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(54) CRIMPED YARN, METHOD FOR MANUFACTURE THEREOF, AND FIBER STRUCTURE

(57) A crimped yarn **characterized in that** a synthetic fiber which comprising an aliphatic polyester resin (A) and a thermoplastic polyamide resin (B) and exposed area ratio of the aliphatic polyester resin (A) with respect to fiber surface area is 5% or less and a crimp is imparted to a multifilament comprising said synthetic fiber, and a fiber structure containing said crimped yarn as at least a part thereof. Furthermore, a crimped yarn in which the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) are constituted by a polymer alloy type synthetic fiber, or a crimped yarn constituted by a sheath/core type composite fiber in which the core component comprises the aliphatic polyester resin (A) or a polymer alloy of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) and the sheath component comprises the thermoplastic polyamide resin (B), and a fiber structure containing said crimped yarn as at least a part thereof.

Sea/island Structure (TEM image) Sea : Dyed portion, Island : Undyed portion

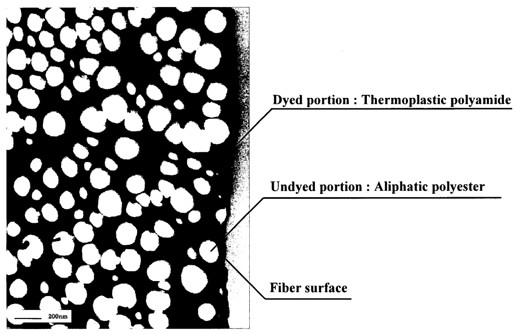

Fig.1

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Description

[Technical Field]

[0001] The present invention relates to a crimped yarn constituted by a synthetic fiber comprising an aliphatic polyester resin and a thermoplastic polyamide resin in which exposed area ratio of the aliphatic polyester resin with respect to the fiber surface area is extremely small.

[Background Art]

[0002] Recently along with the increased concern to the environment in global scale, development of fiber material decomposable in natural environment has been strongly desired. For example, since the main starting material of conventional general purpose plastics is petroleum resource, it has become a big problem that the petroleum resource would be dried up in future, or that the global warning is caused by mass consumption of the petroleum resource.

[0003] For that reason, in recent years, research and development of various plastics and fibers such as of aliphatic polyesters are activated. Among them, fibers made from plastics which can be decomposed by microorganism, i.e., biodegradable plastics have drawn attention.

[0004] In addition, by making plant resources as starting materials which take in carbon dioxide from the air to grow, not only it is expected to be able to control the global warming by circulation of carbon dioxide, but also it may be possible to solve the problem of the shortage of resources. For that reason, plastics of which starting materials are plant resources, i.e., plastics made by biomass have been drawing attention.

[0005] So far, biodegradable plastics made by biomass has problems that not only their mechanical properties and heat resistance are poor, but also their production cost is high, and they have not been used as general purpose plastics. On the other hand, in recent years, as a biodegradable plastic of which mechanical properties and heat resistance are relatively high and its production cost is low, polylactic acid of which starting material is lactic acid obtainable by fermentation of starch is in the spotlight.

[0006] Aliphatic polyester resins represented by polylactic acid have been used for a long time, for example, in medical field as a sewing thread for surgical operation, but recently, by an improvement of its mass production technology, it became possible to compete in cost with other general purpose plastics. Accordingly, development of its commercial product as a fiber has been activated.

[0007] As developments of aliphatic polyester fibers such as of polylactic acid fiber, by taking advantage of its biodegradability, agricultural materials, civil engineering materials or the like are going ahead. Following those, as big scale applications, apparel applications, interior applications such as curtain or carpet, automotive interior applications and industrial material applications are also expected. However, when it is used to the apparel applications or industrial material applications, the poor abrasion resistance of the aliphatic polyester, especially polylactic acid becomes a big problem.

[0008] For example, in case where polylactic acid fiber is used for apparel uses, the fiber have been found to be poor in practical durability such that a color staining occurs easily by a rubbing or the like or, and in a serious case, fiber becomes whitish by a fibrillation or, it is excessively stimulative to skin. And, in case where it is used for car interior, especially for carpet which suffers from hard rubbing, as well as a falling down of pile of polylactic acid easily occurs, weaving also occurs, and in a serious case, a hole may be opened. And, since aliphatic polyester (especially, polylactic acid) easily be hydrolyzed also, the fibrillation or weaving such as above-mentioned becomes serious with lapse of time, and it have been found that its product life is short.

[0009] As methods for improving abrasion resistance of polylactic acid, for example, there are methods by preventing hydrolysis, for example, a method of preventing hydrolysis at fiber production process by decreasing water content of polylactic acid as low as possible or, a method of improving hydrolysis resistance by adding a monocarbodiimide compound. However, in any method of them, although the lowering of abrasion resistance is prevented from the view point that an embrittlement of polylactic acid with the lapse of time is prevented, any of them is not a method of changing the characteristic of polylactic acid that it is easily fibrillated, i.e., it was found that every of them can prevent an embrittlement with the lapse of time, but initial abrasion resistance has not been improved from the conventional one.

[0010] And, as a method of greatly improving abrasion resistance, there is a method of preventing abrasion by decreasing friction coefficient of fiber surface by imparting a lubricant such as aliphatic acid bisamides. However, although such a fiber is effective in case where an external force is small but, for example, in case where a big weight is added as a case of carpet, since cohesion between fibers cannot be sufficiently prevented, polylactic acid is broken and its use is limited.

[0011] And, a technique of improving mechanical characteristics of resin composition by blending polyamide and aliphatic polyester is disclosed (Patent reference 1). According to the method described in Patent reference 1, it is mentioned that, by reinforcing effect of polyamide, mechanical characteristics such as strength, heat resistance and abrasion resistance are increased but, in said method, since the polyamide is a minor component such that its blend ratio is 5 to 40%, the aliphatic polyester forms sea component, and furthermore, since the aliphatic polyester and the polyamide are incompatible and an adhesion force of the interface between these phases is poor, it was found there are problems that the interface is easily peeled off by an external force to become whitish by fibrillation and abrasion speed is also high.

[0012] Furthermore, a technique is disclosed that a high elongation polyamide fiber is prepared by micro-dispersing a polyester in a polyamide to prevent orientation (Patent reference 2). By making it into said polymer alloy fiber, it becomes possible to impart a high bulkiness to a crimped yarn by mixing with a low elongation polyamide unstretched yarn at false twist processing. However, although said polymer alloy fiber is suitable for a sheath yarn at the false twist processing, when it is used for production of an air stuffer crimped yarn which is the object of the present invention, since fiber orientation is rather insufficient, heat shrinkage in the air stuffer crimping machine is insufficient and a 3 dimensional crimp is not developed and only a crimped yarn of which crimp elongation percentage is low can be obtained.

[0013] Furthermore, a composite fiber of which abrasion resistance is improved by arranging a polyamide of which abrasion resistance is high as the sheath component, is disclosed (Patent reference 3). By this technique, it is possible to greatly prevent weaving of fiber. However, in case where a composite fiber is made, it was found that a new problem arises that, at a later stage processing step or when used as a product, external force is concentrated to the interface between the core component and the sheath component (hereafter, referred to as sheath/core interface) of which adhesion force is low, and the sheath/core interface is peeled off and causes an appearance change (becomes whitish). Once the sheath/core interface is peeled off, the peeling extends along fiber longitudinal direction and defects like white streaks are observed sometimes. This is a defect in an application in which, especially, appearance is important. And, there was a problem that, when a peeling between the sheath/core interface arises, the sheath component is split (hereafter, referred to as sheath split), due to an abrasion between the core component and the sheath component and further, it grows to a fibrillation.

[0014] In Patent reference 3, a composite fiber of which abrasion resistance is improved by having a thermoplastic polyamide of a specified thickness as sheath component is disclosed. Said composite fiber exhibits an effect in applications exposed only to relative weak abrasions such as apparel uses. However, in applications exposed to strong external force repeatedly such as carpet or the like, a pealing of the interface occurs easily and an appearance change was easy to occur. And, in Patent reference 3, a crimped yarn (false twisted yarn) in which said composite fiber is used, is disclosed, but it was found that, a crimped yarn comprising the composite fiber is easier to be peeled off at its sheath/core interface than an uncrimped yarn. Furthermore, its peeling resistance may deteriorate according to the change of aliphatic polyester with the lapse of time, and although the composite fiber in which a polyamide is disposed as a sheath component was excellent in abrasion resistance, its peeling resistance was insufficient, and had a defect that an appearance of its product was easy to change.

[Patent reference 1] JP2003-238775A (page 3)
[Patent reference 2] JP2005-206961A (page 3)
[Patent reference 3] JP2004-36035A (scope of claims)

[Disclosure of the Invention]

[Problem to be Solved by the Invention]

[0015] It is the object of the present invention to solve the above-mentioned problem and to provide a crimped yarn and a fiber structure excellent in abrasion resistance as well as excellent in aesthetic appearance after dyeing, constituted by a synthetic fiber comprising an aliphatic polyester resin and a thermoplastic polyamide resin.

[Means for solving the Problem]

[0016] The above-mentioned problem can be achieved by a crimped yarn characterized by being a synthetic fiber comprising an aliphatic polyester resin (A) and a thermoplastic polyamide resin (B) and exposed area ratio of the aliphatic polyester resin (A) with respect to fiber surface area is 5% or less, and a crimp is imparted to a multifilament comprising said synthetic fiber; and a fiber structure characterized by comprising said crimped yarn in at least a portion thereof.

[Effect of the Invention]

[0017] By the present invention, it is possible to provide a synthetic fiber and a fiber structure which is most suitable for general apparel applications or industrial material applications of which abrasion resistance is greatly improved and capable of providing high quality fiber structure.

[Brief Explanation of the Drawings]

[0018]

[Fig. 1] A photograph of a transmission electron microscope (TEM) for explaining the sea/island structure of polymer alloy fiber of the present invention.
[Fig. 2] A photograph of a scanning electron microscope (SEM) of a fiber surface layer of a crimped yarn (Example 1) of the present invention.
[Fig. 3] A schematic view for explaining aspect ratio of the groove formed on fiber surface layer of the crimped yarn.
[Fig. 4] A photograph of a fiber configuration observed from the upper side of an embodiment of BCF yarn of the present invention placed on a black paper in a multifilament state.
[Fig. 5] A photograph of a fiber configuration observed from the upper side of an embodiment of BCF yarn of the present invention placed on a black paper in a state separated into single fibers.
[Fig. 6] A schematic view of a direct spinning·stretching·crimp processing machine preferably used for producing a crimped yarn constituted by a polymer alloy type synthetic fiber of the present invention.
[Fig. 7] A schematic view for explaining hole depth, slit length and slit width of spinning hole, and spinning hole diameter of a spinneret in the production method the present invention.
[Fig. 8] A schematic view for explaining starting point of cooling in the production method of the present invention.
[Fig. 9] A schematic view of a direct spinning· stretching · crimp processing machine preferably used for producing a crimped yarn comprising the sheath/core type composite fiber of the present invention (core component: aliphatic polyester resin).
[Fig. 10] A model view showing preferable examples of cross-sectional shape of the sheath/core type composite fiber of the present invention.
[Fig. 11] A drawing explaining relation between melt viscosity and relative viscosity.
[Fig. 12] A model view of longitudinal-section indicating one embodiment of spinneret used in the method of the present invention.
[Fig. 13] A schematic view indicating one embodiment of false twist processing machine which was used in Example 52 of the present invention.
[Fig. 14] A schematic view of a direct spinning·stretching·crimp processing machine preferably used for producing a crimped yarn constituted by the sheath/core type composite fiber of the present invention (core component : polymer alloy).

[Explanation of codes]

[0019]

1 : Spinning hopper
2 : Twin screw extruding/kneading machine
3 : Spinning block
4 : Spinning pack
5 : Spinneret
6 : Circular chimney (yarn cooling apparatus)
7 : Yarn
8: Oiling device 1
9 : Oiling device 2
10 : Stretch roll
11 : First heating roll (1 FR)
12 : Second heating roll (1 DR)
13 : Third heating roll (2 DR)
14 : Air jet stuffer machine
15 : Cooling roll
16 : Tension measuring detector
17 : take-up roll
18 : Interlacing nozzle
19 : Winder
20 : Cooling air blow-off area
21, 65 : Core component hopper
22, 66 : Sheath component hopper

23 : Single screw extruding/kneading machine of core component side
24 : Single screw extruding/kneading machine of sheath component side
25, 69 : Spinning block
26, 70 : Gear pump of core component side (metering pump)
27, 71 : Gear pump of sheath component side (metering pump)
28, 72 : Spinning pack
29, 73 : Spinneret
30, 74 : Uniflow cooling apparatus
31, 75 : Yarn
32, 76 : Oiling device
33, 77 : First roll
34, 78 : Second roll
35, 79 : Third roll
36, 80 : Fourth roll
37, 81 : Crimp nozzle
38, 82 : Cooling roll
39, 83 : Sixth roll
40, 84 : Seventh roll
41, 85 : Cheese package
42, 86 : Winder
43 : Core component
44 : Sheath component
45 : Spinneret 1 (spinneret having separate flow channels for core component and sheath component)
46 : Spinneret 2 (spinneret just before discharge)
47 : Interlacing nozzle
48 : Stretched yarn cheese
49, 51, 52, 55, 61 : Yarn guide
50 : Yarn
53 : Feed roll
54 : First heater
56 : Cooling plate
57 : Three axis type twister
58 : Stretch roll
59 : Second heater
60 : Delivery roll
62 : Interlacing nozzle
63 : Yarn guide
64 : False twisted yarn
67 : Twin screw extruding/kneading machine of core component side
68 : Twin screw extruding/kneading machine of sheath component side

[Best Embodiment for Carrying Out the Invention]

[0020] The aliphatic polyester resin (A) (hereafter, may be referred to as "component A") mentioned in the present invention is a polymer of which aliphatic alkyl chain is connected with an ester bond. As the aliphatic polyester resin (A) used in the present invention, it is preferable to be crystalline and it is more preferable that its melting point is 150 to 230˚C. And, as kinds the aliphatic polyester resin (A) used in the present invention, for example, polylactic acid, polyhydroxybutyrate, polybutylene succinate, polyglycolic acid, polycaprolactone or the like are mentioned. Polylactic acid is most preferable among the aliphatic polyesters since its melting point is high and excellent in thermal stability.

[0021] The above-mentioned polylactic acid is a polymer having $-(O\text{-}CHCH_3\text{-}CO)_n-$ as its repeating unit, and it is a polymerization product of lactic acid or oligomer of lactic acid such as lactide. Since there are two kinds of optical isomer of lactic acid, D-lactic acid and L-lactic acid, as their polymers, there are poly(D-lactic acid) consisting only of D-type and poly(L-lactic acid) consisting only of L-type and polylactic acid consisting of both of them. Regarding the optical purity of D-lactic acid or L-lactic acid in polylactic acid, as it decreases, crystallinity decreases and melting point depression becomes large. In order to keep the heat resistance of fiber, it is preferable that the melting point is higher than 150˚C or more, and to be 160˚C or more is more preferable. Still more preferably, it is 170˚C or more and especially preferably 180˚C or more.

[0022] However, other than the system in which the two kinds of optical isomers are simply mixed as stated above, after the above-mentioned two kinds of optical isomers are blended and formed into a fiber, if it is subjected to a high temperature heat treatment of 140°C or higher to convert them into a stereo complex in which a racemic crystalline is formed, the melting point can be made as high as 220 to 230°C, and it is preferable. In such cases, the "component A" means a mixture of poly(L lactic acid) and poly(D lactic acid), and when its blend ratio is 40/60 to 60/40, it is best since it can increase ratio of the stereo complex crystal. And, it is preferable to add a crystal nucleating agent at melt spinning in order to form said stereo complex crystal efficiently. As the crystal nucleating agents, other than talc or stratified clay minerals, stearic acid or 12-hydroxystearic acid, stearic acid amide or oleic acid amide, erucic acid amide, methylene bisstearic acid amide, ethylene bisstearic acid amide, ethylene bisoleic acid amide, butyl stearate, stearic acid monoglyceride, calcium stearate, zinc stearate, magnesium stearate, lead stearate, etc., of which compatibility with polylactic acid is high can be applied.

[0023] Furthermore, there is a residual lactide in polylactic acid as a low molecular weight residue, but this low molecular weight residue may become a reason which induces thermal heater stain in stretching or bulking process, or dyeing abnormalities such as dyeing unevenness in dyeing processing step. And, it may accelerate hydrolysis of fiber or fiber product to thereby decrease their durability. Therefore, it is preferable that amount of residual lactide in polylactic acid is 0.3 wt% or less, more preferably 0.1 wt% or less, and still more preferably 0.03 wt% or less.

[0024] And, the component A may, for example in a range which does not impair the property of polylactic acid, be a copolymer in which a component other than lactic acid is copolymerized. As a component to be copolymerized, polyalkylene ether glycols such as polyethylene glycol, aliphatic polyesters such as polybutylene succinate or polyglycolic acid, aromatic polyesters such as polyethylene isophthalate, and ester bond formable monomers such as hydroxycarboxylic acid, lactone, dicarboxylic acid or diol, are mentioned. Among them, polyalkylene ether glycols, of which compatibility with the thermoplastic polyamide resin (B) (hereafter, may be referred to as "component B") is good, is preferable. A copolymerization ratio of such copolymerization component is, in a range not being impaired by a decrease of heat resistance due to a melting point depression, preferably 0.1 to 10 mol% with respect to the polylactic acid.

[0025] To the component A, as a modifier, a particle, a color pigment, a crystal nucleating agent, a flame retardant, a plasticizer, an anti-static agent, an antioxidant, an ultraviolet absorber, a lubricant, etc., may further be added. As the color pigments, other than inorganic pigments such as carbon black, titanium oxide, zinc oxide, barium sulfate and iron oxide, organic pigments such as a cyanine-based, a styrene-based, a phthalocyanine-based, an anthraquinone-based, a perinone-based, an isoindolinone-based, a quinophthalone-based, a quinocridone-based and a thioindigo-based one can be used. Similarly, modifiers such as particles such as various inorganic particles including calcium carbonate, silica, silicone nitride, clay, talc, kaolin, zirconic acid, etc., cross-linked polymer particles or various metallic particles can also be used. Furthermore, polymers such as waxes, silicone oils, various surfactants, various fluororesins, polyphenylene sulfides, polyamides, polyacrylates including ethylene/acrylate copolymer and methyl methacrylate polymer, various rubbers, ionomers, polyurethanes and their thermoplastic elastomers, can be contained in a small amount.

[0026] As the lubricant preferably used in the above-mentioned component A, aliphatic acid amides and/or aliphatic acid esters are mentioned. As the aliphatic acid amides, for example, lauric acid amide, palmitic acid amide, stearic acid amide, erucic acid amide, behenic acid amide, methylol stearic acid amide, methylol behenic acid amide, dimethylol oil amide, dimethyl lauric acid amide, dimethyl stearic acid amide, compounds containing two amide bond in one molecule such as saturated aliphatic acid bisamide, unsaturated aliphatic acid bisamide or aromatic-based bisamide are mentioned, for example, methylene biscaprylic acid amide, methylene biscapric acid amide, methylene bislauric acid amide, methylene bismyristic acid amide, methylene bispalmitic acid amide, methylene bisstearic acid amide, methylene bisisostearic acid amide, methylene bisbehenic acid amide, methylene bisoleic acid amide, methylene biserucic acid amide, ethylene biscaprylic acid amide, ethylene biscapric acid amide, ethylene bislauric acid amide, ethylene bismyristic acid amide, ethylene bispalmitic acid amide, ethylene bisstearic acid amide, ethylene bisisostearic acid amide, ethylene bisbehenic acid amide, ethylene bisoleic acid amide, ethylene biserucic acid amide, butylene bisstearic acid amide, butylene bisbehenic acid amide, butylene bisoleic acid amide, butylene biserucic acid amide, hexamethylene bisstearic acid amide, hexamethylene bisbehenic acid amide, hexamethylene bisoleic acid amide, hexamethylene biserucic acid amide, m-xylilene bisstearic acid amide, m-xylilene bis-12-hydroxystearic acid amide, p-xylilene bisstearic acid amide, p-phenylene-bisstearic acid amide, p-phenylene-bisstearic acid amide, N,N'-distearyl adipic acid amide, N,N'-distearyl sebacic acid amide, N,N'-dioleyl adipic acid amide, N,N'-dioleyl sebacic acid amide, N,N'-distearyl isophthalic acid amide, N,N'-distearyl terephthalic acid amide, methylene bishydroxystearic acid amide, ethylene bishydroxystearic acid amide, butylene bishydroxystearic acid amide and hexamethylene bishydroxystearic acid amide, etc., are mentioned, and other than that, as alkyl substituted type aliphatic acid monoamide, compounds such as saturated aliphatic acid monoamide or unsaturated aliphatic acid monoamide of which amide hydrogen is substituted with alkyl group, for example, N-lauryl lauric acid amide, N-palmityl palmitic acid amide, N-stearyl stearic acid amide, N-benenyl behenic acid amide, N-oleyl oleic acid amide, N-stearyl oleic acid amide, N-oleyl stearic acid amide, N-stearyl erucic acid amide, N-oleyl palmitic acid amide or the like are mentioned. In said alkyl group, a substituent such as hydroxyl group may be introduced in its structure, for example, methylol stearic acid amide, methylol behenic acid amide, N-stearyl-12-hydroxystearic acid amide, N-oleyl 12-hydroxystearic acid amide or the like are included in the alkyl substituted type aliphatic acid monoamide of the present invention.

[0027] As aliphatic acid esters, for example, aliphatic monocarboxylic acid esters such as lauric acid cetyl ester, lauric acid phenacyl ester, myristic acid cetyl ester, myristic acid phenacyl ester, palmitic acid isopropylidene ester, palmitic acid dodecyl ester, palmitic acid tetradodecyl ester, palmitic acid pentadecyl ester, palmitic acid octadecyl ester, palmitic acid cetyl ester, palmitic acid phenyl ester, palmitic acid phenacyl ester, stearic acid, cetyl ester or behenic acid ethyl ester; monoesters of ethylene glycol such as glycol monolaurate, glycol monopalmitate or glycol monostearate, diesters of ethylene glycol such as glycol dilaurate, glycol dipalmitate or glycol distearate; monoesters of glycerin such as glycerin monolaurate, glycerin monomyristate, glycerin monopalmitate or glycerin monostearate; diesters of glycerin such as glycerin dilaurate, glycerin dimyristate, glycerin dipalmitate or glycerin distearate; triesters of glycerin such as glycerin trilaurate, glycerin trimyristate, glycerin tripalmitate, glycerin tristearate, palmitodiolein, palmitodistearin or oleodistearin, etc., are mentioned.

[0028] Among these compounds, it is preferable to use aliphatic acid bisamide or alkyl substituted type aliphatic acid monoamide. Aliphatic acid bisamide or alkyl substituted type aliphatic acid monoamide has a low reactivity of its amide compared to ordinary aliphatic acid monoamide to thereby hardly cause a reaction with polylactic acid at melt molding, and further, since there are many such monoamides of high molecular weight, heat resistance is high and hardly sublimates, and accordingly, it exhibits an excellent slipperiness without impairing its function as a lubricant. In particular, since aliphatic acid bisamide has a lower reactivity of its amide, it can be more preferably used, and ethylene bisstearic acid amide is still more preferable.

[0029] Furthermore, 2 kinds or more of the aliphatic acid amide and the aliphatic acid ester may be used, and the aliphatic acid amide and the aliphatic acid ester may be used together.

[0030] It is necessary that a content of the aliphatic acid amide and/or aliphatic acid ester is 0.1 wt% or more with respect to fiber weight in order to exhibit the above-mentioned characteristics. And, it is preferable that the content is 5 wt% or less since, when the content is too high, mechanical properties of fiber may deteriorate or its color tone may turn worse such that it become yellowish when dyed. More preferable content of said aliphatic acid amide and/or aliphatic acid ester is, 0.2 to 4 wt%, and still more preferably, it is 0.3 to 3 wt%.

[0031] Furthermore, it is preferable that a molecular weight of polylactic acid polymer is high in order to improve abrasion resistance, but when the molecular weight is too high, moldability at melt spinning or stretchability may deteriorate. It is preferable that the weight average molecular weight is 80,000 or more in order to keep abrasion resistance, 100,000 or more is more preferable. Still more preferably, it is 120,000 or more. On the other hand, when the molecular weight exceeds 350,000, since stretchability deteriorates as above-mentioned, molecular orientation is impaired and fiber strength may decrease, as a result. Accordingly, it is preferable that a weight average molecular weight is 350,000 or less, 300,000 or less is more preferable. Still more preferably, it is 250,000 or less. The above-mentioned weight average molecular weight is a value measured by a gel permeation chromatography (GPC) and determined by being converted into the polystyrene equivalent.

[0032] A production method of polylactic acid preferably used as the component A of the present invention is not especially limited, but in concrete, a direct dehydrative condensation method in which lactic acid is subjected to a dehydrative condensation as it is under a presence of an organic solvent and a catalyst (refer to JP-H6-65360A), a method of subjecting at least 2 kinds of homopolymer to a copolymerization and ester interchange reaction under a presence of polymerization catalyst (refer to JP-H7-173266A), furthermore, an indirect polymerization method in which lactic acid is once dehydrated to be converted to cyclic dimer and subjected to a ring opening polymerization (refer to the specification of US Patent No. 2,703,316) are mentioned.

[0033] The thermoplastic polyamide resin (B) used in the present invention is a polymer having an amide bond and as the thermoplastic polyamide resin (B) used in the present invention, for example, polycapramide (nylon 6), polytetramethylene adipamide (nylon 46), polyhexamethylene adipamide (nylon 66), polyundecane amide (nylon 11), polydodecane amide (nylon 12), polyhexamethylene sebacamide (nylon 610), polypentamethylene sebacamide (nylon 510), etc., can be mentioned. Among them, in view of raw material cost, nylon 6 is preferable, and in order to increase adhesion force of interface by increasing compatibility with the component A, it is preferable that methylene chain length of polyamide is long, and in that point, nylon 11, nylon 12, nylon 610 or nylon 510 are preferable. And, in view of providing a material for reducing environmental load, nylon 610 or nylon 510 of which monomer is sebacic acid which is a non-petroleum raw material is preferable. And, the polyamide may be a homopolymer or a copolymer. And, to the component B, a particle, a flame retardant, an antistatic agent or the above-mentioned lubricant preferably used in the component A, etc., may be added. Where, solution viscosity of the thermoplastic polyamide can be measured by known methods, such that, in case of nylon 6, nylon 610 or the like, it is measured by using 98% sulfuric acid solution mentioned later, and an inherent viscosity of nylon 11 is measured by using m-crezol solution.

[0034] Furthermore, in general, aliphatic polyesters cannot be said to be high in heat resistance such that, the melting point is usually 200˚C or less even when it has a melting point, and when it is melted and stored at a temperature exceeding 250˚C, its physical properties may deteriorate rapidly. For that reason, it is preferable that a melting point of the thermoplastic polyamide resin (B) to be blended is 150 to 250˚C, and 150 to 225˚C is more preferable. Still more preferably, it is 150 to 205˚C. However, in consideration of heat resistance of crimped yarn, it is preferable that melting point of the thermoplastic polyamide resin (B) is higher than that of the aliphatic polyester (A). Said thermoplastic polyamide resin may be a copolymer as above-mentioned, but it is preferable to be crystalline since its abrasion resistance may be lowered with lowering of its crystallinity.

[0035] Where, regarding presence or absence of crystallinity in the present invention, it can be decided that the polymer is crystalline when a melting peak can be observed by a differential scanning colorimeter (DSC). And, the higher the crystallinity, the more preferable, and it can be evaluated by crystal melting peak calorie in DSC, as its index. The crystal melting peak calorie △ H is preferably 30 J/g, more preferably 40 J/g and still more preferably, 60 J/g.

[0036] The crimped yarn of the present invention consists of the above-mentioned synthetic fiber comprising the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) and almost no aliphatic polyester resin (A) is exposed on fiber surface, and it is preferable that an exposed area ratio of the aliphatic polyester resin (A) with respect to fiber surface area is 5% or less. As structures having such fiber surface configuration can be achieved by any one of (1) or (2) of (1) "polymer alloy type synthetic fiber having an sea/island structure in which the aliphatic polyester resin (A) forms the island component and the thermoplastic polyamide resin (B) forms the sea component ", or (2) "sheath/core type composite fiber of which core component is the aliphatic polyester resin (A) or a polymer alloy of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B), and the sheath component is the thermoplastic polyamide resin (B)". Regarding preferable embodiments of these (1) and (2) are described in the following.

[0037] At first, the "polymer alloy type synthetic fiber having an sea/island structure in which the aliphatic polyester resin (A) forms the island component and the thermoplastic polyamide resin (B) forms the sea component " which is one of preferable embodiments is explained.

[0038] In the present invention, in case of a synthetic fiber where the component A and the component B are blended to be made into a polymer alloy, blend ratio is not especially limited, but in order to make a polymer alloy having an sea/island structure in which the component A is the island component, and the component B is the sea component, it is preferable that a blend ratio (wt%) of component A/component B is in the range of 5/95 to 55/45. And, in case where the ratio of component A is increased, it is necessary to increase melt viscosity of the component A, ηa, and in case where the ratio component B is increased, it is necessary to increase melt viscosity of the component B, ηb.

[0039] Furthermore, in case of the polymer alloy type synthetic fiber, it is necessary to make a polymer alloy in which the component A is the island component and the component B is the sea component. Accordingly, a blend ratio of the component A and the component B is, since the higher the ratio of the component B, the easier to make the polymer alloy, more preferably, 10/90 to 45/55, still more preferably, 15/85 to 40/60, most preferably, 20/80 to 35/65. And, it is preferable to control a ratio of melt viscosity (ηb/ηa) into the range of 0.1 to 2. More preferably, it is 0.15 to 1.5, still more preferably, 0.2 to 1. Where, method of measurement of the melt viscosity η is explained later in detail, but it is a value measured at the same temperature as the spinning temperature at a shear rate of 1216 sec^{-1}.

[0040] In the polymer alloy type synthetic fiber of the present invention, it is important that the component A and the component B are uniformly blended, but "uniformly blended" mentioned here means the following condition. That is, when a cross-section slice of said synthetic fiber is observed by a transmission electron microscope (TEM) (40,000 times), as shown in Fig. 1, it has a so-called sea/island structure in which the continuous matrix component (black portion) is the sea component, and the approximately circular and dispersed component (white portion) is the island component, and further, it is in a condition that a domain size of the component A constituting the island component is as small as 0.001 to 2 μm in diameter equivalent (diameter of hypothetical circle equivalent to the domain area). By making the domain size of the island component into the above-mentioned range, it is possible to greatly improve abrasion resistance of fiber. Where, the exposed area ratio of aliphatic polyester resin (A) in the polymer alloy type synthetic fiber can be determined by observing the above-mentioned TEM images for the entire peripheral to thereby respectively measure exposed length of the white portion exposed on fiber surface (aliphatic polyester resin) and entire peripheral length of fiber, and calculating a ratio of the lengths.

[0041] Furthermore, an adhesion force with the component B constituting the sea component is improved as the domain size becomes small, since stress concentration is dispersed, but on the other hand, when the domain size is a specified size or less, initial abrasion resistance is apt to decrease. Accordingly, it is preferable that the island domain size is 0.005 to 1.5 μm, and 0.02 to 1.0 μm is more preferable. And, in order to control a glossy texture of the crimped yarn, it is preferable to further control the domain size in a specified range. It becomes possible to raise an appropriate light scattering inside the fiber and to exhibit a glossy texture of a dewy and excellent aesthetic appearance by covering the wavelength range of visible light (0.4 to 0.8 μm) to 1/5 wavelength thereof (0.08 to 0.16 μm) by said domain size. In order to exhibit a beautiful glossy texture, it is preferable that the domain size is in the range of 0.08 to 0.8 μm.

[0042] Where, the above-mentioned domain size of the present invention means, as mentioned later in item G of Examples, a distribution of 80 domains when 100 domains per 1 crimped yarn sample are measured and the largest 10 domain sizes and the smallest 10 domain sizes are excluded.

[0043] Furthermore, in case where a material constituting the crimped yarn of the present invention is the polymer alloy type synthetic fiber, different from a block copolymer in which an aliphatic polyester block and a polyamide block are present alternatively in 1 molecular chain, it is important that the aliphatic polyester molecular chain (component A) and the polyamide molecular chain (component B) are present substantially independently. This difference of conditions can be estimated by observing a melting point depression of the thermoplastic polyamide resin of before and after the compounding, that is, how the melting point based on the thermoplastic polyamide resin in the polymer alloy lowered from the melting point of the thermoplastic polyamide resin before the compounding. If the melting point depression of the thermoplastic polyamide resin is 3˚C or less, the aliphatic polyester and the polyamide have hardly copolymerized (ester-amide interchange has hardly occurred), and it is a polymer alloy condition in which the aliphatic polyester molecular chain and the polyamide molecular chain are present substantially independently. And, since the fiber surface layer is substantially occupied by the thermoplastic polyamide resin which is the sea component, characteristics inherently pertaining to the above-mentioned thermoplastic polyamide resin are reflected to the fiber and the abrasion resistance is greatly improved. Accordingly, in the present invention, it is preferable that the melting point depression of the polyamide compounded is 2˚C or less.

[0044] In case where the material constituting the crimped yarn of the present invention is a polymer alloy type synthetic fiber, a sea/island structure is formed in which the aliphatic polyester resin forms the island component and the thermoplastic polyamide resin forms the sea component. And, by controlling the domain size of the island component, as well as the abrasion resistance is greatly improved, high quality glossiness is also exhibited.

[0045] Here, as above-mentioned, since aliphatic polyester and polyamide usually hardly react (ester-amide interchange hardly occurs), adhesion force of interface of the above-mentioned 2 polymers is not so high as it is. In such circumstance, it is possible to improve abrasion resistance by greatly increasing adhesion force of the interface by further adding a compatibilizer (hereafter, may be referred to as "component C"). The component C is not especially limited as far as it increases the adhesion force of the interface between the component A and the component B, but it is preferable if it is a compound having two or more active hydrogen reactive groups in a molecule, since the adhesion force of interface is increased greatly. By carrying out a spinning in which the compound having two or more active hydrogen reactive groups in a molecule is added to the component A and/or the component B and melt blended, since said compound reacts with any components of the component A and the component B to form a cross-linked structure, a peeling off of the interface can be prevented.

[0046] Here, the active hydrogen reactive group is a group having a reactivity with COOH terminal group, OH terminal group or NH_2 terminal group present at the terminal of polylactic acid resin or of the thermoplastic polyamide resin, for example glycidyl group, oxazoline group, carbodiimide group, aziridine group, imide group, isocyanate group, maleic acid anhydride group or the like are preferably used. And, in the melt spinning which is the production method of the crimped yarn of the present invention, since molding is carried out at a relatively low temperature as 250˚C or less, a compound excellent in low temperature reactivity is selected. Among the above-mentioned reactive groups, glycidyl group, oxazoline group, carbodiimide group or acid anhydride group (group produced from maleic acid anhydride (may be referred to as maleic acid anhydride group) or the like) are preferably used, and especially, glycidyl group or carbodiimide group are preferably used. When 2 or more of the above-mentioned reactive group are present, it can function as a compatibilizer. On the other hand, when it has more than 20 reactive groups in a molecule, since spinnability may deteriorate due to an excessive viscosity increase at the time of spinning, it is preferable that the number of active hydrogen reactive groups in a molecule is 2 or more and 20 or less. More preferably, it is 10 or less, still more preferably 3 or less. And, kind of the reactive group in one molecule may be plural. And, when the compound having 2 or more of the above-mentioned active hydrogen reactive group is a compound of which weight average molecular weight is 250 to 30,000, it is preferable since it is excellent in heat resistance at melt molding and dispersibility. More preferably, it is 250 to 20,000.

[0047] Furthermore, as a compound having these reactive groups, if it is a copolymer graft copolymerized to the main chain of polymer with a side chain having a reactive group, it is preferable since not only it becomes possible to introduce many functional group in a molecule, but also, in general, thermal characteristic such as melting point becomes stable. Although it is possible to select a polymer to be the main chain to be grafted with these reactive groups, in view of easiness of its synthesis, it can be appropriately selected from the group consisting such as of polyester-based polymers, acrylate based polymers including polyacrylate, polymethyl methacrylate or poly(alkyl)methacrylate, polystyrene-based polymers and polyolefin-based polymers.

[0048] Among the component C which can be used in the present invention, as the compound having glycidyl group, for example, a polymer of which monomer unit is a compound having glycidyl group or a compound of which polymer to be the main chain is graft copolymerized with glycidyl group, and furthermore, those having glycidyl group at terminal of polyether unit are mentioned. As the monomer units having the above-mentioned glycidyl group, glycidyl acrylate, glycidyl methacrylate or the like are mentioned. And, other than these units, it is possible to control reactivity of glycidyl group by copolymerizing such as a long chain alkyl acrylate. And, when an average molecular weight of the polymer of which monomer unit is the compound having glycidyl group or the polymer to be the main chain is in the range of 250 to 30,000, it is preferable since a melt viscosity increase, when the component is added to be contained in a high concentration, can be prevented. It is more preferable that the weight average molecular weight is in the range of 250 to 20,000. And, other than that, a compound having 2 or more glycidyl units on triazine ring is also preferable since its heat resistance is high. For example, triglycidyl isocyanurate (TGIC), monoallyl diglycidyl isocyanurate (MADGIC) or the like are preferably used.

[0049] Furthermore, it is the same as to oxazoline group, carbodiimide group, aziridine group, imide group, isocyanate group and maleic acid anhydride group. Among the above-mentioned, compounds having carbodiimide group is more preferable since they are extremely excellent in low temperature reactivity. For example, as examples of carbodiimide compounds, mono or dicarbodiimide compounds such as diphenyl carbodiimide, di-cyclohexyl carbodiimide, di-2,6-dimethyl phenyl carbodiimide, diisopropyl carbodiimide, dioctyl decyl carbodiimide, di-o-toluyl carbodiimide, di-p-toluyl carbodiimide, di-p-nitrophenyl carbodiimide, di-p-aminophenyl carbodiimide, di-p-hydroxyphenyl carbodiimide, di-p-chlorophenyl carbodiimide, di-o-chlorophenyl carbodiimide, di-3,4-dichlorophenyl carbodiimide, di-2,5-dichlorophenyl carbodiimide, p-phenylene-bis-o-toluyl carbodiimide, p-phenylene bis-dicyclohexyl carbodiimide, p-phenylene bis-di-p-chlorophenyl carbodiimide, 2,6,2',6'-tetraisopropyl diphenyl carbodiimide, hexamethylene bis-cyclohexyl carbodiimide, ethylene bis-diphenyl carbodiimide, ethylene bis-di-cyclohexyl carbodiimide, N,N'-di-o-triyl carbodiimide, N,N'-diphenyl carbodiimide, N,N'-dioctyl decyl carbodiimide, N,N'-di-2,6-dimethyl phenyl carbodiimide, N-triyl-N'-cyclohexyl carbodiimide, N,N'-di-2,6-diisopropyl phenyl carbodiimide, N,N'-di-2,6-di-tert-butyl phenyl carbodiimide, N-toluyl-N'-phenyl carbodiimide, N,N'-di-p-nitrophenyl carbodiimide, N,N'-di-p-aminophenyl carbodiimide, N,N'-di-p-hydroxyphenyl carbodiimide, N, N'-di-cyclohexyl carbodiimide, N,N'-di-p-toluyl carbodiimide, N,N'-benzyl carbodiimide, N-octadecyl-N'-phenyl carbodiimide, N-benzyl-N'-phenyl carbodiimide, N-octadecyl-N'-tolyl carbodiimide, N-cyclohexyl N'-tolyl carbodiimide, N-phenyl-N'-tolyl carbodiimide, N-benzyl N'-tolyl carbodiimide, N,N'-di-o-ethyl phenyl carbodiimide, N,N'-di-p-ethyl phenyl carbodiimide, N,N'-di-o-isopropyl phenyl carbodiimide, N,N'-di-p-isopropyl phenyl carbodiimide, N,N'-di-o-isobutyl phenyl carbodiimide, N,N'-di-p-isobutyl phenyl carbodiimide, N,N'-di-2,6-diethyl phenyl carbodiimide, N,N'-di-2-ethyl 6-isopropyl phenyl carbodiimide, N,N'-di-2-isobutyl 6-isopropyl phenyl carbodiimide, N,N'-di-2,4,6-trimethyl phenyl carbodiimide, N, N'-di-2,4,6-triisopropyl phenyl carbodiimide or N,N'-di-2,4,6-triisobutyl phenyl carbodiimide, and polycarbodiimides such as poly(1,6-hexamethylene carbodiimide), poly(4,4'-methylene biscyclohexyl carbodiimide), poly(1,3-cyclohexylene carbodiimide), poly(1,4-cyclohexylene carbodiimide), poly(4,4'-diphenyl methane carbodiimide), poly(3,3'-dimethyl 4,4'-diphenyl methane carbodiimide), poly(naphthylene carbodiimide), poly(p-phenylene carbodiimide), poly(m-phenylene carbodiimide), poly(tolyl carbodiimide), poly(diisopropyl carbodiimide), poly(methyl-diisopropyl phenylene carbodiimide), poly(triethyl phenylene carbodiimide) or poly(triisopropyl phenylene carbodiimide) are mentioned. Among them, polymers of N,N'-di-2,6-diisopropyl phenyl carbodiimide or 2,6,2',6'-tetraisopropyl diphenyl carbodiimide are preferable.

[0050] Furthermore, the 2 or more active hydrogen reactive groups may be the same or different reactive groups, but it is preferable to be the same reactive group in order to control reactivity.

[0051] Furthermore, as the compound used as the component C, other than the above-mentioned compounds having active hydrogen reactive groups, polyalkylene ether glycols is preferable since it peculiarly improve abrasion resistance. As said compounds, for example, polyethylene glycol, polypropylene glycol, polybutylene glycol or the like are mentioned, but among them, polyethylene glycol of molecular weight 400 to 20,000 is preferable in view of heat resistance, dispersibility and cost. More preferred is a polyethylene glycol of molecular weight 600 to 6,000. And, it is more preferable if both terminals of said compound were modified to glycidyl group. And, it is also preferable to use it together with the above-mentioned compound having 2 or more active hydrogen reactive groups.

[0052] Furthermore, as a compound used as the component C, since it is generally melt molded into a fiber at 200 to 250˚C to produce the synthetic fiber of the present invention, a heat resistance durable thereto is required. Accordingly, it is preferable that a heat loss ratio when arrived at 200˚C in a thermogravimetric (TG) analysis is 3% or less. When the heat loss ratio exceeds 3%, since pyrolyzates bleed out at the time of spinning to thereby stain spinneret or spinning machine, not only spinnability is deteriorated but also, due to a smoke of gaseous pyrolyzate, a problem arises sometimes that working environment may be aggravated. It is more preferable that the heat loss ratio is 2% or less, still more preferably, it is 1 % or less. Where, 200˚C heat loss ratio is the weight loss ratio at 200˚C when heated from a normal temperature (10 to 30˚C) up to 300˚C at a heating speed of 10 ˚C/min under nitrogen atmosphere in a thermogravimetric (TG) analysis.

[0053] An adding amount of the component C can be appropriately determined by an equivalency per unit weight of reactive group of the compound to be used, a dispersibility or reactivity when melted, domain size of the island component and blend ratio of the component A and the component B. In view of preventing a peeling off of the interface, it is preferable to be 0.005 wt% or more with respect to the total amount (100 wt%) of the component A, the component B and the component C. More preferably, it is 0.02 wt% or more, still more preferably, 0.1 wt% or more. When the adding amount of the component C is too small, its diffusion to and degree of reaction between the interface of the 2 components are not sufficient, and an increasing effect of adhesion force of the interface may be limited. On the other hand, in order to exhibit the performance of component C without impairing characteristics and spinnability of the component A and the component B to be the base material of the fiber, it is preferable that the adding amount of component C is 5 wt% or less, and 3 wt% or less is more preferable. Still more preferably, it is 1 wt% or less.

[0054] As the above-mentioned, by adding the component C, it is possible to end-cap terminal carboxyl group of the aliphatic polyester, and enhance hydrolysis resistance of the aliphatic polyester. Concentration of the terminal carboxyl group having a self-catalytic function is better to be low, and it is preferable that the total carboxyl terminal group concentration in the aliphatic polyester is 15 eq/ton or less, more preferably, 10 eq/ton or less and still more preferably, 0 to 7 eq/ton.

[0055] Furthermore, for the purpose of accelerating reaction of the compound having the above-mentioned reactive group, it is preferable to add a catalyst of a metal salt of carboxylic acid, in particular, of its metal is an alkali metal or alkali earth metal, in order to enhance reaction efficiency. Among them, it is preferable to use a catalyst based on lactic acid such as sodium lactate, calcium lactate or magnesium lactate. Other than that, for the purpose of preventing a deterioration of heat resistance of the resin due to the adding of a catalyst, it is possible to use a catalyst of which molecular weight is relatively high such as stearic acid metal salt, singly or in combination. Where, an adding amount said catalyst is, in view of controlling dispersibility and reactivity, preferably, 5 to 2000 ppm with respect to the synthetic fiber. More preferably, it is 10 to 1000 ppm and still more preferably, it is 20 to 500 ppm.

[0056] Furthermore, in the crimped yarn of the present invention, it is preferable that at least one kind crystal nucleating agent selected from talc, sorbitol derivative, metal salt of phosphoric acid ester, basic inorganic aluminum compound or salt of melamine compound is contained. Said crystal nucleating agents are crystal nucleating agents effective mainly to the aliphatic polyester resin (A), especially, to polylactic acid. By adding said crystal nucleating agent, it becomes possible to obtain a crimped yarn of which crimp resilience is hardly lost and excellent in fastness.

[0057] As the talc to be used as crystal nucleating agent, i.e., as those exhibiting high crystallization characteristics while maintaining mechanical characteristics of fiber, it is preferable that an average particle diameter D_{50} is 5 μm or less and the amount of talc of which particle diameter is 10 μm or more is 0 to 4.5 vol% or less with respect to the total talc. By being the average particle diameter D_{50} of the talc 5 μm or less, an effect as a crystal nucleating agent greatly increase due to increase of apparent surface area. Accordingly, it is preferable that the particle diameter of talc is 4 μm or less and 3 μm or less is more preferable. Most preferred is 1.5 μm or less. Where, lower limit of the average particle diameter D_{50} of talc is not especially limited, but if the particle diameter becomes small, its aggregation is promoted to cause a poor dispersion in the polymer and accordingly, it is preferable to be 0.2 μm or more. And, it is preferable that the talc of particle diameter 10 μm or more is 4.5 vol% or less with respect to the total amount of talc. When a coarse talc is contained, not only spinnability decreases, but also mechanical characteristics of fiber may deteriorate. Accordingly, a content of talc of which particle diameter exceeds 10 μm is more preferably 0 to 3 vol% with respect to the total amount of the talc, still more preferably, it is 0 to 2 vol% and most preferably, 0 vol%.

[0058] Where, the particle diameter of talc described in the above-mentioned items (1) and (2) is a value obtained from a particle diameter distribution measured by a laser diffraction method using SALD-2000J produced by Shimadzu Corp.

[0059] Furthermore, as the sorbitol derivatives preferably used as the crystal nucleating agent, bisbenzylidene sorbitol, bis (p-methyl benzylidene) sorbitol, bis (p-ethyl benzylidene) sorbitol, bis (p-chlorobenzylidene) sorbitol, bis (p-bromobenzylidene) sorbitol, and furthermore, sorbitol derivatives obtained by chemically modifying the above-mentioned sorbitol derivatives are mentioned.

[0060] Furthermore, as the metal salt of phosphoric acid esters or as the basic inorganic aluminum compounds, compounds described in JP2003-192883A are preferably used.

[0061] Furthermore, as the melamine compound, melamine, substituted melamine compounds of which hydrogen of amino group is substituted with an alkyl group, an alkenyl group or phenyl group (JP-H9-143238A), substituted melamine compounds of which hydrogen of amino group is substituted with a hydroxyalkyl group, a hydroxyalkyl n (oxaalkyl) group or an aminoalkyl group (JP-H5-202157A), deammonia condensates of melamine such as melam, melem, mellon or methone, guanamines such as benzoguanamine or acetoguanamine, can be used. And, as the salt of melamine compound, organic acid salts or inorganic acid salts are mentioned. As the organic acid salts, isocyanuric acid salt, carboxylic acid salts such as of formic acid, acetic acid, oxalic acid, malonic acid, lactic acid or citric acid, aromatic carboxylic acid salts such as of benzoic acid, isophthalic acid or terephthalic acid, are mentioned. It is possible to use these organic acid salts singly or also as a mixture of 2 kinds or more of them. Among these organic acid salts, melamine cyanurate is most preferable. As the melamine cyanurate, those surface treated with a metal oxide sol such as silica, alumina or antimony oxide (JP-H7-224049A), those surface treated with polyvinyl alcohol or cellulose ethers (JP-H5- 310716A) or those surface treated with a nonionic surface active agent of HLB 1 to 8 (JP-H6-157820A) can also be used. Mol ratio of the melamine compound and the organic acid is not especially limited, but it is preferable that a free melamine compound or an organic acid which has not formed a salt is not contained in the salt compound. A production method of the organic acid salt of melamine compound is not especially limited, but in general, it can be obtained as a crystalline powder, when a melamine compound and an organic acid are mixed and reacted in water, and then filtered off or distilled off the water and dried. As the inorganic acid salt, a hydrochloride, a nitrate, a sulfate, a pyrosulfate, alkyl sulfonates such as methane sulfonate or ethane sulfonate, alkyl benzene sulfonates such as of p-toluene sulfonic acid or dodecyl benzene sulfonic acid, a sulfamate, a phosphate, a pyrophosphate, a polyphosphate, a phosphonate, a phenyl phosphonate, an alkyl phosphonate, a phosphite, a borate or a tungstate, etc., are mentioned. Among these inorganic acid salts, melamine polyphosphate, melamine polyphosphate·melam·melem complex salt or p-toluene sulfonate are preferable. Mol ratio of the melamine compound and the inorganic acid is not especially limited, but it is preferable that a free melamine compound or an inorganic acid which has not formed a salt is not contained in the inorganic acid salt compound. Production method of the inorganic acid salt of melamine compound is not especially limited, but in general, it can be obtained as a crystalline powder when a melamine compound and an inorganic acid are mixed and reacted in water, and then filtered off or distilled off the water and by dried. And, production method of pyrophosphate or polyphosphate is described, for example, in the specification of US Patent No. 3,920,796, JP-H10-81691A, JP-H10-306081A, etc.

[0062] Since the adding amount the crystal nucleating agent and the mechanical characteristics of fiber are in an inverse correlation, it is preferable that the adding amount is 0.01 to 2 wt% with respect to the aliphatic polyester (A). If the adding amount is 0.01 wt% or more, since the aliphatic polyester crystallize promptly at the cooling step after leaving the air jet stuffer machine, it is possible to obtain a crimped yarn excellent in crimp fastness. And, by making the adding amount into 2 wt% or less, a crimped yarn excellent in crimp fastness can be obtained while preventing a decrease of mechanical characteristics. It is more preferable that the adding amount of the crystal nucleating agent is 0.05 to 1.5 wt% and still more preferably, it is 0.2 to 1 wt%.

[0063] Furthermore, to the crimped yarn of the present invention, it is preferable to add Cu salt, K salt, Mn salt, Cr salt, tannin or the like in order to improve fastness to light. In particular, CuI or KI is effective to enhance fastness to light of the polyamide resin. Compound to be added may be one kind, or two or more may be used together. An adding amount may be 0.001 to 0.5 wt% with respect to the thermoplastic polyamide resin (B), more preferably, it is 0.005 to 0.2 wt%, still more preferably, 0.01 to 0.1 wt%.

[0064] Furthermore, it is preferable that grooves extending along fiber axis direction are formed on fiber surface of the crimped yarn of the present invention. Said grooves means concave lines present on fiber surface as shown in Fig. 2, and extend approximately in parallel along fiber axis direction (direction of 10° or less to fiber axis). By these grooves, on fiber surface, incident light in the grooves is appropriately diffused and absorbed, and it becomes possible to exhibit a dewy glossiness excellent in aesthetic appearance. It is preferable that the width of grooves is, in order to effectively raise the diffusion, 0.01 to 1 μm, more preferably, it is 0.05 to 0.9 μm, and 0.08 to 0.8 μm is still more preferable. And, when an aspect ratio of the groove (longitudinal axis length of groove/width of groove) is approximately in the range of 3 to 50, a good glossy texture is exhibited without impairing abrasion resistance. The grooves can be grasped by an observation by an electron microscope (SEM). As to width of groove, in SEM images, by a photograph usually magnified 5,000 times, or magnified 1,000 to 10,000 times as required, and by defining maximum width of each groove as its width of groove, 10 widths of groove are measured and its average value is taken as the width of groove of the present invention. And, for the above-mentioned 10 grooves, respective both ends of the grooves are connected by straight lines and the respective length of the straight lines are taken as longitudinal axis length of the groove, and aspect ratios of the respective grooves were determined (refer to Fig. 3). And, it is preferable to control the number of grooves to 1 to 500 grooves in the range of 10 μm × 10 μm in SEM image, since a good glossiness is exhibited without impairing abrasion resistance. More preferred is 3 to 40 grooves and still more preferred is 5 to 30 grooves.

[0065] Furthermore, it is preferable that strength of the crimped yarn of the present invention is, in order to maintain processability or mechanical strength of product, 1 cN/dtex or more, and 1.5 cN/dtex or more is more preferable. Still more preferably, it is 2 cN/dtex or more and especially preferably, 3 cN/dtex or more. An air stuffer crimped yarn (hereafter, referred to as "BCF yarn") having such strength can be produced by the melt spinning·stretching·bulking method mentioned later. And, it is preferable that elongation at break is 15 to 70% since processability for making fiber product is good. More preferably, it is 20 to 65%, still more preferably, 30 to 55%. It is possible to produce a crimped yarn having such elongation by the melt spinning·stretching·bulking method mentioned later. At this time, in view of making a high performance crimped yarn having an elongation at break of the above-mentioned range, it may also be preferable to make the strength to 4 cN/dtex or less.

[0066] Furthermore, it is preferable that a boiling water shrinkage of the crimped yarn is 0 to 15%, since dimensional stability of fiber and fiber product are good. More preferably, it is 0 to 12%, still more preferably, 0 to 8%, most preferably, 0 to 3.5%.

[0067] Furthermore, in conventional polymer alloy fiber of an aliphatic polyester and a polyamide, by an interface tension between polymers, a swelling having a diameter of 1.5 to 10 times of spinning hole diameter called as Barus effect occurs just beneath the spinning hole at the time of melt spinning. For that reason, a thick-and-thin is easy to occur at thinnig and deforming step in spinning, and a yarn break may occur, or a problem may arise in qualities such as yarn unevenness. It was succeeded that the fiber of the present invention is stably formed by, as mentioned later, minimizing Barus effect by kind of polymer, best design of melt viscosity, control of linear discharge velocity from spinneret, optimization of cooling condition just beneath spinneret and control of spinning speed, and even when a swelling occurred by the Barus, as well as by controlling an elongational flow region as close as possible to the spinneret surface, and quick (shortening distance from discharging to completion of thinnig and deformation). Accordingly, yarn unevenness along the fiber longitudinal direction is also small. It is preferable that yarn unevenness (Uster unevenness, U%, Normal value) of the crimped yarn of the present invention is, for its processability or for preventing dyeing unevenness after dyeing, 2% or less and 1.5% or less is more preferable. Still more preferably, it is 1 % or less.

[0068] It is preferable that the crimped yarn of the present invention is a "BCF yarn " (BCF : bulked continuous filament) obtained by an air jet stuffer machine mentioned later. BCF yarn means a filament having an irregular entangled loop-like crimp configuration obtained by turbulent flow effect of hot fluid (dry air, etc.), and its configuration is explained in detail in the first chapter (pages 25 to 39) of "Filament Processing Technical Manual (2nd Bde)" edited by The Textile Machinery society of Japan. Examples of embodiment of BCF yarn are explained by photographs of fiber shape of Fig. 4 and Fig. 5. Fig. 4 is a photograph observed by placing one embodiment of BCF yarn of the present invention on a black paper in multifilament state and Fig. 5 is a photograph of the multifilament of Fig. 4 separated into single fibers and placed on a black paper. As obvious from Fig. 4, loops of single fiber are formed in random direction, and has a crimp configuration in which 2 or more of single fibers are entangled. And, as obvious from Fig. 5, amplitude and periodicity of loop of single fiber is irregular. As shown here, in the BCF yarn, single fibers are respectively folded in loop state and amplitudes of the loop are irregular with no periodicity and have a configuration in which said single fibers are entangled with each other. And, it has not an excessively folded portion and not only high in bulkiness compared to false twisted yarns or the like, but also since it has a characteristic that the residual torque is small, when the crimped yarn or a fiber product in which the crimped yarn is used is abraded, external force is easy to be dispersed to respective single fibers, and a deformation by the external force is hardly occurred.

[0069] Regarding the crimped yarn of the present invention, it is preferable that a crimp elongation percentage after boiling water treatment is 3 to 30%, more preferably it is 5 to 30%, still more preferably, 8 to 30% and especially preferably, 12 to 30%. Here, measurement of the crimp elongation percentage after boiling water treatment is carried out as follows.

[0070] A crimped yarn unwound from a package (crimped yarn winding drum or bobbin) left in an atmosphere of an environmental temperature 25±5°C and relative humidity 60±10% for 20 hours or more, is immersed for 30 minutes in boiling water in a state without a load. After the treatment, it is dried in the air for one day and night (approximately 24 hours) under the above-mentioned environment, and this is used as a sample of crimped yarn after boiling water treatment. This sample is loaded with an initial load of 1.8 mg/dtex, and after leaving for 30 seconds, a marking is made at sample length of 50 cm (L1). Next, after leaving for 30 seconds from the time of loading a measuring load of 90 mg/dtex instead of the initial load, sample length (L2) is measured. And from the following equation, crimp elongation percentage after boiling water treatment (%) is determined.

$$\text{Crimp elongation percentage (\%)} = [(L2-L1)/L1] \times 100.$$

[0071] When a crimp elongation percentage after boiling water treatment of such crimped yarn is lower than 3%, it may be insufficient in crimp development, poor in bulkiness, and for example, when it is made into a carpet or the like, it may become a carped with no voluminous feeling. On the other hand, it is impossible to produce a crimped yarn of which crimp elongation percentage after boiling water treatment is 30% or more, and when said crimp elongation percentage is tried to increase over 30%, strength of crimped yarn may decrease significantly or it may cause a crimp unevenness or a yarn thickness unevenness.

[0072] As to the crimped yarn of the present invention, it is preferable that, in a processing step for making a fabric structure such as dyeing or bulking processing treatment or in a long term use after being made into a product, crimp is hardly lost and product appearance is maintained for a long term. Accordingly, it is preferable that a crimp elongation percentage under a load of 2 mg/dtex after boiling water treatment (hereafter, referred to as "elongation percentage under load") which is an index of crimp fastness is 2% or more. The elongation percentage under load is more preferably, 3% or more, and still more preferably, 5% or more. There is especially no upper limit, but by the technique of the present invention, increasing to around 15% is the limit. Where, the elongation percentage under load can be measured by the method described in Examples.

[0073] As to cross-sectional shape of the polymer alloy type synthetic fiber constituting the crimped yarn of the present invention, it can be freely selected from circular cross-section, hollow cross-section, multi-hollow cross-section, multi-lobal cross-sections such as trilobal cross-section, flat cross-section, W type cross-section, X type cross-section and other non-circular cross-sections, but in order to enhance bulkiness of the crimped yarn to achieve a voluminous fiber structure, non-circular cross-section of its non-circularity (D1/D2) is 1.2 to 7 is preferable. The higher the non-circularity of the non-circular cross-section fiber, the more voluminous fiber structure can be made, but, on the other hand, when the non-circularity is excessively high, flexural rigidity of fiber increases, and there may be problems such that softness decreases, splitting of fiber (fibrillation) occurs or a glaring glossiness is appeared. Accordingly, it is preferable that the non-circularity is in the range of 1.3 to 5.5, and more preferably, it is in the range of 1.5 to 3.5.

[0074] Production method of a crimped yarn constituted by the polymer alloy type synthetic fiber which is one preferable embodiment of the present invention is not especially limited, but, for example, the following method can be employed by using a direct spinning·stretching·crimp processing machine shown in Fig. 6.

[0075] That is, in the above-mentioned combination of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B), it is preferable that, as well as making the blend ratio (wt%) of the component A and the component B into the range of 5/95 to 55/45, the ratio of melt viscosity (ηb/ηa) is controlled into the range of 0.1 to 2. At this time, when the blend ratio of component A is close to the lower limit of the above-mentioned blend ratio, for example, in case where the ratio of component A is 5 to 15 wt%, melt viscosity ratio should be increased as 0.8 to 2, but when the blend ratio of component A is close to the upper limit, for example, in case where the ratio of component A is 45 to 55 wt%, the ratio of melt viscosity should be 0.1 to 0.3, that is, it is necessary to lower the melt viscosity of the thermoplastic polyamide resin (component B) to 1 /10 to 3/10 of the aliphatic polyester resin (component A). This is to make the configuration of the crimped yarn constituted by the polymer alloy fiber of the present invention into a sea/island structure fiber in which the aliphatic polyester resin (A) constitutes the island component. Where, in the above-mentioned range, when the ratio of component A is in the range of 15 to 45 wt%, it is possible to make the aliphatic polyester into an island component by making the ratio of melt viscosity to the range of 0.2 to 1. Where, as the melt viscosity η for calculating the above-mentioned ratio of melt viscosity (ηb/ηa), a value measured at the same temperature as its spinning temperature and at a shear rate of 1216 sec^{-1} is used.

[0076] Next, in combination of the above-mentioned polymer characteristics and blend ratio, the polymer alloy is made into a fiber by once palletized by using such as a twin screw kneading machine, or by kneading followed by a melt spinning. As to adding timing of the compatibilizer (component C), it may be added at the timing of kneading of the component A and the component B, and as to its adding method, it may be mixed and kneaded at the same time with the component A and the component B by supplying the compatibilizer as it is to a kneading machine, or a master pellet containing the component C in a high concentration is prepared beforehand, and it may be supplied to a twin screw kneading machine by blending with pellet of the component A and the component B. Where, in case of preparing a master pellet beforehand, since it is important to prevent a reaction of the compatibilizer, it is preferable that the master pellet is prepared with the component A of which molding temperature can be lowered. Where, the reason for suppressing the reaction of the compatibilizer as small as possible, when said compatibilizer is a reactive type, is to effectively prevent the reactive group reacts one-sidedly to one component.

[0077] As to jacket temperature at the time of kneading in melt extrusion, it is preferable to be carried out, based on melting point of the thermoplastic polyamide (component B) (hereafter, referred to as Tmb), at Tmb+3°C to Tmb+30°C, and it is preferable that shear rate is 300 to 9800 sec^{-1}. By making the jacket temperature and shear rate in these ranges, when a fiber is obtained, as well as it becomes possible to achieve the domain diameter of the present invention, a colorless polymer alloy fiber is obtained. When the jacket temperature exceeds this range or the shear rate exceeds 10000 sec^{-1} to cause a heat generation by the shear, due to a coloring of polymer, applications of the obtained crimped yarn may be limited.

[0078] Similarly, in order to maintain the above-mentioned sea/island structure and to prevent coloring, it is preferable that the spinning temperature is also as low as possible, i.e., it is preferable to carry out spinning at Tmb+3°C to Tmb+40°C. More preferable spinning temperature is Tmb+3°C to Tmb+30°C, and still more preferably, it is Tmb+3°C to Tmb+20°C.

[0079] Furthermore, in order to prevent re-aggregation of island domain in the spinning pack to control domain diameter, a high mesh filtering layer (#100 to #200), a porous metal, a nonwoven fabric filter of small filtering size (filtering size 5 to 30 μm) or a blend mixer in pack (static mixer or high mixer) may be built in. In particular, it is extremely effective that the domain is re-dispersed by a nonwoven fabric filter of filtering size 20 μm or less just before being discharged from spinneret, to control the domain diameter.

[0080] Furthermore, polymer blend substance of aliphatic polyester and polyamide is an incompatible combination, and the molten polymer shows a strong behavior in elastic term, and swelling by Barus effect may become large. Accordingly, it is preferable that a linear discharge velocity at spinning hole of spinneret is, in order to prevent yarn swelling by Barus effect and also to stably extend and make fine to improve spinnability, 0.02 to 0.4 m/sec, 0.03 to 0.3 m/sec is more preferable and 0.04 to 0.2 m/sec is still more preferable. It is also effective to enlarge depth of spinning hole to prevent the Barus. Here, depth of spinning hole means the length from the lower end of inlet hole to discharge surface as shown in Fig. 7(a). And, in case of a circular hole, depth of spinning hole means the length from lower end of tapered portion to discharge surfaces shown in Fig. 7(b). The depth of spinning hole is preferably 0.3 to 5 mm, more preferably, it is 0.4 to 5 mm, and still more preferably, 0.5 to 5 mm.

[0081] Furthermore, it is necessary that a discharged yarn has an elongational flow region as close as possible to the spinneret surface and quick (shortening distance from discharge to completion of thinnig and deformation). Accordingly, it is preferable that a starting point of cooling of the discharged yarn is close to the spinneret surface, i.e., it is preferable to start cooling from a position substantially vertically beneath 0.01 to 0.15 m from the spinneret surface. Where, the starting point of cooling substantially vertically beneath means, as shown in Fig. 8 of an enlarged discharge portion, the intersection "c" of line "a" and line "b", when line "a" is drawn horizontally from the upper end of the cooling air blow-off area and vertical line "b" is drawn downward from the spinneret surface, i.e., it means that the distance "cd" from the spinneret surface "d" to "c" on the vertical line "b" is preferably 0.01 to 0.15 m. The starting point of cooling is more preferably, from the spinneret surface substantially vertically beneath 0.01 to 0.12m, and still more preferably, from the spinneret surface substantially vertically beneath 0.01 to 0.08m.

[0082] Furthermore, the cooling method may be a uniflow type chimney which cools from one direction, or may also be a circular chimney which blows off cooling air from inside to outside of yarn or from outside to inside of yarn, but a circular chimney which cools from inside to outside of yarn is preferable, since a uniform and quick cooling is possible. At this time, it is preferable to cool multifilament by blowing off a gas substantially from a right angle to the multifilament. Here, substantially right angle means that, as shown in Fig. 8, flow line of the cooling air is substantially perpendicular on line "b" (inclination is 70 to 110˚). Where, as to gas used as the cooling air is not especially limited, but a noble gas which is stable at normal temperature (reactivity is extremely low) such as argon, helium, nitrogen, or air are preferably used and among them, nitrogen or air which are cheaply available are especially preferably used.

[0083] Furthermore, at this time, it is preferable that a speed of the cooling air is 0.3 to 1 m/sec, and 0.4 to 0.8 m/sec is more preferable. And, it is preferable that a temperature of the cooling air is low in order to cool the yarn quickly, but in relation to a cost of air conditioning, 15 to 25˚C is practical and preferable. As above-mentioned, the sea/island structure of the present invention is formed by a specific combination of polymers, and further, the sea/island structure can be discharged without a break by controlling spinning temperature, and further, the polymer alloy fiber of the present invention can be stably spun and taken up for the first time by controlling the linear discharge velocity at spinning hole of spinneret or, by controlling cooling method and other conditions. And, the spun multifilament is covered with a known finishing agent for spinning, but at this time, the amount of deposition per yarn is, as a pure oil content, 0.3 to 3 wt% (in case of oiling agent component: water or low viscosity mineral oil = 10 : 90, 3 to 30 wt% emulsion per yarn).

[0084] Furthermore, it is taken up at a spinning speed of 500 to 5000 m/min and wound, or continuously subjected to a stretching · bulking processing. However, when the polymer alloy type synthetic fiber is left in an unstretched state, orientation relaxation is likely to arise and when there is a time difference before the stretching· bulking processing between unstretched yarn packages, an unevenness of strength and elongation characteristics, heat shrinking characteristics or crimp elongation percentage of fiber easily occurs. Accordingly, it is preferable to employ a direct spinning stretching bulking processing method in which spinning, stretching and bulking processing is carried out in 1 step.

[0085] The stretching may be carried out in 1, 2 or 3 stages, but in case where a high strength of 2 cN/dtex or more is required, it is preferable to stretch in 2 stages or more. Fig. 6 is a schematic view of an apparatus for carrying out 2 stage stretching·crimp processing after spinning, but in this case, taking up at 500 to 5000 m/min in 1 FR, and simultaneously heating the 1 FR to approximately 50 to 100˚C, carrying out first stage stretching between the 1 FR (single hot roll) and 1 DR (tandem roll), and successively carrying out 2nd stage stretching between the 1 DR and 2 DR (tandem roll). At this time, it is important that a stretching temperature (1 DR temperature of Fig. 6) for carrying out the 2nd stage stretching is higher than the 1 FR by at least 20˚C or more, in order to improve process stability. Accordingly, in case where 1 FR temperature is adjusted to 50 to 100˚C, 1 DR temperature is adjusted to the range of 70 to 130˚C and in 1 FR temperature +20˚C or more. And, a stretching ratio of the 1 FR to the final stretch roll (in case of Fig. 6, 2 DR) may be controlled such that the elongation at break of the stretched yarn sampled at the exit of the final stretching roll becomes 15 to 65%, and preferably, it is 20 to 60%. At this time, as methods for making the elongation at break into the above-mentioned range, automatically controlling the stretch ratio by recording beforehand the relation between out put of polymer, spinning speed and stretch ratio between respective rolls and the elongation at break of stretched yarn sampled at exit of the final stretch roll by a PLC (programmable controller), or a method of controlling the elongation at break by, in case where the elongation at break of the stretched yarn, when the stretched yarn is sampled at the exit of the final stretch roll, is lower than the above-mentioned range, setting the stretch ratio low, or in case where the elongation at break is high, setting the stretch ratio high, to thereby determine the stretch ratio by controlling such that the elongation at break of said stretched yarn would be in the range of 15 to 65%, etc., are mentioned.

[0086] By setting to the above-mentioned stretching temperature and stretch ratio, it becomes possible to obtain a stretched yarn of which processing stability is high, and of a high strength and small in yarn unevenness (Uster unevenness U%). Further, by heat setting by setting the final stretch roll temperature at Tma-30˚C to Tma+30˚C based on the melting point of the aliphatic polyester resin (component A) (hereafter, referred to as Tma), it becomes possible to obtain a stretched yarn of a predetermined heat shrinkage ratio. And, by heat setting at such high temperature, and further, by subjecting to a high temperature bulking processing in next step, it becomes possible to form micro grooves on fiber surface of the crimped yarn. As a result, a dewy glossiness excellent in aesthetic appearance can be imparted to final product. For the bulking processing, an air jet stuffer machine is used and the crimp processing is carried out at a nozzle temperature of said machine higher than the final stretch roll temperature by 5 to 100˚C.

[0087] Where, as to the air jet stuffer machine, it is described in detail in the first chapter (pages 25 to 39) of "Filament Processing Technical Manual (2nd Bde)" edited by The Textile Machinery society of Japan. That is, it is a crimp processing machine widely used for production of crimped yarns for BCF carpet, and it is a machine which imparts an irregularly entangled loop-like bulkiness to a filament by using turbulent flow effect of air jet. As examples of the machine, several embodiments of the machine are described in Figs. 1-16 to 1-30 of the above-mentioned Filament Processing Technical Manual, and they can be appropriately selected in consideration of fiber thickness of multifilament, fiber thickness of constituting single filament, non-circularity, rigidity, etc.

[0088] At this time, in order to lower the crimp elongation percentage after boiling water treatment, said nozzle temperature should be low, and in order to make the crimp elongation percentage high, said nozzle temperature should be high. However, when said nozzle temperature is set higher than Tmb, since processability deteriorates rapidly, upper limit of the nozzle temperature is Tmb+10°C. And, a hot fluid introduced to the nozzle is not especially limited, e.g., dry air, dry nitrogen, air containing steam, etc., but hot air containing steam is preferable in view of thermal efficiency and running cost.

[0089] The yarn imparted with 3 dimensional crimp by an air jet stuffer machine is successively cooled rapidly by being contacted with a cooling drum, to thereby fix crimp structure. After that, crimp uniformity is improved by loading an appropriate tension to the crimped yarn, and wound into a package at a speed lower than the peripheral speed of the final stretch roll by 10 to 30%. At this time, relax ratio between the final stretch roll (in Fig. 6, 2 DR) and winder may be controlled such that the winding tension would be in the range of 0.05 to 0.12 cN/dtex so that an excessive tension would not be loaded to the crimped yarn, i.e., a yarn with a high crimp elongation percentage is wound at a relax ratio of 20 to 30%, and a yarn of a low crimp elongation percentage is wound at a relax ratio of 10 to 20%.

[0090] Next, regarding the "sheath/core type composite fiber of which core component comprises the aliphatic polyester resin (A), or the polymer alloy comprising the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B), and the sheath component comprises the thermoplastic polyamide resin (B)" which is the another preferable embodiment is explained.

[0091] In the sheath/core type composite fiber, in order to prevent peeling off of the composite interface so that it can be applied to carpet uses to which a strong external force is added repeatedly, it is necessary to have a specified fiber structure.

[0092] As a result of an aggressive investigation of the inventors on the peeling off phenomena of the sheath/core interface in the sheath/core type composite fiber, it was found that, in order to enhance peeling resistance of the crimped yarn, degree of orientation of amorphous phases of the respective core component and sheath component should be low, and in addition, crystallinities in the respective core component and sheath component should be high, that is, by having 2 phase structure of the crystal phase and the unoriented amorphous phase in the respective core component and the sheath component, the peeling resistance is greatly improved. At first, as to the crimped yarn, as a result of investigation of a factor for lowering the peeling resistance, it was found that the molecular orientation of the core component and the sheath component neighboring the sheath/core interface is apt to increase compared to other region than the interface. It was found that, by being the molecular orientation of the respective components neighboring the sheath/core interface high, the sheath/core interface is apt to have a residual stress, and when an external force is added, it triggers a growth of interface peeling while releasing the stress.

[0093] It is not clear as to the factor why the molecular orientation of the core component and the sheath component neighboring the sheath/core interface of the sheath/core type composite fiber becomes high compared to other region, but it is estimated because, probably, when the respective core and sheath components thermally shrink in the crimp processing, an undue force is added to the sheath/core interface. That is, heat shrinkage of the fiber is caused by releasing molecular orientation of amorphous phases of the respective core component and sheath component, but at this time, in case of a sheath/core type composite fiber of which core component and sheath component are different components with each other, both components have differences in heat shrinking characteristics. By this difference of heat shrinking characteristics, heat shrinkages of the respective components are prevented or accelerated by the other component. And, it is estimated that the molecular chains of the core component and the sheath component neighboring the sheath/core interface are affected by an undue stress at transmitting heat shrinkage to each component, and as a result, their molecular orientations are not sufficiently released to be left in an unstable condition. A residual stress is generated in the sheath/core interface by a molecular movement that such molecular chain of unstable orientation condition is orientation relaxed. And when an external force is added, it triggers a growth of an interface peeling while the stress is released. In crimped yarns such as a false twisted yarn or a mechanically crimped yarn, molecular orientation of the above-mentioned core component and sheath component neighboring the sheath/core interface is apt to increase and a residual stress is generated in the sheath/core interface and an interface peeling may occur. On the other hand, it was found that in case where a multifilament comprising the sheath/core type composite fiber is used as a BCF yarn, different from the above-mentioned other processings, the generation of the residual stress of the sheath/core interface is greatly prevented to become an internal structure which hardly arise the interface peeling. It is not clear as to the reason, but it is estimated that, in a crimp processing by air jet stuffer, by the turbulent flow effect of hot fluid, the core component and the sheath component of the respective single fibers can be heated uniformly in a short time close to the melting point of the thermoplastic polyamide resin (B) (Tmb), and simultaneously heat shrank under no tension condition, and in addition, by being cooled immediately and rapidly by a cooling roll, even in the region neighboring the sheath/core interface, it is possible to sufficiently release molecular orientation of the amorphous phase, and the history based on the difference of heat shrinking characteristics of the respective components is hardly remained.

[0094] Furthermore, the residual stress of the sheath/core interface is also stored when the molecular chain of the core component and the sheath component neighboring the sheath/core interface of which orientation condition is unstable is orientation relaxed in later stage processing steps such as dyeing or in a change with lapse of time when used as a product, in particular, in case where the aliphatic polyester (A) is used as the core component, not only in case where it is exposed to heat, but also by a change with lapse of time, the molecular orientation of the amorphous phase is easy to be released. Accordingly, a residual stress in the sheath/core interface is easy to generate and the interface is easy to be peeled off. That is, the lower the molecular orientation of the respective amorphous phases of the core component and sheath component of the crimped yarn, the more excellent the peeling resistance, and it is preferable. And further, the more the crystal phases are present in the core component and sheath component, the more the relaxation movement of the molecular chain of the amorphous phase is bound to render the peeling resistance excellent, and it is preferable.

[0095] The fiber structure of the crimped yarn is closely related to physical properties of the crimped yarn, and the crimped yarn comprising the sheath/core type composite fiber of the present invention is achieved by adjusting to a specified strength, boiling water shrinkage and single fiber thickness.

[0096] Strength of the crimped yarn may become high as the degree of orientation of amorphous phase inside the fiber becomes high. And in ordinary crimped yarn comprising single component, as the strength becomes high, it is more preferable in view of processability and durability when used as a product, but in the crimped yarn in which the sheath/core type composite fiber of the present invention is used, since the lower the degree of orientation of amorphous phase, the more excellent in peeling resistance, it is preferable that the strength is 3 cN/dtex or less. By controlling the strength of crimped yarn of the present invention to 3 cN/dtex or less, the degree of orientation of amorphous phase inside the fiber becomes sufficiently low and a residual stress in the sheath/core interface hardly generates, it becomes a crimped yarn excellent in peeling resistance, and it is preferable. It is preferable that the strength is 2.8 cN/dtex or less since a crimped yarn more excellent in peeling resistance is obtained, to be 2.6 cN/dtex or less is more preferable, and to be 2.4 cN/dtex or less is still more preferable. On the other hand, when the strength is too low, spinnability, processability of later stage processing step and durability as a product may be poor. Accordingly, it is necessary that the strength is 1.5 cN/dtex or more, to be 1.7 cN/dtex or more is preferable, to be 1.9 cN/dtex or more is more preferable and to be 2.1 cN/dtex or more is still more preferable. Where, the strength can be measured by the way indicated in Examples.

[0097] By boiling water treatment, the molecular orientation of the amorphous phase is released and the fiber shrinks. And, at this time, crystal phases present in the fiber function as binding points and prevent relaxation of the amorphous phase. That is, the boiling water shrinkage of the crimped yarn (hereafter, referred to as "boiling water shrinkage") becomes low as the degree of orientation of amorphous phase inside the fiber becomes low and the crystallinity becomes high. That is, in the crimped yarn of the present invention, as the boiling water shrinkage becomes low, the degree of orientation of amorphous phase inside the fiber becomes low and the crystallinity becomes high, and a residual stress in the sheath/core interface hardly generates and the peeling resistance becomes excellent and it is preferable.

[0098] It is possible to measure the boiling water shrinkage by the method shown in Examples, and can be calculated by measuring the change of fiber length under tension free condition between before and after boiling water treatment of the crimped yarn. It is preferable that the boiling water shrinkage of the crimped yarn of the present invention is 6% or less. It is more preferable that the boiling water shrinkage is 5% or less since the crimped yarn becomes more excellent in peeling resistance, to be 4% or less is still more preferable and to be 3% or less is especially preferable. The lower the boiling water shrinkage, the more preferable, and to be 0 to 2% is most preferable. The boiling water shrinkage may be, ideally, 0%.

[0099] Furthermore, it is preferable that the sheath/core type composite fiber of the present invention has a single fiber thickness of 5 to 40 dtex. By being the single fiber thickness 40 dtex or less, in the crimp processing step, the fiber is heated quickly and inside the cross-section of the single fiber is heated uniformly, an undue stress is unlikely to arise in the molecular chain of the core component and sheath component neighboring the sheath/core interface and in the sheath/core interface, a residual stress is hardly left. That is, it is excellent in peeling resistance. And, simultaneously, since a crystallization easily occurs, fiber structure is fixed, and it is preferable since peeling resistance can be maintained for a long term even after dyeing step or after a change with lapse of time. In order to make the molecular orientation of amorphous phase more low, and the crystallinity high, that is, since peeling resistance of the crimped yarn becomes excellent, it is preferabl that the single fiber thickness is as fine as possible, to be 38 dtex or less is preferable, to be 35 dtex or less is more preferable, to be 33 dtex or less is still more preferable and to be 30 dtex or less is especially preferable. On the other hand, however, when the single fiber thickness is excessively fine, although it is easy to form 2 phase structure of a crystal phase and a random amorphous phase in crimping treatment, the crimped yarn is re-extended by a stretch tension added in later crimp extending step, winding tension added in winding step of the crimped yarn, or a tension added in later stage processing step, an undue stress is easily generated in the sheath/core interface. Accordingly, it is preferable that the single fiber thickness is 5 dtex or more. More preferably, it is 6 dtex or more and still more preferably, 8 dtex or more. In the present invention, as above-mentioned, the problem of peeling off which was unavoidable in the crimped yarn constituted from the sheath/core type composite fiber of which core component comprises the aliphatic polyester resin (A) and the sheath component comprises the thermoplastic polyamide resin (B), has been overcome for the first time by controlling into strength : 1.5 to 3 cN/dtex, single fiber thickness : 5 to 40 dtex and boiling water shrinkage : 6% or less.

[0100] In the sheath/core type composite fiber of the present invention, core component comprises the aliphatic polyester resin (A) (hereafter, referred to also as "component A"), or a polymer alloy comprising the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) (hereafter, referred to also as "component B"). In the present invention, it is preferable that the above-mentioned 2 component constitutes 90 wt% or more of the core component, and to be 93 wt% or more is more preferable and to be 95 wt% or more is still more preferable.

[0101] In the sheath/core type composite fiber of the present invention, it is preferable that, by using the polymer alloy of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) as the core component, and by forming so-called sea/island or sea/sea structure in which the component A and the component B penetrate with each other, peeling of the sheath/core interface between the sheath component and the core component is prevented, and a fiber of which abrasion resistance is sufficiently high is obtained. And, the component B to be used as the core component and the component B to be used as sheath component may be the same or different. And, even the content of the component A of the sheath/core type composite fiber is raised to 20 wt% or more, a fiber of which abrasion resistance and heat resistance are high can be obtained.

[0102] Here, it is preferable that the thermoplastic polyamide resin (B) constituting the core component constitutes the sea. Further, in order to raise the ratio of the aliphatic polyester resin (A) in the polymer alloy of the core component, it is important that a melt viscosity of the aliphatic polyester (A) at the time of melt spinning is made higher than the thermoplastic polyamide (B).

[0103] It is preferable that a blend ratio (weight ratio) of the component A and the component B which constitute the core component of the sheath/core type composite fiber of the present invention is, component A/component B = 95/5 to 20/80. By having the component B in the core component, and by the presence of the component B at least in a portion of the sheath/core interface, an adhesion force at the sheath/core interface is improved to thereby prevent interface peeling off, and it is preferable. In case of a sheath/core type composite fiber, when a peeling arises at the sheath/core interface, the fiber becomes easy to be fibrillated. Once a fibrillation starts, abrasion speed of the fiber rapidly increases. Accordingly, in order to enhance abrasion resistance of fiber, it is important to prevent the peeling of the sheath/core interface. The more the component B is contained in the core component, the easier to form the polymer alloy structures (a) or (c) mentioned later which is considered to be preferable in the present invention, and it is preferable since abrasion resistance of fiber becomes excellent. Accordingly, it is preferable that the blend ratio of the component B in the core component is high. On the other hand, however, in order the sheath/core type composite fiber of the present invention to be a material having also an ability of reducing environmental load, it is preferable that plant derived component A is contained as much as possible, that is, it is preferable to lower the ratio of the component B. In order to satisfy both requirements that adhesion force of the sheath/core interface is increased to thereby render the abrasion resistance excellent, and to be a material low in environmental load, it is more preferable that component A/component B is 80/20 to 25/75, to be 70/30 to 30/70 is still more preferable and to be 60/40 to 35/65 is especially preferable.

[0104] As to the blend ratio (weight ratio) of component A/component B of the core component of the present invention, it can be calculated based on the weight ratio of the component A and the component B to be supplied to melt spinning. However, in case where the blend ratio (weight ratio) of the component A and the component B at the production is unclear, it can also be calculated by the following equation, for convenience. That is, the core component of sheath/core type composite fiber of the present invention may contain the component A and the component B and other small amount components, but in such cases, it can be considered that the core component substantially comprises the 2 components only of the component A and the component B, and the blend ratio (weight ratio) of component A/component B can be calculated. At first, sheath/core type composite fiber cross-section slice is observed by a transmission electron microscope (TEM) at a magnification of 40,000 times, and total area (Aa) of the component A and total area (Ab) of the component B constituting the core component are determined. And it was calculated by the following equation by putting as the specific gravity of component A 1.26, and as the specific gravity of component B 1.14.

$$\text{Component A/component B} = (Aa \times 1.26)/(Ab \times 1.14).$$

[0105] Furthermore, in the cross-section, in case where boundary line of sheath component and core component in the cross-section was difficult to decide, taking a similar figure in the cross-section to the fiber cross-section circumscribing the component A which is present at outermost layer and containing the component A in its inside only as boundary line, sheath component and core component was differentiated.

[0106] Furthermore, as the polymer alloy structure of the core component in the single fiber cross-section, the following (a) to (c) are mentioned, and any of these polymer alloy structures, by an effect of interaction between the component B in the core component and the component B in the sheath component, a good abrasion resistance is exhibited. However, among them, since the component B of the core component and the component B of the sheath component forms a continuous phase and greatly improve the abrasion resistance of fiber, it is preferable that the polymer alloy structure of the core component is (a) or (c) and to be (a) is especially preferable.

(a) The component A is the island component and the component B is the sea component (sea/island structure)
(b) The component B is the island component and the component A is the sea component (sea/island structure)
(c) Both of the component A and the component B are sea component (sea/sea structure).

[0107] Here, the "sea/island structure in which the component A is the island component and the component B is the sea component" which is the preferable polymer alloy structure (a) constituting the core component of the present invention is explained with reference to the TEM photograph of Fig. 1. In Fig. 1, the dyed component is the thermoplastic polyamide resin (B) and the undyed component is the aliphatic polyester resin (A). As shown in Fig. 1, a structure in which the component A is divided by the component B, which is a continuous region, into a plural circular domains is defined as the sea/island structure of (a) the component A is the island component and the component B is the sea. Where, so-called sea/island/lake structure in which the component B is present inside the component A which is the island component (approximately circular) is also included in the sea/island structure of the present invention. "Island-in-sea structure in which the component A is the sea component and the component B is the island component" which is the polymer alloy structure (b) is a structure in which the component B is divided into a plurality of approximately circular region by the component A which is a continuous region. And, "sea/sea structure in which both of the component A and the component B are sea component" which is the polymer alloy structure (c) of the present invention is defined as a structure in which both of the component A and the component B are not approximately circular, and the island component and the sea component cannot be differentiated.

[0108] The polymer alloy structure of the core component closely relates to the above-mentioned blend ratio (weight ratio) of the component A and the component B or the viscosity ratio of melt viscosity of the component A (ηa) and melt viscosity of the component B (ηb) mentioned later, and by respectively controlling to appropriate ranges, the alloy structure core component can be controlled.

[0109] Furthermore, in order to obtain the structure (a) which is especially preferable polymer alloy structure, it is preferable to make melt viscosity of the component A ηa high and melt viscosity of the component B ηb low. This is because the polymer alloy structure is affected by the balance of melt viscosities of the component A and the component B. The polymer alloy structure is formed by being subjected to a shear deformation in a molten state, but a structure of which shear stress generated by the shear deformation is smallest is likely to be formed. This is because the energy level of the whole system becomes low and stable. This means that sea component to which the shear is added directly is likely to be formed with a component of which melt viscosity is low, and on the contrary, a component of which melt viscosity is high is likely to constitute island component. That is, in the present invention, to make the structure (a) which is an especially preferable polymer alloy structure, it is preferable that the ratio of melt viscosity ($\eta b/\eta a$) is small, and to be 2 or less is preferable, to be 1.5 or less is more preferable and to be 1 or less is still more preferable. However, when the ratio of melt viscosity becomes too small, since diameter of the island component may become coarse and large, it is preferable that the ratio of melt viscosity ($\eta b/\eta a$) is 0.10 or more, to be 0.15 or more is more preferable and to be 0.20 or more is still more preferable. Where, details of measurement of melt viscosity η is mentioned later, but it means a melt viscosity measured at a temperature of 240˚C and at a shear rate of 1216 sec^{-1}.

[0110] In case where the core component of sheath/core type composite fiber of the present invention is a sea/island structure, it is preferable that the diameter of island component is 0.001 to 2 μm. It is preferable since by making the upper limit of the Island component diameter 2 μm, interface area formed by the component A and the component B greatly increases and fiber abrasion resistance greatly increases. On the other hand, if the diameter of island component is too small, the component A and the component B are compatibilized in a molecular level to impair crystallinity, and abrasion resistance, heat resistance and dyeing fastness of fiber may deteriorate. In view of this point, it is preferable that the lower limit of the island component diameter is 0.001 or more. From this point, it is preferable that diameter of the island component is 0.005 to 1 μm and 0.01 to 0.8 μm is more preferable. Still more preferably it is 0.02 to 0.5 μm.

[0111] Where, the diameter of island component of the present invention is, as explained in detail in Examples, a cross-section slice of said sheath/core type composite fiber is observed by a transmission electron microscope (TEM) (40,000 times), and for 100 islands per 1 sample of sheath/core type composite fiber, diameters of island component were measured (island was taken as a circle and diameter equivalent to area of the hypothetical circle is defined as the island component diameter). By adjusting diameter distribution of said island component to the above-mentioned range, abrasion resistance, heat resistance and dyeing fastness of the fiber are improved.

[0112] Furthermore, since a material constituting the core component of sheath/core type composite fiber is a polymer alloy, different from a block copolymer in which aliphatic polyester block and polyamide block are present alternatively in 1 molecular chain, it is important that the aliphatic polyester molecular chain (component A) and the polyamide molecular chain (component B) are present substantially independently.

[0113] This difference of conditions can be estimated by observing a melting point depressions of the thermoplastic polyamide resin of before and after the compounding, that is, how the melting point based on the thermoplastic polyamide resin in the polymer alloy decreased from the melting point of the thermoplastic polyamide resin before the compounding. If the melting point depression of the thermoplastic polyamide resin is 3˚C or less, the aliphatic polyester and the polyamide have hardly copolymerized (ester-amide interchange has hardly occurred), and it is a polymer alloy condition in which the aliphatic polyester molecular chain and the polyamide molecular chain are present substantially independently.

[0114] By being the component A and the component B are present substantially independently in this way, the thermoplastic polyamide resin (B) which forms the sheath component and the thermoplastic polyamide resin (B) which forms the core component easily arise an interaction to enhance adhesion force of the interface of the sheath component and the core component, and it is preferable. By this effect, characteristics which is inherent to the thermoplastic polyamide resin (B), the sheath component, reflects to fiber characteristics to greatly improve abrasion resistance. For that reason, in the present invention, it is preferable that the melting point depression of the thermoplastic polyamide (B) is 2˚C or less. And, since adhesion force of the interface between the sheath component and the core component increases, it is preferable that the thermoplastic polyamide resin (B) used as the core component and the thermoplastic polyamide resin (B) used as the sheath component are polyamides of which main repeating unit is a same kind of monomer. For example, it may be a combination of nylon 6 and a co polyamide of which main component is nylon 6 or a combination of nylon 6 and nylon 610. Similarly, it is preferable that the melting points of said 2 components are as close as possible since, at the time of melt spinning, it becomes possible to select a spinning temperature at which respective polymers hardly decompose and the obtained fiber is excellent in abrasion resistance. Accordingly, it is preferable that the melting point difference of the thermoplastic polyamide resins used for the core component and the sheath component, respectively, is 30˚C or less, to be 20˚C or less is more preferable and to be 10˚C or less is still more preferable.

[0115] Furthermore, it is preferable that the island component in the polymer alloy of the core component is in a fine and long streak-like configuration along the fiber axis. It is preferable since, by being the Island component streak-like, a composite interface area where one island component adheres to the sea component becomes large and fibrillation can be prevented. And, there is a merit that strength increases by forming the island component fine and long streaks. It is most preferable that, in case where the Island component is streak-like, it is perfectly parallel to fiber axis direction, but in the present invention, those inclined 5˚ or less from fiber axis are defined as fine and long streak-like configuration along fiber axis.

[0116] In the sheath/core type composite fiber of the present invention, since as the content of the component A (wt% of the component A with respect to total fiber weight) increases, it becomes more environmental load reducing material, it is preferable that the content of the component A is high. It is preferable that the content of the component A is 20 wt% or more, to be 30 wt% or more is more preferable and to be 40 wt% or more is still more preferable. On the other hand, in view of excellence in peeling resistance, abrasion resistance or crimp fastness, it is preferable that the content of component A is 80 wt% or less, to be 75 wt% or less is more preferable and to be 70 wt% or less is still more preferable. The content of component A (wt% of component A with respect to total fiber weight) can be calculated by the method described in Examples. That is, from difference between the fiber weight after dissolving off the component A only from the crimped yarn constituted from a sheath/core type composite fiber and the weight of the original crimped yarn is taken as the weight of component A, it is calculated by dividing said weight difference by the weight of the original crimped yarn.

[0117] Furthermore, in case of the sheath/core type composite fiber, it is necessary that the sheath component comprises the thermoplastic polyamide resin (B) only. By having the thermoplastic polyamide (B) as the sheath component, exposed area ratio of aliphatic polyester resin (A) with respect to fiber surface area becomes substantially zero, and abrasion resistance greatly increases, and it is preferable. Where, since, by containing the component B more in the sheath component, it becomes to a material more excellent in abrasion resistance and heat resistance, it is preferable that the component B constitutes 90 wt% or more of the sheath component, to be 93 wt% or more is more preferable, to be 95 wt% or more is still more preferable.

[0118] The thermoplastic polyamide resin (B) may be, as above-mentioned, a copolymer, but as more crystal phase is contained in the sheath/core type composite fiber of the present invention, an orientation relaxation of amorphous phase can be prevented more in later stage processing step or with lapse of time in product use, and it is preferable since a residual stress is hardly generated in the sheath/core interface and excellent in peeling resistance. Accordingly, in the thermoplastic polyamide resin (B), since it is preferable that the crystallinity is as high as possible, it is preferable that a crystal melting peak calorie $\triangle$ H is 10 J/g or more, to be 20 J/g or more is more preferable and to be 30 J/g or more is still more preferable.

[0119] Since the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) of the present invention hardly react, in order to enhance the adhesion force of the sheath/core interface formed by the above-mentioned 2 polymers, it is also preferable to add the above-mentioned compatibilizer (component C). In particular, by adding a compound having two or more active hydrogen reactive groups in a molecule to the component A and/or component B and by melt blending and carrying out spinning, said compound reacts with any component of the component A and the component B to form a cross-linked structure, and it is more preferable since peeling off phenomena of the sheath/core interface can be prevented.

[0120] Furthermore, as the melting points of the component B and the component C becomes closer, at the time of melt spinning, it becomes possible to select a spinning temperature at which respective polymers more hardly thermally decompose, and it is preferable since the obtained fiber is excellent in abrasion resistance. Accordingly, it is preferable that the difference of melting point between the component B and the component C is 30˚C or less, to be 20˚C or less is more preferable and to be 10˚C or less is still more preferable.

[0121] The adding amount of the component C can be appropriately determined according to an equivalency per unit weight of reactive group of a compound to be used, dispersibility and reactivity at the time of melting or content of the component A, but in order to prevent peeling of the sheath/core interface, it is preferable to be 0.005 wt% or more with respect to the total amount of component A, component B and component C. More preferably, it is 0.02 wt% or more and still more preferably, 0.1 wt% or more. When the adding amount of the component C is too small, an amount of reaction at the sheath/core interface is small, and the effect of enhancing the adhesion force at the sheath/core interface may be limited. On the other hand, in order to exhibit the performance of component C without impairing characteristics and spinnability of the component A and the component B to be the base materials of fiber, it is preferable that the adding amount of component C is 5 wt% or less and to be 3 wt% or less is more preferable. Still more preferably, it is 1 wt% or less.

[0122] Furthermore, for the purpose of accelerating reaction of the compound having the above-mentioned reactive group, it is preferable to add a metal salt of carboxylic acid, especially, a catalyst of which metal is alkali metal or alkali earth metal, since it can enhance reaction efficiency. Among them, it is preferable to use a lactic acid-based catalyst such as sodium lactate, calcium lactate or magnesium lactate. Other than that, for the purpose of preventing a lowering of heat resistance due to addition of the catalyst, a catalyst of a relatively high molecular weight such as stearic acid metal salt can be used singly or in combination. Where, it is preferable that an adding amount of said catalyst is, for controlling dispersibility and reactivity, 5 to 2000 ppm with respect to the synthetic fiber. More preferably, it is 10 to 1000 ppm, and still more preferably, 20 to 500 ppm.

[0123] In the sheath/core type composite fiber of the present invention, it is preferable that the sheath/core ratio (weight ratio) is 10/90 to 65/35. However, as the ratio of core component becomes high, the area of sheath/core interface increases and when the ratio of core component is high, the component A, which is low in crystallinity and easy to change with lapse of time, is contained in much amount, a residual stress at the sheath/core interface is likely to arise, and peeling resistance may deteriorate. Accordingly, in order to enhance peeling resistance, it is preferable that an area of the sheath/core interface per unit volume of the core component is large, from this view point, it is preferable that the ratio of core component is low. Furthermore, by increasing the ratio of sheath component, there is a merit that crimp fastness is enhanced. Accordingly, it is preferable that the sheath/core ratio is in the above-mentioned range, to be 10/90 to 50/50 is more preferable and to be 10/90 to 45/55 is still more preferable.

[0124] The sheath/core ratio of the present invention can be calculated by, taking sum of weight of the core component and the sheath component to be supplied to melt spinning as 100, calculating respective ratios of the core component and the sheath component with respect to the sum. However, in case where the weight ratio of the component A and the component B at the time of production is unclear, it can also be calculated by the following equation, for convenience. That is, the core component of sheath/core type composite fiber of the present invention may contain the component A and other small amount components, and the sheath component may contain the component B and other small amount components, but even in such cases, it can be considered that the core component substantially comprises the component A only, and the sheath component comprises the component B only, and the sheath/core ratio as weight ratio of the core component and the sheath component can be calculated. At first, sheath/core type composite fiber cross-section slice is observed by a transmission electron microscope (TEM) at a magnification of 4,000 times, and total area (Aa) of the component A and total area (Ab) of the component B constituting the core component are determined. And it was calculated by the following equation by putting as the specific gravity of component A 1.26, and as the specific gravity of component B 1.14.

$$\text{Sheath/core ratio} = \text{weight ratio core component/weight ratio of sheath component}$$

$$\text{Weight ratio of core component} = [\,(Aa \times 1.26)/(Aa \times 1.26 + Ab \times 1.14)] \times 100$$

$$\text{Weight ratio of sheath component} = [(Ab \times 1.14)/(Aa \times 1.26+Ab \times 1.14)] \times 100.$$

[0125] As to cross-sectional shape of the sheath/core type composite fiber of the present invention, various cross-sectional shapes can be employed such as circular type, Y type, multi-lobal type, polygonal type, flat type or hollow type. And, in case of multifilament, respective single fiber cross-sectional shapes may be the same or different. One embodiment of single fiber cross-sectional shape of the sheath/core type composite fiber of the present invention is shown in Fig. 10. In Fig. 10, respective 42s denote component A and 43s denote component B. In Fig. 10, respective embodiments of circular type, Y type and multi-global type are illustrated. As to the sheath/core type composite fiber of the present invention, it is preferable that the cross-sectional shape is, in concrete, Y type, multi-lobal type or flat type, and Y type or flat type is further preferable.

[0126] In the sheath/core type composite fiber of the present invention, it is preferable that the non-circularity (D3/D4) of single fiber is 1.3 to 4. As the non-circularity of single fiber increases, fiber surface area becomes large, and fiber is rapidly heated in crimp processing step and inside the cross-section of fiber is heated uniformly and, an undue stress is hardly added to molecular chain of the core component and the sheath component neighboring the sheath/core interface, and a fiber excellent in peeling resistance can be obtained, so it is preferable. Accordingly, it is preferable that the non-circularity of single fiber is 1.3 or more, to be 1.5 or more is more preferable, to be 1.8 or more is still more preferable and to be 2.0 or more is especially preferable. On the other hand, however, when the non-circularity is excessively high, cross-sectional shape may have an acute angle portion, and abrasion resistance may deteriorate by an external force being concentrated to said acute angle portion. And, there also is a problem in production process that the core component becomes hard to be coated with the sheath component uniformly in longitudinal direction. In order to solve these problems, it is preferable that the non-circularity is 4 or less, to be 3.8 or less is more preferable, to be 3.5 or less is still more preferable and to be 3.3 or less is especially preferable.

[0127] Regarding the non-circularity of single fiber, a single fiber cross-section is observed by using TEM in the same method as Examples, and it is defined as the ratio of diameter D3 of the circumscribed circle and diameter D4 of the inscribed circle (D3/D4) of the cross-section. When a non-circular cross-section is considered to have an approximately line symmetry or point symmetry, the inscribed circle is a circle inscribing to outlined curve of the single fiber cross-section, and the circumscribed circle is a circle circumscribing to outlined curve of the single fiber cross-section. In case where a non-circular cross-section has not a line symmetry or point symmetry at all, a circle inscribing at least two points with outlined curve of the single fiber and being present inside of the fiber only and having maximum radius which does not intersect with the outlined curve of the single fiber is defined as the inscribed circle. As to the circumscribed circle, a circle circumscribing at least 2 points with outlined curve of the single fiber, being present outside of the single fiber cross-section only, and having minimum radius in the range that circumference of the circumscribed circle and outline of the single fiber does not intersect is defined as the circumscribed circle. At calculating the non-circularity, non-circularity was calculated for 10 cross-sections cut out from different portions and averaged to determine.

[0128] In the sheath/core type composite fiber of the present invention, it is preferable that the non-circularity of core component (D1/D2) is 1.3 to 4. As the non-circularity of core component increases, the sheath/core interface area per unit volume of the core component becomes large, and it is preferable since a fiber excellent in peeling resistance is obtained. Accordingly, it is preferable that the non-circularity of core component is 1.3 or more, to be 1.5 or more is more preferable, to be 1.8 or more is still more preferable and to be 2 or more is especially preferable. On the other hand, when the non-circularity of core component is excessively large, it becomes difficult to uniformly coat with the sheath component in cross-section or in longitudinal direction of the single fiber, and peeling resistance may deteriorate. Accordingly, it is preferable that the non-circularity of core component is 4 or less, to be 3.8 or less is more preferable, to be 3.5 or less is still more preferable and to be 3.3 or less is especially preferable. Where, the non-circularity of core component of the present invention is determined in the same way as above-mentioned non-circularity of single fiber in which the sheath/core composite interface is taken as the cross-sectional shape.

[0129] Cross-sectional shapes of preferable crimped yarns in the present invention are exemplified in Fig. 10. Cross-sectional shape of core component of the single fiber constituting the crimped yarn is optional, but it is preferable that the cross-sectional shape of core component is similar to the cross-sectional shape of single fiber in view of enhancement of adhesion force of the sheath/core interface, and in view of excellence of peeling resistance even when the core component ratio of the crimped yarn, and further, even the content of the component A is high. Here, the similar shape does not mean a mathematically precise similarity, for example, even a case where a cross-sectional shape of single fiber is Y type and a cross-sectional shape of core component is Y type and both non-circularities are different, they should be understood as similar shapes. As a matter of course, the sheath/core type composite fiber of the present invention is not limited to the cross-sectional shapes of Fig. 10. Where, number of core component of sheath/core type composite fiber of the present invention is optional and a single fiber may have one core component inside or may have a plural number of core components. The center of gravity of outlined shape of single fiber cross-section and the center of gravity of outlined shape of core component may be same or different, but since as the fiber surface is covered more uniformly with the sheath component, abrasion resistance becomes more excellent, it is preferable that the center of gravity of the outlined shape of single fiber and the center of gravity of the outlined shape of core component is same. And, outlined shapes of core component of respective single fiber cross-sections in a multifilament, may be same or different.

[0130] Furthermore, when the sheath/core type composite fiber of the present invention is a sheath/core type composite fiber of so-called sea/island type composite fiber in which a plural core components is present in a single fiber cross-section, it is preferable since sheath/core interface area per unit volume of core component increases and peeling resistance is improved. Accordingly, it is preferable that the core component is 3 islands or more, to be 9 islands or more is more preferable and 24 islands or more is still more preferable.

[0131] In the sheath/core type composite fiber of the present invention, in view of excellence of abrasion resistance, it is preferable that the fiber surface is substantially constituted by the sheath component entirely in its longitudinal direction of the fiber, in particular, it is preferable that the component A is not exposed on fiber surface. In particular, in the sheath/core type composite fiber of the present invention is excellent in peeling resistance, and in addition, by being the fiber surface substantially covered with the sheath component, abrasion resistance is greatly improved. And, in order to enhance abrasion resistance and peeling resistance, it is preferable that the sheath component is thick in entire fiber cross-section, and it is preferable that the minimum value of thickness of sheath component is 0.4 μm or more. To be 0.7 μm or more is more preferable and to be 1 μm or more is still more preferable. And, in case where a polymer alloy as the core component in spinning step, there is a merit in production that Barus effect can be prevented to thereby raise processability. On the other hand, when the thickness of sheath is too thick, ratio of the aliphatic polyester resin (A) with respect to the total fiber weight becomes low, and it may be an outside of the purpose of providing a material for reducing environmental load. Accordingly, it is preferable that thickness of the sheath component is 10 μm or less, to be 7 μm or less is more preferable and to be 5 μm or less is still more preferable. Where, in order to thicken the minimum value of thickness of the sheath component, it is preferable to control sheath/core ratio, single fiber thickness and non-circularity of single fiber into the above-mentioned range, and it is preferable to control melt viscosity ratio of component A and component B and spinning temperature into the range mentioned later.

[0132] In the sheath/core type composite fiber of the present invention, as the crystallinity increases, that is, as more crystal phases are contained, the orientation relaxation movement of amorphous phase of the core component and the sheath component can be prevented more easily, and it is preferable since a crimped yarn excellent in peeling resistance can be obtained. Furthermore, as the crystallinity increases, abrasion resistance, heat resistance, dyeing or crimp fastness, etc., become more excellent, and it is preferable. The crystallinity in the present invention can be evaluated by a total heat capacity of melting peak of a differential calorimetric curve measured at heating rate 16 °C/min, and it is preferable that said total heat capacity of melting peak is 50 J/g or more, more preferably, it is 60 J/g or more and still more preferably, 70 J/g or more. In order to exhibit such melting peak, it is necessary to use high crystallinity polymers as the component A and the component B. And, as mentioned later, in order to accelerate crystallization of respective components, it is preferable to control production conditions such as stretch ratio, heat treatment temperature after stretching, and crimp nozzle temperature at crimp processing step.

[0133] In the sheath/core type composite fiber of the present invention, since as the bulkiness of the crimped yarn becomes more excellent, product quality becomes more excellent, it is preferable that crimp elongation percentage after boiling water treatment which is an index of bulkiness of crimped yarn is high. Accordingly, it is preferable that the crimp elongation percentage after boiling water treatment is 5% or more, to be 10% or more is more preferable and to be 15% or more is especially preferable. It is especially not limited as to the upper limit of the crimp elongation percentage after boiling water treatment, but when it is too high, single fiber apt to be folded and peeling resistance may deteriorate. At this point, it is preferable that the elongation percentage after boiling water treatment is 35% or less, to be 33% or less is more preferable and to be 30% or less is especially preferable.

[0134] In the sheath/core type composite fiber of the present invention, in dyeing step or later stage processing step, or in a long term use after being made into a fiber structure, it is preferable that crimp is hardly lost (crimp fastness is high) and voluminous feeling of product can be maintained for a long term. Accordingly, it is preferable that the crimp elongation percentage after boiling water treatment under a load of 2 mg/dtex which is an index of crimp fastness (hereafter, crimp elongation percentage after boiling water treatment under a load of 2 mg/dtex may be simply referred to as "elongation percentage under load") is 2% or more. More preferably, it is 3% or more, still more preferably, 5% or more and especially preferably, 7% or more. There is especially no upper limit, but for example, it is preferable to be 30% or less in order to prevent adverse effects such as dyeing unevenness (dark and light difference) at package terminal surface portion at cheese dyeing processing due to an excessive tightening of winding package. The elongation percentage under load can be measured by the method indicated in Examples.

[0135] Furthermore, it is preferable that the elongation of the sheath/core type composite fiber of the present invention is 15 to 70%, since processability for making into fiber product is good. A crimped yarn having such elongation can be produced by adjusting stretch ratio into a preferable range in the production method mentioned later. More preferably, it is 20 to 60%, still more preferably, 30 to 50%.

[0136] It is preferable that a yarn unevenness of the sheath/core type composite fiber of the present invention is small. By reducing yarn unevenness, it becomes possible to prevent a local concentration of an external force when exposed to an abrasion, and it is preferable since peeling resistance can be enhanced. Accordingly, it is preferable that yarn unevenness (uster U%) (Normal) which is an index of yarn unevenness is 2.5% or less, 2.0% or less is more preferable, 1.5 or less is still more preferable and 1.0 or less is especially preferable. Compared to conventional simple polymer alloy fiber of an aliphatic polyester and a polyamide, in the sheath/core type composite fiber of the present invention, since it has a sheath component on fiber surface, the Barus is prevented and thinnig behavior is stabilized, yarn unevenness is small and also has a merit to be excellent in abrasion resistance. And, in order to reduce yarn unevenness, selecting component A and component B of which melt viscosity ratio is in the preferable range in the present invention, and by stabilizing thinnig behavior of spinline or by carrying out melt spinning, stretching and crimping continuously in 1 step, i.e., subjecting to a direct stretching, crimping without allowing a change with lapse of time of the unstretched yarn, etc., the yarn unevenness can be reduced.

[0137] A production method of the crimped yarn constituted by the sheath/core type composite fiber which is one of a preferable embodiment of the present invention is not especially limited, but for example the following method can be employed by using the direct spinning·stretching·crimp processing machine shown in Fig. 9.

[0138] By raising melt viscosity (ηb) of the thermoplastic polyamide resin (B) to be used, it becomes possible to raise fiber temperature close to the melting point of the thermoplastic polyamide resin (B) (Tmb) at heat treatment and crimp processing step after stretching, without causing a fusion bond between single fibers. By this, in the molecular chain of amorphous phase of the thermoplastic polyamide resin (B), a polarization is progressed to a molecular chain which is crystallized and to a molecular chain which is orientation relaxed to random arrangement, and it is preferable since peeling resistance becomes excellent. On the other hand, in order to prevent sheath/core composite abnormality in spinning step and in view of covering with the sheath component uniformly in fiber cross-section and in fiber longitudinal direction, it is preferable to suppress the melt viscosity of the thermoplastic polyamide resin (B) (ηb) to an appropriate value. For the above, it is preferable that the melt viscosity of the thermoplastic polyamide resin (B) (ηb) is 10 to 300 Pa·sec^{-1}, to be 20 to 250 Pa·sec^{-1} is more preferable and to be 30 to 200 Pa·sec^{-1} is still more preferable.

[0139] In case of a simple sheath/core type composite fiber of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B), by making uniform molecular orientation of the core component and the sheath component in melt spinning step, the respective components are uniformly stretched in later stretching step, and at the time of crimp processing, a difference of heat shrinking characteristics between the core component and the sheath component hardly arises, and an undue stress is hardly added to molecular chain neighboring the sheath/core interface and peeling resistance is improved. Since molecular orientations of the core component and the sheath component are controlled by stresses added to the respective components in elongational deformation, it is preferable that the melt viscosity of the aliphatic polyester resin (A) (ηa) and the melt viscosity of the thermoplastic polyamide resin (B) (ηb) are close, and it is preferable that the melt viscosity ratio (ηb/ηa) which is the ratio of melt viscosity of the component A and the component B is 0.2 to 2. More preferably, it is 0.4 to 1.7, still more preferably, 0.6 to 1.4.

[0140] Here, melt viscosities ηa and ηb in the present invention are, melt viscosity (Pa·sec) of the polymer used for the crimped yarn at temperature 240°C and shear rate 1216 sec^{-1}, and they can be measured by the method described in Examples. And, in case where the component A and the component B used for the crimped yarn cannot be obtained, they can be measured, for convenience, by measuring relative viscosity (ηra) of the component A in the crimped yarn, and measuring relative viscosity (ηrb) of the component B in the crimped yarn, ηa and ηb can be determined for convenience. As indicated by plots of Fig. 11, ηra and ηa, ηrb and ηb are in the relation of the following equations.

Relation between solution viscosity and melt viscosity of component A

$$\log(\eta a) = 4.3049 \times \log(\eta ra)$$

Relation between solution viscosity and melt viscosity of component B

$$\log(\eta b) = 5.2705 \times \log(\eta rb).$$

[0141] Here, the relative viscosity can be measured by the method shown in Examples. That is, by using an Ostwald viscometer, and for the component A o-chlorophenol solution, and for the component B sulfuric acid solution are used, and they are expressed by ratios of drop time of solutions prepared by dissolving at specified concentration, temperature and time respectively and solvents in which respective components are not dissolved, and it is an index indicating solution viscosity.

[0142] Furthermore, in case where a polymer alloy prepared by blending the aliphatic polyester (A) and the thermoplastic polyamide resin (B) is used as the core component, while the respective polymers being separately metered, they are mixed and kneaded at melting point of the component B (Tmb) to melting point of the component B (Tmb)+40°C by using a twin screw extruding/kneading machine or single screw extruding/kneading machine and once a polymer alloy resin is prepared. At this time, it is preferable to use a twin screw extruding/kneading machine in view of easiness of controlling diameter of island component. And, as a method for controlling polymer alloy structure and diameter of island component, it is possible to control by adjusting blend ratio of the above-mentioned 2 components (component A and component B) and melt viscosity ratio in the above-mentioned range, and by kneading in the range of shear rate 200 to 20,000 sec^{-1} and residence time 0.5 to 30 min. In particular, as a method for making the diameter of island component smaller, it is better that the kneading temperature is low, the shear rate is high and the residence time is short in the above-mentioned range. As the polymer alloy resin which constitutes the core component of fiber containing the component A and the component B, those prepared beforehand by an extruding/kneading machine different from a spinning machine may also be used after drying, or may be prepared continuously at the time of spinning by an extruding/kneading machine equipped to a spinning machine. And, in case where it is prepared beforehand, all polymer alloy to be used as the core component may be a chip prepared beforehand, or a master chip in which the component A or the component B is mixed/kneaded in a high concentration is prepared and said master chip and the component A and/or component B may be chip blended and used. Since it is easier to uniformly disperse the component A and the component B, and it is easier to prevent a thermal degradation of the component A, it is also preferably employed to continuously prepare a polymer alloy of the component A and the component B by a single screw kneading machine and/or twin screw extruding/kneading machine equipped to a spinning machine and supply it to a spinning pack.

[0143] By using the direct spinning·stretching·crimp processing machine shown in Fig. 9, at joining and discharging in a spinning hole of spinneret, the aliphatic polyester resin (A) or a polymer alloy of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) as core component and the thermoplastic polyamide resin (B) as sheath component, in a sheath/core ratio (weight ratio) 65/35 to 10/90, by making a combination of which melt viscosity ratio ($\eta b/\eta a$) is in the range of 0.2 to 2 and setting spinning temperature to Tmb to Tmb+30°C provided that the melting point of the thermoplastic polyamide resin (B) is Tmb, a spun yarn is formed at linear discharge velocity 1 to 20 m/min in the spinning hole of spinneret. Said spun yarn is cooled from vertically beneath 0.01 to 0.15 m from spinneret surface as starting point of cooling, by a gas of wind speed 0.3 to 1 m/sec and wind temperature 15 to 25°C from the right angle to perpendicular direction on spinneret surface to obtain a multifilament. Said multifilament is stretched in 2 stages in total stretching ratio 2 to 5 and then, at being subjected to a crimp processing, heat set by setting first stage stretching roll to 50 to 90°C, the second stage stretching roll to 90 to 150°C and final roll after the stretching to 160 to 220°C, and at being supplied to a air jet stuffer crimp processing machine, subjected to a crimp processing by setting nozzle temperature of said machine to a temperature higher than the final roll temperature by 5 to 100°C to form a crimped yarn, taken up by contacting with a cooling drum, and wound at a speed lower than the final roll after stretching by 10 to 30%.

[0144] That is, aliphatic polyester resin (component A) such as polylactic acid or polymer alloy (blend of component A and component B) and the thermoplastic polyamide resin such as nylon 6 (component B) are respectively dried to prepare beforehand a component A of which water content is 10 to 100 ppm and a component B of which water content is 100 to 500 ppm. And after the component A and the component B are molten by separate twin screw extruding/kneading machines or single screw extruding/kneading machines, metered by separate gear pumps into a sheath/core ratio (weight ratio) 65/35 to 10/90 and then, by assembling spinnerets as shown in Fig. 12 as a spinneret constructed inside the spinning pack, joined the component A and the component B and discharged to obtain a spun yarn. Where, in case where a polymer alloy resin comprising the above-mentioned the component A and the component B as a core component, in order to prevent re-aggregation of the island component (component A) in the polymer alloy, as filtering layer for the core component, a device such as assembling a high mesh filtering layer (#100 to #200) or porous metal, nonwoven fabric filter of small filtering size (filtering size 5 to 30 μm), blend mixer in pack (static mixer or high mixer) is necessary. And, the aliphatic polyester and the polyamide in the polymer alloy is an incompatible combination, and since the molten polymer exhibits a strong elastic behavior, a swelling called the Barus occurs and thinnig/deformation may become unstable. The polyamide (component B) which is the sheath component of the present invention has an effect of preventing the Barus, and it is effective to control a melt viscosity of the component B and a thickness of the sheath component into the above-mentioned range. In addition, as methods for preventing the Barus, raising spinning temperature to decrease tensile viscosity, decreasing linear discharge velocity (polymer flow rate at final tapered portion of spinning hole) by enlarging spinning hole diameter of spinneret, Increasing length of L/D which is ratio of spinning hole length and hole diameter, cooling spun yarn rapidly, or the like are effective. Fig. 12 is a longitudinal-section schematic view showing one embodiment of spinneret used in a method of the present invention, and the spinneret is constituted by an assembly of spinneret 2 (46) which is a spinneret just before discharge and spinneret 1 (45) which positioned just before spinneret 2 and has separate flow channels for core component and sheath component.

[0145] When the component A and the component B are melted by a kneading machine, it is preferable that the component A is melted at a temperature of melting point of the component A (Tma) to melting point of the component A (Tma) + 40°C, for example, in case where the component A is polylactic acid of which melting point is 170°C, it is preferable to melt the component A in the range of 170 to 210°C. By melting the component A in the above-mentioned range, hydrolysis of the component A of which heat resistance is low can be prevented, viscosity unevenness of the component A along longitudinal direction becomes hard to occur, spinnability is improved and uniformity of the obtained fiber becomes excellent, and therefore it is preferable. And, it is preferable to melt the component B at a temperature of melting point of the component B (Tmb) to melting point of the component B (Tmb) + 40°C, for example, in case where the component B is nylon 6 of which melting point is 225°C, it is preferable to melt it in the range of 225 to 265°C. By melting the component B in the above-mentioned range, gelation or coloring of the component B can be prevented, and therefore it is preferable.

[0146] Spinning temperature can be determined by the melting point of the component B (polyamide), and best range is melting point of the component B Tmb to Tmb+30°C (for example, in case where melting point of the component B Tmb is 225°C, it is 225 to 255°C). However, heat resistance of the component A is not so high, if it exceeds 250°C when stored in molten state, its physical properties may deteriorate rapidly. Accordingly, as above-mentioned, it is preferable that a thermoplastic polyamide resin (B) of which melting point is 250°C or less is selected as sheath component and setting a spinning temperature to 260°C or less.

[0147] It is preferable that the linear discharge velocity at spinning hole of spinneret is 1 to 20 m/min. By making the linear discharge velocity 20 m/min or less, it becomes possible to uniformly add shear stress in cross-section of single fiber to make a uniform orientation of molecular chain of the core component and the sheath component, and therefore, an undue stress is hardly added to the sheath/core interface by heat shrinkage at a later crimp processing, and a crimped yarn excellent in peeling resistance can be obtained, and therefore, it is preferable. And, by making linear discharge velocity 1 m/min or more, it is possible to prevent a rapid thinnig of spinline, and spinnability, or uniformity of crimped yarn becomes better, and therefore, it is preferable. It is more preferable to control linear discharge velocity to 2 to 15 m/min and to control to 3 to 12 m/sec is still more preferable. Where, the linear discharge velocity in the present invention, for the spinneret just before polymer discharge 2 (46) in Fig. 12, is calculated by the following equation based on spinning hole area, total output and number of holes. When hole shape is different between holes of spinneret, average of discharge area of all holes is calculated and by employing an discharge area of a hole closest to the average area, the linear discharge velocity is calculated by the following equation.

[0148] Fig. 7 is a spinneret longitudinal-sectional view explaining depth of spinning hole, hole diameter, slit length and slit width and a schematic view of spinning hole, and slit length and slit width of Y hole, multi-lobal hole and flat hole are shown in (a) right drawing of non-circular hole and schematic view of spinning hole.

$$\text{linear discharge velocity (m/min)} = Q/H/\rho/A/100$$

Q : Total output (g/min)
H : Number of holes
ρ : Melt density (g/min)

$$\rho = 1.08 \times \text{content of the component A per total fiber weight (wt\%)}/100 + 1.00 \times (1 - \text{content of the component A per total fiber weight (wt\%)}/100)$$

A : Discharge area (cm^2).

[0149] For example, in case where spinneret hole shape is Y hole (refer to Fig. 7 (a) non-circular hole), it can be calculated by the equation, A (cm^2) = 3 × slit width (cm) × slit length (cm)+ (center triangle surrounded by slits), but in case where slit width is ignorably small compared to slit length, by ignoring the area of (center triangle surrounded by slits), the discharge area can be calculated by the equation, A (cm^2) = 3 × slit width (cm) × slit length (cm).

[0150] Furthermore, it is preferable to make L/D, which is ratio of hole diameter (D) and depth of spinning hole (L) of spinning hole of spinneret, 0.6 to 10. By making L/D 10 or less, core component is easily disposed to the center of fiber, and a crimped yarn excellent in peeling resistance can be obtained, and therefore, it is preferable. And, by making L/D 0.6 or more, the core component and sheath component are uniformly distributed to respective holes and sheath/core ratios become uniform between single fibers, i.e., all fibers constituting multifilament are uniformly excellent in peeling resistance, and therefore, it is preferable. It is more preferable that L/D is 0.7 to 8, to be 0.8 to 6 is still more preferable and to be 0.9 to 4 is especially preferable. The depth of spinning hole in the present invention means the depth of spinning hole in the spinneret longitudinal-sectional view shown in Fig. 7, and it is the length of which hole shape is maintained in the same shape as the spinning hole, and it is a portion which controls flow rate when polymer is extruded. And, in case where a spinning hole is circular hole, the hole diameter means the diameter of circular hole in the spinning hole schematic view shown in Fig. 7. Where, in case where a spinning hole is not a circular hole, discharge area A (cm^2) is calculated by the method described in the explanation of the linear discharge velocity, and the diameter of hypothetical circle equivalent to said discharge area is taken as the hole diameter.

[0151] When the component A and the component B are joined and extruded by a spinneret, by controlling sheath/core ratio, melt viscosity ratio of the component A and the component B, melt viscosity of the component B and linear discharge velocity at spinning hole of spinneret into the above-mentioned range, at spinning and stretching steps, molecular orientation of the core component and the sheath component becomes easy to be oriented, in addition, it is possible to uniformly cover with the sheath component along fiber longitudinal direction, and therefore, it is preferable.

[0152] Furthermore, it is preferable to make vertically beneath 0.01 to 0.15 m from spinneret surface as starting point of cooling. By making the starting point of cooling 0.15 m or less, spinline is rapidly cooled, and the core component and the sheath component are easy to be molecularly oriented, and therefore, it is preferable. And, by making the starting point of cooling 0.01 m or more, disadvantages such as discharge abnormality by containing an unmelted polymer in spun yarn by spinneret surface being cooled hardly occurs, and processability in production process is improved, and therefore, it is preferable. Accordingly, it is more preferable that the starting point of cooling is 0.02 to 0.13 m and to be 0.03 to 0.12 m is still more preferable. And, a method of positively heating spinneret surface is also preferable, by arranging a ring heater around the spinneret surface so that the temperature spinneret surface does not lower.

[0153] It is preferable that the cooling air is blown off to spun yarn from a right angle to perpendicular direction on spinneret surface, at wind speed 0.3 to 1 m/sec and wind temperature 15 to 25°C so that temperature of spinneret surface does not lower.

[0154] Furthermore, when the fiber of the present invention is left in a state of an unstretched yarn or a stretched yarn, orientation relaxation is likely to occur, and when there is a time difference between unstretched yarn packages before stretching, or there is a time difference between stretched yarn packages before crimp processing, in particular, the molecular orientation of amorphous phase of the core component, which is easy to be orientation relaxed, relaxes earlier, and difference of heat shrinking characteristics of the core component and the sheath component becomes large, and as a result, a residual stress is easy to be generated at the sheath/core interface of crimped yarn obtained by crimp processing. Accordingly, it is preferable to employ a direct spinning·stretching· crimp processing in which spinning, stretching, crimping are carried out continuously in one step. That is, it is preferable, after spun yarn is taken up by a take-up roll, to carry out continuously, without winding, stretching and heat treatment and then direct crimp processing.

[0155] An unstretched yarn is obtained by taking up a spun yarn, and a stretched yarn obtained by stretching said unstretched yarn is subjected to a crimping, but in order to enhance peeling resistance of the sheath/core type composite fiber of the present invention, it is important, at the crimping, without generating an undue stress at the sheath/core interface, to form a fiber structure polarized to a crystal phase and a random amorphous phase. For that purpose, since it is preferable to highly and uniformly orient the both component in stretched yarn before subjecting to crimping, it is preferable to increase molecular orientation of fiber at stretching step by subjecting stretching to an unstretched yarn obtained at a low spinning speed. This is because, when molecular chains of the core component and the sheath component are oriented in a molten state by increasing spinning speed, a difference is easy to arise in degree of orientation between molecules of the respective components, i.e., it is difficult to make molecular orientations of both component uniform. In molten state, depending on melt viscosity ratio of the component A and the component B, stresses added to respective components are determined, and as spinning speed raises, that is, as spinning tension of process increases, the stress difference added to respective components becomes large. Accordingly, it is preferable to lower spinning speed to make degree of orientations of core component and sheath component of the unstretched yarn uniform. Best spinning speed differs according to melt viscosity ratio of component A and component B and sheath/core ratio, but making spinning speed 3000 m/min or less, spinning tension can be kept low, and it is possible to make degree of molecular orientation of core component and sheath component in unstretched yarn uniform, and therefore, it is preferable. On the other hand, by making spinning speed 300 m/min or more, spinning tension becomes moderately high, fiber oscillation of spinline is prevented to stabilize thinnig behavior, and therefore, it is preferable. It is more preferable that the spinning speed is 350 to 2500 m/min, to be 400 to 2000 m/min is still more preferable and to be 450 to 1500 m/min is especially preferable.

[0156] Unstretched yarn of which molecular orientations of core component and sheath component are low is molecularly oriented in a later stretching step, but at this time, by carrying out stretching stepwise in 2 stages or more, in addition, by raising stretching temperature stepwise, it becomes possible to uniformly increase molecular orientation of the core component and the sheath component, and therefore, it is preferable.

[0157] And it is very important to heat set at 160 to 220˚C by final roll after stretching. By raising heat set temperature to the upper limit to enhance movability of molecular chain, it is possible to polarize molecular chains of respective amorphous phases of the aliphatic polyester (A) and the thermoplastic polyamide resin (B) to a molecular chain to crystallize and to a molecular chain to become random arrangement by orientation relaxation, and therefore, it is preferable. Furthermore, since the above-mentioned temperature range is around the melting point Tma of the aliphatic polyester, a the core component partially melts on the final roll, the stress at the sheath/core interface stored until the heat set is released, and the obtained peeling resistance of crimped yarn is greatly enhanced. More preferably, it is 170˚C or more and still more preferably, 180˚C or more. On the other hand, by making the final roll temperature 220˚C or less, a disadvantage that the sheath component melts, single fiber cross-section deforms and the core component is exposed to surface can be avoided, therefore, it is preferable. More preferably, it is 210˚C or less and still more preferably, 200˚C or less. And, after heat set by the final roll in the above-mentioned range, it is immediately supplied inside the nozzle, that is, by a residual heat effect, it is possible to raise the fiber temperature in the crimp nozzle around the melting point of the thermoplastic polyamide resin (B) (Tmb) in a short time, and at the same time, it is possible to be subjected to a heat shrink under no tension state, and as a result, a crimped yarn of which both of the core component and the sheath component have 2 phase structure of a crystal phase and a random amorphous phase can be obtained, and by this way, for the first time, generation of a stress at the sheath/core interface or a residual stress can be prevented, and peeling resistance can be greatly enhanced. In order to raise fiber temperature in the crimp nozzle, a method of shortening the distance from the final roll to the crimp nozzle, a method of keeping fiber temperature by a heat insulation box or a method of heating by a noncontact heater are preferably employed.

[0158] Where, the final roll temperature is important for controlling "crimp elongation percentage after boiling water treatment " which is an index of bulkiness of the crimped yarn comprising the sheath/core type composite fiber of the present invention, or "elongation percentage under load" which is an index of crimp fastness, and as the final roll temperature is raised high, the crimp elongation percentage after boiling water treatment and the elongation percentage under load can be raised high. In the present invention, while aiming to obtain a crimped yarn excellent in peeling resistance, to make a fiber having a strength of necessary range, it is preferable to control total stretching ratio, stretch roll temperature, final roll temperature after stretching and temperature of crimp nozzle into the preferable range, and at crimp processing, to sufficiently release the molecular orientation of amorphous phase. And, in order to control the boiling water shrinkage of the sheath/core type composite fiber of the present invention into the necessary range, it is preferable to control final roll temperature after stretching and temperature of crimp nozzle into the preferable range and then, after taking up by contacting around cooling drum, to wind in a speed lower than that of the final roll after stretching.

[0159] For example, in case where the stretching is carried out in 2 steps, it is preferable to heat set by setting first stage stretching roll to 50 to 90˚C, the second stage stretching roll to 90 to 150˚C and final roll after stretching to 160 to 220˚C. More preferably, first stage stretch roll is set to 60 to 80˚C, second stage stretch roll to 100 to 140˚C and final roll after stretching to 170 to 210˚C.

[0160] Furthermore, in case where the stretching is carried out in 3 steps, it is preferable to set first stage stretching roll to 50 to 90˚C, second stage stretch roll to 90 to 130˚C, third stage stretch roll to 130 to 160˚C and final roll after stretching to 160 to 220˚C. More preferably, first stage stretch roll is set to 60 to 80˚C, second stage stretch roll to 100 to 120˚C, third stage stretch roll to 140 to 150˚C and final roll after stretching to 170 to 210˚C.

[0161] And, by controlling total stretching ratio to 2 to 5 times, and by appropriately increasing molecular orientation, it becomes possible to immediately finalize heat shrinkage in the crimp nozzle, and history of undue stress being added to the sheath/core interface is hardly left, and therefore, it is preferable. And, as above-mentioned, by stretching at an appropriate stretch ratio, crystallization of the core component and the sheath component can be accelerated, and a crimped yarn capable of maintaining peeling resistance for more long term is obtained, in addition, crimp fastness is also enhanced, and therefore, it is preferable. It is more preferable that the total stretching ratio is 2.5 to 4.5 times and to be 2.8 to 4.3 times is still more preferable. The total stretching ratio of the present invention is defined by the speed ratio of the first stage stretch roll and the final roll after stretching, and it can be calculated by the following equation.

$$\text{Total stretching ratio} = [\text{speed (m/min) of final roll after stretching}]/[\text{speed (m/min) of first stage stretch roll}].$$

[0162] It is preferable that the stretched yarn heat set by the final roll after stretching is imparted with a crimp by a nozzle in an air jet stuffer crimp processing machine. As crimp processing machines for forming a BCF yarn which is a preferable crimp configuration of the present invention, crimp imparting machines which carries out an ordinary hot fluid processing treatment may be used, for example, various crimp imparting methods such as a jet nozzle type, a jet stuffer type and further a gear system are employed. In order to achieve a high crimp imparting and its development, a jet nozzle system is preferable, for example a crimp nozzle such as disclosed in the specification of US Patent No. 3,781,949 is preferably used. In order to enhance peeling resistance of the crimped yarn, it is preferable to raise fiber temperature in the crimp nozzle, to immediately and uniformly heat the core component and the sheath component of respective single fibers to a high temperature state to be heat shrunken, and it is preferable to raise the crimp nozzle temperature higher than the final roll temperature after stretching by 5 to 100˚C.

[0163] In the present invention, in case where stretching step and crimp processing are carried out in separate steps, it is extremely effective to subject the stretched yarn to a heat treatment again by a hot roll or a hot plate before supplying to the crimp nozzle. By carrying out heat treatment again, it becomes easy to raise the fiber temperature in the crimp nozzle and as above-mentioned, history of difference of heat shrinkage characteristics of the core component and the sheath component is hardly left at the sheath/core interface, and therefore, it is preferable. It is preferable that the temperature of re-heat treatment is 160 to 220˚C, to be 170 to 210˚C is more preferable, and to be 180 to 200˚C is especially preferable.

[0164] Furthermore, after imparting crimp, by taking up while contacting with a cooling drum, fiber structure of the crimped yarn can be fixed to lower boiling water shrinkage, and therefore, it is preferable. As the length contacting with the cooling drum of the crimped yarn (contact length) becomes long, the fiber structure can be fixed more and the fiber structure of the crimped yarn becomes hard to change even a stress is added to the crimped yarn in later winding step or in later processing step, and boiling water shrinkage can be maintained low, and therefore, it is preferable. It is preferable that the contact length is 20 cm or more, to be 30 cm or more is more preferable and to be 40 cm or more is still more preferable.

[0165] It is preferable that, after taking up while contacting with the cooling drum, the crimped yarn is wound in a speed lower than that of the final roll after stretching without adding an excessive stress to the crimped yarn. The temperature of the cooling drum is usually 20 to 35˚C. At this time, in case where the winding speed is lower than the final roll speed by 10 to 30%, by this, the fiber structure fixed by the cooling drum is not changed again, boiling water shrinkage can be kept low, a residual stress at the sheath/core interface is hardly generated and a crimped yarn excellent in peeling resistance can be obtained, and therefore, it is preferable.

[0166] Furthermore, by stretching under an appropriate tension between the cooling drum and the winder, maldistribution or unevenness of crimp can be prevented, and uniformity can be enhanced, and therefore, it is preferable. For example, 2 rolls are placed between the cooling drum and the winder, and a method of adding a tension by a speed difference between rolls, can be employed. At this time, when the tension is excessively high, crimp may be lost, accordingly, it is preferable that the tension for stretch is 0.02 to 0.2 cN/dtex and to be 0.04 to 0.15 cN/dtex is more preferable.

[0167] Furthermore, in an arbitrary step of before or after winding the crimped yarn by the winder, it is preferable to subject the crimped yarn to an interlacing treatment. The number and pressure of the interlacing treatment may be controlled such that the CF value of the crimped yarn would be 5 to 30, but since an interlace imparted before the stretching step is loosened sometimes by the stretching, it is preferable to interlace just before winding. And, since the yarn just before winding is under a low tension, it is easy to be interlaced by a compressed air of a low pressure. Accordingly, it is preferable since the crimped yarn is not imparted with an undue stress, and peeling resistance can be improved, and therefore, it is referable. It is preferable that the compressed air for the treatment is 0.05 to 0.5 MPa. By subjecting the crimped yarn to the interlacing treatment with an high speed gas, a uniform heat treatment becomes easy and heat treatment can be shortened.

[0168] On the other hand, it is possible to carry out crimp processing by a false twist processing without limited to the air jet stuffer crimp processing. In this case, by carrying out a processing in which a highly relaxing treatment while being heated after untwisting (Breria processing) is carried out, it is possible to form 2 phase structure of a crystal phase and an unoriented amorphous phase, and peeling resistance is easy to be enhanced, and therefore, it is preferable.

[0169] Thus obtained crimped yarn can be used for fiber structure. Further, the obtained crimped yarn can be processed by ordinary way to a carpet to use as a carpet for a car interior.

[0170] Configuration of the crimped yarn of the present invention may be a filament as it is, or the obtained crimped yarn may be cut in an appropriate length to handle as a staple.

[0171] Where, in case where the crimped yarn is a filament, it is preferable to be interlaced and has a CF value in the range of 3 to 30. Here, CF value can be measured in the way described in Examples, and it is an index indicating a degree of being interlaced. By making CF value 3 or more, unity of the crimped yarn is enhanced, and it becomes possible to reduce friction between single fibers, and at the time of fiber production, or later stage processing or when used as a product, undue stress hardly generates, and peeling resistance becomes excellent, and it is preferable. It is more preferable that the CF value is 5 or more and 7 or more is still more preferable. On the other hand, when CF value is too high, single fibers are too much bound with each other, crimp is bound (crimp elongation percentage after boiling water treatment becomes low), or in bulking up step by heat (for example, dyeing treatment, boiling water treatment or steam treatment), crimp unevenness appears, etc., and for avoiding such adverse effects, it is preferable that the CF value is 30 or less. More preferably, it is 25 or less and still more preferably, 20 or less.

[0172] Furthermore, there is especially no limit as to total fiber thickness (fiber thickness as multifilament) of the crimped yam of the present invention, but since residence time of the crimped yarn in the crimp nozzle can easily be extended, it is preferable that the total fiber thickness is 3000 dtex or less, to be 2500 dtex or less is more preferable and to be 2000 dtex or less is still more preferable. And, for making it easy to prevent pile fall when an external force is added to carpet, it is preferable that the total fiber thickness is 500 dtex or more, to be 600 dtex or more is more preferable and to be 700 dtex or more is still more preferable.

[0173] Where, number of single fibers (number of filaments) constituting the crimped yarn can be freely selected such that the single fiber thickness would be in the range of the present invention.

[0174] Furthermore, in case where the crimped yarn of the present invention is used as a fiber structure, it can be applied to a woven fabric, a knitted fabric, a nonwoven fabric, a pile, cotton, etc., and other fibers may be contained. For example, it may be a paralleled yarn, a twisted yarn, a mixed yarn with a natural fiber, a regenerated fiber, a semi-synthetic fiber or a synthetic fiber. As other fibers, natural fibers such as cotton, linen, wool, silk or regenerated fibers such as rayon or cupra, semi-synthetic fiber such as acetate and synthetic fibers such as nylon, polyester (polyethylene terephthalate, polybutylene terephthalate, etc.), polyacrylonitrile and polyvinyl chloride can be applied.

[0175] Furthermore, as uses of the fiber structure in which the crimped yarn of the present invention is used, there are clothes in which abrasion resistance is required, for example outdoor wear or sports wears such as golf wear, athletic wear, ski wear, snow board wear and pants thereof, casual wears such as boulzon, outers for ladies/gentlemen such as coat, winter clothes and rain wear. And, as uses which requires excellence in durability or moisture degradation resistance in a long term use, a uniform, futons or pillow such as kakefuton (a comforter) or shikifuton (futon mattress), hadakakefuton (thin futon), kotatsu (wooden table frame covered by a futon. Underneath is a heat source) futon, zabuton (cushion for sitting), baby comforter and blanket, sheets or coverings of cushion or the like, mattress or bed pad, sheets for hospital, medical care, hotel and baby or the like, and further, bedding materials such as covering of sleeping-bag, cradle, baby car, etc, and can also be preferably used in these applications. Furthermore, it can also preferably be used for interior materials of automobile, and among them, car carpet which require a high abrasion resistance and moisture degradation resistance are the best applications. Where, it is not limited to these applications and it may be used for, for example, anti-grass sheet for agriculture or waterproof sheet for construction materials. Here, as to car carpet which is a use of preferable fiber structure in the present invention, its processed structure is not limited, for example, carpets having piles represented by woven carpets such as dantsu, wilton, double face, Axminster, tufting, embroidery carpet such as hook do rag, bonded carpets such as bonded, electro-deposition or code, knit carpet such as knit or raschel, compressed carpets such as needle punch, or combinations thereof can be used. In order to obtain a carpet of low cost and voluminous texture, a tufting carpet constituted by at least a front yarn which is pile fiber, a base cloth to which the front yarn is tufted and a backing material laminated to the base cloth is preferable.

[Examples]

[0176] Hereafter, the present invention is explained in detail with reference to examples. Where, as methods of measurement in the examples, the following methods were employed.

A. Weight average molecular weight of aliphatic polyester

[0177] Tetrahydrofuran was mixed to a sample (aliphatic polyester polymer) solution in chloroform to prepare a solution to be measured. This was measured by gel permeation chromatography (GPC), and determined weight average molecular weight in polystyrene equivalent. Where, in case where a weight average molecular weight of aliphatic polyester in a fiber was measured, a sample was dissolved in chloroform, polyamide residue was removed by filtration, and aliphatic polyester was taken out by drying said chloroform solution to thereby provide it to a measurement.

GPC instrument: Waters2690
Column : Shodex GPC K-805L (8 mm ID*300 mm L), 2 columns were connected and used
Solvent : Chloroform (Wako, for HPLC)
Temperature : 40˚C
Flow rate : 1 ml/min
Concentration of sample : 10 mg/4 ml
Filtration : Maishori-disk 0.5μ-TOSOH
Amount of injection : 200μl
Detector: Differential refractometer RI (Waters 2410)
Standard : Polystyrene (concentration : sample 0.15 mg/solvent 1 ml)
Time for measurement: 40 minutes

B. Amount of residual lactide in polylactic acid

[0178] Sample (polylactic acid polymer) 1g was dissolved in dichloromethane 20 ml and acetone 5 ml was added thereto. Furthermore, it was precipitated by making to a constant volume with cyclohexane, and analyzed by GC17A produced by Shimadzu, to thereby determine an amount of lactide by an absolute calibration curve. Where, in case of a polylactic acid in fiber, blend ratio of polylactic acid and polyamide was determined beforehand by TEM image which is mentioned later and amount of the above-mentioned lactide was determined by correcting by the blend ratio.

C. Carboxyl group terminal concentration

[0179] A precisely weighed sample (aliphatic polyester polymer extracted by the following way) was dissolved in o-cresol (water content 5%), and after an appropriate amount of dichloromethane was added to this solution, it was determined by titrating with 0.02 N KOH methanol solution. At this time, since oligomers such as lactide which is cyclic dimer of lactic acid were hydrolyzed to generate carboxylic group terminal, the total carboxyl group terminal concentration including all of carboxyl group terminal from polymer, carboxyl group terminal from monomer and carboxyl group terminal from oligomer was determined. Where, method of extracting aliphatic polyester from polymer alloy fiber (synthetic fiber) or sheath/core type composite fiber is not especially limited, but in the present invention, by using chloroform, aliphatic polyester was dissolved and filtered to remove polyamide, and then the filtrate was dried to extract.

D. Sulfuric acid relative viscosity and inherent viscosity of the thermoplastic polyamide

[0180] Relative viscosity of nylon 6 was measured at 25°C by preparing 0.01 g/mL solution in 98% sulfuric acid. Inherent viscosity of nylon 11 was measured at 20°C by preparing 0.5 wt% solution in m-crezol.

E. Relative viscosity of aliphatic polyester

[0181] Relative viscosity of aliphatic polyester was measured at 25°C by preparing 0.01 g/mL solution in o-chlorophenol.

F. Melting point and heat of crystal fusion of polymer

[0182] By using a differential scanning type calorimeter, DSC-7 model, produced by Perkin Elmer Inc., the temperature showing an extreme value in endothermic curve of fusion measured by heating a sample 20 mg at a heating rate of 10 °C/min was taken as the melting point (°C). In addition, from the area surrounded by the peak which forms said extreme value and the base line (crystal melting peak area), heat of crystal fusion ΔH (J/g) of polymer was determined.

[0183] Furthermore, in case where a raw material polymer cannot be obtained, based on differential calorimetric curve of fiber, the melting point of original polymer is decided. To which component a melting peak of differential calorimetric curve of fiber is pertained is decided by the following way. First, a crimped yarn (fiber 1 : crimped yarn containing the component A and the component B) was subjected, as sample, to a DSC measurement in the same measurement condition as above described, to obtain a differential calorimetric curve 1. Next, the component A in sheath/core type composite fiber (fiber 1) is removed by solvent (chloroform), washed with water and vacuum dried for 24 hours at room temperature. For the obtained fiber (fiber 2 : fiber containing the component B), a DSC measurement was carried out in the same condition as above mentioned to obtain a differential calorimetric curve 2. By comparing the differential calorimetric curves 1 and 2, and by deciding that the disappeared melting peak is the melting peak of the component A, the melting points were determined by differential calorimetric curve 1.

[0184] Next, the component B in sheath component in sheath/core type composite fiber (fiber 1) was removed by solvent (solution in sulfuric acid), washed with water and vacuum dried for 24 hours at room temperature. For the obtained fiber (fiber 3 : fiber containing the component A and the component B), a DSC measurement was carried out in the same condition as above-mentioned to obtain a differential calorimetric curve 3. By comparing the differential calorimetric curves 1, 2 and 3, the melting point of the component B in sheath component was decided. At this time, in order to obtain the fiber 3, a solvent treatment condition (solvent temperature and immersing time) by which only the component B in the sheath component was substantially removed was decided beforehand. That is, sheath/core type composite fiber was immersed in solvent (solution in sulfuric acid) of a specified temperature for a specified time, and then taken out, and the obtained fiber was washed with water and vacuum dried for 24 hours at room temperature. For this fiber, fiber surface is observed by an optical microscope, and confirmed whether the sheath component is removed or not. The above-mentioned operations are repeated for plural solvent treatment conditions (solvent temperature and immersing time), and a solvent treatment condition by which only the component B of the sheath component is substantially removed, was decided.

G. Total heat capacity of melting peak in differential calorimetric curve of crimped yarn

[0185] For sheath/core type composite fiber of the present invention as a sample, differential calorimetric curve was obtained in the same condition as item F. Peaks which show extreme values in endothermic side which are present in the differential calorimetric curve are decided as melting peaks, and heat capacities obtained from the areas of the respective melting peaks were totalized and it was taken as the total heat capacity.

H. Melt viscosity η

[0186] By using Capirograph 1 B produced by Toyo Seiki Co., and, under nitrogen atmosphere, setting measurement temperature to the same temperature as spinning temperature, respective melt viscosities of the aliphatic polyester resin and the thermoplastic polyamide resin at shear rate 1216 sec^{-1} were measured. The measurements were carried out three times and their average value was taken as the melt viscosity. It was measured, in case of sheath/core type composite fiber and for a resin of which melting point is 240˚C or less, at 240˚C, and in case of a resin of which melting point is 240˚C or more, at melting point +20˚C.

I. Exposed area ratio of aliphatic polyester resin with respect to fiber surface area of crimped yarn and size of island domain and blend ratio

[0187] One single fiber constituting a crimped yarn is taken out, and an ultrathin section was cut out in a direction perpendicular to fiber axis (fiber cross-section direction), polyamide component of said cross-section is metal-dyed with phosphotungstic acid, and by a transmission electron microscope (TEM) of a magnification of 40,000 times, blend state of all over the outer surface was observed and taken into a photograph. From this image taken, fiber peripheral length is measured, and further, all exposed lengths of white portions (aliphatic polyester resin) exposed on fiber surface are measured, and exposed area ratio of aliphatic polyester resin was obtained from the total exposed length of the white portions with respect to the fiber periphral length. And further, by using image analyzing software, "WinROOF", of Mitani Corp., as to said TEM image, provided that an island domain (undyed portion) as a circle, a diameter (equivalent to diameter) (2r) calculated from the domain area was taken as its domain size. Where, number of domains to be measured is 100, and 80 domains, excluding 10 domains of largest domain size and 10 domains of smallest domain size, were provided to determine the distribution.

[0188] Where, blend ratio of the component A and the component B in fiber was determined as weight ratio by correcting the cross-sectional areal ratio obtained from the above-mentioned TEM image (5.93 × 4.65 μm) by specific gravities of the respective components. Here, specific gravities of the respective components in this invention are, polylactic acid : 1.24, nylon 6 : 1.14, nylon 11 : 1.04, nylon 610 : 1.08 and nylon 6/66copolymer : 1.14.

TEM instrument: H-7100FA model produced by Hitachi, Ltd.
Condition : Acceleration voltage 100kV.

J. Surface configuration of crimped yarn

[0189] One single fiber constituting crimped yarn was taken out, and its fiber surface condition was observed and taken into a photograph by electron microscope ESEM-2700 produced by Nikon Instech Co., at a magnification of 5,000 times, and from this image taken, by using an image analyzing software "WinROOF" of Mitani Corp., arbitrarily selected 10 widths of groove (maximum width) were measured and its average value was taken as the width of grooves. In addition, respective lengths of the groove were measured and the aspect ratio (length of groove/width of groove) was determined. As number of grooves, grooves present in arbitrarily selected 10 μm × 10 μm were counted.

K. Heat loss ratio of compatibilizer

[0190] By using TG/DTA 6200 of EXSTAR 6000 series produced by Seiko Instrument Inc., sample (component C) approximately 10 mg was weighed by a balance and from its heat loss curve obtained at heating rate 10 ˚C/min, the heat loss ratio at 200±0.5˚C was determined.

L. Sheath/core ratio

[0191] At providing to a melt spinning, a weight of core component (comprises only the component A) and a weight of sheath component (comprises only the component B) were weighed respectively and, provided that total weight of the core component and the sheath component was 100, respective weights of the core component and the sheath component thereto were calculated.

[0192] In case where the weight ratios when produced of the core component and the sheath component are not known, it is possible to calculate by the following equation for convenience. That is, core component of the crimped yarn of the present invention may contain the component A and a small amount of other component, and sheath component may contain the component B and a small amount of other component, but even in such a case, it is possible to consider that the core component substantially comprises the component A only and the sheath component substantially comprises the component B only, and it is possible to calculate the sheath/core ratio as the weight ratio of the core component and the sheath component.

[0193] At first, a cross-sectional slice of crimped fiber was prepared, polyamide component of said slice was metal dyed with phosphotungstic acid, and the cross-sectional area of the crimped fiber was observed by a transmission electron microscope (TEM) at a magnification of 4,000 times and a photograph was taken. At this time, sheath/core interface was decided by considering the undyed region as the component A and the dyed region as the component B, and by image analyzing by the image analyzing software, "WinROOF" of Mitani Corp, total area of the region constituting the core component (Aa) and total area of the region constituting the sheath component (Ab) were determined. And by considering the specific gravity of the component A as 1.26, and the specific gravity of the component B as 1.14, it was calculated by the following equation.

$$\text{Sheath/core ratio} = \text{weight ratio of core component} / \text{weight ratio of sheath component}$$

$$\text{Weight ratio of core component} = [(Aa \times 1.26)/(Aa \times 1.26+Ab \times 1.14)] \times 100$$

$$\text{Weight ratio of sheath component} = [(Ab \times 1.14)/(Aa \times 1.26+Ab \times 1.14)] \times 100$$

TEM instrument : H-7100FA model produced by Hitachi, Ltd.
Condition : accelerating voltage 100kV

M. Identification of core component (polymer alloy) structure in sheath/core type composite fiber

[0194] An ultrathin section was cut out from a direction perpendicular to fiber axis of a sheath/core type composite fiber, polyamide component of said section was metal dyed with phosphotungstic acid and its polymer alloy structure was observed and taken as a photograph by a transmission electron microscope (TEM) at a magnification of 40,000 times. At this time, a case in which the island component is not dyed was identified as polymer alloy structure (a) and a case in which the island component was dyed was identified as polymer alloy structure (b), and a case in which island component and sea component could not be differentiated (respective components were not approximately circular, and island and sea could not be differentiated) was identified as polymer alloy structure (c).

TEM instrument: H-7100FA model of Hitachi, Ltd.
Condition : Acceleration voltage 100kV.

N. Measurement of island component diameter of core component (polymer alloy) of sheath/core type composite fiber

[0195] In the item M, in cases where the polymer alloy structure was identified as (a) or (b), by using an image taken in the same way and by using the image analyzing software "WinROOF" of Mitani Corp., the island component diameter was determined from hypothetical diameter calculated from area of the island component, provided that the island component is a circle. Where, number of islands to be measured was 100 islands per one sample, and its distribution was taken as the island component diameter distribution.

O. Blend ratio (weight ratio) of component A/component B in core component (polymer alloy) in sheath/core type composite fiber

[0196] Weights of the component A and the component B were respectively metered at providing them to a melt spinning, and a blend ratio of the component A and the component B was calculated.

[0197] In case where it is difficult to respectively meter the component A and the component B in production process, the blend ratio (weight ratio) of component A/component B was calculated from sheath/core type composite fiber. The core component of sheath/core type composite fiber of the present invention may contain the component A, the component B and other small amount component, but in such a case, it is possible to calculate the blend ratio (weight ratio) of component A/component B by considering that the core component substantially comprises only 2 components of the component A and the component B. By using the image taken in the item O and by using the image analyzing software "WinROOF" of Mitani Corp., total area of the component A (Aa) and total area of the component B (Ab) constituting the core component were determined, the blend ratio was calculated by the following equation, provided that the specific gravity of the component A was 1.26 and the specific gravity of the component B was 1.14.

$$\text{Component A/the component B} = (Aa \times 1.26)/(Ab \times 1.14)$$

[0198] At this time, in case where boundary line of the sheath component and the core component in the cross-section was difficult to decide, in the cross-section, taking a similar figure to fiber cross-section circumscribing the component A which is present at outermost layer and contains the component A in its inside only as boundary line, sheath component and core component was differentiated.

P. Minimum value of thickness of sheath component

[0199] By using the image taken in accordance with the observing method of cross-section of crimped yarn described in the item L, a thickness was measured at portion where, in said cross-section, thickness of the sheath component is smallest. By randomly changing sampling portion of cross-section slice of the crimped yarn, 10 sheets of image were prepared, and the above-mentioned measurement was carried out for the respective images, and an average value was taken as the minimum value of thickness of sheath component.

Q. Content of aliphatic polyester resin (A)

[0200] 10g sheath/core type composite fiber was taken out and its weight (W1) was weighed by a balance as a sample. Said sample was immersed in 500 ml chloroform of 25°C at 24 hours, to completely dissolve out the component A. The sheath/core type composite fiber after dissolving out treatment was washed with water, and after drying at 25°C for 24 hours, the fiber weight (W2) was weighed. By using W1 and W2, the content of the component A was calculated by the following equation.

$$\text{Content of the component A (wt\%)} = (W1-W2) \times 100/W1$$

R. Fiber thickness

[0201] By a sizing reel, 100 m crimped yarn was measured and taken as a hank, weight of the crimped yarn of 100 m length was measured, and a yarn thickness (dtex) was determined by multiplying said weight 100 times. The measurement was repeated 3 times and its average value was taken as yarn thickness (dtex). In addition, single fiber thickness (dtex) was determined by dividing the yarn thickness by number of filaments.

S. Strength and elongation

[0202] A sample (crimped yarn) was measured by Tensilon UCT-100 of Orientech Inc. in accordance with the constant rate elongation method defined in JIS L1013 (chemical fiber filament yarn test method, 1998). Grip length (sample length) was 200 mm. Where, elongation at break was determined by the elongation at which maximum strength in S-S curve was shown.

T. Boiling water shrinkage (Fusshouu)

[0203] A sample (crimped yarn) was immersed in boiling water for 15 minutes and the boiling water shrinkage was determined by dimensional change between before and after the immersion.

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

L_0 : Hank length after a sample was made into a hank and measured under an initial load of 0.088 cN/dtex.
L_1 : Hank length measured under initial load of 0.088 cN/dtex after the hank of which L0 was measured was treated by boiling water under no load, and dried in the air.

U. Yarn unevenness, U%

[0204] A sample (crimped yarn) was subjected to a U% (Normal) measurement by using UT4-CX/M produced by Zellweger uster Inc., at yarn speed : 200 m/min and measurement time : 1 minute.

V. Crimp elongation percentage after boiling water treatment

[0205] A crimped yarn unwound from a package (crimped yarn wound drum or bobbin) left in an atmosphere of atmospheric temperature 25±5°C and relative humidity 60±10% for 20 hours or more was immersed in boiling water for 30 minutes or more under no load. After the treatment, it was dried in the air for one day and night (approximately for 24 hours) under the above-mentioned atmosphere, and this was used as a sample of crimped yarn after boiling water treatment. This sample was loaded by an initial load of 1.8 mg/dtex, and after passing 30 seconds, a marking was made at sample length of 50 cm (L1). Subsequently, after passing 30 seconds after a load for measurement of 90 mg/dtex instead of the initial load was loaded, a sample length (L2) was measured. And by the following equation, crimp elongation percentage after boiling water treatment (%) was determined.

$$\text{Crimp elongation percentage (\%)} = [(L2-L1)/L1]\times 100.$$

W. Crimp elongation percentage under load after boiling water treatment (elongation percentage under load)

[0206] Crimp elongation percentage was determined in the same way as in the item M except changing to a load of 2 mg/dtex to the crimped yarn when it was subjected to a boiling water treatment, and the value was taken as the elongation percentage under load.

X. CF value

[0207] It was measured in accordance with the condition shown in the degree of interlace of JIS L1013 (Chemical fiber, filament yarn test method) 7.13. Number of tests was 50 times and CF value (Coherence Factor) was determined by the following equation from average value L (mm) of interlacing length.

$$\text{CF value} = 1000/L$$

Y. Non-circularity

[0208] A cross-section of a sample (crimped yarn) was cut out, and the non-circularity was determined by the following equation from diameter D1 of circumscribed circle of the single fiber cross-section and diameter D2 of inscribed circle of the single fiber cross-section.

$$\text{Non-circularity} = D1/D2.$$

Z. Non-circularity of sheath/core type composite fiber

[0209] By using an image taken in accordance with the observing method of the cross-section of crimped yarn described in the item L, it was determined by the following equation from diameter D1 of circumscribed circle of cross-section of the crimped fiber and diameter D2 of inscribed circle of single fiber cross-section. And, in the same way, non-circularity of the core portion was also determined by the following equation from diameter D3 of circumscribed circle and diameter D4 of inscribed circle of the cross-section of core portion.

$$\text{Non-circularity} = D1/D2$$

$$\text{Non-circularity} = D3/D4$$

AA. Evaluation of abrasion resistance of stretched yarn

[0210] A sandpaper (# P600) was wound and fixed to a roller rotating at a constant speed, and one end of a stretched yarn was fixed to a wall and the other end was loaded as shown in Fig. 3, and the stretched yarn was abraded by rotating the roller while traversing the stretched yarn at a constant speed to thereby count a number of roller rotations at which the stretched yarn was broken. Measuring conditions are shown in the following.

Diameter of rotating body : 80 mm
Contact length of yarn : 62.8 mm
Contact angle of yarn : 90°
Number of roller rotations : 160 rpm
Traverse oscillation : 10 mm
Traverse speed : 3 times
Load for measurement: 0.06 cN/dtex.

BB. Abrasion resistance of crimped yarn

[0211] By using twine abrasion tester produced by Ando Tekkosho, #P600 sandpaper was wound on a roller, and a number of roller rotations up to a yarn break was measured in the following conditions.

Diameter of rotating body : 40 mm
Contact length of yarn : 110 mm
Number of roller rotations : 200 rpm
Load for measurement: 0.4 cN/dtex

CC. Average particle diameter D50 of crystal nucleating agent and content of crystal nucleating agent of 10 μm or more

[0212] By using SALD-2000J produced by Shimadzu Corp. and by a laser diffraction method, average particle diameter D50 of crystal nucleating agent (μm) was measured. In addition, from the obtained particle diameter distribution, a volume % of the crystal nucleating agent of 10 μm or more was determined.

DD. Evaluation of spinnability

[0213] Depending on frequency of yarn break for obtaining 100 kg cheese package, the evaluation of spinnability was carried out. The evaluation was classified to 4 classes of excellent (double circle), good (o), fair (△), poor (×).

Double circle : no yarn break
○ : Yarn break 1 to 5 times

△: Yarn break 6 to 10 times
× : Yarn break 11 or more

EE. Abrasion resistance of carpet (abrasion loss ratio)

[0214] Two crimped yarns subjected to S-twist and Z-twist were paralleled and twisted and wound. The wound yarn in cheese package was treated to dye with a metal-complex dye ("Irgaran Red 4GL "[produced by Ciba-Geigy AG]) at 0.6%owf, bath ratio 1 : 50, pH = 7 and at 98°C for 60 minutes. Furthermore, it was washed and hot air dried at 50°C for 24 hours to thereby obtain a dyed twisted yarn. After said twisted yarn was tufted to a PP spunbond nonwoven fabric as a front yarn, a backing material was coated on reverse side of base fabric and dried to thereby obtain a tufting carpet (weight 1200g/m^2).

[0215] The above-mentioned tufting carpet was cut out in a circular shape of diameter 120 mm, and made a 6 mm hole at its center to make a test piece. After measuring weight W0 of said test piece, it was fixed to a taber abrasion tester (Rotary Abaster) prescribed in ASTM D 1175 (1994) with its surface upside, and carried out an abrasion test with H#18 abrasion wheel at compressive load 1 kgf (9.8N), sample holder rotation speed 70 rpm and number of abrasion 5500 times, and sample weight W1 after the abrasion test was measured. The abrasion loss ratio was calculated from these data and by the following equation.

$$\text{Abrasion loss ratio (\%)} = (W0-W1) \times 100/(W2 \times A1/A0)$$

W0 : Weight (g) of circular carpet before measurement
W1 : Weight (g) of circular carpet after measurement
W2 : Weight of carpet (g/m^2)
A0 : Total area of circular carpet (m^2)
A1 : Total area contacting with abrasion wheel (m^2).

FF. Touch of carpet (softness) and appearance (glossy texture)

[0216] The carpet was treated to dye with a metal-complex dye ("Irgaran Red 4GL "[produced by Ciba-Geigy AG]) at 0.6%owf, bath ratio 1 : 50, pH = 7 and at 98°C for 60 minutes. A touch (softness) when said dyed carpet was pushed with palm and glossy texture or gloss unevenness was confirmed under sunlight by visual inspection to thereby evaluate touch and appearance in 4 classes, respectively.

Double circle· extremely excellent
○ · · · excellent
△ · · · equal to conventional one
× · · · inferior to conventional one

GG. Peeling resistance of sheath/core composite interface of sheath/core type composite fiber

[0217] A circular knit fabric comprising the crimped yarn was prepared and said circular knit was treated to dye with a metal-complex dye ("Irgaran Red 4GL "[produced by Ciba-Geigy AG]) at 0.6% owf, bath ratio 1 : 50 (as circular knit fabric), pH = 7 and at 98°C for 60 minutes. After the dyeing, washed with water and hot air dried at 50°C for 24 hours to obtain a dyed circular knit fabric. From the dyed circular knit fabric, narrow card shaped pieces of 50 × 100 mm were cut out as samples, and after subjecting to crease-flex abrasion by using Scott type crease-flex abrasion tester (SCOTT TYPE CREASE-FLEX ABRATION TESTER, produced by Daiei Kagaku Seiki Mfg, Co., model : CF-10N), at number of tests 1000 times, chuck distance 0 mm, abrasion stroke 45 mm and press load 0.5 kg, said sample was taken out, and appearance change of where the crease-flex abrasion was imparted was evaluated by the following criteria. And for the same circular knit, the measurement was carried out 5 times, and overall evaluation was determined by total points of the respective evaluations.

<Evaluation criteria>

[0218]

5 points : No appearance change

4 points : Partially, color loss was found.
3 points : Color loss was found and partially, pilling was found.
2 points : Whitening was found and many pilings were found.
1 point: Whitening was found, many pilings were found and a hole opening was also found.

<Overall evaluation>

[0219]

Double circle (excellent) : 21 to 25 points
○ (good) : 16 to 20 points
△ (fair) : 11 to 15 points
× (poor) : 5 to 10 points.

HH. Abrasion loss ratio of carpet

[0220] According to JIS L 1096 : 1999 8.17.3 Taber-type method, by using H-18 abrasion wheel and by loading 1 kgf (9.8N) load to respective abrasion wheels of left-and-right pair, the carpet was subjected to an abrasion by rotating a predetermined number of rotations, and then from weights of unabraded portion and abraded portion (refer to JIS L 1096 : 1999 Fig. 20), abrasion loss ratio (%) was calculated by the following equation.

$$\text{Abrasion loss ratio (\%)} = [(\text{pile weight of unabraded portion} - \text{pile weight of abraded portion})/\text{pile weight of abraded portion}] \times 100$$

[0221] Two conditions of number of rotations of 300 times and 5500 times were employed.

II. Abrasion loss ratio after wet heat degradation

[0222] An abrasion loss ratio was determined in the same way as above-mentioned item HH for a carpet after being treated under atmosphere of temperature 50°C and humidity 95% for 1200 hours. However, the number of rations was 1000 times.

JJ. Heat resistance of carpet (line mat)

[0223] Appearance change was evaluated by pressing at molding temperature 150°C by 300t press machine produced by Miura Press Seisakusho.

◎ : No change.
○ : A slight pressing mark was observed.
× : Fusion bond of pile occurred.

KK. Color brightness

[0224] A carpet in which the dyed yarn was used was visually inspected and evaluated in the following criteria.

◎ : Particularly excellent.
○ : Excellent.
△ : No difference compared to other synthetic fiber.

LL. Strength of car sheet fabric

[0225] According to the labeled strip method of JIS L 1096 : 1999 8.12.1 A method (strip method), at atmospheric temperature 20°C, 3 test pieces for longitudinally and transversely, respectively, were sampled, yarns were removed from both sides of width to adjust to a width of 30 mm, and a strength at break was measured by constant speed stretch type (Autograph (AG-G) produced by Shimadzu Corp.) tester when tested at grip distance 150 mm and tensile speed

200 mm/min, and calculated an average value of the 6 sheets.

MM. Strength retention of car sheet fabric in 90˚C atmosphere

[0226] Except changing the atmospheric temperature to 90˚C, fabric strength was measured in the same way as above-mentioned item LL, and the strength retention was calculated by the following equation.

$$\text{Strength retention of fabric (\%)} = (\text{strength in } 90°\text{C atmosphere/strength in } 20°\text{C atmosphere}) \times 100$$

NN. Abrasion loss of car sheet fabric

[0227] According to JIS L 1096 : 1999 8.17.3 taber type method, by using H-18 abrasion wheel and by loading 0.5 kgf (4.9N) load to respective abrasion wheels of left-and-right pair, the carpet was subjected to an abrasion by rotating 3,000 times, and then weight loss of the fabric was measured.

[Synthesis example 1] (Production of polylactic acid)

[0228] A lactide produced from L lactic acid of optical purity 99.8% was polymerized in a presence of bis (2-ethylhexanoate) tin catalyst (mol ratio of lactide : catalyst = 10000 : 1) under nitrogen atmosphere at 180˚C for 240 minutes to thereby obtain a polylactic acid P1. Weight average molecular weight of the obtained polylactic acid was 233,000. And, an amount of residual lactide was 0.12 wt%.

[Synthesis example 2] (Production of polylactic acid containing 10 wt% polycarbodiimide)

[0229] After drying P1 and polycarbodiimide "LA-1" produced by Nishinbo Industries, Inc., they were fed to a twin screw kneading extruding machine such that P1 : LA-1 = 90 : 10 (weight ratio), and kneaded at cylinder temperature 200˚C to thereby obtain polylactic acid P2 containing 10 wt% LA-1. Amount of residual lactide of the obtained polylactic acid was 0.14 wt%.

[Synthesis example 3] (Production of polylactic acid)

[0230] A lactide produced from L lactic acid of optical purity 99.8% was polymerized in a presence of bis (2-ethylhexanoate) tin catalyst (mol ratio of lactide : catalyst = 10000 : 1) under nitrogen atmosphere at 180˚C for 150 minutes to thereby obtain polylactic acid P3. Weight average molecular weight of the obtained polylactic acid was150,000. And, amount of residual lactide was 0.10 wt%.

[Synthesis example 4] (Production of polylactic acid (P4))

[0231] A lactide of optical purity 99.5% produced from L lactic acid was polymerized in the presence of bis (2-ethylhexanoate) tin catalyst (mol ratio of lactide : catalyst = 10000 : 1) under nitrogen atmosphere at 180˚C for 220 minutes to thereby obtain a polylactic acid (P4). Weight average molecular weight of the obtained polylactic acid (P4) was 210,000. And, amount of residual lactide was 0.13 wt%. Of the polymer (P4), melting point was 170˚C, heat capacity of melting peak was 45 J/g, melt viscosity was 200 Pa · sec^{-1} and relative viscosity was 3.42. [Synthesis example 5] (Production of polylactic acid (P5))

[0232] A lactide produced from L lactic acid of optical purity 99.5% was polymerized in the presence of bis (2-ethylhexanoate) tin catalyst (mol ratio of lactide : catalyst = 10000 : 1) under nitrogen atmosphere at 180˚C for 350 minutes to thereby obtain a polylactic acid (P5). Weight average molecular weight of the obtained polylactic acid (P5) was 260,000. And, amount of residual lactide was 0.14 wt%. Of the polymer (P5), melting point was 170˚C and heat capacity of melting point peak was 45 J/g. Melt viscosity was 300 Pa·sec^{-1}. Relative viscosity was 3.76.

[Synthesis example 6] (Production of polylactic acid (P6))

[0233] A lactide produced from L lactic acid of optical purity 99.5% was polymerized in the presence of bis (2-ethylhexanoate) tin catalyst (mol ratio of lactide : catalyst = 10000 : 1) under nitrogen atmosphere at 180˚C for 150 minutes to thereby obtain a polylactic acid (P6). Weight average molecular weight the obtained polylactic acid (P6) was 150,000. And, amount of residual lactide was 0.10 wt%. Of the polymer (P6), melting point was 170°C, heat capacity of melting peak was 48 J/g, melt viscosity was 120 Pa · sec^{-1} and relative viscosity was 3.04. [Synthesis example 7] (Production of polylactic acid (P7))

[0234] A lactide produced from L lactic acid of optical purity 99.5% and lactide produced from D lactic acid of optical purity 99.5% was polymerized in a presence of bis (2-ethylhexanoate) tin catalyst (mol ratio of L lactic acid lactide : D lactic acid lactide : catalyst = 8900 : 1100 : 1) under nitrogen atmosphere at 180°C for 220 minutes to thereby obtain a polylactic acid (P7). Weight average molecular weight of the obtained polylactic acid (P7) was 210,000. And, amount of residual lactide was 0.12 wt%. Of the polymer (P7), melting point was 130°C, heat capacity of melting peak was 38 J/g and melt viscosity was 200 Pa · sec^{-1}. Relative viscosity was 3.42.

[Synthesis example 8] (Production of polylactic acid (P8) containing polycarbodiimide 10 wt%)

[0235] After drying P4 and the component C (polycarbodiimide "LA-1" produced by Nishinbo Industries, Inc.), they were fed to a twin screw kneading extruding machine such that P4 : LA-1 = 90 : 10 (weight ratio), and kneaded at cylinder temperature 200°C to thereby obtain a polylactic acid (P8) containing LA-1 10 wt %. Amount of residual lactide of the obtained polylactic acid (P8) was 0.15 wt%. Of the polymer (P8), melting point was 170°C, heat capacity of melting peak was 44 J/g, melt viscosity was 190 Pa · sec^{-1} and relative viscosity was 3.38.

[Synthesis example 9] (Production of polylactic acid (P9) containing MADGIC 10 wt%)

[0236] After drying P4 and the component C (monoallyl diglycidyl isocyanuric acid ((hereafter, referred to as MADGIC) produced by Shikoku Chemicals Corp.), they were fed to a twin screw kneading extruding machine such that P4 : MADGIC = 90 : 10 (weight ratio), and kneaded at cylinder temperature 200°C to thereby obtain a polylactic acid (P9) containing MADGIC 10 wt%. Amount of residual lactide of the obtained polylactic acid (P9) was 0.15 wt%. Of the polymer (P9), melting point was 170°C, heat capacity of melting peak was 44 J/g, melt viscosity was 190 Pa·sec^{-1} and relative viscosity was 3.38.

[Synthesis example 10] (Production of polylactic acid (P10) containing 10 wt% of compound of which main chain is ethylene-glycidyl acrylate and grafted with polymethyl methacrylate)

[0237] After drying P4 and the component C ("Modiper A4200" (hereafter, abbreviated as "Modiper") produced by NOF Corp.), they were fed to a twin screw kneading extruding machine such that P4 : "Modiper " = 80 : 20 (weight ratio), and kneaded at cylinder temperature 200°C to thereby obtain a polylactic acid (P10) containing "Modiper " 20 wt%. Amount of residual lactide of the obtained polylactic acid (P10) was 0.15 wt%. Of the polymer (P10), melting point was 170°C, heat capacity of melting peak was 44 J/g, melt viscosity was 190 Pa·sec^{-1} and relative viscosity was 3.38.

(Example 1)

[0238] The polylactic acid P1 (melting point 177°C) as the component A, nylon 6 of relative viscosity in sulfuric acid 2.15 (melting point 225°C) as the component B were respectively dried to control water content of the component A to 50 to 100 ppm and water content of the component B to 100 to 300 ppm, and chip blended in a blend ratio (weight ratio) P1/nylon 6 = 30/70, and fed to the spinning hopper 1 of a spinning machine provided with a twin screw kneading machine shown in Fig. 6 to thereby introduce into the twin screw extruding/kneading machine 2, and metered and discharged a molten polymer by the spinning block 3 to thereby introduce the molten polymer to the spinning pack 4 assembled therein and spun from the spinneret 5. To the spinneret, the following described Y type holes were provided. At this time, the circular chimney 6 (cooling length 30 cm) was installed such that the uppermost end of blow-off hole was positioned 3 cm beneath the spinneret surface to thereby cool and solidify the yarn 7 and oiled in 2 steps by the oiling device 8 and the oiling device 9. Furthermore, after it was taken up via the stretch roll 10, while setting the temperature of the first heating roll 11 (hereafter, described as 1 FR) to 60°C and spinning speed to 700 m/min, while adjusting the temperature of the second heating roll 12 (hereafter, described as 1 DR) to 120°C, first stage stretching (stretch ratio : 2.7 times) was carried out at 1890 m/min, and furthermore, while adjusting the temperature of the third heating roll 13 (hereafter, described as 2 DR) to 157°C, second stage stretching (stretch ratio : 1.37 times) was carried out at 2590 m/min, successively, subjected to a hot and compressed air treatment by the air stuffer 14 at nozzle temperature 220°C to carry out crimp processing to form a 3-dimensional crimp, and after taking up by contacting with the cooling drum 15, via the tension measuring detector 16, taken up by the take-up roll 17, and while interlacing by the interlacing nozzle 18, wound by the winder 19 under winding tension 120g (0.08 cN/dtex) and at winding speed 2200 m/min (a speed 15% lower than 2 DR speed). The obtained polylactic acid crimped yarn was 1500 dtex, 96 filaments. The melt spinning condition was as follows. Where, linear discharge velocity in spinneret hole under the following conditions is 0.184 m/sec. And, elongation at break of the stretched yarn samples at the exit of 2 DR was 35%.

- · Twin screw extruding machine temperature : 225˚C
- · Shear rate at kneading : approximately 2000 sec^{-1}
- · Spinning temperature : 240˚C
- · Filtering layer : 46#, white morundum sand filled
- · Filter : 20 μm nonwoven fabric filter (Dynaloy)
- · Spinneret : slit width 0.14 mm, slit length 0.7 mm, depth of hole 0.6 mm
- · Out put: 330g/min (1 pack 1 yarn, 96 filaments)
- · Cooling : cooling air temperature 19˚C, wind speed 0.55 m/sec
- · Oiling agent: oiling agent in which polyether-based oiling agent 15 and low viscosity mineral oil 85 was mixed in this ratio was imparted in a ratio of 10% (1.5% owf as pure oiling agent component) to yarn.

[0239] The crimped yarn was sampled approximately 100 kg but in all processes of spinning, stretching and bulking processing, a yarn break and a single fiber break did not occur and the processes were very stable.

[0240] When an observation by TEM of cross-section of the obtained fiber was carried out, it was found that a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 1.5%. And, island domain size was 0.03 to 0.3 μm in diameter equivalent. And, when a section of said fiber cross-section was subjected to an alkali etching to dissolve out polylactic acid and observed, it was confirmed that the island component was dropout and polylactic acid constituted the island component. And, grooves as shown in Fig. 2 were formed on the fiber surface and an average width of said grooves was 0.26 μm, aspect ratio (length of grooves/width of groove) was 20. And, the obtained fiber showed good fiber physical properties that tensile strength was 2.8 cN/dtex, residual elongation : 48%, boiling water shrinkage : 2.8%, yarn unevenness U% : 0.8%, crimp elongation percentage : 12% and non-circularity : 2.5. And, melting points by DSC were around 175˚C (polylactic acid) and around 225˚C (nylon 6), i.e., melting peaks based on the respective components were observed. And, carboxyl group terminal concentration of polylactic acid extracted from said fiber was 18 eq/ton. Further, number of rotations up to yarn break by the abrasion test was 101 rotations, i.e., a good abrasion resistance was shown. Further, when a carpet was prepared by using said crimped yarn and evaluated, it was found that an abrasion loss ratio was 25.5% and it showed a very good abrasion resistance as a carpet. And, a touch was soft and had a moderate hardness and it was a carpet having a dewy and silky glossiness.

(Example 2)

[0241] A BCF yarn was obtained in the same way as Example 1 except changing the blend ratio of P1/the component B to 10/90. The spinnability in Example 2 was very stable as Example 1. When an observation by TEM of cross-section of the obtained fiber was carried out, it was found that a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 0.1 %. And, an island domain size was 0.01 to 0.15 μm in diameter equivalent, i.e., dispersion size of island component was smaller than that of Example 1. And, when a section of said fiber cross-section was subjected to an alkali etching to thereby dissolve out polylactic acid and observed, it was confirmed that the island component was dropout and polylactic acid constituted the island component.

[0242] Furthermore, non-circularity of the obtained fiber was 2.4 and fiber physical properties were also good. And, melting points by DSC were around 175˚C (polylactic acid) and around 225˚C (nylon 6), I.e., melting peaks based on the respective components were observed. Number of rotations up to yarn break by the abrasion test of the obtained multifilament was 185 rotations and it was superior to that of Example 1.

[0243] Furthermore, when a carpet was prepared by using said crimped yarn and evaluated, it was more excellent than that of Example 1 in abrasion resistance, and a carpet having a soft touch was obtained. However, glossy texture was inferior to that of Example 1.

(Example 3)

[0244] A BCF yarn was obtained in the same way as Example 1 except changing the blend ratio of P1/the component B to 40/60. Spinnability in Example 3 was very stable as Example 1. When an observation by TEM of cross-section of the obtained fiber was carried out, a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 3.2%. And, island domain size was 0.03 to 0.8 μm in diameter equivalent and dispersion size of the island component was smaller than that of Example 1. When a carpet was prepared by using said crimped yarn and evaluated, it was found that the carpet of Example 1 was superior in abrasion resistance, but the carpet of this example was more excellent than that of conventional one in both of touch and appearance.

(Example 4)

[0245] A BCF yarn was obtained in the same way as Example 1 except changing the blend ratio of P1/the component B to 5/95. Spinnability in Example 4 was very stable as Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, it was found that a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 0%. And, island domain size was 0.01 to 0.1 μm in diameter equivalent, i.e., dispersion size of the island component was extremely small, and number of islands was also small. And, almost no groove was formed on fiber surface of said crimped yarn. When a carpet was prepared by using said crimped yarn and evaluated, similar to Example 1, although it has a high softness and an excellent touch, its glossy texture was in the same level as that of conventional one.

(Example 5)

[0246] A BCF yarn was obtained in the same way as Example 1 except using nylon 6 of relative viscosity in sulfuric acid 2.05 (melting point 225˚C) as the component B and changing the blend ratio of P1/the component B to 47/53. In Example 5, due to Barus effect just beneath spinneret, swelling of extruded flow was slightly large. And, when crimped yarn was sampled 100 kg, yarn break occurred 2 times and its spinnability was slightly inferior to that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, it was found that a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 5.0%. And, island domain size was 0.03 to 0.8 μm in diameter equivalent and dispersion size of island component was slightly larger than that of Example 1. When a carpet was prepared by using said crimped yarn and evaluated, abrasion resistance was better in Example 1 than in this example. And, although its touch was somewhat hard and coarse, it had a dewy and silky glossiness.

(Comparative example 1)

[0247] A BCF yarn was obtained in the same way as Example 1 except using only the component A (polylactic acid P1). Spinnability of comparative example 1 was stable as that of Example 1. In the obtained crimped yarn, number of rotations up to yarn break by the abrasion test was 9 rotations, i.e., its abrasion resistance was extremely poor. And, when a carpet was prepared by using said crimped yarn and evaluated, abrasion loss ratio was 89% and it was in a level of which application was considerably limited.

(Example 6)

[0248] A BCF yarn was obtained in the same way as Example 1 except using the polylactic acid P3 (melting point 178˚C) as the component A and except changing spinning condition as follows.

- · Shear rate of twin screw kneading machine : approximately 280 sec^{-1}
- · Filtering layer constitution : filled with glass beads of φ1 mm
- · Filter : #200 metal mesh filter

[0249] InExample 6, thinnig point just beneath spinneret was not stable, and discharged flow was slightly unstable. And, when crimped yarn was sampled 100 kg, yarn break occurred 3 times and spinnability was slightly inferior to that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, it was found that it had an sea/island structure, but exposed area ratio of polylactic acid with respect to fiber surface area was 1.9%. And, island domain size in diameter equivalent was 0.3 to 2.5 μm, i.e., dispersion size of island component was large and its distribution was wide. And Uster unevenness U% which indicates yarn unevenness was high as 2.1 %, and it was found that there was a thickness unevenness along the longitudinal direction of the yarn. When a carpet was prepared by using said crimped yarn and evaluated, it was found that an abrasion loss ratio was approximately 2 times compared to that of Example 1. And, its touch was of partially hard and coarse feeling, and glossy texture was also in the same level as conventional one.

(Comparative example 2)

[0250] A BCF yarn was obtained in the same way as Example 1 except using the polylactic acid P3 (melting point 178˚C) as the component A and nylon 6 (melting point 225˚C) of relative viscosity in sulfuric acid 2.90 as the component B. In Comparative example 2, an extremely large swelling was occurred due to Barus effect just beneath spinneret and a wave phenomena in which thinnig point goes up and down occurred and it was an unstable condition. And, when crimped yarn was sampled 100 kg, yarn break frequently occurred as 17 times, and spinnability was considerably bad. And, when an observation by TEM of a cross-section of the obtained fiber was carried out, although it had a sea/island structure, the island component was dyed. At this time, when polylactic acid was dissolved out by alkali etching, only the island component was left, and it was found that the polylactic acid had formed the sea component. And, in said crimped yarn, strength was low as 1.1 cN/dtex, yarn unevenness U% was also extremely bad as 4.5%. When a carpet was prepared by using said crimped yarn and evaluated, it was found that an abrasion loss ratio was 87%, which is in the same level as that of polylactic acid alone (Comparative example 1), and its application was considerably limited.

[Table 1]

Table 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative example 1	Example 6	Comparative example 2
Component A	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA
Weight average molecular weight	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000	15.00,000	15.00,000
Melting point (˚C)	177	177	177	177	177	177	178	178
Amount of residual lactide (wt%)	0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.10
Melt viscosity (Pa · s)	225	225	225	225	225	225	116	116
Component B	N6	N6	N6	N6	N6	-	N6	N6
Relative viscosity (or inherent viscosity)	2.15	2.15	2.15	2.15	2.05	-	2.15	2.90
Melting point (˚C)	225	225	225	225	222	-	225	225
Heat of crystal fusion (J/g)	78	78	78	78	82	-	78	76
Melt viscosity (Pa · s)	58	58	58	58	43	-	58	250
Blend ratio (component A/ component B, %)	30/70	10/90	40/60	5/95	47/53	100/0	40/60	30/70
Melt viscosity ratio (ηb/ηa)	0.26	0.26	0.26	0.26	0.19	-	0.50	1.11
Physical properties of fiber								
Island component	PLLA	PLLA	PLLA	PLLA	PLLA	-	PLLA	N6
Sea component	N6	N6	N6	N6	N6	-	N6	PLLA
Exposed area ratio (%) of Component A	1.5	0.1	3.2	0	5.0	0	1.9	83.3
Domain size of the island component (μm)	0.03 to 0.3	0.01 to 0.15	0.03 to 0.8	0.01 to 0.1	0.03 to 0.8	-	0.3 to 2.5	-
Width of grooves of fiber surface layer (μm)	0.26	0.12	0.36	-	0.38	-	0.85	-

(continued)

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative example 1	Example 6	Comparative example 2
Aspect ratio of groove of fiber surface layer	20	17	24	-	25	-	16	-
Number of grooves of fiber surface layer (grooves)	7	1	10	-	13	-	1	-
Carboxyl terminal concentration (eq/ton)	18	20	17	20	20	17	18	18
Non-circularity of fiber cross-section	2.5	2.4	2.6	2.3	2.3	3.0	2.1	2.8
Fiber thickness (dtex)	1500	1500	1500	1500	1500	1500	1500	1500
Strength (cN/dtex)	2.8	3.0	2.6	3.0	2.4	1.5	2.2	1.1
Elongation (%)	48	44	49	43	50	48	44	38
U% (%)	0.8	0.7	0.9	0.6	1.0	1.0	2.1	4.5
Boiling water shrinkage (%)	2.8	3.0	2.6	3.1	2.4	5.5	3.2	4.0
Wear resistance (number of yarn break)	101	185	85	198	52	9	28	11
Crimp elongation percentage (%)	12	13	10	13	8	4.5	9	2.8
Elongation percentage under load (%)	3.5	4	3	4	2.5	1.5	3	1
Physical properties of fiber structure								
Abrasion loss ratio of carpet (%)	25.5	18.1	32.3	15.0	38.8	89	48.7	87
Touch of carpet (softness)	◎	◎	○	◎	△	×	△	×
Appearance of carpet (glossy texture)	◎	△	◎	△	◎	△	△	×

[0251] Note) In the table, "PLLA" means "polylactic acid " and "N6" means "nylon 6".

(Example 7)

[0252] A BCF yarn was obtained in the same way as Example 1 except using nylon 11 of inherent viscosity 1.45 as the component B. Spinnability in Example 7 was extremely stable as that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, it was found that a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 0.9%. Island domain size in diameter equivalent was 0.05 to 0.5 μm. And, when a section of said fiber cross-section was subjected to an alkali etching to thereby dissolve out polylactic acid and observed, it was confirmed that the island component was dropout and polylactic acid constituted the island component.

[0253] Furthermore, when a carpet was prepared by using said crimped yarn and evaluated, it was bulkier and of a higher quality than that of Example 1, and its abrasion resistance was also excellent. And, both of touch and appearance were very excellent as those of Example 1.

(Example 8)

[0254] A BCF yarn was obtained in the same way as Example 1 except using nylon 610 (melting point 225°C) of relative viscosity in sulfuric acid 2.15 as the component B. Spinnability of Example 8 was extremely stable as that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 1.2%. Island domain size in diameter equivalent was 0.03 to 0.3 μm. And, when a section of said fiber cross-section was subjected to an alkali etching to thereby dissolve out polylactic acid and observed, it was confirmed that the island component was dropout and polylactic acid constituted the island component. Further, when a carpet was prepared by using said crimped yarn and evaluated, it was found that both of touch and appearance were excellent as those of Example 1.

(Example 9)

[0255] A BCF yarn was obtained in the same way as Example 1 except using N6/N66 copolymerized nylon (melting point 198°C) polymerized in a weight ratio of ε-caprolactam/hexamethylene diammonium adipate (66 salt) = 85/15 as the component B. Spinnability in Example 9 was extremely stable as that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 1.4%. Island domain size in diameter equivalent was 0.03 to 0.26 μm. And, when a section of said fiber cross-section was subjected to an alkali etching to thereby dissolve out polylactic acid and observed, it was confirmed that the island component was dropout and polylactic acid had constituted the island component. Further, when a carpet was prepared by using said crimped yarn and evaluated, it was bulkier than that of Example 1. And, both of touch and appearance were very excellent as those of Example 1.

(Example 10)

[0256] A BCF yarn was used in the same way as Example 1 except using the polylactic acid P2 (polycarbodiimide "LA-1" : 10 wt%) containing a compatibilizer (component C) and changing the blend ratio to P1/the component B/P2 = 20/70/10 (concentration of the component C with respect to total amount of the component A and the component B : 1.0 wt%). Spinnability of Example 10 was extremely stable as that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 1.1 %. Island domain size in diameter equivalent was 0.03 to 0.3 μm. Further, when a carpet was prepared by using said crimped yarn and evaluated, its abrasion resistance was more excellent than that of Example 1 as well as both of touch and appearance were very excellent as those of Example 1.

(Comparative example 3)

[0257] A BCF yarn was obtained in the same way as Example 1 except carrying out melt spinning by changing the spinning temperature to 270°C (Tmb+45°C). Where, melt viscosity of the component A was 35Pa·s and melt viscosity of the component B was 28Pa·s ($\eta b/\eta a = 0.8$) at said spinning temperature. In Comparative example 3, a swelling occurred due to Barus effect just beneath spinneret and discharged flow was slightly unstable. And, when crimped yarn was sampled 100 kg, yarn break occurred 5 times, and spinnability was slightly inferior to that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, a portion where sea/island structure was partially reversed and a portion where islands were connected to form a co-continuous structure were coexisted. And, strength was 1.4 cN/dtex which was approximately a half of that of Example 1 as well as Uster unevenness U% which indicates yarn unevenness was high as 2.2%. When a carpet was prepared by using said crimped yarn and evaluated, it was found that an abrasion loss ratio was extremely poor as 76.5%, and its glossy texture was also inferior to that of conventional one.

(Comparative example 4)

[0258] A spinning was carried out in the same way as Example 3, except changing the spinneret to a spinneret with a Y type hole of which slit width 0.43 mm, slit length 2.15 mm and depth of hole 0.6 mm. Although swelling just beneath spinneret did not occur, but thinnig was not stable and it was impossible to spin. Where, linear discharge velocity in spinneret hole in Comparative example 4 was 0.0195 m/sec.

(Comparative example 5)

[0259] A spinning was carried out in the same way as Example 3 except changing the spinneret to a spinneret with a Y type hole of which slit width 0.09 mm, slit length 0.45 mm and depth of hole 0.6 mm. In Comparative example 5, an extremely large swelling occurred due to Barus effect just beneath the spinneret, and accordingly, a wave phenomena in which thinnig point goes up and down occurred and it was impossible to spin.
[Table 2]

Table 2

	Example 7	Example 8	Example 9	Example 10	Comparative example 3	Comparative example 4	Comparative example 5
Component A	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA
Weight average molecular weight	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000
Melting point (˚C)	177	177	177	177	177	177	177
Amount of residual lactide (wt%)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Melt viscosity (Pa·s)	225	225	225	225	35	225	225
Component B	N11	N610	N6/66 copolymer	N6	N6	N6	N6
Relative viscosity (or inherent viscosity)	1.45	2.15	2.15	2.15	2.15	2.15	2.15
Melting point (˚C)	186	225	198	225	225	225	225
Heat of crystal fusion (J/g)	76	78	63	78	78	78	78
Melt viscosity (Pa·s)	89	63	61	58	28	58	58
Component C	-	-	-	LA-1	-	-	-
Heat loss ratio at 200˚C (%)	-	-	-	0.3	-	-	-
Content (wt%)	-	-	-	1.0	-	-	-
Blend ratio (component A/ component B, %)	30/70	30/70	30/70	29.8/70.2	30/70	40/60	40/60
Melt viscosity ratio (ηb/ηa)	0.40	0.28	0.27	0.27	0.80	0.71	0.71
Physical properties of fiber							
Island component	PLLA	PLLA	PLLA	PLLA	PLLA/N6	-	-
Sea component	N11	N610	N6/66 copolymer	N6	PLLA/N6	-	-

(continued)

	Example 7	Example 8	Example 9	Example 10	Comparative example 3	Comparative example 4	Comparative example 5
Exposed area ratio (%) of Component A	0.9	1.2	1.4	1.1	11.8	-	-
Domain size of the island component (μm)	0.05 to 0.5	0.03 to 0.3	0.03 to 0.26	0.03 to 0.3	-	-	-
Width of grooves of fiber surface layer (μm)	0.26	0.23	0.25	0.24	0.46	-	-
Aspect ratio of groove of fiber surface layer	21	22	22	19	15	-	-
Number of grooves of fiber surface layer (grooves)	5 8		8	8	2	-	-
Carboxyl terminal concentration (eq/ton)	18	18	18	5	63	-	-
Non-circularity of fiber cross-section	2.7	2.5	2.6	2.7	1.5	-	-
Fiber thickness (dtex)	1500	1500	1500	1500	1500	-	-
Strength (cN/dtex)	2.5	2.2	2.4	2.7	1.4	-	-
Elongation (%)	43	48	45	42	83	-	-
U% (%)	0.8	0.8	1.0	1.0	2.2	-	-
Boiling water shrinkage (%)	2.2	3.3	4.0	3.7	2.3	-	-
Abrasion resistance (number of yarn break)	95	89	85	132	14	-	-
Crimp elongation percentage (%)	21	10	15	12	4.4	-	-
Elongation percentage under load (%)	4.5	3	4	3.5	1.5	-	-
Physical properties of fiber structure							

(continued)

	Example 7	Example 8	Example 9	Example 10	Comparative example 3	Comparative example 4	Comparative example 5
Abrasion loss ratio of carpet (%)	22.5	29.0	30.0	21.2	76.5	-	-
Touch of carpet (softness)	◎	◎	◎	◎	○	-	-
Appearance of carpet (glossy texture)	◎	◎	◎	◎	×	-	-

[0260] Note) In the table, "N11" means "nylon 11", "N610" means "nylon 610" and "N6/66 copolymer" means "copolymerized nylon of nylon 6 and nylon 66".

(Example 11)

[0261] A BCF yarn was obtained in the same way as Example 1 except changing the cooling air speed of the circular chimney to 0.1 m/sec. In Example 11, swelling occurred due to Barus effect just beneath spinneret, and a slight wave phenomena occurred. Accordingly, in sampling of 100 kg, yarn break occurred 2 times. In the obtained crimped yarn, strength was 1.3 cN/dtex which is approximately a half of that of Example 1 as well as Uster unevenness U% which indicates yarn unevenness was high as 3.3%. When a carpet was prepared by using said crimped yarn and evaluated, it was found that an abrasion loss ratio was slightly low as 46.8% and it had a slightly hard and coarse touch, but had a silky glossy texture and appearance was good.

(Example 12)

[0262] A BCF yarn was obtained in the same way as Example 1 except changing the out put to 277g/min, carrying out second stage stretching (stretch ratio : 1.15 times) with 2 DR speed of 2173 m/min and changing the winding speed to 1847 m/min (a speed lower than 2 DR speed by 15%). Elongation at break of stretched yarn samples at the exit of 2 DR was 76%. In the obtained crimped yarn, strength was 1.8 cN/dtex which was approximately 64% of the strength of Example 1 and Uster unevenness U% which indicates yarn unevenness was slightly high as 1.6%. When a carpet was prepared by using said crimped yarn and evaluated, it was found that an abrasion loss ratio was slightly high as 41.1 %, but it was a level which could be used in limited applications.

(Example 13)

[0263] A BCF yarn was obtained in the same way as Example 1 except changing the set temperature at 2 DR to 130˚C. Spinnability in Example 13 was extremely stable as that of Example 1. When an observation by TEM of a cross-section of the obtained fiber was carried out, it was found that a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 1.5%. Island domain size in diameter equivalent was 0.03 to 0.3 μm which was the same level as Example 1, but almost no groove was formed on fiber surface of said crimped yarn. And, crimp elongation percentage was also a half or less of Example 1. When a carpet was prepared by using said crimped yarn and evaluated, although it had more excellent touch than that of conventional one, glossy texture was the same as that of conventional one.

(Example 14)

[0264] A BCF yarn was obtained in the same way as Example 1 except changing the set temperature at 2 DR to 110˚C. Spinnability of Example 14 was stable as that of Example 1. In the obtained fiber, crimp elongation percentage was 2.5%, i.e., crimp development was weak. And, boiling water shrinkage was high as 11.1%, i.e., Example 1 was better in dimensional stability than this example. When a carpet was prepared by using said crimped yarn and evaluated, it was found that both of touch and glossy texture were same level as those of conventional one.

(Example 15)

[0265] A BCF yarn was obtained in the same way as Example 13 except changing the spinneret to a spinneret with circular holes of diameter 0.62 mm and depth of hole 1.0 mm. Spinnability of Example 15 was extremely stable as that of Example 1. Cross-section of the obtained fiber was approximately perfect circle (non-circularity 1.0), and when cross-section was observed by TEM, a uniformly dispersed sea/island structure was formed, and exposed area ratio of polylactic acid with respect to fiber surface area was 1.7%. Island domain size in diameter equivalent was 0.03 to 0.3 μm, i.e., the same level as Example 1. When a carpet was prepared by using said crimped yarn and evaluated, although it had an excellent touch similar to that of Example 1, but as to glossy texture, Example 1 was better than this example.

(Example 16)

[0266] A BCF yarn was obtained in the same way as Example 1 except subjecting hot compressed air treatment by an air jet stuffer machine at nozzle temperature 150˚C. In said crimped yarn, crimp elongation percentage was low as 2.7%, i.e., crimp development was weak. When a carpet was prepared by using said crimped yarn and evaluated, it was found that although glossy texture was excellent, it had somewhat hard and coarse touch.

[Table 3]

Table 3

	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16
Component A	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA
Weight average molecular weight	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000	23.30,000
Melting point (˚C)	177	177	177	177	177	177
Amount of residual lactide (wt%)	0.12	0.12	0.12	0.12	0.12	0.12
Melt viscosity (Pa·s)	225	225	225	225	225	225
Component B	N6	N6	N6	N6	N6	N6
Relative viscosity (or inherent viscosity)	2.15	2.15	2.15	2.15	2.15	2.15
Melting point (˚C)	225	225	225	225	225	225
Heat of crystal fusion (J/g)	78	78	78	78	78	78
Melt viscosity (Pa·s)	58	58	58	58	58	58
Blend ratio (component A/ component B, %)	30/70	30/70	30/70	30/70	30/70	30/70
Melt viscosity ratio (ηb/ηa)	0.26	0.26	0.26	0.26	0.26	0.26
Physical properties of fiber						
Island component	PLLA	PLLA	PLLA	PLLA	PLLA	PLLA
Sea component	N6	N6	N6	N6	N6	N6
Exposed area ratio (%) of Component A	1.6	1.5	1.5	1.5	1.7	1.5
Domain size of the island component (μm)	0.05 to 0.7	0.04 to 0.4	0.03 to 0.3	0.03 to 0.3	0.03 to 0.3	0.03 to 0.3
Width of grooves of fiber surface layer (μm)	0.33	0.33	-	-	0.25	0.18
Aspect ratio of groove of fiber surface layer	18	17	-	-	21	24
Number of grooves of fiber surface layer (grooves)	6	6	-	-	9	4
Carboxyl terminal concentration (eq/ton)	18	20	18	18	18	18
Non-circularity of fiber cross-section	2.4	2.2	2.5	2.5	1.0	2.5
Fiber thickness (dtex)	1500	1500	1500	1500	1500	1500
Strength (cN/dtex)	1.3	1.8	2.9	3.2	2.8	2.8
Elongation (%)	38	89	48	50	49	48

(continued)

	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16
U% (%)	3.3	1.6	0.7	0.6	0.5	0.8
Boiling water shrinkage (%)	2.7	1.7	8.5	11.1	2.5	4.7
Abrasion resistance (number of yarn break)	36	72	108	118	106	128
Crimp elongation percentage (%)	8	5	4.5	2.5	9	2.7
Elongation percentage under load (%)	2.5	1.5	1.5	1	3	1
Physical properties of fiber structure						
Abrasion loss ratio of carpet (%)	46.8	41.1	33.8	32.2	30.5	33.4
Touch of carpet (softness)	△	○	○	△	◎	△
Appearance of carpet (glossy texture)	○	○	△	△	○	○

(Example 17)

[0267] A BCF yarn was obtained in the same way as Example 1 except dry blending 1 wt% (0.3 wt% to whole fiber) of talc "SG-2000" (average particle diameter D50 : 0.98 μm, particle of 10 μm or more : 0 vol%) produced by Nippon Talc Co. to the polylactic acid P1 (component A). Spinnability in Example 17 was extremely stable as that of Example 1. And, said crimped yarn showed an elongation percentage under load which was 1.4 times of that of Example 1, and crimp fastness was high.

(Example 18)

[0268] A BCF yarn was obtained in the same way as Example 1 except dry blending 1 wt% (0.3 wt% to whole fiber) of melamine cyanurate "MC-600" (average particle diameter 1.6 μm, particle of 10 μm or more : 0 vol%) produced by Nissan Chemical Industries, Ltd. to the polylactic acid P1 (component A). Spinnability in Example 18 was extremely stable as that of Example 1. And, said crimped yarn showed an elongation percentage under load which was approximately 1.8 times of that of Example 1, and crimp fastness was extremely high.

(Example 19)

[0269] A BCF yarn was obtained in the same way as Example 1 except dry blending respectively 0.03 wt% of copper iodide and potassium iodide to nylon 6 (component B) (0.021 wt% to whole fiber, respectively).

[0270] Furthermore, the crimped yarn obtained in Example 1 and the crimped yarn obtained in Example 19 were taken as hanks, and subjected to a light resistance test by using UV Auto-fade-meter (type : U48AU) produced by Suga Test Instrument Co. Strength retentions were determined from strengths of before and after the light resistance test under the following condition. As a result, as compared to the strength retention of crimped yarn of Example 1 of 5%, strength retention of crimped yarn of Example 19 was 91%, i.e., which was a crimped yarn extremely excellent in light resistance.

<UV treatment condition>
UV irradiation time : 100hrs
Black panel temperature : 83°C
In-can temperature : 64±3°C
In-can humidity : relative humidity 50±5% at in-can temperature
Strength retention (%) = strength (cN/dtex) after UV treatment/strength

(cN/dtex) before UV treatment × 100

[Table 4]

Table 4

	Example 17	Example 18	Example 19
Component A	PLLA	PLLA	PLLA
Weight average molecular weight	23.30,000	23.30,000	23.30,000
Melting point (˚C)	177	177	177
Amount of residual lactide (wt%)	0.12	0.12	0.12
Melt viscosity (Pa·s)	225	225	225
Crystal nucleating agent	talc	melamine cyanurate	-
Adding amount of nucleating agent (wt%)	1	1	-
Component B	N6	N6	N6
Relative viscosity (or inherent viscosity)	2.15	2.15	2.15
Melting point (˚C)	225	225	225
Heat of crystal fusion (J/g)	78	78	78
Melt viscosity (Pa·s)	58	58	58
Light stabilizer	-	-	CuI/KI
Adding amount of Light stabilizer (wt%)	-	-	0.03/0.03
Blend ratio (component A/component B, %)	30/70	30/70	30/70
Melt viscosity ratio ($\eta b/\eta a$)	0.26	0.26	0.26
Physical properties of fiber			
Island component	PLLA	PLLA	PLLA
Sea component	N6	N6	N6
Exposed area ratio (%) of Component A	1.6	1.6	1.5
Domain size of the island component (μm)	0.03 to 0.3	0.03 to 0.3	0.03 to 0.3
Width of grooves of fiber surface layer (μm)	0.26	0.25	0.26
Aspect ratio of groove of fiber surface layer	19	18	20
Number of grooves of fiber surface layer (grooves)	8	8	7
Carboxyl terminal concentration (eq/ton)	18	18	18
Non-circularity of fiber cross-section	2.5	2.5	2.5
Fiber thickness (dtex)	1500	1500	1500
Strength (cN/dtex)	2.7	2.7	2.7
Elongation (%)	45	46	47
U% (%)	0.9	0.8	0.8
Boiling water shrinkage (%)	2.5	2.2	2.7
Abrasion resistance (number of yarn break)	102	105	100

(continued)

	Example 17	Example 18	Example 19
Crimp elongation percentage (%)	13	14	12
Elongation percentage under load (%)	5	6.3	3.5
Physical properties of fiber structure			
Abrasion loss ratio of carpet (%)	23.2	22.1	26.0
Touch of carpet (softness)	◎	◎	◎
Appearance of carpet (glossy texture)	◎	◎	◎

(Example 20)

[0271] For core component and sheath component respectively, by using continuous spinning, stretching and crimping machine equipped with a single screw kneading machine shown in Fig. 9, a BCF yarn was obtained by continuously carrying out melt spinning, stretching, heat treatment and crimping treatment.

[0272] To the core component hopper 21 shown in Fig. 9, the component A (P4) was fed, and to the sheath component hopper 22, the component B (N6-1 melting point 225˚C, heat capacity of melting point peak 79 J/g, relative viscosity 2.59 and melt viscosity 150 Pa· sec^{-1}) was fed, the component A and the component B were separately molten and kneaded by the single screw extruding/kneading machines 23 and 24, respectively, and introduced into the spinning block 25, respective polymers were metered and discharged by the gear pumps 26 and 27 to introduce into the spinning pack 28, and spun from the spinneret 29 having 96 holes of trilobal cross-section. At this time, numbers of rotation of gear pumps 26 and 27 for the core component and the sheath component were selected such that sheath/core ratio = 60/40 (weight ratio). And the yarn 31 was cooled and solidified by the uniflow cooling apparatus 30 and oiled by the oiling device 32. Furthermore, after taking up by the first roll 33, the unstretched yarn was stretched by setting a speed of the second roll 34 to a speed of 1.02 times of the speed of the first roll 33 and then, stretched by a speed ratio of the second roll 34 and the third roll 35, heat treated by the third roll 35, stretched again by a speed ratio of the third roll 35 and the fourth roll 36, heat treated again by the fourth roll 36, imparted an air stuffer crimp by the crimping nozzle 37 which uses a hot fluid while the yarn was relaxed (overfeed) between the fourth roll 36 and the cooling roll (cooling drum) 38, fixed its structure by cooling the crimped yarn on surface of the cooling roll (cooling drum) 38, imparted a tension between the sixth roll 39 and the seventh roll 40 such that the crimp was not extended (0.08 cN/dtex, fiber thickness of wound crimped yarn was employed as the fiber thickness), interlaced by the interlacing nozzle 47 between the seventh roll 40 and the winder 42, and wound under a tension which did not extend the crimp (0.08 cN/dtex, fiber thickness of wound crimped yarn was employed as the fiber thickness) to obtain a BCF yarn (cheese package 41) of 1920 dtex 96 filaments which was subjected to spinning, stretching, heat treatment and crimp treatment in one step. Approximately 100 kg was sampled but yarn break, single fiber break or the like did not occur and the spinning was extremely stable. Result of Example 20 is shown in Table 5.

[0273] Where, melt spinning, stretching, heat treatment and crimp treatment conditions are as follows.

- Kneading machine temperature : 230˚C
- Spinning temperature : 245˚C
- Filtering layer : filled with 30# morundum sand
- Filter : 20 μm nonwoven fabric filter
- Spinneret 2 (spinneret just before polymer discharge) : slit width 0.15 mm, slit length 1.5 mm and number of holes 96
- Spinneret 1 (spinneret of schematic view 45 of Fig. 12. Positioned just before spinneret 2 having separate flow channels for core component and sheath component)

  Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3
  Core component; slit width 0.12 mm, slit length 1.2 mm and number of holes per one filament 1
- Out put: 498.6g/min (1 pack 1 yarn, 96 filaments)
- Cooling : uniflow of cooling length 1m was used. cooling air temperature 20˚C, wind speed 0.5 m/sec, cooling starting position was 0.1 m beneath spinneret surface
- Oiling agent: 10% concentration emulsion oiling agent of aliphatic acid ester was deposited to by 10% per yarn
- First roll temperature : 25˚C
- Second roll temperature : 70˚C
- Third roll temperature : 135˚C

- · Fourth roll temperature : 190˚C
- · Cooling roll temperature : 25˚C
- · Sixth roll temperature : 25˚C
- · Seventh roll temperature : 25˚C
- · Heated steam treatment temperature : 230˚C
- · First roll speed : 840 m/min (= second roll speed /1.02)
- · Second roll speed : 857 m/min
- · Third roll speed : 2400 m/min
- · Fourth roll speed : 3000 m/min
- · Cooling roll speed : 80 m/min
- · Sixth roll speed : 2550 m/min
- · Seventh roll speed : 2600 m/min
- · Winding speed : 2550 m/min
- · Total stretching ratio : 3.5 times (second to third roll : 2.8 times, third to fourth roll : 1.25 times).
- · Compressed air for interlacing : 0.2 MPa

[0274] The obtained BCF yarn had a crimp configuration in which single fibers were folded in random direction in loop-like state and the single fibers entangle with each other. Strength was 2.3 cN/dtex, boiling water shrinkage was 2.2%, and single fiber thickness was 20 dtex. In addition, it showed excellent crimp characteristics such that crimp elongation percentage was 25% and elongation percentage under load was 13% and it was a crimped yarn of which crimp is durable. And, when a circular knit and a carpet were prepared by using said crimped yarn, both had voluminous feeling and soft touch and exhibited an aesthetic glossiness and excellent in texture.

[0275] Regarding a circular knit fabric of the obtained crimped yarn, as a result of evaluating peeling resistance, there was no appearance change, and it showed an excellent peeling resistance. And, as a result of abrasion resistance test of a carpet in which the obtained crimped yarn was used, it had an excellent abrasion resistance as abrasion loss ratio 10%, and as to the carpet fabric after the abrasion, whitening of the crimped yarn and a splitting of sheath was not observed.

[0276] As a result of observation by TEM of a cross-section of single fiber of the obtained crimped yarn, core component positioned at center of the single fiber, minimum value of thickness of the sheath component was 3.0 μm, and all core component was covered by the sheath component. That is, exposed area ratio of polylactic acid with respect to fiber surface area was 0%. And, non-circularity of single fiber was 3.0 and non-circularity of core component was 3.0. And, melting points of the obtained crimped yarn in DSC were 169˚C (peak based on the component A) and 224˚C (peak based on the component B), i.e., melting peaks based on each component were observed, and total heat capacity of respective melting peaks was 72 J/g, i.e., a sufficient crystallinity was exhibited.

(Comparative example 6)

[0277] It is tried to obtain a BCF yarn comprising only the component A in the same condition as Example 20 except, in Example 20, without using the component B and changing the spinneret, but at the fourth roll 36 and the crimping nozzle 37, thermal bond between single fibers was serious and spinning was impossible. Therefore, by changing the temperature of the third roll 35, the temperature of the fourth roll 36 and the temperature of the crimping nozzle 37, crimped yarn of Comparative example 6 was obtained (at this time, the speed of the sixth roll 39, the speed of the seventh roll 40 and the winding speed were changed such that the tension would be in the range indicated in Example 20. In addition, the out put was controlled such that the single fiber thickness would be 20 dtex). The spinnability was bad and yarn break occurred 15 times in 100 kg sampling. The result of Comparative example 6 is shown in Table 5, and specification of the spinneret, temperature of the third roll 35, temperature of the fourth roll 36, temperature of the crimping nozzle 37, speed of the sixth roll 39, speed of the seventh roll 40 and winding speed of Comparative example 6 are shown in the following.

- · Spinneret 2 of Comparative example 6 : core component slit width 0.12 mm, slit length 1.2 mm and number of holes per one filament 1 (no flow channel for sheath component)
- · Third roll temperature of Comparative example 6 : 90˚C
- · Fourth roll temperature of Comparative example 6 : 110˚C
- · Crimp nozzle temperature of Comparative example 6 : 150˚C
- · Sixth roll speed : 2650 m/min
- · Seventh roll speed : 2660 m/min
- · Winding speed of Comparative example 6 : 2670 m/min

[0278] From Example 20 and Comparative example 6, it is found that the crimped yarn of the present invention becomes a crimped yarn excellent in abrasion resistance and crimp characteristics by having a sheath component. In peeling resistance test of Comparative example 6, since it has not a sheath component, a peeling of sheath/core interface was not observed, but a few weaving or fibrillation of crimped yarn was observed and void portions were observed in all tests. In addition, in the crimped yarn of Comparative example 6, a few thermally bonded portion was observed, strength was low as 1.2 cN/dtex and yarn break occurred frequently in a process of preparing a circular knit fabric or a carpet. In addition, since highly oriented molecular chains were left in the crimped yarn and the boiling water shrinkage was high as 10%, the peeling resistance, abrasion resistance, crimp characteristics of said crimped yarn deteriorated with the lapse of time.

(Examples 21 to 22, Comparative examples 7 and 8)

[0279] Crimped yarns of Examples 21 to 22 and Comparative examples 7 and 8 were obtained in the same way as Example 20 except changing, in Example 20, temperature of fourth roll 36 (at this time, at this time, the speed of sixth roll 39, the speed of the seventh roll 40 and the winding speed were controlled such that the tension would be that indicated in Example 20). In Examples 21 and 22, although they were not a level which causes a trouble, yarn break occurred one times, respectively. Spinnabilities of Comparative examples 7 and 8 were bad and respective yarn breaks were, in Comparative example 7, 11 times and in Comparative example 8, 13 times. Results of Examples 21 to 22 and Comparative examples 7 and 8 are shown in Table 5. The spinning conditions of Examples 21 to 22 and Comparative examples 7 and 8 are described below.

· Fourth roll temperature

Example 21 : 160˚C
Example 22 : 220˚C
Comparative example 7 : 150˚C
Comparative example 8 : 225˚C

[0280] As can be understood by comparing Examples 20 to 22 and Comparative examples 7 and 8, by employing heat treatment temperature 160 to 220˚C of the final roll after stretching, a crimped yarn having a preferable strength and boiling water shrinkage of the present invention, i.e., a crimped yarn excellent in peeling resistance can be obtained in high productivity. It is understood that this is because, by employing the above-mentioned preferable production condition, effect of partially melting the core component on the final roll after stretching and effect that the fiber becomes in a high temperature condition immediately in the crimp nozzle function synergistically and, without being affected by the difference of heat shrinking characteristics between the core component and the sheath component, 2 phase structure of a crystal phase and a random amorphous phase could be formed in the core component and the sheath component. Where, in the crimped yarn of Comparative example 8, the sheath component partially melted by the heat treatment on the final roll, and an irregularity arose in cross-sectional shape to render a portion of the sheath component thin.

[0281] Furthermore, as can be understood by comparing Examples 20 to 22, by employing the more preferable production method in the present invention, it became a crimped yarn excellent also in crimp characteristics. Therefore, a circular knit fabric and a carpet comprising the crimped yarn of Example 20 exhibited an excellent texture compared to those of Examples 21 to 22.

[Table 5]

Item		Example 20	Comparative example 6	Example 21	Example 22	Comparative example 7	Comparative example 8
Component A	-	P4	P4	P4	P4	P4	P4
Melting point of Component A (Tma)	˚C	170	170	170	170	170	170
Melt viscosity of Component A (ηa)	Pa·sec^{-1}	200	200	200	200	200	200

(continued)

Item		Example 20	Comparative example 6	Example 21	Example 22	Comparative example 7	Comparative example 8
Component B	-	N6-1	-	N6-1	N6-1	N6-1	N6-1
Melting point of Component B (Tmb)	˚C	225	-	225	225	225	225
Melt viscosity of Component B (ηb)	Pa·sec^{-1}	150	-	150	150	150	150
Melt viscosity ratio of the component A and the component B (ηb/ηa)	-	0.75	-	0.75	0.75	0.75	0.75
Sheath/core ratio (core component /sheath component)	-	40/60	100/0	40/60	40/60	40/60	40/60
Content of the component A	wt%	40	100	40	40	40	40
Linear discharge velocity	m/min	7.3	7.3	7.5	6.9	7.7	6.7
Spinning temperature	˚C	245	245	245	245	245	245
Total stretching ratio	-	3.5	3.5	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70	70	70
Third roll temperature	˚C	135	90	135	135	135	135
Fourth roll temperature	˚C	190	110	160	220	150	225
Crimp nozzle temperature	˚C	230	150	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000	3000	3000
Winding speed	m/min	2550	2670	2620	2420	2690	2350

(continued)

Item		Example 20	Comparative example 6	Example 21	Example 22	Comparative example 7	Comparative example 8
(1-winding speed/fourth roll speed) × 100	%	15.0	11.0	12.7	19.3	10.3	21.7
Strength	cN/dtex	2.3	1.2	2.9	1.7	3.6	1.3
Elongation	%	45	45	45	45	45	20
Boiling water shrinkage	%	2.2	10	5.3	1.7	9.2	1.1
Single fiber thickness	dtex	20	20	20	20	20	20
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0	3.0	3.0
U% (normal)	-	1.2	2.5	1.3	1.4	2	1.9
Crimp elongation percentage after boiling water treatment	%	25	4	8	33	4	36
Crimp elongation percentage under load	%	13	1	4	20	2	18
CF value	-	13	13	13	13	13	13
Minimum value of sheath component thickness	μm	3.0	0	3.0	2.0	3.0	0.9
Total heat capacity of melting peak of fiber	J/g	72	46	72	72	72	72
Spinnability	◎ to ×	◎	×	◎	◎	○	×
Abrasion loss ratio	wt%	10	72	19	19	33	34
Peeling resistance	◎ to ×	◎ 24	× 5	○ 18	○ 20	× 10	× 10
Bulkiness	◎ to × ◎	◎	×	○	◎	×	○
Softness	◎ to × ◎	◎	×	○	◎	×	△

(Examples 23 to 24, Comparative examples 9 to 10)

[0282] Crimped yarns of Examples 23 to 24, Comparative example 9 to 10 were obtained in the same way as Example 20 except changing total stretching ratio in Example 20 (speed of the first to third rolls were changed to the following ratio and render the speed of the first roll 33 to a value obtained by dividing the speed of the second roll 34 by1.02). In Examples 23 to 24, although they were not a level which causes a trouble, yarn break occurred one time, respectively. Spinnability of Comparative examples 9 to 10 were bad, and yarn breaks were observed in Comparative example 9, 12 times and in Comparative example 10, 14 times. Results of Examples 23 to 24 and Comparative examples 9 to 10are shown in Table 6. Spinning conditions of Examples 23 to 24 and Comparative examples 9 to 10 are shown below.

· Total stretching ratio

Example 23 : 2.1 times (second to third roll : 1.68 times, third to fourth roll : 1.25 times)
Example 24 : 4.9 times (second to third roll: 3.92 times, third to fourth roll : 1.25 times)
Comparative example 9:1.9 times (second to third roll : 1.52 times, third to fourth roll : 1.25 times)
Comparative example 10 : 5.1 times (second to third roll : 4.08 times, third to fourth roll : 1.25 times)

[0283] As can be understood by comparing Examples 20, 23 to 24 and Comparative examples 9 to 10, by employing total stretching ratio 2 to 5 times, it becomes a crimped yarn of the present invention, i.e., a crimped yarn excellent in peeling resistance. By carrying out stretching in the above-mentioned total stretching ratio, spinning speed can be suppressed in an appropriate range, and the core component and the sheath component of the stretched yarn can be uniformly oriented. Therefore, it is understood that this is because, in the crimp processing, a difference of heat shrinking characteristics between the core component and the sheath component is hard to arise and an undue strain is not generated in molecular chains neighboring the sheath/core interface. And, in Example 20, since it has a more preferable fiber structure (strength and boiling water shrinkage) than those of Examples 23 to 24, it is a crimped yarn excellent in peeling resistance.
[Table 6]

Table 6

Item Example		Example23	Example24	Comparative example 9	Comparative example 10
Component A	-	P4	P4	P4	P4
Melting point of the component A (Tma)	˚C	170	170	170	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200	200
Component B	-	N6-1	N6-1	N6-1	N6-1
Melting point of the component B (Tmb)	˚C	225	225	225	225
Melt viscosity of the component B (ηb)	Pa· sec^{-1}	150	150	150	150
Melt viscosity ratio of the component A and the component B (ηb/ηa)	-	0.75	0.75	0.75	0.75
Sheath/core ratio (core component /sheath component)	-	40/60	40/60	40/60	40/60
Content of the component A	wt%	40	40	40	40
Linear discharge velocity	m/min	7.3	7.3	7.3	7.3

(continued)

Item Example		Example23	Example24	Comparative example 9	Comparative example 10
Spinning temperature	˚C	245	245	245	245
Total stretching ratio	-	2.1	4.9	1.9	5.1
Second roll temperature	˚C	70	70	70	70
Third roll temperature	˚C	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000
Winding speed	m/min	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15.0	15.0	15.0	15.0
Strength	cN/dtex	1.6	3.4	1.3	3.7
Elongation	%	55	20	60	15
Boiling water shrinkage	%	1.3	5.4	2	6
Single fiber thickness	dtex	20	20	20	20
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0
U% (normal)	-	1.5	1.8	2.6	2.5
Crimp elongation percentage after boiling water treatment	%	25	25	25	25
Crimp elongation percentage under load	%	13	13	6	7
Minimum value of thickness of sheath component	μm	3.0	3.0	3.0	3.0
CF value	-	13	13	13	13
Total heat capacity of melting peak of fiber	J/g	72	72	72	72
Spinnability	◎ to ×	◎	◎	×	×
Abrasion loss ratio	wt%	13	14	36	34
Peeling resistance	◎ to ×	○ 20	○ 18	× 9	× 9
Bulkiness	◎ to ×	◎	◎	○	○
Softness	◎ to ×	◎	◎	△	△

(Examples 25 to 27, Comparative examples 11 and 12)

[0284] Crimped yarns of Examples 25 to 27and Comparative examples 11 and 12 were obtained in the same way as Example 20 except changing the number of holes of spinneret in Example 20. Although it was not a level which causes a trouble, yarn break occurred one time in both of Examples 25 and Example 26. Spinnabilities were not good in Comparative examples 11 and 12, and yarn breaks occurred in Comparative example 11, 11 times and in Comparative example 12, 12 times. Results of Examples 25 to 27 and Comparative examples 11 and 12 are shown in Table 7. Spinning conditions of Examples 25 to 27 and Comparative examples 11 and 12 are shown below.

· Number of holes of spinneret

Example 25 : 320
Example 26 : 72
Example 27 : 50
Comparative example 11 : 480
Comparative example 12 : 45.

[0285] As can be understood by comparing Examples 20, 25 to 27and Comparative examples 11 and 12, by making to a crimped yarn of the preferable single fiber thickness in the present invention, it becomes to a crimped yarn excellent in peeling resistance. It is understood that this is because, by making single fiber thickness to 40 dtex or less, the core component and the sheath component are quickly heated in the crimp processing step, without giving an undue strain to the sheath/core interface, and 2 phase structure of a crystal phase and a random amorphous phase could be formed. And, by making the single fiber thickness to 5 dtex or more, it is possible to avoid an adverse effect that the crimped yarn was extended by a tension loaded to the yarn and generated a strain in the sheath/core interface, and the peeling resistance could be improved. And, by comparing circular knit fabrics or carpets comprising only crimped yarn of Examples 25, and 27, a circular knit fabric or a carpet comprising the crimped yarn of Example 20 was excellent in voluminous texture and the voluminous texture was able to be maintained for a long time. That is, by making to a crimped yarn of single fiber thickness 5 to 40 dtex, it became a crimped yarn of which crimp fastness was also high.
[Table 7]

Table 7

Item		Example 25	Example 26	Example 27	Comparative example 11	Comparative example 12
Component A	-	P4	P4	P4	P4	P4
Melting point of Component A (Tma)	˚C	170	170	170	170	170
Melt viscosity of Component A (ηa)	Pa·sec^{-1}	200	200	200	200	200
Component B	-	N6-1	N6-1	N6-1	N6-1	N6-1
Melting point of Component B (Tmb)	˚C	225	225	225	225	225
Melt viscosity of Component B (ηb)	Pa·sec^{-1}	150	150	150	150	150
Melt viscosity ratio of the component A and the component B (ηb/ηa)	-	0.75	0.75	0.75	0.75	0.75

(continued)

Item		Example 25	Example 26	Example 27	Comparative example 11	Comparative example 12
Sheath/core ratio (core component /sheath component)	-	40/60	40/60	40/60	40/60	40/60
Content of the component A	wt%	40	40	40	40	40
Linear discharge velocity	m/min	2.2	9.8	14.1	1.5	15.6
Spinning temperature	˚C	245	245	245	245	245
Total stretching ratio	-	3.5	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70	70
Third roll temperature	˚C	135	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000	3000
Winding speed	m/min	2550	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15.0	15.0	15.0	15.0	15.0
Strength	cN/dtex	2.2	2.1	2.2	1.7	2.5
Elongation	%	45	45	45	45	45
Boiling water shrinkage	%	5.1	4.4	4.8	8.3	9.1
Single fiber thickness	dtex	6	26.7	38.4	4	42.7
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0	3.0
U% (normal)	-	1.4	1.4	1.4	8.3	8.1
crimp elongation percentage after boiling water treatment	%	20	25	22	14	20

(continued)

Item		Example 25	Example 26	Example 27	Comparative example 11	Comparative example 12
Crimp elongation percentage under load	%	7	9	6	2	4
Minimum value of thickness of sheath component	µm	1.6	3.4	9.1	1.3	9.4
CF value	-	13	13	13	13	13
Total heat capacity of melting peak of fiber	J/g	70	70	69	68	62
Spinnability	◎ to ×	○	○	○	×	×
Abrasion loss ratio	wt%	19	13	18	32	35
Peeling resistance	◎ to ×	○ 16	○ 20	○ 17	× 8	× 9
Bulkiness	◎ to ×	○	○	○	△	○
Softness	◎ to ×	○	○	△	○	×

(Examples 28 to 31)

[0286] Crimped yarns of Examples 28 to 31 were obtained in the same way as Example 20 except changing, in Example 20, the resins used as the component A and the component B. A yarn break was not confirmed in Examples 28, 29. In Examples 30 and 31, although it was not a level which causes a trouble, yarn break occurred one time, respectively. Results of Examples 28 to 29 are shown in Table 8. The resins used in Examples 28 to 31 were described below.

· Resins used as core component and sheath component

Example 28 : component A = P4, component B = N6-2 (melting point 225˚C, heat capacity of melting point peak 77 J/g, relative viscosity 2.95, melt viscosity 300 Pa·sec^{-1})
Example 29 : component A = P4, component B = N6-3 (melting point 225˚C, heat capacity of melting point peak 78 J/g, relative viscosity 2.10, melt viscosity 50 Pa.sec^{-1})
Example 30 : component A = P5, component B = N6-3
Example 31 : component A = P6, component B = N6-2

[0287] As can be understood by comparing Examples 20, 28 to 31, it is found that, by making the melt viscosity ratio of the component A and the component B used in the present invention to the preferable range of the present invention, crimped yarns excellent in peeling resistance were obtained. It is understood that this is because, by making to a preferable melt viscosity ratio in the present invention, it becomes possible to make stresses to the core component and the sheath component uniform in melt spinning step, and since almost no difference of molecular orientation between the core component and the sheath component of the unstretched yarn was generated, it was possible that the core component and the sheath component were uniformly oriented in the stretching step, difference of heat shrinking characteristics of the respective component in crimp processing became small and molecular chains neighboring the sheath/core interface was hardly be affected with an undue strain.

[0288] Furthermore, compared to circular knit fabrics or carpets comprising the crimped yarn of Examples 28 to 31, a circular knit fabric or a carpet comprising the crimped yarn of Example 20 was excellent in peeling resistance. And, even when the sheath is fibrillated, the core component is hardly exposed, and it is found that the abrasion resistance

was excellent.
[Table 8]

Table 8

Item		Example 28	Example 29	Example 30	Example 31
Component A	-	P4	P4	P5	P6
Melting point of the component A (Tma)	˚C	170	170	170	170
Melt viscosity of the component A (ηa)	Pa · sec^{-1}	200	200	300	120
Component B	-	N6-2	N6-3	N6-3	N6-2
Melting point of the component B (Tmb)	˚C	225	225	225	225
Melt viscosity of the component B (ηb)	Pa·sec^{-1}	300	50	50	300
Ratio of melt viscosity of the component A and the component B (ηb/ηa)	-	1.50	0.25	0.17	2.50
Sheath/core ratio (core component /sheath component)	-	40/60	40/60	40/60	40/60
Content of the component A	wt%	40	40	40	40
Linear discharge velocity	m/min	7.3	7.3	7.3	7.3
Spinning temperature	˚C	245	245	245	245
Total stretching ratio	-	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70
Third roll temperature	˚C	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000
Winding speed	m/min	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15.0	15.0	15.0	15.0
Strength	cN/dtex	3.2	1.6	1.6	3.2
Elongation	%	45	45	45	45
Boiling water shrinkage	%	4.6	4.8	5.6	5.8
Single fiber thickness	dtex	20	20	20	20
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0
U% (normal)	-	1.2	1.2	1.2	1.2
Crimp elongation percentage after boiling water treatment	%	25	25	25	25
Crimp elongation percentage under load	%	11	9	9	3
Minimum value of thickness of sheath component	μm	2.7	3.0	2.3	0.3
CF value	-	13	13	13	13
Total heat capacity of melting peak of fiber	J/g	74	70	72	70
Spinnability	◎ to ×	◎	◎	○	○
Abrasion loss ratio	wt%	15	17	24	26

(continued)

Item		Example 28	Example 29	Example 30	Example 31
Peeling resistance	◎ to ×	○ 21	○ 18	△ 15	△ 15
Bulkiness	◎ to ×	◎	○	○	△
Softness	◎ to ×	◎	○	△	△

(Examples 32 to 36)

[0289] Crimped yarns of Examples 32 to 36 was obtains in the same way as Example 20 except changing the sheath/core ratio (weight ratio) in Example 20. Results of Examples 32 to 36 are shown in Table 5, and the respective sheath/core ratios are shown in the following.

· Example 32 : core component /sheath component = 20/80
· Example 33 : core component /sheath component = 30/70
· Example 34 : core component /sheath component = 60/40
· Example 35 : core component /sheath component = 70/30
· Example 36 : core component /sheath component = 80/20.

[0290] As can be understood from Examples 20 and 32 to 36, it is possible to obtain crimped yarns of which peeling resistances are more excellent, by employing sheath/core ratios considered to be preferable in the present invention. It is understood that this is because, by employing the preferable sheath/core ratio, an area of the sheath/core interface per a unit volume of the core component becomes large. And, since it is possible to prevent a peeling of the sheath/core interface, the core component is not exposed to be shaved when abraded, and it became a crimped yarn more excellent in abrasion resistance. Further, the crimped yarn of Example 20, compared to those of Examples 32 to 36, was a crimped yarn having a crimp of which peeling resistance and fastness were high and of which bulkiness and softness could be maintained for a long time.
[Table 9]

Table 9

Item		Example 32	Example 33	Example 34	Example 35	Example 36
Component A	-	P4	P4	P4	P4	P4
Melting point of the component A (Tma)	˚C	170	170	170	170	170
Melt viscosity of the component A (ηa)	Pa · sec^{-1}	200	200	200	200	200
Component B	-	N6-1	N6-1	N6-1	N6-1	N6-1
Melting point of the component B (Tmb)	˚C	225	225	225	225	225
Melt viscosity of the component B (ηb)	Pa·sec^{-1}	150	150	150	150	150
Melt viscosity ratio of the component A and the component B (ηb/ηa)	-	0.75	0.75	0.75	0.75	0.75
Sheath/core ratio (core component /sheath component)	-	20/80	30/70	60/40	70/30	80/20
Content of the component A	wt%	20	30	60	70	80
Linear discharge velocity	m/min	7.4	7.4	7.2	7.2	7.1
Spinning temperature	˚C	245	245	245	245	245

(continued)

Item		Example 32	Example 33	Example 34	Example 35	Example 36
Total stretching ratio	-	3.5	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70	70
Third roll temperature	˚C	135	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000	3000
Winding speed	m/min	2550	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15.0	15.0	15.0	15.0	15.0
Strength	cN/dtex	2.4	2.3	2	1.8	1.6
Elongation	%	45	45	45	45	45
Boiling water shrinkage	%	2.1	2.1	2.8	4.8	5.5
Single fiber thickness	dtex	20	20	20	20	20
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0	3.0
U% (normal)	-	1.1	1.1	1.4	1.3	1.3
Crimp elongation percentage after boiling water treatment	%	25	25	25	25	25
Crimp elongation percentage under load	%	14	14	10	6	4
Minimum value of thickness of sheath component	μm	4.4	3.8	1.8	1.3	0.9
CF value	-	13	13	13	13	13
Total heat capacity of melting peak of fiber	J/g	77	75	62	58	51
Spinnability	◎ to × ◎	◎	◎	◎	◎	○
Abrasion loss ratio	wt%	9	9	13	20	28
Peeling resistance	◎ to ×	◎ 25	◎ 24	◎ 23	○ 20	△ 14
Bulkiness	◎ to × ◎	◎	◎	◎	○	△
Softness	◎ to × ◎	◎	◎	◎	△	△

(Examples 37 to 41)

[0291] BCF yarns of Examples 36 to 41 were obtained in the same way as Example 20 except changing the non-circularity of single fiber and the non-circularity of core component in Example 20 by changing the spinneret. Results of Examples 37 to 41 are shown in Table 10 and the respective spinneret specifications are shown in the following.

- Spinneret 2 of Example 37 : slit width 0.3 mm, slit length 1.5 mm and number of holes 96
- Spinneret 1 of Example 37 :

Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3

Core component; slit width 0.12 mm, slit length 0.6 mm and number of holes per one filament 1

- Spinneret 2 Example 38 : slit width 0.15 mm, slit length 2.25 mm and number of holes 96
- Spinneret 1 of Example 38 :

Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3
Core component; slit width 0.12 mm, slit length 1.8 mm and number of holes per one filament 1

- Spinneret 2 of Example 39 : slit width 0.25 mm, slit length 0.75 mm and number of holes 96
- Spinneret 1 of Example 39 :

Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3
Core component; slit width 0.12 mm, slit length 0.48 mm and number of holes per one filament 1

- Spinneret 2 of Example 40 : slit width 0.15 mm, slit length 2.70 mm and number of holes 96
- Spinneret 1 of Example 40 :

Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3
Core component; slit width 0.12 mm, slit length 2.16 mm and number of holes per one filament 1.

- Spinneret 2 of Example 41 : spinneret hole diameter 0.6 mm, spinning hole length 0.6 mm and number of holes 96 · Spinneret 1 of Example 41 :

Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3
Core component; hole diameter 0.6 mm, spinning hole length 0.6 mm and number of holes per one filament 1.

[0292] As can be understood from Examples 20 and 37 to 41, it is found that, by being the non-circularity of single fiber high, the single fiber is easily be uniformly heated in the crimp nozzle, a polarization becomes likely to occur in both components of the core component and the sheath component between a crystal phase and a random amorphous phase, in addition, the adhered area of the core component and the sheath component also becomes large and a crimped yarn excellent in peeling resistance is obtained.

[0293] However, compared to those of Examples 38 and 40, crimped yarns of Examples 20, 37, 39 and 41 were more excellent in abrasion resistance. That is, in the present invention, by making the non-circularity of single fiber into the preferable range, it became easy to uniformly cover with the sheath component (minimum value of thickness of sheath component is large), and since the cross-section of single fiber had not an excessively acute angle, a crimped yarn excellent in peeling resistance and abrasion resistance was obtained.
[Table 10]

Table 10

Item		Example 37	Example 38	Example 39	Example 40	Example 41
Component A	-	P4	P4	P4	P4	P4
Melting point of the component A (Tma)	˚C	170	170	170	170	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200	200	200
Component B	-	N6-1	N6-1	N6-1	N6-1	N6-1
Melting point of the component B (Tmb)	˚C	225	225	225	225	225
Melt viscosity of the component B (ηb)	Pa·sec^{-1}	150	150	150	150	150
Melt viscosity ratio of the component A and the component B (ηb/ηa)	-	0.75	0.75	0.75	0.75	0.75

(continued)

Item		Example 37	Example 38	Example 39	Example 40	Example 41
Sheath/core ratio (core component /sheath component)	-	40/60	40/60	40/60	40/60	40/60
Content of the component A	wt%	40	40	40	40	40
Linear discharge velocity	m/min	3.7	4.9	8.8	4.1	17.5
Spinning temperature	˚C	245	245	245	245	245
Total stretching ratio	-	3.5	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70	70
Third roll temperature	˚C	135	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000	3000
Winding speed	m/min	2550	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15.0	15.0	15.0	15.0	15.0
Strength	cN/dtex	2.4	2.1	2.5	2	2.5
Elongation	%	45	45	45	45	45
Boiling water shrinkage	%	3.1	1.8	4.2	1.6	4.5
Single fiber thickness	dtex	20	20	20	20	20
Non-circularity of single fiber	-	1.4	3.8	1.2	4.2	1.0
Non-circularity of core component	-	1.4	3.8	1.2	4.2	1.0
U% (normal)	-	1	1.5	0.8	2.1	0.7
Crimp elongation percentage after boiling water treatment	%	25	25	25	25	25
Crimp elongation percentage under load	%	10	13	10	15	9
Minimum value of thickness of sheath component	µm	6.4	2.4	7.5	0.8	8.2
CF value	-	13	13	13	13	13
Total heat capacity of melting peak of fiber	J/g	72	74	48	74	45
Spinnability	◎ to ×	◎	○	○	○	◎
Abrasion loss ratio	wt%	10	15	10	20	11
Peeling resistance	◎ to ×	○ 20	◎ 24	○ 16	○ 16	○ 16
Bulkiness	◎ to ×	○	◎	○	◎	○
Softness	◎ to ×	○	◎	○	◎	○

Examples 42 to 44)

[0294] BCF yarns of Examples 42 to 44 were obtained in the same way as Example 36 except changing the chip fed to the core component hopper in Example 36. Results of Examples 42 to 44 are shown in Table 11, and the respective chips fed to the core component hopper are shown in the following.

- Core component chip of Example 42 : chip blend of P4/P8 = 90/10 (weight ratio)
- Core component of Example 43 : chip blend of P4/P9 = 90/10 (weight ratio)
- Core component of Example 44 : chip blend of P4/P10 = 90/10 (weight ratio)

[0295] As can be understood from Examples 36 and 42 to 44, it was found that, by containing the component C (compatibilizer) in the crimped yarn, adhesion force of sheath/core interface was improved, and a crimped yarn excellent in peeling resistance and abrasion resistance could be obtained.

(Example 45)

[0296] A BCF yarn of Example 45 was obtained in the same way as Example 36 except changing the chip fed to the sheath component hopper in Example 36. Result of Example 45 was shown in Table 11, the chip fed to the sheath component hopper is shown in the following.

- Sheath component chip of Example 45 : chip blend of N6-1/N6-4 = 80/20 (weight ratio)

N6-4 : nylon 6 containing 10 wt% EBA obtained by feeding dried N6-1 and a lubricant (tradename, Alflow H-50L produced by NOF Corp.) (ethylene bisstearic acid amide, hereafter, referred to as EBA) to a twin screw kneading extruding machine such that N6-1 : EBA = 90 : 10 (weight ratio), and kneading at cylinder temperature 220˚C. Regarding said polymer, the melting point was 225˚C, the heat capacity of melting peak was 81 J/g, the relative viscosity was 2.59, and the melt viscosity was 150 Pa·sec^{-1}.

[0297] As can be understood from Examples 36 and 45, it was found that, by containing EBA (lubricant) in the crimped yarn to thereby increase smoothness of fiber surface, external force became difficult to be transmitted to the fiber, and a crimped yarn excellent in peeling resistance and abrasion resistance can be obtained.
[Table 11]

Table 11

Item		Example 42	Example 43	Example 44	Example 45
Component A	-	P4/P8blend	P4/P9blend	P4/P10blend	P4
Melting point of the component A (Tma)	˚C	170	170	170	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200	200
Component B	-	N6-1	N6-1	N6-1	N6-1 /N6-4 blend
Melting point of the component B (Tmb)	˚C	225	225	225	225
Melt viscosity of the component B (ηb)	Pa·sec^{-1}	150	150	150	150
Component C	-	LA-1	MADGIC	Modiper	-
Content of Component C	wt%	0.8	0.8	1.6	-
Lubricant	-	-	-	-	EBA
Content of lubricant	wt%	-	-	-	0.2
Melt viscosity ratio of the component A and the component B (ηb/ηa)	-	0.75	0.75	0.75	0.75
Sheath/core ratio (core component /sheath component)	-	80/20	80/20	80/20	80/20
Content of the component A	wt%	79.2	79.2	78.4	79.2
Linear discharge velocity	m/min	7.1	7.1	7.1	7.1

(continued)

Item		Example 42	Example 43	Example 44	Example 45
Spinning temperature	˚C	245	245	245	245
Total stretching ratio	-	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70
Third roll temperature	˚C	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000
Winding speed	m/min	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15	15	15	15
Strength	cN/dtex	1.7	1.7	1.6	1.6
Elongation	%	45	45	45	45
Boiling water shrinkage	%	2.1	2.1	2	2
single fiber thickness	dtex	20	20	20	20
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0
U% (normal)	-	1.3	1.3	1.3	1.3
crimp elongation percentage after boiling water treatment	%	25	25	25	25
Crimp elongation percentage under load	%	4	4	4	6
Minimum value of thickness of sheath component	µm	0.9	0.9	0.9	0.9
CF value	-	13	13	13	13
Total heat capacity of melting peak of fiber	J/g	51	51	51	54
Spinnability	◎ to ×	◎	◎	◎	◎
abrasion loss ratio	wt%	16	16	15	15
Peeling resistance	◎ to ×	○ 20	○ 19	○ 20	○ 19
Bulkiness	◎ to ×	△	△	△	○
Softness	◎ to ×	△	△	△	○

(Examples 46 to 50)

[0298] BCF yarns of Examples 46 to 50 were obtained in the same way as Example 20 except changing the chips used as the component A and the component B in Example 20. Where, in Example 49, since it was impossible to spin at the same spinning temperature as Example 20, the spinning was carried out at spinning temperature 270˚C. Results of Examples 46 to 50 are shown in Table 12, and the respective component A and component B are shown in the following.

- Example 46 : component A/component B = P4/N11
- Example 47 : component A/component B = P4/(N6/N66)
- Example 48 : component A/component B = P4/N610
- Example 49 : component A/component B = P4/N66

· Example 50 : component A/component B = P7/N6-1

N 11 : nylon 11, melt viscosity 150 Pa·sec^{-1}, melting point 185°C and heat capacity of melting peak 42 J/g
N6/N66 : nylon in which monomers of nylon 6 and nylon 66 were copolymerized at a mol ratio 80/20, relative viscosity 2.59, melting point 200°C, heat capacity of melting peak 50 J/g and melt viscosity 150 Pa· sec^{-1}
N610 : nylon 610, relative viscosity 2.59, melting point 225°C, heat capacity of melting peak 68 J/g and melt viscosity 150 Pa· sec^{-1}
N66 : nylon 66, relative viscosity 2.59, melting point 260°C, heat capacity of melting peak 73 J/g and melt viscosity 150 Pa·sec^{-1}

[0299] As can be understood from Example 20 and Examples 46 to 48, it was found that, by using the component B of which crystallinity is high as the sheath component in the present invention, crystallization of the sheath component was further accelerated at the time of crimp processing, and a crimped yarn excellent in peeling resistance could be obtained. And, as the crystallinity of crimped yarn becomes high, the crimp fastness becomes high, and it was a crimped yarn excellent on texture of which bulkiness or softness of a circular knit fabric or a carpet could be maintained for a long time.

[0300] As can be understood from Example 20 and Examples 49 to 50, it is found that, by using the component A and the component B having melting points in preferable range of the present invention, it is possible to prevent generating a viscosity unevenness inside the component A due to heat degradation of the component A, a crimped yarn excellent in peeling resistance can be obtained. Since there is no viscosity unevenness inside the component A, it is easy that the core component and the sheath component were uniformly oriented in the spinning·stretching step, and in the crimp processing, difference of heat shrinking characteristics between the core component and the sheath component is hardly generated. As a result, since it becomes a crimped yarn of which boiling water shrinkage is low, a crimped yarn excellent in peeling resistance can be obtained.

[0301] And, in Example 20, compared to Examples 49 to 50, the core component is disposed in the center portion of fiber cross-section, and by constituting the core component and the sheath component with polymers considered to be preferable in the present invention, since fiber surface is uniformly covered with the sheath component (i.e., minimum value of thickness of sheath component is large), a crimped yarn excellent in abrasion resistance can be obtained.

[0302] Furthermore, in Example 20, compared to Examples 49 to 50, since crystallinity of crimped yarn is high, it was a crimped yarn of which crimp fastness was high, and bulkiness or softness of a circular knit fabric or a carpet could be maintained for a long time, and its texture was excellent.

(Example 51)

[0303] A BCF yarn of Example 51was obtained in the same way as Example 20 except changing the spinning temperature in Example 20 to 270°C. It cannot be said that spinnability was good, and 10 times yarn break occurred in 100 kg spinning.

[0304] As can be understood by comparing Example 20 and Example 51, it is found that, by employing spinning temperature considered to be preferable in the present invention, heat degradation of the component A can be prevented and spinnability can be improved.

[0305] Furthermore, as the viscosity unevenness by heat degradation of the component A is suppressed more, a uniform orientation of the core component and the sheath component becomes more easy in spinning·stretching step, and a difference of heat shrinking characteristics between the core component and the sheath component in the crimp processing step is hardly generated. As a result, since it becomes a crimped yarn of which boiling water shrinkage is low, it becomes a crimped yarn excellent in peeling resistance.

[0306] Furthermore, by preventing thermal degradation of the component A, it became possible to dispose the core component in center portion of fiber cross-section to thereby cover fiber surface uniformly with the sheath component (minimum value of sheath component is large), a crimped yarn excellent in abrasion resistance was obtained.
[Table 12]

Table 12

Item		Example 46	Example 47	Example 48	Example 49	Example 50	Example 51
Component A	-	P4	P4	P4	P4	P7	P4

(continued)

Item		Example 46	Example 47	Example 48	Example 49	Example 50	Example 51
Melting point of the component A (Tma)	˚C	170	170	170	170	130	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200	200	200	200
Component B	-	N11	N6/N66	N610	N66	N6-1	N6-1
Melting point of the component B (Tmb)	˚C	185	200	225	260	225	225
Melt viscosity of the component B (ηb)	Pa· sec^{-1}	150	150	150	150	150	150
Melt viscosity ratio of the component A and the component B (ηb/ηa)		0.75	0.75	0.75	0.75	0.75	0.75
Sheath/core ratio (core component /sheath component)	-	40/60	40/60	40/60	40/60	40/60	40/60
Content of the component A	wt%	40	40	40	40	40	40
Linear discharge velocity	m/min	7.3	7.3	7.3	7.3	7.3	7.3
Spinning temperature	˚C	245	245	245	270	245	270
Total stretching ratio	-	3.5	3.5	3.5	3.5	3.5	3.5
Second roll temperature	˚C	70	70	70	70	70	70
Third roll temperature	˚C	135	135	135	135	135	135
Fourth roll temperature	˚C	190	190	190	190	190	190
Crimp nozzle temperature	˚C	230	230	230	230	230	230
Fourth roll speed	m/min	3000	3000	3000	3000	3000	3000

(continued)

Item		Example 46	Example 47	Example 48	Example 49	Example 50	Example 51
Winding speed	m/min	2550	2550	2550	2550	2550	2550
(1-winding speed /fourth roll speed) × 100	%	15.0	15.0	15.0	15.0	15.0	15.0
Strength	cN/dtex	1.9	2	2.4	1.6	1.6	1.6
Elongation	%	45	45	45	45	45	45
Boiling water shrinkage	%	5.8	5.3	2.4	5.5	5.6	5.3
Single fiber thickness	dtex	20	20	20	20	20	20
Non-circularity of single fiber	-	3.0	3.0	3.0	3.0	3.0	3.0
Non-circularity of core component	-	3.0	3.0	3.0	3.0	3.0	3.0
U% (normal)	-	1.6	1.8	1.5	2.5	2.8	2.4
CF value	-	13	13	13	13	13	13
Crimp elongation percentage after boiling water treatment	%	25	25	25	25	25	25
Crimp elongation percentage under load	%	8	10	10	4	4	4
Minimum value of thickness of sheath component	μm	2.7	3.0	2.9	1.1	0.9	1.0
Total heat capacity of melting peak of fiber	J/g	40	48	53	48	42	47
Spinnability	◎ to ×	○	○	◎	△	△	△
Abrasion loss ratio	wt%	13	15	12	27	26	26
Peeling resistance	◎ to ×	◎ 21	○ 20	◎ 23	△ 14	△ 14	△ 14
Bulkiness	◎ to ×	○	○	◎	△	△	△

(continued)

Item		Example 46	Example 47	Example 48	Example 49	Example 50	Example 51
Softness	◎ to ×	○	○	◎	△	△	△

(Example 52)

[0307] In Example 36, an uncrimped stretched yarn was obtained in the same way as Example 36 except using, a spinning stretching continuous heat treatment machine, i.e., using a machine in which a yarn is wound after heat treatment without being subjected to an air stuffer crimp processing. The condition for preparing stretched yarn is shown in the following.

[0308] Preparing condition of stretched yarn

· Kneading machine temperature : 230˚C
· Spinning temperature : 245˚C
· Filtering layer : filled with 30# morundum sand
· Filter : 20 μm nonwoven fabric filter
· Spinneret 2 (spinneret just before polymer discharge) : slit width 0.15 mm, slit length 1.5 mm and number of holes 96
· Spinneret 1 (spinneret 45 of the schematic view of Fig. 12. Positioned just before spinneret 2 and has separate flow channels for core component and sheath component) :

Sheath component; hole diameter 0.5 mm, spinning hole length 0.5 mm and number of holes per one filament 3
Core component; slit width 0.12 mm, slit length 1.2 mm and number of holes per one filament 1

· Out put: 498.6g/min (1 pack 1 yarn, 96 filaments)
· Sheath/core ratio : core component /sheath component = 80/20
· Cooling : uniflow of cooling length 1 m was used. Cooling air temperature 20˚C, wind speed 0.5 m/sec, cooling starting position was 0.1 m beneath spinneret surface
· Oiling agent: 10% concentration emulsion oiling agent of aliphatic acid ester was deposited to by 10% per yarn
· First roll temperature : 25˚C
· Second roll temperature : 70˚C
· Third roll temperature : 135˚C
· Fourth roll temperature : 190˚C
· Seventh roll temperature : 25˚C
· First roll speed : 840 m/min (= second roll speed /1.02)
· Second roll speed : 857 m/min
· Third roll speed : 2400 m/min
· Fourth roll speed : 3000 m/min
· Seventh roll speed : 2900 m/min
· Winding speed : 2860 m/min
· Total stretching ratio : 3.5 times (second to third roll : 2.8 times, third to fourth roll : 1.25 times)
· Compressed air of interlacing nozzle : 0.2 MPa

[0309] The obtained stretched yarn was subjected to a false twist processing (Breria processing) by using a false twist processing machine shown in Fig. 13. That is, stretched yarn 50 unwound from the stretched yarn cheese 48 is taken up by the feed roll 53 via the yarn guides 49, 51 and 52, and then heated to heat set a twist by the first heater 54 and cooled by the cooling plate 56 via the yarn guide 55. After that, it is untwisted by the three axis type twister 57 and taken up by the stretch roll 58. Next, it is heated by the second heater 59 and, via the delivery roll 60 and the yarn guide 61, interlaced by the interlacing nozzle 62 and then, via the yarn guide 63, wound as the false twisted yarn 64. At this time, the stretching false twist processing was carried out by adjusting the stretch ratio to 1.05 times (= speed of stretch roll 58/speed of feed roll 53), the temperature of the first heater 54 to 180˚C, the temperature of the second heater 59 to 200˚C, the D/Y ratio of the three axis type twister 57 (urethane disk) (= peripheral speed of urethane disk/speed of stretch roll 58) to 1.7, the overfeed ratio ([{speed of stretch roll 58 - speed of delivery roll 60}/speed of stretch roll 58] × 100) to 15%, the speed of the delivery roll 60 to 600 m/min and the compressed air of the interlacing nozzle to 0.2 MPa. At this time, although it was not a level which causes a trouble, yarn breaks arose 3 times in obtaining 100 kg false twisted yarn. In the obtained false twisted yarn, the crimp elongation percentage after boiling water treatment was 20%, the strength was 2.4 cN/dtex, single fiber thickness was 20 dtex, the boiling water shrinkage was 6%, elongation was

45%, the minimum vale of thickness of the sheath component was 0.8 μm and the CF value was 13. In peeling resistance evaluation of the false twisted yarn of Example 52, color fading, whitening and pilling generation were observed, but it can be used when limited to clothing applications or the like to which external force added is small (overall evaluation of peeling resistance was △ (fair), overall evaluation was 12 points). The false twisted yarn of Example 52 had a crimp configuration with an orientation in single fiber loop and also with a residual torque, but the BCF yarn of Example 36 was constituted by single fibers of which loop orientation and oscillation thereof were more irregular and it was a crimped yarn with no residual torque. That is, by a BCF yarn having a crimp configuration considered to be preferable in the present invention, it became possible to disperse external force added to the crimped yarn to thereby obtain a crimped yarn excellent in peeling resistance.

(Comparative example 13)

[0310] A false twisted yarn was obtained in the same way as Example 52 except using in Example 52, a false twist processing machine shown in Fig. 13 to the obtained stretched yam and subjecting to a false twist processing (woolly processing) in the following condition. That is, the stretched yarn 50 unwound from the stretched yarn cheese 48 is taken up by the feed roll 53 via the yarn guides 49, 51 and 52, and then heated to heat set a twist by the first heater 54 and cooled by the cooling plate 56 via yarn guide 55. After that, it is untwisted by the three axis type twister 57 and taken up by the stretch roll 58. Next, it is passed to the delivery roll 60 by taking off the second heater 59 (not heated) and, via the yarn guide 61, interlaced by the interlacing nozzle 62 and then, via the yarn guide 63, wound as the false twisted yarn 64. At this time, the stretching false twist processing was carried out by adjusting the stretch ratio to 1.05 times (= speed of stretch roll 58/speed of feed roll 53), the temperature of the first heater 54 to 180°C, the D/Y ratio of the three axis type twister 57 (urethane disk) (= peripheral speed of urethane disk/speed of stretch roll 58) to 1.7, the speed of the stretch roll 58 and the delivery roll 60 to 600 m/min and the compressed air of the interlacing nozzle to 0.2 MPa. At this time, although it was not a level which causes a trouble, yarn breaks arose 3 times in obtaining 100 kg false twisted yarn. The obtained false twisted yarn was a crimped yarn which exhibited a good bulkiness as the crimp elongation percentage after boiling water treatment was 25%, and the strength was 3.7 cN/dtex, elongation was 28% and the boiling water shrinkage was 13%. In peeling resistance evaluation of the false twisted yarn of Comparative example 13, it was a crimped yarn of which appearance was easy to be changed such that a whitening and pilling was serious and a hole was opened, and was a fiber poor in practical use in view of peeling resistance (overall evaluation of peeling resistance was × (poor), overall evaluation was 5 points). As can be understood by comparing Example 52 and Comparative example 13, it was found that, by subjecting a yarn to a processing of highly relaxing treatment while being heated after unwinding (Breria processing) to thereby decrease orientation of amorphous portion and accelerate crystallization to render both of strength and boiling water shrinkage low, the peeling resistance could be improved.

(Example 53)

[0311] As the component A, the polylactic acid P4 (melting point 170°C, melt viscosity 200 Pa·sec^{-1}), and as the component B to be blended in core component, nylon 6 of relative viscosity in sulfuric acid 2.15 (N6-5, melting point 225°C, melt viscosity 60 Pa·sec^{-1}) and as the component B to be used as sheath component, nylon 6 of relative viscosity in sulfuric acid 2.60 (N6-6, melting point 225°C, melt viscosity 150 Pa·sec^{-1}), were respectively dried and adjusted to water contents from 50 to 100 ppm.

[0312] As spinning machine, a continuous spinning and crimping machine equipped with a twin screw kneading machine shown in Fig. 14 was used, and an air stuffer crimped yarn was obtained by continuously subjecting to a melt spinning, stretching, heat treatment and crimping.

[0313] Component A (P4)/component B (N-1) were separately metered and chip blended such that the blend ratio = 40/60 (weight ratio) and fed to the core component hopper 65 shown in Fig. 14, and the component B (N-2) was fed to the sheath component hopper 66, and the blend polymer of the component A and the component B, and the component B were separately molten and kneaded by twin screw extruding/kneading machines 67and 68, respectively, and introduced to the spinning block 69, the respective polymers were metered and discharged by gear pumps 70 and 71, introduced to spinning pack 72 assembled therein and spun from spinneret 73 having 120 holes of fine trilobal cross-sectional hole. At this time, numbers of rotations of the gear pumps of the core component and the sheath component were selected such that the compositing ratio of core component/sheath component = 80/20 (weight ratio) (the sheath/core type composite fiber contains the component A 32 wt% with respect to total weight). And, the yarn 75 was cooled and solidified by the uniflow cooling apparatus 74, and oiled by the oiling device 76. Further, after taking up by the first roll 77, stretched by the speed ratio of the second roll 78 and the third roll 79, heat treated by the third roll 79, further stretched by the speed ratio of the third roll 79 and the fourth roll 80, heat treated again by the fourth roll 80, imparting an air stuffer crimp by the crimping nozzle 81 in which heated fluid is used while the yarn was relaxed between the fourth roll and the cooling roll, structure of the crimped yarn was fixed by cooling to room temperature on surface of the roll

82, stretched between the sixth roll 83 and the seventh roll 84 by loading a tension to an extent which does not extend the crimp (0.05 to 0.10 cN/dtex, fiber thickness of wound crimped yarn was used as the fiber thickness here) and wound by the winder 86 to obtain an air stuffer crimped yarn of 1800 dtex 120 filaments (cheese package 85) in which spinning, stretching, heat treatment and crimping were carried out in one step. Approximately 100 kg was sampled but yarn break, single fiber break or the like did not occur and the spinning was extremely stable. Result of Example 53 is shown in Table 13.

[0314] Where, melt spinning, stretching, heat treatment and crimping conditions were as follows.

· Kneading machine temperature : 230˚C
· Spinning temperature : 240˚C
· Filtering layer : filled with 30# morundum sand
· Filter : 20 μm nonwoven fabric filter
· Spinneret : slit width 0.15 mm, slit length 1.5 mm and number of holes 120
· Spinneret 2 (spinneret just before polymer discharge) : slit width 0.15 mm, slit length 1.5 mm and number of holes 120
· Spinneret 1 (spinneret 45 of schematic view of Fig. 12. Positioned just before spinneret 2 and has separate flow channels of core component and sheath component) :

Sheath component; hole diameter 0.4 mm, spinning hole length 0.5 mm and number of holes per one filament 4
Core component; slit width 0.08 mm, slit length 1.2 mm and number of holes per one filament 1

· Out put: 360g/min (1 pack 1 yarn, 120 filaments)
· Cooling: uniflow of cooling length 1 m was used. Cooling air temperature 20˚C, wind speed 0.5 m/sec, cooling starting position was 0.1 m beneath spinneret surface
· Oiling agent: 10% concentration emulsion oiling agent of aliphatic acid ester was deposited to by 10% per yarn
· First roll temperature : 25˚C
· Second roll temperature : 75˚C
· Third roll temperature : 140˚C
· Fourth roll temperature : 190˚C
· Cooling roll temperature : 25˚C
· Sixth roll temperature : 25˚C
· Seventh roll temperature : 25˚C
· Heated steam treatment temperature : 225˚C
· First roll speed : 690 m/min
· Second roll speed : 700 m/min
· Third roll speed : 1750 m/min
· Fourth roll speed : 2800 m/min
· Cooling roll speed : 80 m/min
· Sixth roll speed : 2000 m/min
· Seventh roll speed : 2040 m/min
· Winding speed : 2000 m/min

[0315] When cross-section of the obtained air stuffer crimped yarn was observed by TEM, it was found that a uniformly dispersed sea/island structure was formed, and diameter of the island component was 0.05 to 0.30 μm. Furthermore, since undyed component constitutes the island component, it was an sea/island structure in which the component A was the island and the component B was the sea (polymer alloy structure a). Furthermore, it showed an excellent crimp characteristics as crimp elongation percentage 25% and elongation percentage under load 19%, and it was a crimped yarn having a crimp of which crimp was hardly lost. And, a carpet was prepared by using said crimped yarn and as a result of carrying out an abrasion resistance test, it showed an excellent abrasion resistance as an abrasion loss ratio 10%. Furthermore, a circular knit of said crimped yarn was prepared and as a result of evaluation of iron heat resistance, it showed an excellent heat resistance as exhibiting no appearance change at all. Melting points of said crimped yarn by DSC were around 170˚C (peak based on the component A) and around 225˚C (peak based on the component B), i.e., melting peaks based on respective components were observed, and total heat capacity of melting peak based on the respective components was 74 J/g which indicated a sufficient crystallinity.

(Examples 54 to 57)

[0316] Air stuffer crimped yarns of Examples 54 to 57 were obtained in the same way as Example 53 except changing, in Example 53, the blend ratio of the component A and the component B to be fed to the core component hopper. Results of Examples 54 to 57 are shown in Table 13 and respective blend ratios (weight ratio) of the component A and the component B are described below.

- Example 54 : component A/component B = 20/80
- Example 55 : component A/component B = 55/45
- Example 56 : component A/component B = 70/30
- Example 57 : component A/component B = 90/10

[0317] From Examples 54 to 57, in the crimped yarn of sheath/core type composite fiber of the present invention, by containing the component B as a core component, adhesion force of the sheath/core interface increases by an interaction between the component B of the core component and the component B of the sheath component and exhibits an excellent abrasion resistance. Furthermore, by making the blend ratio of the component A and the component B of the core component into the range considered to be preferable in the present invention, the polymer alloy structure of the core component and the diameter of the island component can be made into preferable range, and an air stuffer crimped yarn excellent in abrasion resistance can be obtained. And since it has a crimp of which crimp is hardly lost, qualities when used as carpet represented by bulkiness can be maintained for a long time and furthermore, a carpet with no degradation of the abrasion resistance can be obtained.
[Table 13]

Table 13

Item		Example 53	Example 54	Example 55	Example 56	Example 57
Component A	-	P4	P4	P4	P4	P4
Melting point of the component A (Tma)	°C	170	170	170	170	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200	200	200
Component B to be blended in core component	-	N6-5	N6-5	N6-5	N6-5	N6-5
Melting point of the component B (Tmb) blended in core component	°C	225	225	225	225	225
Melt viscosity of the component B (ηb) blended in core component	Pa · sec^{-1}	60	60	60	60	60
Component B to be used as sheath component	-	N6-6	N6-6	N6-6	N6-6	N6-6
Melting point of the component B to be used in sheath component	°C	225	225	225	225	225
Melt viscosity of the component B to be used as sheath component	Pa· sec^{-1}	150	150	150	150	150
Blend ratio of the component A and the component B to be blended in core component (component A/component B)	-	40/60	20/80	55/45	70/30	90/10

(continued)

Item		Example 53	Example 54	Example 55	Example 56	Example 57
Melt viscosity ratio (ηb/ηa) of Component A and the component B to be blended in core component		0.30	0.30	0.30	0.30	0.30
Sheath/core weight ratio (core component /sheath component)	-	80/20	80/20	80/20	80/20	80/20
Content of the component A	wt%	32	16	44	56	72
Linear discharge velocity	m/min	4.3	4.4	4.3	4.3	4.2
Thickness of sheath component	μm	2.2	2.2	2.2	2.2	2.2
Minimum value of thickness of sheath component	μm	2.0	2.0	2.0	2.0	2.0
Polymer alloy structure *	-	a	a	a	b	b
Diameter of island component	μm	0.05-0.30	0.05-0.70	0.05-1.1	0.05-0.5	0.05-0.20
Crimp elongation percentage after boiling water treatment	%	25	25	25	25	25
Crimp elongation percentage under load	%	19	20	18	14	12
Abrasion loss ratio	wt%	10	9	13	15	18
Non-circularity	-	3.0	3.0	3.0	3.0	3.0
Strength of Crimped yarn	cN/dtex	2.5	2.6	2.5	2.2	2.2
Elongation of crimped yarn	%	45	45	45	45	45
Total heat capacity of melting peaks of Fiber	J/g	74	79	63	59	52
Iron heat resistance	◎ to × ×	◎	◎	◎	○	○
Spinnability	to △	◎	◎	◎	○	○

* Polymer alloy structure was evaluated as the following a to c.
a : Island component is the component A and sea component is the component B
b : Island component is the component B and sea component is the component A
c : Both of the component A and the component B are sea component (sea/sea structure)

(Examples 58 to 60)

[0318] Air stuffer crimped yarns of Examples 58 to 60 were obtained in the same way as Example 53 except, in Example 53, by changing the composite ratio of the core component and the sheath component and changing the thickness of sheath component of the stretched yarn.

[0319] Regarding Examples 58 to 59, spinnability was excellent as there was no yarn break and, on the other hand, in Example 60, yarn break occurred 2 times in 100 kg spinning. Results of Examples 58 to 60 are shown in Table 14, and the respective compositing ratio of the core component and the sheath component (weight ratio) are shown below.

- Example 58 : core component /sheath component = 85/15
- Example 59 : core component /sheath component = 90/10
- Example 60 : core component /sheath component = 95/5

[0320] As can be understood by comparing Example 53 (Table 13) and Examples 58 to 60 (Table 14), as the thickness of sheath component becomes large, a crimped yarn of which crimp elongation percentage is high, elongation percentage under load is high and excellent in abrasion resistance can be obtained. And, as the sheath component becomes thick, a high quality crimped yarn not only excellent in abrasion resistance, but also of which elongation percentage under load is high, that is, crimp is hardly lost, can be obtained.

[Table 14]

fable 14

Item		Example 58	Example 59	Example 60
Component A	-	P4	P4	P4
Melting point of the component A (Tma)	˚C	170	170	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200
Component B to be blended in core component	-	N6-5	N6-5	N6-5
Melting point of the component B to be blended in core component (Tmb)	˚C	225	225	225
Melt viscosity of the component B (ηb) to be blended in core component	Pa· sec^{-1}	60	60	60
Component B to be used as sheath component	-	N6-6	N6-6	N6-6
Melting point of the component B to be used as sheath component	˚C	225	225	225
Melt viscosity of the component B to be used as sheath Pa. component	sec^{-1}	150	150	150
Blend ratio of the component A and the component B to be blended in core component (component A/component B)	-	40/60	40/60	40/60
Melt viscosity ratio of the component A and the component B to be blended in core component (ηb/ηa)	-	0.30	0.30	0.30
Sheath/core weight ratio (core component /sheath component)	-	85/15	90/10	95/5
Content of the component A	wt%	34	36	38
Linear discharge velocity	m/min	4.3	4.3	4.3
Thickness of sheath component	µm	1.6	1.1	0.5
Minimum value of thickness of sheath component	µm	1.4	1.0	0.4
Polymer alloy structure *	-	A	A	A
Diameter of island component	µm	0.05-0.30	0.05-0.30	0.05-0.30
Crimp elongation percentage after boiling water treatment	%	25	25	25
Crimp elongation percentage under load	%	16	14	12
Abrasion loss ratio	wt%	11	14	17
Non-circularity	-	3.0	3.0	3.0
Strength of crimped yarn	cN/dtex	2.5	2.4	2.3
Elongation of crimped yarn	%	45	45	45
Total heat capacity of melting peaks of fiber	J/g	74	72	70

(continued)

Item		Example 58	Example 59	Example 60
Iron heat resistance	◎ to ××	◎	◎	◎
Spinnability	◎ to △	◎	◎	○
* Polymer alloy structure was evaluated as the following a to c. a : Island component is the component A and sea component is the component B. b : Island component is the component B, sea component is the component A c : Both of the component A and the component B are sea component (sea/sea structure)				

(Examples 61 to 65)

[0321] Air stuffer crimped yarns were obtained by subjecting to the spinning, stretching, heat treatment and crimping in the same way as Example 53 except changing, in Example 53, the fourth roll temperature. Regarding Examples 53and61 to 64, spinnings were extremely stable as Barus effects of the spun yarn were small and there was no yarn break, but regarding Example 65, a slight oscillation of yarn on the fourth roll occurred and yarn break arose 1 time. Results of Examples 61 to 65 are shown in Table 15. And, the fourth roll temperatures of Examples 61 to 65 are shown below.

· Example 61 : temperature of fourth roll = 140˚C
· Example 62 : temperature of fourth roll = 150˚C
· Example 63 : temperature of fourth roll = 175˚C
· Example 64 : temperature of fourth roll = 200˚C
· Example 65 : temperature of fourth roll = 210˚C

[0322] When Example 53 (Table 13), Examples 62 to 63 (Table 15) and Examples 61 and 65 (Table 15) were compared, it is found that, by making the crimp elongation percentage into the range considered to be preferable in the present invention, abrasion resistance is greatly improved. Since the crimped yarns of Examples 53 and 62 to 63 are crimped yarns having moderate crimp elongation percentages, the crimped yarns are hardly fall down when abraded by an external force, and since they have moderate flections or entanglements, external force was dispersed to respective single fibers and the crimped yarns exhibited excellent abrasion resistances.
[Table 15]

Table 15

Item		Example 61	Example 62	Example 63	Example 64	Example 65
Component A	-	PLA-1	PLA-1	PLA-1	PLA-1	PLA-1
Melting point of the component A (Tma)	˚C	170	170	170	170	170
Melt viscosity of the component A (ηa)	Pa·sec^{-1}	200	200	200	200	200
Component B to be blended in core component	-	N6-5	N6-5	N6-5	N6-5	N6-5
Melting point of the component B (Tmb) to be blended in core component	˚C	225	225	225	225	225
Melt viscosity of the component B (ηb) to be blended in Core component	Pa ·sec^{-1}	60	60	60	60	60
Component B to be used as sheath component	-	N6-6	N6-6	N6-6	N6-6	N6-6

(continued)

Item		Example 61	Example 62	Example 63	Example 64	Example 65
Melting point of the component B to be used as sheath component	˚C	225	225	225	225	225
Melt viscosity of the component B to be used as sheath component	Pa· sec^{-1}	150	150	150	150	150
Blend ratio (component A/component B) of Component A and the component B to be blended in core component	-	40/60	40/60	40/60	40/60	40/60
Melt viscosity ratio (ηb/ηa) of Component A and component B to be blended in core component	-	0.30	0.30	0.30	0.30	0.30
Sheath/core weight ratio (core component/sheath component)	-	80/20	80/20	80/20	80/20	80/20
Content of the component A	wt%	32	32	32	32	32
Linear discharge velocity	m/min	4.3	4.3	4.3	4.3	4.3
Thickness of sheath component	μm	2.2	2.2	2.2	2.2	2.2
Minimum value of thickness of sheath component	μm	2.0	2.0	2.0	2.0	2.0
Polymer alloy structure *	-	a	a	a	a	a
Diameter of island component	μm	0.05-0.20	0.05-0.20	0.05-0.20	0.05-0.20	0.05-0.20
Crimp elongation percentage after boiling water treatment	%	4	6	15	33	36
Crimp elongation percentage under load	%	2	4	11	25	28
Abrasion loss ratio	wt%	25	18	13	8	18
Non-circularity	-	3.0	3.0	3.0	3.0	3.0
Strength of crimped yarn	cN/dtex	3.5	3	2.7	2.2	1.1
Elongation of crimped yarn	%	45	45	45	45	45
Total heat capacity of melting peak of fiber	J/g	72	73	74	74	75
Iron heat resistance	◎ to ××	◎	◎	◎	◎	◎

(continued)

Item		Example 61	Example 62	Example 63	Example 64	Example 65
Spinnability	◎ to △	◎	◎	◎	◎	○

* Polymer alloy structure was evaluated as the following a to c.
a : Island component is the component A and sea component is the component B.
b : Island component is the component B and sea component is the component A.
c : Both of the component A and the component B are sea component (sea/sea structure)

(Examples 66 to 68)

[0323] Air stuffer crimped yarns of Examples 66 to 68 were obtained by subjecting to spinning, stretching, heat treatment and crimping in the same way as Example 53 except changing, in Example 53, the specification of spinneret hole used and the non-circularity of air stuffer crimped yarn to be obtained. Results of Examples 66 to 68 are shown in Table 16. And, the specifications of spinneret used in Examples 66 to 68 are shown below.

· Example 66
Spinneret 2 (spinneret just before polymer discharge) : slit width 0.20 mm, slit width 0.8 mm and number of holes 120
· Example 67
spinneret 2 (spinneret just before polymer discharge) : slit length 0.18 mm, slit width 1.0 mm and number of holes 120
· Example 68
spinneret 2 (spinneret just before polymer discharge) : slit length 0.12 mm, slit width 1.8 mm and number of holes 120

[0324] As can be understood by comparing Example 53 (Table 13) and Examples 66 to 68, in the present invention, by making an air stuffer crimped yarn of which non-circularity is high, abrasion resistance becomes excellent. That is, in the present invention, as the non-circularity of crimped yarn becomes high, diameter of island component becomes easy to be fine in spinning step and since it has a polymer alloy structure of which islands are uniformly dispersed, adhesion force in the interface of component A/component B of the core component and the component B of the of the sheath component increases, and an excellent crimped yarn excellent in abrasion resistance with no fibrillation is obtained. Furthermore, by changing to a crimped yarn of which non-circularity is high, it becomes to a crimped yarn of which crimp is hardly lost, i.e., it becomes to a crimped yarn of which abrasion resistance does not decrease even when used for a long time.

[Table 16]

Item		Example 66	Example 67	Example 68
the component A	-	P4	P4	P4
Melting point of the component A (Tma)	˚C	170	170	170
Melt viscosity of the component A (ηa)	$\mathrm{Pa \cdot sec^{-1}}$	200	200	200
the component B to be blended in core component	-	N6-5	N6-5	N6-5
Melting point of the component B (Tmb) to be blended in core component	˚C	225	225	225
Melt viscosity of the component B (ηb) blended in core component	$\mathrm{Pa \cdot sec^{-1}}$	60	60	60
Component B to be used as sheath component	-	N6-6	N6-6	N6-6
Melting point of the component B to be blended in sheath component	˚C	225	225	225
Melt viscosity of the component B to be blended in sheath component	$\mathrm{Pa \cdot sec^{-1}}$	150	150	150
blend ratio of the component A and the component B to be blended in core component (component A/ component B)	-	40/60	40/60	40/60

(continued)

Item		Example 66	Example 67	Example 68
melt viscosity ratio of the component A and the component B to be blended in core component (ηb/ηa)	-	0.30	0.30	0.30
sheath/core weight ratio (core component /sheath component)	-	80/20	80/20	80/20
Content of the component A	wt%	32	32	32
linear discharge velocity	m/min	6.1	5.4	4.5
Thickness of sheath component	μm	2.2	2.2	2.2
Minimum value of thickness of sheath component	μm	2.1	2.1	1.9
polymer alloy structure *	-	a	a	a
Diameter of island component	μm	0.05-0.45	0.05-0.35	0.05-0.20
crimp elongation percentage after boiling water treatment	%	25	25	25
Crimp elongation percentage under load	%	10	14	20
abrasion loss ratio	wt%	19	15	8
non-circularity	-	1.2	1.3	4.0
strength of crimped yarn	cN/dtex	2.5	2.5	2.4
elongation of crimped yarn	%	45	45	45
total heat capacity of melting peaks of fiber	J/g	71	72	70
Iron heat resistance	◎ to ××	◎	◎	◎
Spinnability	◎ to △	◎	◎	◎

* Polymer alloy structure was evaluated as the following a to c.
a : Island component is the component A and sea component is the component B.
b : Island component is the component B and sea component is the component A.
c : Both of the component A and the component B are sea component (sea/sea structure)

(Example 69)

(Spinning·stretching·crimp processing)

[0325] Polylactic acid P4 as the component A and nylon 6 (melt viscosity 580 poise, melting point 225°C) as the component B are kneaded in an extruding machine at kneading mass ratio (polylactic acid : nylon) 30 : 70 at kneading temperature 230°C, and supplied to a spinning machine.

[0326] Spinning temperature in the spinning machine was adjusted to 230°C, and after the molten polymer mixture was filtered in a spinning pack by a metallic nonwoven fabric filter of mesh size 20 μm, it was discharged as a yarn from a spinneret having Y type hole of number of holes 54.

[0327] The spun yarn discharged from the spinneret was, after cooled and solidified by a chimney wind, imparted with an oiling agent liquid of 25 % by weight diluted with low viscosity mineral oil and then contacted around a take-up roll (Nelson type roll, rotation speed 700 m/min, roll temperature 65°C).

[0328] The yarn was not wound and successively subjected to first stretching by contacting around first stretch roll (Nelson type roll, rotation speed 600 m/min, roll temperature 110°C). Furthermore, the yarn was, without winding, successively subjected to second stretching by contacting around second stretch roll (Nelson type roll, rotation speed 1800 m/min, roll temperature 150°C).

[0329] Without winding the yarn, the stretched yarn was successively introduced to a crimp processing machine and subjected to a crimp processing by hot compressed air of 170°C and 0.8 MPa, and ejected on a rotating conveyor and cooled. Next, plug-like crimped yarn piece was stretched by a pair of separate roll to unravel the piece. Said crimped yarn was interlaced, wound into a cheese to obtain a crimped yarn of 2000 dtex-94fil.

[0330] As to the obtained crimped yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, by treating with aqueous solution of sodium hydroxide, since the island structure was dissolved and the sea structure remained, it was confirmed that polylactic acid resin formed the island structure and nylon 6formed the sea structure.

[0331] And, domain size of the island structure was 25 to 400nm (average 180nm).

[0332] And, non-circularity of the Y type fiber cross-section was 1.34.

(Yarn twisting)

[0333] The above-mentioned crimped yarn was twisted at 160 t/m S-twist as first twist, furthermore 2 yarns were paralleled and twisted at 160 t/m Z-twist as second twist, and heat set at 105˚C.

(Dyeing)

[0334] Since nylon 6 forms the covering component, in order to dye nylon 6 with a metal-complex dye, the dyeing treatment was carried out in the following way.

[0335] A dyeing bath of bath ratio 1 : 15 was prepared in a dyeing machine, IRGALAN (R) Black RBLN 2.0% owf as a metal-complex dye, acetic acid 0.5 g/l and ammonium sulfate 0.5 g/l as a dyeing auxiliary agent were added, and in said dyeing bath, the above-mentioned twisted yarn was put and subjected to a dyeing treatment at 90˚C for 20 minutes.

(Base cloth)

[0336] A spunbond nonwoven fabric of single fiber thickness 5.5 dtex and weight 100g/m^2 was obtained from the polylactic acid P4 as the base cloth of carpet.

(Tufting)

[0337] The above-mentioned twisted yarn was tufted to the above-mentioned base cloth at 1/8 gauge and 6.8 stitch/mm to thereby obtain a loop carpet for car option mat of pile weight 700g/m^2.

[0338] Abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 3.5%, at 5500 rotation abrasion, 33.3%, and an abrasion loss ratio after wet heat degradation was 5.2%, i.e., it exhibited an excellent abrasion resistance. And, the obtained carpet for option mat exhibited a deep excellent color.

(Example 70)

(Spinning·stretching·crimp processing)

[0339] A spinning· stretching· crimp processing were carried out in the same way as Example 69.

(Yarn twisting)

[0340] Yarn twisting was carried out in the same way as Example 69.

(Dyeing)

[0341] A dyeing was carried out in the same way as Example 69.

(Base cloth)

[0342] The same one as Example 69 was used as the base cloth of carpet.

(Tufting)

[0343] The above-mentioned twisted yarn was tufted to the above-mentioned base cloth, at 1/8 gauge and 7.5 stitch/mm and the pile ends were cut to obtain a saxony carpet for car option mat of which pile length was 10 mm and pile weight was 1100g/m^2.

[0344] The abrasion loss ratio of the obtained carpet for option mat was, at 300 rotation abrasion, 2.2%, at 5500 rotation abrasion, 20.8% and abrasion loss ratio after wet heat degradation was 3.1 %, i.e., it exhibited a good abrasion resistance. And, the obtained carpet for option mat exhibited a deep and excellent color.

(Example 71)

(Spinning·stretching·crimping processing)

[0345] Spinning·stretching·crimping processing was carried out in the same way as Example 69 except changing the total output of polymer and the number of holes of spinneret, and obtained a crimped yarn of 1450 dtex-54fil.

[0346] As to the obtained crimped yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, by treating with aqueous solution of sodium hydroxide, since the island structure was dissolved and the sea structure remained, it was confirmed that polylactic acid resin formed the island structure and nylon 6 formed the sea structure.

[0347] And, domain size of the island structure was 25 to 400nm (average 200nm).

[0348] And, non-circularity the Y type fiber cross-section was 1.34.

(Yarn twisting)

[0349] Yarn twisting was not carried out.

(Dyeing)

[0350] Since nylon 6 forms the covering component, in order to dye nylon 6, dyeing was carried out in the same way as Example 69..

(Base cloth)

[0351] The same one as that of Example 69 was used as a base cloth of carpet.

(Tufting)

[0352] The above-mentioned crimped yarn was tufted to the above-mentioned base cloth at 1/10 gauge and 12 stitch/mm, and the pile ends were cut to obtain a velour carpet for car line mat of which pile length was 6 mm and pile weight was 450g/m^2.

[0353] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 2.6% and abrasion loss ratio after wet heat degradation was 4.2%, i.e., it exhibited a good abrasion resistance. And, the obtained carpet exhibited a deep excellent color. And, heat resistance of the obtained carpet was good as there was no thermal bond.

(Comparative example 16)

(Spinning·stretching·crimping processing)

[0354] A crimped yarn was obtained in the same way as Example 69 except changing the kneading mass ratio of polylactic acid and nylon to 100 : 0.

(Yarn twisting)

[0355] Yarn twisting was carried out in the same way as Example 69.

(Dyeing)

[0356] Since it was 100 % by weight polylactic acid resin, in order to dye polylactic acid resin with a disperse dye, dyeing treatment was carried out in the following way.

[0357] A dyeing bath of bath ratio 1 : 15 was prepared in a dyeing machine and, as disperse dyes, Disperse Yellow KT-1, Disperse Red KT-1, Disperse Blue KT-1 5%owf as total dye concentration, as dyeing auxiliary agent, acetic acid 0.5 g/l and Nicca Sunsalt RM-340 (produced by Nicca Chemical Co.) 0.5 g/l were added, and the above-mentioned twisted yarn was put in said dyeing bath and subjected to a dyeing treatment at 110˚C for 30 minutes.

(Base cloth)

[0358] The same one as that of Example 69 was used as a base cloth for carpet.

(Tufting)

[0359] The crimped yarn was tufted in the same way as Example 69 to thereby obtain a loop carpet of pile weight 700g/m^2.

[0360] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 6.3%, at 5500 rotation abrasion, 95.2% and abrasion loss ratio after wet heat degradation was 25.2%, i.e., every value was inferior to those of Example 69.

(Comparative example 17)

(Spinning·stretching·crimping processing)

[0361] A crimped yarn was obtained in the same way as Example 69 except changing the kneading mass ratio of polylactic acid and nylon to 70 : 30.

[0362] As to the obtained crimped yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, since sea structure was dissolved out and island structure remained after being treated with aqueous solution of sodium hydroxide, it was confirmed that polylactic acid resin formed the sea structure and nylon 6 formed the island structure.

(Yarn twisting)

[0363] Yarn twisting was carried out in the same way as Example 69.

(Dyeing)

[0364] Since polylactic acid resin formed covering component, in order to dye polylactic acid resin with a disperse dye, dyeing was carried out in the same way as Comparative example 16.

(Base cloth)

[0365] The same one as that of Example 69 was used as a base cloth for carpet.

(Tufting)

[0366] The above-mentioned twisted yarn was tufted to the above-mentioned base cloth at 1/8 gauge and 7.5 stitch/mm and the pile ends were cut to thereby obtain a saxony carpet of which pile length was 10 mm and pile weight was 11 g/m^2.

[0367] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 3.2%, at 5500 rotation abrasion, 75.1%, and abrasion loss ratio after wet heat degradation was 18.8%, i.e., it was inferior to that of Example 70.

(Comparative example 18)

(Spinning·stretching·crimping processing)

[0368] A crimped yarn was obtained in the same way as Example 69 except changing the kneading mass ratio of polylactic acid and nylon to 100 : 0.

(Yarn twisting)

[0369] Yarn twisting was carried out in the same way as Example 69.

(Dyeing)

[0370] Since it was 100 % by weight polylactic acid resin, in order to dye polylactic acid resin with a disperse dye, dyeing was carried out in the same way as Comparative example 16.

(Base cloth)

[0371] The same one as that of Example 69 was used as a base cloth for carpet.

(Tufting)

[0372] The above-mentioned twisted yarn was tufted to the above-mentioned base cloth at 1/8 gauge and 7.5 stitch/mm, and the pile ends were cut to thereby obtain a saxony carpet of which pile length was 10 mm and pile weight was 1100g/m^2.
[0373] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 2.4%, at 5500 rotation abrasion, 85.6%, and abrasion loss ratio after wet heat degradation was 19.9%, i.e., it was inferior to that of Example 70.

(Comparative example 19)

(Spinning·stretching·crimping processing)

[0374] A spinning·stretching·crimping processing was carried out in the same way as Example 69 except changing the total output of polymer and the number of holes of spinneret and the kneading mass ratio of polylactic acid and nylon to 70 : 30, and obtained a crimped yarn of 1450 dtex-54fil.
[0375] As to the obtained crimped yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, since sea structure was dissolved out and island structure remained after being treated with aqueous solution of sodium hydroxide, it was confirmed that polylactic acid resin formed the sea structure and nylon 6 formed the island structure.

(Yarn twisting)

[0376] Yarn twisting was not carried out.

(Dyeing)

[0377] Since polylactic acid resin formed covering component, in order to dye polylactic acid resin with a disperse dye, dyeing was carried out in the same way as Comparative example 16.

(Base cloth)

[0378] The same one as that of Example 69 was used as a base cloth for carpet.

(Tufting)

[0379] The above-mentioned crimped yarn was tufted to the above-mentioned base cloth at 1/10 gauge and 12 stitch/mm, and the pile ends were cut to thereby obtain a velour carpet of which pile length was 6 mm and pile weight was 450g/m^2.
[0380] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 40.2%, and abrasion loss ratio after wet heat degradation was 50.3%, i.e., it was inferior to that of Example 71. And, heat resistance of the obtained carpet was inferior to that of Example 71, as a fusion bond of the pile occurred in said test.

(Comparative example 20)

(Spinning·stretching·crimping processing)

[0381] A spinning·stretching·crimping processing was carried out in the same way as Example 69 except changing the total output of polymer, the spinneret and the kneading mass ratio of polylactic acid and nylon to 100 : 0, and obtained a crimped yarn of 1450 dtex-54fil.

(Yarn twisting)

[0382] Yarn twisting was not carried out.

(Dyeing)

[0383] Since it was 100 weight % polylactic acid resin, in order to dye polylactic acid resin with a disperse dye, dyeing was carried out in the same way as Comparative example 16.

(Base cloth)

[0384] The same one as that of Example 69 was used as a base cloth for carpet.

(Tufting)

[0385] The above-mentioned crimped yarn was tufted to the above-mentioned base cloth at 1/10 gauge and 12 stitch/mm, and pile ends were cut to obtain a velour carpet of which pile length was 6 mm and pile weight was 450g/m^2.

[0386] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 43.4%, and abrasion loss ratio after wet heat degradation was 70.2%, i.e., it was inferior to that of Example 71.

[0387] And, heat resistance of the obtained carpet was inferior to that of Example 71, as a fusion bond of the pile occurred in said test.

(Comparative example 21)

(Spinning·stretching·crimping processing)

[0388] A spinning·stretching·crimping processing was carried out in the same way as Example 69 except changing the total output of polymer, the spinneret and the kneading mass ratio of polylactic acid and nylon to 0 : 100 to thereby obtain a crimped yarn of 1560 dtex-96fil.

(Yarn twisting)

[0389] The above-mentioned crimped yarn was twisted at 140 t/m S-twist as first twist and 2 yarns were paralleled and furthermore, twisted at 140 t/m Z-twist as second twist, and heat set at 125˚C.

(Dyeing)

[0390] In order to dye nylon 6, dyeing was carried out in the same way as Example 69.

(Base cloth)

[0391] The same one as that of Example 69 was used as a base cloth for carpet.

(Tufting)

[0392] The above-mentioned twisted yarn was tufted to the above-mentioned base cloth at 1/10 gauge and 8.5 stitch/mm, and pile ends were cut to thereby obtain a saxony carpet of which pile length was 10 mm and pile weight was 1100g/m^2.

[0393] The abrasion loss ratio of the obtained carpet was, at 300 rotation abrasion, 1.0%, at 5500 rotation abrasion, 9.2%, and abrasion loss ratio after wet heat degradation was 2.1 %, i.e., it exhibited a good abrasion resistance. And, the obtained carpet was inferior in color brightness to those of Examples.
[Table 17]

Table 17

Item			Example 69	Example 70	Example 71	Comparative example 16	Comparative example 17	Comparative example 18	Comparative example 19	Comparative example 20	Comparative example 21
Raw yarn	Fiber thickness	dtex	2000	2000	1450	2000	2000	2000	1450	1450	1560
	Pile component		PLA/N6	PLA/N6	PLA/N6	PLA	PLA/N6	PLA	PLA/N6	PLA	N6
	Sea component		N6	N6	N6	PLA	PLA	PLA	PLA	PLA	-
	Weight ratio	PLA/N6	30/70	30/70	30/70	100/0	70/30	100/0	70/30	100/0	0/100
	N6 melt viscosity	poise	580	580	580	-	580	-	580	-	580
	PLA melt viscosity	poise	1210	1210	1210	1210	1210	1210	1210	1210	-
	Tensile strength	cN/ dtex	3.04	3.04	3.04	1.78	2.12	1.78	2.12	1.78	3.52
	Yarn unevenness	U%	1.55	1.55	1.55	1.34	3.12	1.34	3.12	1.34	1.10
Twisted yarn			2ply	2ply	-	2ply	2ply	2ply	-	-	2ply
			160S/ 160Z	160S/ 160Z		160S/160Z	160S/160Z	160S/160Z			140S/140Z
Tuft	Texture		loop	saxony	velour	loop	saxony	saxony	velour	velour	saxony
	Weight	g/m2	700	1100	450	700	1100	1100	450	450	1100
Use	-		option mat	option mat	line mat	option mat	option mat	option mat	line mat	line mat	option mat
Abrasion loss ratio	300 times	%	3.5	2.2	2.6	6.3	3.2	2.4	40.2	43.4	1.0
Abrasion loss ratio	5500 times	%	33.3	20.8	-	95.2	75.1	85.6	-	-	9.2

(continued)

Item			Example 69	Example 70	Example 71	Comparative example 16	Comparative example 17	Comparative example 18	Comparative example 19	Comparative example 20	Comparative example 21
Abrasion loss ratio after Wet heat degradation	300 times	%	5.2	3.1	4.2	25.2	18.8	19.9	50.3	70.2	2.1
Line mat heat resistance		grade	-	-	◎	-	-	-	×	×	-
Color brightness		grade	◎	◎	◎	△	○	△	○	△	△
PLA : polylactic acid N6 : nylon 6											

(Example 72)

(Spinning·stretching)

[0394] Polylactic acid P4 as the component A and nylon 6 (melt viscosity 580 poise, melting point 225˚C) as the component B were mixed and kneaded by an extruding machine at kneading mass ratio (polylactic acid : nylon) 30 : 70 and kneading temperature 230˚C, and supplied to a spinning machine.

[0395] Spinning temperature in the spinning machine was adjusted to 230˚C, and after the polymer mixture was filtered in the spinning pack by a metallic nonwoven fabric filter of mesh size 20 μm, it was discharged as a yarn from a spinneret having circular holes of which number of holes was 26.

[0396] At spinning speed 2000 m/min, an unstretched yarn of 252 dtex-26fil was wound and, after that, subjected to a one stage stretching by a vertical type stretching machine in a condition of stretch ratio 3.0 times, stretching temperature 90˚C and set temperature 130˚C to thereby obtain a stretched yarn of 84 dtex-26fil.

[0397] As to the obtained stretched yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, since the island structure was dissolved and the sea structure remained after treating with aqueous solution of sodium hydroxide, it was confirmed that polylactic acid resin formed the island structure and nylon 6 formed the sea structure.

[0398] And, domain size of the island structure was 15 to 200nm (average 100nm).

(Yarn assembling·knitting)

[0399] 4 of the obtained stretched yarn were assembled and a double jersey for car sheets were prepared.

(Dyeing)

[0400] Since nylon 6 formed covering component, in order to dye nylon 6 with metal-complex dye, dyeing treatment was carried out in the following way.

[0401] A dyeing bath of bath ratio 1 : 15 was prepared in a dyeing machine, by adding IRGALAN (R) Black RBLN 2.0% owf as metal-complex dyes, acetic acid 0.5 g/l and ammonium sulfate 0.5 g/l as dyeing auxiliary agent, and the above-mentioned twisted yarn was put into said dyeing bath, and a dyeing treatment was carried out at 90˚C for 20 minutes.

[0402] The obtained car sheet had a strength having no problem in practical use, and strength retention at 90˚C atmosphere was also of no problem in practical use as 67.9%, and abrasion resistance was also good.

(Example 73)

(Spinning·stretching)

[0403] A stretched yarn of 84 dtex-26fil was obtained in the same way as Example 72 except changing the kneading mass ratio of polylactic acid and nylon (polylactic acid : nylon) to 20 : 80.

[0404] As to the obtained stretched yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, by treating with aqueous solution of sodium hydroxide, since the island structure was dissolved and the sea structure remained, it was confirmed that polylactic acid resin formed the island structure and nylon 6 formed the sea structure.

(Yarn assembling·knitting)

[0405] 4 of the obtained stretched yarn were assembled and a double jersey for car sheets was prepared.

(Dyeing)

[0406] Since nylon 6 formed the covering component, in order to dye nylon 6 with a metal-complex dye, dyeing was carried out in the same way as Example 72.

[0407] The obtained fabric had strength of no problem in practical use, and, strength retention in 90˚C atmosphere was also of no problem in practical use as 75.8%, and abrasion resistance was also good.

(Comparative example 22)

(Spinning·stretching)

[0408] A stretched yarn of 84 dtex-26fil was obtained in the same way as Example 72 except changing the kneading mass ratio of polylactic acid and nylon (polylactic acid : nylon) to 70 : 30.

[0409] As to the obtained stretched yarn, island/sea relation of polylactic acid resin and nylon 6 in the fiber was observed and, since sea structure was dissolved out and sea structure remained after treatment of an aqueous solution of sodium hydroxide, it was confirmed that polylactic acid resin formed the sea structure and nylon 6 formed the island structure.

(Yarn assembling·knitting)

[0410] 4 of the obtained stretched yarn were assembled and prepared a double jersey for car sheets.

(Dyeing)

[0411] Since polylactic acid resin formed covering component, in order to dye polylactic acid resin with a disperse dye, dyeing was carried out in the same way as Comparative example 16.

[0412] The obtained fabric was low in strength retention at 90˚C atmosphere as 29.3%, and abrasion resistance was also inferior to that of Example 72, and its practical use was difficult as a result.

(Comparative example 23)

(Spinning·stretching)

[0413] A stretched yarn was obtained in the same way as Example 72 except changing the kneading mass ratio of polylactic acid and nylon to 100 : 0.

(Yarn assembling·knitting)

[0414] 4 of the obtained stretched yarn were assembled, and a double jersey was prepared in the same way as Example 72.

(Dyeing)

[0415] Since it was 100 % by weight polylactic acid resin, in order to dye polylactic acid resin with a disperse dye, dyeing was carried out in the same way as Comparative example 16.

[0416] The obtained fabric was low in strength retention in 90˚C atmosphere as 25.6%, and abrasion resistance was also inferior to that of Example 72, and its practical use was difficult as a result.

[Table 18]

Table 18

Item			Example 72	Example 73	Comparative example 22	Comparative example 23
Raw yarn	Fiber thickness	dtex	84	84	84	84
	Yarn component		PLA/N6	PLA/N6	PLA/N6	PLA
	Sea component		N6	N6	PLA	PLA
	Weight ratio	PLA/N6	30/70	20/80	70/30	100/0
	N6 melt viscosity	poise	580	580	580	-
	PLA melt viscosity	poise	1210	1210	1210	1210
	Tensile strength	cN/dtex	4.3	4.5	3.2	4.3
	Yarn unevenness	U%	1.1	0.9	1.6	0.8
Fabric	Knit structure		double jersey mocro cloth	double jersey mocro cloth	double jersey mocro cloth	double jersey mocro cloth
	Wale	W/inch	29	29	30	29
	Course	C/inch	48	42	40	42
	Weight	g/m^2	618	498	512	498
	Dyeing condition	˚C×min	90×30	90×30	105×30	110×30
	Tensile strength	N	1286	1336	638	899
	Strength retention at 90˚C atmosphere	%	67.9	75.8	29.3	25.6
	Abrasion loss of Fabric	g	0.15	0.11	0.50	0.47

[Industrial Applicability]

[0417] By the present invention, it is possible to provide a crimped yarn and a fiber structure constituted by a synthetic fiber comprising an aliphatic polyester resin and a thermoplastic polyamide resin excellent in abrasion resistance as well as aesthetic appearance after dyeing, and it is possible to provide a synthetic fiber and a fiber structure most suitable for general apparel applications or industrial material applications.

Claims

1. A crimped yarn **characterized in that** a synthetic fiber comprising an aliphatic polyester resin (A) and a thermoplastic polyamide resin (B) and almost no aliphatic polyester resin (A) is exposed on fiber surface, and a crimp is imparted to a multifilament comprising said synthetic fiber.

2. A crimped yarn according to Claim 1 **characterized in that** a synthetic fiber comprising the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) of which exposed area ratio of the aliphatic polyester resin (A) with respect to fiber surface area is 5% or less and a crimp is imparted to the multifilament comprising said synthetic fiber.

3. A crimped yarn according to Claim 1 **characterized in that** the crimped yarn is a BCF yarn.

4. A crimped yarn according to Claim 1 which is a crimped yarn constituted by a polymer alloy type synthetic fiber containing the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B), and has an sea/island structure in which the aliphatic polyester resin (A) forms an island component and the thermoplastic polyamide resin (B) forms a sea component and a domain size of the island component is 0.001 to 2 μm.

5. A crimped yarn according to Claim 4, wherein the aliphatic polyester resin (A) is a crystalline resin and has a melting point of 150 to 230˚C.

6. A crimped yarn according to Claim 4, wherein the thermoplastic polyamide resin (B) is a crystalline resin and has a melting point of 150 to 250˚C.

7. A crimped yarn according to Claim 4, wherein a blend ratio (weight ratio) of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) is 5/95 to 55/45.

8. A crimped yarn according to Claim 1, wherein the polymer alloy containing the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) is obtained by further adding compound (C) containing two or more active hydrogen reactive groups in a molecule.

9. A crimped yarn according to Claim 8, wherein the active hydrogen reactive group is at least one reactive group selected from the group consisting of glycidyl group, oxazoline group, carbodiimide group and acid anhydride group.

10. A crimped yarn according to Claim 8, wherein a content of the compound (C) containing two or more active hydrogen reactive groups in a molecule with respect to total amount of the aliphatic polyester resin (A), the thermoplastic polyamide resin (B) and the compound (C) containing two or more active hydrogen reactive groups in a molecule is 0.005 to 5 wt%.

11. A crimped yarn according to Claim 4, wherein grooves extending along fiber axis direction are formed on fiber surface and a width of said groove is 0.01 to 1 μm.

12. A crimped yarn according to Claim 11, wherein an aspect ratio of the groove (longitudinal axis length of groove/ width of groove) is 10 to 500.

13. A crimped yarn according to Claim 4, wherein the crimped yarn satisfy the following physical properties.

Strength : 1 cN/dtex or more
Crimp elongation percentage after boiling water treatment: 3 to 30%
Non-circularity (D1/D2) : 1.2 to 7

14. A crimped yarn according to Claim 4, wherein at least one kind crystal nucleating agent selected from talc, a sorbitol derivative, a metal salt of phosphoric acid ester, a basic inorganic aluminum compound and a salt of melamine compound is contained in an amount of 0.01 to 2 wt% with respect to the aliphatic polyester resin (A).

15. A production method of a crimped yarn, wherein, at kneading an aliphatic polyester resin (A) and a thermoplastic polyamide resin (B) in a blend ratio (weight ratio) of 5/95 to 55/45, a combination of which ratio of melt viscosity (ηb/ ηa) is in the range of 0.1 to 2 is selected, and after it is once pelletized or continuously to the kneading, melt spun at a spinning temperature of, provided that the melting point of the thermoplastic polyamide resin (B) is Tmb, Tmb+3˚C to Tmb+40˚C, to thereby form a multifilament at a linear discharge velocity in spinning hole of spinneret of 0.02 to 0.4 m/sec, and by setting a starting point of cooling substantially vertically beneath 0.01 to 0.15 m from the spinneret surface, cooled from substantially the right angle by a gas of a velocity of 0.3 to 1 m/sec and a temperature of 15 to 25˚C, covered said multifilament with a finishing agent for spinning, stretched in 1 to 3 stages while heating with hot rolls of 50 to 130˚C such that an elongation at break of the multifilament would be 15 to 65%, furthermore, heat set by setting a final roll temperature after the stretching at, provided that a melting point of the aliphatic polyester resin (A) is Tma, Tma-30 to Tma+30˚C and fed to an air-jet stuffing machine and subjected to a crimp processing by setting a nozzle temperature of said machine to 5 to 100˚C higher than the final roll after the stretching, to thereby form a 3-dimensionally crimped yarn, taken up by contacting with a cooling drum and wound at a speed 10 to 30% lower than that of the final roll after the stretching.

(wherein, ηa : melt viscosity of the aliphatic polyester resin (A), ηb : melt viscosity of the thermoplastic polyamide resin (B))

16. A production method of a crimped yarn according to Claim 15, wherein compound (C) containing two or more active hydrogen reactive groups in a molecule is added to the aliphatic polyester resin (A) and/or the thermoplastic polyamide resin (B) as a compatibilizer and melted and kneaded.

17. A production method of a crimped yarn according to Claim 15, wherein the compound (C) containing two or more active hydrogen reactive groups in a molecule is added in an amount of 0.005 to 5 wt% with respect to the total amount of the aliphatic polyester resin (A), the thermoplastic polyamide resin (B) and the compound (C) containing two or more active hydrogen reactive groups in a molecule.

18. A production method of a crimped yarn according to Claim 15, wherein at least one kind crystal nucleating agent selected from talc, a sorbitol derivative, a metal salt of phosphoric acid ester, a basic inorganic aluminum compound, a salt of melamine compound is added to the aliphatic polyester resin (A) and/or the thermoplastic polyamide resin (B) and melt kneaded.

19. A production method of a crimped yarn according to Claim 18, wherein at least one kind crystal nucleating agent selected from talc, a sorbitol derivative, a metal salt of phosphoric acid ester, a basic inorganic aluminum compound and a salt of melamine compound is added in an amount of 0.01 to 2 wt% with respect to the aliphatic polyester resin (A).

20. A crimped yarn according to Claim 1 **characterized in that** a crimped yarn constituted by a sheath/core type composite fiber of which core component comprising the aliphatic polyester resin (A) or a polymer alloy of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) and the sheath component comprising the thermoplastic polyamide resin (B), and the following physical properties (1) to (3) are satisfied.

(1) Strength : 1.5 to 3 cN/dtex
(2) Single fiber thickness : 5 to 40 dtex
(3) Boiling water shrinkage : 6% or less

21. A crimped yarn according to Claim 20, wherein a total heat capacity of melting peak of differential calorimetric curve measured for the crimped yarn at a heating rate of 16 ˚C/min is 50 J/g or more.

22. A crimped yarn according to Claim 20, wherein a sheath/core ratio (weight ratio) is 10/90 to 65/35.

23. A crimped yarn according to Claim 20, wherein a non-circularity (D3/D4) of single fiber of the crimped yarn is 1.3 to 4.

24. A crimped yarn according to Claim 20, wherein a crimp elongation percentage after boiling water treatment of the crimped yarn is 5 to 35%.

25. A crimped yarn according to Claim 20, wherein a crimp elongation percentage measured after boiling water treatment under a load of 2 mg/dtex (elongation percentage under load) is 2 to 30%.

26. A crimped yarn according to Claim 20, wherein a blend ratio (weight ratio) of the aliphatic polyester resin (A) and the thermoplastic polyamide resin (B) of the core component is 95/5 to 20/80.

27. A sheath/core type composite fiber according to Claim 26, wherein an alloy structure of the polymer alloy of the core component satisfies the following (1) to (3).

(1) The aliphatic polyester resin (A) forms the island component.
(2) The thermoplastic polyamide resin (B) forms the sea component.
(3) A diameter of the island component is 0.001 to 2 μm.

28. A production method of a crimped yarn **characterized in that**, by using a direct spinning·stretching·crimp processing machine, an aliphatic polyester resin (A) as core component and a thermoplastic polyamide resin (B) as sheath component are joined in a spinning hole of spinneret and discharged to thereby form a spun yarn, said spun yarn is stretched in total stretching ratio of 2 to 5, heat set by setting a final roll temperature after stretching at 160 to

220˚C and subjected to a crimp processing by an air stuffer crimp processing machine.

29. A production method of crimped yarn **characterized in that**, by using a direct spinning·stretching· crimp processing machine, when an aliphatic polyester resin (A) as core component and a thermoplastic polyamide resin (B) as sheath component in a weight ratio of the core component of 10 to 65 wt% are joined and discharged through a spinning hole of spinneret, a combination of melt viscosity ratio ($\eta b/\eta a$) in the range of 0.2 to 2 is selected, spinning temperature is controlled to, provided that the melting point of the thermoplastic polyamide resin (B) is Tmb, Tmb to Tmb+30˚C and linear discharge velocity in spinning hole of spinneret is controlled to 1 to 20 m/min, to thereby form a spun yarn, said spun yarn is cooled by setting a starting point of cooling vertically beneath 0.01 to 0.15 m from spinneret surface, by a gas of wind speed 0.3 to 1 m/sec and wind temperature 15 to 25˚C from the right angle to the perpendicular direction to the spinneret surface to obtain a multifilament, said multifilament is stretched in 2 stages in total stretching ratio of 2 to 5 and then, when subjected to a crimp processing, adjusted the first stage stretching roll to 50 to 90˚C, the second stage stretching roll to 90 to 150˚C and final roll after the stretching to 160 to 220˚C to heat set, and when subjected to an air jet stuffer crimp processing machine, a crimp processing is carried out by setting a nozzle temperature of said machine to a temperature 5 to 100˚C higher than the final roll temperature to thereby form a crimped yarn, and it is taken up by contacting with a cooling drum, and wound at a speed 10 to 30% lower than the final roll after stretching.

30. A production method of a crimped yarn **characterized in that**, by using a direct spinning·stretching·crimp processing machine, a core component comprising a polymer alloy obtained by melt kneading an aliphatic polyester resin (A) and a thermoplastic polyamide resin (B) as core component by a twin screw extruding/kneading machine and/or a single screw extruding/kneading machine, in the range of kneading temperature of from melting point of the thermoplastic polyamide resin (B), (Tmb), to Tmb+40˚C, a shear rate of 200 to 20,000sec^{-1} and a residence time of 0.5 to 30 minutes, and a sheath component comprising a thermoplastic polyamide resin (B) are joined in a spinneret and discharged.

31. A fiber structure containing a crimped yarn described in Claim 1 at least as a part thereof.

32. A fiber structure according to Claim 31 wherein the fiber structure is a carpet.

33. A fiber structure according to Claim 32, wherein it is a carpet for car interior.

Sea/island Structure (TEM image) Sea : Dyed portion, Island : Undyed portion

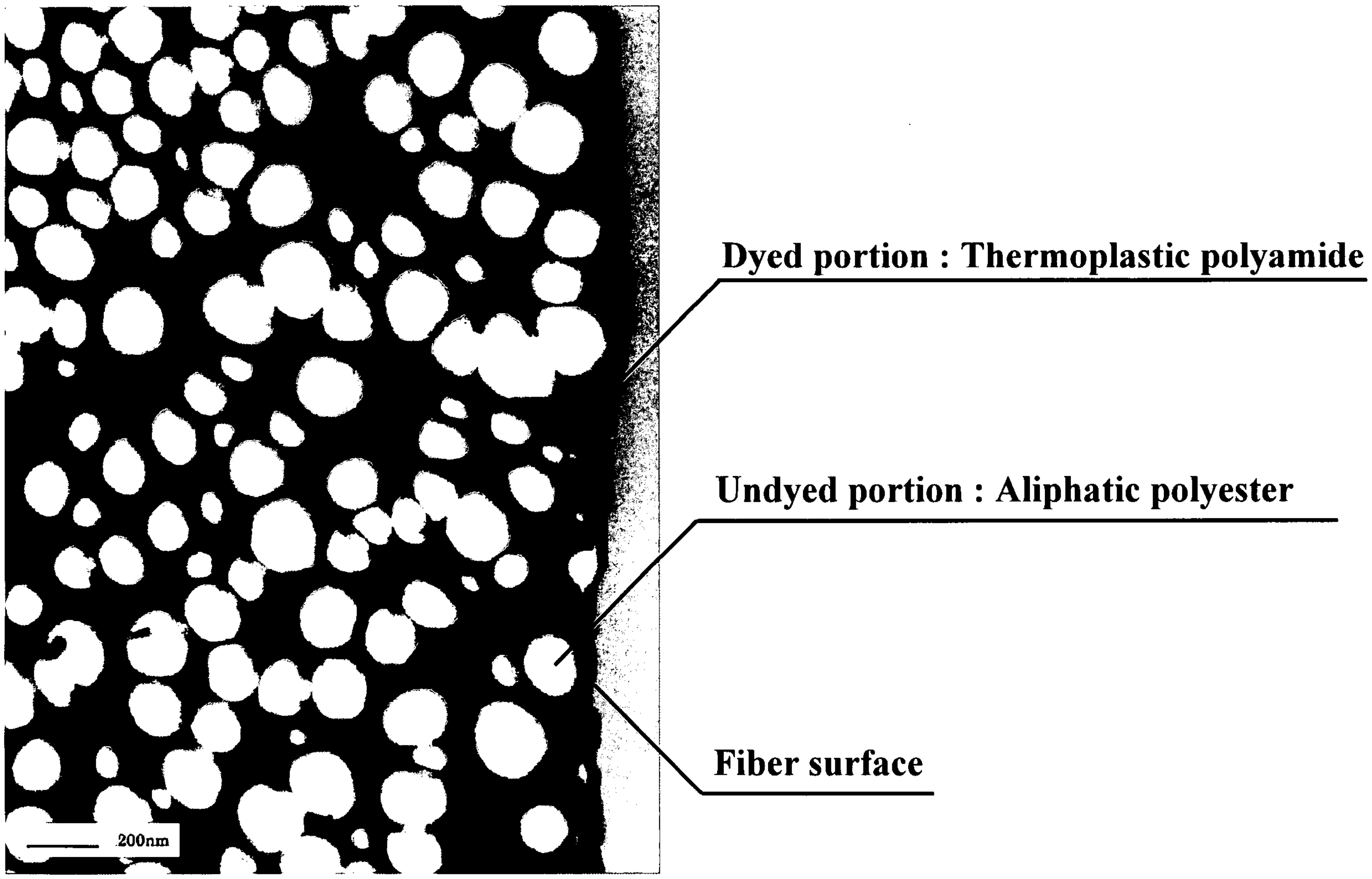


Fig.1

Fiber surface of the fiber of the present invention

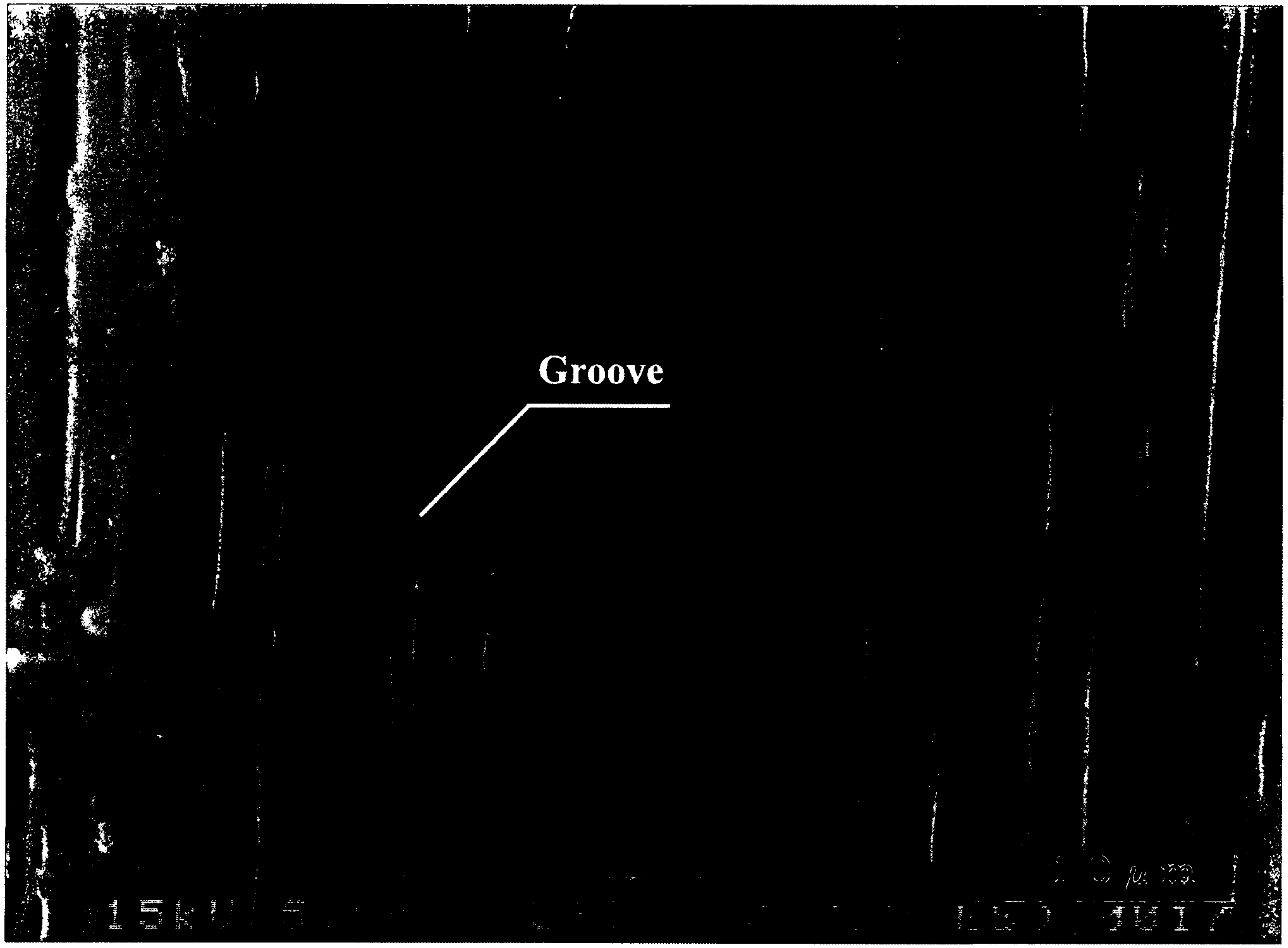


Fig.2

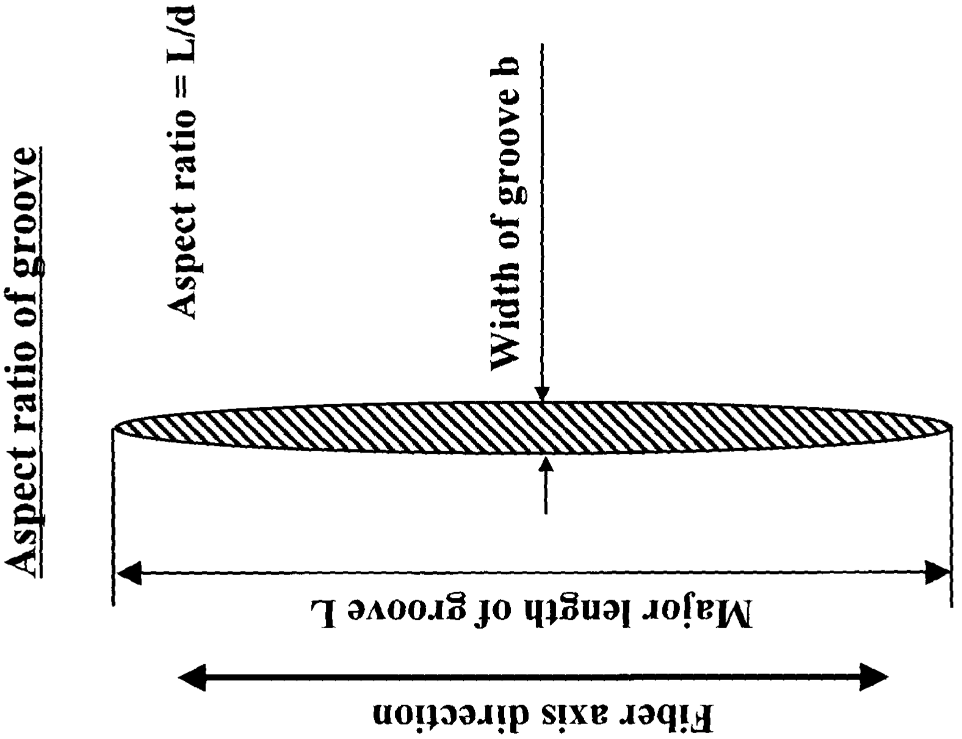

Aspect ratio of groove
Aspect ratio = L/d
Width of groove b
Major length of groove L
Fiber axis direction

Fig.3

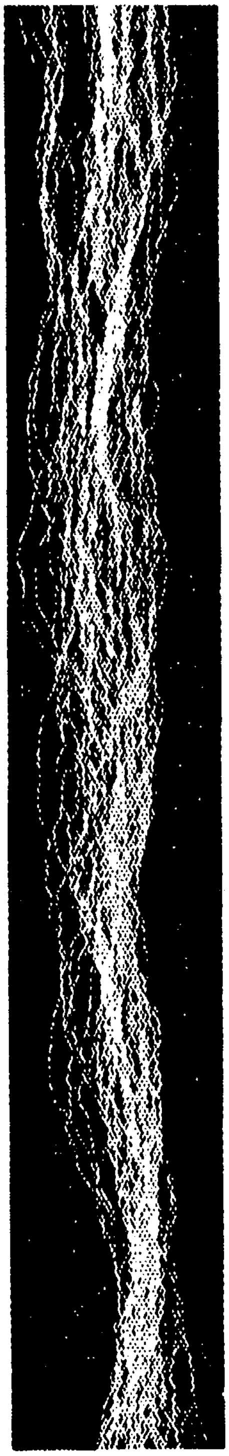


Fig.4

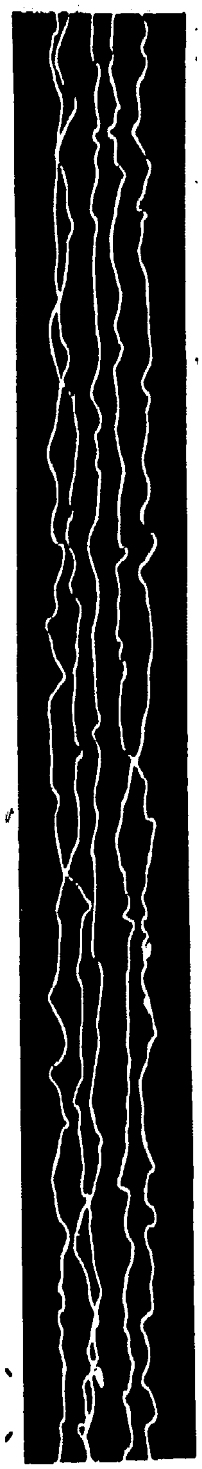


Fig.5

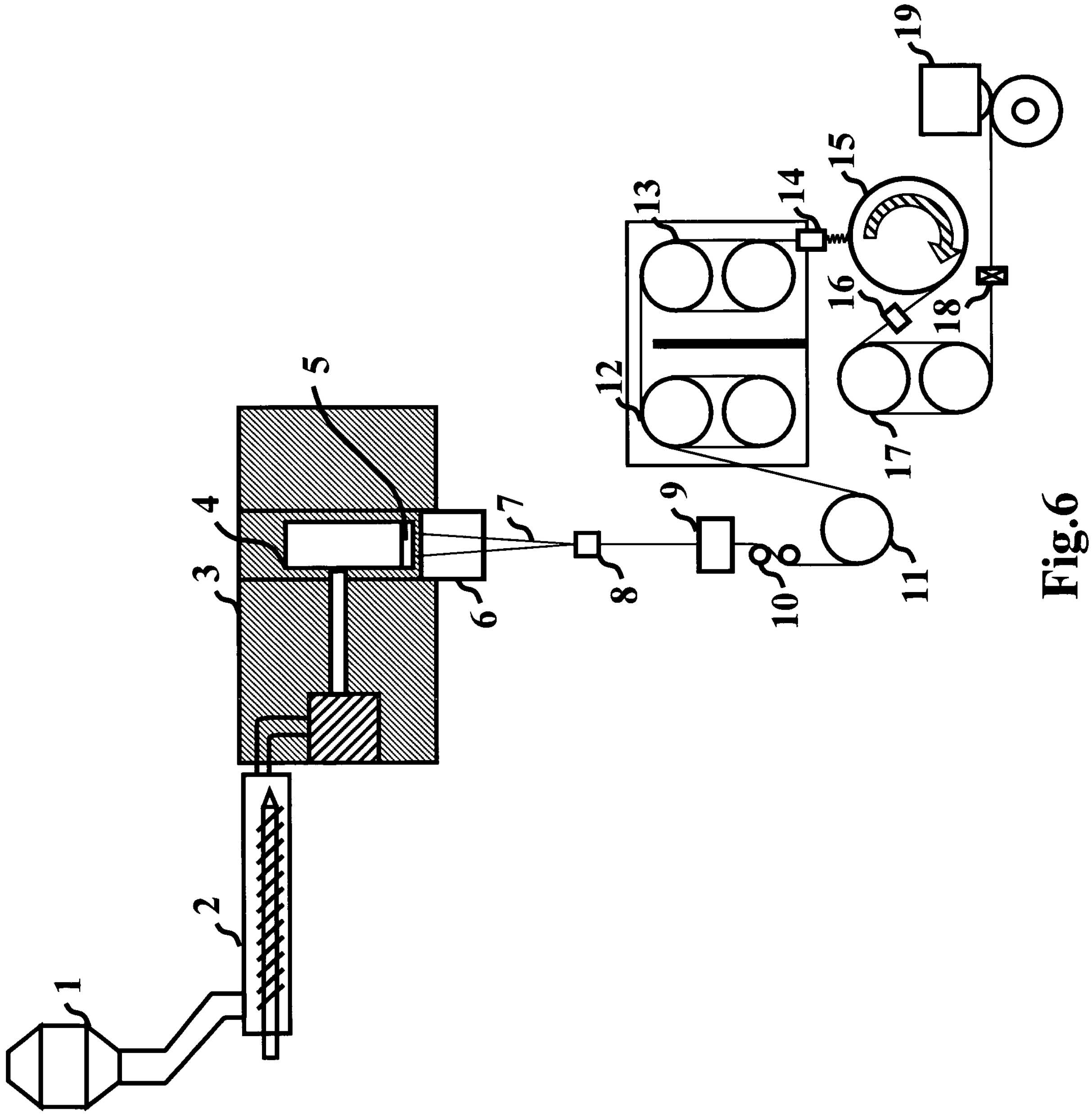
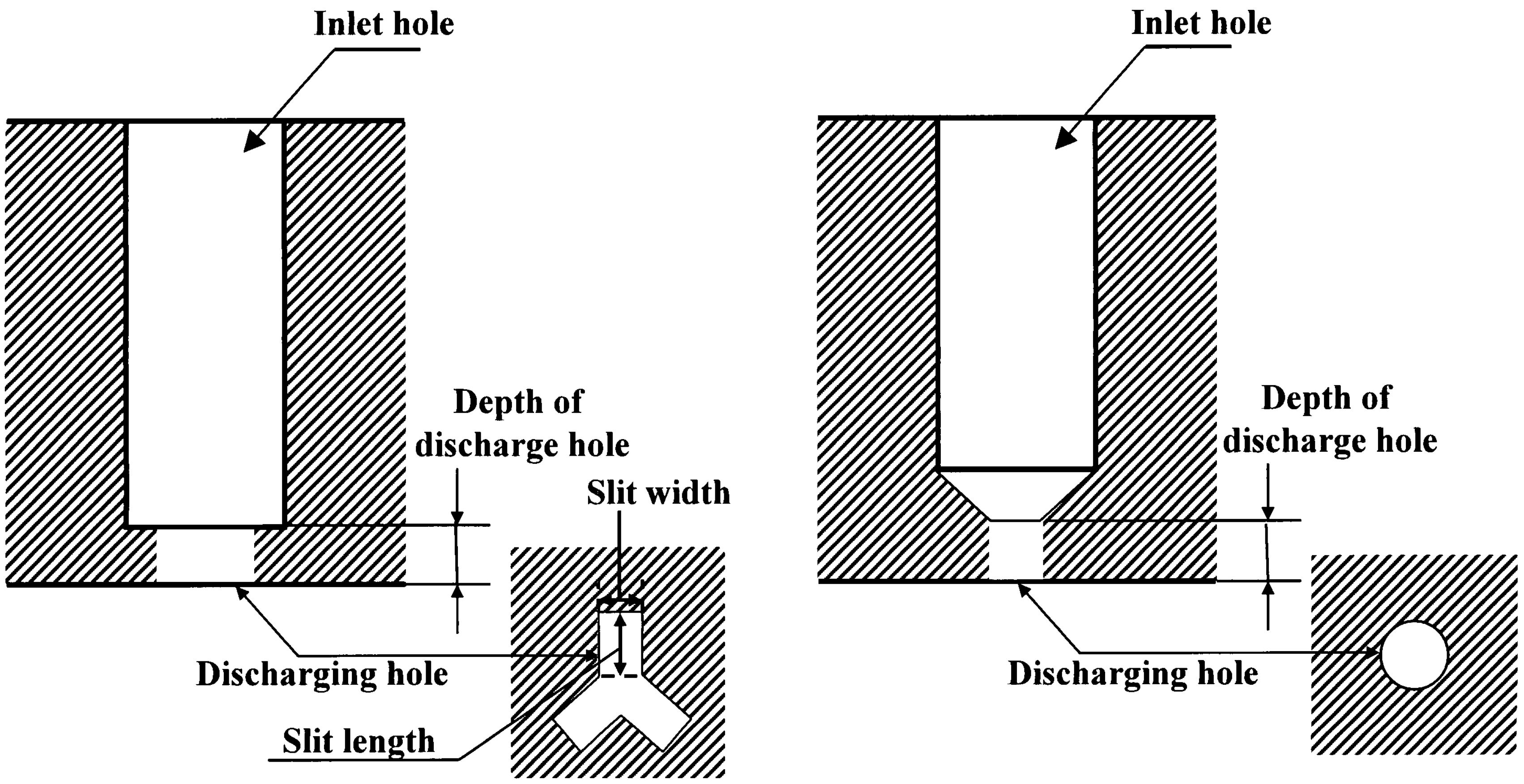


Fig.6

Longitudinal sectional view and discharge hole



(a) Noncircular hole hole

(b) Circular

Fig.7

Explanatory view of starting point of cooling

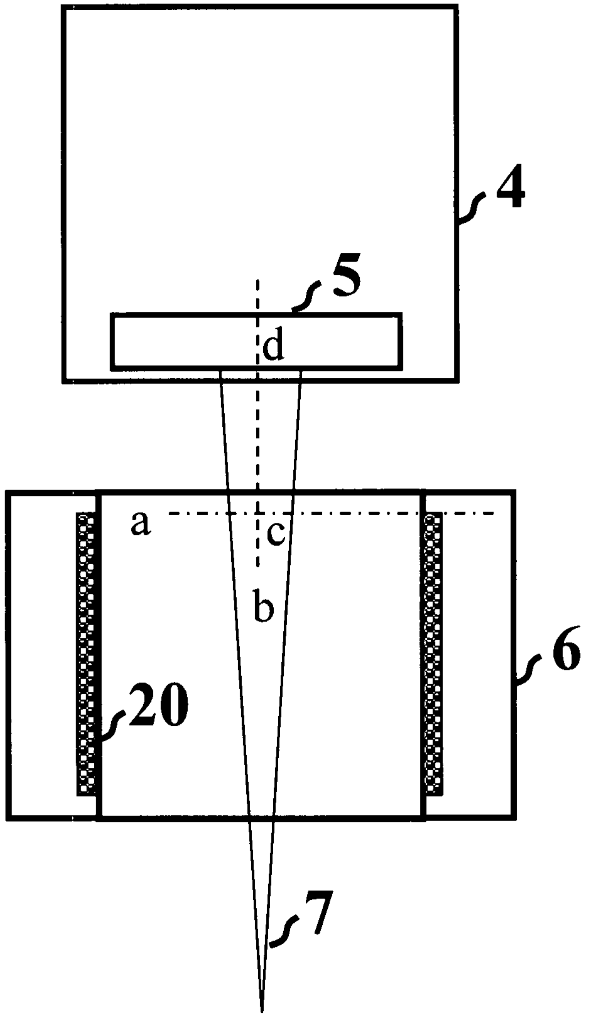


Fig.8

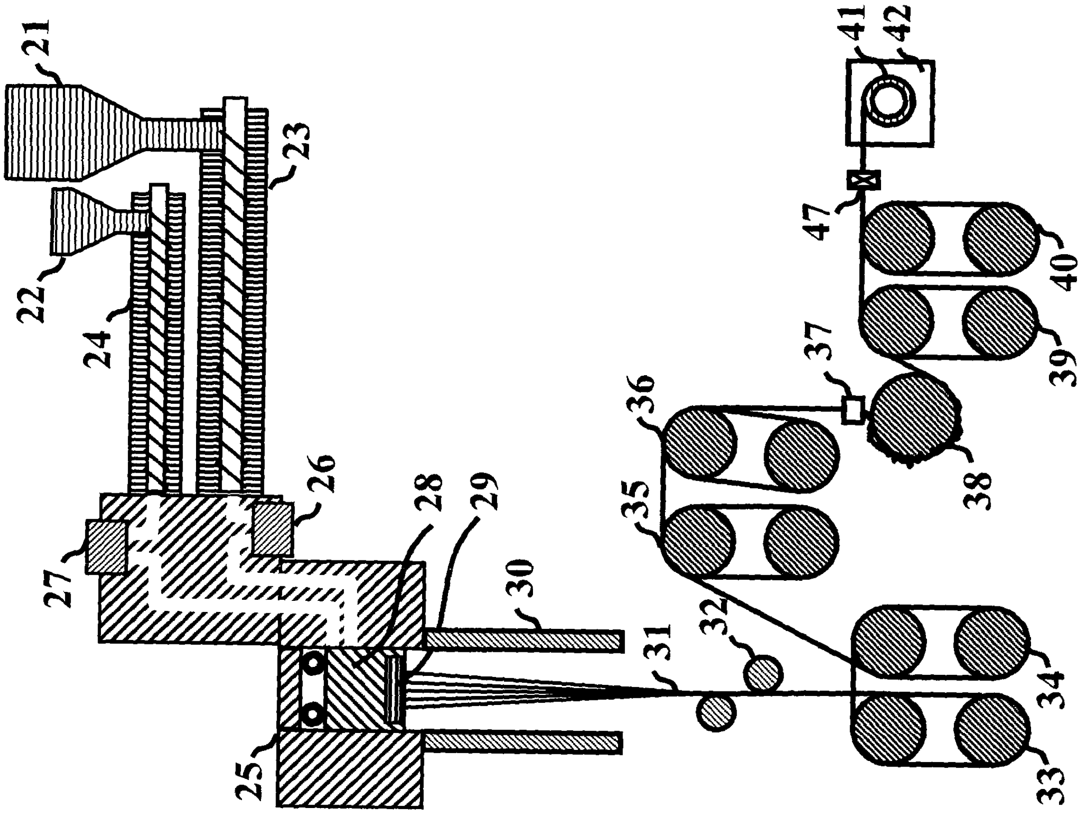
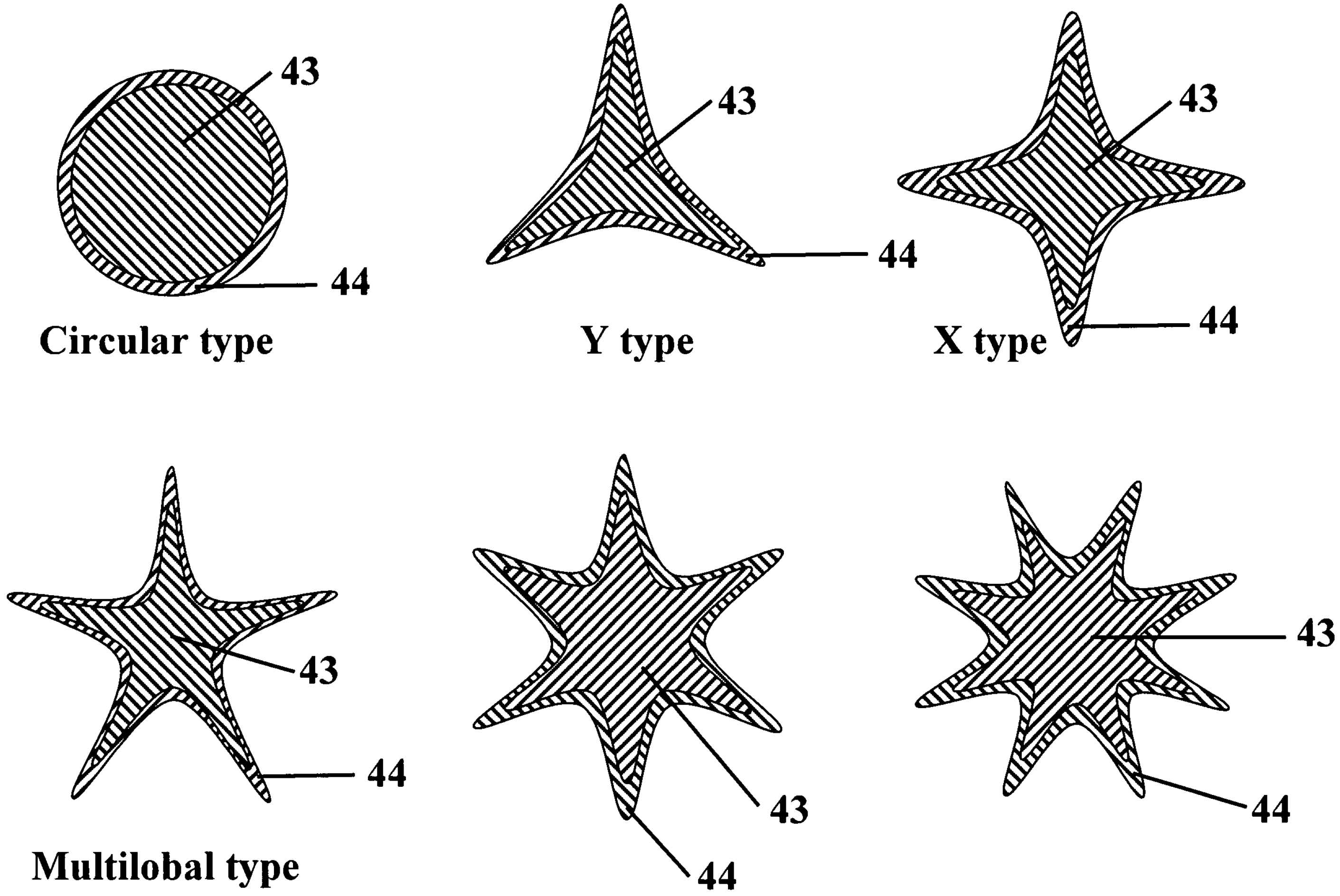


Fig.9



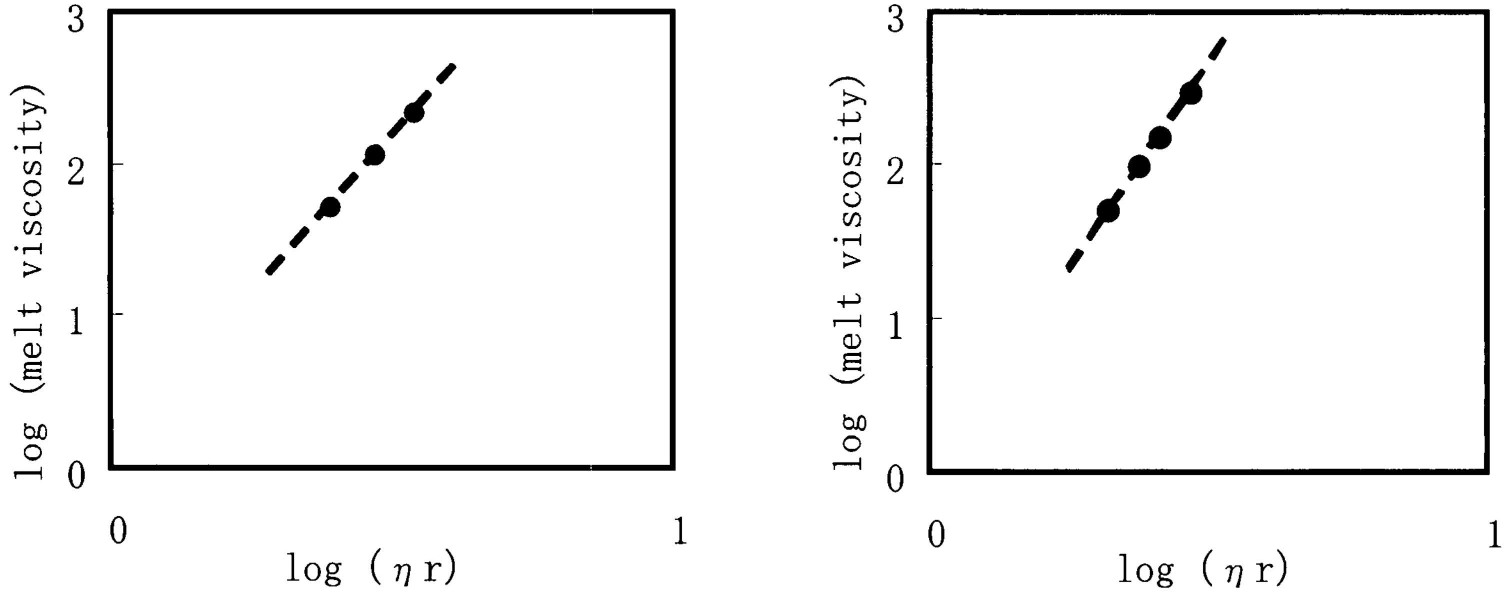
Circular type

Y type

X type

Multilobal type

Fig.10



Relation between solution viscosity and melt viscosity of component A

Relation between solution viscosity and melt viscosity of component B

Fig.11

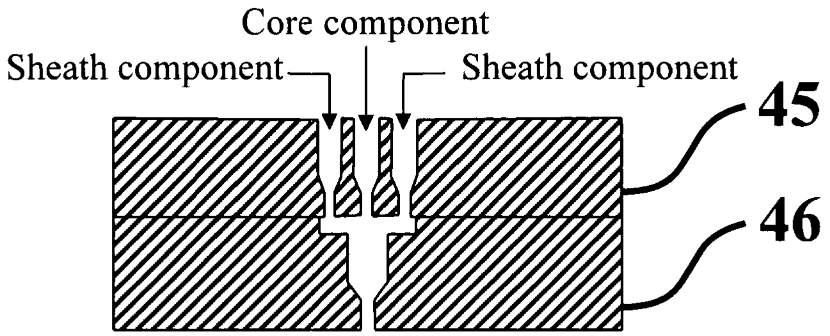


Fig.12

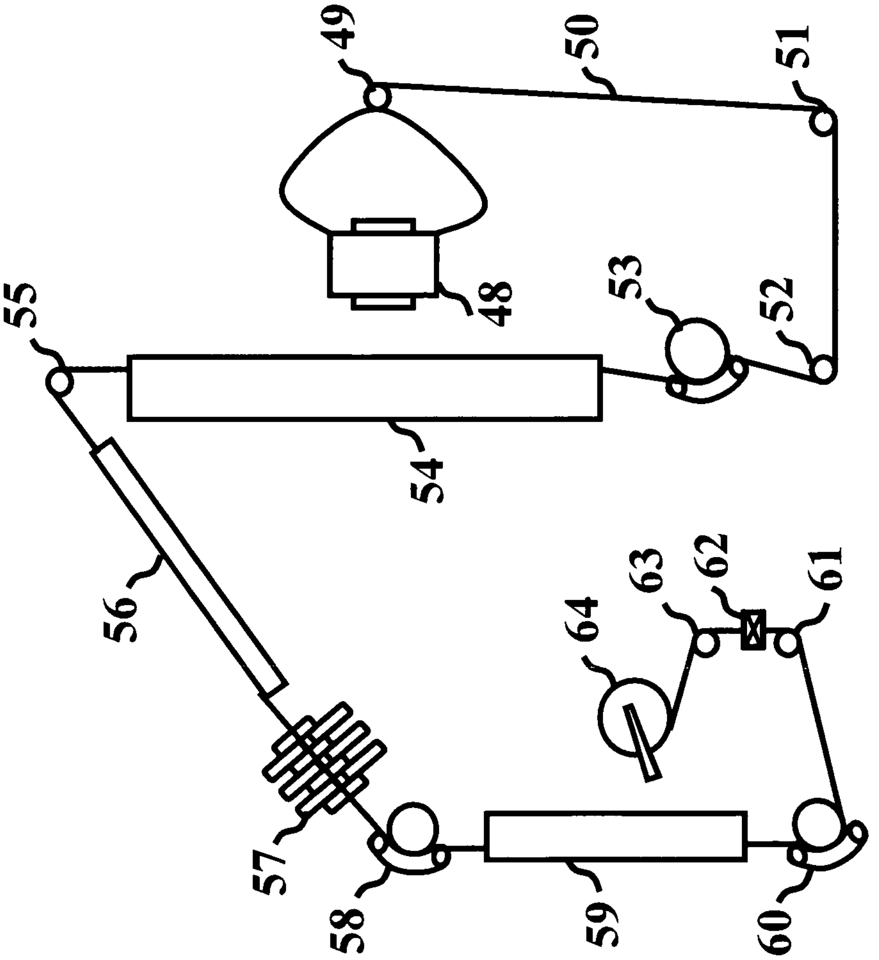


Fig.13

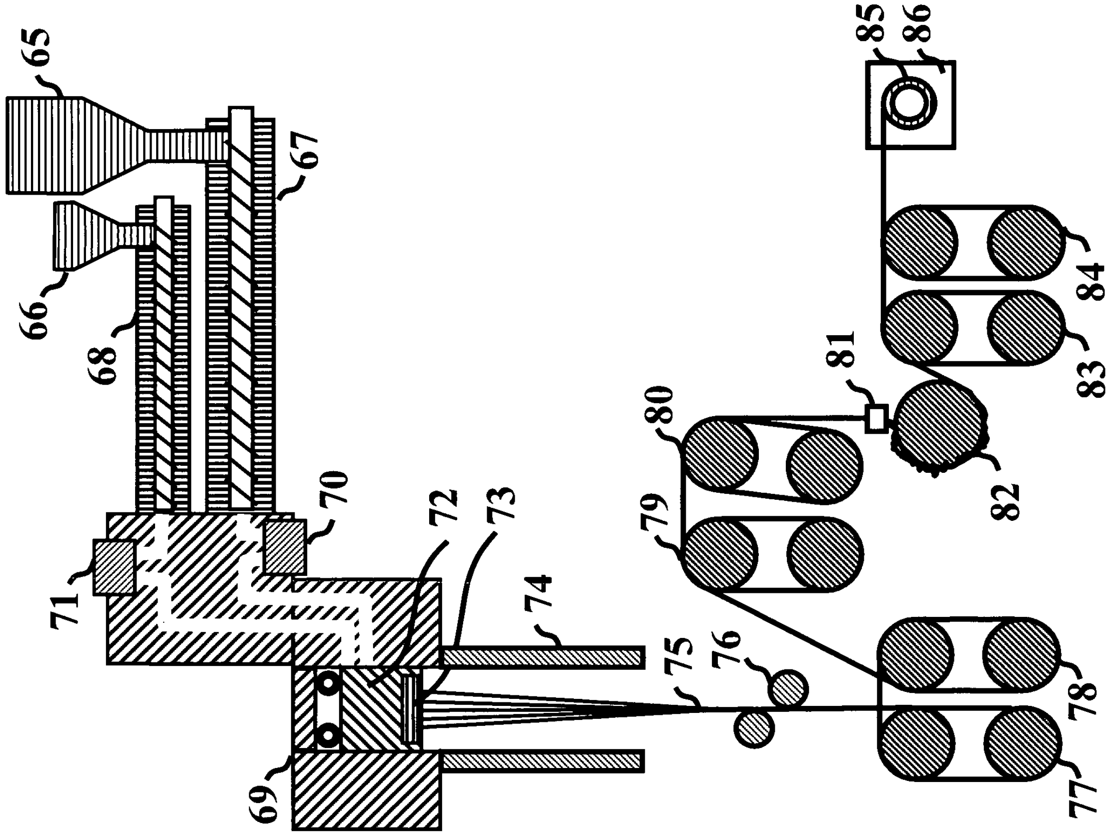


Fig.14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/320700

A. CLASSIFICATION OF SUBJECT MATTER
D01F8/14(2006.01)i, *D01F6/62*(2006.01)i, *D01F6/92*(2006.01)i, *D02G1/12*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D01F8/00-8/18, D01F1/00-6/96, D02G1/0-3/48

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2005-23437 A (Toray Industries, Inc.), 27 January, 2005 (27.01.05), Claims 1, 2; Par. Nos. [0033], [0041]; examples 1, 7 (Family: none)	1-7,11-13, 15-33 8-10,14
X Y	JP 2004-36035 A (Toray Industries, Inc.), 05 February, 2004 (05.02.04), Claims 1, 2; Par. Nos. [0024], [0032]; examples 1 to 11 (Family: none)	1-7,11-13, 15-33 8-10,14
Y	JP 2002-69751 A (Toray Industries, Inc.), 08 March, 2002 (08.03.02), Claim 1; Par. No. [0001] (Family: none)	8-10,16,17

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 22 December, 2006 (22.12.06)	Date of mailing of the international search report 09 January, 2007 (09.01.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/320700

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-48339 A (Unitika Ltd.), 24 February, 2005 (24.02.05), Claim 1; Par. No. [0025] (Family: none)	14,18,19
E,X	JP 2006-336125 A (Unitika Fiber Kabushiki Kaisha), 14 December, 2006 (14.12.06), Claims 1, 3; Par. Nos. [0001], [0025], [0029] to [0032]; example 1 (Family: none)	1-33
E,A	JP 2006-233375 A (Toray Industries, Inc.), 07 September, 2006 (07.09.06), Claims 1 to 11; examples 1 to 10 (Family: none)	1-33

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2003238775 A **[0014]**
- JP 2005206961 A **[0014]**
- JP 2004036035 A **[0014]**
- JP H665360 A **[0032]**
- JP H7173266 A **[0032]**
- US 2703316 A **[0032]**
- JP 2003192883 A **[0060]**
- JP H9143238 A **[0061]**
- JP H5202157 A **[0061]**
- JP H7224049 A **[0061]**
- JP H5310716 A **[0061]**
- JP H6157820 A **[0061]**
- US 3920796 A **[0061]**
- JP H1081691 A **[0061]**
- JP H10306081 A **[0061]**
- US 3781949 A **[0162]**

Non-patent literature cited in the description

- Filament Processing Technical Manual. The Textile Machinery society of Japan **[0068]**