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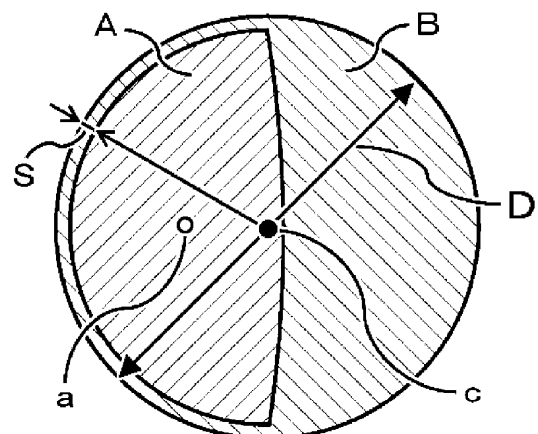
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(54) **COMPOSITE FIBER, MULTIFILAMENT, AND FIBER PRODUCT**

(57) Provided is a composite fiber characterized in that, in a fiber lateral cross section, two types of polyester that differ in molecular weight by not less than 5,000 are comprised, the high molecular weight component is completely covered with the low molecular weight component, and the high molecular weight component has an orientation parameter of 1.5-3.0 and a crystallinity of 0-40%. Also provided is a multifilament characterized in that, in a fiber lateral cross section, two types of polyester that differ in molecular weight by not less than 5,000 are comprised, the high molecular weight component is completely covered with the low molecular weight component, and the high molecular weight component has an orientation parameter of 5.0-15.0 and a crystallinity of 20-50%.

FIG. 1



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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a conjugated fiber suitable for yarn processing, a multifilament suitable for a textile for clothing, and a fiber product including the multifilament.

BACKGROUND ART

10 **[0002]** Synthetic fibers including a polyester, a polyamide, or the like have excellent mechanical properties and dimensional stability, and therefore, the synthetic fibers are widely used from clothing applications to non-clothing applications.

[0003] Nowadays, the lives of people have become more diverse and people are seeking more comfortable lifestyles. There is a growing demand for higher functionality in fiber products around us, and in particular, fibers with advanced

15 **[0004]** A method, in which a multifilament including conjugated fibers having a cross section formed by bonding different polymers is used as a fiber having more comfortable tactility and a comfortable function and used for highly functional clothing having wearing comfort, has been proposed.

[0005] The conjugated fibers exhibit functions related to wearing comfort, such as appropriate resilience and stretchability, by expressing crimps due to a thermal shrinkage difference between polymers. However, when a textile is produced, a crimping form of each conjugated fiber in a multifilament becomes uniform, so that the textile tends to be

20 a uniform textile with no disturbances in appearance or texture.
[0006] On the other hand, in the textile for clothing, there is a tendency to prefer textiles that have the appropriate unevenness that natural materials have. The texture and function of natural materials such as wool, cotton, and silk, which have been frequently used in the textile for clothing for a long time, are extremely excellent in balance, and the appearance and the tactility having a sense of unevenness give people a sense of charm and luxury.

25 **[0007]** An attempt to achieve the tactility and appearance of a natural material using synthetic fibers has been made for a long time, and a yarn processing technique for complicating the tactility and texture to be obtained by changing the synthetic fibers to different non-uniform forms for each conjugated fiber has been proposed.

30 **[0008]** Since basic properties of a polyester, which is a general-purpose resin, are close to properties of natural fibers, there are various attempts using this polyester fiber, and various techniques have been proposed in which a conjugated fiber technique for pasting two kinds of polyester fibers together on the left and right sides and a yarn processing technique for controlling a form of a fiber bundle are combined with each other for the purpose of achieving both wearing comfort by stretching and appearance and tactility close to those of natural fibers.

35 **[0009]** In Patent Literature 1, a conjugated fiber obtained by bonding two kinds of polyesters having different viscosities to each other is subjected to simultaneous drawing and false twisting, so that a multi-crimping form is obtained in which crimps due to a shrinkage difference that are expressed by a high shrinkage on a high viscosity side and a low shrinkage on a low viscosity side during drawing and mechanical crimps imparted by false twisting are combined, and a fabric with improved functionality and texture such as stretchability, resilience, drapability, and soft feeling can be obtained during

40 knitting or weaving.
[0010] In Patent Literature 2, two kinds of polyesters having different viscosities are spun into a side-by-side type or an eccentric core-sheath type and wound up and then subjected to non-uniform drawing at a drawing ratio within a range not exceeding a natural drawing ratio to obtain a multifilament having a thick and thin structure, so that the fabric using the multifilament is said to be a worsted fabric that has high sensitivity such as a natural spunized touch, a delicate

45 worsted feel, and a deep natural appearance, as well as functionality such as stretchability.

CITATION LIST

PATENT LITERATURE

50 **[0011]**

Patent Literature 1: JPH10-72732A

Patent Literature 2: JP2003-328248A

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SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0012] As disclosed in Patent Literatures 1 and 2, a conjugated fiber obtained by bonding two kinds of polyesters having different viscosities to each other is spun and wound up, and then subjected to yarn processing accompanied by drawing, so that there is a possibility that both of the wearing comfort such as appropriate resilience and stretchability obtained by high elasticity and crimp expression derived from the polyester, and the specific tactility or texture obtained by changes in fiber forms due to the yarn processing can be achieved.

[0013] However, Patent Literature 1 discloses a technique of using a conjugated fiber spun at a high speed of 2500 m/min to 3000 m/min in order to perform simultaneous drawing and false twisting. In the high-speed spinning as described in Patent Literature 1, since high-viscosity components may crystallize unnecessarily depending on the viscosity, the shrinkage difference between a high-viscosity component and a low-viscosity component may disappear, and after yarn processing, crimps due to the shrinkage difference may not be expressed.

[0014] On the other hand, in Patent Literature 2, a conjugated fiber wound at a speed of 1000 m/min to 2500 m/min, which is slightly lower than that in Patent Literature 1, is used. However, in Patent Literature 2, if the orientation of molecular chains has hardly progressed and the yarn processing conditions are not controlled within a narrow range, crimps may be hardly expressed, or the fiber structure is not sufficiently developed, and thus the quality of processed yarns and textiles has deteriorated, such as frequent yarn breakage and fluffing during the process due to abrasion during yarn processing.

[0015] An object of the present invention is to solve the above-described problems of the related art, and to provide a conjugated fiber suitable for yarn processing, which has no restrictions on processing conditions and can express good crimps after processing, by controlling a fiber structure formed during spinning within a specific range by controlling a polymer used for the conjugated fiber and a conjugated fiber section in a direction perpendicular to a fiber axis of the conjugated fiber, and to provide a multifilament suitable for a textile for clothing, which has wearing comfort such as good resilience and stretchability when a fabric is formed.

SOLUTION TO PROBLEM

[0016] An object of the present invention is achieved by the following aspects. That is,

(1) a conjugated fiber including two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section, in which a high-molecular weight component is completely covered with a low-molecular weight component, and the high-molecular weight component has an orientation parameter of 1.5 to 3.0 and a crystallinity of 0% to 40%;

(2) the conjugated fiber according to (1), in which the high-molecular weight component is polyethylene terephthalate containing a third component having a copolymerization rate of less than 5 mol%;

(3) a multifilament including a conjugated fiber, in which the conjugated fiber includes two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section, and in the conjugated fiber, a high-molecular weight component is completely covered with a low-molecular weight component, and the high-molecular weight component has an orientation parameter of 5.0 to 15.0 and a crystallinity of 20% to 50%;

(4) a multifilament according to (3) including a conjugated fiber that has a ratio $S_{\min}/D$, which is a ratio of a minimum thickness $S_{\min}$ of a thin portion of the low-molecular weight component to a fiber diameter D , of 0.01 to 0.1, and has a ratio of the thin portion in the low-molecular weight component to a perimeter of entire fiber of 30% or more, in the fiber cross section;

(5) the multifilament according to (3) or (4) having a crimp expression rate of 10% or more;

(6) the multifilament according to any one of (3) to (5) having an elastic modulus of 30 cN/dtex or more; and

(7) a fiber product partially including the multifilament according to any one of (3) to (6).

ADVANTAGEOUS EFFECTS OF INVENTION

[0017] Regarding a conjugated fiber according to one embodiment of the present invention, by controlling the polymers and the cross-sectional morphology, the fiber structure formed during spinning falls within a specific range, and a multifilament having no restrictions on processing conditions and having a high elasticity derived from polyester and good crimp expression can be obtained after processing.

[0018] Regarding a multifilament according to one embodiment of the present invention, by controlling a polymer and a cross-sectional morphology, a fiber structure formed during yarn production falls within a specific range, and a high elasticity derived from the polyester and good crimp expression are obtained, so that a textile for clothing, which has

wearing comfort such as appropriate resilience and stretchability when a fabric is formed, can be obtained.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

[FIG. 1] FIG. 1 is a schematic view of an example of a cross-sectional structure of a conjugated fiber and a multifilament according to one embodiment of the present invention.

[FIG. 2] (a) of FIG. 2 and (b) of FIG. 2 are schematic views of an example of a cross-sectional structure of a conjugated fiber and a multifilament according to one embodiment of the present invention.

[FIG. 3] (a) of FIG. 3 and (b) of FIG. 3 are views related to a cross-sectional structure of a conjugated fiber according to the related art, in which (a) of FIG. 3 illustrates a schematic view of an example of a side-by-side section, and (b) of FIG. 3 illustrates a schematic view of an example of an eccentric core-sheath section.

[FIG. 4] FIG. 4 is a schematic view of an example of a cross-sectional structure of a conjugated fiber and a multifilament in Example 5.

DESCRIPTION OF EMBODIMENTS

[0020] A conjugated fiber according to one embodiment of the present invention includes two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section, in which a high-molecular weight component is completely covered with a low-molecular weight component, and the high-molecular weight component has an orientation parameter of 1.5 to 3.0, and a crystallinity of 0% to 40%, in the fiber cross section.

[0021] A multifilament according to one embodiment of the present invention includes a conjugated fiber which includes two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section and in which a high-molecular weight component is completely covered with a low-molecular weight component, and the high-molecular weight component has an orientation parameter of 5.0 to 15.0 and a crystallinity of 20% to 50%, in the fiber cross section.

[0022] Hereinafter, the present invention will be described in detail along with the preferred embodiments.

[0023] In order to satisfy excellent yarn processability or a process-passing property of a conjugated fiber obtained by bonding two kinds of polyesters having different molecular weights to each other, it is required to improve fiber strength or heat resistance by orientating molecular chains by high-speed spinning or the like. On the other hand, in the conjugated fiber subjected to the high-speed spinning, there is a trade-off relation that both yarn processability and crimping property cannot be achieved, that is, when a shrinkage difference between the high-molecular weight component and the low-molecular weight component is reduced, crimps to be expressed due to the shrinkage difference are not satisfactorily expressed.

[0024] When a fiber structure of the conjugated fiber obtained by such high-speed spinning is analyzed, it is understood that the higher the spinning speed is, the higher the crystallinity of the high-molecular weight component becomes, and accordingly, a shrinkage behavior of the high-molecular weight component after drawing is low shrinkage. It is considered that the reason for forming the low shrinkage lies in that when the fiber structure has a high crystallinity, the probability that the molecular chains are restrained by crystals increases, and the orientation relaxation of the molecular chains during a heat treatment is inhibited. Therefore, it is considered that in the conjugated fiber obtained by the high-speed spinning, the shrinkage difference between the high-molecular weight component and the low-molecular weight component is small, and thus, good crimp expression is not achieved.

[0025] As a result of intensive studies conducted by the present inventors for the purpose of achieving both high orientation and low crystallinity of the high-molecular weight component in the high-speed spinning, the present inventors have found that the high-molecular weight component can have high orientation and reduced crystallinity by forming, in two kinds of polyesters having different molecular weights, a cross section in which the high-molecular weight component is completely covered with the low-molecular weight component. Further, the present inventors have found that the phenomenon becomes remarkable in the high-speed spinning, and have succeeded in creating a conjugated fiber having excellent yarn processability, which is difficult to obtain in the case of side-by-side sections or eccentric core-sheath sections according to the related art, and also having good crimp expression after yarn processing.

[0026] That is, in the side-by-side section or the eccentric core-sheath section according to the related art in which the high-molecular weight component is exposed to the fiber surface, when the polymer is discharged from a spinneret in spinning, flow resistance received by the high-molecular weight component from a wall surface of a discharge hole in the spinneret is large, and crystal nuclei are generated in an excessive amount due to deformation of the molecular chain. When a high stress is applied due to the generation of the crystal nuclei in an excessive amount in winding during spinning or drawing during yarn processing, oriented crystallization may proceed to increase the crystallinity.

[0027] On the other hand, when the low-molecular weight component is applied between the wall surface of the discharge hole and the high-molecular weight component, a vicinity of the wall surface having the highest flow resistance

is likely to be slippery, thereby generating a plug flow effect of decreasing the flow resistance applied to the entire flow. A technical point of the present invention is to use the plug flow effect, and accordingly, the present invention is on the basis that the flow resistance of the high-molecular weight component can be reduced and the generation of crystal nuclei in an excessive amount is prevented, so that both high orientation and low crystallinity of the high-molecular weight component are achieved even in high-speed spinning in which a high stress is likely to be applied during spinning.

[0028] Based on this idea, in the present invention, the larger the molecular weight difference between the polymers to be combined, the more the effect is expressed, and from the viewpoint of achieving the object of the present invention, it is important that in the fiber cross section, the conjugated fiber includes two kinds of polyesters having a molecular weight difference of 5,000 or more, and the high-molecular weight component is completely covered with the low-molecular weight component.

[0029] The molecular weight in the present invention means a weight average molecular weight M_w calculated from molecular weight distribution determined by adding 5 mL of hexafluoroisopropanol as a solvent to 3 mg of chips or fibers, gently stirring the mixture at room temperature, and then using "RI-104 type" manufactured by Showa Denko K.K. as a gel permeation chromatography (GPC) device with monodisperse polymethyl methacrylate (PMMA) as a standard sample. When a measurement is performed using a conjugated fiber as a sample and a double peak is obtained in the molecular weight distribution, a peak value on a low molecular weight side is defined as a molecular weight of the low-molecular weight component, and a peak value on a high molecular weight side is defined as a molecular weight of the high-molecular weight component.

[0030] Regarding the conjugated fiber and the multifilament according to one embodiment of the present invention, in order to obtain a textile for clothing that expresses a good crimp after yarn processing or fabric formation and has a wearing comfort such as an appropriate resilience or stretchability, it is required to include two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section.

[0031] When the molecular weight difference is 5,000 or more, a difference is generated in a stress applied to each component in the spinning and drawing steps, and a high stress is applied to the high-molecular weight component to achieve high orientation, and a low stress is applied to the low-molecular weight component to achieve low orientation. Thereafter, when a heat treatment is performed, a shrinkage difference is generated due to a difference in the orientation relaxation amount, and the fiber can express a crimping form in which the fiber is largely curved towards the high-molecular weight component side having high shrinkage.

[0032] In the present invention, when the molecular weight difference between the polymers to be combined is increased, the shrinkage difference is increased, and better crimps can be expressed. Accordingly, the molecular weight difference in the conjugated fiber and the multifilament according to one embodiment of the present invention is more preferably set to 7,500 or more because the stretchability when the fabric is formed is also enhanced. Further, when the molecular weight difference is set to 10,000 or more, the range is particularly preferable because a gap between the fibers is generated by high crimping, and the bulging feel and resilience when the fabric is formed can also be improved.

[0033] From the viewpoint of crimp expression, it is preferable to increase the molecular weight difference. On the other hand, the practical upper limit of the molecular weight difference is 30,000 because excessive low orientation of the low-molecular weight component causes deterioration in strength or heat resistance, and yarn breakage and fluffing frequently occur in yarn processing or a fabric forming step.

[0034] The molecular weight of the high-molecular weight component is preferably 20,000 or more. Within such a range, the molecular chains are appropriately entangled with each other due to the long molecular chains, the orientation starting from the entanglement is easily promoted, and the high-molecular weight component can be highly oriented easily. When the molecular weight is set to 25,000 or more, the range is more preferable because higher orientation is obtained, so that the elastic modulus of the fiber is also increased and the resilience when the fabric is formed is also improved. It is preferable to increase the molecular weight from the viewpoint of orientation. On the other hand, when the flow resistance in the discharge hole is increased, the oriented crystallization proceeds, the low shrinkage is formed, and therefore, the practical upper limit of the molecular weight of the high-molecular weight component is 50,000.

[0035] It is important to select the polymers constituting the conjugated fiber and the multifilament according to one embodiment of the present invention from polyesters in which a bond present in a main chain is an ester bond, from the viewpoint of achieving the present invention in which an appropriate resilience is obtained from high elasticity when the textile is formed and from the viewpoint of obtaining good color developability during dyeing.

[0036] Examples of the combination of two kinds of polyesters including a high-molecular weight component/a low-molecular weight component according to the present invention include various combinations such as polyethylene terephthalate/polyethylene terephthalate, copolymerized polyethylene terephthalate/polyethylene terephthalate, polybutylene terephthalate/polybutylene terephthalate, polybutylene terephthalate/polyethylene terephthalate, polytrimethylene terephthalate/polytrimethylene terephthalate, polytrimethylene terephthalate/polyethylene terephthalate, polyester-based elastomer/polyethylene terephthalate, and the like. From the viewpoint of stability during yarn processing and imparting durability in use to a fabric by preventing peeling, it is preferable to combine polyesters whose main chains have the same composition as the combination of polymers. Further, from the viewpoint of having a high elastic modulus

and being able to further enhance resilience, the combination of polyethylene terephthalate/polyethylene terephthalate or the combination of copolymerized polyethylene terephthalate/polyethylene terephthalate is particularly preferable.

[0037] Examples of a copolymerization component in the copolymerized polyethylene terephthalate include succinic acid, adipic acid, azelaic acid, sebacic acid, 1,4-cyclohexane dicarboxylic acid, maleic acid, phthalic acid, isophthalic acid, and 5-sodium sulfoisophthalic acid. From the viewpoint that high orientation can be achieved without inhibiting the orientation during high-speed spinning while obtaining the effect of high shrinkage by the copolymerization component, a copolymerization rate of the copolymerization component, that is, a third component other than monomers constituting polyethylene terephthalate is preferably less than 5 mol%. When a copolymerization rate of the third component is set to less than 3 mol%, the range is more preferable because the high elastic properties of polyethylene terephthalate can be maintained, so that the conjugated fiber can be easily restored to an original form even when the crimping form expressed by the heat treatment is stretched and contracted.

[0038] That is, the high-molecular weight component is preferably polyethylene terephthalate containing the third component having a copolymerization rate of less than 5 mol%.

[0039] In addition, the polymer may contain various additives such as an inorganic material such as titanium oxide, silica, and barium oxide, a colorant such as carbon black, a dye, and a pigment, a flame retardant, a fluorescent brightening agent, an antioxidant, and an infrared absorber. In particular, a content of titanium oxide is more preferably within a range of 1.0 wt% or more because it is possible to obtain not only an improvement in the appearance quality such as prevention of appearance unevenness (glare) caused by an increase or a decrease in reflection depending on an angle of incidence of light due to diffuse reflection of light by titanium oxide on a surface of the fiber, but also functionality such as anti-see-through properties and ultraviolet shielding due to titanium oxide inside the fiber.

[0040] From the viewpoint of reducing an environmental load, it is preferable to use a plant-derived biopolymer or a recycled polymer in the present invention. In the present invention, a recycled polymer recycled by any method of chemical recycling, material recycling, and thermal recycling can be used as the polymer described above. Also in the case of using a biopolymer or a recycled polymer, recycled polyethylene terephthalate can be preferably used because polyethylene terephthalate can highlight the features of the present invention due to polymer properties thereof.

[0041] Regarding the conjugated fiber and the multifilament according to one embodiment of the present invention, in order to achieve both high orientation and low crystallinity of the high-molecular weight component and to express good crimps by the heat treatment, the high-molecular weight component is required to be completely covered with the low-molecular weight component in the fiber cross section.

[0042] When the high-molecular weight component is completely covered with the low-molecular weight component, the low-molecular weight component is applied between the wall surface of the discharge hole in the spinneret and the high-molecular weight component when the polymer is discharged from the spinneret in spinning, and the vicinity of the wall surface having the highest flow resistance is likely to be slippery, thereby generating the plug flow effect of decreasing the flow resistance applied to the entire flow. Accordingly, the flow resistance of the high-molecular weight component can be reduced, and generation of crystal nuclei in an excessive amount can be prevented, so that both high orientation and low crystallinity of the high-molecular weight component can be achieved.

[0043] In addition, any cross section can be used as a cross-sectional morphology of the conjugated fiber and the multifilament according to one embodiment of the present invention as long as the high-molecular weight component is completely covered with the low-molecular weight component, and in addition to an eccentric core-sheath type shown in FIG. 1 and (a) and (b) of FIG. 2, examples of the cross-sectional morphology include a sea-island type, a blend type, and the like. From the viewpoint of expressing crimping due to the shrinkage difference at the maximum while obtaining the plug flow effect, it is preferable to form an eccentric core-sheath section in which a thin portion of a sheath component is precisely controlled, as illustrated in FIG. 1 and (a) and (b) of FIG. 2.

[0044] Here, the eccentricity referred to in the present invention means that, in the fiber cross section, a centroid point of the high-molecular weight component is different from a center of a fiber section.

[0045] In the present invention, it is important that the centroid point (a in FIG. 1) of the high-molecular weight component (A in FIG. 1) and the center (c in FIG. 1) of the fiber section are separated from each other. Accordingly, after the heat treatment, the fibers will be significantly curved toward the high-viscosity component that has high shrinkage. Therefore, when the fibers continue to curve in a fiber axis direction, a three-dimensional spiral structure is formed, and good crimp expression can be achieved.

[0046] In addition, when a melt of polymers having a large molecular weight difference is spun out from a spinneret as a composite flow during production of the conjugated fiber and the multifilament according to one embodiment of the present invention, yarn bending in which the high molecular weight polymer is curved towards the low molecular weight polymer side is generated due to the flow resistance difference after discharge, and the composite flow comes into contact with a lower surface of the spinneret or interferes with a composite flow spun out from another portion to cause yarn breakage. However, the plug flow effect reduces the flow resistance of the high-molecular weight component so that the yarn bending can be prevented and stable yarn production is enabled, and thus the above-mentioned range can still be said to be a preferable range.

[0047] Regarding the conjugated fiber and the multifilament according to one embodiment of the present invention, a ratio of a thin portion of the low-molecular weight component to a perimeter of the entire fiber is preferably 30% or more. This means that the high-molecular weight component is present along a contour of the fiber, and better crimps can be expressed because a distance between the centroid point of the high-molecular weight component and the center of the fiber section is maximized in the fiber section. The above ratio is more preferably 40% to 70%, and still more preferably 50% to 60% in order to maximize the centroid point of the high-molecular weight component and the center of the fiber section and to exert the potential of the crimp expression due to the shrinkage difference at the maximum.

[0048] Here, the thin portion in the low-molecular weight component referred to in the present invention means a part in which the thickness (S in FIG. 1) of the low-molecular weight component on an outer periphery of the fiber in a direction of the fiber center is 0.01 times to 0.1 times a fiber diameter determined by converting an area of the fiber section into a perfect circle.

[0049] In the conjugated fiber and the multifilament according to one embodiment of the present invention, a ratio $S_{\min}/D$ of a minimum thickness $S_{\min}$ of the thin portion of the low-molecular weight component (B in FIG. 1) covering the high-molecular weight component (A in FIG. 1) to a fiber diameter D is preferably 0.01 to 0.1. Within such a range, the centroid point of the high-molecular weight component and the center of the fiber section are separated from each other, and therefore, the crimps due to the shrinkage difference can be expressed at the maximum. When $S_{\min}/D$ is set to 0.02 to 0.08, it is possible to exert the crimps due to the shrinkage difference at the maximum and to maintain yarn processing stability and fabric quality without causing a whitening phenomenon or fluffing due to the high-molecular weight component which is inferior in abrasion resistance even when friction or impact is applied to the fibers or the fabric. Therefore, $S_{\min}/D$ is more preferably within the range of 0.02 to 0.08.

[0050] That is, the multifilament according to one embodiment of the present invention preferably includes a conjugated fiber in which the ratio $S_{\min}/D$ of the minimum thickness $S_{\min}$ of the thin portion of the low-molecular weight component to the fiber diameter D is 0.01 to 0.1, and the ratio of the thin portion of the low-molecular weight component to the perimeter of the entire fiber is 30% or more in the fiber cross section.

[0051] In the conjugated fiber and the multifilament according to one embodiment of the present invention, a ratio of a part in which a ratio S/D of a thickness S (S in (a) and (b) of FIG. 2) of a thin portion to the fiber diameter D (D in (a) and (b) of FIG. 2) is 0.05 to 0.10 is preferably 5% to 70% to the entire thin portion in the low-molecular weight component. When the part in which S/D is 0.05 or more is present in a ratio of 5% or more, a plug flow effect to the high-molecular weight component is expressed. When the part in which S/D is less than 0.05 occupies in a ratio of 30% or more, the centroid point of the high-molecular weight component and the center of the fiber section are separated from each other, and therefore, the crimps due to the shrinkage difference can be expressed at the maximum.

[0052] Furthermore, in order to sufficiently express the plug flow effect even in high-speed spinning in which a high stress is likely to be applied during spinning, the ratio of the part in which the ratio S/D of the thickness S of the thin portion to the fiber diameter D is 0.05 to 0.10 to the entire thin portion is more preferably 10 to 60%, and still more preferably 15% to 50%.

[0053] Examples of a cross section in which the ratio of the part in which the ratio S/D of the thickness S of the thin portion to the fiber diameter D is 0.05 to 0.10 to the entire thin portion of the low-molecular weight component is 5% to 70% include an uneven structure in which the thickness S of the thin portion alternately changes on the outer periphery of the fiber as illustrated in (a) of FIG. 2 and an inclined structure in which the thickness S of the thin portion gradually changes on the outer periphery of the fiber as illustrated in (b) of FIG. 2. From the viewpoint that the plug flow effect can be more effectively expressed, a structure in which the thickness S of the thin portion alternately changes on the outer periphery of the fiber as illustrated in (a) of FIG. 2 is preferable.

[0054] In the present invention, the ratio $S_{\min}/D$ of the minimum thickness $S_{\min}$ of the thin portion of the low-molecular weight component to the fiber diameter D, the ratio of the thin portion of the low-molecular weight component to the perimeter of the entire fiber, and the ratio of the part in which the ratio S/D of the thickness S of the thin portion to the fiber diameter D is 0.05 to 0.10 to the entire thin portion of the low-molecular weight component can be determined by the following method. When the conjugated fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion is selected and evaluated.

[0055] First, conjugated fibers are embedded in an embedding agent such as an epoxy resin, and then an image of a cross section is captured with a transmission electron microscope (TEM) at a magnification at which ten or more fibers can be observed, and a cross-sectional morphology is observed. At this time, a contrast of a bonded portion of the cross-sectional morphology is clarified by utilizing the fact that a dyeing difference between polymers can be generated when metal dyeing is performed. When the cross-sectional morphology in the captured image is an eccentric core-sheath section as illustrated in FIG. 1 or (a) and (b) of FIG. 2, regarding ten conjugated fibers randomly extracted in the same image from each image, perimeters of parts, in which a thickness of a low-molecular weight component on an outer periphery of the fiber in the direction of the fiber center, such as "S" in FIG. 1 or (a) and (b) of FIG. 2, is 0.01 times to 0.1 times a fiber diameter determined by converting an area of a fiber section into a perfect circle, are determined and respectively divided by perimeters of the entire fibers and the resulting values are multiplied by 100 to calculate values,

a simple number average of the values is determined, and a value obtained by rounding the simple number average to the nearest whole number is defined as "the ratio (%) of the thin portion in the low-molecular weight component to the perimeter of the entire fibers".

[0056] Regarding the ten conjugated fibers, values are calculated by separately dividing the minimum value of the thicknesses S of the thin portions by values of the fiber diameters D each determined by measuring, in units of μm up to the one decimal place, a diameter determined by measuring an area of the fiber and converting the area into a perfect circle, a simple number average of the values is determined, and a value obtained by rounding the simple number average to two decimal places is defined as "the ratio $S_{\min}/D$ of the minimum thickness $S_{\min}$ of the thin portion of the low-molecular weight component to the fiber diameter D ".

[0057] Regarding the above ten conjugated fibers, perimeters of parts, in which a ratio S/D of a thin portion thickness S to a fiber diameter D that is obtained by dividing the value of the thicknesses S of the thin portions by values of the fiber diameters D each determined by measuring, in units of μm up to the one decimal place, a diameter determined by measuring an area of the fiber and converting the area into a perfect circle is 0.05 to 0.10, are determined and respectively divided by perimeters of the entire thin portions, and the resulting values are multiplied by 100 to calculate values, a simple number average of the values is determined, and a value obtained by rounding the simple number average to the nearest whole number is defined as "the ratio (%) of the part in which the ratio S/D of the thin portion thickness S to the fiber diameter D is 0.05 to 0.10 to the entire thin portions of the low-molecular weight component".

[0058] An area ratio of the high-molecular weight component to the low-molecular weight component in the cross-sectional morphology of the conjugated fiber and the multifilament according to one embodiment of the present invention is preferably within a range of 70/30 to 30/70. Within this range, the centroid point of the high-molecular weight component and the center of the fiber section are sufficiently separated from each other, and therefore, the crimps due to the shrinkage difference can be sufficiently expressed.

[0059] Regarding the conjugated fiber according to one embodiment of the present invention, it is important that an orientation parameter of the high-molecular weight component is 1.5 to 3.0 and the crystallinity thereof is 0% to 40% because yarn processability that is hardly obtained in a side-by-side section according to the related art is excellent and good crimps due to the shrinkage difference after yarn processing can be expressed when the high orientation and low crystallinity of the high-molecular weight component can be achieved even in high-speed spinning.

[0060] Here, the orientation parameter of the high-molecular weight component in the present invention is a value obtained by irradiating a high-molecular weight component in a longitudinal section of a fiber with a laser and performing measurements in polarization directions in directions parallel and perpendicular to a fiber axis using a laser Raman spectroscopy, determining an intensity of a Raman band in a vicinity of 1615 cm^{-1} attributed to the C=C stretching vibration mode (parallel: $I_{1615\text{ parallel}}$, perpendicular: $I_{1615\text{ perpendicular}}$) from a Raman spectrum obtained in each of the measurements, calculating a ratio $I_{1615\text{ parallel}}/I_{1615\text{ perpendicular}}$, and rounding the ratio to one decimal place. In the case of no orientation, the orientation parameter is 1. In addition, when the fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion is selected and evaluated.

[0061] The crystallinity of the high-molecular weight component in the present invention is determined as follows. That is, a high-molecular weight component in a longitudinal section of a fiber is irradiated with a laser, measurements are performed in a polarization direction parallel to a fiber axis using a laser Raman spectroscopy, a full width at half maximum ($\Delta\nu_{1730}$) of a Raman band in a vicinity of 1730 cm^{-1} attributed to a C=O stretching vibration mode is determined, and a value obtained by assigning $\Delta\nu_{1730}$ to the following Formula (1) is defined as the density ρ . A value obtained by rounding a value, which is obtained by assigning the determined density ρ to the following formula (2), to the nearest whole number is defined as crystallinity (%). When the crystallinity of polyethylene terephthalate is determined, a density of a completely amorphous crystal is 1.335 g/cm^3 , and a density of a complete crystal is 1.455 g/cm^3 . In addition, when the fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion is selected and evaluated.

$$\text{Density } \rho \text{ (g/cm}^3\text{)} = (305 - \Delta\nu_{1730})/209 \quad \text{Formula (1)}$$

$$\text{Crystallinity (\%)} = 100 \times (\rho - \text{density of completely amorphous crystal}) / (\text{density of complete crystal} - \text{density of completely amorphous crystal}) \quad \text{Formula (2)}$$

[0062] In the fiber including polyesters, winding at high speed during spinning increases fiber orientation and improves fiber strength. Therefore, with rubbing or the like during processing, not only good yarn processability without yarn breakage can be obtained, but also good processability can be obtained even when the conjugated fiber after being stored for one month or longer is subjected to yarn processing because fibers are sufficiently oriented and there is little change over time.

[0063] In particular, in the case of a fiber including two kinds of polyesters having different molecular weights, the orientation parameter of the high-molecular weight component that easily has high orientation by being applied with a high stress has a strong influence on fiber strength, and therefore, it is required to set the orientation parameter of the high-molecular weight component to be 1.5 or more in the conjugated fiber according to one embodiment of the present invention. Within such a range, there is little change over time, and therefore, handling properties are excellent, and good processability can be obtained in yarn processing such as false twisting. When an orientation parameter is set to 2.0 or more, the orientation after yarn processing is also increased, so that not only the crimp expression due to the shrinkage difference can be further enhanced, but also the heat resistance before drawing is improved. Therefore, undrawn portions may be generated in yarn processing such as non-uniform drawing, excellent processability without fluffing or yarn breakage due to fusion can be obtained even when the fiber comes into contact with a high-temperature heater, and thus, the orientation parameter is particularly preferably within the range of 2.0 or more.

[0064] On the other hand, in order to increase the orientation parameter, it is required to increase the winding speed during spinning, and accordingly, stability during spinning may also be impaired. Therefore, an upper limit of the orientation parameter in the present invention is 3.0.

[0065] Regarding the conjugated fiber according to one embodiment of the present invention, it is required to set the crystallinity of the high-molecular weight component to be 40% or less in the present invention because the orientation relaxation of the molecular chain during the heat treatment is increased and the high-molecular weight component can be highly shrunk by lowering the crystallinity of the high-molecular weight component in the high-speed spinning.

[0066] Within such a range, the shrinkage difference between the high-molecular weight component and the low-molecular weight component is increased, and good crimp expression after the heat treatment can be achieved in yarn processing. From this point of view, it is more preferable to set the crystallinity of the high-molecular weight component to 30% or less because good crimps can be obtained as the crystallinity decreases. Further, when the crystallinity is set to 20% or less, the orientation of the molecular chain is not inhibited by the crystal during drawing in the yarn processing, and further high orientation can be achieved. The crystallinity thereof is particularly preferably 10% or less.

[0067] Regarding the multifilament according to one embodiment of the present invention, it is important that the orientation parameter of the high-molecular weight component is 5.0 to 15.0 and the crystallinity thereof is 20% to 50% because a textile for clothing that expresses polyester-derived high elasticity and good crimps and has a wearing comfort such as an appropriate resilience or stretchability when a fabric is formed can be obtained by achieving both high orientation and low crystallinity of the high-molecular weight component.

[0068] Regarding the multifilament according to one embodiment of the present invention, the orientation parameter of the high-molecular weight component is required to be 5.0 or more in order to obtain good resilience and stretchability when a fabric is formed. Within such a range, the orientation relaxation during the heat treatment is increased, so that the high-molecular weight component is highly shrunk, and not only a high degree of crimp expression required to obtain the stretchability when the fabric is formed is achieved, but also resilience can also be obtained by improving the elastic modulus accompanying the high orientation. From this viewpoint, when the orientation parameter is set to 6.5 or more, not only voids between the fibers are generated due to the high crimp but also the resilience is further increased due to the high elastic modulus, and firm feeling or bulging feel are generated in a fabric, so that the multifilament can be more preferably used as a textile for clothing, which is preferable.

[0069] When the orientation parameter is set to 8.0 or more, high stretch and high resilience due to high crimping stand out, so that a textile having a specific texture with elasticity like rubber can be obtained. Therefore, the orientation parameter is particularly preferably within the range of 8.0 or more. On the other hand, if the orientation parameter is too high, the remaining degree of drawing of the fiber is lost, and when the fabric is formed, the fabric quality may deteriorate due to yarn breakage or fluffing. Therefore, the upper limit of the orientation parameter in the present invention is 15.0.

[0070] Regarding the multifilament according to one embodiment of the present invention, the high-molecular weight component has a low degree crystallinity in high-speed spinning, so that orientation relaxation of the molecular chain during the heat treatment is increased, and the high-molecular weight component can be highly shrunk. Therefore, it is required to set the crystallinity of the high-molecular weight component to 50% or less. Within such a range, the shrinkage difference between the high-molecular weight component and the low-molecular weight component is increased, and good crimps can be expressed by the heat treatment. From this point of view, the crystallinity of the high-molecular weight component is more preferably set to 40% or less because good crimps can be obtained as the crystallinity decreases. Further, when the crystallinity is set to 30% or less, a shrinkage stress can be improved due to the small restriction of the molecular chain caused by the crystal, and the crimps can be expressed regardless of a restriction state of the fiber due to a fabric structure. Therefore, the crystallinity is particularly preferably 30% or less.

[0071] On the other hand, when the crystallinity is too low, the dimensional stability is impaired, excessive shrinkage occurs during the heat treatment, and texture curing due to clogging may occur. Therefore, the lower limit of the crystallinity of the high-molecular weight component in the multifilament according to one embodiment of the present invention is 20%.

[0072] Regarding the multifilament according to one embodiment of the present invention, a crimp expression rate

representing a degree of crimp expression due to a shrinkage difference is preferably 10% or more.

[0073] Here, the crimp expression rate in the present invention is determined as follows. That is, fibers are cut into skeins each having a length of 10 m and treated in 90°C water for 20 minutes with no load (0 cN/dtex), followed by air-drying for 24 hours. Thereafter, an initial load of 0.0018 cN/dtex (2 mgf/d) is applied to the skeins in water at room temperature (25°C), and a skein length L₁ after 2 minutes is measured. Next, the above initial load of 0.0018 cN/dtex is removed in water at room temperature (25°C), the load is changed to a load corresponding to 0.09 cN/dtex (0.1 gf/d), and a skein length L₀ after 2 minutes is measured. Thus, L₀ and L₁ are obtained, and a value obtained by rounding a value determined according to the following formula based on L₀ and L₁ to the nearest whole number is defined as crimp expression rate (%).

$$\text{Crimp expression rate (\%)} = [(L_0 - L_1)/L_0] \times 100 (\%)$$

[0074] When a good crimp with a crimp expression rate of 10% or more is expressed, good stretchability can be obtained when a fabric is formed. Further, when the crimp expression rate is set to 20% or more, not only the stretchability is further improved, but also the voids between the fibers are enlarged by an excluded volume effect due to the expression of the high crimp of the fibers in the multifilament, and the effect of improving the bulging feel is also obtained. Therefore, the crimp expression rate is more preferably within the range of 20% or more. On the other hand, when the crimp expression rate is too high, texture curing may be caused by clogging. Therefore, the upper limit of the crimp expression rate in the present invention is 80%.

[0075] Regarding the multifilament according to one embodiment of the present invention, the elastic modulus is preferably 30 cN/dtex or more.

[0076] Here, the elastic modulus (cN/dtex) in the present invention is a value obtained by elongating a sample by a TENSILON tensile tester from an initial load of 0.1 cN/dtex to a maximum stress of 0.5 cN/dtex with a sample length of 20 cm and a tensile speed of 20 cm/min in accordance with constant speed elongation conditions shown in a standard-state test of JIS L 1013 (2010) 8.5.1, then calculating a slope under a tensile load of 0.3 cN/dtex to 0.5 cN/dtex in the obtained stress-strain curve, determining a simple number average of results obtained by performing the calculation on the ten multifilaments, and rounding the simple number average to the nearest whole number.

[0077] When the multifilament has a high elastic modulus of 30 cN/dtex or more, the bending rigidity is increased, and therefore, good resilience can be obtained when the fabric is formed. Further, when the elastic modulus is set to 50 cN/dtex or more, the bending rigidity is further increased, so that a firm feeling is generated in the fabric, and the multifilament can be more preferably used for clothing. Therefore, the elastic modulus is particularly preferably within the range of 50 cN/dtex or more. On the other hand, when the elastic modulus is too high, flexibility may be impaired and wearing comfort may deteriorate. Therefore, the upper limit of the elastic modulus is 100 cN/dtex.

[0078] Regarding the multifilament according to one embodiment of the present invention, a hysteresis loss rate during recovery from elongation is preferably 0% to 70%.

[0079] Here, the hysteresis loss rate during recovery from elongation in the present invention is determined as follows. That is, a sample is elongated by a TENSILON tensile tester from an initial load of 0.1 cN/dtex to a maximum stress of 0.5 cN/dtex with a sample length of 20 cm and a tensile speed of 20 cm/min in accordance with constant speed elongation conditions shown in a standard-state test of JIS L1013 (2010) 8.5.1 and then is recovered to an original test length position at the same speed. A hysteresis curve is drawn, and an area (A1) of a region sandwiched between a curve during elongation and a curve during recovery and an area (A2) of a region sandwiched between a curve during the elongation and a horizontal axis (axis of elongation) are determined, followed by dividing A1 by A2 and multiplying the resultant value by 100 to calculate a value. A simple number average of results obtained by performing the calculation on ten multifilaments is determined, and a value obtained by rounding the simple number average to the nearest whole number is defined as the hysteresis loss rate (%) during recovery from elongation.

[0080] When the hysteresis loss rate during the recovery from elongation is set to 0% to 70%, the multifilament can be easily recovered to an original form even when the crimp is stretched and contracted. Therefore, when a fabric is formed, the multifilament can be preferably used as a textile for clothing which tends to elongate with a movement of the body, with less strain even when elongated. Further, when the hysteresis loss rate is set to 30% to 60%, excessive tightening of the clothing after stretching is reduced and wearing comfort is enhanced. Therefore, the hysteresis loss rate is more preferably within the range of 30% to 60%.

[0081] Regarding the multifilament according to one embodiment of the present invention, the fiber diameter is preferably set to 10 μm or more. Within such a range, the bending rigidity and the absorption amount of the dye are increased due to the large fiber diameter, and the resilience and a color developing property when the fabric is formed are enhanced. Therefore, the multifilament can be preferably used as the textile for clothing. Further, when the fiber diameter is 18 μm or more, not only the bending rigidity is further increased, but also the bulging feel is increased by increasing a crimp diameter and a pitch. Therefore, the range of 18 μm or more is preferable for clothing applications that require texture

with bulging feel or firm feeling, such as pants and shirts.

[0082] However, when the fiber diameter is 30 μm or more, the bending rigidity is too high, so that the texture may be hard in the textile for clothing. Therefore, the fiber diameter of the fiber in the present invention is preferably less than 30 μm .

[0083] The present invention also relates to a fiber product partially including the above multifilament according to one embodiment of the present invention.

[0084] When the fiber product partially including the multifilament according to one embodiment of the present invention is formed, the multifilament according to one embodiment of the present invention can achieve both high orientation and low crystallinity of the high-molecular weight component, and can express high elasticity derived from polyesters and good crimps, so that wearing comfort such as appropriate resilience and stretchability can be obtained. Therefore, the fiber product can be preferably used for a wide variety of fiber products for interior products such as carpets and sofas, vehicle interior products such as car seats, daily use such as cosmetics, cosmetic masks, and health products by taking advantage of the comfort, in addition to for general clothing such as jackets, skirts, pants, and underwear, as well as textiles for clothing such as sports clothing and clothing materials.

[0085] Hereinafter, an example of a method for producing the conjugated fiber and the multifilament according to one embodiment of the present invention will be described in detail.

[0086] Examples of the method for producing the conjugated fiber and the multifilament according to one embodiment of the present invention include a melt spinning method for producing filaments, a solution spinning method such as wet spinning and dry-wet spinning, a melt blow method and a spunbond method suitable for obtaining a sheet-shaped fiber structure, and the like. From the viewpoint of increasing productivity, the melt spinning method is preferable.

[0087] In the melt spinning method, the conjugated fiber and the multifilament can be produced by using a conjugate spinneret to be described later, and the spinning temperature in this case is preferably a temperature at which a polymer having a high melting point or high viscosity among polymers to be used mainly exhibits fluidity. The temperature at which the polymer exhibits fluidity varies depending on the molecular weight, and it is preferable to set the temperature between the melting point of the polymer and the melting point + 60°C because the production can be stably performed.

[0088] As the conjugate spinneret used for producing the conjugated fiber according to one embodiment of the present invention including two kinds of polyesters, a conjugate spinneret using a distribution plate described in, for example, WO2020/095861 is preferably used, from the viewpoint of producing an eccentric core-sheath section in which a high-molecular weight component is completely covered with a low-molecular weight component and the minimum thickness of a thin portion of the low-molecular weight component and a peripheral length of the thin portion are precisely controlled, which is a feature of the conjugated fiber and the multifilament according to one embodiment of the present invention.

[0089] When a conjugated fiber having an eccentric core-sheath type section is produced using a known conjugate spinneret, it is often very difficult to precisely control a centroid position of a core and a sheath thickness. For example, when the minimum thickness of the thin portion of the low-molecular weight component is reduced and the high-molecular weight component is exposed, not only the high orientation and the low crystallinity of the high-molecular weight component, which are the objects of the present invention, cannot be achieved, but also friction and impact cause a whitening phenomenon or fluffing of a fabric. In contrast, when the minimum thickness of the thin portion of the low-molecular weight component is increased, the crimp expression deteriorates, and thus there may be a problem in that the stretchability deteriorates.

[0090] On the other hand, in the method using the distribution plate, a sectional morphology of the conjugated fiber can be controlled by an arrangement of distribution holes in a final distribution plate disposed most downstream among a plurality of distribution plates. Specifically, when at least some of distribution holes for the low-molecular weight component are arranged in a semicircular circumferential arrangement on an outer side of circumferential portions of a plurality of distribution holes for the high-molecular weight component arranged in a semicircular shape, the conjugated fibers obtained by discharging a conjugated polymer flow from a discharge hole of a spinneret can have an eccentric core-sheath section as illustrated in FIG. 1 or (a) and (b) of FIG. 2, which is preferable. A shape of the thin portion in the fiber section can be controlled by arranging the distribution plate so as to change the number of distribution holes for the low-molecular weight component arranged in the semicircular circumferential arrangement on an outer side of circumferential portions of the plurality of distribution holes for the high-molecular weight component or the discharge amount of the polymer in vicinity of the distribution holes.

[0091] The polymer flow whose cross section is formed by the distribution plate in this way is contracted and discharged from the discharge hole of the spinneret. At this time, the purpose of the discharge hole is to remeasure a flow rate of the conjugated polymer flow in the discharge holes, that is, the discharge amount, and to control the draft (= take-up speed/discharge linear speed) on a spinning line. The hole diameter and the hole length are preferably determined in consideration of the viscosity and the discharge amount of the polymers.

[0092] Regarding the conjugated fiber and the multifilament according to one embodiment of the present invention, the high-molecular weight component is completely covered with the low-molecular weight component, so that it is also possible to prevent deterioration in a yarn production property due to the discharge line bending (kneeing phenomenon)

caused by a flow velocity difference between two kinds of polymers during discharge from the spinneret, which has been a problem in the production of the conjugated fiber including the two kinds of polymers having significantly different molecular weights, that is, viscosity differences. That is, the low-molecular weight component is present on the outer side of the high-molecular weight component, so that a force in a direction opposite to a direction in which the polymer flow is bent is generated, and as a result, it is possible to reduce a force in a direction perpendicular to the spinning line, which is generated from a flow velocity difference between the two kinds of polymers during discharge from the spinneret.

[0093] It has also been found that high-speed yarn production stability is excellent because the high-molecular weight component is completely covered with low-molecular weight component. This is an effect that the high-molecular weight component easily follows the elongation deformation after the discharge from the spinneret by arranging the low-molecular weight component on the outer side. From this viewpoint, regarding the conjugated fiber and the multifilament according to one embodiment of the present invention, it is also necessary that the high-molecular weight component is completely covered with the low-molecular weight component in the section.

[0094] The discharge amount during spinning of the conjugated fiber and the multifilament according to one embodiment of the present invention is, for example, 0.1 g/min/hole to 20.0 g/min/hole per discharge hole as a range in which stable discharge is enabled. In this case, the discharge amount is preferably determined in accordance with a desired fiber diameter in consideration of winding conditions, a drawing ratio, and the like.

[0095] The polymer flow melted and discharged from the discharge hole is cooled and solidified, followed by being converged by applying an oil agent or the like, and the converged polymer flow is taken up by a roller whose circumferential speed is regulated. Here, the take-up speed is determined based on the discharge amount and a target fiber diameter. In the present invention, from the viewpoint of stably producing the conjugated fiber and the multifilament, the take-up speed of the roller may be about 500 m/min to 6000 m/min, and can be changed depending on the physical properties of the polymers and the intended use of the fiber.

[0096] The spun conjugated fibers and multifilaments are preferably drawn from the viewpoint that not only the mechanical properties can be improved by promoting uniaxial orientation of fibers, but also the crimp expression can be improved by expanding the thermal shrinkage difference between the conjugated polymers, which is caused by a stress difference during drawing and an orientation difference during drawing. Under this drawing condition, in the case of a fiber including a thermoplastic polymer that can be melt-spun, for example, the fiber is easily drawn in a fiber axis direction depending on a circumferential speed ratio of a first roller whose temperature is set to a temperature equal to or higher than the glass transition temperature and equal to or lower than the melting point and a second roller whose temperature is set to a temperature corresponding to a crystallization temperature, and is wound up by heat setting using a drawing machine including one or more pairs of rollers. In the case of a polymer that does not exhibit glass transition, a measurement of dynamic viscoelasticity ($\tan \delta$) of the conjugated fibers may be measured, and a temperature equal to or higher than a peak temperature on a high temperature side of the obtained $\tan \delta$ may be selected as a preheating temperature.

[0097] Regarding the drawing, drawing may be performed after the spun conjugated fibers and multifilaments are temporarily wound up, or drawing may be performed immediately after spinning without winding the composite fibers and multifilaments up. It is more preferable to perform yarn processing with drawing from the viewpoint that the wearing comfort during the formation of a fabric is enhanced by changing each conjugated fiber into a different, non-uniform form to create a complicated tactility and texture.

[0098] Here, when the yarn processing with drawing is performed, it is preferable to use a highly oriented undrawn yarn obtained by high-speed spinning. The highly oriented undrawn yarn has a structure with oriented amorphous crystals and appropriate crystal nuclei due to orientation parameters being within a specific range, so that crystallization speed is increased, and yarn breakage due to prevention of fusion bonding in a heater and fluffing due to a decrease in a drawing tension can be prevented. Therefore, the highly oriented undrawn yarn is suitable for yarn processing. In the method for producing such a highly oriented undrawn yarn, there are some differences depending on the fiber diameter, the type of polymers, and the viscosity, but in the study conducted by the present inventors, a conjugated fiber having good yarn processability and satisfying the orientation parameter and the crystallinity of the present invention can be obtained by selecting the winding speed during spinning from a range of 2000 m/min to 4000 m/min.

[0099] The yarn processing is not particularly limited as long as it is a known yarn processing technique such as false twisting or a non-uniform drawing. It is more preferable to perform false twisting or non-uniform drawing from the viewpoint of changing the crimping form to a non-uniform form and making the obtained tactility and texture complicated.

[0100] A method for performing the false twisting is not particularly limited as long as it is a method generally used for polyesters. In consideration of productivity, it is preferable to perform the processing using a friction false twisting device using a disc or a belt. By performing the false twisting, a multi-crimping form in which the crimping due to the shrinkage difference and the mechanical crimping imparted by the false twisting are combined is formed, and when a fabric is formed, random unevenness is generated on a surface of the fabric, and dry touch similar to a natural material can be obtained.

[0101] In order to stably produce a crimped yarn using the present invention by the false twisting, it is preferable to

control a crimping form by the actual number of twists of a yarn bundle in a twisting region.

[0102] That is, it is preferable to set false twisting conditions such as the rotation speed and a processing speed of a twisting mechanism so that false twist number T (unit: time(s)/m), which is the number of twists of the yarn bundles in the twisting region, satisfies the following condition determined in accordance with a total fineness Df (unit: dtex) of yarn bundles after the false twisting.

$$20000/Df^{0.5} \leq T \leq 40000/Df^{0.5}$$

[0103] Here, the false twist number T is measured by the following method. That is, a yarn bundle running in the twisting region in the false twisting step is collected in a length of 50 cm or more so as not to untwist immediately before coming to a twister. Then, the collected yarn sample is attached to a twist tester, and the number of twists is measured by a method described in JIS L1013 (2010) 8.13, which is the false twist number T. When the number of false twists satisfies the above conditions, a multi-crimping form in which the crimping due to the shrinkage difference and the mechanical crimping imparted by the false twisting are combined is formed, and when a fabric is formed, random unevenness is generated on a surface of the fabric, and dry touch similar to a natural material can be obtained.

[0104] The drawing ratio in the twisting region may be adjusted under the above false twisting conditions. The drawing ratio referred to herein is calculated as V_d/V_0 in which V_0 is a circumferential speed of a roller for supplying a yarn to the twisting region and a circumferential speed V_d of a roller installed just behind the twisting mechanism. In the case of using the drawn yarn as a supply yarn, V_d/V_0 may be set to 0.9 times to 1.4 times, and in the case of using the highly oriented undrawn yarn as the supply yarn, V_d/V_0 may be set to 1.2 times to 2.0 times, and the drawing may be performed simultaneously with the false twisting. When the drawing ratio is set within such a range, the entire conjugated fibers in the multifilament can have crimps without generating excessive tension or slack of the yarn bundle in the twisting region.

[0105] In addition, from the viewpoint of firmly fixing the crimps obtained in the false twisting step, a false twisting temperature is preferably determined from a range of $T_g + 50^\circ\text{C}$ to $T_g + 150^\circ\text{C}$ based on the T_g of a polymer on a high T_g side of the conjugated polymer. The false twisting temperature referred to herein means a temperature of a heater installed in the twisting region. When the false twisting temperature is set within such a range, a structure of the polymer greatly twisted and deformed in a conjugated fiber section can be sufficiently fixed, so that the dimensional stability of the crimps obtained in the false twisting step can be improved.

[0106] It is also preferable to obtain a thick and thin structure in which drawn portions and undrawn portions randomly appear in the fiber axis direction by performing drawing at a drawing ratio within a range not exceeding a natural drawing ratio of the conjugated fiber by non-uniform drawing. When the non-uniform drawing is performed, in addition to a difference in the dyeing property between single yarns, a difference in a dyeing property also occurs between the drawn portion and the undrawn portion, so that the shades of the color is further emphasized, and furthermore, the crimping forms are different between the drawn portion and the undrawn portion. Therefore, when a fabric is formed, a grain pattern and the texture can be expressed like a natural material.

[0107] In a method for performing non-uniform drawing, the drawing ratio is preferably within a range of an upper limit of the natural drawing ratio $\times 0.8$ times to the upper limit of the natural drawing ratio. When drawing is performed at the upper limit $\times 0.8$ times or more, the orientation parameter of the high-molecular weight component which is important in the present invention can be satisfied, and a grain pattern can be obtained. In addition, when the false twisting is continuously performed after the non-uniform drawing, a material in which the grain pattern is combined with the texture due to a multi-crimping form can be obtained, and therefore, the above range is a preferable range.

[0108] Regarding the multifilament according to one embodiment of the present invention which has been subjected to the non-uniform drawing, it is preferable that a ratio LR ($L_{\text{thin}}/L_{\text{thick}}$) of a thin portion length (L_{thin}) to a thick portion length (L_{thick}) in the fiber axis direction is 1.40 or more. When LR is set to 1.40 or more, a proportion occupied by thin portions that are drawn portions is increased in the fiber axis direction, and thus, good crimps and high elastic modulus can be expressed in the multifilament.

[0109] The thick portion length (L_{thick}) and the thin portion length (L_{thin}) in the fiber axis direction here are defined as follows: when a load of 0.00135 cN/dtex (1.5 mgf/d) is applied to a multifilament, diameters are measured at 50 positions at intervals of 1.0 mm, a value obtained by multiplying a total number of positions each having a diameter larger than an average diameter among the 50 positions by 1 mm is defined as the thick portion length (L_{thick}), and a value obtained by multiplying a total number of positions each having a diameter smaller than the average diameter by 1 mm is defined as the thin portion length (L_{thin}). Note that LR ($L_{\text{thin}}/L_{\text{thick}}$) is a value obtained by dividing the thin portion length (L_{thin}) by the thick portion length (L_{thick}) and rounding off to the second decimal places.

[0110] The multifilament according to one embodiment of the present invention may be blended with another fiber before or after the yarn processing. The blended spinning method is not particularly limited, and a general blended spinning method such as an interlace blended spinning or a Taslan blended spinning can be used.

[0111] Regarding the multifilament according to one embodiment of the present invention, it is preferable to perform

twisting after yarn processing. When the twists of about 200 times/m to 2000 times/m are imparted, the crimp phase is easily aligned when the crimp is expressed by the heat treatment, so that a hollow structure is generated in the multifilament, and the bulging feel and the resilience can be improved.

[0112] The multifilament according to one embodiment of the present invention is preferably formed into a woven fabric or a knitted fabric, and if necessary, is subjected to textile processing accompanied by a heat treatment, such as a common refining, a relaxation treatment, an intermediate heat setting, dyeing processing, or a finishing heat setting, so that a woven or knitted fabric preferable for a textile for clothing can be obtained, which expresses crimps due to shrinkage difference and has wearing comfort such as good resilience and stretchability.

EXAMPLE

[0113] Hereinafter, the conjugated fiber and the multifilament according to one embodiment of the present invention will be specifically described with reference to Examples.

[0114] Examples and Comparative Examples were evaluated as follows.

A. Molecular Weight of Polymers

[0115] To 3 mg of chips or fibers was added 5 mL of hexafluoroisopropanol as a solvent, the mixture was gently stirred at a standard temperature (25°C), and then using "RI-104 type" manufactured by Showa Denko K.K. as a gel permeation chromatography (GPC) device with monodisperse polymethyl methacrylate (PMMA) as a standard sample to determine a molecular weight distribution, and a weight average molecular weight M_w calculated based on the molecular weight distribution determined was defined as a molecular weight of the polymer. When the measurement was performed using a conjugated fiber as a sample and a double peak was obtained in the molecular weight distribution, a low-molecular weight side was defined as a molecular weight of the low-molecular weight component, and a high-molecular weight side was defined as a molecular weight of the high-molecular weight component.

B. Fineness

[0116] A weight of fibers of 100 m was measured, and a value was calculated by multiplying a value of the weight by 100 times. The operation was repeated 10 times, and a value obtained by rounding an average value thereof to one decimal place was defined as the fineness (dtex).

C. Fiber Diameter D

[0117] Fibers were embedded in an embedding agent such as an epoxy resin, and an image of a fiber cross section in a direction perpendicular to a fiber axis was captured and obtained with a transmission electron microscope (TEM) at a magnification at which fibers of 10 or more filaments can be observed. A diameter determined by measuring an area of a fiber randomly extracted in the same image from each captured image and converting the area into a perfect circle was measured up to the one decimal place in units of μm , then, a simple number average of results obtained by performing the calculation on ten multifilaments was determined, and a value obtained by rounding the simple number average off to the nearest whole number was defined as the fiber diameter D (μm). When the fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion was selected and evaluated.

[0118] D. Cross-sectional morphology (ratio $S_{\min}/D$ of minimum thickness $S_{\min}$ of thin portion of low-molecular weight component to fiber diameter D, ratio of thin portion of low-molecular weight component to perimeter of entire fiber, and ratio of part in which ratio S/D of thin portion thickness S to fiber diameter D is 0.05 to 0.10 to entire thin portion of low-molecular weight component)

Conjugated fibers were embedded in an embedding agent such as an epoxy resin, and then an image of a cross section was captured with a transmission electron microscope (TEM) at a magnification at which ten or more fibers can be observed, and a conjugated fiber section was observed. At this time, a contrast of a bonded portion of the cross-sectional morphology was clarified by utilizing the fact that a dyeing difference between polymers can be generated when metal dyeing was performed. When the cross-sectional morphology in the captured image was an eccentric core-sheath section as illustrated in FIG. 1 or (a) and (b) of FIG. 2, regarding ten conjugated fibers randomly extracted in the same image from each image, perimeters of parts, in which a thickness of a low-molecular weight component on an outer periphery of the fiber in a direction of the center of the fiber, such as "S" in FIG. 1 or (a) and (b) of FIG. 2, was 0.01 times to 0.1 times a fiber diameter determined by converting an area of a fiber section into a perfect circle, were determined and respectively divided by perimeters of the entire fibers and the resulting values were multiplied by 100 to calculate values, a simple number average of the values was determined, and a value obtained by rounding the simple number average to the nearest whole number was defined as "the ratio (%)" of the thin portion of the low-molecular weight component to

the perimeter of the entire fibers".

[0119] Regarding the above ten conjugated fibers, values were calculated by separately dividing the minimum value of the thicknesses S of the thin portions by values of the fiber diameters D each determined by measuring, in units of μm up to the one decimal place, a diameter determined by measuring an area of the fiber and converting the area into a perfect circle, a simple number average of the values was determined, and a value obtained by rounding the simple number average to two decimal places was defined as "the ratio $S_{\min}/D$ of the minimum thickness $S_{\min}$ of the thin portion of the low-molecular weight component to the fiber diameter D ".

[0120] Regarding the above ten conjugated fibers, perimeters of parts, in which a ratio S/D of a thin portion thickness S to a fiber diameter D that was obtained by dividing the value of the thicknesses S of the thin portions by values of the fiber diameters D each determined by measuring, in units of μm up to the one decimal place, a diameter determined by measuring an area of the fiber and converting the area into a perfect circle is 0.05 to 0.10, were determined and respectively divided by perimeters of the entire thin portions, and the resulting values were multiplied by 100 to calculate values, a simple number average of the values is determined, and a value obtained by rounding the simple number average to the nearest whole number was defined as "the ratio (%) of the part in which the ratio S/D of the thin portion thickness S to the fiber diameter D is 0.05 to 0.10 to the entire thin portions of the low-molecular weight component".

[0121] When the conjugated fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion was selected and evaluated.

E. Orientation Parameter of High-molecular Weight Component

[0122] A high-molecular weight component in a longitudinal section of a fiber was irradiated with a laser, measurements were performed in polarization directions in directions parallel and perpendicular to a fiber axis using a laser Raman spectroscopy, an intensity of a Raman band in a vicinity of 1615 cm^{-1} attributed to the $\text{C}=\text{C}$ stretching vibration mode (parallel: $I_{1615\text{ parallel}}$, perpendicular: $I_{1615\text{ perpendicular}}$) was determined from a Raman spectrum obtained in each of the measurements, a ratio $I_{1615\text{ parallel}}/I_{1615\text{ perpendicular}}$ was calculated, and a value obtained by rounding the ratio $I_{1615\text{ parallel}}/I_{1615\text{ perpendicular}}$ to one decimal places was defined as the orientation parameter. In the case of no orientation, the orientation parameter is 1. In addition, when the fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion was selected and evaluated.

F. Crystallinity of High-molecular Weight Component

[0123] A high-molecular weight component in a longitudinal section of a fiber was irradiated with a laser, measurements were performed in a polarization direction parallel to a fiber axis using a laser Raman spectroscopy, a full width at half maximum ($\Delta\nu_{1730}$) of a Raman band in a vicinity of 1730 cm^{-1} attributed to a $\text{C}=\text{O}$ stretching vibration mode is determined, and a value obtained by assigning $\Delta\nu_{1730}$ to the following Formula (1) was defined as the density ρ . A value obtained by rounding a value, which was obtained by assigning the determined density ρ to the following formula (2), to the nearest whole number was defined as crystallinity (%).

$$\text{Density } \rho \text{ (g/cm}^3\text{)} = (305 - \Delta\nu_{1730})/209 \quad \text{Formula (1)}$$

$$\text{Crystallinity (\%)} = 100 \times (\rho - \text{density of completely amorphous crystal}) / (\text{density of complete crystal} - \text{density of completely amorphous crystal}) \quad \text{Formula (2)}$$

[0124] In the case of determining the crystallinity of polyethylene terephthalate, copolymerized polyethylene terephthalate, and polybutylene terephthalate, the density of a completely amorphous crystal was 1.335 g/cm^3 , and the density of a complete crystal was 1.455 g/cm^3 . In addition, when the fiber has a drawn portion and an undrawn portion in the fiber axis direction, only the drawn portion was selected and evaluated.

G. Yarn Processing Stability

[0125] In the yarn processing in each of Examples, the yarn production stability was determined as four stages based on the following standards on the basis of the number of times of yarn breakage per ten million meters (times/ten million meters).

S: Excellent yarn processing stability (number of times of yarn breakage < 1.0)

- A: Good yarn processing stability ($1.0 \leq \text{number of times of yarn breakage} < 2.0$)
 B: Having yarn processing stability ($2.0 \leq \text{number of times of yarn breakage} < 3.0$)
 C: Poor yarn processing stability ($3.0 \leq \text{number of times of yarn breakage}$).

5 H. Crimp Expression Rate

[0126] Fibers were cut into skeins each having a length of 10 m and treated in 90°C water for 20 minutes with no load (0 cN/dtex), followed by air-drying for 24 hours. Thereafter, an initial load of 0.0018 cN/dtex (2 mgf/d) was applied to the skeins in water at room temperature (25°C), and a skein length L1 after 2 minutes was measured. Next, the above initial load of 0.0018 cN/dtex was removed in water at room temperature (25°C), the load was changed to a load corresponding to 0.09 cN/dtex (0.1 gf/d), and a skein length L0 after 2 minutes was measured. Thus, L0 and L1 were obtained, and a value obtained by rounding a value, which was determined according to the following formula based on L0 and L1, to the nearest whole number was defined as crimp expression rate (%).

$$15 \quad \text{Crimp expression rate (\%)} = [(L0 - L1)/L0] \times 100 (\%)$$

I. Elastic Modulus

[0127] A sample was elongated by a TENSILON tensile tester from an initial load of 0.1 cN/dtex to a maximum stress of 0.5 cN/dtex with a sample length of 20 cm and a tensile speed of 20 cm/min in accordance with constant speed elongation conditions shown in a standard-state test of JIS L1013 (2010) 8.5.1, then a slope under a tensile load of 0.3 cN/dtex to 0.5 cN/dtex in the obtained stress-strain curve was calculated, a simple number average of results obtained by performing the calculation on the ten multifilaments was determined, and a value obtained by rounding the simple number average to the nearest whole number was defined as elastic modulus (cN/dtex).

J. Hysteresis Loss Rate During Recovery From Elongation

[0128] A sample was elongated by a TENSILON tensile tester from an initial load of 0.1 cN/dtex to a maximum stress of 0.5 cN/dtex with a sample length of 20 cm and a tensile speed of 20 cm/min in accordance with constant speed elongation conditions shown in a standard-state test of JIS L1013 (2010) 8.5.1 and then was recovered to an original test length position at the same speed. A hysteresis curve was drawn, and an area (A1) of a region sandwiched between a curve during elongation and a curve during recovery and an area (A2) of a region sandwiched between a curve during the elongation and a horizontal axis (axis of elongation) were determined, followed by dividing A1 by A2 and multiplying the resultant value by 100 to calculate a value. A simple number average of results obtained by performing the calculation on ten multifilaments was determined, and a value obtained by rounding the simple number average to the nearest whole number was defined as the hysteresis loss rate (%) during recovery from elongation.

K. Fabric Properties (Bulging Feel and Resilience)

[0129] The number of fibers was adjusted such that a cover factor (CFA) in a warp direction was 800 and a cover factor (CFB) in a weft direction was 1,200, and a 3/1 twill fabric was prepared. Incidentally, CFA and CFB referred to herein are values obtained by measuring a warp density and a weft density of the woven fabric in a section of 2.54 cm in accordance with JIS-L-1096:2010 8.6.1 and calculating based on formulae $CFA = \text{warp density} \times (\text{fineness of warp})^{1/2}$ and $CFB = \text{weft density} \times (\text{fineness of weft})^{1/2}$. The obtained woven fabric was subjected to refining, a wet heat treatment, and heat setting, and then the following method was used to evaluate two texture, the bulging feel and feeling of resilience. **[0130]** For the bulging feel, using a constant pressure thickness meter (PG-14J) manufactured by TELOTECK, a thickness (cm) of a woven fabric of 20 cm × 20 cm was measured under a constant pressure (0.7 kPa), a volume of the woven fabric was calculated, then a value obtained by dividing a weight (g) of the woven fabric by the obtained volume was determined, and a value obtained by rounding off to one decimal places was defined as an apparent density (g/cm³) of the woven fabric. The bulging feel was respectively determined as four stages based on the following standards on the basis of the obtained apparent density.

- S: Excellent bulging feel (apparent density ≤ 0.5)
 A: Good bulging feel ($0.5 < \text{apparent density} \leq 0.8$)
 B: Having bulging feel ($0.8 < \text{apparent density} \leq 1.1$)
 C: Poor bulging feel ($1.1 < \text{apparent density}$).

[0131] For the resilience, using a pure bending tester (KES-FB2) manufactured by KATO TECH CO., LTD., a woven fabric of 20 cm × 20 cm was gripped with an effective sample length of 20 cm × 1 cm, and a width (gf·cm/cm) of hysteresis in a curvature of $\pm 1.0 \text{ cm}^{-1}$ when the woven fabric was bent in a weft direction was calculated. This operation was performed three times for each portion, and a simple number average of results obtained by performing this operation for 10 portions in total was calculated, and a value obtained by multiplying the number average after rounding off to the three decimal places by 100 was defined as a bending recovery $2\text{HB} \times 10^{-2}$ (gf·cm/cm). Note that 1 gf cm/cm = 0.0098 N cm/cm. The feeling of resilience was respectively determined as four stages based on the following standards on the basis of the obtained bending recovery $2\text{HB} \times 10^{-2}$.

- S: Excellent resilience (bending recovery: $2\text{HB} \times 10^{-2} \leq 0.8$)
- A: Good resilience ($0.8 < \text{bending recovery } 2\text{HB} \times 10^{-2} \leq 1.3$)
- B: Having resilience ($1.3 < \text{bending recovery } 2\text{HB} \times 10^{-2} \leq 2.0$)
- C: Poor resilience ($2.0 < \text{bending recovery } 2\text{HB} \times 10^{-2}$).

L. Fabric Properties (Stretchability)

[0132] The number of fibers was adjusted such that a cover factor (CFA) in a warp direction was 800 and a cover factor (CFB) in a weft direction was 1,200, and a 3/1 twill fabric was prepared. Incidentally, CFA and CFB referred to herein are values obtained by measuring a warp density and a weft density of the woven fabric in a section of 2.54 cm in accordance with JIS-L-1096:2010 8.6.1 and calculating based on formulae $\text{CFA} = \text{warp density} \times (\text{fineness of warp})^{1/2}$ and $\text{CFB} = \text{weft density} \times (\text{fineness of weft})^{1/2}$. The obtained woven fabric was subjected to refining, a wet heat treatment, and heat setting, and then the stretchability was evaluated in accordance with the elongation rate A method (constant speed elongation method) described in section 8.16.1 of JIS L1096:2010. A case of a load of 17.6 N (1.8 kg) in a stripping method was used, and test conditions thereof were a sample width of 5 cm x a length of 20 cm, a clamp interval of 10 cm, and a tensile speed of 20 cm/min. In addition, as an initial load, a weight corresponding to a sample width of 1 m was used in accordance with the method of JIS L 1096:2010. A simple number average of results obtained by performing the test three times in a lateral direction of the woven fabric was calculated, and a value obtained by rounding off to the nearest whole number was defined as a fabric elongation rate (%). The stretchability was respectively determined as three stages based on the following standards on the basis of the obtained fabric elongation rate.

- S: Excellent stretchability ($25 \leq \text{elongation rate}$)
- A: Good stretchability ($15 \leq \text{elongation rate} < 25$)
- B: Having stretchability ($5 \leq \text{elongation rate} < 15$)
- C: Poor stretchability (elongation rate < 5).

[Example 1]

[0133] Polyethylene terephthalate (PET, molecular weight: 25,700) was prepared as a polymer A and polyethylene terephthalate (PET, molecular weight: 16,900) was prepared as a polymer B.

[0134] After these polymers were separately melted at 290°C, the melted polymer A and polymer B were weighed such that an area ratio of the polymer A to the polymer B in cross-sectional morphologies was 50/50, followed by being separately flowed into the same spinning pack and discharged from discharge holes formed in a spinneret. In conjugated fibers in Example 1, an eccentric core-sheath section as illustrated in FIG. 1 is formed in which the polymer A as the high-molecular weight PET is completely covered with the polymer B as the low-molecular weight PET, and in a thin portion made of the low-molecular weight PET, a ratio of the thin portion to a perimeter of the entire fiber is 50%, and a ratio of a part in which a ratio S/D of the thin portion thickness S to the fiber diameter D is 0.05 to 0.10 to the entire thin portion is 1%.

[0135] After cooling and solidifying the discharged conjugated polymer flow, an oil agent was applied, and the mixture was wound up at a spinning speed of 2500 m/min to produce conjugated fibers. The orientation parameter of the high-molecular weight PET of the obtained conjugated fibers was 2.1, the crystallinity of the high-molecular weight PET was 24%, and it was confirmed that the obtained conjugated fibers were the conjugated fiber according to one embodiment of the present invention.

[0136] The obtained conjugated fibers according to one embodiment of the present invention were stored in a standard state (temperature: 23°C, relative humidity: 65%) for one month, then fed to a drawing device at a speed of 300 m/min, and subjected to non-uniform drawing at a hot pin temperature of 70°C and a setting temperature of 150°C at the same drawing ratio as the upper limit of the natural drawing ratio of the conjugated fibers, thereby obtaining a multifilament of 115dtex-24 filaments (fiber diameter: 21 μm). The number of times of yarn breakage in this case was 1.5 times/ten million meters, and good yarn processing stability was obtained.

[0137] The obtained multifilament had an eccentric core-sheath section as illustrated in FIG. 1 in which the polymer A as the high-molecular weight PET was completely covered with the polymer B as the low-molecular weight PET, and in a thin portion made of the low-molecular weight PET, a ratio of the thin portion to a perimeter of the entire fiber was 50%, and a ratio of a part in which a ratio S/D of the thin portion thickness S to the fiber diameter D was 0.05 to 0.10 to the entire thin portion was 1%. In addition, the drawn portion and undrawn portion had thick and thin structures that appeared randomly in the fiber axis direction, the orientation parameter of the high-molecular weight PET in the drawn portion was 7.0, and the crystallinity of the high-molecular weight PET thereof was 33%. Accordingly, the obtained multifilament was confirmed to be the multifilament according to one embodiment of the present invention.

[0138] Further, in the properties of the multifilament, the multifilament had a crimp expression property (crimp expression rate: 23%) due to a good shrinkage difference and a high elasticity derived from polyesters (elastic modulus: 62 cN/dtex), and the recovery property (hysteresis loss rate: 53%) when the crimp was drawn was also good.

[0139] Next, the obtained multifilament was twisted at 1000 T/m, and the twisted multifilament was used as a warp and a weft, the number of fibers was adjusted such that the cover factor (CFA) in the warp direction was 800 and the cover factor (CFB) in the weft direction was 1200, the warp and the weft were weaved with a 3/1 twill structure and subjected to a refining treatment at 80°C and a wet heat treatment at 130°C, and then subjected to a heat setting at 180°C, thereby obtaining a woven fabric made of multifilament.

[0140] The woven fabric made of the multifilament expressed good crimps and high elasticity in all the conjugated fibers constituting the multifilament, and thus had an appropriate feeling of resilience (bending recovery 2HB: 1.0×10^{-2} gf/cm/cm) and excellent stretchability (fabric elongation rate: 20%). In addition, complicated voids were generated between the conjugated fibers, so that the woven fabric also had texture such as a bulging feel (apparent density: 0.7 g/cm³), and was suitable for a textile for clothing excellent in wearing comfort that combines texture and function that were directly linked to the wearing comfort of a person. The results are shown in Table 1.

[Example 2]

[0141] The entire process was carried out in accordance with Example 1 except that after cooling and solidifying the discharged conjugated polymer flow, an oil agent was applied, and the mixture was wound up at a spinning speed of 2250 m/min.

[0142] In Example 2, by reducing the winding speed, the oriented crystallization of the high-molecular weight PET was prevented, and the high-molecular weight PET of the obtained conjugated fiber had a low crystallinity. In addition, in the multifilament obtained after the non-uniform drawing, the orientation of the high-molecular weight PET during drawing was not inhibited by the crystals, so that the crimp expression rate and the elastic modulus were improved, and the bulging feel, the stretchability, and the resilience of the obtained woven fabric were also good. The results are shown in Table 1.

[Comparative Example1]

[0143] The entire process was carried out in accordance with Example 1 except that a conjugated fiber was produced by changing the cross-sectional morphology to a cross-sectional morphology, as illustrated in (a) of FIG. 3, in which a high-molecular weight PET and a low-molecular weight PET were bonded in a side-by-side type, and performing winding at a spinning speed of 1400 m/min.

[0144] In Comparative Example 1, the fiber strength and the heat resistance deteriorated due to the change over time caused by the storage for one month in the standard state (temperature: 23°C, relative humidity: 65%), the yarn breakage frequently occurred during the non-uniform drawing, and thus the conjugated fiber can not be processed. The results are shown in Table 1.

[Comparative Examples 2 and 3]

[0145] Comparative Example 2 was carried out in accordance with Example 1 except that the cross-sectional morphology was changed to a section, as illustrated in (a) of FIG. 3, in which the high-molecular weight PET and the low-molecular weight PET were bonded in a side-by-side type. Comparative Example 3 was carried out in accordance with Example 1 except that the cross-sectional morphology was changed to an eccentric core-sheath section, as illustrated in (b) of FIG. 3, in which the high-molecular weight PET was exposed to a surface layer.

[0146] In Comparative Examples 2 and 3, the high-molecular weight PET was exposed to the surface layer, and thus, when the polymers were discharged from the spinneret during spinning, the flow resistance in which the high-molecular weight component was received from the wall surface of the discharge hole in the spinneret was large, the crystal nuclei were generated in an excessive amount due to the deformation of the molecular chain, and the oriented crystallization progressed due to the high-speed spinning during spinning. Therefore, the high-molecular weight PET of the obtained

conjugated fibers had a high crystallinity. In addition, in the multifilament obtained after the non-uniform drawing, the orientation of the high-molecular weight PET during the drawing was inhibited by the crystals, and thus, the crimp expression rate and the elastic modulus deteriorated, and the high-molecular weight PET was exposed to the surface layer. Therefore, the yarn processing stability also deteriorated as compared with Example 1.

[0147] The obtained woven fabric was poor in the bulging feel and the stretchability because the crimp expression rate of the multifilament was small. Further, in Comparative Example 2, the obtained woven fabric was also lack of resilience because the multifilament had a low elastic modulus. The results are shown in Table 1.

[Examples 3 and 4]

[0148] The entire processes were carried out in accordance with Example 1 except that the molecular weight of PET as the polymer A was changed to 30,900 (Example 3) and 23,400 (Example 4).

[0149] In Example 3, by increasing the molecular weight, the orientation of the high-molecular weight PET was increased, and the crimp expression rate and the elastic modulus of the multifilament were improved, so that the bulging feel, the stretchability, and the resilience of the obtained woven fabric were also good.

[0150] In Example 4, even when the molecular weight was reduced, the bulging feel, the stretchability, and the resilience of the obtained woven fabric were maintained at good levels. The multifilament had a low elasticity, and the flexibility of the obtained woven fabric was improved by reducing the molecular weight. The results are shown in Table 1.

[Comparative Example 4]

[0151] The entire process was carried out in accordance with Example 1 except that the molecular weight of PET as the polymer A was changed to 19,500.

[0152] In Comparative Example 4, the molecular weight of the high-molecular weight PET was 20,000 or less, and thus, the orientation of the high-molecular weight PET by high-speed spinning was not promoted, and the high-molecular weight PET had a low orientation. Therefore, the yarn processing stability deteriorated as compared with Example 1. In addition, in the obtained multifilament, the difference in the orientation relaxation between the high-molecular weight PET and the low-molecular weight PET was small, and thus, the crimp expression rate was low, and the bulging feel and the stretchability when a woven fabric was formed were also inferior. The results are shown in Table 1.

[Example 5]

[0153] The process was carried out in accordance with Example 1 except that the cross-sectional morphology was changed to an eccentric core-sheath section, as illustrated in FIG. 4, in which the high-molecular weight PET was covered with the low-molecular weight PET.

[0154] In Example 5, the ratio of the thin portion to the perimeter of the entire fiber was small, so that the high-molecular weight PET was thickly covered with the low-molecular weight PET, and thus the yarn processing stability was excellent, and further, the flow resistance in which the high-molecular weight PET was received from the wall surface of the discharge hole of the spinneret was reduced. Therefore, the crystallinity was also reduced, and the multifilament had a high elastic modulus, so that the resilience of the woven fabric was also improved. The results are shown in Table 1.

[Examples 6 and 7]

[0155] The entire processes were carried out in accordance with Example 1 except that the ratio $S_{\min}/D$ of the minimum thickness $S_{\min}$ of the thin portion of the low-molecular weight component to the fiber diameter D was changed to 0.01 (Example 6) and 0.1 (Example 7).

[0156] In Example 6, when $S_{\min}/D$ was reduced, the bulging feel, the stretchability, and the resilience of the obtained woven fabric were also maintained at good levels. The multifilament had a low elasticity, and the flexibility of the obtained woven fabric was improved by reducing $S_{\min}/D$. In Example 7, by increasing $S_{\min}/D$, the orientation of the high-molecular weight PET was increased, and the elastic modulus of the multifilament was improved, so that the resilience of the obtained woven fabric was also improved. The results are shown in Table 2.

[Example 8]

[0157] The entire process was carried out in accordance with Example 1 except that the conjugated fiber was changed to have an eccentric core-sheath section, as illustrated in (a) of FIG. 2, in which the polymer A as the high-molecular weight PET was completely covered with the polymer B as the low-molecular weight PET, and in a thin portion made of the low-molecular weight PET, a ratio of the thin portion to a perimeter of the entire fiber was 51%, and a ratio of a

part in which a ratio S/D of the thin portion thickness S to the fiber diameter D was 0.05 to 0.10 to the entire thin portion was 25%.

[0158] In Example 8, by changing the thin portion thickness S on an outer periphery of the fiber, the plug flow effect was improved, the oriented crystallization of the high-molecular weight PET by high-speed spinning was prevented, the orientation of the high-molecular weight PET in the obtained multifilament was increased, and the crimp expression rate and the elastic modulus of the multifilament were improved. Therefore, the resilience and the stretchability of the obtained woven fabric were also good. The results are shown in Table 2.

[Examples 9 and 10]

[0159] The entire processes were carried out in accordance with Example 1 except that the polymers A were respectively changed to 4 mol% isophthalic acid-copolymerized polyethylene terephthalate (4 mol% IPA-copolymerized PET, molecular weight: 25,500) (Example 9) and 7 mol% isophthalic acid-copolymerized polyethylene terephthalate (7 mol% IPA-copolymerized PET, molecular weight: 25,300) (Example 10).

[0160] In Examples 9 and 10, as a copolymerization rate of IPA was increased, the crimp expression of the multifilament was good, and the bulging feel and the stretchability of the obtained woven fabric were improved. The results are shown in Table 2.

[Example 11]

[0161] The entire process was carried out in accordance with Example 1 except that the polymer A was changed to polybutylene terephthalate (PBT, molecular weight: 31,400).

[0162] In Example 11, the rubber elasticity properties of PBT were combined with other properties, and the stretching function of the obtained woven fabric was significantly improved. The obtained woven fabric was flexible and had an excellent texture. The results are shown in Table 2.

[Examples 12 and 13]

[0163] The entire processes were carried out in accordance with Example 1 except that the discharge amount was changed so that the fiber diameters were 15 μm (Example 12) and 8 μm (Example 13).

[0164] In Examples 12 and 13, when the fiber diameter was reduced, the bulging feel, the stretchability, and the resilience of the obtained woven fabric were maintained at good levels. When the fiber diameter was reduced, the fiber was thin, so that the irregular reflection of light was increased, and the appearance unevenness (glare) when the textile was formed was prevented to improve the appearance quality, and in addition, the flexibility was also improved because the bending rigidity of a single fiber was reduced. The results are shown in Table 2.

[Example 14]

[0165] The entire process was carried out in accordance with Example 1 except that the obtained conjugated fiber according to one embodiment of the present invention was stored in a standard state (temperature: 23°C, relative humidity: 65%) for one month, and then, between rollers by which the processing speed was 250 m/min and the drawing ratio was 1.2 times the upper limit of the natural drawing ratio, the conjugated fiber was subjected to false twisting using a friction disk at a rotation speed by which the number of false twists was 3000 T/m while being heated by with a heater set to 160°C, and the multifilament according to one embodiment of the present invention having 110dtex-24 filaments was obtained.

[0166] In the false twisting, the number of times of yarn breakage was 1.2 times/ten million meters, which means a good yarn processing stability, the fusion between the conjugated fibers was not observed, and the processability was excellent without defects such as fluffs and neps.

[0167] In Example 14, a multi-crimping form was formed by false twisting, so that the obtained multifilament expressed good crimp expression. When the woven fabric was formed, in addition to the improvement in the bulging feel and the stretchability, random unevenness was generated on a surface of the woven fabric, and a dry touch similar to a natural material was obtained. The results are shown in Table 2.

[Table 1]

		Example 1	Example 2	Comparative Example 1
5 10 15	Polymer	Polymer A	PET molecular weight: 25,700	PET molecular weight: 25,700
		Polymer B	PET molecular weight: 16,900	PET molecular weight: 16,900
		Molecular weight difference (polymer A) - (polymer B)	8,800	8,800
		Conjugation ratio (polymer A/polymer B)	50/50	50/50
20 25 30	Conjugated fiber	Polymer arrangement	FIG. 1	FIG. 1
		$S_{\min}/D$	0.03	0.03
		Ratio (%) of thin portion to perimeter of entire fiber	50	50
		Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	1	1
		Orientation parameter of high-molecular weight component	2.1	1.6
		Crystallinity (%) of high-molecular weight component	24	6
	Yarn processing stability (number of times of yarn breakage (times/ten million meters))		A (1.5)	B (2.0)
35 40 45 50	Multifilament	Polymer arrangement	FIG. 1	FIG. 1
		$S_{\min}/D$	0.03	0.03
		Ratio (%) of thin portion to perimeter of entire fiber	50	50
		Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	1	1
		Fiber diameter (μm)	21	21
		Orientation parameter of high-molecular weight component	7.0	7.4
		Crystallinity (%) of high-molecular weight component	33	28
		Crimp expression rate (%)	23	31
		Elastic modulus (cN/dtex)	62	71
		Hysteresis loss rate (%)	53	57

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(continued)

		Example 1	Example 2	Comparative Example 1
Fabric properties	Bulging feel (apparent density (g/cm ³))	A (0.7)	A (0.6)	-
	Resilience (bending recovery: 2HB × 10 ⁻² (gf-cm/cm))	A (1.0)	A (0.9)	-
	Stretchability (Fabric elongation rate (%))	A (20)	S (26)	-
PET: polyethylene terephthalate				

[Table 1] (continued)

		Comparative Example 2	Comparative Example 3	Example 3
Polymer	Polymer A	PET molecular weight: 25,700	PET molecular weight: 25,700	PET molecular weight: 30,900
	Polymer B	PET molecular weight: 16,900	PET molecular weight: 16,900	PET molecular weight: 16,900
	Molecular weight difference (polymer A) - (polymer B)	8,800	8,800	14,000
	Conjugation ratio (polymer A/polymer B)	50/50	50/50	50/50
Conjugated fiber	Polymer arrangement	(a) of FIG. 3	(b) of FIG. 3	FIG. 1
	S _{min} /D	-	-	0.03
	Ratio (%) of thin portion to perimeter of entire fiber	-	23	48
	Ratio (%) of part in which S/D = 0.05 to 0.10 to entire thin portion	-	45	1
	Orientation parameter of high-molecular weight component	2.4	2.3	2.5
	Crystallinity (%) of high-molecular weight component	45	41	29
Yarn processing stability (number of times of yarn breakage (times/ten million meters))		B (2.3)	B (2.0)	A (1.1)

(continued)

		Comparative Example 2	Comparative Example 3	Example 3
5				
	Polymer arrangement	(a) of FIG. 3	(b) of FIG. 3	FIG. 1
	$S_{\min}/D$	-	-	0.03
10	Ratio (%) of thin portion to perimeter of entire fiber	-	23	48
	Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	-	45	1
15	Fiber diameter (μm)	21	21	21
	Orientation parameter of high-molecular weight component	5.5	6.1	8.2
	Crystallinity (%) of high-molecular weight component	56	51	39
20	Crimp expression rate (%)	6	8	34
	Elastic modulus (cN/dtex)	36	40	71
	Hysteresis loss rate (%)	74	72	46
25	Bulging feel (apparent density (g/cm^3))	C (1.2)	C (1.2)	A (0.6)
	Resilience (bending recovery: $2\text{HB} \times 10^{-2}$ (gf·cm/cm))	C (2.1)	B (2.0)	S (0.8)
30	Stretchability (Fabric elongation rate (%))	C (3)	C (4)	S (28)
	PET: polyethylene terephthalate			

[Table 1] (continued)

		Example 4	Comparative Example 4	Example 5
35				
40	Polymer A	PET molecular weight: 23,400	PET molecular weight: 19,500	PET molecular weight: 25,700
45	Polymer B	PET molecular weight: 16,900	PET molecular weight: 16,900	PET molecular weight: 16,900
	Molecular weight difference (polymer A) - (polymer B)	6,500	2,600	8,800
50	Conjugation ratio (polymer A/polymer B)	50/50	50/50	50/50

(continued)

		Example 4	Comparative Example 4	Example 5
5	Conjugated fiber	Polymer arrangement	FIG. 1	FIG. 4
		$S_{\min}/D$	0.03	0.03
10		Ratio (%) of thin portion to perimeter of entire fiber	52	54
		Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	1	53
15		Orientation parameter of high-molecular weight component	1.8	2.0
		Crystallinity (%) of high-molecular weight component	20	21
20	Yarn processing stability (number of times of yarn breakage (times/ten million meters))		A (1.8)	B (2.2)
	Multifilament	Polymer arrangement	FIG. 1	FIG. 4
		$S_{\min}/D$	0.03	0.03
25		Ratio (%) of thin portion to perimeter of entire fiber	52	54
		Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	1	53
30		Fiber diameter (μm)	21	21
		Orientation parameter of high-molecular weight component	6.3	5.8
		Crystallinity (%) of high-molecular weight component	30	26
35		Crimp expression rate (%)	15	9
		Elastic modulus (cN/dtex)	55	48
		Hysteresis loss rate (%)	59	63
40	Fabric properties	Bulging feel (apparent density (g/cm^3))	B (1.0)	C (1.2)
		Resilience (bending recovery: $2\text{HB} \times 10^{-2}$ (gf·cm/cm))	A (1.2)	B (1.6)
		Stretchability (Fabric elongation rate (%))	B (12)	C (4)
45	PET: polyethylene terephthalate			

[Table 2]

		Example 6	Example 7	Example 8
Polymer	Polymer A	PET molecular weight: 25,700	PET molecular weight: 25,700	PET molecular weight: 25,700
	Polymer B	PET molecular weight: 16,900	PET molecular weight: 16,900	PET molecular weight: 16,900
	Molecular weight difference (polymer A) - (polymer B)	8,800	8,800	8,800
	Conjugation ratio (polymer A/polymer B)	50/50	50/50	50/50
Conjugated fiber	Polymer arrangement	FIG. 1	FIG. 1	(a) of FIG. 2
	S _{min} /D	0.01	0.10	0.02
	Ratio (%) of thin portion to perimeter of entire fiber	48	52	51
	Ratio (%) of part in which S/D = 0.05 to 0.10 to entire thin portion	1	100	25
	Orientation parameter of high-molecular weight component	2.2	2.0	2.2
	Crystallinity (%) of high-molecular weight component	29	20	29
Yarn processing stability (number of times of yarn breakage (times/ten million meters))		A (1.8)	S (0.9)	S (0.9)
Multifilament	Polymer arrangement	FIG. 1	FIG. 1	(a) of FIG. 2
	S _{min} /D	0.01	0.10	0.02
	Ratio of thin portion to perimeter of entire fiber	48	52	51
	Ratio (%) of part in which S/D = 0.05 to 0.10 to entire thin portion	1	100	25
	Fiber diameter (μm)	21	21	21
	Orientation parameter of high-molecular weight component	6.4	7.3	7.3
	Crystallinity (%) of high-molecular weight component	42	30	30
	Crimp expression rate (%)	16	is	34
	Elastic modulus (cN/dtex)	44	69	71
	Hysteresis loss rate (%)	69	48	46
Fabric properties	Bulging feel (apparent density (g/cm ³))	B (1.0)	B (0.9)	A (0.6)
	Resilience (bending recovery: 2HB × 10 ⁻² (gf-cm/cm))	B (1.7)	A (0.9)	S (0.8)
	Stretchability (Fabric elongation rate (%))	B (12)	B (13)	S (28)
PET: polyethylene terephthalate, IPA: isophthalic acid, PBT: polybutylene terephthalate				

[Table 2] (continued)

		Example 9	Example 10	Example 11
Polymer	Polymer A	4 mol% IPA-copolymerized PET molecular weight: 25,500	7 mol% IPA-copolymerized PET molecular weight: 25,300	PBT molecular weight: 31,400
	Polymer B	PET molecular weight: 16,900	PET molecular weight: 16,900	PET molecular weight: 16,900
	Molecular weight difference (polymer A) - (polymer B)	8,600	8,400	14,500
	Conjugation ratio (polymer A/ polymer B)	50/50	50/50	50/50
Conjugated fiber	Polymer arrangement	FIG. 1	FIG. 1	FIG. 1
	$S_{\min}/D$	0.03	0.03	0.03
	Ratio (%) of thin portion to perimeter of entire fiber	50	50	50
	Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	1	1	1
	Orientation parameter of high-molecular weight component	2.0	1.8	2.9
	Crystallinity (%) of high-molecular weight component	20	15	28
Yarn processing stability (number of times of yarn breakage (times/ten million meters))		A (1.8)	B (2.8)	B (2.2)
Multifilament	Polymer arrangement	FIG. 1	FIG. 1	FIG. 1
	$S_{\min}/D$	0.03	0.03	0.03
	Ratio of thin portion to perimeter of entire fiber	51	51	51
	Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	25	25	25
	Fiber diameter (μm)	21	21	21
	Orientation parameter of high-molecular weight component	6.6	6.1	8.1
	Crystallinity (%) of high-molecular weight component	30	26	39
	Crimp expression rate (%)	27	33	41
	Elastic modulus (cN/dtex)	53	41	20
	Hysteresis loss rate (%)	60	70	80

(continued)

		Example 9	Example 10	Example 11
Fabric properties	Bulging feel (apparent density (g/cm ³))	A (0.7)	A (0.6)	S (0.5)
	Resilience (bending recovery: $2HB \times 10^{-2}$ (gf-cm/cm))	A (1.2)	B (1.8)	B (2.0)
	Stretchability (Fabric elongation rate (%))	A (22)	A (24)	S (33)
PET: polyethylene terephthalate, IPA: isophthalic acid, PBT: polybutylene terephthalate				

[Table 2] (continued)

		Example 12	Example 13	Example 14
Polymer	Polymer A	PET molecular weight: 25,700	PET molecular weight: 25,700	PET molecular weight: 25,700
	Polymer B	PET molecular weight: 16,900	PET molecular weight: 16,900	PET molecular weight: 16,900
	Molecular weight difference (polymer A) - (polymer B)	8,800	8,800	8,800
	Conjugation ratio (polymer A/polymer B)	50/50	50/50	50/50
Conjugated fiber	Polymer arrangement	FIG. 1	FIG. 1	FIG. 1
	S_{min}/D	0.03	0.03	0.03
	Ratio (%) of thin portion to perimeter of entire fiber	50	50	50
	Ratio (%) of part in which $S/D = 0.05$ to 0.10 to entire thin portion	1	1	1
	Orientation parameter of high-molecular weight component	2.1	2.1	2.1
	Crystallinity (%) of high-molecular weight component	24	24	24
Yarn processing stability (number of times of yarn breakage (times/ten million meters))		A (1.4)	A (1.3)	A (1.2)

(continued)

		Example 12	Example 13	Example 14
Multifilament	Polymer arrangement	FIG. 1	FIG. 1	FIG. 1
	S _{min} /D	0.03	0.03	0.03
	Ratio of thin portion to perimeter of entire fiber	51	51	51
	Ratio (%) of part in which S/D = 0.05 to 0.10 to entire thin portion	25	25	25
	Fiber diameter (μm)	15	8	21
	Orientation parameter of high-molecular weight component	7.0	7.0	8.2
	Crystallinity (%) of high-molecular weight component	33	33	38
	Crimp expression rate (%)	22	22	45
	Elastic modulus (cN/dtex)	62	62	72
	Hysteresis loss rate (%)	53	53	58
Fabric properties	Bulging feel (apparent density (g/cm ³))	A (0.7)	A (0.8)	S (0.4)
	Resilience (bending recovery: 2HB × 10 ⁻² (gf-cm/cm))	A (1.2)	B (1.4)	A (0.9)
	Stretchability (Fabric elongation rate (%))	A (18)	A (16)	S (35)
PET: polyethylene terephthalate, IPA: isophthalic acid, PBT: polybutylene terephthalate				

INDUSTRIAL APPLICABILITY

[0168] Regarding a conjugated fiber according to one embodiment of the present invention, by controlling the polymers and the cross-sectional morphology, the fiber structure formed during spinning falls within a specific range, and a multifilament having no restrictions on processing conditions and having a high elasticity derived from polyester and good crimp expression can be obtained after processing.

[0169] In addition, in the multifilament according to one embodiment of the present invention, by controlling the polymers and the conjugated fiber section, the fiber structure formed during yarn production falls within a specific range, and a high elasticity derived from the polyesters and good crimp expression can be achieved, so that wearing comfort such as appropriate resilience and stretchability can be obtained when a fabric is formed. Therefore, the multifilament can be preferably used for a wide variety of fiber products for interior products such as carpets and sofas, vehicle interior products such as car seats, daily use such as cosmetics, cosmetic masks, and health products by taking advantage of the comfort, in addition to for general clothing such as jackets, skirts, pants, and underwear, as well as textiles for clothing such as sports clothing and clothing materials.

[0170] Although the present invention has been described in detail with reference to specific embodiments, it is apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit and the scope of the present invention.

[0171] The present application is based on the Japanese patent application (JP2021-189921) filed on November 24, 2021, the contents of which are incorporated herein by reference.

REFERENCE SIGNS LIST

[0172]

A: high-molecular weight component

B: low-molecular weight component

A: centroid point of high-molecular weight component in conjugated fiber section

C: center of conjugated fiber section

S: thickness of low-molecular weight component in eccentric core-sheath section

D: fiber diameter

5 **Claims**

1. A conjugated fiber comprising two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section, wherein a high-molecular weight component is completely covered with a low-molecular weight component, and the high-molecular weight component has an orientation parameter of 1.5 to 3.0 and a crystallinity of 0% to 40%.
2. The conjugated fiber according to claim 1, wherein the high-molecular weight component is polyethylene terephthalate containing a third component having a copolymerization rate of less than 5 mol%.
3. A multifilament comprising a conjugated fiber, wherein the conjugated fiber comprises two kinds of polyesters having a molecular weight difference of 5,000 or more in a fiber cross section, and in the conjugated fiber, a high-molecular weight component is completely covered with a low-molecular weight component, and the high-molecular weight component has an orientation parameter of 5.0 to 15.0 and a crystallinity of 20% to 50%.
4. The multifilament according to claim 3 comprising a conjugated fiber that has a ratio $S_{\min}/D$, which is a ratio of a minimum thickness $S_{\min}$ of a thin portion in the low-molecular weight component to a fiber diameter D, of 0.01 to 0.1, and has a ratio, which is a ratio of the thin portion in the low-molecular weight component to a perimeter of entire fiber, of 30% or more, in the fiber cross section.
5. The multifilament according to claim 3, having a crimp expression rate of 10% or more.
6. The multifilament according to claim 3, having an elastic modulus of 30 cN/dtex or more.
7. A fiber product partially comprising the multifilament according to any one of claims 3 to 6.

FIG. 1

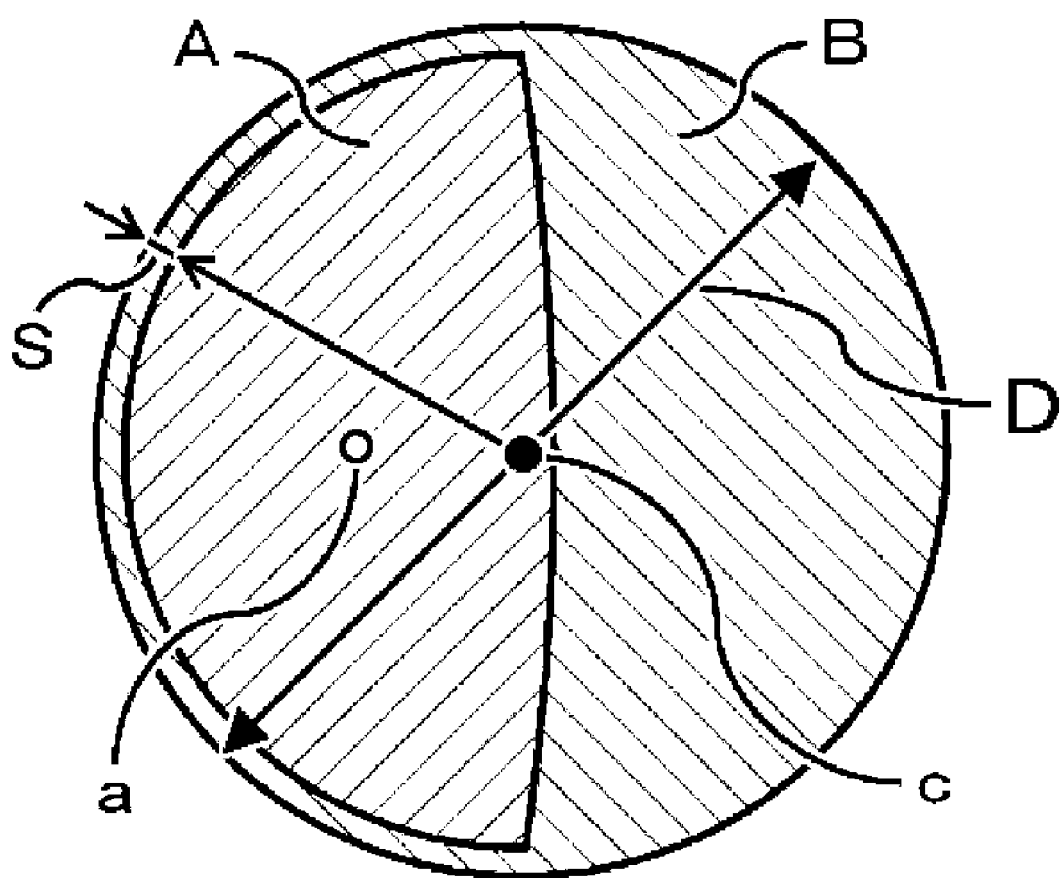
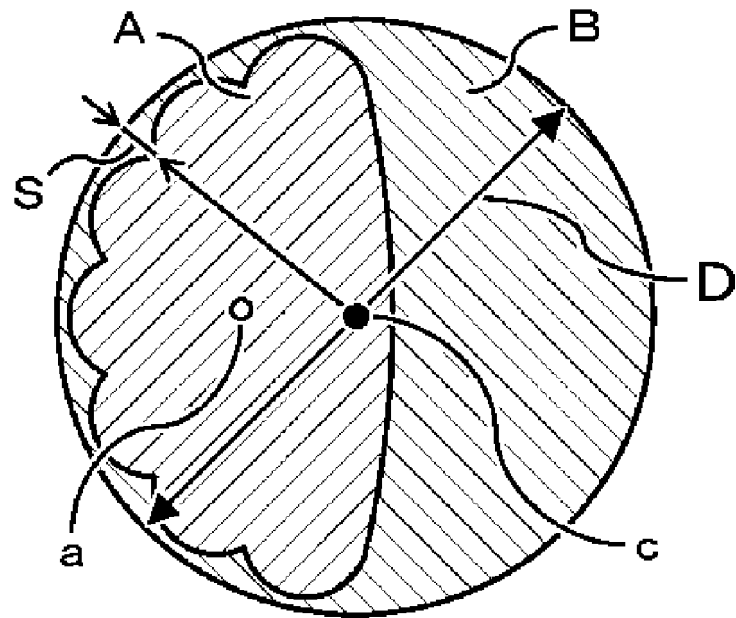


FIG. 2

(a)



(b)

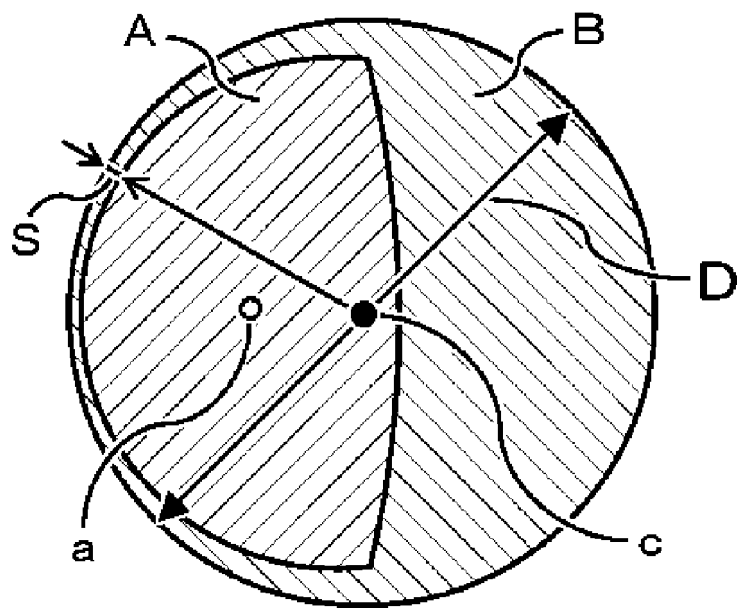
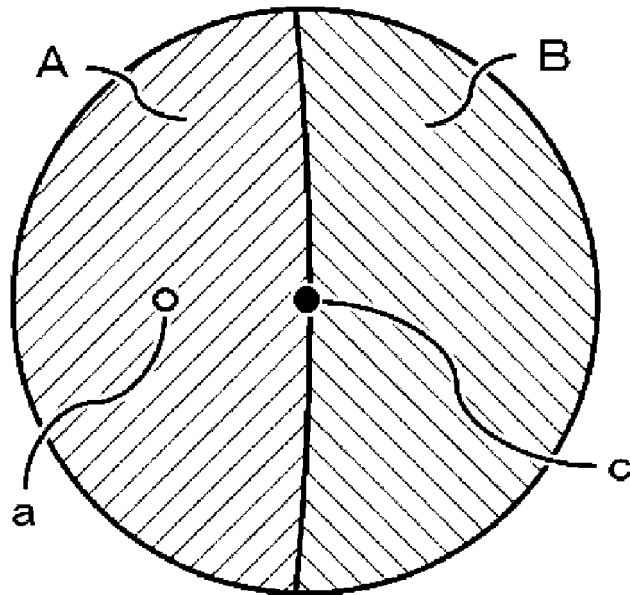


FIG. 3

(a)



(b)

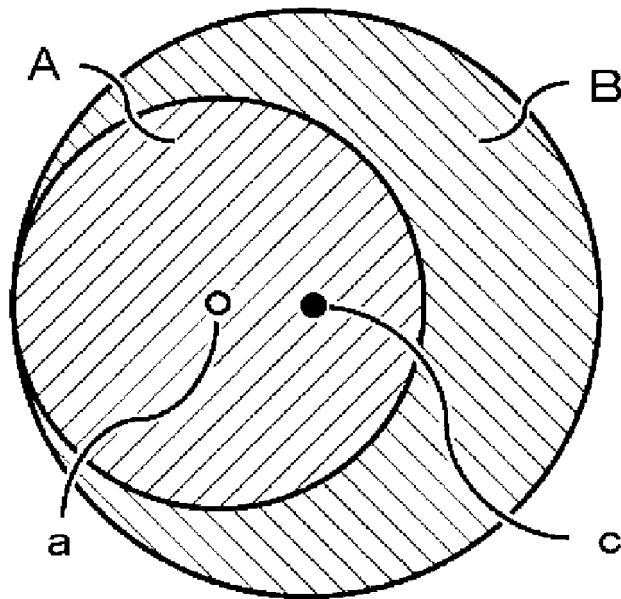
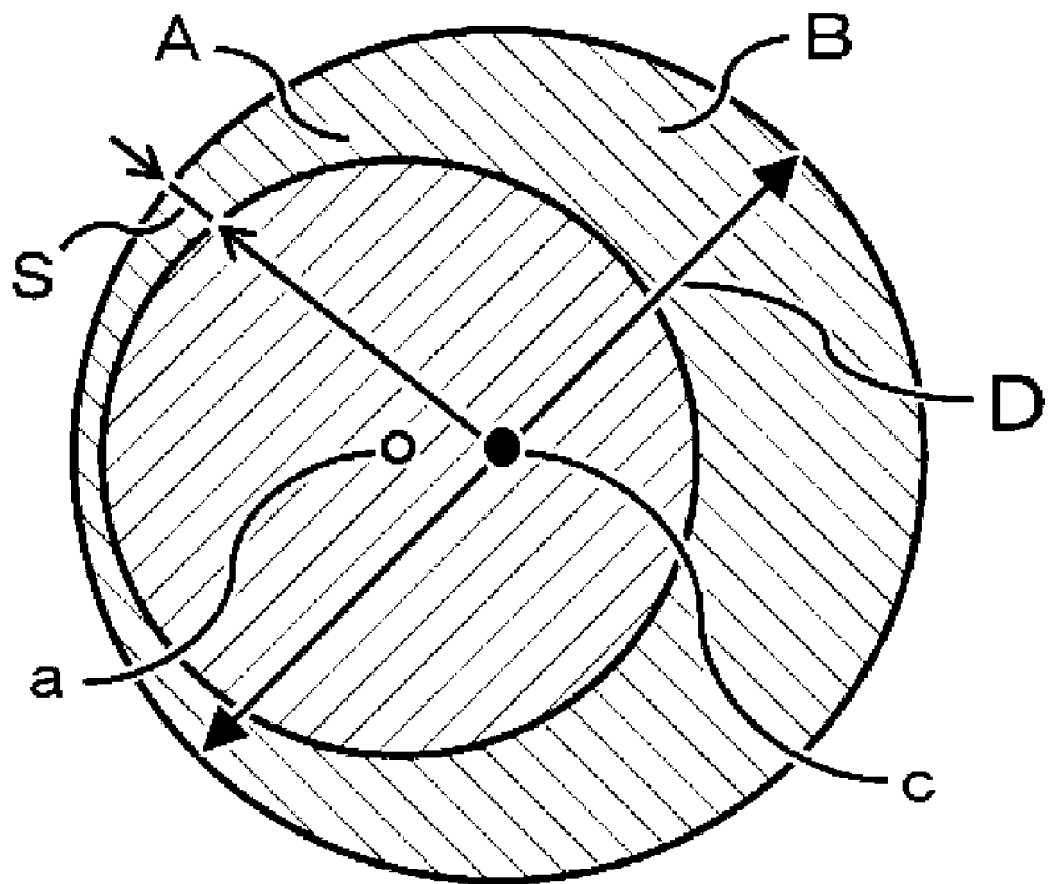


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/043081

A. CLASSIFICATION OF SUBJECT MATTER

D01F 8/14(2006.01)i

FI: D01F8/14 B

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)

D01F8/00-8/18; D02G1/00-3/48; D03D1/00-27/18

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 1971-2023

Registered utility model specifications of Japan 1996-2023

Published registered utility model applications of Japan 1994-2023

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.
A	JP 2021-98907 A (TORAY IND., INC.) 01 July 2021 (2021-07-01) claims, paragraphs [0025]-[0112], fig. 1, 2	1-7
A	WO 2018/110523 A1 (TORAY IND., INC.) 21 June 2018 (2018-06-21) claims, paragraphs [0035], [0039]-[0150], fig. 2, 3	1-7
A	JP 2008-13887 A (UNITICA FIBERS LTD.) 24 January 2008 (2008-01-24) claim 1, paragraphs [0001], [0010]-[0030]	1-7
A	WO 2019/142718 A1 (TORAY IND., INC.) 25 July 2019 (2019-07-25) claims, paragraphs [0017]-[0065]	1-7
A	JP 2013-174039 A (FIBERWEB INC.) 05 September 2013 (2013-09-05) whole document	1-7
A	JP 11-93021 A (ASAHI CHEM. IND. CO., LTD.) 06 April 1999 (1999-04-06) whole document	1-7

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

* Special categories of cited documents:	"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
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Date of the actual completion of the international search

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Date of mailing of the international search report

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Name and mailing address of the ISA/JP

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/043081

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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WO 2018/110523 A1	21 June 2018	US 2020/0087820 A1 claims, paragraphs [0053]- [0175], fig. 2, 3 EP 3556915 A1 CN 110088365 A KR 10-2019-0087462 A	
JP 2008-13887 A	24 January 2008	(Family: none)	
WO 2019/142718 A1	25 July 2019	US 2021/0054536 A1 claims, paragraphs [0017]- [0064] EP 3741885 A1 CN 111566266 A	
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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- WO 2020095861 A [0088]
- JP 2021189921 A [0171]