A thermoformable lap (1) includes a first web (3) and a second web (4) made of linking fibres (3a, 4a) made of a first thermoreactivatable material having a first reactivation temperature. An intermediate layer (2) is arranged between the first web (3) and the second web (4), and includes reinforcement fibres (2a) and granules (2b) of a second thermoreactivatable material having a second reactivation temperature that is higher than the first reactivation temperature. Certain sections (3b, 4b) of linking fibres of the first and second webs (3, 4) penetrate into the intermediate layer (2) and partially adhere to one another and to the reinforcement fibres (2a) of the intermediate layer (2), ensuring the cohesion of the assembly. Such a lap can be manufactured at a lower cost and at high speed, and can be used for the production of parts by heat moulding.
THERMOFORMABLE LAP HAVING REINFORCEMENT FIBRES

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to the thermofusable laminates based on thermoplastic fibers and thermostable material, that can be used to produce parts made of composite material by hot pressing.

[0002] The present invention relates to a method for bonding thermoplastic fibers and thermostable material, that can be hot molded. The glass fibers and the thermoplastic polymer powder are mixed and encapsulated between two outer layers whose edges are sealed and which prevent the glass fibers and the powder from escaping. The outer layers are formed using a thermoplastic material compatible with the thermoplastic polymer powder. However, if a first drawback is that the very production of the thermoplastic material in powder form is relatively costly, a second drawback is that such known layers with fine powder are sensitive to ageing, and require particular and restrictive storage conditions (short duration, low temperature, absence of ultraviolet rays, etc.). A third drawback is that the laps can be cut only along preformed link lines along which the outer layers are sealed to one another.

[0003] The present invention relates to a novel thermofusable lap structure with reinforcement fibers and thermostable material, which is stable in storage, which can be produced at a lower cost and at a high rate, while exhibiting good properties for the production of satisfactory molded parts, notably by being able to be subsequently cut to any size, according to the needs, without out allowing the thermoplastic material to escape.

[0004] A first idea upon which the invention is based is how to design a thermofusable lap which can be produced based on a thermostable material which is available at a lower cost, such as granules of thermostable material.

[0005] A second idea upon which the invention is based is how to devise other means for ensuring the cohesion of the thermostable material with the glass fibers and with the outer layers.

[0006] To achieve these aims, and others, the invention proposes a thermofusable lap based on reinforcement fibers linked to a thermostable material, comprising:

- a first web and a second web made of linking fibers, at least the surface of which is made of a thermostable material having a first reactivation temperature;
- an intermediate layer arranged between the first and second webs,
- the intermediate layer having reinforcement fibers and granules of a second thermostable material having a second reactivation temperature higher than the first reactivation temperature;
- at least certain sections of linking fibers of the first and second webs penetrating into the intermediate layer and partially adhering to one another and to the reinforcement fibers of the intermediate layer, to link the first and second webs to the intermediate layer.

[0007] The use of the second thermostable material in the form of granules makes it possible to very significantly reduce the cost of production of the thermofusable lap. The thermofusable lap so constructed exhibits a low sensitivity to ageing, such that the storage cost is reduced. This use of a material in granule form is made possible by the presence of the first and second webs made of linking fibers, which enclose the materials forming the intermediate layer and prevent the granules from escaping during the handling of the thermofusable lap. At the same time, the penetrating sections of linking fibers, which partially adhere to one another and to the reinforcement fibers of the intermediate layer, ensure the cohesion of the assembly, allowing for the handling of the thermofusable lap from its place of production to the place of use for forming a final part, and allow for a subsequent cutting of the lap to any size, according to the needs, while effectively preventing the granules from escaping.

[0008] The presence of the first and second webs made of linking fibers also makes it possible to use reinforcement fibers in a non-woven form, the webs preventing the reinforcement fibers from escaping during the handling of the thermofusable lap. The need to involve a weaving loom is thus avoided.

[0009] In the following description and in the claims, the expression “granules” describes any material grain types that can have various forms, round or angular, and a size from a fraction of a millimeter to a few millimeters. Such granules are commonly available in the trade for thermostable materials, notably materials of polyamide type. They are generally called “plastic pellets”, are used in particular for injection molding, and are obtained by extrusion through a hole die, then by cropping the cords obtained when cold.

[0010] The expression “thermostable” means that the material, after construction of the lap, can subsequently be fluidized to spread and adhere to the glass fibers.

[0011] A first example is a thermostable material of epoxy type, which can be partially polymerized to be in solid form at room temperature. This material is in the solid state at room temperature. By raising the temperature, its viscosity can be temporarily lowered, and it is then sufficiently fluidized to spread between the glass fibers, before hardening by polymerization.

[0012] A second example is a thermostable material, whose viscosity can be lowered whenever its temperature is raised.

[0013] Thus, the expression “thermostable” covers the thermostable plastic materials, but also the other resins that can be fluidized at least once by heat, for example the epoxy resins.

[0014] The reinforcement fibers can advantageously be glass fibers. The benefits of the good reinforcement properties provided by glass fiber are thus obtained.

[0015] In the linking fibers, the first thermostable material can, for example, be a polyaniline/copolyamide (PA6/CoPA), a polyethylene, a copolypropylene, an acrylic, or ethyl vinyl acetate. The first reactivation temperature (in this case the melting point) of such a material is of the order of 110°C to 150°C.
[0022] The linking fibers can be made of a single first thermoreactive material, or, alternatively, can be made of a central core of polyamide, polyester or polypropylene and an outer sheath made of a first thermoreactive material with a first reactivation temperature that is lower than that of the central core.

[0023] According to an advantageous embodiment, the second thermoreactive material in granules can be a polyamide.

[0024] The linking fibers can be fiber sections, advantageously sections with a length of approximately 30 to 75 millimeters.

[0025] According to a first embodiment, in the intermediate layer, the reinforcement fibers can be sections of reinforcement fibers mixed with the granules of second thermoreactivatable material. Production is thus simple, the intermediate layer being able to be made in a single step.

[0026] According to a second embodiment, the intermediate layer can be laminated in layers of reinforcement fibers and layers of granules of second thermoreactivatable material. This second embodiment offers the advantage of being able to use long reinforcement fibers, the arrangement of which can be ensured continuously by successive layers.

[0027] According to another aspect, the invention proposes a method for manufacturing a thermofusable lap as defined above, comprising the steps of:

- a) on a support, depositing a first web made of linking fibers,
- b) depositing, on the first web, reinforcement fibers and granules of second thermoreactivatable material, forming an intermediate layer,
- c) depositing, on the intermediate layer, a second web made of linking fibers,
- d) performing a needling to make the sections of linking fibers of the first and second webs penetrate into the intermediate layer,
- e) heating the assembly to a sufficient temperature to soften the linking fibers and render them adhesive, without reactivating the granules of second thermoreactivatable material,
- f) cold calendering the assembly.

[0030] The needling makes sections of linking fibers penetrate into the intermediate layer. During the subsequent heating, the linking fibers are rendered adhesive and their penetrating sections can adhere to the reinforcement fibers and to the granules of the intermediate layer. The materials of the intermediate layer, which exhibit a higher reactivation temperature, are unaffected by the operation of heating and softening the linking fibers, and retain their properties. During the cold calendering, the linking fibers are once again solidified but their penetrating sections remain glued to the reinforcement fibers and to the granules, ensuring the cohesion of the assembly.

[0035] The invention can advantageously be applied to the production of parts by thermofoming a lap so constructed.

[0036] It is then sufficient to place the lap in a hot pressing mold which will raise the temperature of the lap to a sufficient value to provoke not only the reactivation of the linking fibers, but also the reactivation of the granules of second thermoreactivatable material. The second thermoreactivatable material then constitutes a resin which coats the reinforcement fibers and which, after cooling, becomes solid and gives the part its final shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] Other objects, features and advantages of the present invention will emerge from the following description of particular embodiments, given in relation to the attached figures, in which:

[0038] FIG. 1 is a schematic view in longitudinal cross section of a thermofusable lap according to a first embodiment of the present invention;

[0039] FIG. 2 is a schematic view in longitudinal cross section of a thermofusable lap according to a second embodiment of the present invention; and

[0040] FIG. 3 schematically illustrates in longitudinal cross section a thermofusable lap of FIG. 2 during needling.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0041] As illustrated in the figures, a thermofusable lap according to the present invention comprises an intermediate layer 2 arranged between a first web 3 and a second web 4.

[0042] The intermediate layer 2 comprises reinforcement fibers 2a and granules 2b of a second thermoreactivatable material.

[0043] The first web 3 and the second web 4 are made of linking fibers respectively 3a and 4a, at least the surface of which is made of a first thermoreactivatable material.

[0044] The first thermoreactivatable material forming the linking fibers 3a and 4a has a first reactivation temperature $T_1$ of the order of 110°C to 135°C.

[0045] The second thermoreactivatable material in the form of granules 2b has a second reactivation temperature $T_2$ which is higher than the first reactivation temperature $T_1$.

[0046] Sections 3b and 4b of certain linking fibers of the first and second webs 3 and 4 penetrate into the intermediate layer 2 and partially adhere to one another and to the reinforcement fibers 2a of the intermediate layer 2.

[0047] The reinforcement fibers 2a can be made of any materials that provide satisfactory reinforcing mechanical properties for the final parts produced using the thermofusable lap 1 according to the invention.

[0048] For example, the reinforcement fibers 2a can be glass fibers, carbon fibers, vegetable fibers.

[0049] The linking fibers 3a and 4a can be made of any material that has a sufficiently low reactivation temperature and good bonding properties. They can be made of a single first thermoreactivatable material, for example polyamide/copolyamide (PA6/CoPA), polyethylene, a copolypropylene, ethyl vinyl acetate. The melting point of such materials is of the order of 110°C to 150°C, and these materials exhibit good bonding properties. The linking fibers must also be compatible with the second thermoreactivatable material of the granules 2b: similar reactivation temperatures, capacity to be combined upon reactivation.

[0050] As an alternative, the linking fibers 3a, 4a can be two-component chemical fibers, comprising a central core of polyamide, polyester or polypropylene, and an outer sheath made of copolyamide, copolypropylene, copolyester, polyethylene, ethyl vinyl acetate, or any other material that has a reactivation temperature lower than that of the central core. Good results will be able to be obtained by using a central core of polyester and an outer sheath made of copolypropylene, or a central core of polypropylene and an outer sheath made of polyethylene.
Due to the fact that the central core of the two-component linking fiber has a higher reactivation temperature than the outer sheath, any accidental risk of complete fusion of the linking fibers 3a and 4a during the manufacture of the thermoformable lap 1 is avoided.

The risk, during a heating step for the manufacture of the thermoformable lap 1, that the sections of linking fiber are, through an excessively high or badly controlled heating, completely melted, forming uniform or impermeable layers which do not effectively adhere to the intermediate layer 2 after the manufacture of the final part, is also effectively limited. The core of the two-component fibers is not (or is very little) altered by the heating, and the linking properties of the linking fibers 3a and 4a are thus conserved.

The penetrating sections 3b and 4b of linking fiber are distributed evenly on the surface of the thermoformable lap 1, for example with a surface density of 5 to 50 penetrating sections per square centimeter of thermoformable lap 1, and ensure a cohesion of the assembly, while conserving the properties of deformability and flexibility of the thermoformable lap 1.

The second thermoactivatable material in the form of granules 2b is advantageously a polyamide. Such a material constitutes a resin whose reactivation temperature is clearly higher than the first reactivation temperature of the linking fibers 3a and 4a, for example of the order of 240°C to 280°C. This way, in the thermoformable lap 1 before use for the production of a final part, the second thermoactivatable material remains in the form of granules 2b, simply juxtaposed with the reinforcement fibers 2a and enclosed by the webs 3 and 4.

In the embodiment illustrated in FIG. 1, the intermediate layer 2 is laminated in a plurality of layers of reinforcement fibers 20a, 20b and 20c, and a plurality of layers of granules of second thermoactivatable material 20d and 20e. An advantageous variant consists in eliminating the central layer 20b.

In the embodiment illustrated in FIG. 2, the intermediate layer 2, the reinforcement fibers are sections of reinforcement fibers 2a mixed with the granules 2b of thermoactivatable material, forming a generally uniform layer in which the sections of reinforcement fibers 2a and the granules 2b are evenly distributed.

The thermoformable lap 1 according to the invention can be produced in the form of a continuous strip that is packed in a reel of long length. The reels also have a great width. The thermoformable lap so produced can be cut lengthwise and widthwise at will, to be re-packed or thermoformed.

In the embodiment illustrated in FIG. 1, in which the intermediate layer 2 is laminated, the reinforcement fibers can be continuous glass fibers, or sections of loose cut glass fiber in all orientations.

In the second embodiment illustrated in FIG. 2, the reinforcement fibers should preferably be fiber sections, for example approximately 50 to 150 millimeters, loose in all orientations, and mixed with the granules 2b.

To manufacture such a thermoformable lap 1, the following method can be used:

a) On a support, the first web 3 made of linking fibers 3a is deposited; the linking fibers can be fiber sections of a first thermoactivatable material; the web can be produced on a conventional carding machine, and deposited continuously on the support itself by longitudinal displacement;

b) On the second web 3, reinforcement fibers 2a and granules 2b of second thermoactivatable material are deposited, to form the intermediate layer 2; to produce the lap of the embodiment of FIG. 2, the deposition of the reinforcement fibers 2a and of the granules 2b is performed by gravity, continuously and in a mixture, by letting a mixture of reinforcement fibers 2a and of granules 2b fall onto the first web 3, as the first web 3 borne by the support advances;

c) On the intermediate layer 2 so formed, a second web 4 of linking fibers 4a is deposited; this second web can also be produced using a conventional carding machine; the deposition of the second web is performed continuously as the assembly of the first web 3 and of the intermediate layer 2 advances;

d) Downstream, a needling is performed by the penetration of needles from the top face and the bottom face of the assembly, which makes sections of linking fiber 3b and 4b of the first and second webs 3 and 4 penetrate into the intermediate layer 2; FIG. 3 illustrates this step and needles 8 which include driving bars 8b can be distinguished;

e) The assembly is then heated to a temperature that is sufficient to soften and render adhesive the linking fibers 3a and 4a, in particular the penetrating sections 3b and 4b of linking fiber which penetrate into the intermediate layer 2; the temperature must be lower than the reactivation temperature of the granules 2b of second thermoactivatable material;

f) Finally, the assembly so formed is cold calendered, to once again solidify the linking fibers 3a, 4a, 3b, 4b.

EXAMPLE

On a planar support in continuous longitudinal displacement, a first web 3 of sections of linking fibers 3a of polyamide having a unitary yarn count of between approximately 2 derrier and approximately 4 derrier is continuously deposited, the web leaving a conventional carding machine.

On the first web 3 in continuous longitudinal displacement, a mixture of reinforcement fibers 2a and of granules 2b is made to fall to constitute an intermediate layer 2; the reinforcement fibers 2a are sections of glass fiber having a unitary yarn count of approximately 30 tex to 100 tex and a length of approximately 50 to 150 millimeters, in all orientations; the granules have a size of approximately 2 millimeters and are of 606 type polyamide, having a reactivation temperature of approximately 240°C to 280°C.

During the continuous longitudinal advance of the assembly formed by the first web 3 and the intermediate layer 2, the second web 4 made of linking fibers 4a is continuously deposited, said linking fibers 4a being fiber sections of polyamide having a unitary yarn count of between approximately 2 derrier and approximately 4 derrier, the web leaving a conventional carding machine.

The preform of thermoformable lap 1 so produced is introduced by means of a conveyor belt into a needling machine; the density of the needles 8 is 10 per square centimeter; the depth of penetration of the needles 8 is 12 millimeters, chosen as a function of the thickness of the lap to be produced; the scrolling speed of the belt is 8 to 15 meters per minute.

After the needling operation, the thermoformable lap preform 1 is introduced into a through-air oven comprising a heating part 12 meters long and a scrolling speed of 8 to 15 meters per minute; the temperature of the through-air oven is approximately 120°C, corresponding to the softening temperature of the linking fibers 3a and 4a.
VI. At the output of the through-air oven, there is a cold calendaring operation which gives the thermoformable lap 1 its final thickness which is approximately 4 to 10 millimeters.

The substance weight of the thermoformable lap 1 so produced is between 800 and 1800 grams per square meter, containing from 200 to 1000 grams per square meter of reinforcement fibers and from 200 to 1000 grams per square meter of granules 2b of second thermoreactivatable material.

The thermoformable lap 1 according to the invention can advantageously be applied in the manufacture of composite parts of various forms by thermoforming of the lap 1.

The part is shaped by introducing the thermoformable lap 1 into a heating mold, which raises the temperature of the lap 1 to a value higher than the temperature T2 of reactivation of the granules of second thermoreactivatable material. The second thermoreactivatable material then becomes fluid and diffuses between the reinforcement fibers 2a to then give the part its final form after cooling or polymerization.

The present invention is not limited to the embodiments which have been explicitly described, but it includes the various variants and generalizations thereof contained within the scope of the claims hereinbelow.

1. Thermoformable lap (1) based on reinforcement fibers linked to a thermoreactivatable material, comprising:

   a first outer layer and a second outer layer, having a first thermoreactivatable material with a first reactivation temperature,
   an intermediate layer (2) arranged between the first and second outer layers,
   the intermediate layer (2) having reinforcement fibers (2a) and a second thermoreactivatable material with a reactivation temperature higher than the first reactivation temperature,

   wherein:

   the second thermoreactivatable material is in the form of granules (2b),
   the outer layers consist of a first web (3) and a second web (4) made of linking fibers (3a, 4a), at least the surface of which is made of the first thermoreactivatable material having a first reactivation temperature,
   at least certain sections (3b, 4b) of linking fibers of the first and second webs (3, 4) penetrate into the intermediate layer (2) and partially adhere to one another and to the reinforcement fibers (2a) of the intermediate layer (2).

2. Thermoformable lap (1) based on reinforcement fibers (2a) as claimed in claim 1, wherein the reinforcement fibers (2a) are glass fibers.

3. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein the first thermoreactivatable material is a polyamide/copolyamide (PA6/CoPA), a polyethylene, a copolypropylene, an acrylic or ethyl vinyl acetate.

4. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein the linking fibers (3a, 4a) consist of a single first thermoreactivatable material.

5. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein the linking fibers (3a, 4a) consist of a central core of polyamide, polyester or polypropylene and an outer sheath made of a first thermoreactivatable material with a first reactivation temperature that is lower than that of the central core.

6. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein the second thermoreactivatable material in granules (2b) is a polyamide.

7. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein the linking fibers (3a, 4a) are fiber sections.

8. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein, in the intermediate layer (2), the reinforcement fibers (2a) are sections of reinforcement fibers (2a) mixed with the granules (2b) of second thermoreactivatable material.

9. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, wherein the intermediate layer (2) is laminated in layers of reinforcement fibers (20a, 20b, 20c) and layers of granules of second thermoreactivatable material (20d, 20e).

10. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, containing from 200 to 1000 grams per square meter of reinforcement fibers (2a) and from 200 to 1000 grams per square meter of granules (2b) of second thermoreactivatable material.

11. Thermoformable lap (1) based on reinforcement fibers as claimed in claim 1, being in the form of a reel-packaged continuous strip.

12. Method for manufacturing a thermoformable lap (1) as claimed in claim 1, comprising the steps of:

   a) on a support, depositing a first web (3) made of linking fibers (3a),
   b) depositing, on the first web (3), reinforcement fibers (2a) and granules (2b) of second thermoreactivatable material, forming an intermediate layer (2),
   c) depositing, on the intermediate layer (2), a second web (4) made of linking fibers (4a),
   d) forming a needling to make the sections of linking fibers (3b, 4b) of the first and second webs (3, 4) penetrate into the intermediate layer (2),
   e) heating the assembly to a sufficient temperature to soften the linking fibers (3a, 4a, 3b, 4b) and render them adhesive,
   f) cold calendaring the assembly.

13. Application of a thermoformable lap (1) as claimed in claim 1 to the production of parts by thermoforming the lap.

* * * * *