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(54) **Multi-axial multilayer woven fabric, process for its manufacture and use of such fabric for a reinforcement composite**

(57) The present invention relates to a multilayer, multiaxial woven fabric, a manufacturing process and the use of said fabric for a reinforcement composite. This woven fabric is formed from a structure of at least two layers joined to one another, being joined by a warp - weft process, with the orientation of the weft yarns of adjacent cloths (10, 11, 12) superimposed at different angles with respect to the warp yarns (15) to form stacked layers, wherein the rebonding of the different stacked layers is done with weft yarns (13, 14) of the cloths (10, 11, 12) themselves.

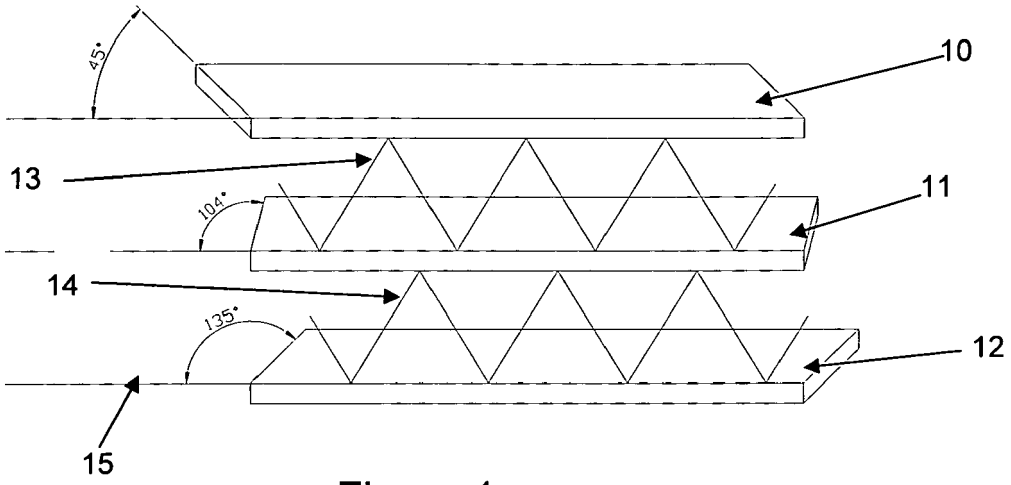

Figura 1

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Description

[0001] The present invention relates to a multilayer, multiaxial woven fabric that has been designed to be the reinforcement base material acting like an inner core or framework of a reinforcement composite, i.e., a synthetic, multilayer, high performance composite, based on the mentioned fabric and one or several resins which are particularly for use in the aeronautics industry, wind power generation industry, in construction, etc., and particularly resistant to multidirectional stresses, delamination, impact and breaking. The fabric can be made from any type of fiber that adapts to the conditions required for its final application.

[0002] In a second aspect, the invention also relates to a manufacturing process for manufacturing the mentioned multilayer, multiaxial woven fabric.

[0003] The invention also provides a use of the mentioned multilayer, multiaxial woven fabric to form a reinforcement composite.

State of the Art

[0004] The following can be mentioned as background of the invention:

- The classic double cloth fabric with angles of the weft with respect to the warp yarn being 0° and 90°;
- Stacked fabric structures formed by several layers of fabric joined to one another by needling, stitching or resinating.

[0005] Patent EP 441719 B1, relating to a multilayer flexible structure resistant to shear action comprising two layers of fabric retaining a reinforcement element providing increased resistance between such layers, said two layers of fabric being joined to one another by means of a layer of a material having a modulus of elasticity with respect to a shear stress is also known in the state of the art, wherein said reinforcement element increasing the resistance consists of a weft knitting structure based on parts which maintain freedom of movement without breaking under the action forces exerted parallel to the surface thereof.

[0006] Patent application WO 0377692 discloses a cut-resistant fabric which comprises at least two layers and/or two directions of individual elements, at least one individual element of which is a reinforcement element comprising a reinforcement fiber and said elements are not interwoven, rather they only have an indirect connection created by chemical, plastic or rubber elements, or by connecting elements which are weaker than the reinforcement element.

[0007] Patent application CN 201511560 discloses a triaxial fabric used for a composite applied to the blades of a generator, wherein adjacent layers are stacked to form an integral structure, and wherein a first layer of yarn is in a direction of 0 degrees, and it is the base layer on which a second layer of yarn is arranged at + 45° which is based on the base layer and the third layer is a layer of yarn at -45°, the three layers being stitched together to form said triaxial structure.

[0008] In turn, patent application WO 2011/033145 discloses a double cloth fabric comprising a first cloth woven with yarns with a first composition (intimate mixture of meta-aramid and para-aramid fibers) and a second cloth with a second composition of the same fibers, both cloths being joined to one another by means of linking stitches (preferably warp yarns of the first cloth or of the second cloth) with a concentration comprised between 5 and 50 linking stitches/cm^2, said stitches being produced from the yarns that are an intimate mixture of meta-aramid fibers and para-aramid fibers and the para-aramid yarn of the second layer being arranged in warp and/or weft, preferably in warp and weft.

[0009] Unlike the mentioned background documents, the invention proposes another linking configuration between the various layers forming it which allows stacking a high number of layers, providing a core that is highly resistant to multidirectional stresses and therefore having properties that are quite favorable for a reinforcement composite in which it is integrated after the conventional resinating step.

Brief Description of the Invention

[0010] The invention proposes a woven structure and a manufacturing process based on technical yarns, forming a woven structure of several cloths joined to one another by a warp-weft process at different angles of the weft yarns with respect to the warp yarns, forming several stacked layers.

[0011] The objective of the invention is to manufacture composites based on said multilayer, multiaxial fabric that are more resistant to multidirectional stresses, particularly resistant to delamination and impacts. Known composites tend to peel when these types of stresses are applied, particularly when a certain threshold is exceeded. The fabrics of the invention are comparatively much more resistant due to the special multiaxial rebonding defining them.

[0012] Technical yarns such as carbon fiber, glass fiber, polyester, and polyvinyl alcohol type yarns, as well as combinations thereof, and yarns with various rectangular or planar sections, as well as yarns with a circular section, are used to prepare the mentioned woven structure.

[0013] The new woven structure consists of a fabric similar to that which is already known as double cloth fabric but with the innovation that it includes wefts with angles with respect to the warp (understood as being 0°) of $\pm\ \theta$, i.e. with an angle θ having in principle any value, to be chosen according to the features of the fabric as the core of a composite.

[0014] The proposed woven structure is obtained from rebonding with wefts of the adjacent cloths themselves.

They are joined correlatively, i.e., a first cloth is joined with a second cloth, the second cloth with a third cloth, etc. It is not necessary to use auxiliary yarns or other methods for joining cloths such as needling or stitching, which is advantageous because the multilayer, multiaxial fabric obtained does not experience external aggressions and it maintains its structure intact, without destroying the fibers. The rebonding is performed at the same time as weaving using weft yarns of the adjacent cloths in forming stacked layers. This process allows rebonding between layers at different angles, i.e., one layer at 90°, the next layer at 45° (or a different orientation), etc., which is neither provided for nor suggested in the aforementioned fabrics applied for the described purpose.

[0015] Therefore, in the stacked cloths some cloths adopt a direction of the conventional warp and weft yarns (0°, 90°) and others (0°, + θ) or (0°, - θ).

[0016] This arrangement provides a multiaxial shed providing high resistance to stresses in multiple directions that can be applied in the final composite, formed from a plurality of cloths joined to one another, forming a stack of layers.

[0017] To manufacture the multilayer, multiaxial woven fabric described, the warp yarns are placed in a warp unwinder, each cloth with its corresponding yarn, a layer being obtained by joining two cloths with the weft yarns of both. Then the yarns are passed through a multilayer mechanism which selects the layers to form the shed. The layers are then woven by means of a mechanism which allows multiaxial rebonding according to the previously explained structure. The layers fmally pass through a fabric regulator and the multilayer, multiaxial fabric is finally collected and will subsequently move on to a conventional resinating step to form a composite.

[0018] Although the manufacturing process for manufacturing the multilayer, multiaxial fabric involves greater difficulty, it allows stacking many more layers than in a conventional fabric (more than 3 and up to a number of 14-20).

Brief Description of the Drawing

[0019] Sole Figure 1 of the drawings schematically shows an embodiment of a multilayer, multiaxial woven fabric according to the principles of this invention.

Description of an Embodiment

[0020] The attached Figure 1 shows an embodiment of a multiaxial woven fabric, comprising in this case three cloths 10, 11 and 12 woven according to a known warp - weft process, determining three stacked layers which are rebonded from wefts of the cloths themselves, the cloths being correlatively joined to one another, showing that the orientation of the weft yarns of each layer with respect to the warp yarns is different from the previous one, specifically being arranged from top to bottom at 135°, 104° and 45° with respect to a reference orientation of 0°.

[0021] In order to understand the proposal of this invention, it must be taken into account that a layer in this specification will be considered as the set of two adjacent cloths 10, 11 linked by the weft yarns of both.

[0022] Therefore, in the example shown in Figure 1, rebonding yarns 13 comprise weft yarns of cloth 10 and of cloth 11 and rebonding yarns 14 integrate weft yarns of cloths 11 and 12. The cloths 10, 11 and 12 forming the stacked layers have been drawn separated from one another for better understanding of the proposal providing, as indicated, a fabric suitable for obtaining a composite or composite structure that is very resistant to multidirectional stresses, particularly resistant to delamination and to impacts.

[0023] The invention also provides that in addition to obtaining the rebonding yarns from the weft yarns 13, 14 of two adjacent cloths to form a layer, additional weft yarns are complementarily used.

[0024] As indicated, the woven structure is obtained from technical yarns, for example carbon fiber yarns, glass fiber yarns or yarns of another suitable nature, provided that the material of the technical yarn is not a determining factor of the fabric structure or of the manufacturing process

[0025] The manufacturing process for manufacturing a multilayer, multiaxial woven fabric according to the invention comprises the following steps:

- placing the warp yarns in a warp unwinder, each layer with its corresponding yarn;
- arranging the warp yarns through a multilayer mechanism which selects the layers to form the shed;
- weaving the layers by means of a mechanism which makes multiaxial rebonding possible, with certain selected orientations of the weft yarns with respect to the warp yarns of the layers.

[0026] All the mentioned devices, such as the unwinder, the multilayer mechanism and the fabric regulator, are of a conventional structure in weaving.

[0027] The layers thus obtained are then passed through a fabric regulator and the multilayer, multiaxial fabric is then collected and will subsequently move on to a resinating process to obtain a composite.

[0028] The invention thus proposes using a multilayer, multiaxial woven fabric for a reinforcement composite comprising a woven structure in the form of several layers joined to one another by a warp-weft process, with the weft yarns of the layers oriented at different angles with respect to the warp yarns.

Claims

1. A multilayer, multiaxial woven fabric formed from a structure of at least two layers joined to one another, **characterized in that** said joining is obtained by a

warp - weft process, with the orientation of the weft yarns of cloths (10, 11, 12) superimposed at different angles with respect to the warp yarns (15).

2. The multilayer, multiaxial woven fabric according to claim 1, **characterized in that** the different stacked layers are rebonded with weft yarns (13, 14) of the cloths (10, 11, 12) themselves.

3. The multilayer, multiaxial woven fabric according to any one of the preceding claims, **characterized in that** the cloths (10, 11, 12) are correlatively joined to one another to form the stacked layers of the fabric.

4. The multilayer, multiaxial woven fabric according to any one of the preceding claims, **characterized in that** it comprises more than three layers.

5. The multilayer, multiaxial woven fabric according to claim 4, **characterized in that** it comprises 4 to 12 layers.

6. The multilayer, multiaxial woven fabric according to any one of the preceding claims, **characterized in that** the yarns of the woven structure are technical yarns chosen from a group comprising carbon fiber, glass fiber, polyester, and polyvinyl alcohol, as well as combinations thereof.

7. The multilayer, multiaxial woven fabric according to claim 6, **characterized in that** the yarn section is planar or circular.

8. A manufacturing process for manufacturing a multilayer, multiaxial woven fabric comprising the following steps:

- placing the warp yarns (15) in a warp unwinder, each layer with its corresponding yarn;
- arranging the warp yarns (15) through a multilayer mechanism which selects the layers to form the shed;
- weaving the layers by means of a mechanism providing multiaxial rebonding by means of orienting the weft yarns (13, 14) of the woven cloths (10, 11, 12) at different angles with respect to the warp yarns.

9. The manufacturing process for manufacturing a multilayer, multiaxial woven fabric according to claim 6, **characterized in that** the layers obtained are passed through a fabric regulator and the multilayer, multiaxial fabric is collected.

10. Use of a multilayer, multiaxial woven fabric for a reinforcement composite comprising a woven structure in the form of several cloths joined to one another forming several superimposed layers by a warp-weft process, with the weft yarns of the cloths joining the layers to one another and oriented at different angles with respect to the warp yarns.

11. Use according to claim 9, **characterized in that** the rebonding of two cloths to form a layer is done with wefts of the cloths (10, 11, 12) themselves.

12. Use according to claim 10, **characterized in that** the rebonding of the cloths (10, 11, 12) to form a layer is done with weft yarns in addition to those of the cloths (10, 11, 12) themselves.

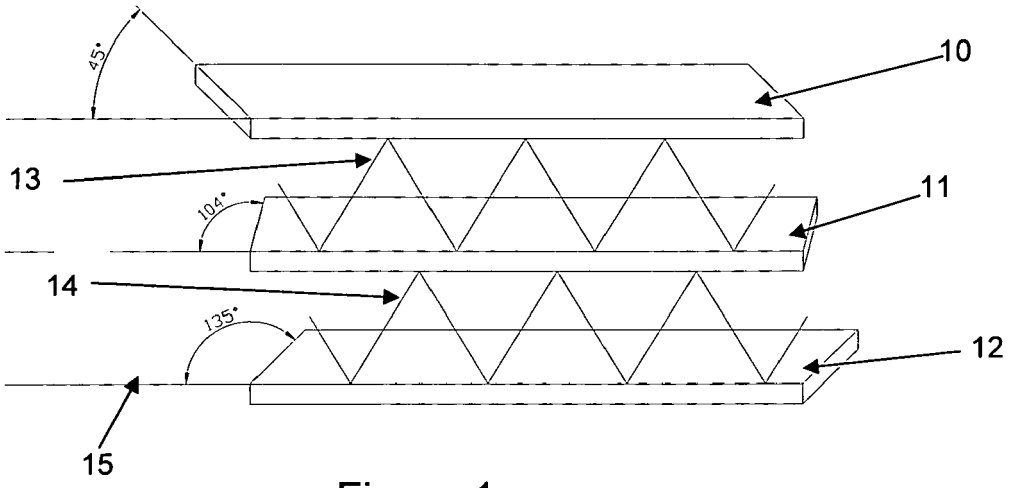

Figura 1

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EUROPEAN SEARCH REPORT

Application Number
EP 11 38 0109

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 May 2012	Iamandi, Daniela

CATEGORY OF CITED DOCUMENTS

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