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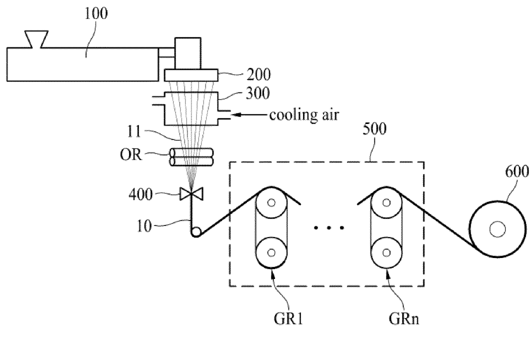
(54) POLYETHYLENE YARN, MANUFACTURING METHOD THEREFOR, AND COOLING SENSATION FABRIC INCLUDING SAME

(57) Disclosed is a polyethylene yarn which enables the manufacture of a skin cooling fabric having dimensional stability and having improved weavability which enables the manufacture of a skin cooling fabric capable of providing a user with a soft tactile sensation as well as a cooling sensation, a method for manufacturing the same, and a skin cooling fabric including the same. The polyethylene yarn has a shrinkage stress at 70 °C and 100 °C of 0.005 to 0.075 g/d, respectively. Also, the polyethylene yarn has a "dry thermal shrinkage rate at 70 °C" of 0.1 to 0.5 %, a "dry thermal shrinkage rate at 100 °C" of 0.5 to 1.5 %, and a "wet thermal shrinkage rate at 100 °C" of 0.1 to 1 %.

【FIG. 1】



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Description

[Technical Field]

[0001] The present invention relates to a polyethylene yarn, a method for manufacturing the same, and a skin cooling fabric including the same. More particularly, the present invention relates to a polyethylene yarn which enables the manufacture of a skin cooling fabric having a dimensional stability and having improved weavability which can provide a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation, a method for manufacturing the same, and a skin cooling fabric including the same.

[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.
[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.
[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.
[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.
[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.
[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 600,000 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 high strength of 28 g/d or more, a high tensile modulus of 759 g/d 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, it is unsuitable for use in the manufacture of skin cooling fabrics that are intended for contacting with the user's skin.
[0008] Even if yarns for skin cooling fabrics are made of polyethylene having a relatively lower weight average molecular weight than that of UHMWPE, excessively high shrinkage stress, dry thermal shrinkage, and wet thermal shrinkage at high temperatures may result in deformation of the fabric during the dyeing and heat setting processes of the fabric and during the washing of the final product.

[DETAILED DESCRIPTION OF THE PRESENT DISCLOSURE]

[Technical Problem]

[0009] Therefore, the present invention is directed to providing a polyethylene yarn that can prevent one or more of the problems due to limitations and disadvantages of the related arts, a method for manufacturing the same, and a skin cooling fabric including the same.
[0010] An aspect of the present invention is to provide a polyethylene yarn capable of providing a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation, and also having improved weavability that enables the manufacture of a skin cooling fabrics having excellent dimensional stability.
[0011] Another aspect of the present invention is to provide a method for manufacturing a polyethylene yarn capable of providing a user with a soft tactile sensation as well as a cooling feeling or a cooling sensation, and also having improved weavability that enables the manufacture of a skin cooling fabrics having excellent dimensional stability.
[0012] Yet another 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, and also having excellent dimensional stability.

[0013] 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]

[0014] In accordance with one aspect of the present invention as described above, a polyethylene yarn is provided, wherein,

(i) in a graph showing a shrinkage stress due to the temperature rise, obtained under the conditions of an initial load of 0.1 g/d and a temperature rising rate of 2.5 °C/s, a shrinkage stress at 70 °C, and the shrinkage stress at 100 °C were 0.005 to 0.075 g/d, respectively,
(ii) a dry thermal shrinkage rate after being placed in air at 70 °C for 15 minutes under a load of 0.1 g/d is 0.1 to 0.5 %,
(iii) a dry thermal shrinkage rate after being placed in air at 100 °C for 15 minutes under a load of 0.1 g/d is 0.5 to 1.5 %, and
(iv) a wet thermal shrinkage rate after being immersed in hot water at 100 °C for 30 minutes is 0.1 to 1 %.

[0015] The polyethylene yarn may have an interlacing number of 10 to 40 ea/m.

[0016] Oil pick-up (OPU) of the polyethylene yarn may be 1 to 4 wt%.

[0017] The polyethylene yarn may be a twisted yarn having a twist number of 50 to 300 TPM (twists per meter) in the Z direction.

[0018] The polyethylene yarn may have tensile strength of more than 4 g/d and 6 g/d or less, a tensile modulus of 15 to 80 g/d, elongation at break of 14 to 55 %, and crystallinity of 60 to 85 %.

[0019] The polyethylene yarn may have a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol.

[0020] The polyethylene yarn may have total fineness of 75 to 450 denier, and the polyethylene yarn may include a plurality of filaments each having a DPF (denier per filament) of 1 to 5 denier.

[0021] The polyethylene yarn may have a circular cross-section.

[0022] In accordance with another aspect of the present invention, a skin cooling fabric including the polyethylene yarns as a weft yarn and a warp yarn is provided, wherein

(i) dry thermal shrinkage rates in the directions of warp and weft after heat treatment in a chamber at 70 °C for 15 minutes are 0.1 to 1.0 %, respectively,
(ii) dry thermal shrinkage rates in the directions of warp and weft after heat treatment in a chamber at 100 °C for 15 minutes are 0.3 to 1.2 %, respectively, and
(iii) wet thermal shrinkage rates in the directions of warp and weft after immersion in hot water at 100 °C for 30 minutes are 0.2 to 1.0 %, respectively.

[0023] The dry thermal shrinkage rate and the wet thermal shrinkage rate are measured according to the ASTM D 1776 method.

[0024] The skin cooling fabric at 20 °C may have a thickness direction thermal conductivity of 0.0001 W/cm· °C, a thickness direction heat transfer coefficient of 0.001 W/cm^2· °C, and a contact cold sensation (Q_{max}) of 0.1 W/cm^2 or more.

[0025] The area density of the skin cooling fabric may be 75 to 800 g/m^2.

[0026] In accordance with another aspect of the present invention, a method for manufacturing a polyethylene yarn is provided, including the steps of:

melting a polyethylene having a density of 0.941 to 0.965 g/cm^3, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a melt index (MI) (at 190 °C) of 6 to 21 g/10 min,
extruding the molten polyethylene through a spinneret having a plurality of spinning holes;
cooling a plurality of filaments formed when the molten polyethylene is discharged from the holes of the spinneret;
drawing a multifilament composed of the cooled filaments using a multistage drawing part including a series of godet rollers; and
winding the drawn multifilament with a winder,
wherein an overfeed ratio defined by Equation 1 below is 6 to 10 %.

$$\text{[Equation 1] OFR (\%)} = 100 - [(V_1/V_2)\times 100]$$

[0027] In Equation 1, OFR is the overfeed ratio, V_1 is the speed of the last godet roller of the multistage drawing part, and V_2 is the speed of the winder.

[0028] 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]

[0029] The polyethylene yarn for a skin cooling fabric of the present invention has high thermal conductivity, shrinkage properties adjusted to an appropriate range, and excellent weavability, and can be easily manufactured at a relatively low cost without causing environmental problems.

[0030] In addition, the skin cooling fabric woven from the polyethylene yarn of the present invention (i) can consistently provide a user with a cooling sensation regardless of external factors such as humidity, (ii) can continuously provide a user with a sufficient cooling sensation without sacrificing air permeability, (iii) can provide a soft tactile sensation to a user, and (iv) does not cause deformation due to post-processing such as dyeing, heat setting, etc., as well as washing of the final product.

[BRIEF DESCRIPTION OF DRAWINGS]

[0031] 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]

[0032] 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.

[0033] In order to make the user feel a sufficient cooling sensation, the yarns used in the manufacture of the skin cooling fabric are preferably polymer yarns having high thermal conductivity.

[0034] 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).

[0035] 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 60 % or more.

[0036] 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/cm^3 have relatively high crystallinity as compared with yarns made from low density polyethylene (LDPE) having a density of 0.910 to 0.925 g/cm^3 and yarns made from linear low density polyethylene (LLDPE) having a density of 0.915 to 0.930 g/cm^3.

[0037] 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 (Mw). The UHMWPE generally refers to a linear polyethylene having a weight average molecular weight (Mw) of 600,000 g/mol or more, whereas the HMWPE generally refers to a linear polyethylene having a weight average molecular weight (Mw) of 20,000 to 250,000 g/mol.

[0038] 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.

[0039] 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. Therefore, the polyethylene yarn for a skin cooling fabric of the present invention is a yarn formed of HMWPE.

[0040] The polyethylene yarn of the present invention has the following shrinkage properties:

(i) in a graph showing a shrinkage stress due to a temperature rise, obtained under the conditions of an initial load of 0.1 g/d and a temperature rising rate of 2.5 °C/s, the shrinkage stress at 70 °C and the shrinkage stress at 100 °C were 0.005 to 0.075 g/d, respectively;
(ii) the dry thermal shrinkage rate after being placed in air at 70 °C for 15 minutes under a load of 0.1 g/d is 0.1 to 0.5 %;
(iii) the dry thermal shrinkage rate after being placed in air at 100 °C for 15 minutes under a load of 0.1 g/d is 0.5 to 1.5 %; and
(iv) the wet thermal shrinkage rate after being immersed in hot water at 100 °C for 30 minutes is 0.1 to 1 %.

[0041] If the shrinkage stress at 70 °C and the shrinkage stress at 100 °C of the polyethylene yarn is too small, the crystallinity and orientation of the yarn are reduced due to the low draw ratio in the drawing step, and thus, the fabric made from the yarn does not have a sufficient cooling sensation. Therefore, the shrinkage stress at 70 °C and the shrinkage stress at 100 °C of the polyethylene yarn are preferably 0.005 g/d or more, respectively.

[0042] However, if the shrinkage stress at 70 °C and the shrinkage stress at 100 °C is too large, the yarn has excessively high strength due to the high draw ratio in the drawing step, and thus, the weavability is lowered and the cuttability of the final fabric is also lowered. Therefore, the shrinkage stress at 70 °C and the shrinkage stress at 100 °C of the polyethylene yarn are preferably 0.075 g/d or less, respectively.

[0043] Specifically, the polyethylene yarn has shrinkage stress at 70 °C of 0.005 to 0.075 g/d, 0.005 to 0.050 g/d, 0.007 to 0.025 g/d, or 0.007 to 0.015 g/d. The polyethylene yarn has a shrinkage stress at 100 °C of 0.005 to 0.075 g/d, 0.015 to 0.060 g/d, 0.025 to 0.050 g/d, or 0.030 to 0.045 g/d.

[0044] If the dry thermal shrinkage rate at 70 °C of the polyethylene yarn is too low, the shrinkage due to heat is too small, and in the case of a fabric woven with this yarn, the spacing between the warp and weft intersections (i.e., voids) becomes excessively large, allowing air to easily pass through, which reduces the cooling sensation of the fabric. Therefore, the dry thermal shrinkage rate at 70 °C of the polyethylene yarn is preferably 0.1 % or more.

[0045] However, if the dry thermal shrinkage rate at 70 °C is too high, excessive shrinkage due to heat occurs in the heat treatment step or the heat treatment step after dyeing in the fabric manufacturing process, the fabric becomes stiffer, and the tactile sensation of the final fabric is reduced. Therefore, the dry thermal shrinkage rate at 70 °C of the polyethylene yarn is preferably 0.5 % or less.

[0046] Specifically, the polyethylene yarn may have a dry thermal shrinkage rate at 70 °C of 0.10 to 0.50 %, 0.20 to 0.50 %, 0.20 to 0.40 %, or 0.20 to 0.35 %.

[0047] As the dry thermal shrinkage rate at 100 °C of the polyethylene yarn is lower, it is more advantageous in terms of dimensional stability. However, shrinkage due to heat is insufficient, and thus the tensile strength and tear strength of the final fabric become insufficient, such that a phenomenon in which the fabric is easily torn occurs. Therefore, the dry thermal shrinkage rate at 100 °C of the polyethylene yarn is preferably 0.5 % or more.

[0048] However, if the dry thermal shrinkage rate at 100 °C is too high, excessive shrinkage due to heat occurs during the heat treatment step or the post-dyeing heat treatment step in the fabric manufacturing process, the fabric becomes stiffer, and the tactile sensation of the final fabric is reduced. In addition, it is difficult to accurately match the final fabric density and the fabric width to be designed. Therefore, the dry thermal shrinkage rate at 100 °C of the polyethylene yarn is preferably 1.5 % or less.

[0049] Specifically, the polyethylene yarn may have a dry thermal shrinkage rate at 100 °C of 0.50 to 1.50 %, 0.75 to 1.50 %, 0.75 to 1.25 %, or 0.80 to 1.00 %.

[0050] As the wet thermal shrinkage rate at 100 °C of the polyethylene yarn is lower, it is more advantageous in terms of dimensional stability. However, shrinkage due to heat is insufficient, and thus the tensile strength and tear strength of the final fabric become insufficient, such that a phenomenon in which the fabric is easily torn occurs. Therefore, the wet thermal shrinkage rate at 100 °C of the polyethylene yarn is preferably 0.1 % or more.

[0051] However, if the wet thermal shrinkage rate at 100 °C is too high, not only is the fabric size reduced or the fabric becomes stiffer due to excessive shrinkage of the yarn when performing the post-dyeing heat treatment step, but also the fabric is deformed when end consumers wash the fabric. Therefore, the wet thermal shrinkage rate at 100 °C of the polyethylene yarn is preferably 1 % or less.

[0052] Specifically, the polyethylene yarn may have a wet thermal shrinkage rate at 100 °C of 0.10 to 1.00 %, 0.50 to 1.00 %, 0.50 to 0.90 %, or 0.70 to 0.85 %.

[0053] According to one embodiment of the invention, the polyethylene yarn may have an interlacing number of 10 to 40 ea/m.

[0054] The interlacing is performed to strengthen the convergence between filaments forming the yarn. The better the convergence between filaments, the higher the weavability of the yarn. However, in the case of conventional polyethylene yarns having relatively high strength and relatively low elongation, the interlacing number was at the level of 3 to 5 ea/m because of the high risk of causing pills or yarn breakage in the interlacing process.

[0055] In contrast, since the polyethylene yarn of the present invention has relatively low strength and relatively high elongation, a high level of interlacing (i.e., 10 ea/m or more) can be imparted without causing pills or yarn breakage. However, even in the case of polyethylene yarn of the present invention, if the interlacing number exceeds 40 ea/m, there is a risk of causing pills or yarn breakage.

[0056] In the case of conventional polyethylene yarn, it was necessary to additionally perform a twisting step in order to satisfy the required convergency in spite of the low interlacing number of 5 ea/m or less. On the contrary, the polyethylene yarn according to one embodiment of the present invention can satisfy the required convergence even without a separate twisting step, because of the high interlacing number of 10 ea/m or more, and thus the productivity of the yarn can be improved.

[0057] However, the polyethylene yarn of the present invention is not limited to untwisted yarn, and in order to further improve the convergence of the filaments, it may be a twisted yarn. For example, the polyethylene yarn of the present invention may be a twisted yarn having a twist number of 50 to 300 TPM (twists per meter) in the Z direction. If the twist number is less than 50 TPM, a satisfactory convergence strengthening effect cannot be achieved. On the other hand, if the twist number exceeds 300 TPM, not only does the final fabric become stiffer but also the smoothness of the fabric surface is degraded, which is disadvantageous in terms of cooling sensation.

[0058] According to one embodiment of the present invention, the oil pick-up (OPU) of the polyethylene yarn may be 1 to 4 wt%.

[0059] The emulsion attached to the filaments forming the yarn is to improve the weavability of the yarn. If the OPU is less than 1 wt%, continuous weaving is impossible due to generation of pills or yarn breakage in the weaving step. On the other hand, when the OPU exceeds 4 wt%, an excessive amount of emulsion causes oil to adhere continuously to the loom body when weaving the fabric with the yarn, causing problems in weavability. In the refining and dyeing step, the emulsion is not properly removed, or there is a burden of having to perform many washing steps for complete removal.

[0060] The polyethylene yarn according an embodiment of the present invention has tensile strength of 4 g/d or more and 6 g/d or less, a tensile modulus of 15 to 80 g/d, elongation at break of 14 to 55 %, and crystallinity of 60 to 85 %. Preferably, the polyethylene yarn has tensile strength of 4.5 g/d to 5.5 g/d, a tensile modulus of 40 to 60 g/d, elongation at break of 20 to 35 %, and crystallinity of 70 to 80 %.

[0061] If the tensile strength is more than 6 g/d, the tensile modulus is more than 80 g/d, or 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, such that the user may feel discomfort. Conversely, if the tensile strength is 4 g/d or less, the tensile modulus is less than 15 g/d, or the elongation at break exceeds 55 %, pills may form on fabrics and even breakage of the fabric occurs when the user continuously uses fabrics made from these polyethylene yarns.

[0062] If the crystallinity of the polyethylene yarn is less than 60 %, its thermal conductivity is low, and thus the fabric made therefrom cannot provide the user with a sufficient cooling sensation. That is, since the polyethylene yarn has crystallinity of 60 to 85 %, the skin cooling fabric produced using the same may have thermal conductivity in the thickness direction of 0.0001 W/cm· °C or more, a heat transfer coefficient in the thickness direction of 0.001 W/cm^{2}· °C or more at 20 °C, and a contact cold sensation (Qmax) of 0.1 W/cm^{2} or more.

[0063] The polyethylene yarn according to an embodiment of the present invention has a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol. The weight average molecular weight (Mw) of the polyethylene yarn is closely related to the physical properties of polyethylene used as a raw material.

[0064] The polyethylene yarn of the present invention may have a DPF (Denier Per Filament) of 1 to 5. That is, the polyethylene yarn may include a plurality of filaments each having a fineness of 1 to 5 denier. In addition, the polyethylene yarn of the present invention may have total fineness of 75 to 450 denier.

[0065] In a polyethylene yarn having a predetermined total fineness, if the fineness of each filament exceeds 5 denier, the smoothness of the fabric made form the polyethylene yarn becomes insufficient and the contact area with the body becomes small, thus making it impossible to provide a user with a sufficient cooling sensation. In general, the DPF can be adjusted through the discharge amount per hole of a spinneret (hereinafter, referred to as the "single-hole discharge amount") and the draw ratio.

[0066] 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 an uniform cooling sensation to the user.

[0067] 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 75 to 800 g/m^{2}. If the area density of the fabric is less than 75 g/m^{2}, the deneness 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/m^{2}, 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.

[0068] According to one embodiment of the present invention, the skin cooling fabric of the present invention includes the above-mentioned polyethylene yarns of the present invention as a warp yarn and a weft yarn, and may be a fabric having a cover factor of 400 to 2000 according to Equation 2 below.

[Equation 2]

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

[0069] In Equation 2, 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).

[0070] 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.

[0071] The skin cooling fabric of the present invention has the following features:

(i) dry thermal shrinkage rates in the directions of warp and weft after heat treatment in a chamber at 70 °C for 15 minutes are 0.1 to 1.0 %, 0.2 to 0.8 %, or 0.25 to 0.45 %, respectively,
(ii) dry thermal shrinkage rates in the directions of warp and weft after heat treatment in a chamber at 100 °C for 15 minutes are 0.3 to 1.2 %, 0.5 to 1.0 %, or 0.75 to 0.95 %, respectively, and
(iii) wet thermal shrinkage rates in the directions of warp and weft after immersion in hot water at 100 °C for 30 minutes are 0.2 to 1.0 %, 0.5 to 1.0 %, or 0.65 to 0.85 %.

[0072] The dry thermal shrinkage rate and the wet thermal shrinkage rate of the fabric are measured according to the ASTM D 1776 method.

[0073] The skin cooling fabric according to one embodiment of the present invention has, at 20 °C:

(i) thermal conductivity in the thickness direction of 0.0001 W/cm· °C or higher, or 0.0003 to 0.0005 W/cm· °C;
(ii) a heat transfer coefficient in the thickness direction of 0.001 W/cm^2· °C or higher, or 0.01 to 0.02 W/cm^2· °C; and
(iii) a contact cold sensation (Q_{max}) of 0.1 W/cm^2 or more, 0.1 to 0.3 W/cm^2, or 0.1 to 0.2 W/cm^2.

[0074] The measurement method of the thermal conductivity, heat transfer coefficient, and contact cold sensation (Q_{max}) of the fabric will be described later.

[0075] In order to manufacture polyethylene yarns having the above-mentioned shrinkage properties, tensile strength, tensile modulus, elongation at break, and crystallinity, not only process factors such as (i) the spinning temperature, (ii) the L/D of the spinneret, (iii) the discharge linear velocity from the spinneret of the molten polyethylene, (iv) the distance from the spinneret to the multistage drawing part [specifically, the first godet roller part of a multistage drawing part], (v) cooling conditions, and (vi) spinning speed, etc., should be precisely controlled, but it is also necessary to select a raw material having physical properties that are suitable for the present invention.

[0076] Hereinafter, a method for manufacturing a polyethylene yarn for a skin cooling fabric of the present invention will be described in detail with reference to FIG. 1.

[0077] First, a chip-shaped polyethylene is injected into an extruder 100 and melted.

[0078] The polyethylene used as a raw material for the manufacture of the polyethylene yarn of the present invention has a density of 0.941 to 0.965 g/cm^3, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a melt index (MI) (at 190 °C) of 6 to 21 g/10 min.

[0079] In order to manufacture a fabric that provides a high cooling sensation, the polyethylene yarn needs to have a high crystallinity of 60 to 85 %, and in order to manufacture a polyethylene yarn having such a high crystallinity, it is essential to use a high density polyethylene (HDPE) having a density of 0.941 to 0.965 g/cm^3.

[0080] When the weight average molecular weight (Mw) of polyethylene used as a raw material is less than 50,000 g/mol, the finally obtained polyethylene yarn is made difficult to express a strength of 4 g/d or more and a tensile modulus of 15 g/d or more, and as a result, pills may form on fabrics. On the contrary, when the weight average molecular weight (Mw) of the polyethylene exceeds 99,000 g/mol, the weavability of polyethylene yarn is not good due to the excessively high strength and tensile modulus, the stiffness is too high, and it is unsuitable for use in the manufacture of skin cooling fabrics that are intended for contacting with the user's skin.

[0081] When the melt index (MI) of polyethylene used as a raw material is less than 6 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 polyethylene, and the uniformity and processability of the extrudate are reduced, thus increasing the risk of yarn breakage during the spinning process. On the other hand, when the melt index (MI) of the polyethylene exceeds 21 g/10min, the flowability in the extruder 100 becomes relatively good, but it may be difficult for the finally obtained polyethylene yarn to have strength of greater than 4 g/d and a tensile modulus of 15 g/d or more.

[0082] Optionally, a fluorine-based polymer can be added to polyethylene.

[0083] As the method of adding the fluorine-based polymer, (i) a method of injecting a master batch containing polyethylene and a fluorine-based polymer together with a polyethylene chip into the extruder 100 and then melting them therein, or (ii) a method of injecting the fluorine-based polymer into an extruder 100 through a side feeder while injecting the polyethylene chip into the extruder 100, and then melting them together, may be mentioned.

[0084] By adding a fluorine-based polymer to the polyethylene, the occurrence of yarn breakage during the spinning process and the multistage stretching process can be further suppressed, and thus the productivity can be further improved. As a nonlimiting example, the fluorine-based polymer added to the polyethylene may be a tetrafluoroethylene copolymer. The fluorine-based polymer may be added to the polyethylene in such amount that the content of fluorine in the finally produced yarn becomes 50 to 2500 ppm.

[0085] After the polyethylene having the above-described physical properties is injected into the extruder 100 and melted, the molten polyethylene is transferred to a spinneret 200 by a screw (not shown) in the extruder 100, and extruded through a plurality of spinning holes formed in the spinneret 200.

[0086] The number of holes in the spinneret 200 may be determined according to the DPF and 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.

[0087] 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 preferably maintained at 150 to 315 °C, preferably 250 to 315 °C, more preferably 265 to 310 °C.

[0088] 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 polyethylene may be thermally decomposed and it may be difficult to express the high strength.

[0089] 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 polyethylene, 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 polyethylene passing through the spinneret 200.

[0090] As the molten polyethylene is discharged from the holes of the spinneret 200, the solidification of the polyethylene is started by the difference between the spinning temperature and the ambient 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 collectively referred to as "filament".

[0091] The plurality of filaments 11 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.

[0092] 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 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 over-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.

[0093] Subsequently, the filaments 11 that are cooled and completely solidified are converged by a converging part 400 to form a multifilament 10.

[0094] As illustrated in FIG. 1, the method of the present invention may further include a step of applying an emulsion onto the cooled filaments 11 using an oil roller (OR) or oil jet, before forming the multifilament 10. The emulsion applying step may be performed through a metered oiling (MO) method.

[0095] Optionally, the step of forming the multifilament 10 through a converging part 400 and the step of applying the emulsion may be performed at the same time.

[0096] The oil may be applied to the filaments 11 according to the dual roller system, which is a two-stage system. In the case of this system, the amount of oil pick-up (OPU) can be adjusted to 1 to 4 wt% by setting the rotation speed to 5 to 20 rpm.

[0097] As illustrated in FIG. 1, the polyethylene yarn of the present invention may be produced via a direct spinning drawing (DSD) process. 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.

[0098] Alternatively, after the multifilament 10 is first wound as an undrawn yarn, the undrawn yarn can be drawn, thereby manufacturing the polyethylene yarn of the present invention. The polyethylene yarn of the present invention may be manufactured through a two-step process of first melt spinning polyethylene to produce an undrawn yarn and then drawing the undrawn yarn.

[0099] If the total draw ratio applied in the drawing process is less than 3.5, in particular, less than 2.5, (i) the finally obtained polyethylene yarn cannot have crystallinity of 60 % or more, and thus the fabric made from the yarn cannot provide a user with a sufficient cooling sensation, and (ii) the polyethylene yarn cannot have strength of greater than 4 g/d, a tensile modulus of 15 g/d or more, and elongation at break of 55 % or less, and as a result, pills may form on the fabric produced from the yarn.

[0100] On the other hand, when the total draw ratio is greater than 7.5, in particular, greater than 8.5, the finally obtained polyethylene yarn cannot have strength of 6 g/d or less, a tensile modulus of 80 g/d 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.

[0101] 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.

[0102] 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.

[0103] 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.

[0104] Interlacing of the multifilament 10 that has passed through the multistage drawing part 500 may be performed. In this case, the nozzle pressure of an interlacing apparatus is adjusted so that the number of interlacings may be 10 to 40 ea/m.

[0105] After the interlacing step, the multifilament 10 is wound on the winder 600, thereby completing the manufacture of the polyethylene yarn for a skin cooling fabric of the present invention.

[0106] As described above, when the interlacing step is performed with a high number of interlacings of 10 to 40 ea/m, it is possible to satisfy the required convergence without a separate twisting step, but in order to further improve the convergence of the filaments, a step of twisting the polyethylene yarn with a twist number of 50 to 300 TPM (twists per meter) in the Z direction may be further performed in addition to the interlacing step.

[0107] In order to ensure the low shrinkage rate of the polyethylene yarn of the present invention, it is important to control the tension between the last roller (GRn) of the multistage drawing part 500 and the winder 600. According to the present invention, the over feed ratio defined by Equation 1 below is 6 to 10 %.

$$\text{[Equation 1] OFR (\%)} = 100-[(V_1/V_2) \times 100]$$

in Equation 1, OFR is the overfeed ratio, V_1 is the speed of the last godet roller (GRn), and V_2 is the speed of the winder 600.

[0108] 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

[0109] A polyethylene yarn containing 200 filaments and having total fineness of 400 denier was produced using the apparatus illustrated in FIG. 1. In detail, a polyethylene chip having a density of 0.961 g/cm^3, a weight average molecular weight (Mw) of 87,660 g/mol, a polydispersity index (PDI) [ratio (Mw/Mn) of weight average molecular weight (Mw) to number average molecular weight (Mn)] of 6.4, and a melt index (MI at 190 °C) of 11.9 g/10 min was injected into an extruder 100 and melted. The molten polyethylene 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 5.0. The spinneret temperature was 270 °C.

[0110] The filaments 11 formed while being discharged from the spinneret 200 were finally cooled to 25 °C by cooling air having a wind speed of 0.5 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. Simultaneously with the converging step, a step of applying oil through the MO (Metered Oiling) method was performed.

[0111] 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 80 to 125 °C, and the temperature of the rear stage roller part was set to be higher than the temperature of the roller part immediately before.

[0112] After the multifilament 10 was drawn at a total draw ratio of 7.5 by the multistage drawing part 500, 20 ea/m of interlacing was produced and wound on the winder 600 at an overfeed ratio of 6.5 %, thereby obtaining a polyethylene yarn with an OPU of 3 wt%.

Example 2

[0113] A polyethylene yarn was obtained in the same manner as in Example 1, except that a polyethylene chip having a density of 0.958 g/cm^3, a weight average molecular weight (Mw) of 98,290 g/mol, a polydispersity index (PDI) of 8.4, and a melt index (MI at 190 °C) of 6.1 g/10 min was used, the spinneret temperature was 275 °C and the overfeed ratio was 7.5 %.

Example 3

[0114] A polyethylene yarn was obtained in the same manner as in Example 1, except that a polyethylene chip having a density of 0.948 g/cm^3, a weight average molecular weight (Mw) of 78,620 g/mol, a polydispersity index (PDI) of 8.2, and a melt index (MI at 190 °C) of 15.5 g/10 min was used, the spinneret temperature was 260 °C, and the total draw ratio was 7.0.

Comparative Example 1

[0115] A polyethylene yarn was obtained in the same manner as in Example 1, except that a polyethylene chip having a density of 0.962 g/cm^3, a weight average molecular weight (Mw) of 98,550 g/mol, a polydispersity index (PDI) of 4.9, and a melt index (MI at 190 °C) of 6.1 g/10 min was used, the spinneret temperature was 280 °C, and the overfeed ratio was 2.0 %.

Comparative Example 2

[0116] A polyethylene yarn was obtained in the same manner as in Example 1, except that a polyethylene chip having a density of 0.961 g/cm^3, a weight average molecular weight (Mw) of 98,230 g/mol, a polydispersity index (PDI) of 7.0, and a melt index (MI at 190 °C) of 2.9 g/10 min was used, the spinneret temperature was 295 °C, the total draw ratio was 8.2, and the overfeed ratio was 3.0 %.

Comparative Example 3

[0117] A polyethylene yarn was obtained in the same manner as in Example 1, except that a polyethylene chip having a density of 0.961 g/cm^3, a weight average molecular weight (Mw) of 180,550 g/mol, a polydispersity index (PDI) of 6.4, and a melt index (MI at 190 °C) of 0.6 g/10 min was used, the spinneret temperature was 295 °C, 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 temperature of the godet roller parts was set to 70 to 130 °C, and the overfeed ratio was 2.5 %.

Test Example 1

[0118] The shrinkage properties, toughness, tensile strength, tensile modulus, elongation at break, and crystallinity of the polyethylene yarn prepared by each of Examples 1 to 3 and Comparative Examples 1 to 3 were respectively measured as follows, and the results are shown in Table 1 and Table 2 below.

(1) Shrinkage stress of polyethylene yarn

[0119] The polyethylene yarn was cut to prepare a sample having a length of 1000 mm. A thermal stress tester (Kanebo Eng., KE-2) was used to obtain a graph showing the shrinkage stress of the sample according to the temperature rise. The initial load was 0.1 g/d and the temperature rising rate was 2.5 °C/s. From the graph, the shrinkage stresses at 70 °C and 100 °C were obtained, respectively.

(2) Dry thermal shrinkage rate of polyethylene yarn

[0120] The dry thermal shrinkage rate of the polyethylene yarn was measured using Testrite MK-V (Testrite Ltd.). In detail, the polyethylene yarn was cut to prepare a sample having a length (L_0) of 1000 mm. The sample was placed in air at 70 °C (or 100 °C) for 15 minutes under a load of 0.1 g/d and removed, and then left at room temperature for 10 minutes. Then, the length of the sample (i.e., length L_1 after shrinkage) was measured, and the dry thermal shrinkage rate at 70 °C (or 100 °C) was calculated by Equation 3 below.

$$\text{[Equation 3] Dry Thermal Shrinkage Rate (\%) at 70 °C (or 100 °C)} = [(L_0 - L_1)/L_0] \times 100$$

where L_0 is the length before shrinkage, and L_1 is the length after shrinkage.

(3) Wet thermal shrinkage rate of polyethylene yarn

[0121] The polyethylene yarn was cut to prepare a sample having a length (L_0) of 1000 mm. The sample was completely immersed in hot water at 100 °C for 30 minutes under a load of 0.1 g/d and removed, and then left at room temperature for 120 minutes. Then, the length of the sample (i.e., length L_1 after shrinkage) was measured, and the wet thermal shrinkage rate was calculated by Equation 4 below.

$$\text{[Equation 4] Wet Thermal Shrinkage Rate at 100 °C (\%)} = [(L_0 - L_1)/L_0] \times 100$$

where L_0 is the length before shrinkage, and L_1 is the length after shrinkage.

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

[0122] The tensile strength, tensile modulus, and elongation at break of the polyethylene yarns were determined using an Instron universal tensile tester (Instron Engineering Corp., Canton, Mass) in accordance with ASTM D885 (sample length: 250 mm, tensile speed: 300 mm/min, and initial load: 0.05 g/d).

(5) Crystallization of polyethylene yarn

[0123] 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-Kα radiation
- Power: 45 KV × 25 mA
- Mode: continuous scan mode
- Scan angle range: 10° to 40°
- Scan speed: 0.1 °/s

[Table 1]

		Example 1	Example 2	Example 3
PE	Density (g/cm^3)	0.961	0.958	0.948
	Mw (g/mol)	87,660	98,290	78,620
	PDI	6.4	8.4	8.2
	MI (g/10min)	11.9	6.1	15.5
Spinneret temperature (°C)		270	275	260
Total draw ratio		7.5	7.5	7.0
Over feed ratio (%)		6.5	7.5	6.5

(continued)

		Example 1	Example 2	Example 3
PE yarn	Shrinkage stress (g/d) at 70 °C	0.008	0.011	0.007
	Shrinkage stress (g/d) at 100 °C	0.035	0.045	0.034
	Dry thermal shrinkage rate (%) at 70 °C	0.25	0.35	0.23
	Dry thermal shrinkage rate (%) at 100 °C	0.85	0.97	0.83
	Wet thermal shrinkage rate (%) at 100 °C	0.72	0.85	0.70
	Tensile strength (g/d)	4.6	5.3	4.5
	Tensile modulus (g/d)	49.6	56.3	44.6
	Elongation at break (%)	25	22	26
	Crystallinity (%)	72	74	71

[Table 2]

		Com parative Example 1	Com parative Example 2	Com parative Example 3
PE	Density (g/cm^3)	0.962	0.961	0.961
	Mw /mol	98,550	98,230	180,550
	PDI	4.9	7.0	6.4
	MI (g/10min)	6.1	2.9	0.6
Spinneret temperature (°C)		280	295	295
Total draw ratio		7.5	8.2	14.5
Over feed ratio (%)		2.0	3.0	2.5
PE yarn	Shrinkage stress (g/d) at 70 °C	0.025	0.038	0.052
	Shrinkage stress (g/d) at 100 °C	0.083	0.092	0.125
	Dry thermal shrinkage rate (%) at 70 °C	0.65	0.72	0.93
	Dry thermal shrinkage rate (%) at 100 °C	1.65	1.75	2.2
	Wet thermal shrinkage rate (%) at 100 °C	1.2	1.4	1.7
	Tensile strength (g/d)	6.5	7.1	18.0
	Tensile modulus (g/d)	63.4	67.2	493
	Elongation at break (%)	13.5	12.7	6.0
	Crystallinity (%)	73	73	80

Example 4

[0124] The plain weave was performed using the polyethylene yarn of Example 1 as a warp yarn and a weft yarn, thereby manufacturing a fabric having a warp density of 30 ea/inch and a weft density of 30 ea/inch.

Example 5

[0125] A fabric was manufactured in the same manner as in Example 4, except that the polyethylene yarn of Example

2 was used instead of the polyethylene yarn of Example 1.

Example 6

[0126] A fabric was manufactured in the same manner as in Example 4, except that the polyethylene yarn of Example 3 was used instead of the polyethylene yarn of Example 1.

Comparative Example 4

[0127] A fabric was manufactured in the same manner as in Example 4, except that the polyethylene yarn of Comparative Example 1 was used instead of the polyethylene yarn of Example 1.

Comparative Example 5

[0128] A fabric was manufactured in the same manner as in Example 4, except that the polyethylene yarn of Comparative Example 2 was used instead of the polyethylene yarn of Example 1.

Comparative Example 6

[0129] A fabric was manufactured in the same manner as in Example 4, except that the polyethylene yarn of Comparative Example 3 was used instead of the polyethylene yarn of Example 1.

Test Example 2

[0130] The contact cold sensation (Q_{max}), thermal conductivity (thickness direction), heat transfer coefficient (thickness direction), stiffness, dry thermal shrinkage rate (at 70 °C & 100 °C), and wet thermal shrinkage rate (at 100 °C) of the fabrics respectively manufactured by Examples 4 to 6 and Comparative Examples 4 to 6 were measured as follows, and the results are shown in Tables 3 and 4 below.

(1) Contact cold sensation (Q_{max}) of fabric

[0131] 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 a 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.

[0132] 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/cm^2. 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 Qmax values was calculated.

(2) Thermal conductivity and heat transfer coefficient of fabric

[0133] 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 a RH of 65 ± 2 %. Then, the thermal conductivity and 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.

[0134] In detail, as illustrated in FIG. 3, the fabric sample 23 was placed on a base plate 21 maintained at 20 °C, and the T-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 5 and 6 below.

$$[\text{Equation 5}]\ K = (W^*D)/(A^*\Delta T)$$

$$[\text{Equation 6}]\ K = K/D$$

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 cm^2) 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 (Watt), and k is a heat transfer coefficient (W/cm^2· °C).

(3) Stiffness of fabric

[0135] 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.

(4) Dry thermal shrinkage rate of fabric

[0136] A fabric was cut to prepare a sample having a size of 20 cm x 20 cm (warp direction length x weft direction length). Lines having a length of 20 cm (i.e., "length before shrinkage", L_0) in the warp and weft directions were marked on the sample, respectively. The sample was heat-treated in a chamber at 70 °C (or 100 °C) for 15 minutes and then left at ambient temperature for 10 minutes. Then, the lengths of the lines displayed on the sample (i.e., "length after shrinkage", L_1) were respectively measured, and the dry thermal shrinkage rate at 70 °C (or 100 °C) was calculated by Equation 7 below with respect to each of the warp direction and the weft direction.

$$[\text{Equation 7}]\ \text{Dry thermal shrinkage rate (\%) at 70 °C (or 100 °C)} = [(L_0-L_1)/L_0] \times 100$$

where L_0 is "length before shrinkage" (i.e., 20 cm) and L_1 is "length after shrinkage".

(5) Wet thermal shrinkage rate of fabric

[0137] A fabric was cut to prepare a sample having a size of 20 cm × 20 cm (warp direction length × weft direction length). Lines having a length of 20 cm (i.e., "length before shrinkage", L_0) in the warp and weft directions were marked on the sample, respectively. The sample was treated with hot water at 100 °C for 30 minutes using an IR dyeing machine, and then left at ambient temperature for 120 minutes. Then, the lengths of the lines displayed on the sample (i.e., "length after shrinkage", L_1) were respectively measured, and the wet thermal shrinkage rate was calculated by Equation 8 below with respect to each of the warp direction and the weft direction.

$$[\text{Equation 8}]\ \text{Wet thermal shrinkage rate (\%) at 100 °C} = [(L_0-L_1)/L_0] \times 100$$

where L_0 is "length before shrinkage" (i.e., 20 cm) and L_1 is "length after shrinkage".

[Table 3]

		Example 4	Example 5	Example 6
Qmax (W/cm^2)		0.158	0.165	0.148
Thermal conductivity (W/cm· °C)		0.00042	0.00048	0.00037
Heat transfer coefficient (W/cm^2· °C)		0.0124	0.0142	0.0122
Stiffness (kgf)		0.45	0.52	0.43
Dry thermal shrinkage rate (%) at 70 °C	Warp direction	0.35	0.45	0.33
	Weft direction	0.32	0.42	0.29

(continued)

		Example 4	Example 5	Example 6
Dry thermal shrinkage rate (%) at 100 °C	Warp direction	0.85	0.93	0.82
	Weft direction	0.80	0.88	0.76
Wet thermal shrinkage rate (%) at 100 °C	Warp direction	0.75	0.83	0.73
	Weft direction	0.70	0.76	0.66

[Table 4]

		Com parative Example 4	Com parative Example 5	Com parative Example 6
Qmax (W/cm^2)		0.165	0.168	0.169
Thermal conductivity (W/cm· °C)		0.00056	0.00060	0.00064
Heat transfer coefficient (W/cm^2· °C)		0.00148	0.00150	0.00155
Stiffness (kgf)		0.65	0.72	0.95
Dry thermal shrinkage rate (%) at 70 °C	Warp direction	1.05	1.18	1.45
	Weft direction	1.02	1.13	1.39
Dry thermal shrinkage rate (%) at 100 °C	Warp direction	1.35	1.48	1.88
	Weft direction	1.25	1.33	1.68
Wet thermal shrinkage rate (%) at 100 °C	Warp direction	1.3	1.55	2.0
	Weft direction	1.18	1.44	1.82

[Explanation of Symbols]

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

(i) in a graph showing a shrinkage stress due to the temperature rise, obtained under the conditions of an initial load of 0.1 g/d and a temperature rising rate of 2.5 °C/s, a shrinkage stress at 70 °C, and a shrinkage stress at 100 °C, were 0.005 to 0.075 g/d, respectively,
(ii) a dry thermal shrinkage rate after being placed in air at 70 °C for 15 minutes under a load of 0.1 g/d is 0.1

to 0.5 %,
(iii) a dry thermal shrinkage rate after being placed in air at 100 °C for 15 minutes under a load of 0.1 g/d is 0.5 to 1.5%, and
(iv) a wet thermal shrinkage rate after being immersed in hot water at 100 °C for 30 minutes is 0.1 to 1 %.

2. The polyethylene yarn of claim 1, wherein
the polyethylene yarn has an interlacing number of 10 to 40 ea/m.

3. The polyethylene yarn of claim 1, wherein
an oil pick-up (OPU) of the polyethylene yarn is 1 to 4 wt%.

4. The polyethylene yarn of claim 1, wherein
the polyethylene yarn is a twisted yarn having a twist number of 50 to 300 TPM (twists per meter) in the Z direction.

5. The polyethylene yarn of claim 1, wherein
the polyethylene yarn has tensile strength of more than 4 g/d and 6 g/d or less, a tensile modulus of 15 to 80 g/d, elongation at break of 14 to 55 %, and crystallinity of 60 to 85 %.

6. The polyethylene yarn of claim 1, wherein
the polyethylene yarn has a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol.

7. The polyethylene yarn of claim 1, wherein

the polyethylene yarn has total fineness of 75 to 450 denier, and
the polyethylene yarn includes a plurality of filaments each having a DPF (denier per filament) of 1 to 5 denier.

8. The polyethylene yarn of claim 1, wherein
the polyethylene yarn has a circular cross-section.

9. A skin cooling fabric comprising the polyethylene yarns of any one of claims 1 to 8 as a weft yarn and a warp yarn, wherein

dry thermal shrinkage rates in the directions of warp and weft after heat treatment in a chamber at 70 °C for 15 minutes are 0.1 to 1.0 %, respectively,
dry thermal shrinkage rates in the directions of warp and weft after heat treatment in a chamber at 100 °C for 15 minutes are 0.3 to 1.2 %, respectively, and
wet thermal shrinkage rates in the directions of warp and weft after immersion in hot water at 100 °C for 30 minutes are 0.2 to 1.0 %, respectively.

10. The skin cooling fabric of claim 9, wherein
the skin cooling fabric at 20 °C has a thickness direction thermal conductivity of 0.0001 W/cm· °C, a thickness direction heat transfer coefficient of 0.001 W/cm^2· °C, and a contact cold sensation (Q_{max}) of 0.1 W/cm^2 or more.

11. The skin cooling fabric of claim 9, wherein
the area density of the skin cooling fabric is 75 to 800 g/m^2.

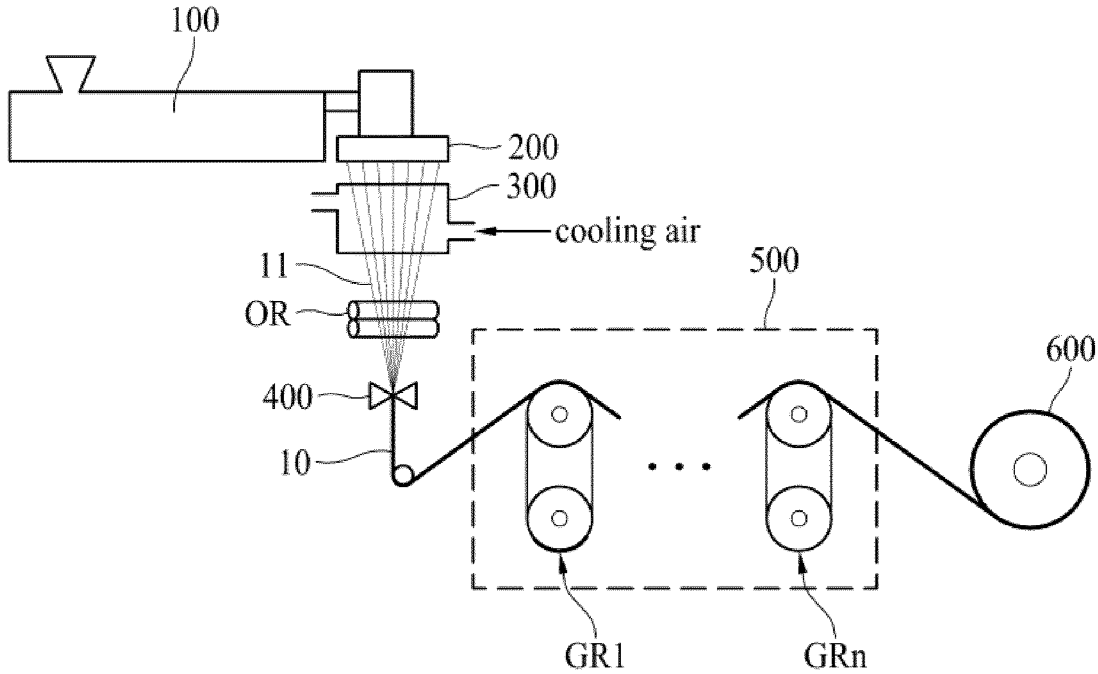
12. A method for manufacturing a polyethylene yarn comprising the steps of:

melting a polyethylene having a density of 0.941 to 0.965 g/cm^3, a weight average molecular weight (Mw) of 50,000 to 99,000 g/mol, and a melt index (MI) (at 190 °C) of 6 to 21 g/10 min;
extruding the molten polyethylene through a spinneret having a plurality of spinning holes;
cooling a plurality of filaments formed when the molten polyethylene is discharged from the holes of the spinneret;
drawing a multifilament comprised of the cooled filaments using a multistage drawing part including a series of godet rollers; and
winding the drawn multifilament with a winder,
wherein an overfeed ratio defined by Equation 1 below is 6 to 10 %:

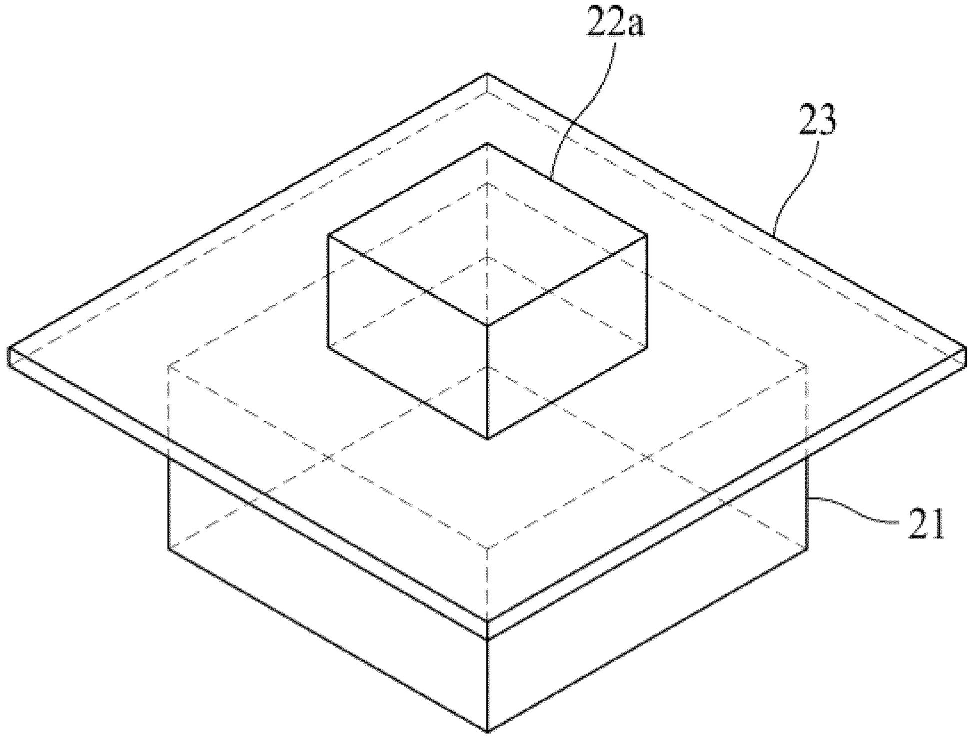
$$[\text{Equation 1}]\ OFR\ (\%) = 100 - [(V_1/V_2)\times 100]$$

in Equation 1, OFR is the overfeed ratio, V_1 is the speed of the last godet roller of the multistage drawing part, and V_2 is the speed of the winder.

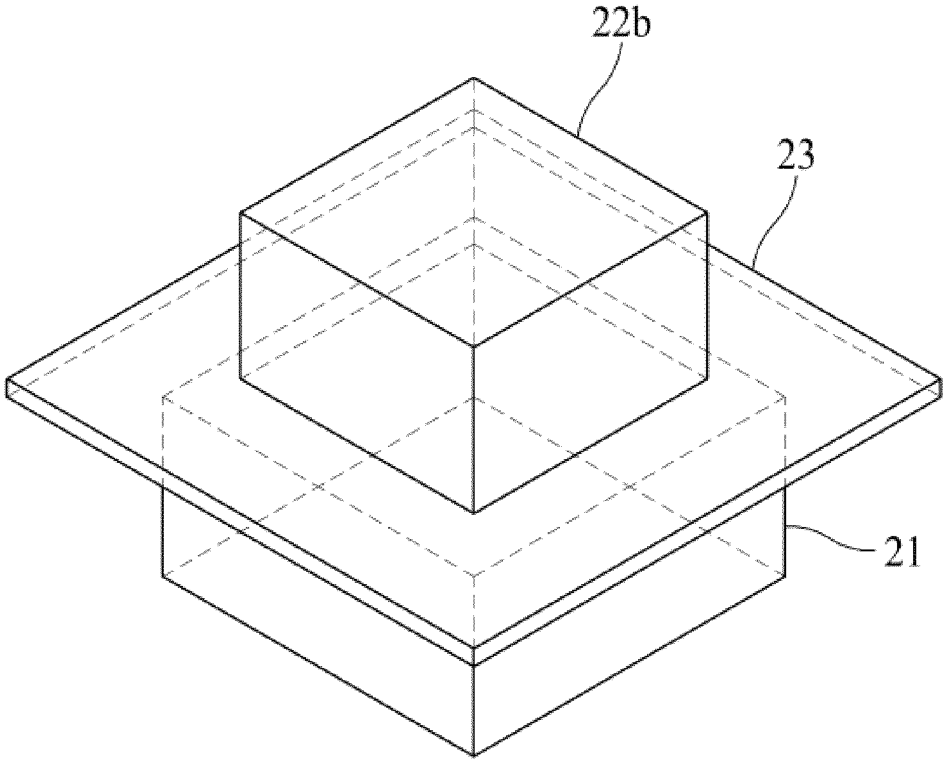
【FIG. 1】



【FIG. 2】



【FIG. 3】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/018559

A. CLASSIFICATION OF SUBJECT MATTER

D01F 6/04(2006.01)i, D02G 3/26(2006.01)i, D03D 15/04(2006.01)i, D01D 5/088(2006.01)i, D01D 5/098(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D01F 6/04; D01D 10/02; D01D 5/08; D01D 5/088; D02G 3/04; D02G 3/36; D02G 3/38; D03D 15/00; D02G 3/26; D03D 15/04; 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) & Keywords: polyethylene, shrinkage stress, yarn, dry heat shrinkage, cooling

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2016-0059653 A (SAMYANG CORPORATION) 27 May 2016 See claim 1; and paragraph [0058].	1-12
A	JP 2013-139654 A (TEIJIN LIMITED) 18 July 2013 See claims 1-3.	1-12
A	JP 2012-207328 A (DU PONT-TORAY CO., LTD.) 25 October 2012 See claims 1-3.	1-12
A	KR 10-2011-0089404 A (FINA TECHNOLOGY, INC.) 08 August 2011 See claims 1-11.	1-12
A	KR 10-2017-0135342 A (DONGMYUNG TECHNOLOGIES CO., LTD. et al.) 08 December 2017 See claim 1.	1-12
E	KR 10-2137243 B1 (KOLON INDUSTRIES, INC.) 23 July 2020 See claims 1-12.	1-12

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

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"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
22 SEPTEMBER 2020 (22.09.2020)	**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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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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