



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

(43) Date of publication:
06.07.2022 Bulletin 2022/27

(21) Application number: **19957885.7**

(22) Date of filing: **27.12.2019**

(51) International Patent Classification (IPC):
D03D 15/00 ^(2021.01) **D01F 6/04** ^(2006.01)
D01D 5/088 ^(2006.01) **D01D 5/098** ^(2006.01)

(52) Cooperative Patent Classification (CPC):
D01D 5/088; D01D 5/098; D01F 6/04; D03D 15/00

(86) International application number:
PCT/KR2019/018557

(87) International publication number:
WO 2021/132767 (01.07.2021 Gazette 2021/26)

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

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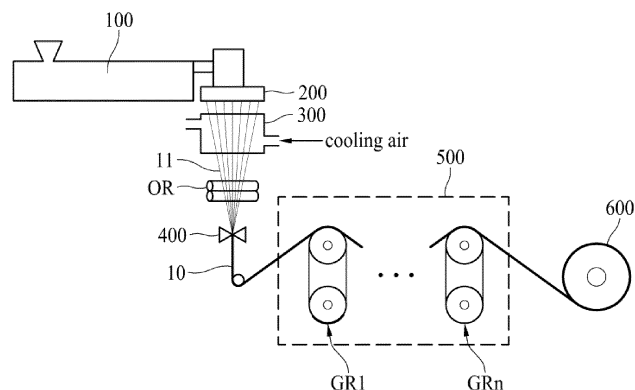
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(54) **COOLING SENSATION FABRIC, POLYETHYLENE YARN THEREFOR, AND METHOD FOR MANUFACTURING POLYETHYLENE YARN**

(57) Disclosed is a skin cooling fabric that can provide a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation, a polyethylene yarn having improved weavability, and a method for manufacturing the yarn. The skin cooling fabric of the present invention

includes a plurality of weft yarns, and a plurality of warp yarns, wherein each of the weft yarns and warp yarns has a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, elongation at break of 14 to 55 %, and crystallinity of 55 to 85 %.

[FIG. 1]



Description

[Technical Field]

5 **[0001]** The present invention relates to a skin cooling fabric, a polyethylene yarn therefor, and a method for manufacturing a polyethylene yarn. More particularly, the present invention relates to a fabric which can provide a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation, a polyethylene yarn having improved weavability that can be used in the manufacture of the fabric, and a method for manufacturing the yarn.

10 [Background Art]

[0002] As global warming progresses, there is an increasing need for fabrics that can be used to overcome intense heat. Factors that can be considered in developing fabrics that can be used to overcome the intense heat include (i) removal of factors that cause intense heat and (ii) removal of heat from the user's skin.

15 **[0003]** A method focused on the removal of factors of intense heat, a method of reflecting light by applying an inorganic compound to the surface of the fiber (for example, see JP 4227837B), a method of scattering light by dispersing inorganic fine particles inside and on the surface of the fiber (for example, see JP 2004-292982A) and the like have been proposed. However, blocking these external factors can only prevent additional intense heat, and for users who already feel heat, there is a limit that not only can it not be a significant solution, but also the tactile sensation of the fabric is degraded.

20 **[0004]** On the other hand, as a method capable of removing heat from a user's skin, a method of improving moisture absorption of the fabric in order to utilize the heat of evaporation of sweat (for example, see JP 2002-266206A), a method of increasing a contact area between the skin and the fabric in order to increase the heat transfer from the skin to the fabric (for example, see JP 2009-24272A), and the like have been proposed.

25 **[0005]** However, in the case of using the evaporation heat of sweat, since the function of the fabric depends greatly on external factors such as humidity or the user's constitution, there is a problem that its consistency cannot be guaranteed. In the case of a method of increasing the contact area between the skin and the fabric, as the contact area increases, the air permeability of the fabric decreases, so that many cooling effects that the user wants cannot be obtained.

30 **[0006]** Thus, it may be desirable to increase heat transfer from the skin to the fabric by improving the thermal conductivity of the fabric itself. To achieve this purpose, JP 2010-236130A proposes manufacturing fabrics using ultra-high strength polyethylene fibers (Dyneema® SK60) having high thermal conductivity.

35 **[0007]** However, Dyneema® SK60 fiber used in JP 2010-236130A is an Ultra High Molecular Weight Polyethylene (UHMWPE) fiber having a weight average molecular weight of 500,000 g/mol or more. Even if it exhibits high thermal conductivity, since it can be produced only by a gel spinning method due to the high melt viscosity of UHMWPE, there is a problem that environmental problems are caused and considerable costs are required to recover the organic solvent. Further, since Dyneema® SK60 fiber has a high tensile strength of 28 g/de or more, a high tensile modulus of 759 g/de or more, and a low elongation at break of 3 to 4 %, the weavability is not good. In addition, since Dyneema® SK60 fiber has excessively high stiffness, there is a problem that it is unsuitable for use in the manufacture of skin cooling fabrics that are intended for contacting with the user's skin.

40 [DETAILED DESCRIPTION OF THE PRESENT DISCLOSURE]

[Technical Problem]

45 **[0008]** Therefore, the present invention is directed to providing a skin cooling fabric that can prevent one or more of the problems due to limitations and disadvantages of the related arts, a polyethylene yarn therefor, and a method for manufacturing polyethylene yarn.

[0009] An aspect of the present invention is to provide a fabric capable of providing a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation.

50 **[0010]** Another aspect of the present invention is to provide a polyethylene yarn having improved weavability which can be used in the manufacture of the fabric capable of providing a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation.

[0011] Yet another aspect of the present invention is to provide a method for manufacturing a polyethylene yarn having improved weavability which can be used in the manufacture of the fabric capable of providing a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation.

55 **[0012]** Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention.

[Technical Solution]

[0013] In accordance with one aspect of the present invention as described above, a skin cooling fabric including a plurality of polyethylene yarns is provided, wherein each of the polyethylene yarns has a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, elongation at break of 14 to 55 %, and crystallinity of 55 to 85 %.

[0014] The polyethylene yarn may have crystallinity of 60 to 85 %.

[0015] The polyethylene yarn has a density of 0.941 to 0.965 g/cm³, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol.

[0016] The ratio of the weight average molecular weight to the number average molecular weight (Mw/Mn ratio) of the polyethylene may be 5.5 to 9.

[0017] The polyethylene yarn may have total fineness of 75 to 450 denier, and the polyethylene yarn may include filaments having a DPF (denier per filament) of 1 to 5.

[0018] The polyethylene yarn may have a circular cross-section.

[0019] The weight per unit area (area density) of the skin cooling fabric may be 150 to 800 g/m², the thermal conductivity in the thickness direction of the skin cooling fabric at 20 °C may be 0.0001 W/cm·°C or more, the heat transfer coefficient in the thickness direction of the skin cooling fabric at 20 °C may be 0.001 W/cm²·°C or more, and a contact cold sensation (Q_{max}) of the skin cooling fabric at 20 °C may be 0.1 W/cm² or more.

[0020] The skin cooling fabric may be a fabric including the polyethylene yarns as a weft yarn and a warp yarn.

[0021] The cover factor of the fabric defined by Equation 1 below may be 400 to 2000.

[Equation 1]

$$CF = (W_D * W_T^{1/2}) + (F_D * F_T^{1/2})$$

in Equation 1, CF is a cover factor, W_D is a warp density (ea/inch), W_T is a weft fineness (denier), F_D is a weft density (ea/inch), and F_T is a weft fineness (denier).

[0022] In accordance with another aspect of the invention, a polyethylene yarn for skin cooling fabric having a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, elongation at break of 14 to 55, and crystallinity of 55 to 85 %, is provided.

[0023] The polyethylene yarn may have crystallinity of 60 to 85 %.

[0024] The polyethylene yarn may include a polyethylene polymer having a density of 0.941 to 0.965 g/cm³, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol.

[0025] The ratio of the weight average molecular weight to the number average molecular weight (Mw/Mn ratio) of the polyethylene may be 5.5 to 9.

[0026] The polyethylene yarn may have total fineness of 75 to 450 denier, and the polyethylene yarn may include filaments having a DPF of 1 to 5.

[0027] The polyethylene yarn may have a circular cross-section.

[0028] In accordance with another aspect of the invention, a method for manufacturing a polyethylene yarn for skin cooling fabric is provided, including the steps of:

melting a polyethylene polymer having a density of 0.941 to 0.965 g/cm³, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol to prepare a spinning dope;
extruding the spinning dope through a spinneret having a plurality of spinning holes;
cooling a plurality of filaments formed when the spinning dope is discharged from the holes of the spinneret; and
drawing a multifilament composed of the cooled filaments.

[0029] The polyethylene may have a melt index (MI) of 1 to 25 g/10 min at 190 °C.

[0030] The ratio of the weight average molecular weight to the number average molecular weight (Mw/Mn ratio) of the polyethylene may be 5.5 to 9.

[0031] The drawing step may be performed at a draw ratio of 2.5 to 8.5.

[0032] The general description related to the present invention given above is intended only to illustrate or disclose the present invention, and should not be construed as limiting the scope of the present invention.

[ADVANTAGEOUS EFFECTS]

[0033] Since the skin cooling fabric of the present invention is woven with a yarn having high thermal conductivity, it is possible to consistently provide a user with a cooling sensation regardless of external factors such as humidity.

[0034] Also, the skin cooling fabric of the present invention can continuously provide a user with a sufficient cooling sensation without sacrificing air permeability.

[0035] In addition, the skin cooling fabric of the present invention can be easily manufactured at a relatively low cost without causing environmental problems, and can provide a soft tactile sensation to a user.

[BRIEF DESCRIPTION OF DRAWINGS]

[0036] The accompanying drawings, which are included to provide further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention, and together with the description serve to explain the principle of the invention.

FIG. 1 schematically shows an apparatus for manufacturing a polyethylene yarn according to an embodiment of the present invention.

FIG. 2 schematically shows an apparatus for measuring the contact cold sensation ($Q_{\max}$) of a skin cooling fabric.

FIG. 3 schematically shows an apparatus for measuring the thermal conductivity and heat transfer coefficient in the thickness direction of the skin cooling fabric.

[DETAILED DESCRIPTION OF THE EMBODIMENTS]

[0037] Hereinafter, embodiments according to the present invention will be described in detail with reference to the accompanying figures. However, the embodiments described below are provided for illustrative purposes only to help clear understanding of the present invention, and should not be construed as limiting the scope of the present invention.

[0038] It will be apparent to those skilled in the art that various modifications, additions, and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Accordingly, the present invention includes modifications and alterations which fall within the scope of inventions as claimed and equivalents thereto.

[0039] The skin cooling fabric according to an embodiment of the present invention may be a woven fabric or a knitted fabric.

[0040] In order to provide a fabric having high thermal conductivity so that the user can feel a sufficient cooling sensation, the yarns used in the manufacture of the fabric are preferably polymer yarns having high thermal conductivity.

[0041] In the case of a solid, heat is generally transferred through the movement of free electrons and lattice vibrations called "phonon". In the case of a metal, heat is transferred in the solid mainly by the movement of free electrons. In contrast, in the case of nonmetallic materials such as polymers, heat is mainly transferred through the phonon within the solid (especially in the direction of the molecular chains connected via covalent bonds).

[0042] In order to improve the thermal conductivity of the fabric so that the user can feel a cooling sensation, it is necessary to enhance the heat transfer capability through the phonon of the polymer yarn by increasing the crystallinity of the polymer yarn to 55 % or more, preferably 60 % or more.

[0043] According to the present invention, in order to produce a polymer yarn having such high crystallinity, high density polyethylene (HDPE) is used. This is because yarns made from high density polyethylene (HDPE) having a density of 0.941 to 0.965 g/cm³ have relatively high crystallinity as compared with yarns made from low density polyethylene (LDPE) having a density of 0.910 to 0.925 g/cm³ and yarns made from linear low density polyethylene (LLDPE) having a density of 0.915 to 0.930 g/cm³.

[0044] The high density polyethylene (HDPE) yarn used in the manufacture of the skin cooling fabric of the present invention has crystallinity of 55 to 85 %, preferably 60 to 85 %.

[0045] Meanwhile, the high density polyethylene (HDPE) yarn may be classified into an ultra high molecular weight polyethylene (UHMWPE) yarn and a high molecular weight polyethylene (HMWPE) yarn according to their weight average molecular weight (M_w). The UHMWPE generally refers to a linear polyethylene having a weight average molecular weight (M_w) of 500,000 g/mol or more, whereas the HMWPE generally refers to a linear polyethylene having a weight average molecular weight (M_w) of 20,000 to 250,000 g/mol.

[0046] As mentioned above, since UHMWPE yarns such as Dyneema® can only be produced by gel spinning due to the high melt viscosity of UHMWPE, there is a problem that environmental problems are caused and considerable costs are required to recover the organic solvent.

[0047] Since HMWPE has a relatively low melt viscosity compared to UHMWPE, melt spinning is possible, and as a result, environmental and high cost problems associated with UHMWPE yarns can be overcome.

[0048] However, when producing a yarn having crystallinity of 55 to 85 %, or 60 to 85 %, using HMWPE having a weight average molecular weight (Mw) of more than 99,000 g/mol, the finally obtained HMWPE yarn has a high tensile strength of 13 g/de or more, a high tensile modulus of 300 g/de or more, and a low elongation at break of 10 % or less. Consequently, similar to UHMWPE yarns, the weavability is not good, the stiffness is too high, and thus it is unsuitable for use in the manufacture of cold-sensitive fabrics that are intended for contacting with the user's skin.

[0049] In order to solve such problems (i.e., not only to enable the manufacture of a fabric that the user can feel a soft tactile sensation, but also to have good weavability), the polyethylene yarn of the present invention has crystallinity of 55 to 85 %, preferably 60 to 85 %, while having a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, and elongation at break of 14 to 55 %.

[0050] If the tensile strength is more than 8.5 g/de, if the tensile modulus is more than 80 g/de, or if the elongation at break is less than 14 %, not only is the weavability of the polyethylene yarn not good, but also the fabric produced using the yarn is excessively stiff, and thus the user may feel discomfort.

[0051] Conversely, if the tensile strength is less than 3.5 g/de, if the tensile modulus is less than 15 g/de, or if the elongation at break exceeds 55 %, pills may form on fabrics when the user continuously uses the fabrics made from these polyethylene yarns.

[0052] Specifically, the polyethylene yarn may have a tensile strength of 3.5 to 8.5 g/de, 4.5 to 7.0 g/de, or 5.0 to 6.5 g/de.

[0053] Further, the polyethylene yarn may have a tensile modulus of 15 to 80 g/de, 20 to 70 g/de, 30 to 65 g/de, 40 to 60 g/de, or 45 to 60 g/de.

[0054] In addition, the polyethylene yarn may have elongation at break of 14 to 55 %, 15 to 40 %, 16 to 30 %, or 17 to 20 %.

[0055] Further, the polyethylene yarn may have crystallinity of 55 to 85 %, 60 to 85 %, or 65 to 75 %.

[0056] In order to have crystallinity of 55 to 85 % and simultaneously have a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, and elongation at break of 14 to 55 %, the polyethylene yarn of the present invention may include a high density polyethylene (HDPE) having a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol.

[0057] If the weight average molecular weight (Mw) of the HDPE is too small, the finally obtained polyethylene yarn becomes difficult to express a tensile strength of 3.5 g/de or more and a tensile modulus of 15 g/de or more, and as a result, pills may form on fabrics. Therefore, it is preferable that the polyethylene has a weight average molecular weight (Mw) of 50,000 g/mol or more.

[0058] However, if the weight average molecular weight (Mw) of the HDPE is too large, the weavability of the polyethylene yarn is not good, the stiffness is too high and it is unsuitable to use in the manufacture of skin cooling fabrics that are intended for contacting the user's skin. Therefore, it is preferable that the polyethylene has a weight average molecular weight (Mw) of 99,000 g/mol or less.

[0059] Specifically, the polyethylene may have a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, 65,000 to 99,000 g/mol, or 75,000 to 99,000 g/mol.

[0060] The weight average molecular weight (Mw) and the number average molecular weight (Mn) of the polyethylene can be measured using the following gel permeation chromatography (GPC) after completely dissolving the polyethylene yarn in a solvent.

- Analytical equipment: PL-GPC 220 system
- Column: 2 × PLGEL MIXED-B (7.5 × 300 mm)
- Column temperature: 160 °C
- Solvent: trichlorobenzene (TCB) + 0.04 wt% dibutylhydroxytoluene (BHT) (after drying with 0.1 % CaCl₂)
- Dissolution condition: Measure the solution which passed through the glass filter (0.7 μm) after dissolution at 160 °C for 1 to 4 hours.
- Injector, Detector temperature: 160 °C
- Detector: RI Detector
- Flow rate: 1.0 ml/min
- Injection volume: 200 μl
- Standard sample: polystyrene

[0061] According to an embodiment of the present invention, the ratio of the weight average molecular weight (Mw) to the number average molecular weight (Mn) (Mw/Mn ratio) of the polyethylene, that is, the polydispersity index (PDI), may be 5.5 to 9, 6.0 to 9.0, or 6.4 to 8.5.

[0062] If the PDI of the polyethylene is less than 5.5, the flowability is poor due to the relatively narrow molecular weight distribution, and the processability during melt extrusion is deteriorated, resulting in a yarn breakage due to discharge unevenness during the spinning process. On the contrary, when the PDI of the polyethylene is more than 9, the melt flowability and the processability during melt extrusion are improved due to the wide molecular weight distribution, but the low molecular weight polyethylene is excessively contained, so that the finally obtained polyethylene yarn is

made difficult to express a tensile strength of 3.5 g/de or more and a tensile modulus of 15 g/de or more, and as a result, pills may form on fabrics.

[0063] The polyethylene yarn of the present invention includes filaments having a DPF of 1 to 5, and may have total fineness of 75 to 450 denier.

[0064] In a polyethylene yarn having predetermined total fineness, if the fineness of each filament, that is, the DPF (Denier Per Filament) exceeds 5 denier, the smoothness of the fabric made from the polyethylene yarn becomes insufficient and the contact area with the body becomes small, thus making it impossible to provide a user with sufficient cooling sensation. In general, the DPF can be adjusted through the discharge amount per hole of the spinneret (hereinafter, referred to as the "single-hole discharge amount") and the draw ratio.

[0065] The polyethylene yarn of the present invention may have a circular cross-section or a non-circular cross-section, but it is desirable to have a circular cross-section from the viewpoint that it can provide a uniform cooling sensation to the user.

[0066] The skin cooling fabric of the present invention made from the polyethylene yarn described above may be a woven or knitted fabric having a weight per unit area (i.e., area density) of 150 to 800 g/m². If the area density of the fabric is less than 150 g/m², the denseness of the fabric will be insufficient and there will be many voids in the fabric. These voids reduce the cooling sensation of the fabric. On the other hand, if the area density of the fabric exceeds 800 g/m², the fabric is very stiff due to the excessively dense fabric structure, causing a problem in the tactile sensation felt by the user, and the high weight causes a problem in use.

[0067] According to one embodiment of the present invention, the skin cooling fabric of the present invention may be a fabric having a cover factor of 400 to 2000. The cover factor is defined by Equation 1 below.

$$\text{[Equation 1]} \quad CF = (W_D * W_T^{1/2}) + (F_D * F_T^{1/2})$$

[0068] In Equation 1, CF is a cover factor, W_D is a warp density (ea/inch), W_T is a weft fineness (denier), F_D is a weft density (ea/inch), and F_T is a weft fineness (denier).

[0069] If the cover factor is less than 400, there is a problem that the denseness of the fabric is insufficient, and the cooling sensation of the fabric is lowered due to too many voids existing in the fabric. On the other hand, if the cover factor is more than 2000, the denseness of the fabric is excessively high, the tactile sensation of the fabric becomes worse, and a problem in use can occur due to the high fabric weight.

[0070] In the skin cooling fabric of the present invention, the thermal conductivity in the thickness direction of the fabric at 20 °C is 0.0001 W/cm·°C or higher, 0.0003 to 0.0005 W/cm·°C, or 0.00035 to 0.00047 W/cm·°C; the heat transfer coefficient in the thickness direction of the skin cooling fabric at 20 °C is 0.001 W/cm²·°C or higher, 0.01 to 0.02 W/cm²·°C, or 0.012 to 0.015 W/cm²·°C. In addition, the skin cooling fabric of the present invention at 20 °C has a contact cold sensation ($Q_{\max}$) of 0.1 W/cm² or more, 0.1 to 0.3 W/cm², or 0.1 to 0.2 W/cm². The measurement method of the thermal conductivity, heat transfer coefficient, and contact cold sensation ($Q_{\max}$) of the fabric will be described later.

[0071] Hereinafter, a method for manufacturing a polyethylene yarn for skin cooling fabric of the present invention will be described in detail with reference to FIG. 1.

[0072] First, in order to melt the polyethylene to produce a spinning dope, an HDPE chip is introduced into an extruder 100.

[0073] The polyethylene used in the present invention is a high density polyethylene (HDPE) having a density of 0.941 to 0.965 g/cm³. Preferably, it has a weight average molecular weight (M_w) of 50,000 to 99,000 g/mol and a number average molecular weight (M_n) of 10,500 to 14,000 g/mol.

[0074] In order to produce a fabric that provides a high cooling sensation, the polyethylene yarn must have high crystallinity of 55 to 85 %, preferably 65 to 85 %, and in order to produce a polyethylene yarn having such a high crystallinity, the use of HDPE having a density of 0.941 to 0.965 g/cm³ is essential.

[0075] Further, as described above, when the weight average molecular weight (M_w) of the HDPE is less than 50,000 g/mol, the finally obtained polyethylene yarn is made difficult to express a tensile strength of 3.5 g/de or more and a tensile modulus of 15 g/de or more, and as a result, pills may form on fabrics. On the contrary, when the weight average molecular weight (M_w) of the HDPE exceeds 99,000 g/mol, the weavability of polyethylene yarn is not good due to the excessively high tensile strength and tensile modulus, and the stiffness is too high, and thus it is unsuitable for use in the manufacture of skin cooling fabrics that are intended for contacting with the user's skin.

[0076] According to an embodiment of the present invention, the ratio of the weight average molecular weight (M_w) to the number average molecular weight (M_n) (M_w/M_n ratio), that is, the polydispersity index (PDI) of the HDPE, may be 5.5 to 9. When the PDI of the HDPE is less than 5.5, the flowability is poor due to the relatively narrow molecular weight distribution, and the processability during melt extrusion is deteriorated, which causes yarn breakage due to discharge unevenness during the spinning process. On the contrary, when the PDI of the HDPE exceeds 9, the melt flowability and the processability at the time of melt extrusion are improved due to the wide molecular weight distribution,

but the low molecular weight polyethylene is excessively contained, so that the finally obtained polyethylene yarn is made difficult to have a tensile strength of 3.5 g/de or more and a tensile modulus of more than 15 g/de, and as a result, pills may form on fabrics.

[0077] According to an embodiment of the present invention, the HDPE may have a melt index (MI) of 1 to 25 g/10 min at 190 °C. When the melt index (MI) of the HDPE is less than 1 g/10 min, it is difficult to ensure smooth flowability in an extruder 100 due to the high viscosity and low flowability of the molten HDPE, and it is difficult to ensure the uniformity of the extrudate. On the other hand, when the melt index (MI) of HDPE exceeds 25 g/10 min, the flowability in the extruder 100 becomes relatively good, but the finally obtained polyethylene yarn may be made difficult to have a tensile strength of 3.5 g/de or more and a tensile modulus of 15 g/de or more.

[0078] Optionally, in order to suppress the occurrence of yarn breakage and thus improve the productivity, a spinning dope further including a fluorine-based polymer may be used in addition to HDPE. As a non-limiting example, the fluorine-based polymer may be a tetrafluoroethylene copolymer.

[0079] Such spinning dope may be obtained via (i) a method of introducing a master batch containing HDPE and a fluorine-based polymer together with an HDPE chip into the extruder 100 and then melting them therein, or (ii) a method of introducing the fluorine-based polymer into an extruder through a side feeder while introducing the HDPE chip into the extruder 100, and then melting them together.

[0080] The fluorine-based polymer may be present in the spinning dope in such amount that the content of fluorine in the spinning dope becomes 50 to 2500 ppm.

[0081] The spinning dope is transferred to a spinneret 200 by a screw (not shown) in the extruder 100, and is extruded through a plurality of spinning holes formed in the spinneret 200.

[0082] The number of holes in the spinneret 200 may be determined according to the total fineness of the produced yarn. For example, when manufacturing a yarn having total fineness of 75 denier, the spinneret 200 may have 20 to 75 holes. Further, when manufacturing a yarn having total fineness of 450 denier, the spinneret 200 may have 90 to 450 holes, preferably 100 to 400 holes.

[0083] The melting step in the extruder 100 and the extrusion step through the spinneret 200 are preferably performed at 150 to 315 °C, preferably 250 to 315 °C, more preferably 265 to 310 °C. That is, the extruder 100 and the spinneret 200 are maintained at 150 to 315 °C, preferably 250 to 315 °C, more preferably 265 to 310 °C. When the spinning temperature is less than 150 °C, the spinning temperature is low so that the HDPE may not be uniformly melted and thus spinning may be difficult. On the other hand, when the spinning temperature exceeds 315 °C, the HDPE may be thermally decomposed and it may be difficult to express high strength.

[0084] L/D, which is the ratio of the hole length L to the hole diameter D of the spinneret 200, may be 3 to 40. When L/D is less than 3, a die swell phenomenon occurs during melt extrusion, and it becomes difficult to control the elastic behavior of HDPE, resulting in a poor spinning property. Further, when the L/D exceeds 40, a non-uniform discharge phenomenon may occur due to a pressure drop along with yarn breakage caused by a necking phenomenon of the molten HDPE passing through the spinneret 200.

[0085] As the spinning dope is discharged from the holes of the spinneret 200, solidification of the spinning dope is started by a difference between the spinning temperature and the room temperature, and simultaneously a semi-solidified filament is formed. In this specification, not only the semi-solidified filament but also the completely solidified filament are commonly referred to as "filament".

[0086] The plurality of filaments 11 formed while the spinning dope is discharged from the holes of the spinneret 200 are completely solidified by being cooled in a quenching zone 300. The cooling of the filaments 11 may be performed by an air cooling method.

[0087] In the quenching zone 300, the cooling of the filaments 11 is preferably performed so as to be cooled to 15 to 40 °C using a cooling air having a wind speed of 0.2 to 1 m/s. When the cooling temperature is less than 15 °C, the elongation may be insufficient due to excessive cooling, which may cause yarn breakage in the drawing process. When the cooling temperature exceeds 40 °C, the fineness deviation between filaments 11 increases due to non-uniform solidification which may cause yarn breakage in the drawing process.

[0088] Subsequently, the filaments 11 that are cooled and completely solidified are converged by a converging part 400 to form a multifilament 10.

[0089] Optionally, as illustrated in FIG. 1, the method of the present invention may further include a step of applying an oil onto the cooled filaments 11 using an oil roller (OR) or oil jet, before forming the multifilament 10. The oil applying step may be performed through a metered oiling (MO) method.

[0090] Optionally, the step of forming the multifilament 10 through a converging part 400 and the oil applying step may be performed at the same time.

[0091] After the multifilament 10 is first wound as an undrawn yarn, the undrawn yarn can be drawn at a draw ratio of 2.5 to 8.5, preferably 3.5 to 7.5, thereby manufacturing the polyethylene yarn of the present invention. That is, the polyethylene yarn of the present invention may be manufactured through a two-step process of first melt spinning HDPE to produce an undrawn yarn and then drawing the undrawn yarn.

[0092] Alternatively, as illustrated in FIG. 1, the polyethylene yarn of the present invention may be produced via a direct spinning drawing (DSD) process. That is, the multifilament 10 is directly transferred to a multistage drawing part 500 including a plurality of godet roller parts GR1 ... GRn and multistage-drawn at a total draw ratio of 2.5 to 8.5, preferably 3.5 to 7.5, and then wound on a winder 600. Such direct spinning drawing (DSD) process is advantageous in terms of productivity and manufacturing cost compared to the two stage process.

[0093] If the draw ratio applied in the drawing process is less than 2.5, (i) the finally obtained polyethylene yarn cannot have crystallinity of 55 % or more, and thus the fabric made from the yarn cannot provide a user with sufficient cooling sensation, and (ii) the polyethylene yarn cannot have a tensile strength of 3.5 g/de or more, a tensile modulus of 15 g/de or more, and elongation at break of 55 % or less, and as a result, pills may form on the fabric produced from the yarn.

[0094] On the other hand, when the draw ratio exceeds 8.5, the finally obtained polyethylene yarn cannot have a tensile strength of 8.5 g/de or less, a tensile modulus of 80 g/de or less, and elongation at break of 14 % or more. Therefore, not only is the weavability of the polyethylene yarn not good, but also the fabric produced using the yarn becomes excessively stiff, thus making the user feel discomfort.

[0095] If the linear velocity of the first godet roller part (GR1) that determines the spinning speed of the melt spinning of the present invention is determined, the linear velocity of the remaining godet roller parts is appropriately determined so that in the multistage drawing part 500, a total draw ratio of 2.5 to 8.5, preferably 3.5 to 7.5, can be applied to the multifilament 10.

[0096] According to one embodiment of the present invention, by appropriately setting the temperature of the godet roller parts (GR1 ... GRn) of the multistage drawing part 500 in the range of 40 to 140 °C, heat-setting of the polyethylene yarn may be performed through the multistage drawing part 500.

[0097] For example, the temperature of the first godet roller part (GR1) may be 40 to 80 °C, and the temperature of the last godet roller part (GRn) may be 110 to 140 °C. The temperature of each of the godet roller parts excluding the first and last godet roller parts (GR1, GRn) may be set to be equal to or higher than the temperature of the godet roller part immediately before. The temperature of the last godet roller part (GRn) may be set to be equal to or higher than the temperature of the godet roller part immediately before, but may be set slightly lower than that temperature.

[0098] Multi-stage drawing and heat setting of the multifilament 10 are carried out by the multistage drawing part 500 at the same time, and the multistage drawn multifilament 10 is wound around a winder 600, thereby completing the manufacture of the polyethylene yarn for skin cooling fabric of the present invention.

[0099] Hereinafter, the present invention will be described in more detail by way concrete examples. However, these examples are only to aid the understanding of the present invention and the scope of the present invention is not limited thereto.

Example 1

[0100] A polyethylene yarn containing 200 filaments and having total fineness of 400 denier was produced using the apparatus illustrated in FIG. 1. In detail, an HDPE chip having a density of 0.964 g/cm³, a weight average molecular weight (Mw) of 98,290 g/mol, a number average molecular weight (Mn) of 11,730 g/mol, and a melt index (MI at 190 °C) of 3 g/10 min was introduced into an extruder 100 and melted to obtain a spinning dope, and the spinning dope was extruded through a spinneret 200 having 200 holes. L/D which is the ratio of the hole length L to the hole diameter D of the spinneret 200 was 6. The spinneret temperature was 290 °C.

[0101] The filaments 11 formed while being discharged from the spinneret 200 were finally cooled to 30 °C by a cooling air having a wind speed of 0.45 m/s in a quenching zone 300, and were converged into a multifilament 10 by the converging unit 400 and moved to the multistage drawing part 500.

[0102] The multistage drawing part 500 was composed of a total of five stage godet rollers, the temperature of the godet roller parts was set to 70 to 115 °C, and the temperature of the rear stage roller part was set to be equal to or higher than the temperature of the roller part immediately before.

[0103] After the multifilament 10 was drawn at a total draw ratio of 7.5 by the multistage drawing part 500, it was wound on a winder 600, thereby obtaining a polyethylene yarn.

[0104] The plain weave was performed using the polyethylene yarns as a warp yarn and a weft yarn, thereby obtaining a 0.31 mm thick fabric (warp density: 30 ea/inch, weft density: 30 ea/inch).

Example 2

[0105] A polyethylene yarn was obtained in the same manner as in Example 1, except that an HDPE chip having a density of 0.958 g/cm³, a weight average molecular weight (Mw) of 87,660 g/mol, a number average molecular weight (Mn) of 13,510 g/mol, and a melt index of 6.4 g/10 min (MI at 190 °C) was used. The plain weave was performed using the polyethylene yarn as warp and weft yarns, thereby obtaining a 0.31 mm thick fabric (warp density: 30 ea/inch, weft density: 30 ea/inch).

Example 3

[0106] A polyethylene yarn was obtained in the same manner as in Example 1, except that an HDPE chip having a density of 0.961 g/cm³, a weight average molecular weight (M_w) of 78,620 g/mol, a number average molecular weight (M_n) of 12,150 g/mol, and a melt index of 11 g/10 min (MI at 190 °C) was used. The plain weave was performed using the polyethylene yarn as warp and weft yarns, thereby obtaining a 0.32 mm thick fabric (warp density: 30 ea/inch, weft density: 30 ea/inch).

Example 4

[0107] A polyethylene yarn was obtained in the same manner as in Example 1, except that the number of filaments constituting the polyethylene yarn (total fineness: 400 denier) was 48. The plain weave was performed using the polyethylene yarns as a warp yarn and a weft yarn, thereby obtaining a 0.33 mm thick fabric (warp density: 30 ea/inch, weft density: 30 ea/inch).

Example 5

[0108] A polyethylene yarn was obtained in the same manner as in Example 3, except that the number of filaments constituting the polyethylene yarn (total fineness: 400 denier) was 48. The plain weave was performed using the polyethylene yarns as a warp yarn and a weft yarn, thereby obtaining a 0.33 mm thick fabric (warp density: 30 ea/inch, weft density: 30 ea/inch).

Comparative Example

[0109] A polyethylene yarn was obtained in the same manner as in Example 1, except that an HDPE chip having a density of 0.961 g/cm³, a weight average molecular weight (M_w) of 18,000 g/mol, a number average molecular weight (M_n) of 25,714 g/mol, and a melt index of 0.5 g/10 min (MI at 190 °C) was used, and it was drawn at a total draw ratio of 14 through the multistage drawing part 500 composed of a total of eight stage godet roller parts. The plain weave was performed using the polyethylene yarns as a warp yarn and a weft yarn, thereby obtaining a 0.32 mm thick fabric (warp density: 30 ea/inch, weft density: 30 ea/inch).

Test Example

[0110] The tensile strength, tensile modulus, elongation at break, and crystallinity of the polyethylene yarn prepared by each of the examples and comparative examples were measured as follows, and the thermal conductivity, heat transfer coefficient, contact cold sensation (Q_{max}), and stiffness of the fabric obtained by each of the examples and comparative examples were measured as follows. The measurement results are shown in Table 1 and Table 2 below.

(1) Tensile strength, tensile modulus, and elongation at break of polyethylene yarn

[0111] The tensile strength (g/de), tensile modulus (g/de), and elongation at break (%) of the polyethylene yarn were respectively measured using an Instron universal tensile tester (Instron Engineering Corp., Canton, Mass) in accordance with ASTM D885. The sample length was 250 mm, the tensile speed was 300 mm/min and the initial load was set at 0.05 g/d.

(2) Crystallization of polyethylene yarn

[0112] The crystallinity of the polyethylene yarn was measured using an XRD instrument (X-ray diffractometer) (manufacturer: PANalytical, model name: EMPYREAN). In detail, the polyethylene yarn was cut to prepare a sample having a length of 2.5 cm. The sample was fixed to a sample holder, and then measurement was performed under the following conditions.

- Light source (X-ray source): Cu-K α radiation
- Power: 45 KV $\times$ 25 mA
- Mode: continuous scan mode
- Scan angle range: 10° to 40°
- Scan speed: 0.1°/s

(3) Contact cold sensation ($Q_{\max}$) of fabrics

[0113] A fabric sample having a size of 20 cm × 20 cm was prepared and then allowed to stand for 24 hours under the conditions of a temperature of 20 ± 2 °C and RH of 65 ± 2 %. Then, the contact cold sensation ($Q_{\max}$) of the fabric was measured using a KES-F7 THERMO LABO II (Kato Tech Co., LTD.) apparatus under the test environment of a temperature of 20 ± 2 °C and 65 ± 2 % RH.

[0114] In detail, as illustrated in FIG. 2, the fabric sample 23 was placed on a base plate (also referred to as "Water-Box") 21 maintained at 20 °C, and a T-Box 22a (contact area: 3 cm × 3 cm) heated to 30 °C was placed on the fabric sample 23 for only 1 second. That is, the other surface of the fabric sample 23 whose one surface was in contact with the base plate 21 was brought into instantaneous contact with the T-Box 22a. The contact pressure applied to the fabric sample 23 by the T-Box 22a was 6 gf/cm². Then, the $Q_{\max}$ value displayed on a monitor (not shown) connected to the apparatus was recorded. Such a test was repeated 10 times and the arithmetic mean value of the obtained $Q_{\max}$ values was calculated.

(4) Thermal conductivity and heat transfer coefficient of fabrics

[0115] A fabric sample having a size of 20 cm × 20 cm was prepared and then allowed to stand for 24 hours under the conditions of a temperature of 20 ± 2 °C and RH of 65 ± 2 %. Then, the thermal conductivity and the heat transfer coefficient of the fabric were measured using a KES-F7 THERMO LABO II (Kato Tech Co., LTD.) apparatus under the test environment of a temperature of 20 ± 2 °C and 65 ± 2 % RH.

[0116] In detail, as illustrated in FIG. 3, the fabric sample 23 was placed on a base plate 21 maintained at 20 °C, and a BT-Box 22b (contact area: 5 cm × 5 cm) heated to 30 °C was placed on the fabric sample 23 for 1 minute. Even while the BT-Box 22b was in contact with the fabric sample 23, heat was continuously supplied to the BT-Box 22b so that the temperature could be maintained at 30 °C. The amount of heat (i.e., heat flow loss) supplied to maintain the temperature of the BT-Box 22b was displayed on a monitor (not shown) connected to the apparatus. Such a test was repeated 5 times and the arithmetic mean value of the obtained heat flow loss was calculated. Then, the thermal conductivity and the heat transfer coefficient of the fabric were calculated using Equations 2 and 3 below.

$$[\text{Equation 2}] K = (W \cdot D) / (A \cdot \Delta T)$$

$$[\text{Equation 3}] K = k / D$$

where K is a thermal conductivity (W/cm · °C), D is a thickness (cm) of the fabric sample 23, A is a contact area (= 25 cm²) of the BT-Box 22b, ΔT is a temperature difference (= 10 °C) on both sides of the fabric sample 23, W is a heat flow loss (Watts), and k is a heat transfer coefficient (W/cm² · °C).

(5) Stiffness of fabrics

[0117] The stiffness of the fabric was measured by the circular bend method using a stiffness measuring device in accordance with ASTM D 4032. As the stiffness (kgf) is lower, the fabric has softer properties.

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[Table 1]

			Example 1	Example 2	Example 3
5 10 15	PE yarn	PE	Density (g/cm ³)	0.964	0.958
			Mw (g/mol)	98,290	87,660
			Mn (g/mol)	11,730	13,510
			Mw/Mn	8.38	6.49
			MI (g/10 min)	3	6.4
	Fabric	Tensile strength (g/de)		6.5	5.7
		Tensile modulus (g/de)		57	51
		Elongation at break (%)		17	18
		Crystallinity (%)		69	67
		DPF (de)		2	2
20 25	Fabric	Thickness (mm)		0.31	0.31
		Thermal conductivity (W/cm· °C)		0.000461	0.000453
		Heat transfer coefficient (W/cm ² · °C)		0.014752	0.014285
		Qmax (W/cm ²)		0.173	0.170
		Stiffness (kgf)		0.11	0.11

[Table 2]

			Example 4	Example 5	Comparative Example
30 35 40	PE yarn	PE	Density (g/cm ³)	0.964	0.961
			Mw (g/mol)	98,290	78,620
			Mn (g/mol)	11,730	12,150
			Mw/Mn	8.38	6.47
			MI (g/10 min)	3	11
		Tensile strength (g/de)		6.5	6.0
		Tensile modulus (g/de)		57	53
		Elongation at break (%)		17	18
		Crystallinity (%)		69	67
		DPF (de)		8.33	8.33
45 50	Fabric	Thickness (mm)		0.33	0.33
		Thermal conductivity (W/cm· °C)		0.000405	0.000398
		Heat transfer coefficient (W/cm ² · °C)		0.012342	0.012168
		Qmax (W/cm ²)		0.146	0.147
		Stiffness (kgf)		0.23	0.22

[Explanation of Symbols]

100: extruder 200: spinneret
 300: quenching zone 11: filaments
 OR: oil roller 400: converging part

(continued)

10:	multifilament	500:	multistage drawing part
GR1:	first godet roller part	GRn:	last godet roller part
600:	winder	21:	base plate
22a:	T-Box	22b:	BT-Box
23:	fabric sample		

Claims

1. A skin cooling fabric comprising a plurality of polyethylene yarns, wherein each of the polyethylene yarns has a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, elongation at break of 14 to 55 %, and crystallinity of 55 to 85 %.
2. The skin cooling fabric of claim 1, wherein the polyethylene yarn has a density of 0.941 to 0.965 g/cm³, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol.
3. The skin cooling fabric of claim 2, wherein the ratio of the weight average molecular weight to the number average molecular weight (Mw/Mn ratio) of the polyethylene is 5.5 to 9.
4. The skin cooling fabric of claim 1, wherein the polyethylene yarn has total fineness of 75 to 450 denier, and the polyethylene yarn includes a plurality of filaments having fineness of 1 to 5 denier.
5. The skin cooling fabric of claim 1, wherein an area density of the skin cooling fabric is 150 to 800 g/m², and the thermal conductivity in the thickness direction of the skin cooling fabric at 20 °C is 0.0001 W/cm· °C or more, a heat transfer coefficient in the thickness direction of the skin cooling fabric at 20 °C is 0.001 W/cm²· °C or more, a contact cold sensation (Q_{max}) of the skin cooling fabric at 20 °C is 0.1 W/cm² or more.
6. The skin cooling fabric of claim 1, wherein the skin cooling fabric is a fabric including the polyethylene yarns as a weft yarn and a warp yarn.
7. A polyethylene yarn for skin cooling fabric having a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, elongation at break of 14 to 55 %, and crystallinity of 55 to 85 %.
8. The polyethylene yarn for skin cooling fabric of claim 7, wherein the polyethylene yarn has crystallinity of 60 to 85 %.
9. The polyethylene yarn for skin cooling fabric of claim 7, wherein the polyethylene yarn includes a polyethylene polymer having a density of 0.941 to 0.965 g/cm³, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol.
10. The polyethylene yarn for skin cooling fabric of claim 9, wherein a ratio of the weight average molecular weight to the number average molecular weight (Mw/Mn ratio) of the polyethylene is 5.5 to 9.
11. The polyethylene yarn for skin cooling fabric of claim 7, wherein the polyethylene yarn has total fineness of 75 to 450 denier, and the polyethylene yarn includes a plurality of filaments has fineness of 1 to 5.
12. A method for manufacturing a polyethylene yarn for skin cooling fabric comprising the steps of:

melting a polyethylene polymer having a density of 0.941 to 0.965 g/cm³, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a number average molecular weight (Mn) of 10,500 to 14,000 g/mol to prepare a spinning dope;

extruding the spinning dope through a spinneret having a plurality of spinning holes;

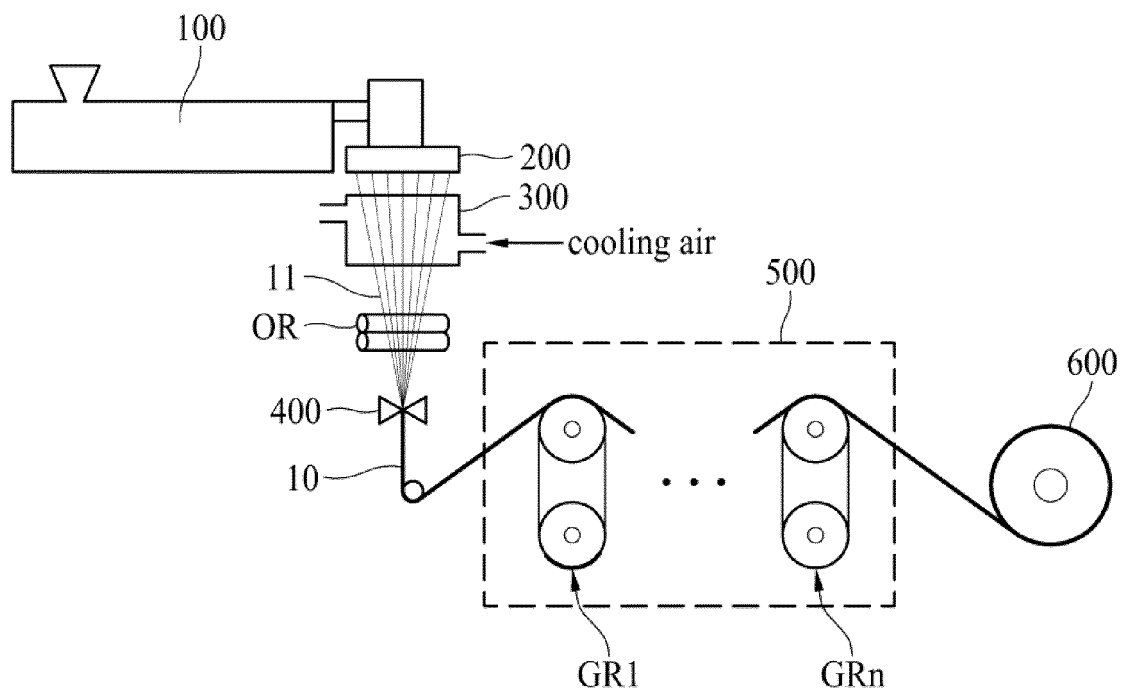
cooling a plurality of filaments formed when the spinning dope is discharged from the holes of the spinneret; and drawing a multifilament comprised of the cooled filaments.

13. The method for manufacturing a polyethylene yarn for skin cooling fabric of claim 12, wherein the polyethylene has a melt index (MI) of 1 to 25 g/10 min at 190 °C.

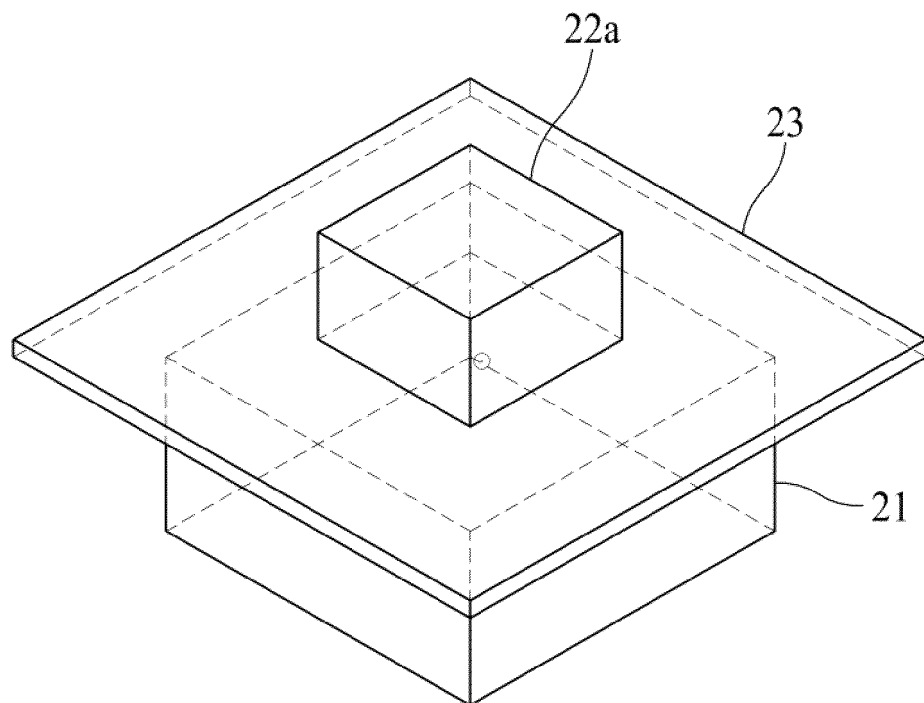
14. The method for manufacturing a polyethylene yarn for skin cooling fabric of claim 12, wherein a ratio of the weight average molecular weight to the number average molecular weight (Mw/Mn ratio) of the polyethylene is 5.5 to 9.

15. The method for manufacturing a polyethylene yarn for skin cooling fabric of claim 12, wherein the drawing step is performed at a draw ratio of 2.5 to 8.5.

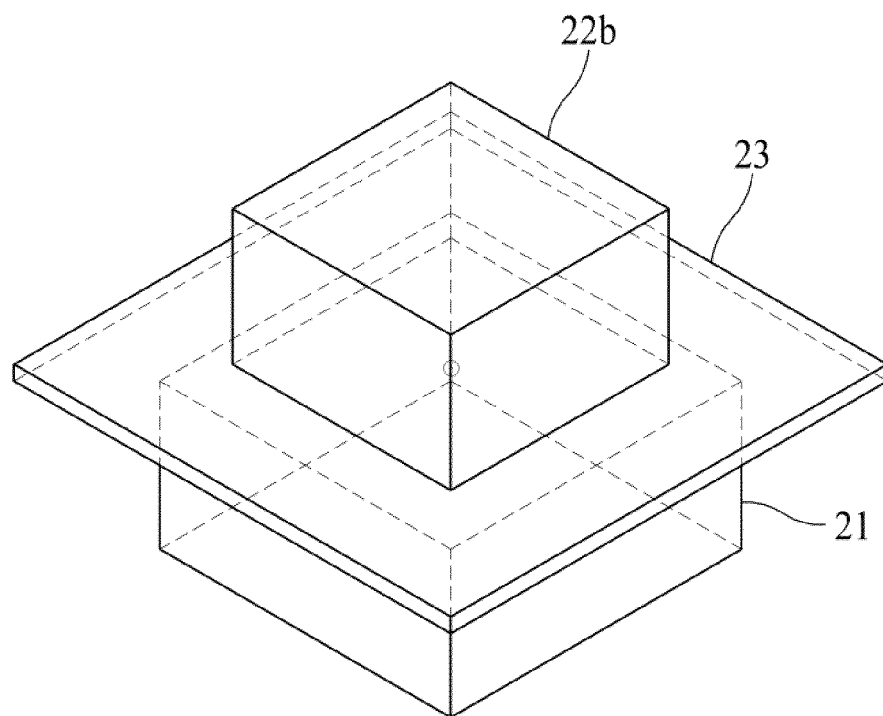
【FIG. 1】



【FIG. 2】



【FIG. 3】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2019/018557

A. CLASSIFICATION OF SUBJECT MATTER <i>D03D 15/00(2006.01)i, D01F 6/04(2006.01)i, D01D 5/088(2006.01)i, D01D 5/098(2006.01)i</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) D03D 15/00; D01D 5/088; D01F 6/04; D01F 6/30; D01F 6/46; D03D 15/02; D04B 1/16; D04B 21/00; D01D 5/098 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models: IPC as above Japanese utility models and applications for utility models: IPC as above																								
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS (KIPO internal) & Key words: polyethylene, cooling, fabric, tensile strength, crystallinity																								
C. DOCUMENTS CONSIDERED TO BE RELEVANT																								
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>JP 2004-323983 A (JAPAN POLYOLEFINS CO., LTD.) 18 November 2004 See paragraphs [0001] and [0080].</td> <td>1-11</td> </tr> <tr> <td>Y</td> <td>JP 2015-071840 A (TOYOBO CO., LTD.) 16 April 2015 See claims 1 and 5; and paragraphs [0028]-[0029] and [0061].</td> <td>1-11</td> </tr> <tr> <td>X</td> <td>JP 63-165120 A (NAT RES DEV) 08 July 1988 See page 5, example 1; and page 6, example 6.</td> <td>12-15</td> </tr> <tr> <td>Y</td> <td></td> <td>2-3,9-10</td> </tr> <tr> <td>A</td> <td>KR 10-0250899 B1 (CHAI DDUANPAYEN KUNGYEAGGISHUYEN GGUWEWON) 01 April 2000 See claims 1, 4 and 14-15.</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>JP 2010-236130 A (TOYOBO CO., LTD.) 21 October 2010 See claim 1.</td> <td>1-15</td> </tr> <tr> <td>E</td> <td>KR 10-2020-0002119 A (KOLON INDUSTRIES, INC.) 08 January 2020 See claims 1, 3-5, 7-8, 10-14 and 16-19.</td> <td>1-15</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	JP 2004-323983 A (JAPAN POLYOLEFINS CO., LTD.) 18 November 2004 See paragraphs [0001] and [0080].	1-11	Y	JP 2015-071840 A (TOYOBO CO., LTD.) 16 April 2015 See claims 1 and 5; and paragraphs [0028]-[0029] and [0061].	1-11	X	JP 63-165120 A (NAT RES DEV) 08 July 1988 See page 5, example 1; and page 6, example 6.	12-15	Y		2-3,9-10	A	KR 10-0250899 B1 (CHAI DDUANPAYEN KUNGYEAGGISHUYEN GGUWEWON) 01 April 2000 See claims 1, 4 and 14-15.	1-15	A	JP 2010-236130 A (TOYOBO CO., LTD.) 21 October 2010 See claim 1.	1-15	E	KR 10-2020-0002119 A (KOLON INDUSTRIES, INC.) 08 January 2020 See claims 1, 3-5, 7-8, 10-14 and 16-19.	1-15
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Date of the actual completion of the international search 22 SEPTEMBER 2020 (22.09.2020)	Date of mailing of the international search report 22 SEPTEMBER 2020 (22.09.2020)																							
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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