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(54) **NOVEL STRENGTHENING COMPOSITE**

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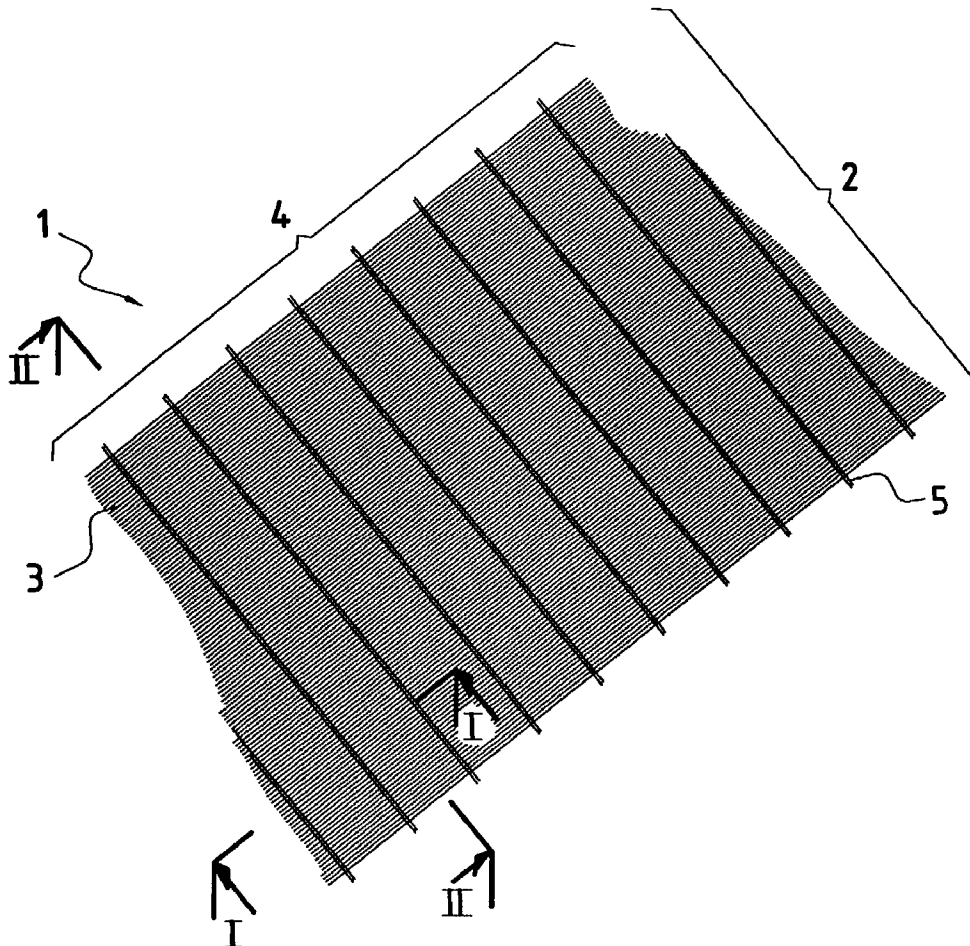
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(57) **ABSTRACT**

According to the invention, in the unidirectional strengthening composite (1) based on thread laps, said thread laps consist of a first lap (2) of mutually parallel strengthening threads (3), a second lap (4) of bonding threads (5) composed of a fibrous core coated with a thermoplastic and running transversely to the threads (3) of the first lap (2), being crossed without interlacing, said strengthening threads (3) of the first lap (2) being bonded, at least locally, to the bonding threads (5) of the second lap (4) by fusion of the thermoplastic, and optionally a third lap (6) of strengthening threads (7) parallel to one another and to those of the first lap (2) and bonded, at least locally, to the coated bonding threads (5) of the second lap (4) being trapped between the strengthening threads (3) of the first lap (2) and the strengthening threads (7) of the third lap (6).



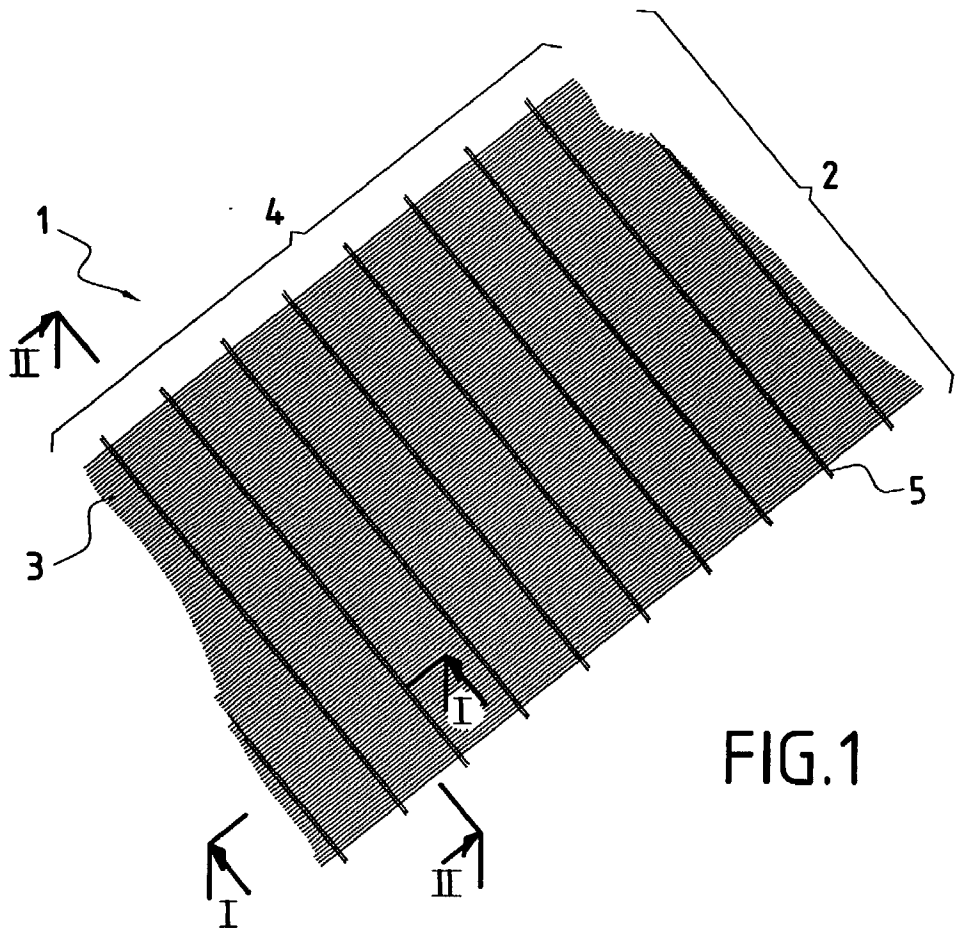
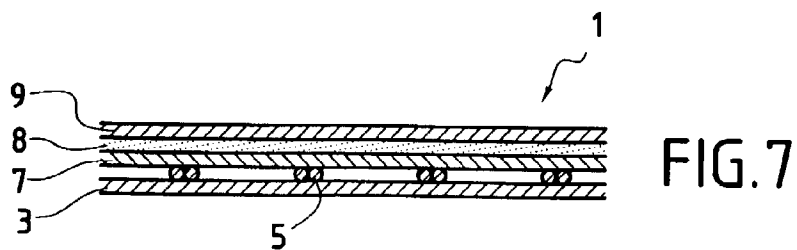
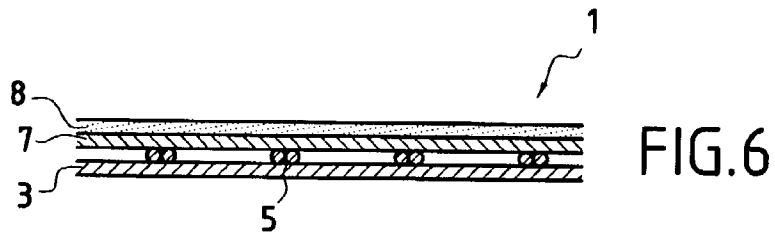
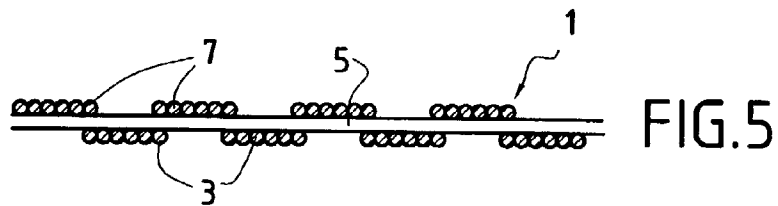
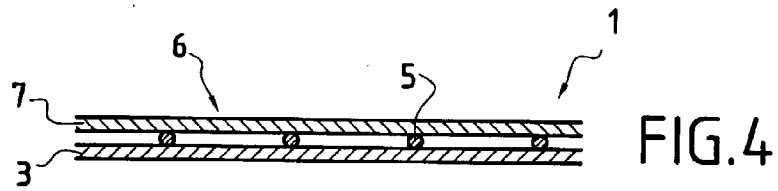
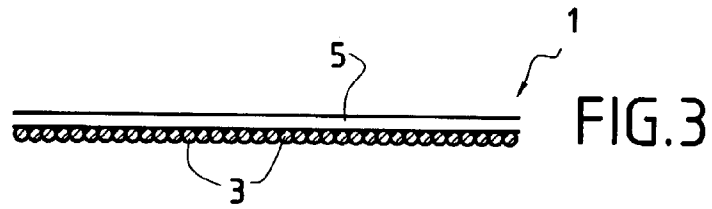
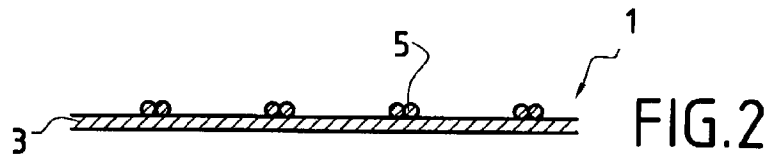


FIG.1



### NOVEL STRENGTHENING COMPOSITE

[0001] The present invention relates to the field of unidirectional strengthening products of coherent character which are intended more particularly for forming reinforcements.

[0002] In numerous fields it is desirable to be able to strengthen a manufactured product so as to enhance certain mechanical characteristics imparted by the constituent material used to manufacture said product. Thus it is known to use reinforcements together with cement, concrete, plastics and resins.

[0003] In the above fields, a reinforcement is generally made of a meshwork constructed or produced from fibers which can be unidirectional for certain applications or woven in webs of greater or lesser width.

[0004] Such a reinforcement consists for example of a unidirectional strengthening composite composed of laps of glass, carbon or aramide fibers or threads joined together by straight or zigzag stitching by means of a polyester thread. Such a product has a number of disadvantages, among which there must be mentioned a ribbed surface state due to the presence of stitching that creates overthicknesses. In some cases such a surface state is incompatible with the intended application. Furthermore, the stitching compacts the strengthening threads, thereby decreasing the accessibility of these threads to the resin which will subsequently be injected in the manufacture of composite parts.

[0005] Among the disadvantages, there should also be mentioned the production cost of such a product, given that the machines employed must have multi-needle heads in order to create straight or zigzag stitching, each needle necessarily being supplied with its own thread. The operation of such a machine therefore requires substantial preparatory work which will burden the production cost of the product.

[0006] Another disadvantage concerns the presence of sewing threads made of a different material from that of the glass, carbon or aramide fibers forming the laps.

[0007] The prior art, especially patent U.S. Pat. No. 4,460, 633, proposes the use of non-woven reinforcements based on cross thread laps, comprising at least a first warp thread lap and a second weft thread lap impregnated with an adhesive, the two laps being bonded at their intersection. Impregnation of the weft threads with the adhesive is effected when the reinforcements are created, the impregnation process being difficult to execute. It is in fact very difficult, if not impossible, to avoid impregnating the warp threads as well, the consequence of which is to detract from the future mechanical properties of the strengthened materials subsequently obtained.

[0008] In this context, the object of the invention is to overcome these disadvantages by proposing a novel unidirectional strengthening composite of coherent and semi-rigid character, and of planar shape, which is obtained by a simplified process. "Unidirectional strengthening composite" is understood as meaning a fibrous composite in which the threads performing the strengthening function of the composite are all orientated in the same direction and therefore are all substantially parallel to one another. These threads can be distributed over one or two laps. "Coherent character" should be considered to mean that the product

according to the invention is made in such a way as to have inherent strength and be capable of withstanding certain handling stresses or even processing stresses in the manufacture of a subsequent semifinished product.

[0009] To achieve the above objective, in the unidirectional strengthening composite according to the invention based on thread laps, said thread laps consist of:

[0010] a first lap of mutually parallel strengthening threads,

[0011] a second lap of bonding threads composed of a fibrous core coated with a thermoplastic and running transversely to the threads of the first lap, being crossed without interlacing, said strengthening threads of the first lap being bonded, at least locally, to the bonding threads of the second lap by fusion of the thermoplastic,

[0012] and optionally a third lap of strengthening threads parallel to one another and to those of the first lap and bonded, at least locally, to the coated bonding threads by fusion of the thermoplastic, the coated bonding threads of the second lap being trapped between the strengthening threads of the first lap and the strengthening threads of the third lap.

[0013] The composite according to the invention is bonded by means of coated threads already available commercially. The use of such coated threads makes it possible to dispense with the impregnation step, which is expensive to carry out. This also eliminates the risks of impregnating the other laps.

[0014] The present invention further relates to a process for the manufacture of a unidirectional strengthening composite according to the invention which comprises the following steps:

[0015] forming a first lap of mutually parallel strengthening threads and superimposing on this first lap a second lap of bonding threads composed of a fibrous core coated with a thermoplastic and running transversely to the strengthening threads of the first lap, being crossed without interlacing,

[0016] and bonding said laps at their intersection by thermocompression.

[0017] Various other characteristics will become apparent from the following description referring to the attached drawings, which show, by way of non-limiting Examples, embodiments of the subject of the invention.

[0018] FIG. 1 is a partial perspective of a strengthening composite according to the invention.

[0019] FIG. 2 is a partial section approximately along the plane I-I of FIG. 1, intentionally on a larger scale.

[0020] FIG. 3 is a partial section approximately along the plane II-II of FIG. 1, intentionally on a larger scale.

[0021] FIG. 4 is a section analogous to FIG. 2 except that it illustrates another embodiment.

[0022] FIG. 5 is a section analogous to FIG. 3 except that it illustrates another embodiment.

[0023] FIG. 6 is a section analogous to FIG. 2 except that it illustrates another embodiment.

[0024] FIG. 7 is a section analogous to FIG. 2 except that it illustrates another embodiment.

[0025] FIG. 1 shows that the strengthening composite according to the invention, designated in its entirety by reference 1, comprises at least a first lap 2 of strengthening threads 3, which are conventionally called warp threads by analogy with weaving processes, and which run parallel to one another. As shown in FIG. 1, these strengthening threads 3 are preferably contiguous so as to give a substantially non-perforated strengthening composite. The bonding between the strengthening threads of the first lap is assured by a second lap 4 of bonding threads 5 composed of a fibrous core coated with a thermoplastic, and conventionally called weft threads, which also run parallel to one another and are crossed, without interlacing, with the strengthening threads 3 of the first lap 2. In the Examples illustrated in FIGS. 1 and 2, the coated bonding threads 5 run in a general direction that is orthogonal to that of the strengthening threads 3. However, it must be considered that an oblique orientation could also be chosen. The coated bonding threads 5 comprise a core based on a similar material to that of the strengthening threads 3, which is coated with a layer of thermoplastic.

[0026] The second lap 4 of bonding threads 5 is much less dense than the first lap 2 of strengthening threads 3 and actually forms a perforated parallel network. In the second lap 4 the bonding threads 5 are spaced apart. A possible scenario is for the coated bonding threads 5 to be distributed in uniformly spaced groups of two, three or four threads, the spacing that exists between each bonding thread or group of bonding threads having a pitch, preferably a uniform pitch, advantageously of between 1 and 10 cm.

[0027] In contrast to the coated bonding threads 5 of the second lap 4, the strengthening threads 3 of the first lap are not coated. The coated bonding threads 5 of the second lap assures the cohesion of the strengthening composite 1 according to the invention, while the strengthening threads 3 of the first lap perform the strengthening function in a single direction. In the case of the unidirectional composite according to the invention, it can be considered that 100% of the threads that perform the strengthening function are orientated in the same direction, namely the strengthening direction. As illustrated in FIGS. 1, 2 and 3, the strengthening threads 3 of the first lap 2 are much more numerous than the coated bonding threads 5 of the second lap 4, which is why the composite according to the invention is described as a unidirectional strengthening composite, the strengthening threads 3 of the first lap 2 giving the strengthening direction.

[0028] The laps 2 and 4 are associated so as to possess a relative strength that imparts a coherent character to the strengthening composite 1. The interlinking between the strengthening threads 3 of the first lap 2 and the coated bonding threads 5 of the second lap 4 is assured by fusion or softening of the thermoplastic that coats the bonding threads 5, followed by its return to the solid state. The bonding between the strengthening threads 3 of the first lap 2 and the coated bonding threads 5 of the second lap 4 is effected at their intersection, solely by virtue of the thermoplastic used to coat the bonding threads 5. The coating on the bonding threads 5 must be sufficient to enable all the strengthening threads 3 of the first lap 2 to be bonded to the

second lap 4. By way of example, it will be possible to use bonding threads 5 coated with between 10 and 500 g of thermoplastic per 1000 linear meters, for example at a rate of one bonding thread per centimeter.

[0029] In one preferred embodiment, shown specifically in FIG. 4, the product 1 according to the invention has a third lap 6 of strengthening threads 7 parallel to one another and to those of the first lap 2, the coated bonding threads 5 of the second lap 4 being trapped between the strengthening threads 3 of the first lap 2 and the strengthening threads 7 of this third lap 6. Here again, it is implicit that the strengthening threads 7 of the third lap 6 are not coated. The strengthening threads 7 of this third lap 6 are also bonded, at least locally, to the coated bonding threads 5 by fusion of the thermoplastic, bonding taking place at the intersection of the strengthening threads 7 of the third lap 6 with the coated bonding threads 5 of the second lap 4. The amount of thermoplastic must therefore be adapted so as to assure the bonding of the first lap 2 with the second lap 4 and the bonding of the third lap 6 with the second lap 4. The lap 4 of bonding threads 5 is must less dense than the lap(s) of strengthening threads. The bonding threads are present in just the right amount required to assure bonding between the strengthening threads. Also, advantageously, at least 95% by weight of the composite according to the invention consists of strengthening threads 3 and optionally 7.

[0030] For greater clarity, the laps 2 and 6 of strengthening threads 3 and 7 are shown in the attached drawings with a single layer of strengthening threads. In practice, of course, these laps generally consist of bundles of strengthening threads extending over several layers.

[0031] The strengthening threads 3 and 7 can be contiguous in each of the laps 2 and 6. Provision can also be made for the strengthening threads 3 and 7 to be arranged in slivers, the slivers of the first lap 2 preferably being contiguous with the slivers of the third lap 6, as illustrated in FIG. 5. Preferably, these slivers have a constant spacing and the spacing for the lap 2 is identical to the spacing for the lap 6. The possibility of having contiguous strengthening threads in one of the laps 2 or 6 and strengthening threads arranged in slivers in the other lap cannot be excluded either. In all the cases illustrated in the present invention, the strengthening threads distributed over one or optionally two laps form a unidirectional strengthening network ensuring that the composite according to the invention has a coverage of approximately 100%. The composite according to the invention is therefore preferably non-perforated, i.e. the strengthening threads have a coverage of approximately 100%.

[0032] Without implying a limitation, the strengthening threads 3 and 7 can each independently have a titer of between 20 and 1000 tex in the case of aramide threads, of between 68 and 9600 tex in the case of glass threads and of between 68 and 6000 tex in the case of carbon threads. These threads can take the form of single strands of circular or analogous transverse cross section, in the form of single strands of a flat nature, in a multifilamentous form that may or may not be spread out like a sliver, or in a multifilamentous form organized so that the filaments run parallel to one another. Preferably, the strengthening threads are multifilamentous. The strengthening threads may or may not be twisted. Advantageously, the strengthening threads in the

first lap 2 and/or the third lap 6 can also be bulked or texturized, in which case they will perform an additional function as a reservoir for the thermosetting material or resin which will subsequently be injected.

[0033] The coated bonding threads 5 are generally stiffer and have a titer e.g. of between 30 and 600 tex. Nevertheless, it may be considered that the strengthening function of the composite according to the invention is principally performed by the strengthening threads 3 of the first lap and optionally the strengthening threads 7 of the second lap, if present. The sole function of the coated bonding threads 5 is to assure the coherence of the composite, said threads all being orientated in approximately the same direction.

[0034] The strengthening threads 3 and 7, as well as the fibrous core of the coated bonding threads 5, are made e.g. of a material selected from glass, carbon, aramide and high performance (HP) synthetics. The thermoplastic is selected from polypropylene, polyethylene, polyamide, polyethylene terephthalate, polyester, ethylene/vinyl acetate and mixtures thereof.

[0035] The strengthening threads 3 are preferably of the same nature and composition for the whole of the first lap 2. The same applies to the core of the coated bonding threads 5 of the second lap 4 and to the strengthening threads 7 of the third lap 6.

[0036] The present invention further relates to a process for the manufacture of a strengthening composite according to the invention which comprises the following steps:

[0037] forming a first lap 2 of mutually parallel strengthening threads 3 and superimposing on this first lap 2 a second lap 4 of bonding threads 5 coated with a thermoplastic and running transversely to the strengthening threads 3 of the first lap 2, being crossed without interlacing,

[0038] and bonding said laps 2 and 4 at their intersection by thermocompression.

[0039] The strengthening threads 3, or warp threads, forming the first lap 2 are laid down and stretched in the direction of production by techniques known to those skilled in the art, for example by using a cylinder/roller combination. The weft threads 5 of the second lap 4 are laid down e.g. with the aid of a weft carriage or a turbine machine. A new lap 6 of warp threads 7 can then be superimposed on the lap of weft threads. The different laps are then passed through a heating zone with a calendering action so as to melt the coating on the bonding threads 5 and thereby bond the lap threads together in order to impart cohesion between the different laps 2, 4 and 6 and provide the strengthening composite 1 with inherent strength, it then being possible for said composite to be handled and used for processing.

[0040] Appropriate operating conditions for achieving such a result involve e.g. raising the temperature in an enclosure to around 160 to 230° C., depending on the matrix materials used, and then establishing a calendering pressure of between 0.5 and 5 bar before cooling to ambient temperature. Thus the product 1 according to the invention can be obtained in a simple and clean manner. Such a product 1 is also easy to store, handle and cut up. The product according to the invention is perfectly suitable for use as a

reinforcement for resins or bitumens. Nevertheless, such a product is characterized by elastic deformability, enabling it to be rolled up if desired.

[0041] FIG. 6 shows another embodiment in which the strengthening composite 1 can be associated, over at least one of its large faces 1a or 1b, on the surface of the strengthening threads 3 of the first lap 2 and/or on the surface of the strengthening threads 7 of the third lap 6, with a layer 8 of anti-tear thermoplastic powder compatible with the subsequent processing resins. The purpose of this layer 8 is to strengthen the cohesion of the strengthening composite, especially when there are numerous strengthening warp threads, and hence to improve its handling. The anti-tear powder will e.g. consist of, or be based on, epoxy resin or polyethylene terephthalate. The deposition weight per unit surface area of such a layer can be between 2 and 50 g/m<sup>2</sup>. This anti-tear powder is deposited so as at least partially to cover the strengthening threads of the first lap 2 and/or of the third lap 6, and the bond between the layer 8 and the first lap 2 of strengthening threads 3 and/or the third lap 6 of strengthening threads 7 can be obtained by the same operation as that used to establish the bond on the one hand between the first lap 2 and the second lap 4 and on the other hand between the third lap 6 and the second lap 4.

[0042] Furthermore, the layer 8 subsequently makes it possible to trim the composite according to the invention. In fact, as shown in FIG. 7, this layer 8 of anti-tear powder is e.g. associated with a sheet 9 for imparting a particular appearance. This sheet 9 can be a nonwoven made of a synthetic material such as polyethylene terephthalate or glass. Its strength on the composite 1 is assured by virtue of the anti-tear powder.

[0043] Provision could also be made to associate this layer 8 of thermoplastic powder with a mat of chopped fibers, for example glass fibers.

[0044] The strengthening composite 1 according to the invention can be used in the manufacture of gliding devices, skis, wind blades or pultruded elements.

[0045] The above invention is not limited to the Examples which have been described and shown, it being possible for various modifications to be applied without departing from the framework of the invention.

What is claimed is:

1. A unidirectional strengthening composite (1) based on thread laps, wherein said thread laps consist of:

a first lap (2) of mutually parallel strengthening threads (3),

a second lap (4) of bonding threads (5) composed of a fibrous core coated with a thermoplastic and running transversely to the threads (3) of the first lap (2), being crossed without interlacing, said strengthening threads (3) of the first lap (2) being bonded, at least locally, to the bonding threads (5) of the second lap (4) by fusion of the thermoplastic,

and optionally a third lap (6) of strengthening threads (7) parallel to one another and to those of the first lap (2) and bonded, at least locally, to the coated bonding threads (5) by fusion of the thermoplastic, the coated bonding threads (5) of the second lap (4) being trapped

between the strengthening threads (3) of the first lap (2) and the strengthening threads (7) of the third lap (6).

2. A composite according to claim 1 wherein at least 95% by weight of the strengthening composite (1) consists of strengthening threads (3, 7).

3. A composite according to claim 1 or 2 wherein the strengthening threads (3, 7) have a coverage of approximately 100%.

4. A strengthening composite (1) according to one of claims 1 to 3 wherein the coated bonding threads (5) have a titer of between 30 and 600 tex.

5. A strengthening composite (1) according to one of claims 1 to 3 wherein the coating of thermoplastic on the coated bonding threads (5) is between 10 and 500 g per 1000 linear meters.

6. A strengthening composite (1) according to one of claims 1 to 3 wherein the strengthening threads (3) of the first lap (2) are bulked or texturized.

7. A strengthening composite (1) according to one of claims 1 to 3 wherein the strengthening threads (3) of the first lap (2) are at least partially covered with an anti-tear thermoplastic powder (8).

8. A strengthening composite (1) according to claim 7 wherein the anti-tear thermoplastic powder (8) is covered by a sheet (9) for imparting a particular appearance, which is intimately bonded to the product (1) by at least partial fusion of the anti-tear powder (8).

9. A strengthening composite (1) according to claim 8 wherein the anti-tear powder (8) is associated with a mat of chopped glass fibers.

10. A strengthening composite (1) according to claim 3 wherein the strengthening threads (3 and 7) are contiguous in the first lap (2) and optionally in the third lap (6).

11. A strengthening composite (1) according to claim 3 wherein the strengthening threads are distributed over a first lap (2) of strengthening threads (3) that are mutually parallel and arranged in a sliver, and over a third lap (6) of strengthening threads (7) that are parallel to one another and to those

of the first lap and are also arranged in a sliver, the slivers of the first lap being contiguous with those of the third lap so that the strengthening threads have a coverage of approximately 100%.

12. A strengthening composite according to one of claims 1 to 3 wherein the bonding threads (5) are distributed in groups of two, three or four.

13. A strengthening composite according to claim 1 or 12 wherein the spacing existing between each bonding thread (5) or group of bonding threads (5) has a pitch of between 1 and 10 cm.

14. A strengthening composite (1) according to claims 1 to 3 wherein the thermoplastic is selected from polypropylene, polyethylene, polyamide, polyethylene terephthalate, polyester, ethylene/vinyl acetate or mixtures thereof.

15. A strengthening composite (1) according to one of claims 1 to 3 wherein the strengthening threads (3 and 7), as well as the coated core of the bonding threads (5), are made of a material selected from glass, carbon, aramide and HP synthetics.

16. A process for the manufacture of a strengthening composite (1) according to one of claims 1 to 15 which comprises the following steps:

forming a first lap (2) of mutually parallel strengthening threads (3) and superimposing on this first lap (2) a second lap (4) of bonding threads (5) composed of a fibrous core coated with a thermoplastic and running transversely to the strengthening threads (3) of the first lap (2), being crossed without interlacing,

and bonding said laps (2 and 4) at their intersection by thermocompression.

17. Use of a strengthening composite (1) according to one of claims 1 to 15 in the manufacture of skis, wind blades or pultruded elements.

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