(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 012 358 A1

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

(43) Date of publication:
27.04.2016 Bulletin 2016/17

(21) Application number: **13887549.7**

(22) Date of filing: **20.06.2013**

(51) Int Cl.:
D01F 6/04 *(2006.01)* ***D01D 5/42*** *(2006.01)*
D02G 1/02 *(2006.01)*

(86) International application number:
PCT/CN2013/077545

(87) International publication number:
WO 2014/201652 (24.12.2014 Gazette 2014/52)

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

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(54) **SINGLE YARN, SINGLE YARN PRODUCT, AND PREPARATION METHOD THEREFOR**

(57) The invention relates to a single yarn, a single yarn product and a preparation method thereof, wherein the preparation method of the single yarn comprises: converging or converging and twisting an ultra high molecular weight polyethylene thin film or strip to obtain the single yarn. The single yarn product comprises at least a body prepared from the above-mentioned single yarn. The single yarn obtained by converging or converging and twisting the ultra high molecular weight polyethylene thin films or strips in the invention replaces traditional ultra high molecular weight polyethylene fibers to develop and prepare various products. In addition to the advantages of wear resistance, impact resistance, corrosion resistance, UV resistance and the like which are similar to those of the ultra high molecular weight polyethylene fibers, the single yarn also has the unique advantages of good structural integrity, high strength, high strength utilization ratio, high production efficiency, low processing cost, light weight, small linear density and the like, and therefore the single yarn can replace the traditional ultra high molecular weight polyethylene fibers in the preparation of various products and has a very wide application range.

Fig. 2

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Description

Field of the Invention

[0001] The present invention relates to the technical field of high polymer materials, in particular relates to a single yarn, a single yarn product and a preparation method thereof.

Background of the Invention

[0002] Ultra high molecular weight polyethylene (Ultra High Molecular Weight Polyethylene, referred to as UHMW-PE) is a thermoplastic engineering plastic with a linear structure and excellent comprehensive performances, and one of the important applications of the material is to prepare a high-strength fiber on the basis of the material.

[0003] The ultra high molecular weight polyethylene fiber is a high-performance fiber, has the advantages of high strength, wear resistance, impact resistance, corrosion resistance, UV resistance and the like and can be widely used in multiple fields, for example, the ultra high molecular weight polyethylene fiber can be used for preparing ropes, hangers, fishing nets, various textiles and the like in the civil field, can be applied to the preparation of bulletproof vests, bulletproof helmets and the like in the field of individual protection products, and can also be applied to the preparation of bulletproof floors, armored protection plates and the like in the field of national defense military supplies.

[0004] As the ultra high molecular weight polyethylene fiber has a silk-like structure (the fiber number of the single yarn is about 2.5 deniers), so that in the process of preparing the various products based on the ultra high molecular weight polyethylene fiber, multiple fibers with the silk-like structures need to be arranged respectively, the process is complex, and the cost is high; and furthermore, in the preparation process of the product, the surfaces of the fibers are liable to the generation of burrs due to friction, and the fibers are liable to breaking, distortion, intertwining and other phenomena, thereby being not conductive to realizing integral uniform stress of the multiple fibers, enabling the strength of the integral strength of the prepared product to be often lower than the strength of the multiple ultra high molecular weight polyethylene fibers and realizing a relatively low strength utilization ratio.

Summary of the Invention

[0005] A brief summary of the present invention is given below to facilitate the basic understanding of some aspects of the present invention. It should be understood that the summary is not an exhaustive summary of the invention. It is not intended to determine key or important parts of the invention or limit the scope of the invention. It only aims at presenting some concepts in a simplified form as a prelude to the more detailed description which will be discussed later.

[0006] The present invention provides a high-strength and low-cost single yarn, a single yarn product and a preparation method thereof.

[0007] In the first aspect, the present invention provides a preparation method of a single yarn, including: converging or converging and twisting an ultra high molecular weight polyethylene thin film or strip to obtain the single yarn.

[0008] Optionally, the converging of the ultra high molecular weight polyethylene thin film or strip includes: converging the ultra high molecular weight polyethylene thin film or strip along the straightening direction of a molecular chain thereof.

[0009] Optionally, the related parameters of the ultra high molecular weight polyethylene thin film at least meet one or more of the following conditions:

the linear density is above 5000 deniers;
the width is above 100mm;
the thickness is below 0.2mm;
the breaking strength is above 10 grams/denier;
the tensile modulus is above 800 grams/denier; and
the elongation at break is below 6%.

[0010] Optionally, the related parameters of the ultra high molecular weight polyethylene strip at least meet one or more of the following conditions:

the linear density is above 100 deniers;
the width is 1-100mm;
the thickness is below 0.2mm;
the breaking strength is above 10 grams/denier;
the tensile modulus is above 800 grams/denier; and
the elongation at break is below 6%.

[0011] Optionally, the twisting direction for twisting is left twisting or right twisting, and/or the twist for twisting is 1-100/m.

[0012] In the second aspect, an embodiment of the present invention provides a single yarn, which is prepared by adopting the preparation method of the single yarn.

[0013] In the third aspect, an embodiment of the present invention provides a preparation method of a single yarn product, which includes at least the following step: preparing a body of the single yarn product from the single yarns prepared according to claim 6. Optionally, the preparing of the body from the single yarns includes: unidirectionally arranging, connecting, converging, twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing the multiple single yarns into a whole.

[0014] Optionally, the preparing of the body from the single yarns includes: converging, twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing the multiple single yarns into a whole to form a single-strand structure and plying the multiple single-strand structures

into a whole.

[0015] Optionally, the plying of the multiple single-strand structures into a whole includes: twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing the multiple single-strand structures into a whole.

[0016] Optionally, the preparing of the body from the single yarns includes: crisscross compounding and laminating multiple single-layer structures formed by unidirectionally arranging and connecting the multiple single yarns at certain angles into a whole.

[0017] In the fourth aspect, the present invention provides a single yarn product, which is prepared by adopting the preparation method of the single yarn product.

[0018] The technical solutions provided by the present invention are essentially different from traditional technologies using ultra high molecular weight polyethylene and are revolutionary innovations against the traditional technologies, namely, the single yarns prepared by converging or converging and twisting the ultra high molecular weight polyethylene thin films or strips replace traditional ultra high molecular weight polyethylene fibers to develop and prepare various products. In addition to the advantages of wear resistance, impact resistance, corrosion resistance, UV resistance and the like which are similar to those of the ultra high molecular weight polyethylene fibers, the single yarn also has the unique advantages of good structural integrity, high strength, high strength utilization ratio, high production efficiency, low processing cost, light weight, small linear density and the like, and therefore the single yarn can replace traditional ultra high molecular weight polyethylene fibers in the preparation of various products and is widely used in various fields, such as civil use, individual protection, national defense military supplies, civil engineering, industrial construction, offshore operations, fishing, ship manufacturing, sports goods and the like.

[0019] These and other advantages of the present invention will be evident through the following detailed description of optional embodiments of the invention in conjunction with the accompanying drawings.

Brief Description of the Drawings

[0020] The present invention can be better understood through the following description in conjunction with the accompanying drawings, wherein the same or similar reference symbols are used in all the drawings to represent the same or similar parts. The accompanying drawings in conjunction with the detailed description are included in the description and form one part of the description, and are used for further illustrating the optional embodiments of the invention and explaining the principle and the advantages of the present invention. Wherein,

Fig. la is a schematic diagram of an optional structure of an ultra high molecular weight polyethylene thin film provided by an embodiment of the present invention;

Fig. lb is a schematic diagram of an optional structure of an ultra high molecular weight polyethylene strip provided by an embodiment of the present invention;

Fig. 2 is a schematic diagram of an optional structure of a single yarn after converging the thin film or strip provided by an embodiment of the present invention;

Fig. 3 is a schematic diagram of an optional structure of a woven fabric or strip provided by an embodiment of the present invention;

Fig. 4 is a schematic diagram of an optional structure of a knitted fabric or strip provided by an embodiment of the present invention;

Fig. 5 is a schematic diagram of an optional structure of a net with a mesh structure provided by an embodiment of the present invention;

Fig. 6 is a schematic diagram of an optional structure of a twisted rope provided by an embodiment of the present invention;

Fig. 7 is a schematic diagram of an optional structure of a woven rope provided by an embodiment of the present invention;

Fig. 8 is a schematic diagram of an optional structure of a unidirectional fabric prepared on the basis of the single yarn provided by an embodiment of the present invention;

Fig. 9 is a schematic diagram of an optional structure of a non-woven fabric with an intersection angle of 90 degrees provided by an embodiment of the present invention; and

Fig. 10 is a schematic diagram of an optional structure of a non-woven fabric with a gradually increased intersection angle provided by an embodiment of the present invention.

[0021] Those skilled in the art should understand that elements in the accompanying drawings are only illustrated for simplicity and clarity, and are not necessarily drawn to scale. For example, the sizes of some elements in the accompanying drawings may be exaggerated relative to other elements so as to assist in the improvement of the understanding of the embodiments of the present invention.

Detailed Description of the Embodiments

[0022] The exemplary embodiments of the present invention will be described in detail below in conjunction with the accompanying drawings. For clarity and brevity, not all the characteristics of the actual implementation ways are described in the description. However, it should be understood that, in the process of developing any of these actual embodiments, many decisions which are specific to the implementation ways must be made to facilitate the implementation of specific targets of development staff, such as those limiting conditions which are related to a system and business, and these limiting conditions can change along with different implementation ways. In addition, it should also be understood that, al-

though the development work may be very complex and time-consuming, the development work is just a routine task for those skilled in the art and benefiting from the disclosure of the present invention.

[0023] Herein, it still needs to be noted that, in order to prevent the unnecessary details from obscuring the present invention, only the device structure and/or the treatment steps which are closely related to the solutions of the present invention are described in the accompanying drawings and the description, and the representations and the descriptions of the parts and the treatments which are not closely related to the invention and known to those of ordinary skill in the art are omitted.

[0024] Ultra high molecular weight polyethylene is polyethylene with a molecular weight of above 1 million. The traditional technologies using the ultra high molecular weight polyethylene take ultra high molecular weight polyethylene fibers as the basis to prepare various products. The technical solutions provided by the various embodiments of the present invention are essentially different from the traditional technologies using ultra high molecular weight polyethylene and are revolutionary innovations against the traditional technologies, namely, an ultra high molecular weight polyethylene thin film or strip is used for replacing traditional ultra high molecular weight polyethylene fibers to develop and prepare application products, and the core concept mainly includes the following contents:

(1) The ultra high molecular weight polyethylene thin film or strip is used for replacing traditional ultra high molecular weight polyethylene fibers to prepare a single yarn, namely, the single yarn is prepared by converging or converging and twisting the ultra high molecular weight polyethylene thin film or strip.

(2) The single yarns obtained by converging or converging and twisting the ultra high molecular weight polyethylene thin films or strips replace the traditional ultra high molecular weight fibers in the development of various products (hereinafter referred to as single yarn products).

[0025] Wherein, as shown in Fig. Ia, the ultra high molecular weight polyethylene thin film 101 is a thin slice which is prepared from ultra high molecular weight polyethylene and has a certain width and thickness, wherein the width is much greater than the thickness. As shown in Fig. Ib, the ultra high molecular weight polyethylene strip 102 is a strip-like thin slice which can be prepared independently or be formed by performing slitting process step before and after stretching the thin film, wherein the width of the strip is less than the width of the thin film, and the thickness is equivalent to that of the thin film or greater than the thickness of the thin film.

[0026] The ultra high molecular weight polyethylene thin film or strip provided by the present invention is different from the ultra high molecular weight polyethylene fibers and also different from a plane formed by bonding the multiple ultra high molecular weight polyethylene fibers, and the significant difference lies in that the ultra high molecular weight polyethylene thin film or strip provided by the present invention has a certain width and thickness and is an integral structure without integration points or trim lines.

[0027] The single yarn provided by each of the various embodiments of the invention is prepared on the basis of the ultra high molecular weight polyethylene thin film or strip. In the preparation process of the single yarn, the ultra high molecular weight polyethylene thin film or strip is taken as a whole for treatment, thereby having good structural integrity, being simple in preparation process, eliminating a complex process for respectively arranging multiple fiber silks, obviously reducing the probability of generating burrs on the surface of the thin film or strip and also obviously reducing the probability of producing breaking, distortion, intertwining and other phenomena in the thin film or strip. When the single yarn formed by converging the ultra high molecular weight polyethylene thin film or strip is used for bearing a load, the ultra high molecular weight polyethylene thin film or strip is stressed as a whole, so that the strength of the single yarn adopting the ultra high molecular weight polyethylene thin film or strip is higher than that of a product prepared by adopting the ultra high molecular weight polyethylene fiber with the same denier number, and the single yarn has the advantages of good structural integrity, high strength, high strength utilization ratio, high production efficiency, low processing cost, light weight, small linear density, good flexibility and the like.

[0028] The single yarn provided by each of the various embodiments of the present invention can completely replace traditional ultra high molecular weight polyethylene fibers to prepare the products to be widely applied in various fields. Specifically, in various embodiments of the present invention, the single yarn can substitute the ultra high molecular weight polyethylene fibers to prepare various single yarn products. In the preparation process of the single yarn product, the single yarn is taken as the basis for processing treatment. Compared with the similar products obtained by processing treatment on the basis of the ultra high molecular weight polyethylene fibers, the single yarn product has the advantages of good structural integrity, simple preparation process and high production efficiency. When the single yarn product bears the load, each single yarn is stressed as a whole, so that the strength of the single yarn product prepared by adopting the single yarns is higher than that of the similar product prepared on the basis of the ultra high molecular weight polyethylene fibers with the same denier number, the strength utilization ratio is effectively improved, and the single yarn product simultaneously has the advantages of good structural integrity, light weight, small linear density, environmental friendliness and the like.

Embodiment of single yarn and preparation method thereof

[0029] A single yarn 201 provided by an embodiment of the present invention is formed by converging an ultra high molecular weight polyethylene thin film or strip. As shown in Fig. 2, the ultra high molecular weight polyethylene thin film or strip can be converged to prepare the single yarn. For example, an optional process flow is as follows: placing the ultra high molecular weight polyethylene thin film or strip on a bobbin creel, releasing and enabling the ultra high molecular weight polyethylene thin film or strip to sequentially pass through a thread guide mechanism and a bunching mechanism and then be wound on a tube core. The prepared single yarn has the advantages of good structural integrity, high strength, high strength utilization ratio, high production efficiency, low processing cost, light weight, good flexibility and the like. In addition, as the single yarn is formed by converging the ultra high molecular weight polyethylene thin film or strip, compared with the similar products formed by bonding the ultra high molecular weight polyethylene fibers, the single yarn further has the advantages of no glue, environmental friendliness and the like.

[0030] Optionally, the single yarn can also be prepared by converging and twisting the ultra high molecular weight polyethylene thin film or strip, namely, the ultra high molecular weight polyethylene thin film or strip is firstly converged and then twisted to prepare the single yarn. The twisting direction and the twist for twisting can be determined according to actual needs and are not limited in the various embodiments of the present invention, for example, the twisting direction for twisting of the ultra high molecular weight polyethylene thin film or strip can be left twisting or right twisting, and the twist is 1-100/m. The single yarn prepared according to the solution further has the advantages of good compactness and effect of being less liable to looseness, is convenient to process the single yarn product and can reduce the processing cost and improve the production efficiency.

[0031] Optionally, in the preparation process of the single yarn, the ultra high molecular weight polyethylene thin film or strip can be converged along the straightening direction of a molecular chain thereof. As the ultra high molecular weight polyethylene has a linear structure, the strength of the ultra high molecular weight polyethylene thin film or strip along the straightening direction of the molecular chain thereof is the maximum. Thus, when the single yarn is prepared by converging along the straightening direction of the molecular chain thereof, the strength of the single yarn can be improved, the loss which may be caused to the strength performance of the thin film for strip by converging treatment can also be reduced, and the strength utilization rate is high.

[0032] Optionally, the related parameters of the ultra high molecular weight polyethylene thin film at least meet one and more of the following conditions: the linear density is above 5000 deniers; the width is above 100mm; the thickness is below 0.2mm; the breaking strength is above 10 grams/denier; the tensile modulus is above 800 grams/denier; and the elongation at break is below 6%.

[0033] By preparing the single yarn on the basis of the ultra high molecular weight polyethylene thin film with one or more above-mentioned properties, the single yarn has higher integral strength and can better meet the preparation requirements of high-strength load, bulletproof and other products.

[0034] Optionally, the related parameters of the ultra high molecular weight polyethylene thin film at least meet one or more of the following conditions: the linear density is above 100deniers; the width is 1-100mm; the thickness is below 0.2mm; the breaking strength is above 10grams/denier; the tensile modulus is above 800grams/denier; and the elongation at break is below 6%. By preparing the single yarn on the basis of the ultra high molecular weight polyethylene strip with one or more above-mentioned properties, the single yarn has higher integral strength and can better meet the preparation requirements of high-strength load, bulletproof and other products.

[0035] In addition to the advantages of wear resistance, impact resistance, corrosion resistance, UV resistance and the like which are similar to those of the ultra high molecular weight polyethylene fibers, the single yarn formed by converging or converging and twisting the ultra high molecular weight polyethylene thin film or strip provided by the various solutions in this embodiment also has the unique advantages of good structural integrity, high strength, high strength utilization ratio, high production efficiency, low processing cost, light weight, small linear density and the like, and therefore the single yarn can replace traditional ultra high molecular weight polyethylene fibers in the preparation of the various products and is widely used in various fields, such as civil use, individual protection, national defense military supplies, civil engineering, industrial construction, offshore operations, fishing, ship manufacturing, sports goods and the like.

Embodiment of single yarn product and preparation method thereof

[0036] The single yarn product provided by the embodiment includes at least a body prepared from the above-mentioned single yarn. Namely, the single yarn product can be the body prepared from the single yarns, or the single yarn product includes not only the body prepared from the single yarns, but also a reinforcer, a flame-retardant layer and other accessories, and the composition is not limited in the invention. After the body is prepared from the single yarns, if the preparation of the single yarn product includes not only the body, but also the reinforcer, a flame-retardant sleeve and other accessories, the processing of other accessories can be implemented by adopting the prior art, which will not be described in detail herein.

[0037] The single yarn product provided by the embodiment of the present invention uses the single yarns formed by converging or converging and twisting the ultra high molecular weight polyethylene thin films or strips to replace traditional ultra high molecular weight polyethylene fibers as raw materials and is prepared by adopting one or more processes of unidirectional arranging, converging, twisting, interweaving, bonding, intertwining, hot-pressing and the like.

(1) Optionally, the multiple single yarns are unidirectionally arranged, connected, converged, twisted, interwoven, bonded, intertwined and/or hot-pressed into a whole to prepare the body of the single yarn product.

For example, the multiple single yarns formed by converging the ultra high molecular weight polyethylene thin films or strips can be twisted to prepare a twisted rope. The product form of the twisted rope prepared by the solution is not limited, for example, the twisted rope can be used as a brake rope, a guide rope of a helicopter, a suspension rope on a deceleration parachute or an aircraft, an electric traction rope and the like, and the twisted rope can better meet the special requirements of these products on strength, weight and other performances of the ropes.

For example, the single yarns prepared by converging and twisting the ultra high molecular weight polyethylene thin films or strips can be processed into a woven fabric or strip 301 (as shown in Fig. 3), a knitted fabric or strip 401 (as shown in Fig. 4), a plaited fabric or strip, a net 501 with a mesh structure (as shown in Fig. 5) and other single yarn products by adopting weaving, knitting, plaiting and other interweaving processes. The product of the single yarn product prepared by the solution can include, but is not limited to, an airfreight net, a deep water net cage, an ocean-going drag net, a high-strength structure, a high-strength suitcase, a high pressure-resistant storage tank, a bulletproof vest, a bulletproof plate, a geogrid, a bulletproof and explosion-proof suitcase, an armored plate, a protection door, a bulletproof seat and the like, and the single yarn product can better meet the special requirements of these products on strength, weight and other performances of the products.

For example, the single yarns formed by converging and twisting the ultra high molecular weight polyethylene thin films or strips can be unidirectionally interwoven and sewn side by side to form the shape of a flat strip. The product of the single yarn product prepared by the solution can include, but is not limited to, a hoisting strip and the like, and the single yarn product can better meet the special requirements of these products on strength, weight and other performances of the products.

(2) Optionally, the multiple single yarns can be converged, twisted, interwoven, bonded, intertwined and/or hot-pressed into a whole to form a single-strand structure, and the multiple single-strand structures were plied into a whole. The plying implementation ways can include, but are not limited to twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing to form a whole.

[0038] For example, the multiple single yarns are converged and then twisted to prepare a single-strand structure, and the multiple single-strand structures were twisted into a whole to prepare a twisted rope 601 (as shown in Fig. 6). The number of strands of the twisted rope can be determined according to actual needs and is not limited in the present invention. The twisted rope with a multi-strand structure has better strength than the single-strand twisted rope, and can be, but is not limited to, a brake rope, a guide rope of a helicopter, a suspension rope on a deceleration parachute or an aircraft, an electric traction rope and the like, and the twisted rope can better meet the special requirements of these products on strength, weight and other performances of the ropes.

[0039] For example, the multiple single yarns can be interwoven into a whole by adopting a weaving process to prepare a woven rope 701 (as shown in Fig. 7). The product form of the single yarn product prepared by the solution can include, but is not limited to, a guide rope of a helicopter, a suspension rope on a deceleration parachute or an aircraft, an electric traction rope; a ship motoring rope, a cable rope, an anchoring rope, a tank drag rope and fixed anchoring ropes for supertankers, ocean engineering and lighthouses.

[0040] Example 3: the multiple single yarns can be unidirectionally arranged and connected into a whole to prepare a single yarn product with a single-layer structure.

[0041] For example, the multiple single yarns can be arranged in parallel along the length direction of the single yarns and connected into a whole through binding connection, bonding or hot-pressing connection and other non-interweaving ways to prepare a unidirectional fabric 801 (as shown in Fig. 8). The unidirectional fabric prepared by the solution can be used for, but is not limited to, the preparation of strengthening structures, high-strength suitcases, bulletproof plates, impact-resistant plates, bulletproof helmets, bulletproof and explosion-proof suitcases and other products, and can better meet the special requirements of these products on strength, weight, bullet-proofness and other performances of fabric.

[0042] Example 4: single-layer structures obtained by unidirectionally arranging and connecting the multiple single yarns are crisscross compounded and laminated into a whole at certain angles to prepare a single yarn product with a multi-layer structure. Wherein, the intersection angles of any two adjacent single-layer structures can be the same, the intersection angles can be any angle in the range of 0-90 degrees, for example, the intersection angle is 45 degrees; or the intersection angle is

90 degrees, if the multiple layers of the unidirectional fabrics 801 are sequentially crisscross laminated by 0/90 degrees, and the various layers of the unidirectional fabrics are bonded or hot-pressed for connection, thereby preparing the single-yarn product with the multi-layer structure, such as a non-woven fabric 901 (as shown in Fig. 9). The single yarn production prepared by the solution has high strength, when the single yarn product is subject to shooting of a bullet and other strong impact force, a force-bearing point can be diffused to a force-bearing surface, energy is rapidly diffused, and the bulletproof performance is good. Based on the single yarn product, the single yarn products with other product forms can be further prepared, such as non-woven fabric, strengthening structures, high-strength suitcases, bulletproof plates, impact-resistant plates, bulletproof helmets, bulletproof and explosion-proof suitcases and other products, and the single yarn products can better meet the special requirements of these products on strength, weight, bullet-proofness and other performances.

[0043] Or, the intersection angles of at least two single-layer structures in the various single-layer structures are different from the intersection angles of other single-layer structures. For example, if the intersection angles of the two adjacent single-layer structures from the first single-layer structure are gradually increased, the single-layer structures with different intersection angles (unidirectional fabric 801) are laminated into a whole, thereby preparing the single yarn product with the multi-layer structure 1001 (as shown in Fig. 10). The single yarn products with other product forms can be further prepared on the basis of the single yarn product, such as strengthening structures, high-strength suitcases, bulletproof plates, impact-resistant plates, bulletproof helmets, bulletproof and explosion-proof suitcases and other products, and the single yarn products can better meet the special requirements of these products on strength, weight, bullet-proofness and other performances.

[0044] According to the various solutions in the embodiment, the single yarns obtained by converging or converging and twisting the ultra high molecular weight polyethylene thin films or strips replace traditional ultra high molecular weight fibers as the raw materials to prepare various single yarn products. In the preparation process of the single yarn product, the single yarn is taken as the basis for processing treatment. Compared with the similar products obtained by processing treatment on the basis of the ultra high molecular weight polyethylene fibers, the single yarn product has the advantages of good structural integrity, simple preparation process and high production efficiency. When the single yarn product bears the load, each single yarn is stressed as a whole, so that the strength of the single yarn product prepared by adopting the single yarns is higher than that of the similar product prepared on the basis of the ultra high molecular weight polyethylene fibers with the same denier number, the strength utilization ratio is effectively improved, and the prepared single yarn product further has the unique advantages of good structural integrity, high strength, high strength utilization ratio, high production efficiency, low processing cost, light weight, small linear density and the like, and can be widely used in various fields, such as civil use, individual protection, national defense military supplies, civil engineering, industrial construction, offshore operations, fishing, ship manufacturing, sports goods and the like.

[0045] The product forms of the single yarn products are rich and diverse and can not be listed exhaustively. The exemplary embodiments in the description of the present invention are only used for description and should not be construed as essentially limiting the technical solutions of the present invention.

[0046] In the various embodiments of the present invention, the serial numbers and/or the sequences of the embodiments are only used for description and do not represent the superiority and inferiority of the embodiments. The description of the embodiments places an emphasis on different parts, and the part which is not described in detail in a certain embodiment can refer to the related description in other embodiments.

[0047] In the embodiments of the device, the method and the like of the present invention, it is obvious that all the parts or all the steps can be decomposed, combined and/or re-combined after decomposition. These decompositions and/or re-combinations should be considered as equivalent solutions of the present invention. At the same time, in the above description of the specific embodiments of the present invention, the characteristics described and/or illustrated against one implementation way can be used in one or more other implementation ways in the same or similar manner, and can be combined with the characteristics in other implementation ways or can be used for substituting the characteristics in other implementation ways.

[0048] It should be emphasized that, the term 'including/containing' refers to the existence of the characteristics, elements, steps or components when being used herein, but does not exclude the existence or addition of one or more other characteristics, elements, steps or components.

[0049] Finally, it should be noted that, although the present invention and the advantages have been described in detail, it should be understood that various modifications, substitutions and changes can be made without exceeding the spirit and the scope of the present invention limited by the accompanying claims. Furthermore, the scope of the present invention is not limited to the specific embodiments of processes, equipment, means, methods and steps described in the description. According to the disclosure of the present invention, those of ordinary skill in the art can easily understand that the processes, the equipment, the means, the methods or the steps which are existing, will be developed in the future and execute the basically same functions with the corresponding embodiments or obtain the basically same results can be used. Thus, the accompanying

claims aim at including such processes, equipment, means, methods or steps within the scope.

Claims

1. A preparation method of a single yarn, comprising: converging or converging and twisting an ultra high molecular weight polyethylene thin film or strip to obtain the single yarn.

2. The preparation method of the single yarn according to claim 1, wherein the converging of the ultra high molecular weight polyethylene thin film or strip comprises: converging the ultra high molecular weight polyethylene thin film or strip along the straightening direction of a molecular chain thereof.

3. The preparation method of the single yarn according to claim 1 or 2, wherein the related parameters of the ultra high molecular weight polyethylene thin film at least meet one or more of the following conditions:

   the linear density is above 5000 deniers;
   the width is above 100mm;
   the thickness is below 0.2mm;
   the breaking strength is above 10 grams/denier;
   the tensile modulus is above 800 grams/denier; and
   the elongation at break is below 6%.

4. The preparation method of the single yarn according to claim 1 or 2, wherein the related parameters of the ultra high molecular weight polyethylene strip at least meet one or more of the following conditions:

   the linear density is above 100 deniers;
   the width is 1-100mm;
   the thickness is below 0.2mm;
   the breaking strength is above 10 grams/denier;
   the tensile modulus is above 800 grams/denier; and
   the elongation at break is below 6%.

5. The preparation method of the single yarn according to claim 1 or 2, wherein the twisting direction for twisting is left twisting or right twisting, and/or the twist for twisting is 1-100/m.

6. A single yarn, wherein the single yarn is prepared by adopting the preparation method of the single yarn according to any one of claims 1-5.

7. A preparation method of a single yarn product, comprising at least the following step:

   preparing a body of the single yarn product from the single yarns prepared according to claim 6.

8. The preparation method of the single yarn product according to claim 7, wherein the preparing of the body from the single yarns comprises: unidirectionally arranging, connecting, converging, twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing the multiple single yarns into a whole.

9. The preparation method of the single yarn product according to claim 7, wherein the preparing of the body from the single yarns comprises: converging, twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing the multiple single yarns into a whole to form a single-strand structure and plying the multiple single-strand structures into a whole.

10. The preparation method of the single yarn product according to claim 9, wherein the plying of the multiple single-strand structures into the whole comprises: twisting, interweaving, bonding, intertwining, sewing and/or hot-pressing the multiple single-strand structures into a whole.

11. The preparation method of the single yarn product according to claim 7, wherein the preparing of the body from the single yarns comprises: crisscross compounding and laminating multiple single-layer structures formed by unidirectionally arranging and connecting the multiple single yarns at certain angles into a whole.

12. A single yarn product, wherein the single yarn product is prepared by adopting the preparation method of the single yarn product according to any one of claims 7-11.

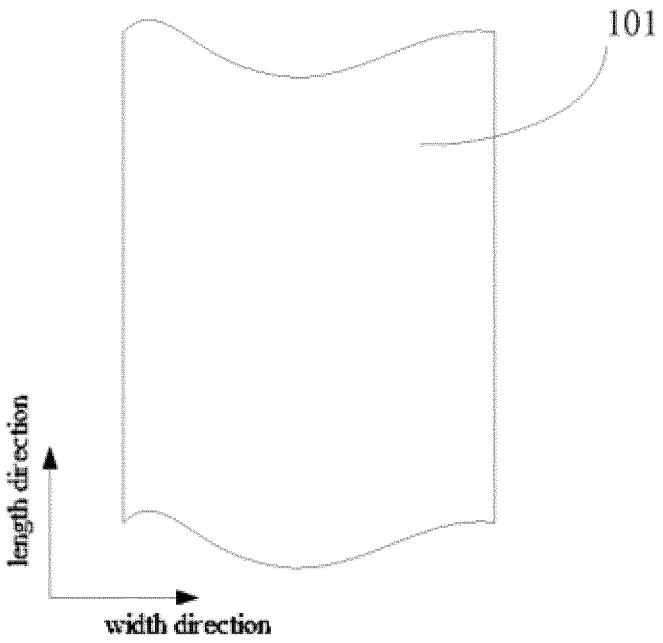
101
length direction
width direction

Fig. 1a

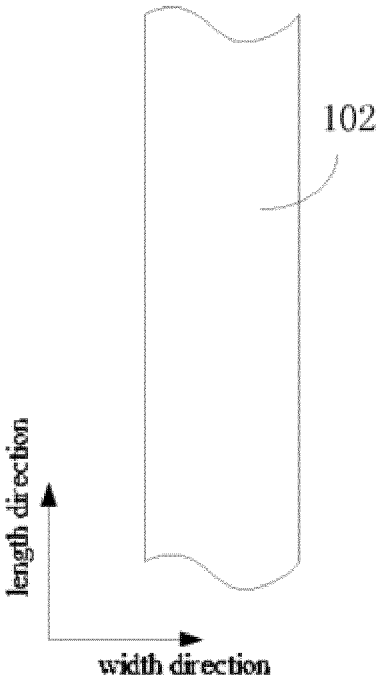
102
length direction
width direction

Fig. 1b

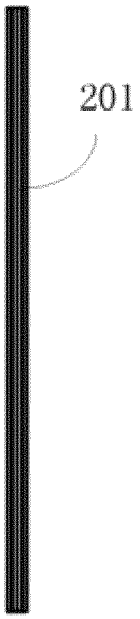

Fig. 2

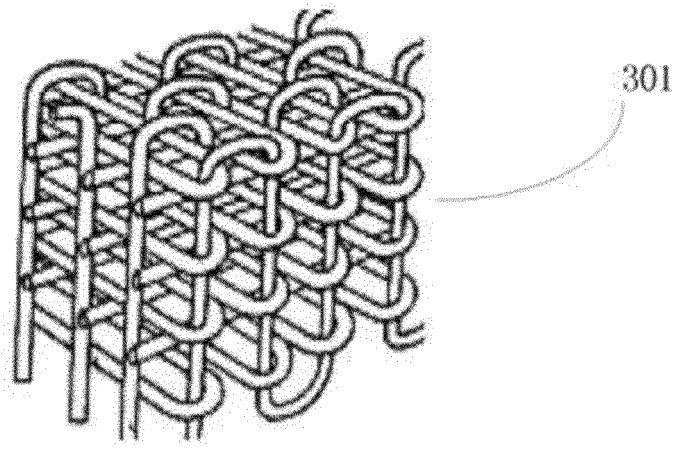

Fig. 3

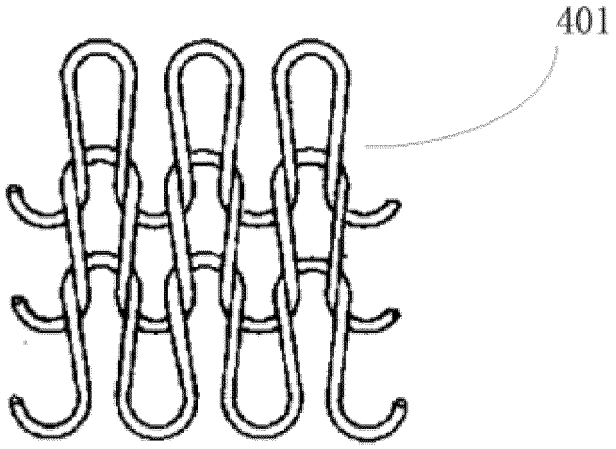

Fig. 4

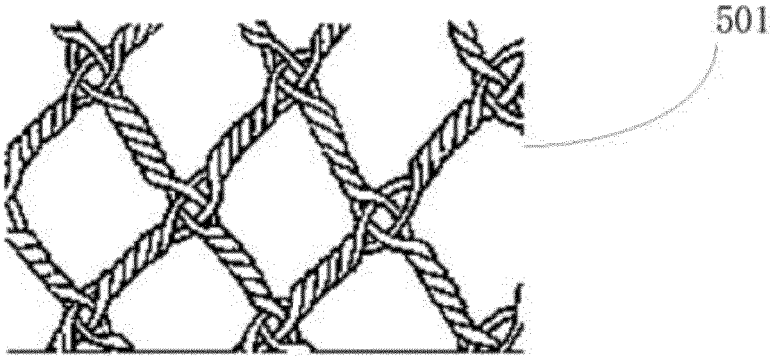

Fig. 5

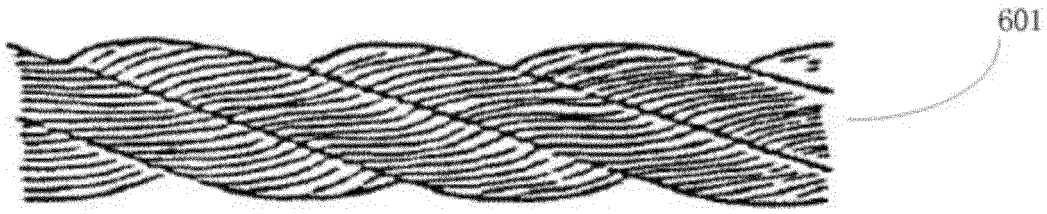

Fig. 6

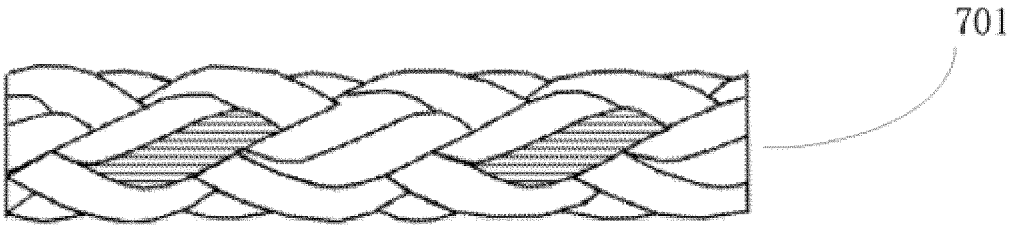

Fig. 7

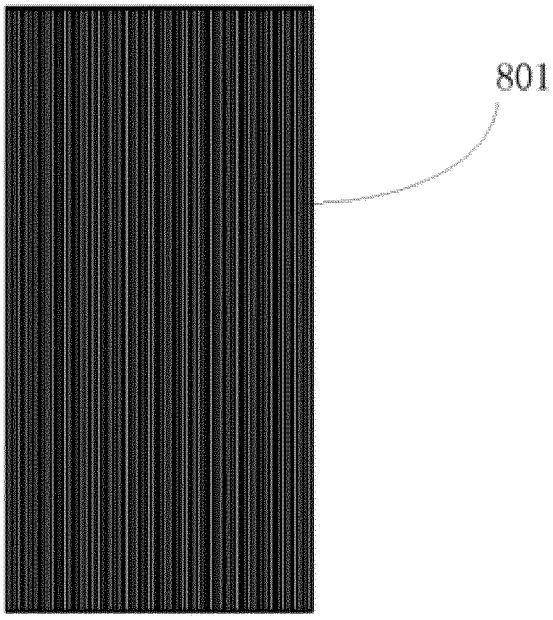

Fig. 8

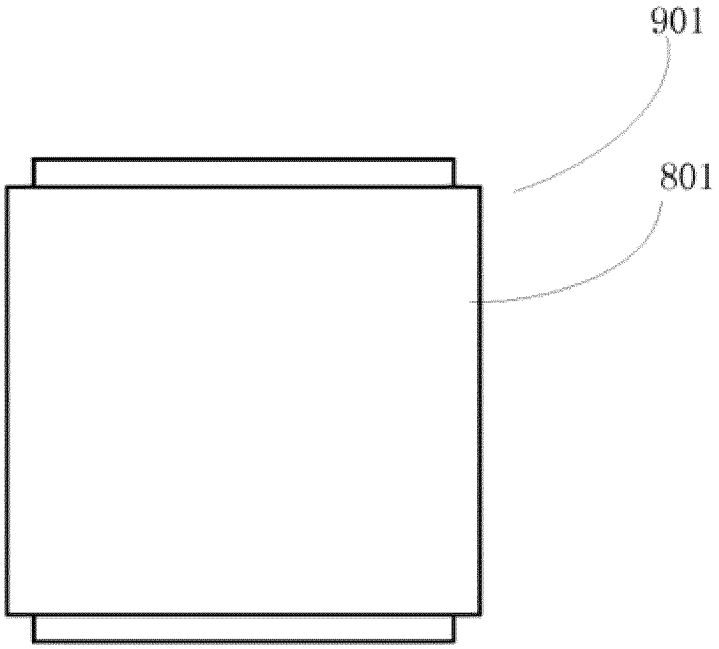

Fig. 9

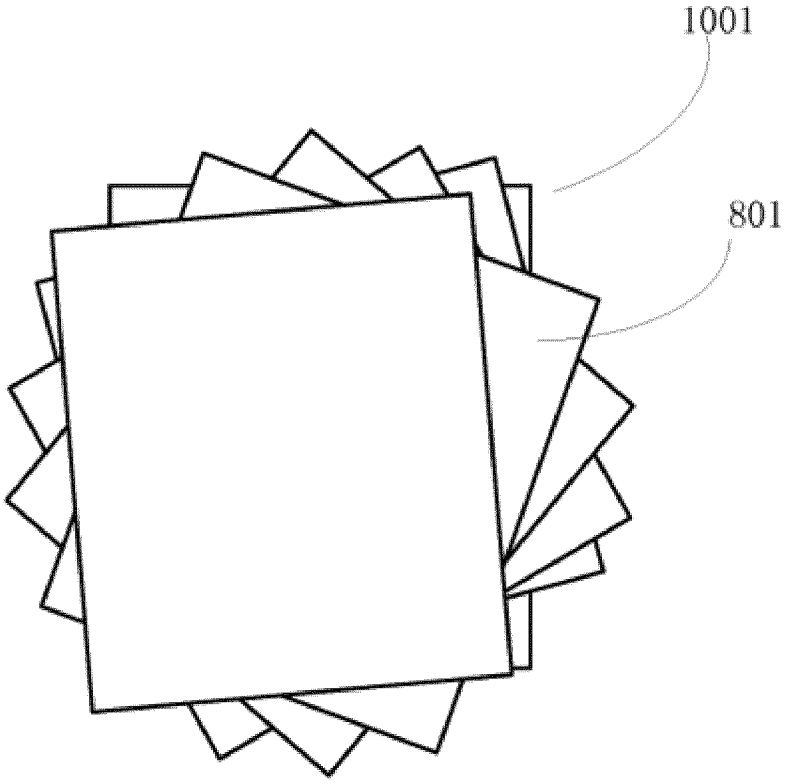

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/077545

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet
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)

IPC: D01D 5/42; D01F 6/04; D01F 6/02; D01F 6/00; D02G 1/-

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

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

WPI, EPODOC, CNPAT, CNKI: UHMWPE, ultra, high, molecular, weight, polyethylene, yarn, monofilament, slip, slit+, twist+, twist+, film, belt

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102149861 A (TEIJIN ARAMID BV) 10 August 2011 (10.08.2011) description, paragraphs [0012] to [0070]	1-12
Y		1-12
Y	US 5578373 A (NIPPON OIL CO., LTD. et al.) 26 November 1996 (26.11.1996) column 11, lines 15 to 40 and column 12, lines 40 to 50	1-12
Y	US 5702657 A (NIPPON OIL CO., LTD. et al.) 30 December 1997 (30.12.1997) column 20, lines 15 to 30	1-12
Y	CN 102947382 A (TEIJIN ARAMID BV) 27 February 2013 (27.02.2013) description, paragraph [0066]	1-12
Y	JP 4-370234 A (MITSUI PETROCHEM IND CO LTD et al.) 22 December 1992 (22.12.1992) the whole document	1-12

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January 2014 (28.01.2014)	27 March 2014 (27.03.2014)

Name and mailing address of the ISA	Authorized officer
State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	HUANG, Junsheng Telephone No. (86-10) 82246774

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/077545

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102149861 A	10.08.2011	RU 2011104720 A	20.08.2012
		CN 102149861 B	18.09.2013
		IN 201100137 P4	23.09.2011
		HK 1151324 A0	27.01.2012
		EP 2300644 A1	30.03.2011
		CA 2730214 A1	14.01.2010
		AU 2009268019 A1	03.02.2011
		ZA 201100263 A	26.10.2011
		JP 5339553 B2	13.11.2013
		JP 2011527387 A	27.10.2011
		WO 2010003971 A1	14.01.2010
		MX 2011000348 A	30.04.2011
		TW 201005144 A	01.02.2010
		KR 20110038688 A	14.04.2011
		US 2011124835 A1	26.05.2011
US 5578373 A	26.11.1996	CA 2054427 A1	02.05.1992
		JPH 05214657 A	24.08.1993
		JP 2938613 B2	23.08.1999
		EP 0483780 B1	12.03.1997
		EP 0483780 A2	06.05.1992
		EP 0483780 A3	02.12.1992
		CA 2054427 C	10.01.1995
US 5702657 A	30.12.1997	EP 0721021 B1	11. 07.2001
		JP 3764196 B2	05.04.2006
		EP 0721021 A3	22.01.1997
		DE 69521674 D	16.08.2001
		CA 2166132 A1	28.06.1996
		JPH 08229967 A	10.09.1996

Form PCT/ISA /210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/077545

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
		EP 0721021 A2	10.07.1996
		CA 2166132 C	05.09.2000
CN 102947382 A	27.02.2013	EP 2556112 A1	13 .02.2013
		US 2013025444 A1	31.01.2013
		JP 2013523967 A	17.06.2013
		WO 2011124650 A1	13.10.2011
JP 4-370234 A	22.12.1992	None	

Form PCT/ISA /210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/077545

Continuation of: **A. CLASSIFICATION OF SUBJECT MATTER**

D01F 6/04 (2006.01) i

D01D 5/42 (2006.01) i

D02G 1/02 (2006.01) i

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