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(54) Title: PIN/HOLE JOINT CONSTRUCTION AND LAMINATE THEREOF

(57) Abstract: A pin/hole joint construction in a laminate (1) comprises layers (9) of fibres and resin bonded to one another. At least one hole (2) extends transversely completely through the layers in the laminate, in which hole a pin (3) is accommodated that bears against the inner surface of the hole for transferring forces between the laminate and the pin. In the laminate a first region (13) is defined in which the layers are directly on top of one another and a second region (14) in which at least one reinforcing layer (5) is provided that is bonded to the adjacent layers of fibres and resin, in which second region the at least one hole is located. All layers of fibres and resin are continued into the second region.
Pin/hole joint construction and laminate therefor

The invention relates to a pin/hole joint construction in a laminate that comprises layers of fibres and resin bonded to one another, wherein at least one hole extends transversely completely through the layers in the laminate, in which hole a pin is accommodated that bears against the inner surface of the hole for transferring forces between the laminate and the pin, in which laminate a first region is defined in which the layers are directly on top of one another and a second region in which at least one reinforcing layer is provided that is bonded to the adjacent layers of fibres and resin, in which second region the at least one hole is located.

A pin/hole joint construction of this type is disclosed in WO-A 0056541. The joint construction concerned can be a bolted joint, but such a construction also arises with other joints, such as with rivets. An important factor when determining the strength of such a pin/hole joint construction is the maximum permissible surface pressure. The surface pressure is equal to the stress that on average is exerted on the inner surface of the hole by the pin, such as the shaft of the bolt, in contact with it. The stress must, of course, remain below the value at which either the material or the cohesion of the laminate fails.

The reinforcing material can, for example, be a metal. Since metal has a higher maximum permissible surface pressure than the materials from which the laminate is composed, a fairly high force can be transferred between the pin and the laminate. In the first instance, the force is therefore taken up by the material bordering the hole in the reinforcing material. Transfer of force then takes place by sheer stresses via the bonding surfaces between the layers of reinforcing material and the laminate layers.

In the known pin/hole joint construction a laminate is used in which the orientation of fibres in the layers of fibres and resin differs from layer to layer in the conventional manner. Layers with a specific orientation of fibres are continued from the first region into the second region in which the hole is located. Other layers, however, do not extend as far as said second region. Layers of reinforcing material are incorporated in the second region at the location of the interrupted layers of fibres and resin. These layers of reinforcing material butt onto the interrupted layers of fibres and resin.

Such a pin/hole construction is used for joining the longitudinal stringers in a wing construction, which are stressed mainly in the longitudinal direction thereof. For this reason the layers of fibres and resin in which the orientation of fibres is coincident with the
longitudinal direction of the stringers are therefore also continued into the second region.

This known pin/hole construction has various disadvantages. First of all, the production thereof is problematical. The laminate is made up by stacking the layers on top of one another in a mould. The interrupted layers of fibres and resin have to be shortened to the correct extent, such that these can be accommodated alongside the layers of reinforcing material with accurate abutment. There is the risk that these layers shift with respect to one another and start to overlap one another, which has a severe adverse effect on the quality of the finished laminate. The production of laminates with a single or double curvature is also not easy in view of the problems that arise in bringing these layers into abutment with one another in the correct manner.

A further disadvantage is that the strength and fatigue characteristics of this known pin/hole construction are limited. To a substantial extent this is caused by the fact that only layers with a specific orientation of fibres are continued into the second region in which the pin extends.

The aim of the invention is, therefore, to provide a pin/hole construction of the abovementioned type that does not have these disadvantages. Said aim is achieved in that all layers of fibres and resin are continued into the second region.

Because in the pin/hole construction according to the invention the layers of fibres and resin are not shortened but are continued uniformly into the second region, the production process can be carried out much more easily and without the risk of overlaps. Moreover, the strength and fatigue characteristics of the pin/hole construction according to the invention are outstanding because layers with different fibre orientations now also participate directly in the transfer of forces.

The pin/hole construction according to the invention can be made in various ways. Preferably, there is a reinforcing layer between each two layers of fibres and resin and each reinforcing layer is bonded on both surfaces thereof to an adjacent layer of the laminate.

According to a further advantageous embodiment, provision is made that there is a reinforcing layer on at least one of the surfaces of the laminate, which reinforcing layer is bonded to said surface of the laminate.

The reinforcing layer, such as a metal layer, ensures that the outside of the laminate is flat in the second region. Specifically, when forming, in particular vacuum forming, from laminates made with plastic fibres the side facing away from the mould is relatively rough and uneven. This problem is solved by using a metal reinforcing layer on that side.
As already mentioned, the orientation of the fibres in the various layers can differ, for example 0°, 90°, +45°, −45°.

The invention furthermore relates to a laminate for use with the pin/hole construction as described above, comprising layers of fibres and resin bonded to one another, wherein at least one hole in which a pin can be accommodated extends transversely completely through the layers in the laminate, in which laminate a first region is defined in which the layers are directly on top of one another, and a second region in which at least one reinforcing layer is provided that is bonded to the adjacent layers of fibres and resin, in which second region the at least one hole is located.

Reference is made to the method for the production of a laminate as disclosed in NL-A 1019601 that is covered with metal layers on both surfaces. Such a method can also be used for the production of a laminate only part of which is covered by metal layers, at the location of the pin/hole construction.

According to the invention this can be achieved by means of a method for the production of a laminate with a hole though it as described above, which laminate has two outer layers consisting of metal, comprising the following steps:
- provision of a first metal layer,
- placing a stack of layers of fibres and resin and metal layers located between them on the first metal layer, which layers of fibres and resin have a larger surface size than the metal layers, with the formation of a semi-finished product,
- applying a vacuum when introducing the resin,
- and, after applying said fibre material, impregnating the resin material into said fibre material and applying an internal vacuum under external atmospheric conditions.

The invention will be explained in more detail below with reference to an illustrative embodiment shown in the figure.

The pin/hole joint construction according to the invention shown in the figure comprises a laminate 1 known per se. In the laminate 1 a first region 13 in which the layers 9 of fibres and resin are bonded directly to one another and a second region 14 in which a hole 2 has been made can be differentiated. There is a pin 3, for example the shaft of a connecting bolt, in the hole 2. Force transfer takes place between the shaft and the inner surface 4 of the hole 2. The pin 3 is pressed against the surface 4, as a result of which a certain so-called surface pressure is produced. The limiting factor in the strength of the joint construction is therefore constituted by the laminate 1.
According to the invention the strength of the laminate can be appreciably increased by incorporating several reinforcing layers 5 therein. These reinforcing layers 5 consist of thin metal layers. The reinforcing layers 5, which each have a hole 6 that is in contact with the pin 3, take over a portion of the force that is transferred by the pin 2 to the laminate 1.

The reinforcing metal layers 5 within the laminate have two surfaces 7, 8, each of which is bonded to a surface of a layer from the laminate 1.

The supplementary reinforcing layers 5 ensure that the forces are transferred from the pin 3 into the laminate 1 over a relatively large surface area by means of sheer forces. Because the thickness of the additional reinforcing layers is restricted, the thickness in the region of the hole 2 also remains restricted, and this is in any event no greater than the thickness of the conventional joint construction with a single, relatively thick metal insert.

The additional reinforcing layers 5 can be both in the laminate, that is to say can be bonded to the laminate on both surfaces. However, reinforcing layers 5 can also be on the outer surfaces of the laminate 1, which reinforcing layers 5 are then bonded to the laminate on one of their surfaces.

The supplementary reinforcing layers 5 can be applied in a known manner, for example by manual lamination, vacuum injection, pressure injection, pre-pregging, winding and the like.

As a consequence of the improved transfer of force between the pin 3 and the laminate 1, the distance 11 from the hole 2 to the edge 12 of the laminate can also be smaller and can be, for example, 2.5 times the diameter of the hole 2.

A supplementary advantage of the joint construction according to the invention is that there are found to be no creep effects in the joint construction. This has the advantage that a joint construction constructed in the form of a bolted joint does not have to be tightened after some time because the fibre layers are enclosed between the layers 5.
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Claims

1. Pin/hole joint construction in a laminate (1) that comprises layers (9) of fibres and resin bonded to one another, wherein at least one hole (2) extends transversely completely through the layers (9) in the laminate (1), in which hole (2) a pin (3) is accommodated that bears against the inner surface (4) of the hole (2) for transferring forces between the laminate (1) and the pin (3), in which laminate (1) a first region (13) is defined in which the layers (9) are directly on top of one another and a second region (14) in which at least one reinforcing layer (5) is provided that is bonded to the adjacent layers (9) of fibres and resin, in which second region (14) the at least one hole (2) is located, characterised in that all layers (9) of fibres and resin are continued into the second region (14).

2. Joint construction according to Claim 1, wherein there is a reinforcing layer (5) between each two layers (9) of fibres and resin.

3. Joint construction according to Claim 1 or 2, wherein each reinforcing layer (5) consists of metal.

4. Joint construction according to one of the preceding claims, wherein each reinforcing layer (5) is bonded on two surfaces thereof to an adjacent layer (9) of the laminate.

5. Joint construction according to one of the preceding claims, wherein there is a reinforcing layer (5) on at least one of the surfaces of the laminate (1), which reinforcing layer (5) is bonded to said surface of the laminate (1).

6. Joint construction according to one of the preceding claims, wherein the orientation of fibres in the layers (9) of fibres and resin differs from one layer to another.

7. Joint construction according to one of the preceding claims, wherein the orientation of fibres is 0° and/or 90° and/or 45° and/or -45°.

8. Joint construction according to one of the preceding claims, wherein the layers (9) of fibres and resin and the reinforcing layers (5) have a double curvature.

9. Laminate (1) for use with a pin/hole joint construction according to one of the preceding claims, comprising layers (9) of fibres and resin bonded to one another, wherein at least one hole (2) in which a pin (3) can be accommodated extends transversely completely through the layers (9) in the laminate (1), in which laminate a first region (13) is defined in which the layers (9) are directly on top of one another, and a second region in which at least one reinforcing layer (5) is provided that is bonded to the adjacent layers (9)
of fibres and resin, in which second region (14) the at least one hole (2) is located, characterised in that all layers (9) of fibres and resin are continued into the second region (14).

10. Assembly comprising at least two laminates (1) with a hole (2) though them according to Claim 9, as well a pin (3) that is accommodated in the holes (2) of the laminates (1).

11. Method for the production of a laminate according to Claim 9, which laminate has two outer layers consisting of metal, comprising the following steps:
- provision of a first metal layer (5),
- placing a stack of layers (9) of fibres and resin and metal layers (5) located between them on the first metal layer (5), which layers (9) of fibres and resin have a larger surface size than the metal layers (5), with the formation of a semi-finished product,
- applying a vacuum when introducing the resin,
- and, after applying said fibre material, impregnating the resin material into said fibre material and applying an internal vacuum under external atmospheric conditions.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B32B3/06 B29C70/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C F16C B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>EP 0 783 960 A (BOEING CO) 16 July 1997 (1997-07-16) figure 5 column 15, line 48 - column 16, line 21</td>
<td>1-9</td>
</tr>
<tr>
<td>Y</td>
<td>DANIEL GAY: &quot;Matériaux composites&quot; 1991, HERMES, FRANCE, XP002291365 page 160; figures</td>
<td>1,9,10</td>
</tr>
<tr>
<td>X</td>
<td>GB 706 096 A (BRIAN PARKYN; ERNEST BADER) 24 March 1954 (1954-03-24) claim 1</td>
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Further documents are listed in the continuation of box C.

X Patent family members are listed in annex.

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<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
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<tbody>
<tr>
<td>JP 9193296 A</td>
<td></td>
<td>US 6114050 A</td>
<td>05-09-2000</td>
</tr>
<tr>
<td>GB 706096 A</td>
<td>24-03-1954</td>
<td>NONE</td>
<td></td>
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