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METHOD OF FORMING THERMOPLASTIC FILM WITH
NONWOVEN FABRIC-LIKE PATTERN

The present invention relates to a method of forming a surface of a thermoplastic film with a nonwoven fabric-like pattern defined by individual fibers intertwined at random.

It is well known to press a thermoplastic film, which has previously been heat-softened, against a mold carrying thereon a given pattern and thereby to form a surface of said film with a pattern in conformity to said given pattern on the mold surface. It is also well known to place such a film under the effect of vacuum or pressure so as to be reliably forced as closely as possible against the mold and thereby to obtain a pattern in faithful conformity even with fine irregularities present on the mold surface.

In the field of sanitary articles such as disposable diapers and sanitary napkins, a plastic film used as an important component of such articles is often brought in close contact with the user's skin during use of the articles. To alleviate a sticky feeling of a plastic

film being closely in contact with the user's skin, the film surface has sometimes been formed with a woven or nonwoven fabric-like pattern so that such a pattern may generate on the film surface appropriate irregularities serving to reduce an area of the film surface to be contacted by the user's skin and correspondingly to alleviate said undesirable sticky feeling, on one hand, and to alleviate a surface gloss peculiar to plastic and thereby to improve the aesthetic appearance of the sanitary articles, on the other hand.

The formation of a woven fabric-like pattern on the surface of a plastic film can be achieved in a relatively simplified process, for example, by vacuum molding with use of a wire gauze as a mold. However, the formation of a nonwoven fabric-like pattern on the film surface can require an unacceptable amount of labor and cost to make a mold, since irregularities corresponding to individual fibers should be formed on the surface of the metal mold by means of engraving or etching.

Accordingly, it is a principal object of the invention to solve the problems of the prior art as has been mentioned above by molding a plastic film utilizing a metal fiber surfaced mold.

The object set forth above is achieved, in accordance with a first aspect of the invention, by a method of forming a surface of a thermoplastic film with a nonwoven fabric-like pattern defined by many individual metal fibers intertwined at random, said method comprising steps of: supplying a heat-softened thermoplastic film to a mold assembly including a nonwoven fabric-like layer composed of many individual metal fibers intertwined at random and being air-permeable in the direction of its thickness, an air-permeable layer serving to support said nonwoven fabric-like layer from the underside thereof, and a suction means adapted to exert a vacuum effect on the nonwoven fabric-like layer from the upper side to the underside thereof and forming the surface of said film with a pattern in conformity to a pattern on the upper side of the nonwoven fabric-like layer under said vacuum effect.

The object set forth above is achieved, in accordance with a second aspect of the invention, by said method comprising steps of: supplying a heat-softened thermoplastic film to a molding assembly including a nonwoven fabric-like layer composed of many individual metal fibers intertwined at random, a layer serving to

support said nonwoven fabric-like layer from the underside thereof, and a squeezing means provided face to face with the upper side of said nonwoven fabric-like layer and cooperating with said nonwoven fabric-like layer to squeeze said thermoplastic film therebetween, and forming the surface of said film with a pattern in conformity to a pattern on the upper side of the nonwoven fabric-like layer under the squeezing effect.

With the methods of molding the thermoplastic film according to these first and second aspects of the invention, the previously heat-softened film is conformed to the nonwoven fabric-like pattern defined by the metal fibers layer under the vacuum effect or the squeezing effect and thereby the surface of film is formed with a nonwoven fabric-like pattern. The molding assembly is easily made merely by fixing said nonwoven fabric-like metal fibers layer onto the supporting layer.

The invention will now be described in more detail by way of example, with reference to the accompanying drawings in which,

Fig. 1 is a schematic diagram illustrating a

method of forming a film with a nonwoven fabric-like pattern, in accordance with one embodiment of the invention;

Fig. 2 is a perspective view showing, as partially broken away, a rotatable drum; and

Fig. 3 is a schematic diagram illustrating another embodiment of the present invention.

Fig. 1 schematically illustrates a molding process employing a method of the invention. This process flows from the left hand to the right hand as viewed in the diagram and comprises a delivery roll 2, a rotatable molding drum 3, a take-up roll 4, and guide rolls 5 distributed at desired locations along a path of a thermoplastic film 1. The rotatable drum 3 includes an air-permeable peripheral wall 6 rotatably driven clockwise by a shaft 7 and a suction chamber 10 defined by a V-shaped partition within the rotatable drum 3 so that a section of the peripheral wall 6 corresponding to the suction chamber 10 is subjected to a vacuum effect exerted in the direction from the outside to the inner side of the peripheral wall 6 and the remainder section of the peripheral wall 6

extending in front and in rear of the suction chamber 10 is free from such a vacuum effect, i.e., left open to the atmosphere. Above the rotatable drum 3, there are provided an infrared heater 11 and a cooling fan 12 facing each other with the suction chamber 10 between.

During this molding process, the film 1 delivered from the delivery roll 2 is heat-softened by the infrared heater 11 as it travels along the peripheral wall 6 of the rotatable drum 3, then reaches the section of the peripheral wall 6 defined by the suction chamber 10, whereupon forced in close contact with the peripheral wall 6 under a vacuum effect and formed with a pattern in conformity to the surface pattern of the peripheral wall 6. Thereafter the pattern thus formed on the surface of the film 1 is fixed under blast from the cooling fan 12.

Fig. 2 is a perspective view showing, as partially broken away, nonwoven fabric-like metal fibers layer 21 and side plates 22 of the rotatable drum 3, details of which will be described later. In the rotatable drum 3, the air-permeable peripheral wall 6 comprises a perforated plate 20 and said nonwoven fabric-like metal fibers layer 21 covering the outer surface of said perforated plate 20. The drum 3 further includes a pair of side plates 22 fixed

to the perforated plate 20 at longitudinally opposite ends thereof and the shaft 7 fixed to these side plates 22. The shaft 7 partially constructed in the form of a double tube having its inner tube defined by a vacuum tube 25 which is connected at one end with the suction chamber 10 and connected at the other end with a vacuum pump (not shown). The nonwoven fabric-like metal fibers layer 21 is fixed by screws 26 to the perforated plate 20.

Metal fibers made of steel, stainless steel or any other metal intertwined at random so as to present an appearance like a nonwoven fabric sheet is generally referred to as nonwoven fabric-like metal fibers layer 21 and an example of such nonwoven fabric-like metal fibers layer is a card web or felt made of stainless steel staples or filaments manufactured by NIPPON SEISEN Co., Ltd. in Japan and commercially available under the trademark NASLON. It should be understood that said card web can be obtained by carding the metal fibers with various cards and said felt can be obtained by needle punching said web. Metal fibers suitable to be used with the invention should have a circular or substantially circular cross-section, an average fiber diameter of 10 to $400\mu\text{m}$ (10^{-6}m), preferably 30 to $200\mu\text{m}$, a fiber length of 15 to 200mm, preferably 50

to 150mm, a weight per unit area as the web or felt of 80 to 2,000g/m², preferably 150 to 1,000g/m², and a thickness as the web or felt of 3 to 10mm. Such conditions have empirically been proved to optimize the air-permeability in the direction of thickness of the web or felt so that the film 1 can be reliably molded in conformity to the surface of said web or felt covering the perforated plate 20 under the vacuum effect exerted from the interior of the rotatable drum 3. Advantageously, the damage of said web or felt due to repetitive molding is relatively insignificant. Thermoplastic fibers less than 50%, preferably less than 30% by weight, may be mixed and welded to metal fibers to prevent individual metal fibers once intertwined from getting loose and to improve the efficiency of needle punching to obtain the felt.

Fig. 3 is a schematic diagram illustrating a molding process different from the process of Fig. 1. As illustrated, the process comprises between the infrared heater 11 and the cooling fan 12 a squeezing roll 30 facing the rotatable drum 3 and adapted to be counterclockwise rotated. The squeeze roll 30 cooperates with the rotatable drum 3 to squeeze the heat-softened film 1 therebetween and thereby to form the surface of the film 1 with the pattern

defined by the nonwoven fabric-like metal fibers layer 21. The roll 30 may be an incompressible roll made of steel or a compressible roll made of heat-resisting rubber. The roll 30 may be used with the vacuum suction means of Fig. 1, if desired. It will be obviously understood that the process illustrated by Fig. 3 will be identical to the process of Fig. 1 except for the presence of the squeezing roll 30.

According to the invention, the nonwoven fabric-like metal fibers layer is fixed to a support member to make a mold and thereby the mold can be easily made at a low cost with respect to materials as well as labor.

CLAIMS

1. A method of forming a surface of a thermoplastic film with a nonwoven fabric-like pattern defined by many individual fibers intertwined at random, said method comprising steps of: applying a heat-softened thermoplastic film to a molding assembly including a nonwoven fabric-like layer comprising individual metal fibers intertwined at random and being air-permeable in the direction of its thickness, an air-permeable layer serving to support said nonwoven fabric-like layer from the underside thereof, and applying a suction means adapted to exert a vacuum effect on the nonwoven fabric-like layer from the upper side of the underside thereof and forming the surface of said film with a pattern in conformity to a pattern on the upper side of the nonwoven fabric-like layer under said vacuum effect.

2. A method of forming a surface of thermoplastic film with a nonwoven fabric-like pattern defined by many individual fibers intertwined at random, said method comprising steps of: applying a heat-softened thermoplastic film to a molding assembly including a nonwoven fabric-like layer comprising individual metal fibers intertwined at random, a layer serving to support

said nonwoven fabric-like layer from the underside thereof, and applying squeezing means face to face with the upper side of said nonwoven fabric-like layer and cooperating with said nonwoven fabric-like layer to squeeze said thermoplastic film therebetween, and forming the surface of said film with a pattern in conformity to a pattern on the upper side of the nonwoven fabric-like layer under the squeezing effect.

3. A method according to Claim 1 or 2, wherein thermoplastic fibers less than 50% by weight are mixed and welded to the metal fibers of said nonwoven fabric-like layer.

4. A method according to claim 1, 2 or 3, wherein the metal fibers have an average diameter of 10 to 400 μ m.

5. A method according to any preceding claim, wherein the metal fibers have a length of 15 to 200 μ m.

6. A method according to any preceding claim, wherein said nonwoven fabric-like layer has a weight per unit area of 80 to 2000g/m².

7. A method according to any preceding claim, wherein said nonwoven fabric-like layer has a thickness of 3 to 10mm.

8. A method according to any preceding claim, wherein said nonwoven fabric-like layer comprises a card web or felt made of metal staples or filaments.