REINFORCED NONWOVEN FABRIC

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Abstract

A flat textile structure has a reinforcing grid and at least one pile layer which is placed flat on at least one surface of the reinforcing grid. The flat textile structure has a weight per unit area of from 40 to 140 g/m². The pile layer is formed predominantly of carbon fibers. The carbon fibers in the flat textile structure have a proportion of the weight per unit area of from 60 to 97%, the reinforcing grid has a proportionate weight per unit area of from 2.5 to 12.5 g/m² and the flat textile structure is strengthened.
REINFORCED NONWOVEN FABRIC

AREA OF THE INVENTION

[0001] The present invention relates to a woven material that has been reinforced for improved handling during the manufacturing process, a component incorporating the reinforced nonwoven material, and its use. In particular, the present invention relates to a carbon fiber nonwoven with a reinforcing grid contained therein.

BACKGROUND OF THE INVENTION

[0002] During the manufacture of flat textile structures with a relatively low cohesion among the textile fibers, for example in the case of nonwoven or pile, the simplest handling processes can pose a problem, such as rolling the flat structures on and off, and automatically feeding them to additional production stages. One possible way of counteracting this problem is to integrate a reinforcing grid into the flat structure. This basic structure of reinforcing layers incorporated between pile layers represents the starting point of the present invention.

[0003] Disclosed in DE 92 07 367 U1 is a laminate whose surfaces were formed using spunbonded fabric, and which consists of at least two layers of spunbonded fabric and at least one scrim layer, preferably a scrim layer made out of reinforcing yarns, wherein the scrim layers or scrim layer lie(s) between a respective two spunbonded fabric layers (DE 92 07 367 U1, page 2, 2nd complete sentence).

[0004] DE 10 2006 060 241 A1 discloses a carrier insert comprised of a flat textile structure and a reinforcement, in which the flat textile structure, which already exhibits the reinforcement, was solidified hydrodynamically. Described in particular are spunbonded fabrics, which are generated by randomly depositing freshly melt-spun filaments, and consist of endless synthetic fibers made up of melt-spinable polymer materials (DE 10 2006 060 241 A1, paragraph [0036]).

[0005] EP 1 584 737 A1 discloses a strengthened, flat nonwoven, which encompasses at least two layers of endless fiber nonwoven made of polyester and a glass fiber grid secured between the nonwoven layers.

[0006] The cited publications relate primarily to the use of the flat textile structures for manufacturing bituminized roof or liner sheeting. Primarily melt spinable polymers are here used for the nonwoven materials, and not carbon fibers. However, no special requirements on weight reduction and mechanical stability are necessary in such applications. For this reason, the known instructions are inadequate for the manufacture of components subject to more stringent requirements in this regard, for example in the automotive or aviation industries.

[0007] Therefore, these applications also require thin flat textile structures, which allow the finished component that ultimately integrates the flat textile structure to withstand the highest possible mechanical loads. As a result, the present invention is geared toward flat textile structures made up completely or predominantly of carbon fibers.

[0008] One difficulty posed by carbon fibers in terms of manufacturing technique has to do with the composition of the carbon fiber surface. In comparison to other polymer fibers, carbon fibers have a very smooth surface. As a consequence, carbon fibers in flat textile structures exhibit a very weak adhesion between the fibers, and hence lead to a low cohesion between the flat textile structures. This low adhesion or low cohesion finally impacts the manufacturing process for flat textile structures comprised of carbon fibers, thus necessitating a reinforcing grid.

[0009] Also required is a flat textile structure that satisfies certain optical and tactile requirements. The reinforcing grid contained in the nonwoven material must be as inconspicuous as possible from outside, and the meshes of the reinforcing grid should not produce any troughs on the surface of the flat textile structure.

[0010] However, primarily the nonwoven layers are responsible for the mechanical stability of the final component that integrates the flat textile structure owing to their percentage of carbon fibers, so that the presence of a reinforcing grid has a detrimental effect on the strength-weight ratio for the component.

[0011] In addition, the use of a reinforcing grid influences the draping characteristics of the nonwoven material. The draping ability here deteriorates as the strength of the reinforcing grid rises.

[0012] At the same time, however, the reinforcing grid must satisfy the purpose for which used, specifically provide adequate reinforcement for the flat textile structure, so as to ensure an improved handling of the latter in the manufacturing process.

[0013] Therefore, the object of the present invention is to prepare a flat textile structure that exhibits the mentioned desired characteristics, while largely avoiding the mentioned shortcomings.

SUMMARY OF THE INVENTION

[0014] The object of the present invention is achieved by an advantageous combination of layer thickness or weight per unit area for the flat textile structure, the proportion of carbon fibers in the weight per unit area, and the proportionate weight per unit area of the reinforcing grid.

[0015] One aspect of the present invention involves a flat textile structure encompassing a reinforcing grid and at least one pile layer flatly situated on at least one surface of the reinforcing grid, characterized in that

[0016] the flat textile structure exhibits a weight per unit area of from 40 to 140 g/cm²,

[0017] the pile layer consists predominantly of carbon fibers,

[0018] the carbon fibers in the flat textile structure make up 60 to 97% of the weight per unit area,

[0019] the reinforcing grid exhibits a proportionate weight per unit area of from 2.5 to 12.5 g/m², and

[0020] the flat textile structure is solidified.

[0021] Another aspect of the present invention is an article that encompasses at least two flat textile structures flatly joined together according to the present invention.

[0022] Another aspect of the present invention is a component that encompasses the flat textile structure according to the invention or the article according to the invention impregnated with a polymer matrix.

[0023] Another aspect of the present invention is the use of the component according to the invention for manufacturing parts of an automobile.

DETAILED DESCRIPTION OF THE INVENTION

[0024] FIG. 1 shows the schematic structural design of a flat textile structure (1) according to one aspect of the present invention. The reinforcing grid (3) according to the invention,
as represented by its grid braces (30), is here secured between two pile layers (2) according to the invention, as represented by its fibers (20).

[0025] FIG. 2 shows the schematic structural design of a preferred embodiment of the flat textile structure (1) according to the invention. Two vertically stacked pile layers (2) here lie on one side of the reinforcing grid (3), while one pile layer (2) lies on the other side. This embodiment is preferred because the surface of the flat textile structure (1) exhibits better optical and tactile characteristics on the side with the two vertically stacked pile layers (2). This becomes advantageous when primarily only one side of the component is visible in the subsequent component that integrates the flat textile structure (1), for example in the case of vehicle doors.

[0026] FIG. 3 shows the schematic structural design of an embodiment of the flat textile structure (1) according to the invention. Two vertically stacked pile layers (2) here lie on one side of the reinforcing grid (3), while the other side of the reinforcing grid (3) remains clear. This embodiment is advantageous in particular when the optical and tactile requirements relate exclusively to one side of the flat textile structure (1).

[0027] The term "pile layer" is known to the expert. It refers to a loose layer of randomly intertwined single fibers that has not been solidified, for example through needling.

[0028] Methods for manufacturing a pile layer (2) are known to the expert, for example willowing or carding. Depending on the method, the alignments for the single fibers (20) in the pile layer (2) are more or less homogeneously distributed. However, the fibers (20) in the pile layer (2) exhibit a preferred direction in some methods, for example in the carding method. This means that the alignment of the fibers (20) in the pile layer (2) is more often encountered in one specific direction than in other directions. This is because the fibers (20) are always combed back and forth in the same direction in the carding process. As a consequence, the resulting pile layer (2) frequently exhibits a greater strength longitudinally to the preferred direction of the fibers (20) than perpendicular thereto. In the present invention, the term "preferred direction" of the pile layer (2) must be understood in the light of the definition provided here.

[0029] A "woven" or "woven material" or a "woven layer" or "woven material layer" refers to a pile layer (2) that has been solidified, for example through needling.

[0030] Methods for solidifying a pile layer (2) into a woven layer, for example needling, are known to the expert. Solidification methods can be thermal, mechanical or chemical in nature. Thermal solidification typically involves melting open a medium that is already added to the flat textile structure before the pile is manufactured, for example. However, mechanical methods encompass needling and stitching. The chemical method typically involves spraying on an adhesive. The methods relating to the pile layer (2) are also applied during the solidification of the flat textile structure (1) according to the invention. All pile layers (2) present in the flat textile structure (1) and the reinforcing grid (3) are here joined together. During mechanical solidification, this occurs in such a way as to interweave the grid braces of the reinforcing grid (3) with individual fibers of the adjoining pile layers (2), which yields a stronger connection between the reinforcing grid (3) and pile layers (2).

[0031] If the pile layer (2) that was further processed into a woven exhibits a preferred direction for the fibers (20), this can often also be discerned from the surface of the woven material, for example after the pile layer (2) has been needled.

[0032] Within the framework of this invention, the flat textile structure (1) according to the invention is referred to as "nonwoven plies" in certain contexts.

[0033] In a preferred embodiment of the present invention, the flat textile structure (1) exhibits a weight per unit area of 80-110 g/m², wherein the carbon fibers in the flat textile structure (1) have a proportionate weight per unit area of 65 to 84%, and the reinforcing grid (3) has a proportionate weight per unit area of 3 to 10 g/m². This embodiment is especially suited for use in components in the automotive industry to replace thin metal sheets, for example engine hoods, doors, fenders, etc.

[0034] The reinforcing grid (3) can be located between two consecutive pile layers (2) inside the flat textile structure (1). The advantage here is that the desired optical and tactile composition can be ensured on both surfaces of the flat textile structure (1).

[0035] Aside from that, it can also be advantageous for the reinforcing grid (3) to be located on the outside of the flat textile structure (1). Very thin flat textile structures (1) can here be fabricated, at least one side of which exhibits the desired optical and tactile composition. As a result, this embodiment is especially suited for use in components according to the invention, which as intended are visible only from one side in the finished product, for example, vehicle doors.

[0036] According to the invention, the pile layers (2) are comprised predominantly of carbon fibers. Within the framework of this invention, the portion that does not consist of carbon fibers is referred to as the "foreign fiber portion". Depending on the context, the foreign fiber portion can relate both to the entire flat textile structure, as well as only to the pile layer (2). A low foreign fiber portion is basically desired, since the stability of the component according to the invention drops as the foreign fiber portion rises. However, carbon fibers are very cost-intensive. Therefore, once a sufficient stability has been reached for the component, foreign fibers can be added to the fibers to be processed in a targeted manner, specifically in such a way that the carbon fibers make up a percentage of the overall weight per unit area of the flat textile structure (1) according to the subject matter of the present invention, preferably a percentage measuring 65 to 84%.

[0037] No special limitations are placed on the material and composition of the reinforcing grid (3). It preferably consists of threads of endless fibers (30), which are present as scrims, wovens, knots or knits, wherein scrims are preferred, since they are the easiest to fabricate, and exhibit the smallest layer thickness at the intersecting points by comparison to knits.

[0038] For example, the fibers in the reinforcing grid (3) can consist of polyester, glass, polyamide, polyethylene, aramide fibers and/or carbon, wherein polyester and glass represent preferred materials for reasons of cost in conjunction with the ratio between strength and fiber thickness.

[0039] Regardless of whether the reinforcing grid (3) is comprised of scrims, wovens, knots or knits, the structural constituents of the reinforcing grid (3) are referred to as "braces" or "grid braces" and "intersecting points" within the framework of this invention, in keeping with the general meaning ascribed to a grid.

[0040] The preferred titers for the braces (30) in the reinforcing grid (3) preferably measure 120 to 350 dtex. Also
preferred are titer between 150 and 280 dtex, since optimal results are achieved in this range with respect to the strength and slope of the troughs, which are formed by the meshes of the reinforcing grid (3) on the surface of the flat textile structure (1) according to the invention, and a sufficient draping ability is ensured.

[0041] The intersecting points of the reinforcing grid (3) can exhibit a binding agent. If the reinforcing grid (3) is a scrim layer, it is preferred that a binding agent be used at the intersecting points. No special limitations are placed on the selection of binding agent. However, PVAC-based binding agents are preferred, since they are hot sealable, and make it especially easy and inexpensive to manufacture the reinforcing grid (3).

[0042] In terms of structural design, the reinforcing grid (3) preferably consists of two to three blades of parallel braces (30). However, more than three blades are also possible.

[0043] If the structural design consists of two blades of parallel braces (5a), the checkerboard structure (5) is preferred, i.e., the reinforcing grid (3) exhibits square meshes. FIG. 5 provides a schematic view depicting a cutout from this structure. The advantage here is that the maximum isotropy for the strength of the flat structure, meaning with a directionally independent strength. The distance between the braces (5a) preferably measures 10 to 50 mm in the embodiment, more preferably 10 to 18 mm, since the troughs described above are less pronounced given smaller meshes.

[0044] If the structural design consists of three blades of parallel braces (4a, 4b, 4c), the braces of one blade are referred to as “longitudinal braces” (4a), and the braces of the other two blades are referred to as “diagonal braces” (4b, 4c). FIG. 4 provides a schematic view depicting a cutout from this structure. Preference here goes to a structural design in which one blade of diagonal braces (4b) is situated at an angle greater than 45° and less than 90° relative to the longitudinal braces (4a), while these angles are less than −45° and greater than −90° for the other blade of diagonal braces (4c), and the angles for both blades of diagonal braces (4b, 4c) relative to the longitudinal braces (4a) are each numerically equal. Viewed in isolation, the blades of the diagonal braces (4b, 4c) thus form rhomboid meshes. In this embodiment, the distance between the longitudinal braces (4a) preferably measures 5 to 20 mm. In this embodiment, the distance between the diagonal braces (4b, 4c) within a blade preferably measures 7 to 50 mm, since the troughs described above are sparingly pronounced as a result, while a sufficient strength is ensured at the same time.

[0045] Regardless of how the grid (3) is designed, a blade of parallel braces (30) of the reinforcing grid (3) is preferably aligned longitudinally to the preferred direction of the fibers (20) in the pile layers (2), if any, while combining the reinforcing grid (3) and pile layers (2). This helps to simplify the manufacturing process.

[0046] A method for manufacturing the flat textile structure (1) according to the invention in which the reinforcing grid (3) is situated between two consecutive pile layers (2) typically encompasses the same steps, preferably within a continuous process:

[0047] a) Manufacturing a pile layer (2) with the desired weight per unit area,
[0048] b) Manufacturing additional pile layers (2) as needed, and applying the latter to the pile layer (2) manufactured in a),
[0049] c) Applying the reinforcing grid (3) to the pile layer (2) manufactured in a), or on the stack of pile layers (2) manufactured in a) and b), if necessary,
[0050] d) Applying at least one additional pile layer (2) on the reinforcing grid (3) prepared in c),
[0051] e) Solidifying the plies placed on top of the other in a) to d), for example through needling, and
[0052] f) Gathering the flat structure (1) created in c), for example on a roller.

[0053] A method for manufacturing the flat textile structure (1) according to the invention in which the reinforcing grid (3) is secured to the outside of the flat textile structure (1) typically encompasses the following steps, preferably within a continuous process:

[0054] a) Applying at least one pile layer (2) on a reinforcing grid (3),
[0055] b) Solidifying the plies placed on top of the other in a), for example through needling, and
[0056] c) Gathering the flat structure (1) created in b), for example on a roller.

[0057] The term “ply” in conjunction with the method described above refers to both a pile layer (2) and the reinforcing grid (3).

[0058] In another aspect of the present invention, several plies of the flat textile structure (1) according to the invention, hereinafter referred to as “nonwoven plies”, can be flatly joined together, thereby giving rise to the article according to the invention.

[0059] The preferred directions of the individual nonwoven plies (1), if any, can be aligned parallel to each other. However, depending on how and where the article is used, it can also be advantageous to flatly join the nonwoven plies (1) at different angles to each other with respect to their preferred direction. One preferred embodiment provides a composite of three nonwoven plies (1), wherein the preferred direction of the middle and upper nonwoven ply (1) is aligned at an angle of 45° or −45° to the preferred direction of the lower nonwoven ply (1). This yields an increased isotropy for the strength of the article and components fabricated from the latter.

[0060] For example, the connection between the nonwoven plies (1) according to the invention can be achieved by simply stitching them together, or through renewed needling. However, other types of joining are also possible.

[0061] In a preferred embodiment, at least one grid ply can be provided between two or more nonwoven plies (1) of the article according to the invention. During the impregnation process, e.g., while injecting a fluid polymer matrix, for manufacturing the component according to the invention, this allows the polymer material to better penetrate into the complex of several nonwoven plies and optimally impregnate the latter, without the individual nonwoven plies (1) slipping relative to each other. The grid ply can be structured based on the reinforcing grid (3) according to the invention. However, a grid with a different structural design can also be used. Knits or scurms consisting of polyester threads are here preferred, since they are easy and inexpensive to manufacture.

[0062] In another aspect of the present invention, the flat textile structure (1) according to the invention or article according to the invention is impregnated with a polymer matrix, leading to the component according to the invention.

[0063] No special limitations are placed on the materials in the polymer matrix. Suitable materials for the polymer matrix
usually include resins, such as polyester resins, epoxy resins and vinyl ester resins, which are used in the manufacture of fiber composite materials.

[0064] Suitable methods for impregnating flat textile structures (1), for example resin injection or infusion methods, are known to the expert. Subsequent hardening, for example through exposure to an elevated temperature, yields a component in the desired form. As a result, it is most often necessary to drape the flat textile structure (1) on a rigid mold beforehand. The flat textile structure (1) according to the invention is here distinguished by an optimal draping ability due to its configuration.

[0065] In another aspect of the present invention, the component according to the invention is used to manufacture automobile parts. No special limitations are here placed on the type and functionality of the components. Non-load bearing parts are here preferred.

[0066] Load-bearing parts in an automobile, such as A, B or C columns, are highly stressable components. If they consist of fiber composite materials, use is usually made of woven matting or scrims, wherein the fiber bundles in the woven matting or scrims are aligned in such a way as to optimally absorb or divert acting forces, i.e., fiber bundles in the woven matting of scrims are preferably aligned in the direction of applied force. In nonwoven materials, the strength is distributed in all directions owing to the structure, wherein the preferred directions generated by combing the pile can again elevate the anisotropy for the strength of the nonwoven material. This is why fiber composite materials fabricated out of nonwovens can be used in highly stressable components of a vehicle. However, the combined use of nonwoven materials and woven matting or scrims is also possible, for example in the form of nonwoven scrim complexes.

1.17. (canceled)

18. A flat textile structure, comprising:
a reinforcing grid;

at least one pile layer formed predominantly of carbon fibers, said at least one pile layer being disposed flat on at least one surface of said reinforcing grid;

the flat textile structure having a weight per unit area of from 40 to 140 g/cm²;
said carbon fibers in said flat textile structure making up 60 to 97% of the weight per unit area;
said reinforcing grid (3) having a proportionate weight per unit area of from 2.5 g/m² to 12.5 g/m²; and

wherein said flat textile structure is solidified.

19. The flat textile structure according to claim 18, wherein:
said flat textile structure has a weight per unit area of 80-110 g/m²;
said carbon fibers in said flat textile structure have a proportionate weight per unit area of 65 to 84%; and

said reinforcing grid has a proportionate weight per unit area of 3 g/m² to 10 g/m².

20. The flat textile structure according to claim 18, wherein said reinforcing grid (3) is located on an outside surface of said flat textile structure.

21. The flat textile structure according to claim 18, wherein said reinforcing grid is located between two adjacent pile layers.

22. The flat textile structure according to claim 18, wherein said reinforcing grid is formed of one or both of polyester or glass.

23. The flat textile structure according to claim 18, wherein said reinforcing grid includes braces having a titer of 120 dtex to 350 dtex.

24. The flat textile structure according to claim 18, wherein said reinforcing grid is formed with intersecting points and said intersecting points have a binding agent.

25. The flat textile structure according to claim 18, wherein said reinforcing grid is a laid scrim.

26. The flat textile structure according to claim 18, wherein said reinforcing grid comprises a blade of parallel longitudinal braces in a given direction, and blades of parallel diagonal braces disposed diagonally to said parallel longitudinal braces, wherein one blade of said parallel diagonal braces is disposed at an angle greater than 45° and less than 90° relative to said parallel longitudinal braces, and another blade of said parallel diagonal braces is disposed at an angle less than −45° and greater than −90°, and the angles for both blades of said parallel diagonal braces relative to said parallel longitudinal braces are each numerically equal.

27. The flat textile structure according to claim 26, wherein said longitudinal braces are spaced 5 to 20 mm apart from one another, and said diagonal braces are spaced 7 to 50 mm apart from one another.

28. The flat textile structure according to claim 18, wherein said reinforcing grid has a checkerboard layout.

29. The flat textile structure according to claim 28, wherein the respective said parallel braces are spaced 10 to 50 mm apart from one another.

30. The flat textile structure according to claim 18, wherein said pile layers comprise predominantly staple fibers.

31. An article of manufacture, comprising at least two flatly joined flat textile structures according to claim 18.

32. A component, comprising a flat textile structure according to claim 18 impregnated with a polymer matrix.

33. A component, comprising at least two flatly joined flat textile structures according to claim 18 impregnated with a polymer matrix.

34. An automobile part, comprising a flat textile structure according to claim 18 impregnated with a polymer matrix and formed into an automobile component part.