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NONWOVEN FABRIC OF POLYPROPYLENE FIBER
AND PROCESS FOR MAKING THE SAME

This invention relates to a nonwoven fabric made of continuous polypropylene fiber and to a process for making the same.

Japanese Patent No. 2887611 describes a process for making a nonwoven fabric of continuous microfibers having a fineness less than 1 denier. According to the process described in this Patent, continuous microfibers are stretched once on a step of melt spinning and then stretched again until its fineness is reduced to a desired value. The continuous microfibers having a fineness thereof reduced in this manner are collected and bonded together, for example, by adhesion to obtain the desired nonwoven fabric.

The prior art described above offers a nonwoven fabric comprising continuous microfibers of a fineness sufficiently reduced to ensure a comfortable soft touch. This invention aims to add this comfortable soft touch nonwoven fabric with a high breaking extension.

The object set forth above is achieved by a first aspect of this invention relating to the product, on one hand, and by

a second aspect of this invention relating to the process for making this product.

Specifically, the object set forth above is achieved, according to its first aspect, by an improvement in the nonwoven fabric made of continuous polypropylene fiber.

The improvement according to the first aspect of this invention is in that the continuous fibers have a fineness of 0.006 ~ 5.8 deniers, a birefringence of 0.019 ~ 0.030 and a tensile breaking extension of 100 ~ 300 % wherein the fibers are subjected to substantially mechanical entanglement to maintain the form of a nonwoven fabric.

According to one preferred embodiment of the first aspect, said nonwoven fabric has a tensile strength of 1 - 3 g/d.

The object set forth above is achieved, according to the second aspect of this invention, by an improvement in the process for making a nonwoven fabric comprising the steps of stretching the continuous polypropylene fibers extruded from a plurality of nozzle orifices, accumulating the continuous polypropylene fibers on a belt travelling in one direction and entangling the continuous fibers together to obtain a desired form of a nonwoven fabric.

The improvement according to the second aspect of this invention is in by that the process comprises the steps of

heating a region of an extruder in the vicinity of said nozzle substantially at a temperature of said continuous fibers being extruded in molten state, guiding the continuous fibers through guide passage of a sucker extending through between in- and outlet thereof and being supplied with compressed air at the normal temperature discharged in a direction defined from the inlet toward the outlet, stretching the continuous fibers along a path extending between the nozzle and the sucker and thereby reducing a fineness of the continuous fibers, and orienting polypropylene molecules sufficiently to obtain a desired birefringence.

Fig. 1 is a diagram schematically illustrating the process for making a nonwoven fabric.

Details of a nonwoven fabric and a process for making the same according to this invention will be more fully understood from the description given hereunder with reference to the accompanying drawing.

Fig. 1 is a diagram schematically illustrating the process for continuously making nonwoven fabric 100 using a melt spinning machine 1, a sucker 2, an endless belt conveyor 3, a high pressure water jet ejector 4 and a take-up roller 6.

The melt spinning machine 1 includes a material feed hopper and a screw feed extruder (not shown), the latter being provided at its forward end with spinning nozzle 11 and hot blast blow-off orifices 12 on both sides of the nozzle 11. As material, polypropylene having MFR, for example, of 10 ~ 80 g/10 min is used. 600 orifices of the nozzle 11 each having an orifice diameter, for example, of 0.35 mm are arranged in line at the orifice pitch of 1 mm in a direction perpendicular to the plane of the drawing. Continuous polypropylene fiber 15 is discharged through each of these orifices of the nozzle 11 at a rate of 0.13 ~ 0.40 g/min/nozzle. The blow-off orifices 12 breathe out hot blast substantially at the same temperature as a temperature of polypropylene being discharged in molten state, i.e., at a temperature of approximately 230°C on the assumption that polypropylene is discharged through the nozzle 11 at a temperature of approximately 230°C. The hot blast is breathed out at a rate of 1 ~ 3 Nm³/min and prevents polypropylene being extruded from being rapidly cooled.

The sucker 2 has guide passage 16 for the continuous fibers 15 and blow-off orifices 17 opening into the guide passage 16 from both sides thereof to breathe out compressed air at the normal temperature. The guide passage 16 has an inlet 18 and an outlet 18 for the continuous fibers 15. The sucker

2 is positioned so that a distance P between the nozzle 11 and the inlet 18 of the sucker 2 is 500 mm or less, preferably 100 ~ 300 mm. The continuous fibers 15 travelling over the distance P preferably have a temperature falling nearly to the melting point thereof as the continuous fibers 15 reach the inlet 18. Over a distance Q between the blow-off orifices 17 and the outlet 19, the continuous fibers 15 are supplied with compressed air at the normal temperature breathed out toward the outlet 19. The distance Q is preferably in a range of 20 ~ 500 mm and the expression "normal temperature" used herein should be understood to be the temperature in a range of 10 ~ 50°C. The compressed air is of 0.5 ~ 2 kgf/cm²G and supplied at a flow rate of Nm³/min. The continuous fibers 15 entering the guide passage 16 are quenched by the compressed air at the normal temperature nearly to the normal temperature and, at the same time, stretched appropriately to achieve a fineness of 0.006~5.8 deniers and a birefringence Δn of 0.019 ~ 0.030. After stretched in this manner, the continuous fibers 15 preferably have a tensile strength of 1 ~ 3 g/d.

The endless conveyor belt 3 has its width extending in the direction orthogonal to the plane defined by the drawing. A distance R between the nozzle 11 and the conveyor belt 3 is dimensioned preferably in a range of 300 ~ 1500 mm, more

preferably in a range of 400 ~ 600 mm by correspondingly adjusting the distances P and Q. The conveyor belt 3 travels rightward as viewed in the drawing at a speed of 2 ~ 8 m/min. The conveyor belt 3 is made of material having a breathable nature and a suction box 21 is opposed to the sucker 2 with this conveyor belt 3 therebetween. The continuous fibers 15 emerging from the outlet 19 swing transversely as well as longitudinally of the conveyor belt 3 under the effect of compressed air and suction. Consequently, the continuous fibers 15 are accumulated on the conveyor belt 3 in an irregular pattern to form web 22.

The high pressure water jet ejector 4 has single or dual or more nozzle array(s) 24 each comprising a plurality of orifices 23 arranged in line transversely of the conveyor belt 3 at a pitch of 0.3 ~ 3 mm and a suction box 26 opposed to these nozzle array(s) with the conveyor belt 3 therebetween. In the case of dual nozzle arrays 24, for example, the orifices 23 of the first array may stabilize texture of the web 22 by ejecting water jet streams of 20kgf/cm² and the orifices 23 of the second array serve may partially orienting the continuous fibers 15 so as to extend in a travelling direction of the web 22 or may partially intertwine the continuous fibers 15 with one another to improve a tensile strength of the web 22. The web 22 may

be subsequently dried on a step of drying (not illustrated) to form nonwoven fabric 26 which is, in turn, taken up by the take-up roller 6 in the form of a roll.

The continuous fibers 15 and the nonwoven fabric 26 obtained through the above-mentioned series of steps under operating conditions as will be described have presented physical properties as follow:

(Operating conditions)

Resin used as the starting material: Polypropylene (MFR = 70 g/10 min)

Spinning nozzle:

Orifice diameter: 0.35 mm

Number of orifices: 600

Orifice pitch: 1 mm

Temperature: 230°C

Discharge: 0.13 g/min/nozzle

Hot blast:

Temperature: 230°C

Flow rate: 1.5 Nm³/min

Compressed air at the normal temperature:

Pressure: 1.0 kgf/cm²G

Flow rate: 6.0 Nm³/min

Conveyor belt:

Distance from the spinning nozzle: 490 mm

Travelling speed: 4.4 m/min

High pressure water jet ejection:

First array: at a pressure of 20 kgf/cm²

Second array: at a pressure of 100 kgf/cm²

(Physical properties of the continuous fibers)

Average fiber diameter: 8.9 μ m (0.51 d)

Standard deviation of the fiber diameter: 1.03

Tensile strength: 1.72 g/d

Tensile breaking extension: 6.38 mm

Condition of tension:

Distance between chucks: 0 mm

Tensile speed: 10 mm/min

Birefringence (Δn): 0.027

(Physical properties)

Basis weight: 34.2 g/m²

Thickness (under a measuring load of 3 g/cm²): 0.48 mm

Tensile strength in MD (machine direction): 16550 g/width of
50 mm)

Tensile breaking extension in MD: 193 %

Tensile strength in CD (cross direction): 8248 g/width of 50
mm

Tensile breaking extension in CD: 197 %

Condition of tension:

Distance between chucks: 10 mm

Tensile speed: 10 mm/min

As will be apparent from the physical properties of the continuous fibers and the nonwoven fabric as indicated above, the novel process for making a nonwoven fabric enables the continuous fibers 15 to have a relatively small fineness, e.g., of 0.006 ~ 05.8 d and, at the same time, enables unevenness possibly occurring in the fineness to be alleviated. The continuous fibers 15 obtained by such a novel process are practically free from heat-sealing with one another but only mechanically entangled with one another throughout the process to form the nonwoven fabric 26. In addition, such mechanical entanglement is not tight because the fiber is continuous, so these continuous fibers 15 moderately restrict their relative movement. The nonwoven fabric 26 made of such continuous fibers 15 offer soft and comfortable touch. The continuous fibers 15 appropriately stretched to obtain a birefringence of 0.019 ~ 0.030 have a high breaking extension since a degree at which the polypropylene molecules have been stretched is not so high that a stretchability of the continuous fibers 15 might be significantly restricted thereby. For example, a tensile test with 0 mm distance between chucks indicated that the continuous

fibers 15 as a typical embodiment of this invention can be stretched to 6.38 mm. The nonwoven fabric 26 formed by mechanically entangling such continuous fibers 15 with one another under the effect of high pressure water jet streams has a breaking extension as high as 100 ~ 300 % in MD as well as in CD because of a high breaking extension of the continuous fibers 15 and a moderate intertwinning among these fibers 15. The nonwoven fabric 26 as one embodiment of this invention has a breaking extension of 193 % in MD and a breaking extension of 197 % in CD.

The nonwoven fabric 26 obtained by the novel process is useful not only as disposable sanitary articles such as disposable diapers, sanitary napkins or disposable gowns to be used on the medical site but also as filters, wet wipes or the like.

The process according to this invention makes it possible to obtain a nonwoven fabric made of polypropylene having a fineness of 0.006 ~ 5.8 deniers, a birefringence of 0.019 ~ 0.030 and a tensile strength of 1 ~ 3 g/d. In this nonwoven fabric, a degree at which the polypropylene molecules are oriented in the course of spinning the continuous fibers is relatively low and, in addition, the continuous fibers are intertwined one with another not so tightly that they might significantly restrict

their relative movement. Such continuous fibers offer a comfortable soft touch and a high breaking extension.



WHAT IS CLAIMED IS:

1. A nonwoven fabric made of continuous polypropylene fiber comprising:

said continuous fibers having a fineness of 0.006 ~ 5.8 deniers, a birefringence of 0.019 ~ 0.030 and a tensile breaking extension of 100 ~ 300 % wherein said fibers are subjected to substantially mechanical entanglement to maintain the form of a nonwoven fabric.

2. The nonwoven fabric according to Claim 1, wherein said nonwoven fabric has a tensile strength of 1 ~ 3 g/d.

3. A process for making a nonwoven fabric comprising the steps of stretching continuous polypropylene fibers extruded from a plurality of nozzle orifices, accumulating said continuous polypropylene fibers on a belt travelling in one direction and entangling said continuous fibers together to obtain a desired form of a nonwoven fabric;

said process further comprising the steps of:

heating a region of an extruder in a vicinity of said nozzle substantially at a temperature of said continuous fibers being extruded in molten state;



guiding said continuous fibers through guide passage of a sucker extending through between in- and outlet thereof and being supplied with compressed air at the normal temperature discharged in a direction defined from said inlet toward said outlet;

stretching said continuous fibers along a path extending between said nozzle and said sucker and thereby reducing a fineness of said continuous fibers; and

orienting polypropylene molecules sufficiently to obtain a desired birefringence.

4. The process according to Claim 3, wherein said continuous fibers are at a temperature higher than a melting point thereof in the vicinity of said nozzle with the fineness being reduced, said temperature of said continuous fibers gradually drops approximately to said melting point as said continuous fibers flow from the vicinity of said nozzle to said inlet of said sucker and said continuous fibers are substantially stretched to obtain a desired birefringence as said continuous fibers are quenched within said sucker to the normal temperature.

5. The process according to Claim 3, wherein said step of heating comprising a step of blowing hot blast substantially



at the same temperature as a temperature of said continuous fibers being extruded into a region in the vicinity of said nozzle.

6. The process according to Claim 3, wherein said continuous fibers are stretched within said sucker so that said continuous fibers may have a fineness of 0.006 ~ 5.8 deniers.

7. The process according to Claim 3, wherein said polypropylene molecules are oriented within said sucker so that said continuous fibers may have a birefringence of 0.019 ~ 0.030.

8. The process according to Claim 3, wherein said process further includes a step of intertwining said continuous fibers with one another under an effect of high pressure water jet streams.

9. The process according to Claim 3, wherein said belt is spaced from said nozzle by a distance of 400 ~ 600 mm.