45 **[0012]** Therefore, an object of the present invention is to provide a monofilament which is suitable for direct digital platemaking, in which a positive film is not used and direct platemaking is performed without a dyeing process, excellent in laser transparency so that an emulsion curing time can be shortened, and also excellent in higher order passability in a weaving process.

50 SOLUTION TO PROBLEM

[0013] In order to achieve the above object, the present invention includes any one of the following configurations (1) to (3).

55 (1) A polyester monofilament for a screen mesh cloth, the polyester monofilament having: a transmittance of 30% or more when the polyester monofilament is irradiated with a wavelength of 405 nm; a breaking strength of 4.3 cN/dtex to 9.0 cN/dtex; a breaking elongation of 11.0% to 50.0%; and a 10% modulus of 2.5 cN/dtex to 9.0 cN/dtex.

(2) The polyester monofilament for a screen mesh cloth according to (1), in which a coefficient of dynamic friction between a raw yarn and a satin metal is 0.100 to 0.170.

(3) A woven mesh fabric for direct digital platemaking, in which the polyester monofilament according to (1) or (2) is disposed on at least a part of at least one of a warp and a weft.

ADVANTAGEOUS EFFECTS OF INVENTION

[0014] According to the present invention, the monofilaments of the present invention having excellent transparency at a wavelength of 405 nm used for exposure can be suitably used for direct digital platemaking, and the emulsion curing time can be shortened, high-definition screen printing can be performed in a short time, and printing defects such as fluffing and scum occurring during weaving can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0015]

[FIG. 1] FIG. 1 is a schematic view for illustrating a sample preparation method when measuring a transmittance of the polyester monofilament for a screen mesh cloth of the present invention.

[FIG. 2] FIG. 2 is a schematic view for illustrating a method of measuring the dynamic friction coefficient between a raw yarn and a satin metal in the polyester monofilament for a screen mesh cloth of the present invention.

[FIG. 3] FIG. 3 is a schematic view showing an example of a spinning device in a two-step method used in the present invention.

[FIG. 4] FIG. 4 is a schematic view showing an example of a drawing device in the two-step method used in the present invention.

[FIG. 5] FIG. 5 is a schematic view showing an example of a yarn production device in a one-step method (direct spinning drawing method) used in the present invention.

DESCRIPTION OF EMBODIMENTS

[0016] The polyester monofilament for a screen mesh cloth of the present invention is a polyester monofilament containing polyethylene terephthalate as a main component. Here, the term "main component" refers to a component that occupies 60 wt% or more of all components, and "containing polyethylene terephthalate as a main component" indicates that polyethylene terephthalate is contained at 60 wt% or more with respect to the resin components constituting the monofilament.

[0017] The polyester monofilament for a screen mesh cloth of the present invention has a transmittance of 30% or more when irradiated with a wavelength of 405 nm for a monofilament wound uniformly in a certain direction at a density of 0.018 g/cm² on a transparent acrylic plate having a thickness of 2 mm.

[0018] FIG. 1 is a schematic view for illustrating a sample preparation method when measuring a transmittance of the polyester monofilament for a screen mesh cloth of the present invention.

[0019] As shown in FIG. 1, a transparent acrylic plate 1 having a thickness of 2 mm is placed in an aligned winding evaluation device 2, and the transparent acrylic plate 1 is rotated while being traversed. The monofilament Y that has been unwound and run through a nip roll 4, a tensor 5, a direction change roll 6, and a yarn path regulation guide 7 are wound around the transparent acrylic plate 1 uniformly in a certain direction at a density of 0.018 g/cm² via an unwinding guide 3, thereby producing a plate-wound sample 8. Thereafter, after the plate-wound sample 8 is placed on the spectrophotometer, the transmittance T1 of the plate-wound sample 8 for a wavelength of 405 nm of the laser used for emulsion curing is measured. On the other hand, since the transparent acrylic plate 1 alone exhibits constant absorption for the wavelength of 405 nm, the transmittance (T0 = 10%) of the transparent acrylic plate 1 alone at 405 nm is measured, and the transmittance (T2) of the polyester monofilament for a screen mesh cloth at 405 nm is calculated according to the following formula (1).

$$T2 (\%) = T1 + (100 - T0) \quad (1)$$

[0020] As a result of intensive studies by the present inventors, it has been found that it is important for the polyester monofilament for a screen mesh cloth used in direct digital platemaking to have a transmittance of 30% or more for a wavelength of 405 nm. By using a monofilament having a transmittance of 30% or more, the emulsion curing time can be shortened when irradiated with the laser required for emulsion curing, and screen printing with high accuracy can be performed in a short time. When the transmittance is lower than 30%, emulsion curing is insufficient in a short time, and printing cannot be performed in a designed pattern in some cases. A more preferable transmittance of the monofilament when irradiated with a wavelength of 405 nm is 35% or more. The upper limit of the transmittance is not particularly

limited, but the transmittance is preferably 80% or less, and more preferably 70% or less, from the viewpoint of higher order passability in the weaving process.

[0021] In order to obtain such a monofilament having a high transmittance at a wavelength of 405 nm, for example, it is preferable to use a bright polyester in which the content of titanium oxide contained in the polyester is reduced. Although bright monofilaments having high transmittance can be obtained by other methods, it is preferable to minimize the content of titanium oxide commonly known as a matting agent, and the content of titanium oxide is preferably 0.030 wt% or less, more preferably 0.027 wt% or less.

[0022] The polyester monofilament for a screen mesh cloth of the present invention is formed of a polyethylene terephthalate which contains terephthalic acid as a main acid component and ethylene glycol as a main glycol component and 90 mol% or more of which is composed of a repeating unit of ethylene terephthalate. However, the polyester monofilament may include a copolymerization component capable of forming another ester bond at a ratio of less than 10 mol%, as long as the transmittance at a wavelength of 405 nm, which is a feature of the present invention, is not inhibited. In addition, a metal catalyst, an inorganic particle, a lubricant, an antioxidant, a flame retardant, an antistatic agent, or the like can be added to the polyethylene terephthalate as necessary within a range that does not impair the transmittance which is a feature of the present invention.

[0023] The intrinsic viscosity of the yarn in the polyester monofilament for a screen mesh cloth of the present invention is preferably 0.60 to 0.90, and more preferably 0.60 to 0.82, from a viewpoint of the strength and the yarn production stability of the obtained monofilaments.

[0024] The cross-sectional form of the yarn in the polyester monofilament for a screen mesh cloth of the present invention can be either a single component or a core-sheath composite. However, since the laser may be reflected and scattered at the interface of the core sheath in the case of the core-sheath composite yarn, the monofilament is preferably a single component yarn.

[0025] The polyester monofilament for a screen mesh cloth of the present invention has a breaking strength of 4.3 cN/dtex to 9.0 cN/dtex and a breaking elongation of 11.0% to 50.0%. In the case where the strength is too high and the elongation is too low, the process passability in yarn production and weaving is lowered and yarn breakage occurs frequently, so that the breaking strength is 9.0 cN/dtex or less and the breaking elongation is 11.0% or more, preferably the breaking strength is 6.2 cN/dtex or less and breaking elongation is 25.0% or more. Further, in the case where the strength is too low and the elongation is too high, when the monofilament is processed into a screen mesh cloth, a cloth stretch occurs and excellent dimensional stability may not be obtained and the printing accuracy may be lowered. Therefore, the breaking strength is set to 4.3 cN/dtex or more and the breaking elongation of 50.0% or less.

[0026] The polyester monofilament for a screen mesh cloth of the present invention has a 10% modulus of 2.5 cN/dtex to 9.0 cN/dtex. In the case where the 10% modulus is too low, the cloth stability may not be obtained, and the printing accuracy may be lowered. On the other hand, in the case where the 10% modulus is too high, the surface of the fiber becomes highly oriented, and it may be difficult to inhibit fluffing defects and scum defects that occur during weaving. Therefore, the 10% modulus is from 2.5 cN/dtex to 9.0 cN/dtex and the preferred 10% modulus is from 2.8 cN/dtex to 5.0 cN/dtex.

[0027] The single fiber fineness of the polyester monofilament for a screen mesh cloth of the present invention is preferably 65.0 dtex or less from the needs for screen mesh cloth use, and preferably 4.0 dtex or more from a standpoint of the yarn production property. More preferably, the single fiber fineness thereof is from 8.0 dtex to 62.0 dtex.

[0028] The boiling water shrinkage rate of the polyester monofilament for a screen mesh cloth of the present invention is preferably 5.0% to 12.0%. In the case where the crystallization of the monofilament excessively proceeds, although the boiling water shrinkage rate decreases, the yarn may be whitened due to the proceeding of excessive crystallization. In this case, since the transmittance with respect to the wavelength of 405 nm which is a feature of the present invention may be inhibited, the boiling water shrinkage rate is preferably 5.0% or more. Further, when the boiling water shrinkage rate is within 12.0%, dimensional stability during heat setting can be obtained, and therefore the boiling water shrinkage rate is preferably within 12.0%. More preferably, the boiling water shrinkage rate is 6.0% to 10.0%.

[0029] The dynamic friction coefficient between the raw yarn and the satin metal (hereinafter, also referred to as the dynamic friction coefficient between the raw yarn and the satin metal) in the polyester monofilament for a screen mesh cloth of the present invention is preferably 0.100 to 0.170. The satin metal is a metal having fine unevenness on the surface, and in the present invention, the dynamic friction coefficient between the original yarn and the satin metal having a surface roughness of 6S is measured. By setting the dynamic friction coefficient between the raw yarn and the satin metal to 0.170 or less, it is possible to reduce the abrasion of the surface of the yarn due to the abrasion resistance with the reed in the weaving, to reduce the printing defects due to the fluffing defects on the shavings and the powdery scum defects, and to improve the printing accuracy of the screen mesh cloth. For example, in a bright monofilament in which the content of inorganic particles such as titanium oxide having a function as a lubricant is minimized, it is important to reduce the dynamic friction coefficient between the raw yarn and the satin metal and to improve the process passability in weaving, and the dynamic friction coefficient between the raw yarn and the satin metal is preferably 0.170 or less. On the other hand, in the case where the dynamic friction coefficient between the raw yarn and the satin metal is 0.100 or

more, it is possible to inhibit a decrease in the process passability due to insufficient tension in the yarn production process and the weaving process. Therefore, the dynamic friction coefficient between the raw yarn and the satin metal is preferably 0.100 or more. More preferably, the dynamic friction coefficient between the raw yarn and the satin metal is 0.130 or more.

[0030] In addition, an oil adhesion amount of the drawn yarn in the polyester monofilament for a screen mesh cloth of the present invention is preferably 0.10 wt% to 0.70 wt%. By setting the oil adhesion amount to 0.10 wt% or more, it is possible to inhibit an increase in the dynamic friction coefficient between the raw yarn and the satin metal, and to reduce the fluffing defects and scum defects caused by insufficient formation of an oil film. On the other hand, by setting the oil adhesion amount to 0.70 wt% or less, it is possible to inhibit the oil from falling off due to abrasion with the reed in the weaving process, thereby reducing the scum defects. Therefore, the oil adhesion amount is preferably 0.10 wt% to 0.70 wt%, and more preferably 0.10 wt% to 0.50 wt%.

[0031] Next, a method for producing the polyester monofilament for a screen mesh cloth of the present invention will be described. The spinning method of the polyester monofilament of the present invention is not particularly limited, and common techniques can be used. For example, after the polyethylene terephthalate is subjected to melt extrusion and the polyethylene terephthalate is filtered in a predetermined spinning pack, the yarn discharged from a spinneret is solidified by cooling air, and after an oil agent is applied by an oil feed roll, the yarn is taken up via a godet roll to obtain an undrawn yarn. The undrawn yarn may be processed in a two-step method in which the undrawn yarn is wound once and then drawn by a drawing machine, or may be processed in a one-step method (direct spinning drawing method) in which the undrawn yarn is continuously drawn without once winding. For the purpose of inhibiting the orientation of the fiber surface, the fiber discharged from the spinneret may be passed through a heat-insulating cylinder that has been actively heated.

[0032] In the oil agent applied to the polyester monofilament for a screen mesh cloth of the present invention, as an oil component concentration excluding water in the emulsion, a fatty acid alkyl ester-based smoothing agent is preferably contained in an amount of 45 wt% to 65 wt%, more preferably 50 wt% to 60 wt% from the viewpoint of higher order passability. For example, in a bright polyester monofilament in which the content of inorganic particles such as titanium oxide having a function as a lubricant is minimized, compared to a typical polyester monofilament for a screen mesh cloth, it is difficult to form fine unevenness on the fiber surface. Therefore, the dynamic friction coefficient between the raw yarn and the satin metal increases, and it is difficult to inhibit fluffing defects and scum defects caused by abrasion resistance with the reed in weaving only by adding the fatty acid alkyl ester-based smoothing agent.

[0033] Then, in the case where a modified silicone product, which is a smoothing agent, is contained in the emulsion in an amount of 6 wt% to 8 wt% in terms of the oil component concentration excluding moisture, the dynamic friction coefficient between the raw yarn and the satin metal can be reduced. In the case where 6 wt% or more of the modified silicone product is contained, it is possible to reduce the dynamic friction coefficient between the raw yarn and the satin metal in the bright polyester monofilament such that the bright polyester monofilament can withstand the abrasion resistance with the reed in the weaving. On the other hand, if the content of the modified silicone product exceeds 8 wt%, the dynamic friction coefficient between the raw yarn and the satin metal may not be reduced further, and the effect of reducing the dynamic friction coefficient between the raw yarn and the satin metal may not be obtained anymore. In the case where the content of the modified silicone product is 8 wt% or less, it is possible to inhibit destabilization of an oil film on an oil feed roller due to a decrease in surface tension and a decrease in uniform adhesion of an oil agent, and thus fluffing and scum defects can be prevented. Therefore, in the bright polyester monofilament, the content of the modified silicone product contained in the emulsion is preferably 6 wt% to 8 wt%, more preferably 7 wt% to 8 wt%, in terms of the oil component concentration excluding moisture.

[0034] Antistatic agents such as alkyl sulfonate, extreme pressure agents such as alkyl phosphate, oil film reinforcing agents, emulsifiers, pH adjusters, preservatives or the like may be added to the oil agent applied to the polyester monofilament of the present invention as long as the smoothness is not impaired.

[0035] The emulsion concentration of the oil agent applied to the polyester monofilament of the present invention is preferably 2 wt% to 12 wt%, more preferably 2 wt% to 10 wt%, from the viewpoint of the scattering of the oil and the stability of the oil film on the oil feed roller.

[0036] The spinning speed of the polyester monofilament of the present invention, that is, the speed of the godet roll used to obtain the undrawn yarn, is preferably 500 m/min to 1,300 m/min. In the case where the speed of the godet roll is 500 m/min or more, it is possible to stabilize the runnability of the yarn, and in the case where the speed of the godet roll is 1,300 m/min or less, it is possible to inhibit the fiber surface orientation before drawing from being promoted and reduce fluffing and scum defects caused as a result thereof. A more preferred spinning speed is 700 m/min to 1,200 m/min.

[0037] The method of drawing the polyester monofilament of the present invention is not particularly limited, and may be based on a common technique, for example, after one-stage heating drawing between a first hot roll and a second hot roll, the yarn is wound through a cold godet roll to obtain a drawn yarn. In addition, instead of the one-stage heating drawing, a two-stage heating drawing method may be employed in which the first-stage heating drawing is performed between the first hot roll and the second hot roll, and the second-stage heating drawing is performed between the second

hot roll and a third hot roll.

[0038] As for the temperature in drawing of the polyester monofilament of the present invention, the temperature of the first hot roll is preferably within a range of from the glass transition temperature +10°C to the glass transition temperature +30°C of the polyester as the core component, and the temperature of the second hot roll is preferably within a range of 130°C to 200°C in a case of the first-stage heating drawing. In the case where the temperature of the second hot roll is 130°C or higher, the fiber orientation can be controlled to promote crystallization of the fiber, thereby increasing the strength of the yarn. On the other hand, in the case where the temperature of the second hot roll is 200°C or lower, not only the yarn production property is good but also whitening of the yarn due to the promotion of excessive crystallization can be inhibited. A more preferred temperature of the second hot roll is 130°C to 150°C.

[0039] The draw ratio of the polyester monofilament of the present invention is preferably 3.0 times or more in total in order to obtain a target yarn having a high strength and a high modulus. In addition, in order to inhibit a decrease in the process passability in the yarn production process and the weaving process, it is necessary to keep room for elongation of the yarn, and to inhibit the fluffing and scum defects in the weaving. Therefore, the draw ratio is preferably 6.0 times or less in total. A more preferable total draw ratio is 3.5 to 5.0 times. Further, in the case of drawing the polyester monofilament for a screen mesh cloth of the present invention, the filament can be wound at the same speed between the final hot roll and the cold godet roll, or a relaxing treatment for setting a speed difference between the two rolls can be performed for the purpose of preventing orientation of an amorphous portion.

[0040] The woven mesh fabric produced using the polyester monofilament of the present invention can be suitably used for direct digital platemaking. The polyester monofilament of the present invention is preferably disposed in at least a part of at least one of a warp and a weft of the woven mesh fabric, and it is more preferable that at least one of the warp and the weft of the woven mesh fabric is formed of the polyester monofilament of the present invention, and it is particularly preferable that both the warp and the weft be formed by the polyester monofilament of the present invention.

EXAMPLES

[0041] Next, a polyester monofilament for a screen mesh cloth of the present invention will be described in detail with reference to Examples. The evaluation in Examples was performed in accordance with the following method.

(1) Transmittance of Monofilament and Woven Mesh Fabric

[0042] As shown in FIG. 1, a transparent acrylic plate 1 having a thickness of 2 mm (manufactured by MISUMI Group Inc.: Model ACSH series) was placed in an aligned winding evaluation device 2 manufactured by EIKO Industrial Co., Ltd. The transparent acrylic plate 1 was rotated at 550 rpm while being traversed, and a monofilament Y that had been run through a nip roll 4, a tensor 5, direction change rolls 6, and a yarn path regulation guide 7 by applying a tension of 10 g was wound around the transparent acrylic plate 1 for four rounds (eight layers) uniformly in a certain direction at a density of 0.018 g/cm² via an unwinding guide 3 to obtain a plate-wound sample 8. The number of rounds in winding a yarn on the traverse-moved transparent acrylic plate 1 was determined by the fineness (fiber diameter) of the yarn, and was four rounds (eight layers) in the case of 32 dtex (54 μm). In the case where a yarn having a different fineness (fiber diameter) was wound, the number of rounds (number of layers) was adjusted such that the density of the wound sample was the same. For example, the number of rounds is eight (16 layers) for 8 dtex (27 μm), five (10 layers) for 20 dtex (43 μm), and nine (18 layers) for 6 dtex (24 μm).

[0043] Subsequently, the plate-wound sample 8 of the monofilament was placed in a spectrophotometer (Model SPECTROPHOTOMETER CM-3700d) manufactured by Konica Minolta Co., Ltd., and then the transmittance T1 of the plate-wound sample 8 at 405 nm, which is the wavelength of the laser used for emulsion curing, was measured. On the other hand, since the transparent acrylic plate 1 alone exhibits a certain absorption at a wavelength of 405 nm, the transmittance (T0 = 10%) at 405 nm was similarly measured with the transparent acrylic plate 1 alone. Using the obtained T0 and T1, the transmittance (T2) of a monofilament alone at 405 nm was calculated according to the following formula (1).

$$T2 = T1 + (100 - T0) \quad (1)$$

[0044] On the other hand, for the transmittance of the woven mesh fabric, one woven mesh fabric was placed in a spectrophotometer in the same manner as described above without a transparent acrylic plate, and then a transmittance T3 at a wavelength of 405 nm was measured.

[0045] The transmittance measurement in the spectrophotometer is performed in the measurement mode: transmission mode, geometry: di = 0°, de = 0°, specular light treatment: SCI, measurement diameter: LAV (25.4 mm), UV conditions: 100% Full.

(2) Intrinsic Viscosity (IV)

[0046] The intrinsic viscosity (IV) of the yarn in the polyester monofilament was calculated according to the following formula (2).

[0047] The relative viscosity η_r in the formula (2) was obtained by the following formula (3) by dissolving 0.8 g of a sample in 10 mL of o-chlorophenol (hereinafter abbreviated as OCP) having a purity of 98% or more at 25°C and using an Ostwald viscometer at a temperature of 25°C.

$$\text{Intrinsic Viscosity (IV)} = 0.0242 \eta_r + 0.2634 \quad (2)$$

$$\eta_r = \eta/\eta_0 = (t \times d)/(t_0 \times d_0) \quad (3)$$

In formula (3),

η : Viscosity of sample solution

η_0 : Viscosity of OCP

t : Drop time of solution (seconds)

d : Solution density (g/cm³)

t_0 : Drop time of OCP (seconds)

d_0 : Solution density (g/cm³).

(3) Glass Transition Temperature (Tg)

[0048] Glass transition temperature Tg (°C) was determined as follows: 10 mg of a powder of the polyester to be used was collected; the temperature was raised at 16 °C/min with a differential scanning calorimeter (PerkinElmer Co., Ltd.: DSC-4 type), and the peak associated with the glass transition developed in the temperature rise process was processed with a data processing system manufactured by PerkinElmer Co., Ltd.

(4) Strength, Elongation, 10% Modulus

[0049] A Tensilon tensile tester manufactured by ORIENTEC Co., Ltd. was used to measure the strength, elongation, and modulus at 10% elongation at break at an initial sample length of 20 cm and a tensile speed of 2 cm/min were measured, and the average value of the values measured three times was determined as the strength (cN/dtex), elongation (%), and 10% modulus (cN/dtex), respectively.

(5) Single Fiber Fineness

[0050] The fineness of the monofilament was skeined by 500 m, and the value obtained by multiplying the mass of the skein by 20 was taken as the fineness.

(6) Boiling Water Shrinkage Rate

[0051] A monofilament was skeined using a measuring machine having a frame circumference of 100 cm to prepare a skein having 10 turns. A constant load was applied to the obtained skein, and the initial skein length L0 (mm) was measured. The weight was removed, immersed in warm water at 100°C for 15 minutes, dried for 30 minutes or more, and then subjected to a constant load to measure a skein length L1 (mm) after shrinkage, and the boiling water shrinkage rate (%) was calculated according to the following formula (4).

$$\text{Boiling water shrinkage rate} = (L_0 - L_1)/L_0 \times 100 \quad (4)$$

[0052] The load (g) applied during measurement of the initial skein length and the skein length after shrinkage was set according to the following formula (5) based on the total fineness T (dtex) of the yarn.

$$\text{Load} = T \times 0.9 \times (1/30) \times 20 \quad (5)$$

(7) Dynamic Friction Coefficient between Raw Yarn and Satin Metal

[0053] By the running yarn method, the yarn was brought into contact with a fixing pin (surface roughness: 6S (HRMS)) made of satin metal having a diameter d of 35 mm at a contact angle of $\theta = 180^\circ$, and unwound and run at a yarn speed of 55 m/min. That is, as shown in FIG. 2, when the monofilament Y unwound from a package (not shown) through an unwinding guide (not shown) was applied the load $N1 (= 10 \text{ g})$ by a balancer 9, then was passed through a fixing pin 11 made of satin metal through a direction change guide 10, and was taken up by a take-up roll 14 through a tension meter 13 after passing through a direction change guide 12, $N2 \text{ (g)}$ measured by the tension meter 13 was measured and calculated according to the following formula (6).

$$\text{Dynamic friction coefficient between raw yarn and satin metal} = 1/\pi \times \log e (N2/N1) \quad (6)$$

(8) Uster Unevenness U% (N)

[0054] A fineness variation chart (Diagram Mass) was obtained under the following measurement conditions using a Uster Tester UT-4CX manufactured by Zellweger Co., Ltd. without using a twister, and simultaneously, an average deviation rate (U%) was measured in the normal mode.

Yarn feeding speed: 200 m/min
 Measuring yarn length: 200 m
 Disk tension strength: 10%
 Scale: -10% to 10%

(9) Screen mesh cloth Quality

[0055] Using each of the polyester monofilaments in Examples and Comparative Examples of the present invention for both of the warp and the weft, a screen mesh cloth having a width of 2.2 m and a length of 300 m was woven by a loom made by Sulzer at a loom rotation speed of 200 rotations/min.

[0056] The obtained screen mesh cloth was caused to run at a speed of 2 m/min, a skilled inspection technician visually inspected the fluff and scum according to the inspection rules for a screen mesh cloth, and comprehensively evaluated the fluffing and scum based on the following four grades. The pass levels are A and B.

- A: The number of fluffing and scum defects is 0 to 1 per 30 m in length
- B: The number of fluffing and scum defects is 2 to 5 per 30 m in length
- C: The number of fluffing and scum defects is 6 to 9 per 30 m in length
- D: The number of fluffing and scum defects is 10 or more per 30 m in length

(10) Printing Accuracy

[0057] The printing evaluation was performed by direct digital platemaking using the screen mesh cloth. That is, the photosensitive emulsion was applied to the screen mesh cloth obtained in (9) and then was irradiated with a 405 nm laser for 40 seconds to form a 50 μm line pattern at intervals of 50 μm . After that, the line accuracy and the distortion of the printing pattern due to dimensional stability in printing 1000 sheets were observed, and comprehensively evaluated based on the following four grades. The pass levels are A, B, and C.

- A: The line accuracy and dimensional stability are extremely good
- B: The line accuracy is extremely good, and dimensional stability is good Alternatively, the line accuracy is good, and dimensional stability is extremely good
- C: The line accuracy and dimensional stability are good
- D: The line accuracy is good, but dimensional stability is poor

[0058] Alternatively, the line boundary may be uneven, but dimensional stability is good

(Example 1)

[0059] A polyethylene terephthalate (glass transition temperature: 80°C) with a titanium oxide content of 0.025 wt%, which had been polymerized and chipped by a common method, was melted at a temperature of 287°C using an extruder

(pressure melter), weighed by a pump, and then flowed into a common single component spinneret. The pipe passage time of the polymer was 30 minutes, and the pressure applied to the spinneret was 10 MPa. Thereafter, the yarn discharged from the spinneret was spun using a spinning device equipped with the equipment as shown in FIG. 3. That is, the polyester monofilament discharged from the spinneret 15 was cooled by applying a cooling air of 20 m/min by a yarn cooling air blowing device 16, an oil agent having an emulsion concentration of 4 wt% was applied by an oil feed roll 17, and then was taken up by a non-heated godet roll 18 at a speed of 900 m/min, thereby obtaining an undrawn yarn package 19. The oil agent applied to the undrawn yarn contains 54 wt% of a fatty acid alkyl ester and 7 wt% of a modified silicone product as a smoothing agent, an alkyl phosphate as an extreme pressure agent, an alkyl sulfonate as an antistatic agent, a nonionic ester and a nonionic ether as an emulsifier.

[0060] Subsequently, the undrawn yarn package 19 was used to perform drawing using a drawing device equipped with the equipment as shown in FIG. 4. That is, the yarn passed through a feed roll 20 was taken over by a first hot roll 21 heated to a temperature of 91°C at a speed of 174 m/min and by a second hot roll 22 heated to a temperature of 130°C at a speed of 710 m/min, so that drawing at a draw ratio of 4.1 and the heat setting were performed. Further, the drawn yarn was taken over by a cold godet roll 23 at a speed of 710 m/min, and then wound while the spindle rotational speed was controlled so as to obtain a drawn yarn package 24 of a polyester monofilament of 31.8 dtex (fiber diameter 54 μm).

[0061] The obtained polyester monofilament had a breaking strength of 4.7 cN/dtex, a breaking elongation of 44.5%, a 10% modulus of 3.0 cN/dtex, a titanium oxide amount of 0.025 wt%, and other physical properties are as shown in Table 1. When the obtained 31.8 dtex (54 μm) polyester monofilament was wound on a transparent acrylic plate for four rounds (eight layers) and irradiated with a wavelength of 405 nm, the transmittance was 39%.

[0062] Table 1 shows the evaluation results of the quality of the screen mesh cloth based on fluffing and scum defects when the obtained polyester monofilament was woven with a mesh number #120 and the printing evaluation results based on the line accuracy and the dimensional stability when irradiated with 405 nm laser for 40 seconds. The quality of the screen mesh cloth was very good as the fluffing and scum defects w 0 to 1 per 30 m in length. When the woven mesh fabric was irradiated with a wavelength of 405 nm, the transmittance was 82%. As a result of the printing evaluation, the line accuracy was extremely good, good results were obtained for dimensional stability, and overall excellent printing accuracy was obtained.

(Example 2)

[0063] A polyester monofilament of 32.0 dtex was obtained in the same manner as in Example 1 except that the titanium oxide content was changed to 0.001 wt%.

[0064] The titanium oxide amount of the obtained polyester monofilament is 0.001 wt%, and the other physical properties are as shown in Table 1. The transmittance when irradiated with a wavelength of 405 nm was as high as 46%, which was higher than that of Example 1, because of the decrease in the titanium oxide content. On the other hand, since the formation of fine unevenness on the fiber surface is prevented because of the decrease in the titanium oxide content, the dynamic friction coefficient between the raw yarn and the satin metal was slightly higher than that in Example 1. As for the screen mesh cloth quality, the fluffing and scum defects were the same as those in Example 1, and the results were extremely good. When the woven mesh fabric was irradiated with a wavelength of 405 nm, the transmittance was 86%. As the printing evaluation results, the line accuracy and the dimensional stability were the same as those in Example 1, and excellent printing accuracy was obtained.

(Comparative Example 1)

[0065] A polyester monofilament of 32.5 dtex was obtained in the same manner as in Example 1 except that the transmittance when irradiated with a wavelength of 405 nm was set to 18% by changing the titanium oxide content to 0.500 wt%.

[0066] The titanium oxide amount of the obtained polyester monofilament is 0.500 wt%, and the other properties are as shown in Table 1. Since the titanium oxide content was increased, the dynamic friction coefficient between the raw yarn and the satin metal was lower than that in Example 1, but the transmittance when irradiated with a wavelength of 405 nm was significantly reduced to 18%. As for the screen mesh cloth quality, the result was extremely good as in Example 1. On the other hand, the transmittance when the woven mesh fabric was irradiated with a wavelength of 405 nm was 68%. As the printing evaluation results, since the time for emulsion curing was insufficient, unevenness occurred at the line boundary, and the printing accuracy was significantly inferior to that in Example 1 from the viewpoint of line accuracy.

(Example 3)

[0067] A polyester monofilament of 32.4 dtex was obtained in the same manner as in Example 1 except that the intrinsic viscosity was changed.

[0068] The obtained polyester monofilament had an intrinsic viscosity of 0.77, a breaking strength of 5.5 cN/dtex, a breaking elongation of 32.4%, and a 10% modulus of 3.9 cN/dtex. The other physical properties were as shown in Table 1, by increasing the IV as compared with Example 1, the stress applied to the yarn during spinning and drawing was increased, and a yarn with the high strength, low elongation, and high modulus was obtained. As for the screen mesh cloth quality, the result was extremely good as in Example 1. As the printing evaluation results, the line accuracy was extremely good, and because of the high strength and low elongation, the dimensional stability was improved as compared with Example 1, and the printing accuracy was extremely good.

[0069] Results of Examples 1 to 3 and Comparative Example 1 are shown in Table 1.

Table 1

			Example 1	Example 2	Comparative Example 1	Example 3
Kind of Polyester			PET	PET	PET	PET
Yarn production Process			Two-step Method	Two-step Method	Two-step Method	Two-step Method
Drawing Method			One-stage Drawing	One-stage Drawing	One-stage Drawing	One-stage Drawing
Cross-sectional Form of Yarn			Single Component	Single Component	Single Component	Single Component
Oil Emulsion	Content of Fatty Acid Alkyl Ester	wt%	54	54	54	54
	Content of Modified silicone product	wt%	7	7	7	7
	Emulsion Concentration	wt%	4	4	4	4
Spinning Godet Roll	Speed	m/min	900	900	900	900
First Hot Roll	Temperature	°C	91	91	91	91
	Speed	m/min	174	174	174	174
Second hot roll	Temperature	°C	130	130	130	130
	Speed	m/min	710	710	710	710
Drawing Cold Godet Roll	Speed	m/min	710	710	710	710
Draw ratio		Times	4.1	4.1	4.1	4.1
Titanium Oxide Content of Yarn		wt%	0.025	0.001	0.500	0.025
Intrinsic Viscosity of Yarn		-	0.64	0.64	0.63	0.77
Single Fiber Fineness		dtex	31.8	32.0	32.5	32.4
Breaking Strength		cN/dtex	4.7	4.8	4.7	5.5
Breaking Elongation		%	44.5	43.6	44.9	32.4
10% Modulus		cN/dtex	3.0	3.1	2.9	3.9
Boiling Water Shrinkage Rate		%	6.7	6.8	6.5	8.8

(continued)

		Example 1	Example 2	Comparative Example 1	Example 3	
Dynamic Friction Coefficient between Raw yarn and Satin Metal		-	0.159	0.168	0.141	0.148
Oil Adhesion Amount of Drawn Yarn		wt%	0.13	0.14	0.15	0.16
Uster Unevenness U% (N)		%	0.99	1.15	0.97	1.01
Transmittance when Monofilament was irradiated with Wavelength of 405 nm		%	39	46	18	35
Screen mesh cloth	Platemaking/Printing Method		Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking
	Mesh Number		#120	#120	#120	#120
	Transmittance when Woven Mesh Fabric was irradiated with Wavelength of 405 nm	%	82	86	68	-
	Screen mesh cloth Quality		A	A	A	A
	Printing Accuracy		B	B	D	A

(Example 4)

[0070] A polyester monofilament of 31.1 dtex was obtained in the same manner as in Example 1 except that the intrinsic viscosity was changed.

[0071] The obtained polyester monofilament had an intrinsic viscosity of 0.92, a breaking strength of 6.3 cN/dtex, a breaking elongation of 21.3%, and a 10% modulus of 5.1 cN/dtex. The other physical properties were as shown in Table 2, and as in Example 3, a yarn with a high strength, a low elongation, and a high modulus was obtained by increasing IV as compared with Example 1. As for the screen mesh cloth quality, the result was extremely good as in Example 1. As the printing evaluation results, because of the increase in intrinsic viscosity, the shear stress at the spinneret increased, resulting in the Uster unevenness U% (N) being slightly worse than in Example 1 and resulting in inferior fiber diameter uniformity, the line accuracy was slightly inferior to that in Example 1. On the other hand, because of the high strength and low elongation, dimensional stability was improved as compared with Example 1, and the overall printing accuracy was the same as that in Example 1.

(Comparative Example 2)

[0072] A polyester monofilament of 33.0 dtex was obtained in the same manner as in Example 1 except that the intrinsic viscosity was changed.

[0073] The obtained polyester monofilament had an intrinsic viscosity of 0.55, a breaking strength of 4.2 cN/dtex, a breaking elongation of 52.4%, and a 10% modulus of 2.3 cN/dtex. The other physical properties were as shown in Table 2, and a yarn having a low strength, a high elongation, and a low modulus was obtained by lowering the IV as compared with Example 1. As for the screen mesh cloth quality, the result was extremely good as in Example 1. As the print evaluation results, since the modulus was lower than that in Example 1, the cloth tensioning stability was lowered, and the line accuracy was lowered as compared with Example 1. The dimensional stability was also greatly lowered from the occurrence of the cloth elongation due to the low strength and high elongation, and the printing accuracy was significantly inferior to that in Example 1.

(Example 5)

[0074] A polyester monofilament of 33.0 dtex was obtained in the same manner as in Example 1 except that the spinning speed (the speed of the spinning godet roll) was changed.

[0075] The obtained polyester monofilament had a breaking strength of 6.0 cN/dtex, a breaking elongation of 26.5%,

a 10% modulus of 4.7 cN/dtex, and other physical properties as shown in Table 2. In the case where the spinning speed was high, the orientation of the fiber surface was increased, fluffing defects and scum defects in the weaving process were slightly increased as compared with Example 1, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, the line accuracy was extremely good, and because of the high strength and low elongation, the dimensional stability was improved as compared with Example 1, and the printing accuracy was extremely good.

(Example 6)

[0076] A polyester monofilament of 32.7 dtex was obtained in the same manner as in Example 1 except that the content of the fatty acid alkyl ester in the oil agent was changed.

[0077] The physical properties of the obtained polyester monofilament were as shown in Table 2, and the dynamic friction coefficient between the raw yarn and the satin metal was 0.190, which was higher than that in Example 1. Because of the higher friction than in Example 1, fluffing defects and scum defects were slightly increased in the weaving process, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, both the line accuracy and the dimensional stability were the same as those in Example 1, and excellent printing accuracy was obtained.

[0078] The results of Examples 4 to 6 and Comparative Example 2 are shown in Table 2.

Table 2

			Example 4	Comparative Example 2	Example 5	Example 6
Kind of Polyester			PET	PET	PET	PET
Yarn production Process			Two-step Method	Two-step Method	Two-step Method	Two-step Method
Drawing Method			One-stage Drawing	One-stage Drawing	One-stage Drawing	One-stage Drawing
Cross-sectional Form of Yarn			Single Component	Single Component	Single Component	Single Component
Oil Emulsion	Content of Fatty Acid Alkyl Ester	wt%	54	54	54	43
	Content of Modified silicone product	wt%	7	7	7	7
	Emulsion Concentration	wt%	4	4	4	4
Spinning Godet Roll	Speed	m/min	900	900	1320	900
First Hot Roll	Temperature	°C	91	91	91	91
	Speed	m/min	174	174	174	174
Second hot roll	Temperature	°C	130	130	130	130
	Speed	m/min	710	710	710	710
Drawing Cold Godet Roll	Speed	m/min	710	710	710	710
Draw ratio		Times	4.1	4.1	4.1	4.1
Titanium Oxide Content of Yarn		wt%	0.025	0.025	0.025	0.025
Intrinsic Viscosity of Yarn		-	0.92	0.55	0.64	0.64
Single Fiber Fineness		dtex	31.1	33.0	33.0	32.7

(continued)

		Example 4	Comparative Example 2	Example 5	Example 6	
Breaking Strength		cN/dtex	6.3	4.2	6.0	4.7
Breaking Elongation		%	21.3	52.4	26.5	44.3
10% Modulus		cN/dtex	5.1	2.3	4.7	3.0
Boiling Water Shrinkage Rate		%	11.1	6.1	9.6	6.6
Dynamic Friction Coefficient between Raw Yarn and Satin Metal		-	0.161	0.155	0.159	0.190
Oil Adhesion Amount of Drawn Yarn		wt%	0.15	0.12	0.15	0.15
Uster Unevenness U% (N)		%	1.45	1.17	1.00	0.97
Transmittance when Monofilament was irradiated with Wavelength of 405 nm		%	35	37	37	37
Screen mesh cloth	Plate making/Printing Method		Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking
	Mesh Number		#120	#120	#120	#120
	Screen mesh cloth Quality		A	A	B	B
	Printing Accuracy		B	D	A	B

(Example 7)

[0079] A polyester monofilament of 32.1 dtex was obtained in the same manner as in Example 1 except that the content of the modified silicone product in the oil agent was changed to 2 wt%.

[0080] The physical properties of the obtained polyester monofilament were as shown in Table 3, and the dynamic friction coefficient between the raw yarn and the satin metal was 0.203, which was higher than that of Example 1. Because of the higher friction than in Example 1, fluffing defects and scum defects were slightly increased in the weaving process, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, the line accuracy was slightly inferior to that in Example 1 since partial fluffing and printing defects occurred. The dimensional stability was good as in Example 1, and the overall printing accuracy was slightly inferior to that in Example 1, but generally excellent printing accuracy was obtained.

(Example 8)

[0081] A polyester monofilament of 33.0 dtex was obtained in the same manner as in Example 1 except that the content of the modified silicone product in the oil agent was changed to 5 wt%.

[0082] The physical properties of the obtained polyester monofilament were as shown in Table 3, and the dynamic friction coefficient between the raw yarn and the satin metal was 0.184, which was higher than that of Example 1. Because of the higher friction than in Example 1, fluffing defects and scum defects were slightly increased in the weaving process, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, both the line accuracy and the dimensional stability were the same as those in Example 1, and excellent printing accuracy was obtained.

(Example 9)

[0083] A polyester monofilament of 33.1 dtex was obtained in the same manner as in Example 1 except that the content of the modified silicone product in the oil agent was changed to 9 wt%.

[0084] The physical properties of the obtained polyester monofilament were as shown in Table 3, and the dynamic friction coefficient between the raw yarn and the satin metal was 0.160, which was equivalent to that in Example 1. However, the oil film cracking on the oil feed roll occurred in the yarn production process. As a result, non-uniform adhesion of oil to the yarn was considered to have occurred, and fluffing defects and scum defects increased slightly during the weaving process, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, both the line accuracy and the dimensional stability were the same as those in Example 1, and excellent printing accuracy was obtained.

(Example 10)

[0085] A polyester monofilament of 32.9 dtex was obtained in the same manner as in Example 1 except that the oil adhesion amount of the drawn yarn was changed to 0.35 wt%. The physical properties of the obtained polyester monofilament were as shown in Table 3. As for the screen mesh cloth quality, the fluffing and scum defects were the same as those in Example 1, and the result was extremely good. As the printing evaluation results, the line accuracy and the dimensional stability were the same as those in Example 1, and excellent printing accuracy was obtained.

[0086] The results of Examples 7 to 10 are shown in Table 3.

Table 3

			Example 7	Example 8	Example 9	Example 10
Kind of Polyester			PET	PET	PET	PET
Yarn production Process			Two-step Method	Two-step Method	Two-step Method	Two-step Method
Drawing Method			One-stage Drawing	One-stage Drawing	One-stage Drawing	One-stage Drawing
Cross-sectional Form of Yarn			Single Component	Single Component	Single Component	Single Component
Oil Emulsion	Content of Fatty Acid Alkyl Ester	wt%	54	54	54	54
	Content of Modified silicone product	wt%	2	5	9	7
	Emulsion Concentration	wt%	4	4	4	4
Spinning Godet Roll	Speed	m/min	900	900	900	900
First Hot Roll	Temperature	°C	91	91	91	91
	Speed	m/min	174	174	174	174
Second hot roll	Temperature	°C	130	130	130	130
	Speed	m/min	710	710	710	710
Drawing Cold Godet Roll	Speed	m/min	710	710	710	710
Draw ratio		Times	4.1	4.1	4.1	4.1
Titanium Oxide Content of Yarn		wt%	0.025	0.025	0.025	0.025
Intrinsic Viscosity of Yarn		-	0.64	0.64	0.64	0.64

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(continued)

		Example 7	Example 8	Example 9	Example 10	
Single Fiber Fineness		dtex	32.1	33.0	33.1	32.9
Breaking Strength		cN/ dtex	4.6	4.6	4.7	4.8
Breaking Elongation		%	44.8	45.2	44.8	43.2
10% Modulus		cN/ dtex	3.0	2.9	3.0	3.1
Boiling Water Shrinkage Rate		%	6.5	6.3	6.4	6.9
Dynamic Friction Coefficient between Raw Yarn and Satin Metal		-	0.203	0.184	0.160	0.145
Oil Adhesion Amount of Drawn Yarn		wt%	0.14	0.14	0.13	0.35
Uster Unevenness U% (N)		%	0.99	0.99	0.96	1.04
Transmittance when Monofilament was irradiated with Wavelength of 405 nm		%	38	38	35	37
Screen mesh cloth	Platemaking/ Printing Method		Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking
	Mesh Number		#120	#120	#120	#120
	Screen mesh cloth Quality		B	B	B	A
	Printing Accuracy		C	B	B	B

(Example 11)

[0087] A polyester monofilament of 33.1 dtex was obtained in the same manner as in Example 1 except that the oil adhesion amount of the drawn yarn was changed to 0.07 wt%.

[0088] The physical properties of the obtained polyester monofilament were as shown in Table 4, and the dynamic friction coefficient between the raw yarn and the satin metal was 0.191, which was higher than that in Example 1. Because of the higher friction than in Example 1, fluffing defects and scum defects were slightly increased in the weaving process, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, the line accuracy was slightly inferior to that in Example 1 since partial fluffing and printing defects occurred. The dimensional stability was good as in Example 1, and the overall printing accuracy was slightly inferior to that in Example 1, but generally excellent printing accuracy was obtained.

(Example 12)

[0089] A polyester monofilament of 32.1 dtex was obtained in the same manner as in Example 1 except that the oil adhesion amount of the drawn yarn was changed to 0.75 wt%.

[0090] The physical properties of the obtained polyester monofilament were as shown in Table 4, by increasing the oil adhesion amount of the drawn yarn as compared with Example 1, the oil was dropped in the weaving process and scum defects were generated, and the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, the line accuracy was slightly inferior to that in Example 1 since scum was partially mixed in the woven fabric and printing defects were generated. The dimensional stability was good as in Example 1, and the overall printing accuracy was slightly inferior to that in Example 1, but generally excellent printing accuracy was obtained.

(Example 13)

[0091] A polyester monofilament of 32.1 dtex was obtained in the same manner as in Example 1 except that the temperature of the first hot roll was changed in the drawing step.

[0092] The physical properties of the obtained polyester monofilament were as shown in Table 4. As for the screen mesh cloth quality, the result was extremely good as in Example 1. As the printing evaluation results, since the preheating for drawing was insufficient, the Uster unevenness U% (N) was slightly worse as compared with Example 1, resulting in inferior fiber diameter uniformity, so that the line accuracy was slightly inferior to that in Example 1. The dimensional stability was as good as in Example 1, and the overall printing accuracy was slightly inferior to that in Example 1, but generally excellent printing accuracy was obtained.

(Example 14)

[0093] A polyester monofilament of 31.8 dtex was obtained in the same manner as in Example 1 except that the speed of the first hot roll was changed and the draw ratio was changed to 4.7 times in the drawing process.

[0094] The obtained polyester monofilament had a breaking strength of 5.5 cN/dtex, a breaking elongation of 30.0%, a 10% modulus of 4.3 cN/dtex, and other physical properties as shown in Table 4. Compared to Example 1, the fiber surface orientation was increased due to a high draw ratio, and the number of fluffing defects and the number of scum defects were slightly increased in the weaving process. As a result, the screen mesh cloth quality was slightly inferior to that in Example 1, but not problematic in practical use. As the printing evaluation results, the line accuracy and the dimensional stability were the same as those in Example 1, and excellent printing accuracy was obtained.

[0095] The results of Examples 11 to 14 are shown in Table 4.

Table 4

			Example 11	Example 12	Example 13	Example 14
Kind of Polyester			PET	PET	PET	PET
Yarn production Process			Two-step Method	Two-step Method	Two-step Method	Two-step Method
Drawing Method			One-stage Drawing	One-stage Drawing	One-stage Drawing	One-stage Drawing
Cross-sectional Form of Yarn			Single Component	Single Component	Single Component	Single Component
Oil Emulsion	Content of Fatty Acid Alkyl Ester	wt%	54	54	54	54
	Content of Modified silicone product	wt%	7	7	7	7
	Emulsion Concentration	wt%	4	4	4	4
Spinning Godet Roll	Speed	m/min	900	900	900	900
First Hot Roll	Temperature	°C	91	91	75	91
	Speed	m/min	174	174	174	150
Second hot roll	Temperature	°C	130	130	130	130
	Speed	m/min	710	710	710	710
Drawing Cold Godet Roll	Speed	m/min	710	710	710	710
Draw ratio		Times	4.1	4.1	4.1	4.7

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(continued)

		Example 11	Example 12	Example 13	Example 14
5	Titanium Oxide Content of Yarn	wt%	0.025	0.025	0.025
	Intrinsic Viscosity of Yarn	-	0.64	0.64	0.64
	Single Fiber Fineness	dtex	33.1	32.1	31.8
10	Breaking Strength	cN/ dtex	4.7	4.7	4.7
	Breaking Elongation	%	46.1	44.1	44.0
	10% Modulus	cN/ dtex	2.9	3.0	3.0
15	Boiling Water Shrinkage Rate	%	6.5	6.3	6.7
	Dynamic Friction Coefficient between Raw Yarn and Satin Metal	-	0.191	0.152	0.164
20	Oil Adhesion Amount of Drawn Yarn	wt%	0.07	0.75	0.15
	Uster Unevenness U% (N)	%	1.31	1.00	1.71
25	Transmittance when Monofilament was irradiated with Wavelength of 405 nm	%	36	40	35
30	Screen mesh cloth	Platemaking/ Printing Method	Direct Digital Platemaking	Direct Digital Platemaking	Direct Digital Platemaking
		Mesh Number	#120	#120	#120
		Screen mesh cloth Quality	B	B	A
35		Printing Accuracy	C	C	C

(Example 15)

[0096] A polyester monofilament of 20.0 dtex (fiber diameter of 43 μm) was obtained in the same manner as in Example 1 except that the draw ratio was changed to 4.3 times by changing the first hot roll speed and the target fineness was changed by changing the discharge amount.

[0097] The obtained polyester monofilament had a breaking strength of 5.6 cN/dtex, a breaking elongation of 32.5%, a 10% modulus of 4.1 cN/dtex, and other physical properties as shown in Table 5. The polyester monofilament of 20.0 dtex (43 μm) was wound around a transparent acrylic plate for five rounds (10 layers) so as to have a density equivalent to that of a plate-wound sample obtained by winding a filament of 32 dtex (54 μm) for four rounds (8 layers), and the transmittance when irradiated with a wavelength of 405 nm was 37%.

[0098] In order to make the strength of the screen mesh cloth equal to that in Example 1, the obtained polyester monofilament was woven with a mesh number #220, and the cloth quality and the printing accuracy were evaluated. As for the screen mesh cloth quality, the result was extremely good as in Example 1. As the printing evaluation results, the line accuracy was extremely good, and in addition, the dimensional stability was improved due to the high strength and high modulus as compared with Example 1, and the printing accuracy was extremely good.

(Example 16)

[0099] A polyester monofilament of 8.0 dtex (fiber diameter of 27 μm) was obtained in the same manner as in Example 1 except that the draw ratio was changed to 4.3 times by changing the first hot roll speed and the target fineness was changed by changing the discharge amount.

[0100] The obtained polyester monofilament had a breaking strength of 5.4 cN/dtex, a breaking elongation of 37.0%, a 10% modulus of 3.8 cN/dtex, and other physical properties as shown in Table 5. A polyester monofilament of 8.0 dtex (27 μm) was wound around a transparent acrylic plate for eight rounds (16 layers) so as to have a density equivalent to that of a plate-wound sample obtained by winding a filament of 32 dtex (54 μm) for four rounds (8 layers), and the transmittance when irradiated with a wavelength of 405 nm was 38%.

[0101] In order to make the strength of the screen mesh cloth equal to that in Example 1, the obtained polyester monofilament was woven with a mesh number #380, and the cloth quality and the printing accuracy were evaluated. As for the screen mesh cloth quality, the result was extremely good as in Example 1. As the printing evaluation results, the line accuracy was extremely good, and in addition, the dimensional stability was improved because of the high strength and high modulus as compared with Example 1, and the printing accuracy was extremely good.

[0102] The results of Examples 15 to 16 are shown in Table 5.

Table 5

			Example 15	Example 16
Kind of Polyester			PET	PET
Yarn production Process			Two-step Method	Two-step Method
Drawing Method			One-stage Drawing	One-stage Drawing
Cross-sectional Form of Yarn			Single Component	Single Component
Oil Emulsion	Content of Fatty Acid Alkyl Ester	wt%	54	54
	Content of Modified silicone product	wt%	7	7
	Emulsion Concentration	wt%	4	4
Spinning Godet Roll	Speed	m/min	900	900
First Hot Roll	Temperature	°C	91	91
	Speed	m/min	165	165
Second hot roll	Temperature	°C	130	130
	Speed	m/min	710	710
Drawing Cold Godet Roll	Speed	m/min	710	710
Draw ratio		Times	4.3	4.3
Titanium Oxide Content of Yarn		wt%	0.025	0.025
Intrinsic Viscosity of Yarn		-	0.72	0.71
Single Fiber Fineness		dtex	20.0	8.0
Breaking Strength		cN/dtex	5.6	5.4
Breaking Elongation		%	32.5	37.0
10% Modulus		cN/dtex	4.1	3.8
Boiling Water Shrinkage Rate		%	8.2	8.0
Dynamic Friction Coefficient between Raw yarn and Satin Metal		-	0.162	0.157
Oil Adhesion Amount of Drawn Yarn		wt%	0.16	0.20
Uster Unevenness U% (N)		%	0.81	0.62
Transmittance when Monofilament was irradiated with Wavelength of 405 nm		%	37	38

(continued)

			Example 15	Example 16
Screen mesh cloth	Platemaking/Printing Method		Direct Digital Platemaking	Direct Digital Platemaking
	Mesh Number		#220	#380
	Screen mesh cloth Quality		A	A
	Printing Accuracy		A	A

(Example 17)

[0103] A core-sheath composite polyester monofilament was produced by a one-step method (direct spinning and drawing method) using a yarn production device equipped with the equipment shown in FIG. 5. That is, polyethylene terephthalate (glass transition temperature: 80°C) having a titanium oxide content of 0.025 wt% and an intrinsic viscosity of 1.00 as a high-viscosity polymer, and polyethylene terephthalate (glass transition temperature 80°C) having a titanium oxide content of 0.025 wt% and an intrinsic viscosity of 0.51 as a low-viscosity polymer were polymerized by a common method to form a chip. The obtained two kinds of polyethylene terephthalate were melted at a temperature of 298°C using an extruder, weighed by a pump at a polymer temperature of 295°C, and flowed into a common composite spinneret 25 so that the high-viscosity polymer was arranged in the core component and the low-viscosity polymer was arranged in the sheath component at a core-sheath ratio of 80:20. The pressure applied to the spinneret was 18 MPa for the core component, and the pipe passage time of the core component polymer was 10 minutes. Thereafter, the polyester monofilament discharged from the composite spinneret 25 was actively heated and maintained warm by a heat-insulating cylinder 26 at 380°C, and then was cooled by applying cool air at a speed of 10 m/min by a yarn cooling blowing device 27. After applying an oil agent having an emulsion concentration of 10 wt% by an oil feed roll 28, the yarn was taken up by a non-heated spinning godet roll 29 at a speed of 500 m/min, and was, without being wound up once, taken up by a first hot roll 30 heated to a temperature of 91 °C at a speed of 505 m/min, a second hot roll 31 heated to a temperature of 91 °C at a speed of 2,092 m/min and a third hot roll 32 heated to a temperature of 200°C at a speed of 2,929 m/min, so that two-stage drawing at a draw ratio of 5.8 times and heat setting were performed. Further, after taken up by the cold godet rolls 33, 34 at a speed of 2,929 m/min, the drawn yarn was wound while the spindle rotational speed was controlled such that the winding tension was 0.3 cN/dtex by a yarn winding device 35, thereby obtaining a drawn yarn package 36 of a core-sheath composite polyester monofilament of 6.0 dtex (fiber diameter of 24 μm). The oil agent applied to the polyester monofilament contains 54 wt% of a fatty acid alkyl ester and 7 wt% of silicone modified product as a smoothing agent, an alkyl phosphate as an extreme pressure agent, an alkyl sulfonate as an antistatic agent, a nonionic ester and a nonionic ether as an emulsifier.

[0104] The obtained polyester monofilament had a breaking strength of 8.5 cN/dtex, a breaking elongation of 13.7%, a 10% modulus of 8.1 cN/dtex, a titanium oxide amount of 0.025 wt%, an intrinsic viscosity of 0.81, and other physical properties as shown in Table 6. When a polyester monofilament of 6.0 dtex (24 μm) was wound around a transparent acrylic plate for nine rounds (18 layers) such that the density was equivalent to that of a plate-wound sample in which a filament of 32 dtex (54 μm) was wound four rounds (eight layers), and was irradiated with the wavelength of 405 nm, the transmittance was 31%. It was considered that since the cross-sectional shape of the yarn was a core-sheath composite, light rays with a wavelength of 405 nm were slightly reflected and scattered at the interface between the core and the sheath, and the transmittance was slightly lower than that in Example 1.

[0105] Table 6 shows the evaluation results of the screen mesh cloth quality due to fluffing and scum defects when the obtained polyester monofilament was woven with a mesh number #420 and the printing evaluation results based on the line accuracy and the dimensional stability. As the screen mesh cloth quality, a low-viscosity polymer was arranged in the sheath component, but due to the high modulus, the fluffing and scum defects was 2 to 5 per 30 m in length, which was slightly inferior to that in Example 1, but there was no problem in practical use. As the printing evaluation results, although the transmittance of the yarn was slightly lower than that in Example 1, the line accuracy was not affected and the cloth stability was improved, extremely good line accuracy was obtained as in Example 1. With respect to dimensional stability, extremely excellent dimensional stability was obtained due to the high strength and the low elongation, and overall excellent printing accuracy was obtained as compared with Example 1.

(Comparative Example 3)

[0106] Similarly to Example 17, a core-sheath composite polyester monofilament was produced by a one-step method (direct spinning drawing method). At this time, the speed of the spinning godet roll was changed to 475 m/min, the speed

of the first hot roll was changed to 480 m/min, and the draw ratio was changed to 6.2. In addition, the temperature of the third hot roll was changed to 220°C, and the other manufacturing conditions were similar to Example 17, a core-sheath composite polyester monofilament of 6.0 dtex (fiber diameter of 24 μm) was obtained.

[0107] The physical properties of the polyester monofilament obtained were as follows: a breaking strength of 9.2 cN/dtex, a breaking elongation of 10.2%, a 10% modulus of 9.1 cN/dtex, a boiling water shrinkage rate of 4.8%, and a titanium oxide content of 0.025 wt%, and the other physical properties were as shown in Table 6. When a polyester monofilament of 6.0 dtex (24 μm) was wound around a transparent acrylic plate for nine rounds (18 layers) such that the density was equivalent to that of a plate-wound sample in which a filament of 32 dtex (54 μm) was wound four rounds (eight layers), and was irradiated with the wavelength of 405 nm, the transmittance was 26%. In addition to the reflection and scattering of light rays of 405 nm due to a core-sheath composite cross section, the yarn was slightly whitened because of the proceeding of excessive crystallization. As a result, the transmittance was inferior to that in Example 1.

[0108] Table 6 shows the evaluation results of the screen mesh cloth quality based on fluffing and scum defects when the obtained polyester monofilament was woven with a mesh number #420 and the printing evaluation results based on the line accuracy and the dimensional stability. In the weaving process, the drawing margin of the cloth was reduced by decreasing the low elongation, and the yarn breakage was increased. As for the screen mesh cloth quality, the number of fluffing and scum defects were 6 to 9 per 30 m in length because of the higher draw ratio and the higher modulus as compared with Example 17. The result was significantly inferior to that in Example 1. As the printing evaluation results, since the transmittance of the yarn was lower than that in Example 1, the emulsion curing was more or less insufficient, though it was better than Comparative Example 1, and the line boundary was uneven, so that the printing accuracy was far inferior to Example 1 from the viewpoint of line accuracy.

[0109] The results of Example 17 and Comparative Example 3 are shown in Table 6.

[Table 6]

			Example 17	Comparative Example 3
Kind of Polyester			PET	PET
Yarn production Process			One-step Method	One-step Method
Drawing Method			Two-stage Drawing	Two-stage Drawing
Cross-sectional Form of Yarn			Core-sheath Composite	Core-sheath Composite
Oil Emulsion	Content of Fatty Acid Alkyl Ester	wt%	54	54
	Content of Modified silicone product	wt%	7	7
	Emulsion Concentration	wt%	10	10
Spinning Godet Roll	Speed	m/min	500	475
First Hot Roll	Temperature	°C	91	91
	Speed	m/min	505	480
Second hot roll	Temperature	°C	91	91
	Speed	m/min	2092	2092
Third hot roll	Temperature	°C	200	220
	Speed	m/min	2929	2929
Drawing Cold Godet Roll	Speed	m/min	2929	2929
Draw ratio		Times	5.8	6.2
Titanium Oxide Content of Yarn		wt%	0.025	0.025
Intrinsic Viscosity of Yarn		-	0.81	0.81
Single Fiber Fineness		dtex	6.0	6.0

(continued)

			Example 17	Comparative Example 3
5	Breaking Strength	cN/ dtex	8.5	9.2
	Breaking Elongation	%	13.7	10.2
10	10% Modulus	cN/ dtex	8.1	9.1
	Boiling Water Shrinkage Rate	%	6.2	4.8
	Dynamic Friction Coefficient between Raw yarn and Satin Metal	-	0.166	0.166
15	Oil Adhesion Amount of Drawn Yarn	wt%	0.48	0.48
	Uster Unevenness U% (N)	%	0.74	0.77
20	Transmittance when Monofilament was irradiated with Wavelength of 405 nm	%	31	26
	Screen mesh cloth	Platemaking/Printing Method	Direct Digital Platemaking	Direct Digital Platemaking
		Mesh Number	#420	#120
25		Screen mesh cloth Quality	B	C
		Printing Accuracy	A	D

[0110] Although the present invention has been described in detail with reference to specific embodiments, it will be apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the present invention. This application is based on Japanese Patent Application No. 2018-182614 filed on September 27, 2018, the contents of which are incorporated herein by reference.

REFERENCE SIGNS LIST

[0111]

- Y: Monofilament
- d: Diameter of satin metal roll
- 1: Transparent acrylic plate
- 2: Aligned winding evaluation device
- 3: Unwinding guide
- 4: Nip roll
- 5: Tensor
- 6: Direction change roll
- 7: Yarn path regulation guide
- 8: Plate-wound sample
- 9: Balancer
- 10: Direction change guide
- 11: Fixing pin made of satin metal
- 12: Direction change guide
- 13: Tension meter
- 14: Take-up roll
- 15: Spinneret
- 16: Yarn cooling air blowing device
- 17: Oil feed roll
- 18: Godet roll
- 19: Undrawn yarn package

20: Feed roll
 21: First hot roll
 22: Second hot roll
 23: Cold godet roll
 24: Drawn yarn package 25: Composite spinneret
 26: Heat-insulating cylinder
 27: Yarn cooling air blowing device
 28: Oil feed roll
 29: Spinning godet roll
 30: First hot roll
 31: Second hot roll
 32: Third hot roll
 33: Cold godet roll
 34: Cold godet roll
 35: Yarn winding device
 36: Drawn yarn package

Claims

1. A polyester monofilament for a screen mesh cloth, the polyester monofilament having:
 - a transmittance of 30% or more when the polyester monofilament is irradiated with a wavelength of 405 nm;
 - a breaking strength of 4.3 cN/dtex to 9.0 cN/dtex;
 - a breaking elongation of 11.0% to 50.0%; and
 - a 10% modulus of 2.5 cN/dtex to 9.0 cN/dtex.
2. The polyester monofilament for a screen mesh cloth according to claim 1, wherein a coefficient of dynamic friction between a raw yarn and a satin metal is 0.100 to 0.170.
3. A woven mesh fabric for direct digital platemaking, wherein the polyester monofilament according to claim 1 or 2 is disposed on at least a part of at least one of a warp and a weft.

FIG. 1

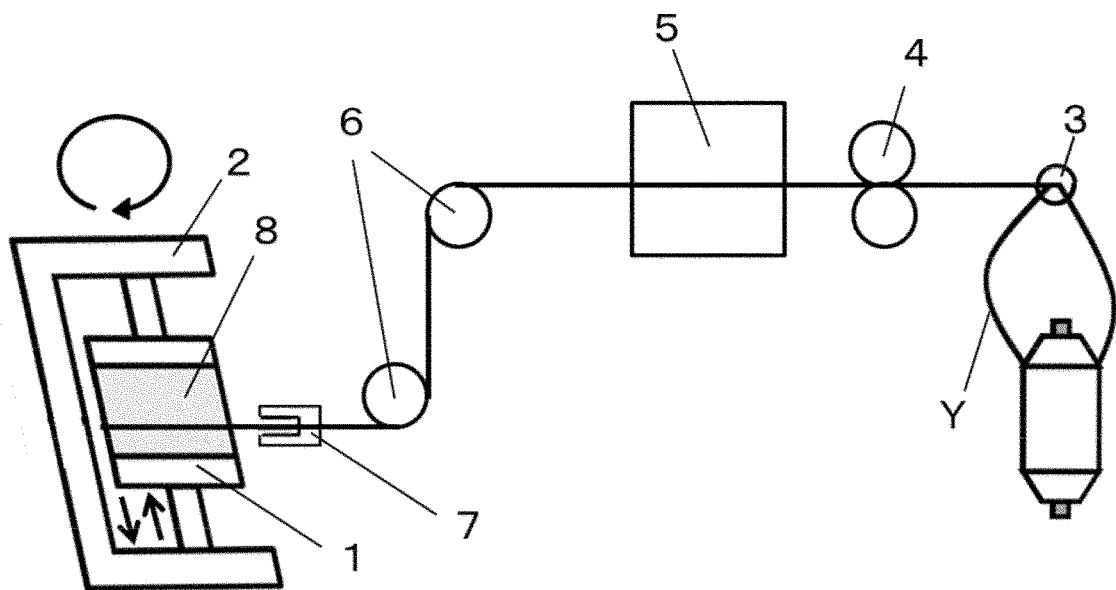


FIG. 2

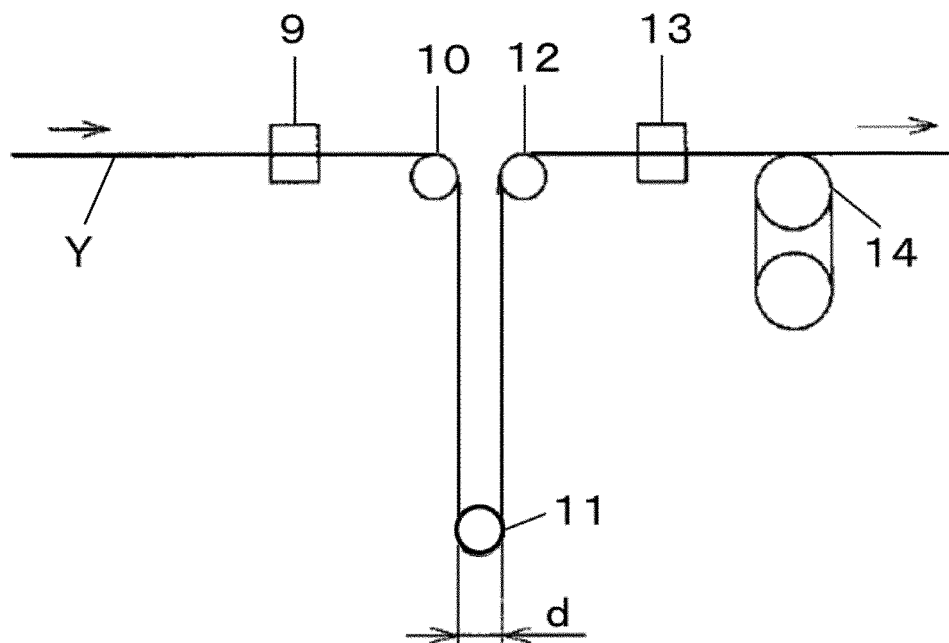


FIG. 3

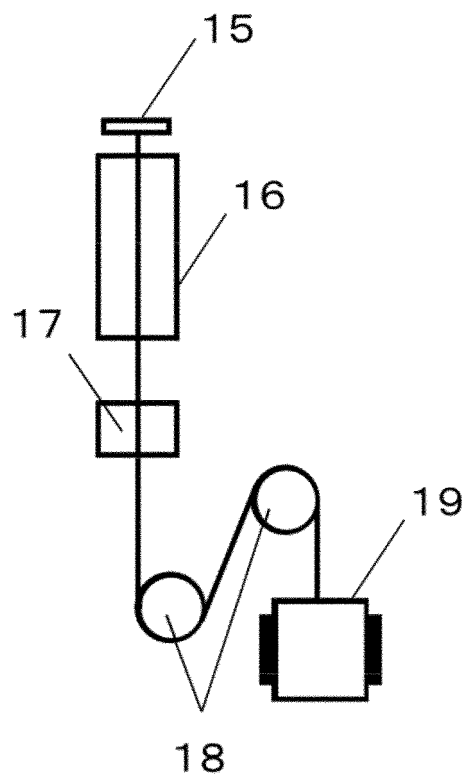


FIG. 4

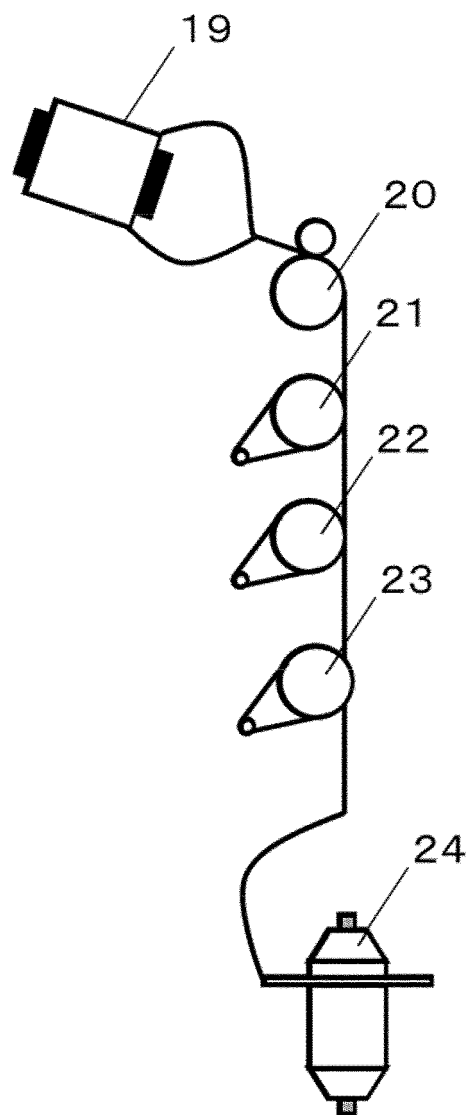
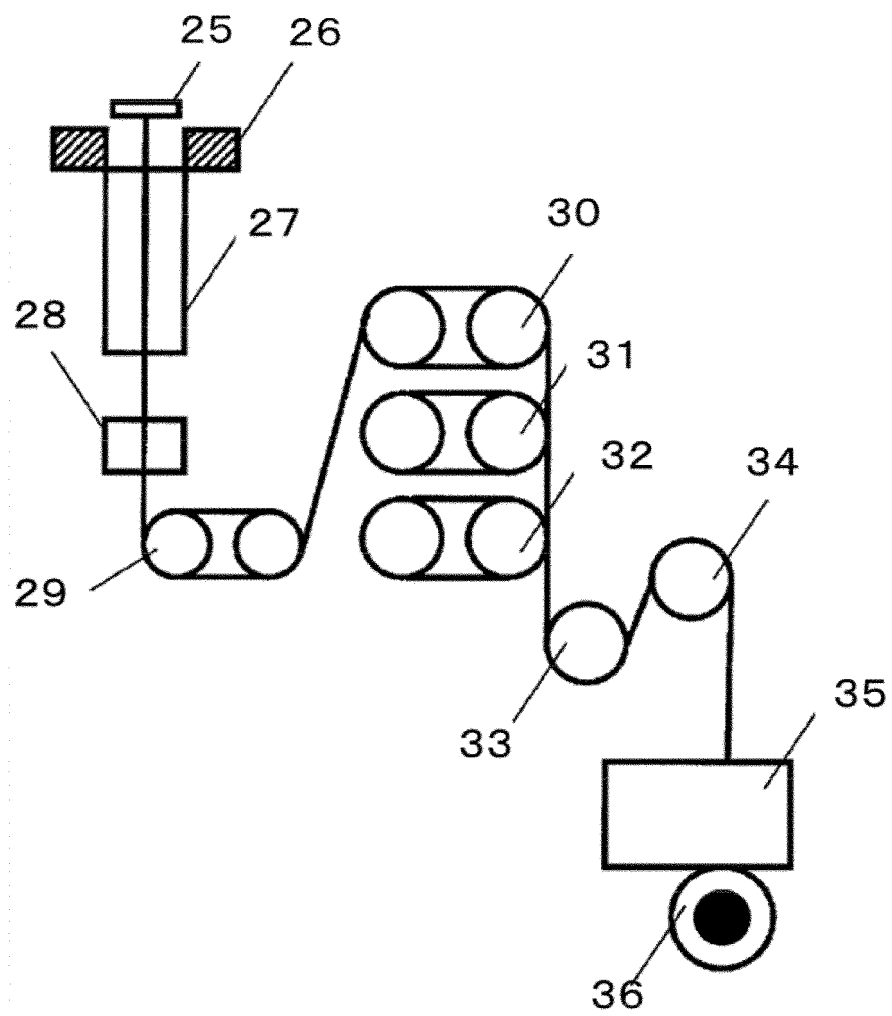


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/037722

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. D01F6/62 (2006.01) i, B41N1/24 (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)

Int.Cl. B41N1/00-99/00, D01F1/00-6/96, D01F9/00-9/04

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)

JSTPlus/JMEDPlus/JST7580 (JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 119078/1985 (Laid-open No. 028567/1987) (NBC INDUSTRIES CO., LTD.) 20 February 1987, claims, page 6, bottom line to page 7, line 10, examples, fig. 2, 3 & US 4749611 A; claims, column 3, line 9 to column 5, line 20, fig. 1-3	1-3



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
04 December 2019 (04.12.2019)Date of mailing of the international search report
17 December 2019 (17.12.2019)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/037722

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2016-069789 A (TORAY INDUSTRIES, INC.) 09 May 2016, paragraph [0032], examples & TW 201619461 A	1-3
Y	JP 2009-221620 A (TORAY INDUSTRIES, INC.) 01 October 2009, claims, paragraph [0022], examples (Family: none)	1-3
Y	JP 2007-046217 A (TORAY INDUSTRIES, INC.) 22 February 2007, claims, paragraphs [0018], [0019], examples (Family: none)	2
Y	JP 03-082819 A (TORAY INDUSTRIES, INC.) 08 April 1991, claims, page 5, lower left column, lines 2-4, examples (Family: none)	1-3
A	JP 2003-019875 A (SUZUTORA KK) 21 January 2003 (Family: none)	1-3
A	CN 103603069 A (WUXI JINTONG CHEMICAL FIBER CO., LTD.) 26 February 2014 (Family: none)	1-3

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REFERENCES CITED IN THE DESCRIPTION

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- WO 2011086954 A [0007]
- JP 2009221620 A [0007]
- JP 2011016279 A [0007]
- JP 2016041859 A [0007]
- JP 2018182614 A [0110]