Nov. 5, 1974 MASAHIDE YAZAWA 3,846,205

METHOD FOR PRODUCING LAMINATED MATERIALS OF FIBERS

Filed Oct. 9, 1970

FIG. 1A.

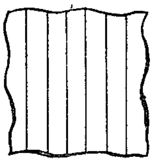


FIG. 1B.

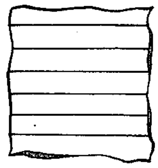


FIG. 1C.

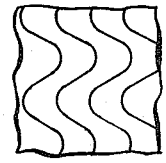


FIG. 1D.

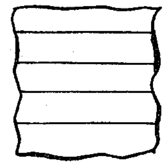


FIG. 1E.

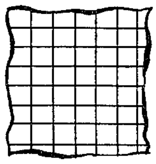


FIG. 1F.

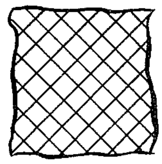


FIG. 1G.

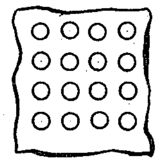


FIG. 2.

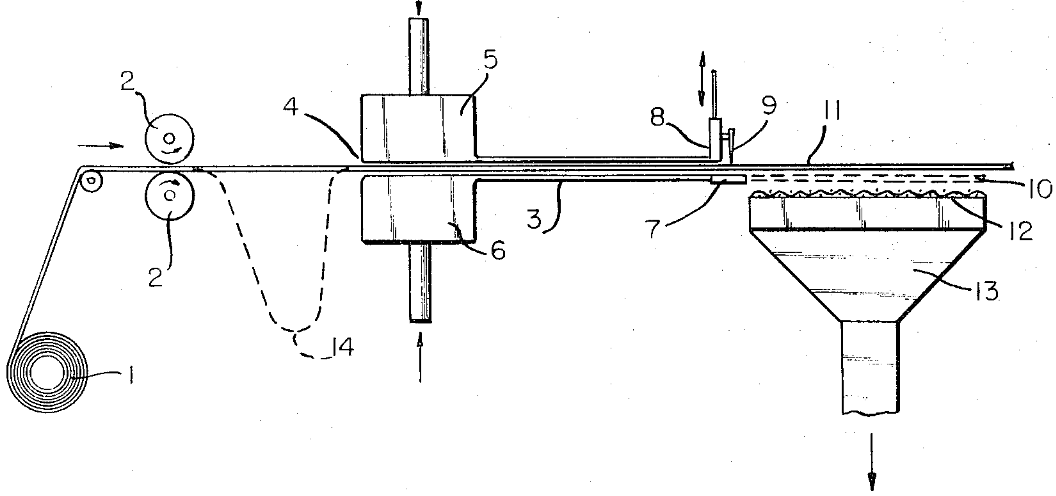
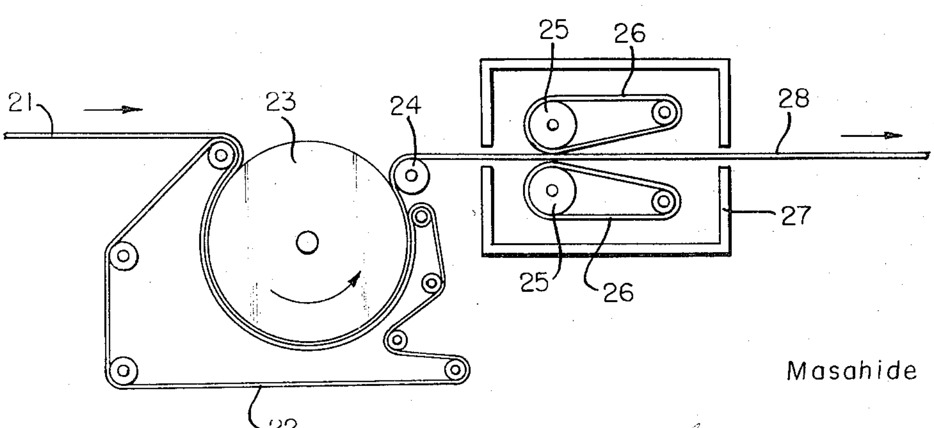


FIG. 3.



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3,846,205

METHOD FOR PRODUCING LAMINATED MATERIALS OF FIBERS

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Continuation-in-part of abandoned application Ser. No. 686,938, Nov. 30, 1967. This application Oct. 9, 1970, Ser. No. 79,707
Claims priority, application Japan, June 5, 1967, 42/35,819
Int. Cl. B32b 7/14
U.S. Cl. 156—291 14 Claims

ABSTRACT OF THE DISCLOSURE

A method for producing a flexible, gas-permeable non-woven material of web of split fibers and laminates thereof, in which fibers of a spread web of split fibers are fixed in parallel or in crossed arrangement without substantial slacking with a relatively small amount of a shaped binder having a lower softening temperature than the heat-resisting temperature of the web, by means of pressure-adhering on heating at a temperature lower than the heat-resisting temperature of the web but within the softening temperature range of the adhesive binder, in a manner so as to leave loosely fixed or unfixed parts amid firmly fixed fiber parts, and different from that in the conventional non-woven fabric manufacture, during the travelling step of the said web.

This application is a continuation-in-part of applicant's copending application, Ser. No. 686,938, filed Nov. 30, 1967, and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a method for producing a non-woven material whose spread fiber distribution is partially fixed with an adhesive binder forming a pattern, and lamination thereof.

It is known that when the film of a fiber-forming polymer is stretched uniaxially by several or ten-odd times on heating, it becomes easy to subdivide into fibers of network structure which lies parallel to its stretched direction, and substantially endless continuous split-fibers having a network structure of interconnected fibers, the thickness of which is generally from ten to several ten deniers, can be obtained by incompletely subdividing it along the lengthwise direction thereof into a web of interconnecting fibers, for instance, by cutting it with a tap-shaped cutter or by splitting it with a brush-shaped cutter, or by slide-rubbing it under a tension on a revolving file. As one of the applications of split-fiber obtained from a narrow tape, it is woven or knitted after only being twisted by similar methods to those of conventional filament yarns or spun yarns.

Noticing that the split-fiber from such a stretched film can be obtained in the form of a flat web of interconnected fibers which can be spread to a wider desired width than that of the original stretched film, the present inventor perceived that if several webs of split fibers are piled, while they are spread and elongated without substantial slacking, to a suitable thickness and their fiber distribution is fixed with an adhesive binder, products, especially suitable for packaging and having strength higher than those obtained by the use of conventional thermoplastic cut fibers, can be obtained at a low cost. Probably due to the fact that the split fibers are so difficult for handling, there has not been known even a single prior art in which the manufacture of non-woven materials from the split fibers is disclosed. In this connection, a U.S. patent application entitled, "Method for Producing Plastic Materials Reinforced With Split Fibers," was filed by the inventor on Nov. 11, 1967 as U.S. Patent Application No. 682,598, now abandoned.

The said invention, however, relates mainly to a method for producing reinforced film incorporated with split-fiber and its application, in which when incorporated split-fiber is rather smaller in quantity than that of film as an adhesive binder, the product is generally of higher practical value. The reason is that if the adhesive binder is so amply supplied in a state of a film on one surface of the split-fiber web that it covers almost all over the surfaces of fibers of the spread split-fiber uniformly, but if the fibrous layer is thick, fibers on one side which the film is in contact, are fixed well to each other with ample supply of the adhesive binder there, whereas fibers nearer to the other side are less permeated with the adhesive binder, leading to incomplete adhesion there and as a result, fibers on this side tend to become fluffy, hence a product without fluff cannot be obtained unless the quantity of the film as the adhesive binder is increased. The tenacity of a fibrous laminate increases with the increasing quantity of incorporated split-fiber and so, if the film laminate, incorporated with split-fiber of the said invention, is used for making heavy duty bags, which require high tenacity, the quantity or thickness of film to be applied must be increased to such an extent as to lose pliability of the product and so it becomes unsuitable for practical application.

It is an object of the present invention to provide a method for producing non-woven materials of split-fiber or laminates thereof in which fibers of spread split-fiber are fixed in parallel or in crossed arrangement by using relatively small amount of adhesive binder in a manner so as to leave loosely gathered fiber parts amid firmly fixed fiber parts, and different from that in the conventional non-woven fabric manufacture.

It is another object of the present invention to provide laminates of webs of spread split-fiber having high gas permeability and flexibility due to the existence of non-adhered parts.

It is a further object of the present invention to provide a method for producing a laminated product composed of a web of spread split-fiber fixed partially as above-mentioned as a principal substrate and films, paper sheets or metal foils laminated on its surface which is useful as heavy-duty packaging materials having reduced gas permeability, and in which flexibility is still retained.

It is still a further object of the present invention to provide a method for enhancing flexibility, gas permeability, slip-prevention, or as-if-woven appearance of the laminate by embossing.

It is still a further object of the present invention to provide a method for constructing laminates of warp and weft webs (cross-lamination) efficiently in commercial operation.

These objects and other advantages can be attained by the method of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the forms of filaments, bristles or tapes of a polymer applied as an adhesive binder, being piled on before or after pressure-adhering to a web of split-fiber or its laminate in longitudinal, lateral or slanting stripes 1A; being in longitudinal stripes, 1B in lateral stripes, 1C in wavy stripes, 1D in a ladder pattern, 1E in a lattice or checker pattern, 1F in a network pattern, and 1G in a perforated film.

FIG. 2 is a schematic drawing showing one feature of the present invention in which warp and weft fiber layers are crossed. The prefixed web of split-fiber is used as a weft, that is, in the course of travelling the warp fed from a roll under a tension, the weft fed from another roll is blown out over the warp at regular intervals by the same length as the width of it through a duct by a rapid current of fluid, in such a way that the warp and the weft cross at right or oblique angle to each other, then the blowing of fluid is stopped, the blown out weft is cut and deposited upon the warp by the guidance of suction from a suction box installed under the travelling warp web. In this case an additional adhesive binder may be placed upon said warp before the weft is blown out. Piled warp and weft are fixed with an adhesive binder according to the second feature of the present invention to construct the cross arrangement of warp and weft webs.

FIG. 3 shows the process where split-fiber webs on which an adhesive binder is distributed are subjected to pressure-adhering and, further, given a pattern of network, texture of concave and convex figures on the surface of the product obtained above by embossing with metal net belts, fabric belts or rollers having an uneven surface, after the said fiber webs are preheated on a heated drum insulated with a backing canvas.

DESCRIPTION OF THE INVENTION

As afore-mentioned in the section of "background of the invention," in the specification of the present invention, the term "split fiber" does not mean short-web, substantially endless, consisting of interconnected fibers, showing a network structure on spreading widthwise, each of which fibers lies in parallel with the longitudinal direction of the web, is arranged side by side in a single layer, and has generally a tenacity of from two to seven grams per denier and a thickness of from ten to several tens deniers and obtained by incompletely subdividing a uniaxially stretched (oriented) film of a fiber forming organic polymeric material along the longitudinal direction of the web into interconnecting fibers, for instance, by cutting it with a tap-shaped cutter, by splitting it with a brush shaped cutter, or by slide-rubbing it under a tension on a revolving file.

A non-woven material consisting of one or more webs of split-fiber, elongated length-wise without slacking, each web of which has been spread to a definite width wider than its original width, is piled one upon another to give a definite thickness, is hereinunder referred shortly as a "warped fiber."

According to the first feature of the present invention, during the process where at least one web of split-fiber is travelling under a tension in the form of warp of a given width and a given thickness ("warped fiber"), filaments, bristles, tapes or as powder of an adhesive binder polymer, having a lower softening temperature than the heat resisting temperature of said fiber, are distributed on the warped fiber in longitudinal, lateral, or slanting stripes, as shown in FIG. 1, for example, (a) in longitudinal stripes, (b) in lateral stripes, (c) in wavy stripes, (d) in a ladder pattern, and (e) in a lattice pattern, or the shaped product of the adhesive binder polymer in a network form or in the state of a perforated film (hereinafter referred as "shaped adhesive binder" for simplicity) is piled on said warped fiber, and tapes of the adhesive binder are usually laid on their salvages to fix them, and then the whole is subjected to pressure-adhering to form into a web of non-woven material at a temperature lower than the heat resisting temperature of the fiber but within the range of the softening temperature of the adhesive binder polymer to fix preliminarily the fiber distribution.

In the case of a thermoplastic fiber, however, warped fiber easy to handle in a subsequent processing step can be obtained by only pressure-adhering at a temperature in the softening range and lower than the heat resisting temperature of the fiber without using an adhesive binder so as to temporarily attain fixing of the fiber arrangement, and it is usually more convenient to wind up the product thus obtained on a beam, as it is, because no fluffing or no confusion of fibers takes place on unwinding or rewinding it in a subsequent processing step. This preparatory procedure is one of the features of the present invention.

According to the second feature of the present invention, two or more webs of the warped fibers, for non-woven material obtained by the above-mentioned method, are piled to a desired thickness in such a manner that the fibers of each web are parallel to those of others, or if necessary shaped adhesive binder in inserted additionally into the boundary surfaces of each web in the above-mentioned way, and the distribution of the fibers of the webs is fixed by pressure-adhesion on heating at a temperature lower than the heat-resisting temperature of the fibers but within the softening temperature range of the adhesive binder polymer or in another case a temporarily fixed preparatory product for the subsequent step, is prepared by pressure-adhering only the fibers on heating at their softening point without using adhesive binder.

This laminate of webs of the non-woven material affords a useful material for strong flexible strings, bands, or tapes when slitted along the main fiber axis so as to give desired width.

It is necessary, however, to apply an additional adhesive binder before pressure adhesion according to the second feature to attain the firmer fixing between fibers or between webs at places where the shaped adhesive binder is located, when the adhesive binder has not been used at all, the amount of the binder is too small, or the applied binder is very thin and scarce in the step of web preparation where the binder is used only for the purpose of fixing the fiber distribution, according to the first feature of the invention.

According to the third feature of the present invention, the webs of warped fibers, or sheet-like material, obtained by the above-mentioned method, or their laminates are piled up in such a combination of weft and warp that their fibers cross each other perpendicularly or obliquely, and if necessary, with an additional shaped adhesive binder being distributed on the boundary or upper and lower surfaces of them as in the method of the first feature, and the whole is subjected to pressure-adhering integrally on heating at a temperature lower than the heat resisting temperature of the fibers so that only the parts of fibers which are fully impregnated with a softened shaped adhesive binder are firmly fixed, thereby producing a laminate, having parts consisting of loosely gathered fibers encircled by edges of firmly fixed parts with a shaped adhesive binder, and containing a larger quantity of fibers relative to the total laminate, which is strong and pliable for its thickness. The reason is that parts of fibers temporarily fixed by pressure-adhering on heating without an adhesive binder are weak in adhesion and they are detached easily by bending or rubbing, but only the parts firmly fixed with the adhesive binder remain stable. The laminated product obtained by the method of the present invention which contains 80–120 g./m.^{2} of fibers and 20–40 g./m.^{2} of the adhesive binder polymer in the state of a lattice or network which effects firm adhesion at the places where the binder polymer is located, has sufficient gas permeability for rice or barley bags, having sufficient tenacity for them and can take the place of the fabric of 170–200 g./m.^{2} made of the same kind of stretched tapes or the fabric of 500–600 g./m.^{2} made of jute.

According to the fourth feature, in the above-mentioned method for producing a laminated product composed of weft and warp fibers, during the process where the web of warped fiber or non-woven material described in the first feature is travelling under a tension as a warp with a certain width, another web of non-woven material, or its laminate described in the second feature is blown out, as a weft, at regular intervals by the length corresponding to the width of the warp through a flat duct, then the blowing thereof is stopped, and it is cut and then laid directly or indirectly on the travelling web of warp.

The fiber distribution of web of weft used in the present invention, which is fixed by the methods of the first and the second features, is not disturbed even when the web of weft is cut by a length necessary as a weft by a suitable method in spite of inconvenience of split-fiber for handling because of its limpness and non-stiffness and structure which allows air to pass through easily. If the web of weft used in the present invention is guided by the current of a fluid with an apparatus shown in FIG. 2 by the method of the fourth feature, it can be fed at regular intervals only by the length corresponding to the width of the warp web without disturbing its fibers and laid on the web of warp after it is cut. That is, in FIG. 2, a web of warp **1**, wound up with their distribution fixed by the methods of the first and the second features, is delivered to a pinch roller **2** at a fixed velocity and introduced into a flat duct **3** via a slit **4** and compressed air of several tenth atmosphere gauge is supplied to the duct at the upper and lower parts of its head, **5** and **6**, so that the web in the duct is blown horizontally out of the end of a duct, **7**, into the atmosphere. Immediately after it is blown out by the length which corresponds to the width of the warp web **10** measured along the direction of blowing of the fluid, the opening at the end of the duct is shut with a valve **8** to stop the blow of the fluid and the web simultaneously and at the same time the web is cut along the edge of the warp web **10** with a cutting knife or a melt cutter **9** as a web of weft, while the blown web of weft is going down in a substantially elongated state by gravitation. In this figure, the travelling web of warp **10**, is made to move perpendicularly to the surface of paper and just below the blown web of weft and a suction box **13** with a perforated plate or a screen **12** is installed below **10**. The internal pressure of the suction box **13** is reduced, and then the cut web of weft fibers is sucked right down and placed on the travelling web of warp. Immediately after the placed web of weft is carried away by its width in the direction of the warp, perpendicular to the paper surface, the end of the duct is opened again to blow air and then the web of weft, **14**, which is fed continuously with a pinch roller **2** and accumulated before the entrance of the duct, while the blow is suspended, is sucked into the duct and blown toward the outlet, and then the web of weft accumulated between the pinch roller and the entrance of the duct advances, leaving a portion of the web subjected to a tension and straightened. At this moment, the outlet of the duct is shut to stop the blow of compressed air and the web, and the web of weft fibers is cut as stated before. By repeating this operation, a weft and a warp can be combined with each other to form their laminate (cross-lamination). The above-mentioned method is for combining them directly. However, they can be combined indirectly by another method in which the web of weft, blown out from the flat duct and cut by a length equal to the web is made to stick electrostatically to a metal plate or a rake-shaped arm and then transferred from it at regular intervals onto the warp travelling with charge of opposite electricity. If it is necessary to add an adhesive binder, a shaped adhesive binder can be laid between webs of weft and warp.

This method of piling webs of weft and warp by blowing is advantageous in not disturbing the distribution of fibers because it is already fixed by the methods of the first and the second features, even if the flow of the fluid applied is considerably turbulent. The method of FIG. 2 is adopted for combining a weft and a warp which

are prearranged independently by the use of warping machine, respectively without using any binder in place of what are prepared according to the first and the second feature of this invention and thus combined weft and warp fibers are subjected to pressure-adhering on heating with an adhesive binder in the form of a shaped product e.g. net or strip form. Such a method is also included in the scope of the present invention.

According to the fifth feature of the present invention, as an adhesive binder in the methods of the first, second and third features, the shaped products of an optional adhesive binder polymer having a lower softening temperature than heat resisting temperature of the fibers can be used. However, among them particularly those of an adhesive binder which is a polymer of the same kind or is selected from the group consisting of copolymers containing the same constituent monomer as that of the polymer of the fibers (hereinunder shortly referred as "a polymer of the same kind or group as that of the split fiber") but has a softening temperature lower than the heat resisting temperature of the split-fiber because of non-oriented state of molecules or being a copolymer, can be used to attain greater inter-fiber adhesion by utilizing the strong affinity of the binder to fibers.

The heat resisting temperature of high density polyethylene filament or split-fiber, for example, is 125–127° C. but the tape-like shaped product of low density polyethylene is softened completely at 110–115° C. and can adhere to polyethylene split-fiber firmly by way of welding as the result of which a very strong laminated product can be obtained. This fact has been confirmed experimentally.

The heat resisting temperature of the split-fiber obtained from stretched polypropylene film is about 150° C. When non-stretched film thereof containing much of amorphous ingredient and thus having a lower softening temperature was used as an adhesive binder for said split-fiber, a very strong laminated product was obtained by pressure-adhering on heating at 140–145° C.

As it is shown in Example 1 hereinafter, when the web of split-fibers of polypropylene was subjected to pressure-adhering on heating at 115–130° C. using high pressure polyethylene film as an adhesive binder, the resultant product does not appear to be different from the above, but when it was placed under load for testing its strength, the fibers were separated easily from the film, and the strength of the resultant laminated product was almost equal to that of the split-fiber incorporated, showing a small increase only by the sizing effect of the adhesive binder used. On the other hand, when polypropylene film containing much of amorphous polypropylene was used as an adhesive binder for pressure-adhering on heating at 140–145° C., the fibers and the film adhered so firmly to each other that the fibers were not separated from the film until the product was broken, and further it was very tenacious.

In general the tenacity of ordinary split fibers prepared from a stretched film is reduced with the increase of the number of split single fibers, because load is not dispersed evenly on each single fiber and therefore only by propert twisting strength of the split-fiber approaches to that of the original stretched film, but the fibers fixed together by way of welding with the film of a polymer of the same group are nearly equal in strength to the stretched film before splitting, even if not twisted and their adhesion does not collapse until the fibers are broken under load, so a very strong laminated product can be obtained from them. This fact has been confirmed by experiment.

Example 1

In this example, the product obtained using the shaped products of an adhesive binder made from the polymer of the same kind or group as that of the split-fiber used was compared in strength with that obtained using an adhesive binder made from a different kind of polymer.

TABLE 1

Polymer	Stretched tape as the raw material: Tenacity (g./d.)	Stretched tape as the raw material: Elongation, percent	After subdivided and not twisted: Tenacity (g./d.)	After subdivided and not twisted: Elongation percent
Polyethylene (P.E.)	4.5	17	2.4	28
Polypropylene (P.P.)	3.8	20	2.2	12

Each web of the above-mentioned two kinds of split-fiber, spread into warped fiber of 7 g./m.^{2}, was subjected to pressure-adhering together with film of a low softening temperature having a weight of 18 g./m.^{2} as an adhesive binder and the respective resultant products were piled on each other as a weft and a warp, and then the whole was subjected to pressure-adhering again on heating to produce three laminated products of different combination. Each of the final product, containing 36 g./m.^{2} of film and 14 g./m.^{2} of fiber, i.e., 28% of fiber, was used as a specimen. The result of testing in its tenacity and elongation was as shown in Table 2.

In Table 2, the tenactiy was calculated as mean values of those obtained by dividing the strength (measured with a Schopper-type tester) of pieces of the product cut in 50 mm. width, only with the total deniers of split-fiber contained in the loaded direction of each piece, weft or warp direction separately. The tenacity of film of P.E. or P.P., used was about 0.8 g./d.

TABLE. 2

Combination of split fibers	Adhering temperature (° C.)	Tenacity (g./d.)		Elongation, percent		Increasing rate of tenacity,* percent (Warp + Weft) ÷ 2
		Warp	Weft	Warp	Weft	
P.E. film and P.P. split-fiber	110	3.8	3.8	13	13	73
P.E. film and P.E. split-fiber	115	8.0	7.7	17	16	230
P.P. film and P.P. split-fiber	145	7.3	7.8	29	28	240

*Increasing rate of tenacity, percent=

$$\frac{\text{Tenacity of product} - \text{Tenacity of S.F. not twisted}}{\text{Tenacity of S.F. not twisted}} \times 100$$

wherein: S.F. means split-fiber. Tenacity is expressed in g./d.

As evident in Tables 1 and 2, it is seen that when adhesion between film and split-fiber is great because of the same kind of polymer, the tenacity of the product is so large as that of stretched tape before subdividing, owing to the strong effect of adhesion on non-twisted split-fiber, plus the combined effect of tenacity of the film, but when P.E. film and P.P. split-fiber are combined, the tenacity of the product does not increase over the ordinary effect of sizing and adhesion is broken under a comparatively small load.

As evident in Tables 1 and 2, by using a polymer of the same kind or group as that of the split-fiber as an adhering binder, according to the present invention, it is possible to attain sufficiently strong adhesion even when a reduced quantity of an adhesive binder is used.

The production of a tenacious product by the use of a polymer of the same kind or group as that of the split-fiber is used for making a tenacious multipiled product. This is applied not only to the present invention but also attains a remarkable effect in the other inventions by the present inventor, U.S. Pat. No. 3,551,229 entitled, "Method for Producing the Non-woven Fabrics of Split Fibers," that is, the process for adhering of spread nets of split fiber deposited on a screen with an adhesive binder. The example of polyolefin has been described in the above and similarly, tenacious products can be obtained by such combinations as the film of the copolymer of 60% vinyl chloride and 40% acrylonitrile vs. the split-fiber of polyacrylonitrile (containing more than 85% of acrylonitrile), film of polyvinyl chloride vs. split-fiber of the copolymer of 60% vinyl chlo-

ride and 40% acrylonitrile, film of polyvinyl chloride unstretched, or externally or internally plasticized, vs. split-fiber of polyvinyl chloride, and film of lower softening point polyester vs. split-fiber of ordinary polyester.

For split-fiber of various polymers, films of the polymers of the same kinds or group suitable as an adhesive binder whose softening temperature are lower than the heat-resisting temperature of the respective split-fiber, can be found easily.

According to the sixth feature of the present invention, unoriented or oriented film, or metal foil is laid on the web of warped fiber, the non-woven material, or the multipiled product obtained by the methods of the first, second, third and fifth features and subjected to pressure-adhering on heating to produce pliable and water-proof laminates, and also paper is laid on and subjected to pressure-adhering on heating similarly to the above to attain printability, slip prevention and antistatic effect owing to the nature of paper surface. These products, though having thick fiber layers, are very pliable because laminated film, paper and metal foil are thin.

According to the seventh feature of the present invention, the multipiled products obtained by the methods of the first, second, third and sixth features, in the state of being heated at a temperature lower than the heat-resisting temperature of the split-fiber but within the range of the softening point of the adhesive binder polymer, and being clamped between screen belts or cloth belts, are passed between pressure rollers or embossing rollers so as to be pressure-adhered as above-mentioned under a high pressure, whereby they are impressed with a network or texture pattern or the uneven pattern of the embossing rollers, and products are obtained which appear as if they were woven, having a slip preventing effect by the impressed unevenness of their surface and being more pliable than before. When the products of the first, second and third features are embossed, gas permeable products having a very high practical and commercial value, can be obtained.

FIG. 3 shows the process wherein a web of the non-woven material of the first feature, the laminate of the non-woven material of the second feature or the multipiled product of the third feature travelling as a web **21** and if necessary, incorporated with additional shaped adhesive binder laid on said web or laminate, before pressure-adhered on heating, is passed between a hot surface of a heating drum **23** and a backing canvas **22** which covers the principal part of the heating surface of the drum or if necessary, moved in series over the surfaces of many heating drums of this kind, one by one, during which process it is heated at a temperature, lower than the heat resisting temperature of the split-fiber but within the range of the softening temperature of the adhesive binder polymer, then fixed integrally by pressure-adhering directly or indirectly through the backing canvas with a pressure roller **24** and if necessary, before cooled, is pressed again by passing through embossing rollers **25**, or metal net or cloth belts **26** in a heating chamber **27** so as to be impressed with a network or cloth texture pattern or the uneven pattern of the embossing rollers **25**. Thus the product **28** having an uneven pattern impressed on it can be obtained.

In alternative method, the pressure roller **24** is used only for preliminary pressure adhesion and pressure adhesion can be mainly effected by embossing or by another bank of heated powerful pressure rolls.

When a metal net belt is used, the surface of the embossing roller is preferably of rubber, when a cloth belt is used, it may be of metal, and when uneven pattern is given only with embossing rollers, metal rollers having uneven surfaces are used. On carrying out the embossing, at a lower pressure, heating must be effected at a higher temperature as close as possible to the heat resisting temperature of the split-fiber but at a higher pressure, heating is effected at a lower temperature. By this method, a network pattern is impressed not only on the parts containing the adhesive binder polymer but also the parts composed of fibers alone which are temporarily fixed together in the course of pressure-adhesion. As a result, the product is turned to have as-if-woven appearance, increased pliability over that before embossing and gas permeability. The parts composed of fibers alone, however, is liable to detach when bent or rubbed. The product becomes thus softer and more pliable but the parts firmly fixed with the binder will not be detached.

According to the eighth feature of the present invention, the multipiled product composed mainly of warp fiber, among the products obtained by the methods of the first, second, third, sixth and seventh feature, is cut longitudinally to produce strings, bands and tapes, which are very pliable and heat-sealable and scarcely break laterally in virtue of the adhesive binder or a small quantity of weft fiber mixed with them. The product, even if it contains a large quantity of warp fiber which dominates strength of the product, is very pliable because it has parts composed of fibers alone together with parts firmly jointed by pressure-adhering with an ahesive binder and moreover even if film is laminated on its surface, it is only on its surface, so harmful effect is not given to pliability. The parts composed of fibers jointed with an adhesive binder polymer prevent slipping when embossed with a network or texture pattern. It is an advantage of this method that thermoplastic film laminated on its surface gives a heat-sealing property and paper or metal foil laminated on its surface enhances the appearance and the commercial value and a combination effect of physical properties of the laminated component is brought about to the product.

An application of the product obtained in the present invention, will be explained. The products obtained by the methods of the first, second, and third features can be used as the core fibers of shaped products of cement, because a fluid mixed with cement can pass the laminated products easily when the adhesive binder for fixing the distribution of weft and warp fiber is placed with greater intervals. Especially they are effective in improving the impact resistance of such thin products of cement as slates or tiles. With regard to this feature, fibers of heat-treated polyvinyl alcohol, partially hydrolyzed acrylonitrile, polyvinyl chloride, and polyamides which are highly polar give better results than those of polyolefins and polyesters.

Several features of the present invention have been outlined in the above. Next they will be explaned in more detail as follows.

Firstly the terms used in the present patent application will be defined. The heat resisting temperature of fibers means the highest temperature at which the fibers maintained at a fixed length, are heated for a time, without accompaniment of reduction of strength or if any without accompaniment of such an extent of reduction of strength which may be harmful to their commercial value. The softening temperature of a fiber or a shaped product of an adhesive binder means the range of temperature in which a plastic deformation to an arbitrary shape occurs under its working perssure and time. The melting point is defined as the temperature at which the mutual transfer of the center of gravity of the molecules takes place freely among them during said deformation. Generally speaking, with the increase of molecular orientation, density increases and the softening temperature rises by several or ten-odd degree for some polymers. Needless to speak of, if a plasticizer is added to the product, its softening (melting) temperature falls.

As the shaped products of polymers usable for adhesive binders, there are illustrated those of the polymers of the same kinds or the polymers selected from the group consisting of copolymers containing the same constituent-monomer as the polymer of split-fiber used in the present invention, which has a high affinity to the fibers and lower softening temperature than the fiber, or those of the thermoplastic polymers which have —Cl, —COOH, —OAc, —$CONH_2$ or —OH radicals in their side chains and are highly adherent.

Illustrative fibers used in the present invention, include split-fiber prepared from stretched films of polyethylene, polypropylene, polyvinyl chloride, polyvinyl alcohol, polyacrylonitrile, polyvinylidene chloride, fluorine-containing polymers, nylon, polyesters, cellulose esters, and the copolymers of their groups. A wide web of split fiber can be obtained easily and at a low cost from wide stretched film and the split fibers obtained immediately after splitting can be easily and uniformly spread and each fiber of them is arranged regularly in a network, so if its fiber distribution is subjected to fixing with an adhesve binder by the method of the first feature continuously and wound on a beam, fluffing will not take place thereafter at unwinding or rewinding process. Accordingly, they can be used conveniently in constructing the laminate of weft and warp.

Further, in case of untwisted split fibers, they are stronger, when their single fibers are thicker in size and smaller in number, while they are weaker when the single fibers are finer in size and larger in number. However, if they are twisted suitably, their tenacity approaches that of the original stretched film. Thus it is believed that their molecular construction is not damaged substantially by the process of splitting. Then for the product of the present invention which are used for packaging, the denier of their single fibers should be larger than that of split fibers for clothing or upholstery uses because damage caused by fluffing in the final product is less. For making thicker single fibers, the teeth of the cutter and splitter or the thickness of the stretched film is controlled. For making interior or upholstery material, generally stretched film, 15–20 microns thick, is split into a web of fine fibers of 10–20 denier and for making rice or barley bags, the thickness of the stretched film is 30–50 microns and the denier of the single fiber is 30–100 denier. For making bags for packaging such powder as flour of some polymer, split fibers having single fibers of as fine as 10–20 denier are used.

The tubular film of high density polyethylene was collapsed flat and cut at its selvages to make 2 pieces of film, 200 mm. wide and 160 microns thick (±10% tolerance in thickness) both of which were wound at the same time on a bobbin. Five of such a bobbin were arranged in parallel, each two pieces of such films laid one over another were passed, without being touched each other, through boiling water so as to stretch by 6 times and then all of the films are arranged in parallel side by side and while they were moving on rollers, one by one in series, installed in an oven heated at 115–120° C., they were stretched by 10 times the original length in total and while they were travelling at a velocity of 100 m./min. after stretching, they were arranged in parallel with a space apart and passed at a contact angle of 80° C. on a rod file of 25 mm. in diameter and of medium roughness, revolving as a splitter at a surface velocity of 300 m./min. in the same direction as that of the running stretched film. The single fibers of the split-fiber thus obtained, had a denier within 50–150 denier. After passing through the splitter, all webs of the spit-fiber obtained, during their travelling, were spread and arranged in parallel in a uniform density within the width of about 1 m., as a warp. On the other hand, 30 pieces of unstretched bristles, 3000 deniers, made of high pressure polyethylene, were arranged in parallel and after passing through a comb of 32 mm. in pitch, which was installed crosswise to the warp and was moving in a reciprocating motion to and fro at a rate of 400 times per minute, with an amplitude of 35 mm., they were deposited on the spread fibers arranged in parallel at the inlet of a heating drum with a backing canvas, as shown in FIG. 3, the temperature of which was maintained at 115° C. with steam. At the outlet of the drum, the entire material was subjected to pressure-adhering together at a pressure of 10 kg./cm.². As a result, the distribution of spread fibers were fixed in wavy form with the bristles of high pressure polyethylene as an adhesive binder, leaving unfixed portions of fibers between nighboring wavy pattern of the adhesive binder polymer and the resultant product was wound on a beam-winding bobbin, as it was. The fixed web of fibers, thus wound up, contained about 30 g./m.² of split-fiber and about 10 g./m.² of the adhesive binder polymer.

On this web of the fiber, weft fiber prepared similarly to the above were laid by using the cross-laminating apparatus of FIG. 2 and then the resultant product composed of weft and warp fibers was fixed with adhesive binder by pressure-adhering together after preheated at 115° C. with the pressure-adhering apparatus of FIG. 3 and embossed at a pressure of 50 kg./cm.² by passing it through between metal network belts of 15 meshes. As a result, the fibers of the product were forced to gather from the projected parts of the net belt to the recessed parts of it and thus the surface of the product had unevenness like a woven fabric, and the parts composed only of fibers were fixed, though incompletely, and the product thus obtained appeared as if woven. The boundary surfaces of the webs would not come off owing to the adhesive binder spread toward both sides.

This product of laminated weft and warp fibers weighed about 80 g./m.². containing about 75% of fibers. Its tenacity was 50 kg. or more per width of 50 mm. and its elongation was 20–40%, and it was strong enough for a rice or barley bag (for which purpose the strength of 50 kg. per width of 50 mm. is necessary). The adhesive binder was spread evenly within the width of 3–4 mm., adhering the fibers to each other in the net-like way. The parts composed of fibers only which were not in contact with the adhesive binder polymer were shaped like deformed squares, the sides of which are about 20–25 mm. long and through which air could be passed freely. A sampling pipe, 7–8 mm. in diameter, with a pointed top, was thrusted into the part composed only of fibers, after being rubbed to afford small gap of fibers. After pulling out the sampling pipe, the fibers around the resultant hole recover their original locations thereafter, excluding the apprehension that rice or barley should drop through it. In case where the product, thus obtained appears thin and weak, however, a 4-ply product obtanied by sandwitching two webs of weft between two webs of warp before they are pressure-adhered on heating will be preferably used for making rice and barley bags.

For preventing the product of the present invention from the pentration of ultra-violet rays, it may be incorporated with a UV absorber or colored with some pigment, or paper may be laminated on it before the entire material is subjected to pressure-adhering together on heating, by the method of the sixth feature hereof. For making the bags of cement or the like which are required to be water-proof, non-oriented or oriented film may be laminated on it. For making light duty bags, the content (g./m.²) of split-fiber may be reduced and then film may be laminated on it. According to the method of the present invention, the webs of fiber adhere to each other completely with an ample quantity of an adhesive binder at certain intervals, and so even if fibers become fluffy on the other surface of the film because of its thickness, it can be used practically without troubles.

The laminated or embossed product, obtained by the method of the present invention which contains generally 50–90% of fiber can be sewn and when film is laminated on its surface, it can be jointed by the heat-sealing method. The bands or tapes obtained by the method of the eight feature become heat-sealable if the webs of warped fibers are piled up upto a necessary thickness and films are laminated on their surface and then the entire material is subjected to pressure-adhering.

The web of warped fiber laminated with film or paper on it can be used as the raw-stuff for an adhesive tape containing a rubber-type adhesive.

Anyway, the laminate of warped fibers or the product of laminated weft and warp, obtained by the method of the present invention, in which the webs of split-fiber are so fixed that the product has parts firmly jointed by pressure adhesion with a shaped adhesive binder polymer and parts composed of fibers alone, has a high content of fiber and is pliable for its thickness and very strong in virtue of its good fiber distribution arranged in one or two principal directions, that is weft or warp, which fibers are in the state substantially elongated lengthwise without slacking. Though conventional filament yarns and tows can be used for this purpose, it is a characteristic advantage of the present invention that product of higher practical value can be obtained at a very low cost by using inexpensive split fibers prepared from stretched film and utilizing the method of the first feature of the present invention combined with those of the second and third, and then products of high practical value can be produced at a very low cost.

In the past, stretched film or woven fabric of stretched tapes was laminated with unstretched film by pressure-adhesion or by extrusion-lamination, or coated with an emulsion before dried, and then laminated with unstretched film by pressure-adhesion. Thus obtained product was used in the similar applications, but as split fiber has larger surface areas, it gives firmer adhesion. This is also a characteristic of the present invention. Accordingly, in this case, adhesion is firm inspite of the fact that adhesion is made only locally at places where the adhesive binder polymer is located in a pattern, and gas permeability is effected and pliability is increased, thus the characteristic advantage of the present invention is further evidenced.

Different from the conventional non-woven fabrics, which consist of short fibers, the product of the present invention contains longer interconnected fibers of split fibers, so it can be used for producing the products which needs special high strength.

If the product, excellent in gas permeability, obtained by the method of the present invention, is accompanied with a defective in the point that it is liable to fluff under surfacial abrasion because of webs of fine fiber, a following remedy may often be useful: i.e. a suitable adhesive binder in emulsion form is sprayed only onto the surface of the product or an half-finished product and dried up, and, if necessary, set on heating for preventing the fluffing of the surface.

What is claimed is:

1. A method for producing a flexible gas permeable non-woven material consisting of at least one web of split fibers which comprises arranging side by side the split fibers of at least one web of split fibers having a network structure, elongated lengthwise without substantial slacking and substantially parallel to each other; laying on the said web of split fibers a preformed solid shaped pattern of adhesive binder polymer which covers the surface of the said web of split fibers only locally those portions of said web which underly said shaped pattern of adhesive and; thereafter pressure adhering the resulting assembly to bind said adhesive and said web so as to leave loose and unfixed parts amid firmly fixed fiber parts, said shaped adhesive binder having a softening temperature range lower than the heat resisting temperature of said web said pressure-adhering being effected by heating said materials at a temperature lower than the heat resisting temperature of the said web but within the softening temperature range of the said adhesive binder.

2. A method according to claim **1**, wherein at least two layers of the non-woven material are piled one upon another and are subjected to a pressure-adhering integrally on heating at a temperature lower than the heat resisting temperature of the fiber but within the softening temperature range of the polymer of which the adhesive binder is composed.

3. A method according to claim 1, wherein said adhesive binder is so applied as to form a stripe pattern.

4. A method according to claim 1, wherein said adhesive binder is so applied as to form a net pattern.

5. A method according to claim 1, wherein said adhesive binder is so applied as to form a checkered pattern.

6. A method according to claim 1, wherein said adhesive binder is so applied as to form a ladder pattern.

7. A method according to claim 1, wherein said adhesive binder is applied in the form of perforated film.

8. A method according to claim 1, wherein said adhesive binder is chiefly composed of the same polymer as that of the split-fiber and has a lower softening temperature range than the heat resisting temperature of the split-fiber.

9. A method according to claim 1, wherein said adhesive binder is chiefly composed of a polymer selected from a group of copolymer, one of the main constituent monomers of which copolymer is the same as that of the principal constituent monomer of the split fiber, and which copolymer has a lower softening temperature range than the heat resisting temperature of the split-fiber.

10. A method according to claim 2, wherein the pressure adhering of piled layers of the non-woven material is effected in the presence of additional adhesive binder inserted between respective layers.

11. A method according to claim 2, wherein the layers of the non-woven material are laminated in such an arrangement that the fibers of the layers are substantially parallel to each other.

12. A method according to claim 2, wherein the layers of the non-woven material are laminated in such an arrangement that the fibers of the layers are substantially crosswise to each other.

13. A method according to claim 12, wherein the arrangement of layers of the sheet-like material is carried out by blowing a first sheet-like material as a weft, through a flat duct by a rapid current of a fluid upon a second sheet-like material, as a warp, during the travelling step of the warp by the length corresponding to the width of the second, as measured along the direction of blowing of the fluid, stopping the blowing of the fluid, cutting the first along the edge of the second to fall on the second, and repeating the above-mentioned procedure at a given interval.

14. A method according to claim 1 wherein a flexible gas permeable non-woven laminated material of webs of split fibers is produced by laminating one face of a first web of split fibers to one face of at least one additional web of split fibers, by means of a solid shaped patterned adhesive laid on said face of the first web prior to disposing said additional web thereon.

References Cited

UNITED STATES PATENTS

3,510,389	5/1970	Olson	161—148
3,485,705	12/1969	Harmon	264—DIG. 47
3,484,916	12/1969	Johnstone	161—154
3,003,304	10/1961	Rasmussen	57—157
3,452,128	6/1969	Rains	156—180
3,470,285	9/1969	Kim et al.	264—147
3,500,517	3/1970	Dekker et al.	264—147
3,368,934	2/1968	Vosburgh	156—62.4
3,428,506	2/1969	Johnstone	264—DIG. 47
3,496,260	2/1970	Guenther et al.	264—147
3,495,752	2/1970	Kim et al.	28—1
3,639,199	2/1972	Brandts et al.	161—148
2,880,111	3/1959	Drelich et al.	161—148
3,484,330	12/1969	Sokolowski et al.	161—148
2,705,692	4/1955	Petterson	161—148
3,616,797	11/1971	Champaigne et al.	161—148

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