

ELASTICALLY STRETCHABLE LAMINATED SHEET
AND PROCESS FOR MAKING THE SAME

This invention relates to an elastically stretchable laminated sheet having pleats.

Japanese Patent Gazette No. 1994-86712 discloses a process for making a composite elastic material having pleats. This process of prior art comprises steps of intermittently bonding stretched elastic web and pleat-formable web to each other and then allowing said elastic web to contract and thereby to form the composite elastic material. In this composite elastic material, said pleat-formable web is formed with a plurality of pleats as said elastic web contracts.

In the case of this composite elastic material of prior art, a height of said pleats varies depending on an amount by which said elastic material is stretched again in the same direction as the direction in which said elastic material has initially been stretched. Depending on particular applications of such composite elastic member, it is undesirable that the height of the pleats is reduced.

In view of the problem as has been described above, it is a principal object of this invention to provide an

elastically stretchable laminated sheet formed with pleats improved so that practically no change in the length of these pleats even when the sheet is stretched again.

This invention aiming to achieve the object set forth above has a first aspect relating to an article and a second aspect relating to a process for making this article.

The object set forth above is achieved, according to said first aspect of this invention, by an improvement in the elastically stretchable laminated sheet comprising a first fibrous layer formed by elastically stretchable fiber of thermoplastic elastomer and a second fibrous layer formed by non-stretchable thermoplastic synthetic fiber and bonded to at least one surface of said first fibrous layer.

The improvement according to said first aspect of this invention is characterized by that said first fibrous layer has a substantially uniform thickness and elastic stretchability at least in a first direction of this first direction and a second direction being orthogonal to each other; and said second fibrous layer has on said surface a plurality of high basis weight zones extending in parallel one to another in said second direction and a plurality of low basis weight zones defined between respective pairs of the adjacent high basis weight zones and extending in said

second direction, said high basis weight zones being thicker than said low basis weight zones, and is bonded intermittently in said first direction to said first fibrous layer so that said elastic stretchability of said first fibrous layer is lower in regions defined immediately below said high basis weight zones than in regions defined immediately below said low basis weight zones.

Said first aspect of this invention includes preferred embodiments as follow:

(1) Said first and second fibrous layers are bonded to each other by means of heat-sealing or adhesion so that a ratio per unit area at which said first fibrous layer and said high basis weight zones are bonded together is larger than a ratio per unit area at which said first fibrous layer and said low basis weight zones are bonded together.

(2) Said second fibrous layer undulates in said first direction with crests defined by said high basis weight zones and alternate troughs defined by said low basis weight zones.

(3) Said first fibrous layer has a basis weight of 10 ~ 200 g/m² and said second fibrous layer has a basis weight of 10 ~ 100 g/m² in said high basis weight zones and a basis weight of 1 ~ 10 g/m² in said low basis weight zones corresponding to 1 ~ 30 % of the basis weight in said high

basis weight zones.

(4) Said first and second fibrous layers are formed by continuous fibers.

The object set forth above is achieved, according to the second aspect of this invention, by an improvement in the process for continuously making a elastically stretchable laminated sheet comprising a first fibrous layer formed by elastically stretchable fiber of thermoplastic elastomer and a second fibrous layer formed by non-stretchable thermoplastic synthetic fiber and bonded to at least one surface of said first fibrous layer.

The improvement according to said second aspect of this invention is characterized by that: said first fibrous layer and said second fibrous layer are formed by a first spinning machine and a second spinning machine, respectively; said first spinning machine has a plurality of first nozzles arranged in a first direction extending transversely of said laminated sheet at a substantially regular pitch and said first fibrous layer having a substantially uniform thickness is continuously formed by first continuous fibers discharged from said first nozzles onto a belt travelling in a second direction orthogonal to said first direction; said second spinning machine has a plurality of second nozzles arranged

in said first direction and defining two or more nozzle arrays each consisting of at least three nozzles arranged at a substantially regular pitch and spaced one from another by a dimension larger than said pitch so that said second fibrous layer may be formed by second continuous fibers discharged from said second nozzles onto the surface of said first fibrous layer being relatively thick with a relatively high basis weight in regions immediately below said arrays of the second nozzles and a relatively thin with a relatively low basis weight in regions immediately below zones defined between respective pairs of the adjacent nozzle arrays; and said first and second fibrous layers are bonded to each other intermittently at least in said first direction of said first and second directions so that a ratio per unit area at which said first fibrous layer and said high basis weight zones are bonded together is larger than a ratio per unit area at which said first fibrous layer and said low basis weight zones are bonded together.

According to one preferred embodiment, said second nozzles defining said nozzle arrays are arranged at a pitch of 0.8 ~ 3.5 mm and each pair of the adjacent nozzle arrays are spaced from each other by a dimension of 10 ~ 50 mm.

Fig. 1 is a perspective view of a laminated sheet;

Fig. 2 is a perspective view of pants-type diaper;

Fig. 3 is a sectional view taken along a line III - III in Fig. 2;

Fig. 4 is a diagram schematically illustrating a process for making the laminated sheet; and

Fig. 5 is a diagram schematically illustrating an arrangement of nozzles as an extruder having these nozzles is viewed from below.

Details of an elastically stretchable laminated sheet 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 drawings.

A laminated sheet 1 shown by Fig. 1 in a perspective view comprises a base layer 2 and an outer layer 3 formed on an upper surface 2A of said base layer 2. The base layer 2 is elastically stretchable and formed by intertwining elastically stretchable component fibers 4 made of thermoplastic elastomer such as styrene elastomer. The component fibers 4 are preferably continuous fibers, more preferably continuous fibers having a diameter of 0.5 ~ 50 μm and preferably having a basis weight of 10 ~ 20 g/m^2 , more

preferably of $10 \sim 100 \text{ g/m}^2$. The component fibers 4 are intertwined in purely mechanical fashion or by means of heat-sealing or adhesion. Such base layer 2 has an elongation at break at least of 300 % in X-direction and/or Y-direction orthogonal to said X-direction and can restore its initial dimension after the base layer 2 has been stretched by 50 ~ 100 % at least in X-direction.

The outer layer 3 is formed by intertwining non-stretchable component fibers 6 of thermoplastic synthetic resin and said synthetic resin may be selected from a group including polyethylene, polypropylene, polyester, nylon and the like. The component fibers 6 are preferably continuous fibers, for example, polypropylene having a diameter of $0.5 \sim 50 \text{ }\mu\text{m}$. The outer layer 3 has a lower surface 10 and an upper surface 11 wherein said lower surface 10 is a substantially flat surface placed upon the upper surface 2A of the base layer 2 and said upper surface 11 presenting undulations formed by a plurality of crests 12 and a plurality of troughs 13 each extending between each pair of the adjacent crests 12 both extending in Y-direction. These crests 12 and troughs 13 are alternately arranged in X-direction. Each of the crests 12 defines a region having a basis weight of $10 \sim 100 \text{ g/m}^2$ and a width of 5 ~ 100 mm as measured in X-direction.

Each of the troughs 13 defines a region having a basis weight corresponding to 1 ~ 30 % of the basis weight of the crest 12 and less than 10 G/m² and a width of 5 ~ 40 mm as measured in X-direction. The crest 12 is thicker than the trough 13 and the basis weight gradually decreases from the crest 12 toward the trough 13. The lower surface 10 of the outer layer 3 is bonded to the upper surface 2A of the base layer 2 by means of adhesion, heat-sealing or intertwinement of the component fibers. It is important for this operation of bonding to adjust a ration of an area over which the base layer 2 is bonded to the crests 12 to an area over which the base layer 2 is bonded to the troughs 13 so as to establish a relationship as follows; a stretchability of the crests 12 and the zones of the base layer 2 immediately underlying the crests 12 is relatively small while a stretchability of the troughs 13 and the zones of the base layer 2 immediately underlying the troughs 13 is relatively large when the laminate sheet 1 is stretched in X-direction; preferably, said stretchability of the crests 12 and the zones of the base layer 2 is 1/3 of or less than the stretchability of the troughs 13 and the zones of the base layer 2 immediately underlying the troughs 13. For example, assumed that the base layer 2 and the outer layer 3 are bonded to each other at

regions 17 in which these two layers 2, 3 are subjected to a heat-embossing, the crests 12 will be formed with relatively many bond regions 17 so that an area over which the outer layer 3 is bonded to the base layer 2 immediately under the crests 12 is larger than an area over which the outer layer 3 is bonded to the base layer 2 immediately under the troughs 13. In other words, the bond regions 17 are relatively close one to another along the crests 12 while the bond regions 17 are relatively remote one from another along the troughs 13. While shapes of the bond regions 17 are not specified, it is desired to arrange these bond regions 17 intermittently at least in X-direction rather than in Y-direction so that the laminated sheet 1 can be smoothly stretched in X-direction.

With the laminated sheet 1 obtained in this manner, the outer layer 3 has its component fibers 6 reoriented in X-direction or stretched between each pair of the adjacent bond regions 17, 17 preferentially along the troughs 13 as the laminated sheet 1 is stretched in X-direction. At the same time, the zones of the base layer 2 immediately underlying the troughs 13 are elastically stretched. Along the crests 12 of the outer layer 3 and the zones of the base layer 2 immediately underlying the crests 12, movement of their component fibers 4, 6 is restricted by the bond regions

17 which are adjacent one to another and therefore practically no change occurs in the height of the crests 12 as measured from the troughs 13 even when the laminated sheet 1 is stretched in X-direction. On the other hand, the stretchability of the laminated sheet 1 is limited by the non-stretchable crests 12 as the laminated sheet 1 is stretched in Y-direction.

Fig. 2 is a perspective view of a disposable pants-type diaper 21 using the belt-like laminated sheet 1 as a waist-hole elastic member and Fig. 3 is a sectional view taken along a line III - III in Fig. 2. The laminated sheet 1 is bonded to the inner surface of the diaper 21, more specifically to the inner surface of a sheet 22 in front and rear trunk regions of the diaper 21 so that the outer layer 3 is placed against a diaper wearer's skin. The crests 12 and the troughs 13 of the laminated sheet 1 extend vertically of the diaper 21 and the troughs 13 function as ventilation channels connecting the inside and the outside of the diaper 21 put on the wearer's body. Such diaper can be stretched circumferentially of the wearer's trunk without any significant collapse of said ventilation channels and any significant change in the depth of the channels. In this way, this diaper 21 ensures a predetermined breathability

regardless of the waist size of the diaper's wearer.

Fig. 4 is a schematic diagram exemplarily illustrating a process for making the laminated sheet 1. A production line according to this process comprises a first spinning machine 41, a second spinning machine 42, an embossing machine 43 and a take-up roller 44 arranged in this order as viewed from left to right. Below said first and second spinning machines 41, 42, an endless conveyor belt 46 clockwise travels. First and second vacuum suction devices 47, 48 immediately underlie said first and second spinning machines 41, 42, respectively, with said belt 46 therebetween.

The first spinning machine 41 has a plurality of nozzles 51 arranged at a substantially regular pitch transversely of the belt 46, each being adapted to discharge continuous fiber 52 of thermoplastic elastomer toward the belt 46. The nozzle 51 is operatively associated with hot blast nozzles 53 provided on both sides of the nozzle 51, respectively, so that the continuous fiber 52 can be stretched under the effect of the hot blast blown off downward from said hot blast nozzles 53 and accumulated on the belt 46 so as to form the base layer 2 of the laminated sheet 1.

The second spinning machine 42 basically comprises an extruder 42A and a sucker 42B. The extruder 42A has a

plurality of nozzles 54 arranged transversely of the belt 46, each being adapted to discharge a non-stretchable continuous fiber 57 of thermoplastic synthetic resin. The nozzle 54 is operatively associated with hot blast nozzles 58 provided on both sides of the nozzle 54, respectively, so that the continuous fiber 57 may be kept hot and guided into the sucker 42B under the effect of the hot blast blown off from said nozzles 58. Within the sucker 42B, blow-off nozzles 59 blow compressed air at the normal temperature downward so that the continuous fiber 57 may be quenched and guided by this compressed air at the normal temperature toward the base layer 2 lying on the belt 46 so as to form the outer layer 3 of the laminated sheet 1. The continuous fiber 57 is stretched as it travels between the extruder 42A and the sucker 42B.

Fig. 5 is a diagram schematically illustrating the manner in which said plurality of nozzles 54 are arranged in the extruder 42A as said extruder 42A is viewed from below. The extruder 42A of the second spinning machine 42 has two or more nozzle arrays 61 each consisting of at least three nozzles 54 arranged at a substantially regular pitch of 0.8 ~ 3.5 mm transversely of the belt 46. Each of the nozzle arrays 61 has a dimension of 5 ~ 200 mm as measured transversely of the belt 46 and each pair of the adjacent nozzle arrays 61,

61 are spaced from each other by 2 ~ 50 mm. An amount of the continuous fibers 57 discharged from the nozzles 54 of the second spinning machine 42 arranged as has been described above and accumulated on the base layer 2 is relatively large immediately below the nozzle arrays 61 and relatively small immediately below the zones defined between respective pairs of the adjacent nozzle arrays 61, 61. As viewed transversely of the belt 46, the crests 12 as seen in Fig. 1 are formed immediately below the nozzle arrays 61 and the troughs 13 are formed immediately below the zones defined between respective pairs of the nozzle arrays 61, 61.

Referring again to Fig. 4, the embossing machine 43 comprises a first roll 43A having a plurality of embossing projections 45 on its peripheral surface and a second roll 43B having a smooth peripheral surface so that the projections 44 on the first roll 43A heated at a desired temperature may be pressed against the upper surface of the outer layer 3 to form the bond regions 17 as seen in Fig. 1. The projections 44 are intermittently arranged transversely of the belt 46. On the laminated sheet 1, the projections 45 are formed so that the number thereof per unit area, in other words, a total area of the bond regions 17 is larger in the crests 12 than in the troughs 13 and more preferably the number of the

projections 45 in the crests 12 is at least 1.3 times the number of the projections 45 in the troughs 13. On the laminated sheet 1, it is also possible to form said projections 45 so that a total area, rather than the number, of the bond regions 17 in the crests 12 is at least 1.3 times a total area of the bond regions 17 in the troughs 13. The laminated sheet 1 formed in this manner is taken up on the take-up roll 44.

It is possible without departing the scope of this invention to bond the base layer 2 and the outer layer 3 by means other than the embossing, for example, needle punching or high pressure water jet injection. While the outer layer 3 is illustrated to be formed only on the upper surface 2A of the base layer 2, it is also possible to form the outer layer 3 only on the lower surface 2B (See Fig. 1) or to form the outer layers 3, 3 on both surfaces 2A, 2B. In the latter case in which the outer layers 3, 3 are formed on both surfaces 2A, 2B of the base layer 2, the crests 12, 12 and the troughs 13, 13 are arranged on both surfaces 2A, 2B back to back, respectively.

In the laminated sheet according to this invention, the outer layer made of non-stretchable fibers is bonded to any one of the upper and lower surfaces of the base layer made

of elastically stretchable fibers. In the outer layer, the crests and the troughs are alternately arranged to extend in one direction in parallel one to another and the area over which the crests and the base layer are bonded together is larger than the area over which the troughs and the base layer are bonded together. This unique construction allows the crests to restrict the stretchability of the base layer without any change in the height of the crests themselves as the laminated sheet is stretched in the direction orthogonal to said one direction.

WHAT IS CLAIMED IS:

1. An elastically stretchable laminated sheet (1) comprising a first fibrous layer (2) formed by elastically stretchable fiber (4) of thermoplastic elastomer and a second fibrous layer (3) formed by non-stretchable thermoplastic synthetic fiber (6) and bonded to at least one surface (2A) of said first fibrous layer (2), said elastically stretchable laminated sheet (1) being characterized by that:

said first fibrous layer (2) has a substantially uniform thickness and elastic stretchability at least in a first direction of this first direction (X) and a second direction (Y) being orthogonal to each other; and

said second fibrous layer (3) has on said surface (2A) a plurality of high basis weight zones extending in parallel one to another in said second direction (Y) and a plurality of low basis weight zones defined between respective pairs of the adjacent high basis weight zones and extending in said second direction (Y), said high basis weight zones being thicker than said low basis weight zones, and is bonded intermittently in said first direction (X) to said first fibrous layer (2) so that said elastic stretchability of said first fibrous layer (2) is lower in regions defined immediately below said high basis

weight zones than in regions defined immediately below said low basis weight zones.

2. The laminated sheet (1) according to Claim 1, wherein said first and second fibrous layers (2), (3) are bonded to each other by means of heat-sealing or adhesion so that a ratio per unit area at which said first fibrous layer (2) and said high basis weight zones are bonded together is larger than a ratio per unit area at which said first fibrous layer (2) and said low basis weight zones are bonded together.

3. The laminated sheet (1) according to Claim 1 or 2, wherein said second fibrous layer (3) undulates in said first direction (X) with crests (12) defined by said high basis weight zones and alternate troughs (13) defined by said low basis weight zones.

4. The laminated sheet (1) according to any one of Claims 1 ~ 3, wherein said first fibrous layer (2) has a basis weight of 10 ~ 200 g/m² and said second fibrous layer (3) has a basis weight of 10 ~ 100 g/m² in said high basis weight zones and a basis weight of 1 ~ 10 g/m² in said low basis weight zones corresponding to 1 ~ 30 % of the basis weight in said high basis

weight zones.

5. The laminated sheet (1) according to any one of Claims 1 ~ 4, wherein said first and second fibrous layers (2), (3) are formed by continuous fibers.

6. A process for continuously making a elastically stretchable laminated sheet (1) comprising a first fibrous layer (2) formed by elastically stretchable fiber (4) of thermoplastic elastomer and a second fibrous layer (3) formed by non-stretchable thermoplastic synthetic fiber (6) and bonded to at least one surface (2A) of said first fibrous layer (2), said process being characterized by that:

said first fibrous layer (2) and said second fibrous layer (3) are formed by a first spinning machine (41) and a second spinning machine (42), respectively;

said first spinning machine (41) has a plurality of first nozzles (51) arranged in a first direction extending transversely of said laminated sheet (1) at a substantially regular pitch and said first fibrous layer (2) having a substantially uniform thickness is continuously formed by first continuous fibers (52) discharged from said first nozzles (51) onto a belt (46) travelling in a second direction

orthogonal to said first direction;

said second spinning machine (42) has a plurality of second nozzles (54) arranged in said first direction and defining two or more nozzle arrays each consisting of at least three nozzles arranged at a substantially regular pitch and spaced one from another by a dimension larger than said pitch so that said second fibrous layer (3) may be formed by second continuous fibers (57) discharged from said second nozzles (54) onto the surface of said first fibrous layer (2) being relatively thick with a relatively high basis weight in regions immediately below said arrays of the second nozzles (54) and a relatively thin with a relatively low basis weight in regions immediately below zones defined between respective pairs of the adjacent nozzle arrays; and

said first and second fibrous layers (2), (3) are bonded to each other intermittently at least in said first direction of said first and second directions so that a ratio per unit area at which said first fibrous layer (2) and said high basis weight zones are bonded together is larger than a ratio per unit area at which said first fibrous layer (2) and said low basis weight zones are bonded together.

7. The process according to Claim 6, wherein said second

nozzles (54) defining said nozzle arrays are arranged at a pitch of 0.8 ~ 3.5 mm and each pair of the adjacent nozzle arrays are spaced from each other by a dimension of 10 ~ 50 mm.