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(54) **MELT SPINNING APPARATUS AND NON-WOVEN FABRIC PRODUCTION METHOD**

(57) A melt spinning apparatus includes a spinning unit including plural spinning nozzles that spin filaments, a cooling unit that cools the filaments spun from the spinning nozzles, and a cooling air supply unit that faces the cooling unit and supplies cooling air to the cooling unit through an air-permeable partition. In the melt spinning apparatus, the cooling air supply unit includes a first cool-

ing air supply unit at a vertically upper side and a second cooling air supply unit at a vertically lower side, divided into two stages in a vertical direction through a partition, there is a gap between an end, facing the air-permeable partition, of the partition and a face of a side, facing the partition, in the air-permeable partition, and the distance (distance A) of the gap is 55 mm or less.

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Description

Technical Field

5 **[0001]** The present disclosure relates to a melt spinning apparatus and to a method of manufacturing a non-woven fabric.

Background Art

10 **[0002]** Examples of methods of manufacturing spunbonded non-woven fabrics include a method in which spun filaments are cooled by cooling air introduced into a cooling chamber, drawn through nozzles using cooling air as drawing air on an as-is basis, and scattered on a mesh belt.

[0003] In a step of manufacturing a spunbonded non-woven fabric, cooling air is sprayed on a large number of continuous filaments melt-spun from spinning nozzles, thereby cooling the filaments. A sufficient volume of cooling air is needed in the case of increasing the amount of discharged filaments in order to enhance productivity in such a case. A small volume of cooling air results in insufficient cooling of the filaments, thereby causing a resin block (shot) to be prone to be generated on a web. In contrast, a large volume of cooling air causes yarn breakage to be prone to occur due to supercooling.

20 **[0004]** Thus, a method and apparatus of manufacturing a non-woven fabric, in which yarn breakage does not occur even in the case of increasing the volume of cooling air, a fiber diameter can be reduced without deteriorating productivity, and a non-woven fabric can be stably manufactured, are proposed (see, for example, Patent Document 1). Specifically, Patent Document 1 proposes the method of manufacturing a non-woven fabric, in which cooling air introduced into a cooling chamber is divided into at least two stages in a vertical direction, and the air velocity of cooling air in a bottom stage is allowed to be higher than the air velocity of cooling air in a top stage.

Citation List

Patent Document

30 **[0005]** Patent Document 1: Japanese Patent Application Laid-Open (JP-A) No. 2002-317372

SUMMARY OF INVENTION

Technical Problem

35 **[0006]** However, the method and apparatus of manufacturing a non-woven fabric, proposed in Patent Document 1, have a problem that the uniformity (texture) of the mass distribution of an overall non-woven fabric is prone to be deteriorated, whereby so-called yarn fluctuation is prone to occur.

40 **[0007]** The present invention was made under such circumstances with an object of providing a melt spinning apparatus in which yarn breakage and yarn fluctuation can be suppressed, and a method of manufacturing a non-woven fabric using the apparatus.

Solution to Problem

45 **[0008]** Specific means for addressing the above problem include the following aspects.

<1> A melt spinning apparatus comprising:

50 a spinning unit comprising a plurality of spinning nozzles that spin filaments;
a cooling unit that cools the filaments spun from the spinning nozzles; and
a cooling air supply unit that faces the cooling unit and supplies cooling air to the cooling unit through an air-permeable partition,
wherein the cooling air supply unit comprises a first cooling air supply unit at a vertically upper side and a second cooling air supply unit at a vertically lower side, divided into two stages in a vertical direction through a partition,
55 there is a gap between an end, facing the air-permeable partition, of the partition and a face of a side, facing the partition, in the air-permeable partition, and a distance (distance A) of the gap is 55 mm or less.

<2> The melt spinning apparatus according to <1>, wherein the distance A is 5 mm or more.

<3> The melt spinning apparatus according to <1> or <2>, wherein a ratio of a distance (distance B) from a nozzle face, on which the spinning nozzles of the spinning unit are disposed, to the partition, with respect to the distance A (distance B/distance A), is from 5 to 50.

<4> The melt spinning apparatus according to any one of <1> to <3>, wherein a ratio of a height (h_2) of the second cooling air supply unit, to a height (h_1) of the first cooling air supply unit, is from 0.5 to 1.5.

<5> The melt spinning apparatus according to any one of <1> to <4>, wherein a thickness of the air-permeable partition is from 10 mm to 50 mm.

<6> The melt spinning apparatus according to any one of <1> to <5>, wherein a ratio of a thickness of the air-permeable partition to the distance A (thickness of air-permeable partition/distance A) is from 0.5 to 5.0.

<7> The melt spinning apparatus according to any one of <1> to <6>, wherein the air-permeable partition has a honeycomb shape.

<8> The melt spinning apparatus according to any one of <1> to <7>, wherein the cooling air supply unit comprises a flow regulating plate that regulates the cooling air supplied to the cooling unit, upstream of the air-permeable partition, in a direction of cooling air supply.

<9> The melt spinning apparatus according to any one of <1> to <8>, further comprising a first controller that performs control so that a temperature of cooling air supplied to the first cooling air supply unit is from 10°C to 40°C, and a temperature of cooling air supplied to the second cooling air supply unit is higher than the temperature of the cooling air supplied to the first cooling air supply unit by 10°C or more and is from 30°C to 70°C.

<10> The melt spinning apparatus according to any one of <1> to <9>, further comprising a second controller that performs control so that a ratio (V_1/V_2) of an average air velocity (V_1) of cooling air supplied to the first cooling air supply unit, with respect to an average air velocity (V_2) of cooling air supplied to the second cooling air supply unit, is from more than 0 to 0.7.

<11> The melt spinning apparatus according to any one of <1> to <10>, further comprising a drawing unit that draws the filaments cooled in the cooling unit,

wherein a ratio of a distance (distance B) from a nozzle face, on which the spinning nozzles of the spinning unit are disposed, to the partition, with respect to a distance (distance C) from the nozzle face, on which the spinning nozzles of the spinning unit are disposed, to an inlet of the drawing unit (distance B/distance C), is from 0.2 to 0.8.

<12> The melt spinning apparatus according to any one of <1> to <11>, further comprising a collecting unit that collects cooled and drawn filaments to form a non-woven web, wherein the melt spinning apparatus is used for manufacturing a spunbonded non-woven fabric.

<13> A method of manufacturing a non-woven fabric, comprising manufacturing a non-woven fabric from filaments spun from the plurality of spinning nozzles using the melt spinning apparatus according to any one of <1> to <12>.

<14> The method of manufacturing a non-woven fabric according to <13>, wherein a temperature of cooling air supplied to the first cooling air supply unit is from 10°C to 40°C, and a temperature of cooling air supplied to the second cooling air supply unit is higher than the temperature of the cooling air supplied to the first cooling air supply unit by 10°C or more and is from 30°C to 70°C.

<15> The method of manufacturing a non-woven fabric according to <13> or <14>, wherein a ratio (V_1/V_2) of an average air velocity (V_1) of cooling air supplied to the first cooling air supply unit, with respect to an average air velocity (V_2) of cooling air supplied to the second cooling air supply unit, is from more than 0 to 0.7.

<16> The method of manufacturing a non-woven fabric according to any one of <13> to <15>, wherein the filaments comprises a propylene-based polymer.

Advantageous Effects of Invention

[0009] The present disclosure can provide a melt spinning apparatus in which yarn breakage and yarn fluctuation can be suppressed, and a method of manufacturing a non-woven fabric using the apparatus.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a schematic configuration view illustrating a partial cross section of a melt spinning apparatus of the present disclosure.

Fig. 2 is a graph indicating a relationship between the height of a cooling air supply unit and the air velocity (outlet value) of cooling air in Examples 1 to 3.

FIG. 3 is a graph indicating a relationship between the height of a cooling air supply unit and the air velocity (outlet value) of cooling air in Examples 1 to 3 and Comparative Examples 1 to 6.

DESCRIPTION OF EMBODIMENTS

[0011] Specific embodiments of the invention will be described in detail below. However, the invention is not limited to the embodiments described below, and can be modified and carried out within the scope of an object of the invention, if appropriate.

[0012] In the present disclosure, any numerical value range indicated by the term "to" represents any range including the numerical values described before and after the term "to" as the lower limit value and the upper limit value, respectively.

[0013] In a numerical range expressed in a stepwise manner in the present disclosure, the upper or lower limit value expressed in one numerical range may be replaced by the upper or lower limit value in another numerical range expressed in a stepwise manner. In a numerical range expressed in the present disclosure, the upper or lower limit value of the numerical range may be replaced by values described in Examples.

[0014] In the present disclosure, in a case in which an embodiment is explained with reference to a drawing, the configuration of the embodiment is not limited to a configuration illustrated in the drawing. The sizes of members in each drawing are conceptual, and the relative relationships between the sizes of the members are not limited thereto.

[Melt Spinning Apparatus]

[0015] A melt spinning apparatus of the present disclosure includes a spinning unit including plural spinning nozzles that spin filaments, a cooling unit that cools the filaments spun from the spinning nozzles, and a cooling air supply unit that faces the cooling unit and supplies cooling air to the cooling unit through an air-permeable partition, wherein the cooling air supply unit includes a first cooling air supply unit at a vertically upper side and a second cooling air supply unit at a vertically lower side, divided into two stages in a vertical direction through a partition, there is a gap between an end, facing the air-permeable partition, of the partition and a face of a side, facing the partition, in the air-permeable partition, and the distance (distance A) of the gap is 55 mm or less.

[0016] The melt spinning apparatus of the present disclosure includes the cooling air supply unit including the first cooling air supply unit at the vertically upper side and the second cooling air supply unit at the vertically lower side, divided into the two stages in the vertical direction through the partition, and includes the gap between the end, facing the air-permeable partition, of the partition and the face of the side, facing the partition, in the air-permeable partition, wherein the distance (distance A) of the gap is 55 mm or less. It is presumed that as a result, a difference between the air velocities of cooling airs in the boundary of the first cooling air supply unit at the vertically upper side and the second cooling air supply unit at the vertically lower side, in the cooling unit, can be decreased, the cooling airs with the small air velocity difference in the vicinity of the boundary are supplied to the filaments, and therefore, turbulence caused by mixing the cooling airs having different air velocities is suppressed, whereby yarn breakage and yarn fluctuation can be suppressed.

[0017] The configuration of the melt spinning apparatus of the present disclosure will be described below with reference to Fig. 1. As illustrated in Fig. 1, the melt spinning apparatus 100 includes a spinning unit 1, a cooling chamber (cooling unit) 3, a cooling air supply unit 4, an air-permeable partition 8, and a drawing unit 9. The cooling air supply unit 4 is divided into two stages through a partition 7, and includes a first cooling air supply unit 5 at a vertically upper side and a second cooling air supply unit 6 at a vertically lower side. There is a gap between an end, facing the air-permeable partition 6, of the partition 7 and a face of a side, facing the partition 7, in the air-permeable partition 6.

[0018] The melt spinning apparatus 100 is an apparatus that discharges a resin composition supplied to the spinning unit 1, from plural spinning nozzles into the cooling chamber 3, and cools and draws the discharged filaments. The melt spinning apparatus 100 may be an apparatus used for manufacturing a spunbonded non-woven fabric, and may include, for example, a collecting unit that forms a non-woven web on which the cooled and drawn filaments are deposited, and an entanglement unit that subjects the non-woven web to heating and pressurization treatment.

[0019] The melt spinning apparatus 100 includes the spinning unit 1 including the plural spinning nozzles through which filaments are spun. For example, a resin composition melt-kneaded with an extruder is supplied to the spinning unit 1, and the resin composition supplied to the spinning unit 1 is discharged as filaments from the plural spinning nozzles disposed on a nozzle face 2 into the cooling chamber 3.

[0020] The resin composition may include a resin used for manufacturing a non-woven fabric. Examples of the resin used for manufacturing a non-woven fabric include a polyester resin, a polyurethane resin, a polyamide resin, and a polyolefin resin. Especially, a polyolefin resin is preferred, and a propylene-based polymer is more preferred, in view of excellent productivity.

[0021] The propylene-based polymer may be a polymer including propylene as a constitutional unit, may be a propylene homopolymer, may be a propylene random copolymer, or may be a mixture thereof.

[0022] The propylene random copolymer is preferably a random copolymer in which the content of propylene with respect to all constitutional units is 50% by mol or more. The propylene random copolymer is preferably a propylene- α -olefin random copolymer.

[0023] In the propylene random copolymer, the content of propylene with respect to all the constitutional units is preferably from 70% by mol to 99.5% by mol, more preferably from 80% by mol to 98% by mol, and still more preferably from 90% by mol to 96% by mol.

[0024] The α -olefin is preferably an α -olefin having two or more carbon atoms, excluding propylene, more preferably an α -olefin having 2 or from 4 to 8 carbon atoms, and still more preferably ethylene which is an α -olefin having 2 carbon atoms.

[0025] Specific examples of the α -olefin include ethylene, 1-butene, 1-pentene, 1-hexene, 1-octene, and 4-methyl-1-pentene.

[0026] Such α -olefins may be used singly, or in combination two or more kinds thereof.

[0027] The resin composition may include another component as well as the resin used for manufacturing a non-woven fabric. Examples of the other component include another polymer, an organic peroxide, a surfactant, a coloring agent, an antioxidant based on phosphorus, phenol, or the like, a weathering stabilizer based on benzotriazole or the like, a light stabilizer based on a hindered amine or the like, an anti-blocking agent, a dispersant such as calcium stearate, a lubricant, a nucleating agent, a pigment, a softening agent, a hydrophilization agent, a water repellent, an aid, a water repellent, a filler, an antibacterial agent, a pesticide, an insect repellent, an agent, a natural oil, and a synthetic oil.

[0028] The melt spinning apparatus 100 includes the cooling chamber 3 in which filaments spun from the spinning nozzles are cooled. Cooling air is supplied from the cooling air supply unit 4 into the cooling chamber 3 through the air-permeable partition 8, and the filaments are cooled by the supplied cooling air. An exhaust-nozzle for exhausting a vapor of low-molecular-weight polymer may be mounted between the nozzle face 2, which is an upper portion of the cooling chamber 3, and the cooling air supply unit 4.

[0029] The melt spinning apparatus 100 includes the cooling air supply unit 4 that faces the cooling chamber 3 and supplies cooling air to the cooling chamber 3 through the air-permeable partition 8. The cooling air supply unit 4 includes the first cooling air supply unit 5 at the vertically upper side and the second cooling air supply unit 6 at the vertically lower side, divided into two stages in a vertical direction. As illustrated in Fig. 1, the first cooling air supply unit 5 and the second cooling air supply unit 6 supply cooling airs in the directions of arrows in Fig. 1.

[0030] As illustrated in Fig. 1, such cooling air supply units 4 supply cooling airs from two directions, facing each other, to the cooling chamber 3 through such air-permeable partitions 8, respectively.

[0031] The cooling air supply unit 4 may include a flow regulating plate that regulates cooling air supplied to the cooling chamber 3, upstream of the air-permeable partition 8 in the direction of cooling air supply. As a result, the direction of cooling air supplied to the cooling chamber 3 is regulated, and yarn breakage and yarn fluctuation can be more preferably suppressed.

[0032] It is preferable that $(L \times h)/d$ satisfies 0.056 or more assuming that the width of the cooling air supply unit 4 is L (m), the height of the cooling air supply unit 4 is h (m), and the distance of the gap is d (mm). In such a case, the height h of the cooling air supply unit 4 corresponds to $h_1 + h_2$ + the thickness of the partition 7 in Fig. 1, and the width of the cooling air supply unit 4 is the length of the inner side of the cooling air supply unit 4, excluding an outer wall, in the direction orthogonal to the direction of cooling air supply and the height of the cooling air supply unit 4 in Fig. 1.

[0033] The width L of the cooling air supply unit 4 and the height h of the cooling air supply unit 4 means the width and height of the cooling air outlet of the cooling air supply unit 4. Accordingly, $(L \times h)$ means the area of a face, through which cooling air passes, of the cooling air outlet of the cooling air supply unit 4, and $(L \times h)/d$ means the ratio of the area to the distance d of the gap.

[0034] $(L \times h)/d$ may be from 0.056 to 0.614, or may be from 0.112 to 0.448. Yarn breakage can be more preferably suppressed in a case in which $(L \times h)/d$ is 0.056 or more, and yarn fluctuation can be more preferably suppressed in a case in which $(L \times h)/d$ is 0.614 or less.

[0035] The distance d of the gap may be 50 mm or less, may be 45 mm or less, and may be 40 mm or less, in view of more preferably suppressing yarn breakage.

[0036] The numerical value of the distance d of the gap is not particularly limited as long as the gap is present. The distance d may be 5 mm or more, and may be 10 mm or more, in view of more preferably suppressing yarn fluctuation.

[0037] The width L of the cooling air supply unit 4 is not particularly limited. The width L may be from 3 m to 7 m, and may be from 4 m to 6 m. The height of the cooling air supply unit 4 is not particularly limited. The height may be from 0.4 m to 1.0 m, and may be from 0.6 m to 0.8 m.

[0038] The ratio of a distance (distance B) from the nozzle face 2 to the partition 7 with respect to the distance A which is the distance d of the gap (distance B/distance A) may be from 5 to 50.

[0039] The ratio of the height (h_2) of the second cooling air supply unit 6 to the height (h_1) of the first cooling air supply unit 5 may be from 0.5 to 1.5, and may be from 0.8 to 1.2.

[0040] The melt spinning apparatus 100 may further include a first controller that controls the temperature (first temperature) of cooling air supplied to the first cooling air supply unit 5 and the temperature (second temperature) of cooling air supplied to the second cooling air supply unit 6.

[0041] The first temperature refers to the temperature of cooling air in the inlet of the first cooling air supply unit 5, and

the second temperature refers to the temperature of cooling air in the inlet of the second cooling air supply unit 6.

[0042] In view of more preferably suppressing yarn breakage, the first controller preferably performs control so that the second temperature is higher than the first temperature, and more preferably performs control so that the first temperature is from 10°C to 40°C, and the second temperature is higher than the first temperature by 10°C or more and is from 30°C to 70°C.

[0043] The melt spinning apparatus 100 may further include a second controller that controls the average air velocity (V_1) of cooling air supplied to the first cooling air supply unit 5 and the average air velocity (V_2) of cooling air supplied to the second cooling air supply unit 6. The second controller may be the same as or different from the first controller.

[0044] V_1 refers to the average air velocity of cooling air in the inlet of the first cooling air supply unit 5, and V_2 refers to the average air velocity of cooling air in the inlet of the second cooling air supply unit 6.

[0045] The second controller preferably controls the average air velocity of cooling air so that V_2 is more than V_1 in view of preferably suppressing yarn breakage.

[0046] In view of more preferably suppressing yarn breakage, the second controller preferably performs control so that the ratio of V_1 to V_2 (V_1/V_2) is from more than 0 to 0.7, more preferably performs control so that $0.01 \leq V_1/V_2 \leq 0.5$ is achieved, and still more preferably performs control so that $0.05 \leq V_1/V_2 \leq 0.4$ is achieved.

[0047] The melt spinning apparatus 100 includes the air-permeable partition 8 that separates the cooling air supply unit 4 and the cooling chamber 3 from each other. The air-permeable partition 8 has permeability, and therefore, cooling air supplied from the cooling air supply unit 4 is introduced into the cooling chamber 3 through the air-permeable partition 8.

[0048] The air-permeable partition 8 is not particularly limited as long as the air-permeable partition 8 is a partition having permeability. In view of the regulation of cooling air, the air-permeable partition 8 preferably has a lattice shape such as a quadrangular shape, or a honeycomb shape such as a hexagonal shape or an octagonal shape, and more preferably has a honeycomb shape.

[0049] In view of strength and the regulation of cooling air, the thickness of the air-permeable partition 8 is preferably from 10 mm to 50 mm, and more preferably from 20 mm to 40 mm.

[0050] The ratio of the thickness of the air-permeable partition to the distance A (thickness of air-permeable partition/distance A) is preferably from 0.5 to 5.0, more preferably from 0.5 to 1.5, and still more preferably from 0.8 to 1.2.

[0051] The melt spinning apparatus 100 further includes the drawing unit 9 that draws filaments cooled in the cooling chamber 3. The drawing unit 9 is a thin bottleneck that is arranged at the vertically lower side of the cooling chamber 3, and that is throttled from both right and left sides. In the drawing unit 9, cooling air has an increased air velocity, becomes drawing air, and allows the cooled filaments to be drawn.

[0052] The ratio of the distance (distance B) from the nozzle face 2 to the partition 7 with respect to a distance (distance C) from the nozzle face 2 to the inlet of the drawing unit 9 (distance B/distance C) is preferably from 0.2 to 0.8, and more preferably from 0.2 to 0.6.

[Method of Manufacturing Non-Woven Fabric]

[0053] A method of manufacturing a non-woven fabric of the present disclosure is a method of manufacturing a non-woven fabric from filaments spun from plural spinning nozzles using the melt spinning apparatus of the present disclosure. A non-woven fabric of which the yarn breakage and yarn fluctuation are suppressed can be obtained by the method.

[0054] The method of manufacturing a non-woven fabric of the present disclosure may include, for example, a step of discharging a resin composition, supplied to a spinning unit, from plural spinning nozzles into a cooling unit, a step of cooling discharged filaments, a step of drawing the cooled filaments, and a step of collecting the drawn filaments to form a non-woven web. The method of producing a non-woven fabric of the present disclosure may further include a step of subjecting the non-woven web to heating and pressurization treatment.

[0055] In view of more preferably suppressing yarn breakage, it is preferable that the temperature of cooling air supplied to a first cooling air supply unit is from 10°C to 40°C, and the temperature of cooling air supplied to a second cooling air supply unit is higher than the temperature of cooling air supplied to the first cooling air supply unit by 10°C or more and is from 30°C to 70°C.

[0056] In view of preferably suppressing yarn breakage, the average air velocity (V_2) of cooling air supplied to the second cooling air supply unit is preferably more than the average air velocity (V_1) of cooling air supplied to the first cooling air supply unit. In view of more preferably suppressing yarn breakage, the ratio of V_1 to V_2 (V_1/V_2) is preferably from more than 0 to 0.7, more preferably $0.01 \leq V_1/V_2 \leq 0.5$, and still more preferably $0.05 \leq V_1/V_2 \leq 0.4$.

[0057] The average air velocity (V_1') of cooling air supplied from the first cooling air supply unit to the cooling unit and the average air velocity (V_2') of cooling air supplied from the second cooling air supply unit to the cooling unit may be adjusted by controlling V_1 and V_2 . For example, the ratio of V_1' to V_2' (V_1'/V_2') may be adjusted to be from more than 0 to 0.7, may be adjusted to be $0.01 \leq V_1'/V_2' \leq 0.5$, and may be adjusted to be $0.1 \leq V_1'/V_2' \leq 0.5$, by controlling V_1 and V_2 .

Examples

[0058] The invention will be more specifically described below with reference to Examples. However, the invention is not limited to the following Examples unless the invention departs from the gist of the invention.

[Examples 1 to 3 and Comparative Examples 1 to 6]

[0059] A non-woven fabric was manufactured using a melt spinning apparatus illustrated in Fig. 1. A propylene homopolymer having a melt flow rate of 60 g/10 minutes, measured at a load of 2.16 kg and a temperature of 230°C according to ASTM D 1238, was used as a resin used for manufacturing the non-woven fabric. The melting temperature of the resin was set at 200°C, a single-hole discharge rate from a spinning nozzle was set at 0.57 g/min, and the air velocity of cooling air was set as set forth in Table 1. The temperature of upper-stage cooling air and the temperature of lower-stage cooling air were 23°C, the ratio of the height (h_2) of a lower-stage cooling air supply unit (second cooling air supply unit) to the height (h_1) of an upper-stage cooling air supply unit (first cooling air supply unit) was 1, and distance B/distance C was 0.47. The thickness of a partition was one 16th of the height of the upper-stage cooling air supply unit.

[0060] A supply unit inlet value set forth in Table 1 refers to the average air velocity value of cooling air supplied to the inlet of the upper-stage cooling air supply unit or the lower-stage cooling air supply unit.

[0061] A supply unit outlet value set forth in Table 1 refers to the average air velocity value of cooling air exhausted from the outlet (air-permeable partition) of the upper-stage cooling air supply unit or the lower-stage cooling air supply unit.

[0062] An ANEMOMASTERANEMOMETER (Model 6114) manufactured by KANOMAX was used for measuring an air velocity.

[0063] Fig. 2 and Fig. 3 illustrate graphs, each indicating a relationship between the height of a cooling air supply unit and the air velocity (outlet value) of cooling air in Examples 1 to 3 and Comparative Examples 1 to 6. With regard to the height position of the cooling air supply unit, the height position of the upper end of the upper-stage cooling air supply unit corresponds to the upper end of the ordinate of each graph, the height position of the lower end of the lower-stage cooling air supply unit corresponds to the lower end of the ordinate of each graph, and the height position of the partition corresponds to the center of the ordinate of each graph, in Fig. 2 and Fig. 3.

[0064] The yarn breakage and yarn fluctuation of non-woven fabrics obtained in Examples 1 to 3 and Comparative Examples 1 to 6 were evaluated for evaluating spinnability.

<Yarn Breakage>

[0065] The yarn breakage was evaluated based on observation results obtained by spinning and forming a melt-kneaded propylene homopolymer consecutively for 10 minutes. The results are set forth in Table 1.

-Evaluation Criteria-

[0066]

- A: No occurrence of yarn breakage
- B: Occurrence of yarn breakage

<Yarn Fluctuation>

[0067] The yarn fluctuation was evaluated by spinning and forming a melt-kneaded propylene homopolymer and observing the state of yarn fluctuation at the position (height position at which the partition was disposed) of the distance B from the nozzle face in the cooling unit. The results are set forth in Table 1.

-Evaluation Criteria-

[0068]

- A: No occurrence of yarn fluctuation (there is no possibility that the amplitude of the fluctuation of a filament comes into contact with an adjacent filament)
- B: Occurrence of yarn fluctuation (there is a possibility that the amplitude of the fluctuation of a filament comes into contact with an adjacent filament)

[Table 1]

	Symbol	Unit	Example 1	Examp e 2	Examp e 3	Compar ative Examp le 1	Compar ative Examp le 2	Compar ative Examp le 3	Compar ative Examp le 4	Compar ative Examp le 5	Compar ative Examp le 6
Distance of Gap	d	mm	50	25	10	60	60	0	70	80	100
(Height×Width)/ Distance of Gap	(h×L)/d		0.061	0.123	0.307	0.051	0.051	-	0.044	0.038	0.031
Average Air Velocity of Upper-Stage Cooling Air (Supply Unit Inlet Value)	V_1	m/s	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Average Air Velocity of Lower-Stage Cooling Air (Supply Unit Outlet Value)	V_2	m/s	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
Average Air Velocity Ratio (Supply Unit Inlet Value)	V_1/V_2	-	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Average Air Velocity of Upper-Stage Cooling Air (Supply Unit Outlet Value)	V'_1	m/s	0.84	0.82	0.80	1.19	1.19	0.77	1.30	1.31	1.28
Maximum Air Velocity of Upper-Stage Cooling Air (Outlet Value)	$V'_{1 \max}$	m/s	1.00	1.01	1.07	1.50	1.78	0.78	1.51	1.51	1.46
Average Air Velocity of	V'_2	m/s	1.80	1.84	1.88	1.44	1.45	1.89	1.36	1.35	1.38
Lower-Stage Cooling Air (Supply Unit Outlet Value)											
Minimum Air Velocity of Lower-Stage Cooling Air (Outlet Value)	$V'_2 \min$	m/s	1.10	1.14	1.31	0.93	0.84	1.29	0.89	0.97	1.08
Average Air Velocity Ratio (Supply Unit Outlet Value)	V'_1/V'_2	-	0.47	0.44	0.43	0.83	0.82	0.41	0.95	0.97	0.93

(continued)

	Symbol	Unit	Example 1	Examp e 2	Examp e 3	Compar ative Examp e 1	Compar ative Examp e 2	Compar ative Examp e 3	Compar ative Examp e 4	Compar ative Examp e 5	Compar ative Examp e 6
Air Velocity Difference between Upper and Lower Stages	$\Delta V' = V'_{1\text{ max}} - V'_{2\text{ min}}$	m/s	-0.10	-0.13	-0.24	0.57	0.94	-0.51	0.61	0.53	0.39
Spinnability	Yarn breakage		A	A	A	B	B	A	B	B	B
	Yarn fluctuation		A	A	A	A	A	B	A	A	A

[0069] As set forth shown in Table 1 and illustrated in Figs. 2 and 3, air velocity difference between upper and lower stages (a value obtained by subtracting the maximum air velocity of a lower stage from the maximum air velocity of an upper stage) in each of Examples 1 to 3 was less than that in each of Comparative Examples 1 to 6, and yarn breakage and yarn fluctuation in Examples 1 to 3 were suppressed.

Reference Signs List

[0070]

- | | | |
|----|-----|--------------------------------|
| 10 | 1 | Spinning unit |
| | 2 | Nozzle face |
| | 3 | Cooling chamber (cooling unit) |
| | 4 | Cooling air supply unit |
| | 5 | First cooling air supply unit |
| 15 | 6 | Second cooling air supply unit |
| | 7 | Partition |
| | 8 | Air-permeable partition |
| | 9 | Drawing unit |
| | 10 | Filaments |
| 20 | 100 | Melt spinning apparatus |

Claims

1. A melt spinning apparatus comprising:

a spinning unit comprising a plurality of spinning nozzles that spin filaments;
 a cooling unit that cools the filaments spun from the spinning nozzles; and
 a cooling air supply unit that faces the cooling unit and supplies cooling air to the cooling unit through an air-permeable partition,
 wherein the cooling air supply unit comprises a first cooling air supply unit at a vertically upper side and a second cooling air supply unit at a vertically lower side, divided into two stages in a vertical direction through a partition,
 there is a gap between an end, facing the air-permeable partition, of the partition and a face of a side, facing the partition, in the air-permeable partition, and a distance (distance A) of the gap is 55 mm or less.

2. The melt spinning apparatus according to claim 1, wherein the distance A is 5 mm or more.

3. The melt spinning apparatus according to claim 1 or 2, wherein a ratio of a distance (distance B) from a nozzle face, on which the spinning nozzles of the spinning unit are disposed, to the partition, with respect to the distance A (distance B/distance A), is from 5 to 50.

4. The melt spinning apparatus according to any one of claims 1 to 3, wherein a ratio of a height (h_2) of the second cooling air supply unit, to a height (h_1) of the first cooling air supply unit, is from 0.5 to 1.5.

5. The melt spinning apparatus according to any one of claims 1 to 4, wherein a thickness of the air-permeable partition is from 10 mm to 50 mm.

6. The melt spinning apparatus according to any one of claims 1 to 5, wherein a ratio of a thickness of the air-permeable partition to the distance A (thickness of air-permeable partition/distance A) is from 0.5 to 5.0.

7. The melt spinning apparatus according to any one of claims 1 to 6, wherein the air-permeable partition has a honeycomb shape.

8. The melt spinning apparatus according to any one of claims 1 to 7, wherein the cooling air supply unit comprises a flow regulating plate that regulates the cooling air supplied to the cooling unit, upstream of the air-permeable partition, in a direction of cooling air supply.

9. The melt spinning apparatus according to any one of claims 1 to 8, further comprising a first controller that performs

control so that a temperature of cooling air supplied to the first cooling air supply unit is from 10°C to 40°C, and a temperature of cooling air supplied to the second cooling air supply unit is higher than the temperature of the cooling air supplied to the first cooling air supply unit by 10°C or more and is from 30°C to 70°C.

- 5 **10.** The melt spinning apparatus according to any one of claims 1 to 9, further comprising a second controller that performs control so that a ratio (V_1/N_2) of an average air velocity (V_1) of cooling air supplied to the first cooling air supply unit, with respect to an average air velocity (V_2) of cooling air supplied to the second cooling air supply unit, is from more than 0 to 0.7.
- 10 **11.** The melt spinning apparatus according to any one of claims 1 to 10, further comprising a drawing unit that draws the filaments cooled in the cooling unit, wherein a ratio of a distance (distance B) from a nozzle face, on which the spinning nozzles of the spinning unit are disposed, to the partition, with respect to a distance (distance C) from the nozzle face, on which the spinning nozzles of the spinning unit are disposed, to an inlet of the drawing unit (distance B/distance C), is from 0.2 to 0.8.
- 15 **12.** The melt spinning apparatus according to any one of claims 1 to 11, further comprising a collecting unit that collects cooled and drawn filaments to form a non-woven web, wherein the melt spinning apparatus is used for manufacturing a spunbonded non-woven fabric.
- 20 **13.** A method of manufacturing a non-woven fabric, comprising manufacturing a non-woven fabric from filaments spun from the plurality of spinning nozzles using the melt spinning apparatus according to any one of claims 1 to 12.
- 25 **14.** The method of manufacturing a non-woven fabric according to claim 13, wherein a temperature of cooling air supplied to the first cooling air supply unit is from 10°C to 40°C, and a temperature of cooling air supplied to the second cooling air supply unit is higher than the temperature of the cooling air supplied to the first cooling air supply unit by 10°C or more and is from 30°C to 70°C.
- 30 **15.** The method of manufacturing a non-woven fabric according to claim 13 or 14, wherein a ratio (V_1/N_2) of an average air velocity (V_1) of cooling air supplied to the first cooling air supply unit, with respect to an average air velocity (V_2) of cooling air supplied to the second cooling air supply unit, is from more than 0 to 0.7.
- 35 **16.** The method of manufacturing a non-woven fabric according to any one of claims 13 to 15, wherein the filaments comprises a propylene-based polymer.

FIG.1

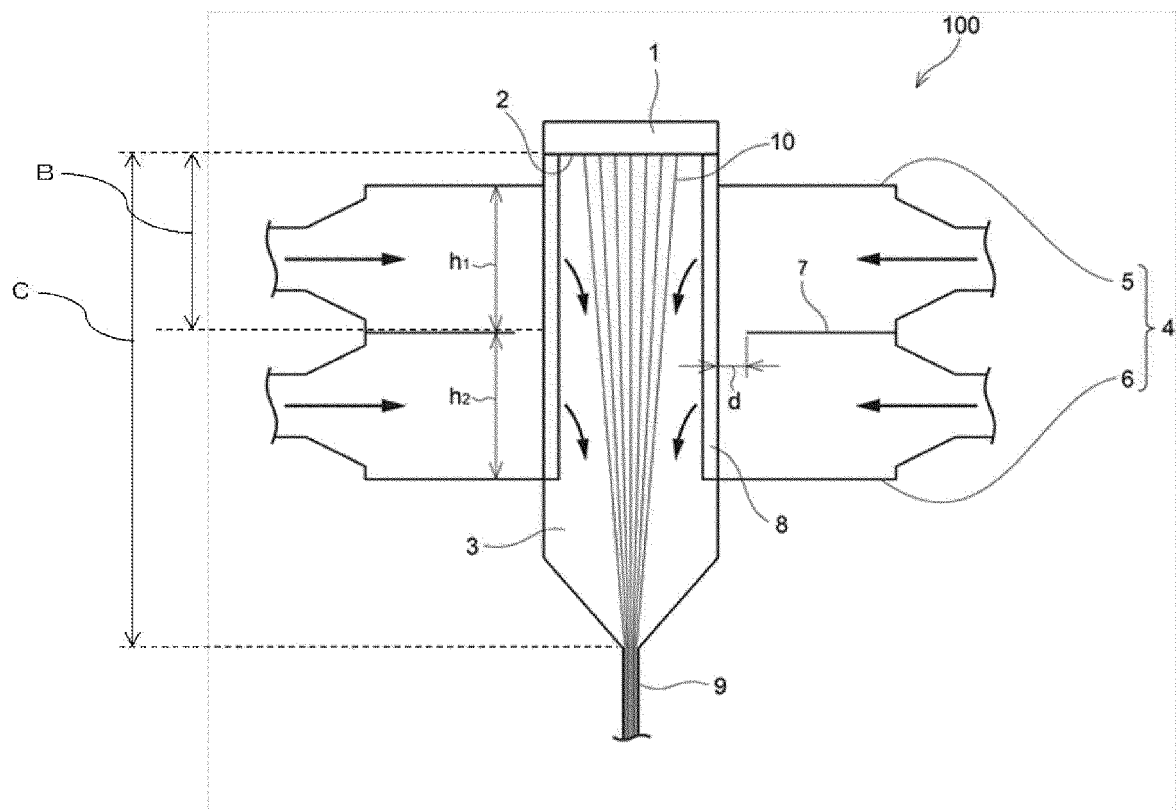


FIG.2

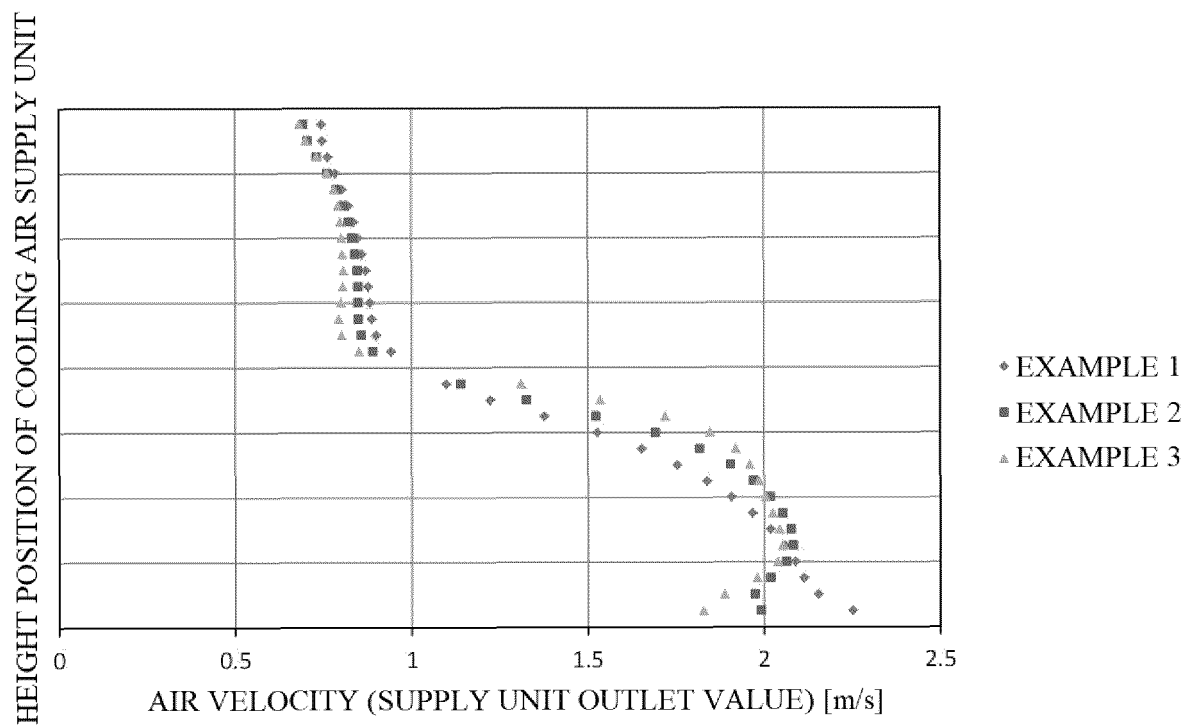
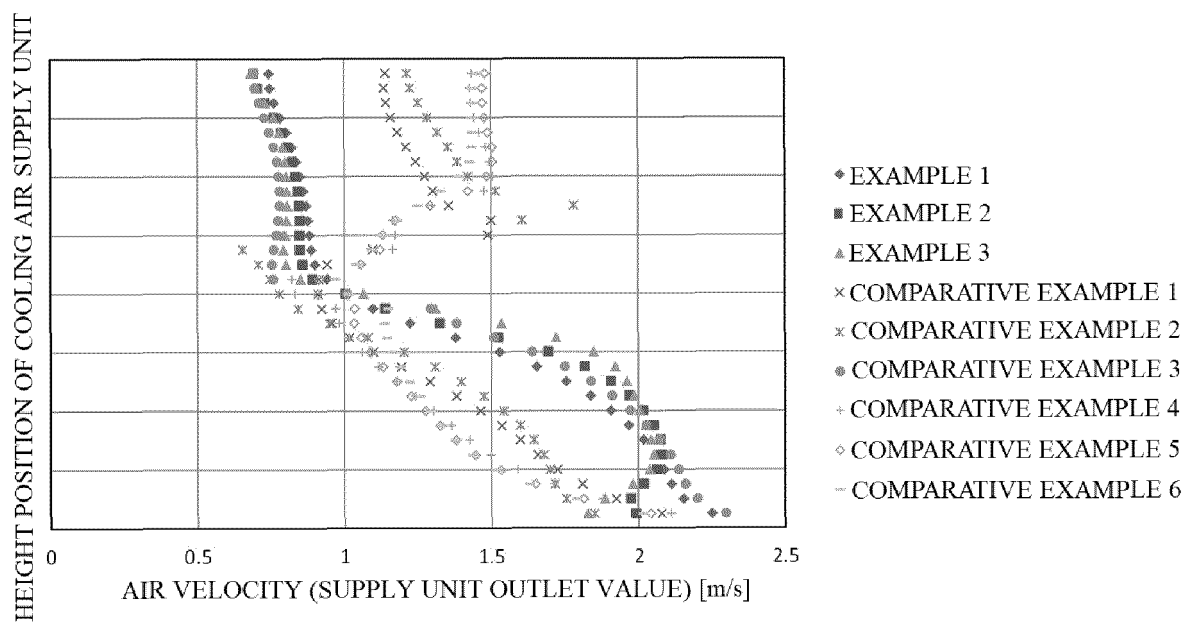


FIG.3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/047370

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. D01D5/092 (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)

Int.Cl. D01D1/00-13/02, D04H1/00-18/04

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 46-36421 Y2 (NIPPON ESTER CO., LTD.) 15 December 1971, claims, drawings (Family: none)	1-16
A	JP 2007-46224 A (MITSUI CHEMICALS, INC.) 22 February 2007, claims, drawings (Family: none)	1-16
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 83321/1989 (Laid-open No. 22070/1991) (NIPPON ESTER CO., LTD.) 06 March 1991, claims, drawings (Family: none)	1-16

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

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Date of the actual completion of the international search

18.01.2019

Date of mailing of the international search report

29.01.2019

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/047370

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 023767/1974 (Laid-open No. 119708/1975) (TORAY INDUSTRIES, INC.) 30 September 1975, claims, drawings (Family: none)	1-16
A	CD-ROM Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 141990/1972 (Laid-open No. 98506/1974) (TORAY INDUSTRIES, INC.) 24 August 1974, claims, drawings (Family: none)	1-16
A	US 3070839 A (THOMPSON) 01 January 1963, claims, drawings (Family: none)	1-16
A	JP 63-275767 A (REINFENHAUSER GMBH & CO. MASCHINENFABRIK) 14 November 1988, claims, drawing & JP 63-275766 A & US 4813864 A, claims, drawings & US 4851179 A	1-16

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002317372 A [0005]