Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

Technical Field

[0001] The present invention relates to a method of automatically (robotically) placing fiber means into a plurality of channels of a mold to form the ribs of a structural member. The present invention also relates to a fiber placement head for use in placing fiber means, preferably automatically, into a plurality of channels of a mold utilizing a number of such heads.

Background Art

[0002] So-called isogrid structures have been developed that are very advantageous in terms of weight and strength. Such composite isogrid structures comprise a ribbed latticework by itself, or with the addition of a skin or panel on one or both sides of the ribs. Such isogrid structures are formed by placing fiber means into the channels of a female mold. After completion of placement of the fiber means into the channels, the resulting latticework is cured, if necessary, and removed from the mold. A skin, such as a composite layer, can be placed on one side of the latticework and cured therewith prior to removal from the mold, or skin or panels can be placed on one or both sides after removal from the mold. Skin or panels can be secured to the ribs by, for example, an appropriate adhesive. The skin can, for example, be a preimpregnated tape or woven cloth. The panels can be made of any suitable material. Isogrid structures can be used for a variety of purposes. By way of example only, isogrid structures, be they in the form of panels, cylinders, cones or any other suitable shape, can be used for deck- ing, shipping containers, walking bridges, housing material, automotive applications, shrouds, signs, support structures, wings and fuselages, spacecraft structure, etc. The ribbed latticework by itself can be used, for example, as reinforcement for a poured structure, such as in concrete slabs.

[0003] Up until now, no quick and economical means have been available for placing fiber means into molds to form the ribbed isogrid latticework structure. Pursuant to some heretofore known approaches, fiber means have been placed into the mold one channel at a time. At best such procedures are at least partially manually performed.

[0004] US 5,200,251 A discloses a cylindrical isogrid structure made of wound fibers and a method of making such a structure. A single fiber placement head is movable in one direction. A cylindrical mandrel for forming the isogrid structure is rotatable relative to the fiber placement head. A similar method and device is disclosed in WO 90/07425 A. A mandrel for forming a grid is carrying rectangular disposed grooves. A single fiber placement head fills rovings into the angular disposed grooves.

[0005] DE 33 31 494 A1 proposes to use multiple fiber placement heads to place tapes of carbon fibers synchronously in parallel to each other on a carrier foil. The tapes are placed flush to each other in order to form a continuous flat fiber material. Every single placement head is controlled independently to form a flat material contour, which is as close as possible to the desired structure contour. The structure contour is cut out of the flat carbon fiber material being formed by the multiple strips of a carbon fiber tape. However, the arrangement is adapted to place flat fiber material and not fiber tows, and is therefore not suitable to fill channels of a mold in order to form ribs of a structural member.

[0006] A procedure also known from conventional fiber placement systems uses reciprocating shoes that push and pull a wide band of fiber tows or tapes onto the top of the mold or into the mold channels. This known process is not continuous, it pulsates, and is very slow. In addition, the fiber placement systems are bulky and expensive. Applicant is not aware of any more relevant art, and certainly none that provides for an automatic, multiple head lay-down process.

[0007] It is therefore an object of the present invention to provide a continuous fiber placement method and fiber placement heads that are very time and cost effective.

Brief Description of the Drawings

[0008] The features of the invention, and its technical advantages, can be seen from the following description of the preferred embodiments together with the claims and the accompanying schematic drawings, in which:

Fig. 1 shows one exemplary embodiment of a female mold with channels used for practicing the method and apparatus of the present invention;
Fig. 1a is an enlarged view of several triangular nodal areas of the mold of Fig. 1;
Fig. 2 is a front view of a table and gantry for placing fiber means into the mold of Fig. 1;
Fig. 3 is a top view of the apparatus of Fig. 2;
Fig. 4 is a side view of the apparatus of Fig. 2;
Figs. 5a and 5b are detailed views showing two positions of the fiber placement head assembly of the present invention;
Fig. 6 shows one exemplary embodiment of a ribbed isogrid latticework structure without a skin covering, showing attachment means;
Fig. 7 is a side view of a further exemplary embodiment for processing a cylindrical mold;
Fig. 8 is a top view of the apparatus of Fig. 7;
Fig. 9 is a front view of the apparatus of Fig. 7;
Fig. 10 is a side view of another embodiment.
Disclosure of the Invention

[0009] The method of the present invention is characterized primarily by providing relative movement between a mold and the fiber-placement heads, while providing such relative movement simultaneously placing the fiber means into a number of the channels of the mold by means of the heads, and repeating the relative movement and placement as often as necessary to dispose into the channels a desired thickness of the fiber means, thus forming a lattice structure.

[0010] The fiber-placement head of the present invention is characterized by a single motor-driven wheel for continuously withdrawing fiber means from a spindle or other supply thereof, means for guiding the fiber means into the channels of a mold, and means for compacting the fiber means in the channels.

[0011] Pursuant to the present invention, a plurality of such fiber-placement heads can be used in an apparatus that is characterized by means for providing relative movement between the heads and a mold, and means for automatically controlling the heads and the relative movement between such heads and the mold.

[0012] The inventive method and fiber-placement heads make it possible to significantly reduce the time and cost for disposing fiber means simultaneously into a number of the channels of a mold to form the ribs of a structural member. In particular, by the use of several such heads, the number of passes required to effect placement of the fiber means into the mold channels is reduced. In other words, a multiple lay-down process of fiber means into the mold channels is provided. In addition, by reducing manual operations in conjunction with the placement of the fiber means into the mold channels, the time for effecting such fiber placement is greatly reduced, as is the cost for the overall production.

[0013] Further specific features of the present invention will be described in detail subsequently.

Detailed Description of Preferred Embodiments

[0014] Referring now to the drawings in detail, an example of an isogrid mold used in conjunction with the method and apparatus of the present invention is shown in Fig. 1. This mold is indicated generally by the reference numeral 10, and is a female mold cast from a male mold designed for a particular application, or can also be made from a solid or hard material using a cutting device such as a router. The mold can be made of polymeric material, including rubber and foam, or can be made of some other material, such as particle board. The aforementioned male mold can be a metallic isogrid-patterned casting tray that is machined. However, it would also be possible to provide a composite male mold using a stereolithography mold process. The female mold 10 can then be cast by pouring polymeric material, such as SILASTIC™, therein and allowing the casting tray and SILASTIC™ silicone rubber to cure, for example, at room temperature for 24 hours, to form the female mold.

[0015] Grooves or channels 11 are disposed in one surface of the mold 10 and form the isogrid design. These channels 11 extend in three different directions, preferably at 60° relative to one another, e.g. +60, -60, and 0, so as to form triangles between them, preferably equilateral triangles. The embodiment of the mold 10 shown in Fig. 1 is a flat mold. Other shapes of the mold 10 are also possible, and will be discussed in detail subsequently.

[0016] The following discussion will first be made in conjunction with the production of a flat panel using the flat female mold 10 of Fig. 1. In order to place fiber means into the channels 11 of the mold 10, the mold is placed on an X, Y, Z computer table as illustrated in Fig. 2; in this embodiment, the gantry 20 completes the form of the X, Y, Z table. An isogrid structure, such as a panel, is now ready for initial fabrication by having respective preimpregnated fiber means, for example in the form of fiber tows, placed into the grooves or channels 11, and the nodes 12, of the mold 10. This is accomplished in an automatic manner by means of a plurality of fiber placement head assemblies 22, which will be described in greater detail subsequently. The fiber placement head assemblies, or heads, 22 are movable relative to the mold 10 in order to place fiber means into the channels 11 in several different directions. For example, the heads 22 are disposed on the head transport shaft 23 in such a way as to be movable thereon. In addition, the gantry 20 is movable on a base portion 24 thereof in both a direction perpendicular to the shaft 23 and at an angle thereto. Spindles or spools 26 of impregnated fiber means are also disposed on the gantry 20 by means of appropriate brackets. From the top view of Fig. 3, it can be seen that a movement of the heads 22 at an angle to both the shaft 23 and the track means 27, in order to place fiber means in the angled channels 11, is accomplished by moving the heads 22 not only along the shaft 23 but also in a direction perpendicular thereto on the track means 27. This is accomplished by the motors 28, which are computer driven, for controlling and moving the heads 22 and the gantry 20. It would also be possible to dispose a mold 10 on the table in such a way that rather than being stationary, the mold is movable. Thus, for example, the mold 10 could be movable in two directions perpendicular to one another, or the mold could be movable in one direction while the heads 22 are movable in a direction perpendicular thereto, thereby being able to place fiber means into all of the channels 11 of the mold 10.

[0017] Fig. 4 illustrates how the spindles 26 are respectively disposed on shafts 30 that are mounted in support means 31. This side view of the inventive apparatus also shows how the heads 22 travel along the shaft 23 and the track means 27 for placement of fiber means into...
the channels 11 of the mold 10. The number of spindles 26 should correspond to the number of heads 22, and are preferably moved with the heads.

Figs. 5a and 5b are detailed views showing two different positions of the fiber placement head assembly 22. The heads 22 allow for the placement, compaction, heating and cutting of the fiber means 33, such as a fiber tow or band of filaments impregnated with resin and stored and withdrawn from the respective spindles 26. The fiber means 33 is first fed through a series of guide rollers 34. The fiber means 33 is then passed about a guide roller 35 that is part of the rocker arm tensioning means or mechanism 36, such as a spring-supported or any other suitable tensioning means, for maintaining proper tension on the fiber means and for controlling the speed of the non-reciprocating wheel 37 of the continuous feed system 38. This wheel 37, which is driven by motor means 39, serves to continuously withdraw fiber means 33 from the spindle 26 and feed it through the fiber placement head assembly 22. The fiber means is disposed about part of the circumference of the wheel 37. Compaction rollers 40 and 41 are provided in order to help hold the tacky fiber means 33 against the wheel 37 and to prevent slippage of the fiber means relative to the wheel 37. The guide roller 42 is part of a further rocker arm tensioning means 43 that maintains the proper tension of the fiber means 33, whereby, by the means of a computer that reads the tension, the speed of the wheel 37 is adjusted to speed up or slow down feed of the fiber means if necessary. The two tensioning means 36 and 43 are preferably synchronized with one another and with the speed of the motor means 39, so that if the tension of the fiber means 33 is not within a specified range, appropriate adjustments can be automatically made. A further guide roller 44 is also provided.

During placement of the fiber means 33 into a channel 11 of the mold 10, a compaction roller 45 is lowered by means of the rocker and rotating arm assembly 46, which includes a pneumatic piston and solenoid motor 47. The pneumatic piston serves to control the pressure of the compaction roller 45, which ensures that the fiber means 33 is properly disposed in the channel 11 by applying appropriate pressure to the fiber means. A guide roller 48, such as a V-shaped guide roller, which is also disposed on the assembly 46, guides the fiber means 33 to the compaction roller 45. This guide roller 48 also serves for controlling the lay-down and flaring (if desired) of the fiber means 33 as well as cutting thereof. A curing means 49, such as a fiber optic tube, hot gas tube, etc., can be provided in order to partially cure or heat the fiber means 33, if desired, prior to placement thereof in the channel 11. A cutting means 50 is also provided in order to cut the fiber means 33 when the end of a channel 11 has been reached, as will be described in detail subsequently.

Pursuant to a presently preferred embodiment of the present invention, the number of fiber placement head assemblies 22 will correspond to the greatest number of channels 11 that extend in a given direction in the mold 10. For example, in the embodiment of the fiber placement system illustrated in Fig. 3, the number of heads 22 will correspond to the number of channels 11 extending in either angular direction. In such a case, it is then merely necessary, for each layer of fiber means 33, to make three passes with the fiber placement head assemblies 22 at the mold 10 in order to place the fiber means into the mold channels 11, namely once in each of the three directions in which the channels 11 extend. However, it is not absolutely necessary that the number of heads 22 correspond to the number of channels 11 in any given direction. For large molds, it may not be practical to do so. Nonetheless, multiple heads 22 will always be provided so that the number of passes in any given direction can be minimized, and the speed, and hence cost, of production of the isogrid structures will be very economical. Although, as indicated, the inventive process operates with multiple fiber placement head assemblies 22, the invention will now be explained in greater detail in conjunction with only one head 22.

In Fig. 5a, the fiber placement head assembly 22 is shown in a position prior to lay-down of the fiber means 33. The head 22, as shown by the arrow, moves to the left as viewed in the drawing. In this position prior to lay-down, the compaction roller 45 is raised and the guide roller 48 is lowered. This guide roller 48 could be provided with “grabber means” for the fiber means 33, or could be provided with an appropriate surface that acts to “grab” the fiber means. As illustrated, the fiber means 33 has been threaded through the head assembly 22 and is ready to be placed into a channel 11. It should also be noted, as can be seen in Fig. 3, that not all of the channels 11, namely those that extend at an angle, are of the same length, so that varying lengths of fiber means are placed in the channels by their respective heads 22. The position of the head 22 illustrated in Fig. 5a is maintained, for example, until the edge of the mold 10 has been reached. However, if the fiber means 33 is to be flared, the position illustrated in Fig. 5a can be maintained for a longer period of time. In this context, the term flaring means that individual fiber means are to be separated from another. This takes place near the edge of the mold 10 by means of a wider channel portion on the mold itself. Such flaring of the fiber means 33 is used, for example, to provide a means for either interconnecting isogrid structures or for connecting an isogrid structure to another structure. Other means for such connections are also possible and will be discussed in detail subsequently. In order to effect the flaring or separation of the fiber means 33, the rocker and rotating arm assembly 46 can be rotated as indicated in Fig. 5a in order to alter the position of the guide roller 48. When it is desired to compact the fiber means 33 within the channel 11, the guide roller 48 is raised and the larger compaction roller 45 is lowered, as shown in Fig. 5b. When the appropriate length of the fiber means 33 in the channel 11 has been achieved, either at the end of the channel or even beyond the channel, the fiber
of the present invention in conjunction with a cylindrical mold 10A. This mold can again be made from a polymeric material, for example a flexible material, which allows the mold to be wrapped to the desired shape. However, the mold 10A could also be a solid material having channels machined therein.

[0025] In Fig. 7, the mold 10A is disposed on a rotatable mandrel 52, which is motor driven. The fiber placement head assemblies 22 are disposed on a circular part of the gantry 20A, as shown in Fig. 9. The gantry 20A is mounted such that it can move on the track means 27, so that the gantry 20A, and hence the heads 22, can be moved in the direction of the double arrow of Fig. 7 in a direction parallel to the axis of the rotatable mandrel 52. Thus, by rotating the mold 10A on the mandrel 52, and/or by moving the heads 22 in a direction parallel to the axis of the mandrel 52, fiber means 33 can be placed into all of the channels 11 of the mold 10A using the heads 22 in the manner previously described.

[0026] In a similar manner, the present invention can be used to produce a conical isogrid structure, as shown in Figs. 10 and 11, as well as Fig. 9.

[0027] As indicated previously, the inventive process and fiber placement head assembly are intended to operate automatically. This is accomplished by means of a programmable controller, such as the controller 53 indicated in Figs. 7, 8 and 10, 11. The controller 53 is programmed to respond to and control a number of operating parameters, including speed of feed of the fiber means 33 through the fiber placement head assemblies 22, speed of lay-down of the fiber means 33, the number of heads 22 that are operating, the length of fiber means 33 to be placed into the channels 11, the number of passes to be executed by the heads 22, etc. The controller 53 is programmed in conjunction with the specific isogrid structure being produced, and also responds to various operating parameters, including tension on the fiber means 33 in the heads 22, by means of appropriate sensors that feed information to the controller 23. Known means are provided for sensing and transmitting parameter values to said controller 53 as well as adjustment signals back therefrom to the head assembly 22 and other working components.

[0028] The fiber means 33 can be made of any suitable material, including glass, fiberglass, graphite, polyamide resins, etc. In addition, the fiber means can be in the form of fiber tows made up of a large number of individual filaments, they could be large individual filaments, or they could be bands made up of several fiber tows. The fibers are impregnated with varying types and amounts of resin, for example thermosetting, thermoplastic, and non-thermal cure resins, the selected quantity or proportion of which can vary depending upon the resin material and the particular application of the isogrid structure, especially whether or not skins or other panels are to be attached to the ribbed structure.

[0029] In view of the foregoing, it can be seen that this invention not only provides a new fiber placement meth-
od, but also provides a new head for realizing such a method, especially in an apparatus that carries the mold with its channels, all for producing an isogrid structure, for example in the form of panels, cylinders, cones or any other desired shape.

[0030] The present invention is, of course, in no way restricted to the specific disclosure of the specification and drawings, but also encompasses any modifications within the scope of the appended claims.

Claims

1. A method of placing fiber means into a plurality of channels (11) of a mold (10) of any desired shape to form ribs of a structural member, said channels (11) extending in different directions, said method characterized by the steps of: providing multiple fiber placement heads (22); while providing relative movement between said mold (10) and said heads (22) in several different directions, simultaneously placing said fiber means (33) into a number of said channels (11) of said mold (10) by means of said heads (22); and repeating said relative movement and placing step as often as necessary to dispose into said channels (11) a desired thickness of said fiber means (33).

2. A method according to claim 1, characterized in that said channels (11) of said mold (10) extend in three different directions relative to one another, and wherein said providing relative movement and placing step comprises placing said fiber means (33) into those channels (11) extending in a first direction, then placing said fiber means into those channels (11) extending in a second direction, and then placing said fiber means into those channels (11) extending in a third direction, wherein said providing relative movement and placing step comprises moving said heads (22) in a direction relative to said mold (10), or moving said mold in a first direction relative to said heads, or wherein said providing relative movement and placing step comprises moving said heads (22) simultaneously in two different directions that extend perpendicular to one another.

3. A method according to claim 2, characterized by the additional step of disposing said mold (10) on a mandrel (52), and wherein said providing relative movement and placing step comprises rotating said mold (10) relative to said heads (22) and moving said heads or said mold in a direction parallel to an axis of rotation of said mandrel (52).

4. A method according to claim 2, characterized in that the step of placing said fiber means (33) comprises guiding said fiber means into said channels (11) and compacting the same therein; and also characterized by the additional step of cutting said fiber means (33) at or shortly after reaching the end of a channel (11) subsequent to said placing step, and/or by the additional step of heating or initializing curing of said fiber means (33) prior to said step of placing said fiber means into said channels (11), and/or by the additional step of flaring said fiber means (33) during a subsequent step of placing the same relative to the previous placement of fiber means and prior to the end of a channel (11), and/or by the additional step of continuously withdrawing said fiber means (33) from a supply means (26) thereof.

5. A method according to claim 2, which to effect said step of placing said fiber means (33) is characterized by the step of using a number of said fiber placement heads (22) that corresponds to the greatest number of said channels (11) in any given direction of said mold (10).

6. A multiple fiber-placement head arrangement for placing fiber tows simultaneously into a plurality of channels (11) of a mold (10), to form ribs of a structural member, said channels (11) extending in different directions, each of said heads (22) being characterized by:

a single motor driven wheel (37) for continuously withdrawing fiber tows from a supply means (26) thereof and for feeding said fiber tows through said fiber-placement head (22), wherein said fiber tows are disposed about part of a circumference of said wheel (37);

guide rollers for guiding said fiber tows through said fiber-placement head (22); and

means (45-47) for compacting said fiber tows in said channels (11), wherein said wheel (37) feeds said fiber tows to said means for compacting.

7. A fiber-placement head arrangement according to claim 6, characterized in that said supply means (26) is preferably a respective spindle for said head (22), and also characterized by at least one further guide roller for guiding said fiber means (33) into said channels (11) of said mold, wherein said means for compacting comprises a compacting roller (45), with a pneumatic piston and solenoid motor assembly (47) further being provided for controlling movement and pressure to be exerted by said at least one further guide roller and said compacting roller (45) upon said fiber means (33), and by means for controlling the speed of said wheel (37) such that said wheel maintains appropriate tension on said fiber means (33).

8. A fiber placement head arrangement according to
claim 7, characterized by at least one tensioning means (36, 43) for adjusting tension on said fiber means (33) as the same travels through said head (22), and preferably also by heating or curing means (49) for said fiber means (33), and cutting means (50) for cutting said fiber means after placement thereof in a channel (11), wherein said cutting means is disposed upstream of and adjacent to said compacting roller (45).

9. A fiber-placement head arrangement according to claim 6 further characterized by:

means (20) for providing relative movement between said mold (10) and said heads (22); and means (53) for automatically controlling said heads (22) and said relative movement.

10. A fiber-placement head arrangement according to claim 9, characterized that said means (20) for providing relative movement is a gantry on which said heads (22) are movably mounted, and that may include a rotatable mandrel (52) for receiving said mold (10) thereon, wherein said means (53) for automatically controlling said heads (22) is a programmable controller (53) for controlling operating parameters of said heads and of said relative movement between said mold (10) and said heads (22).

Patentansprüche

1. Verfahren zum Anordnen von Fasermitteln in mehreren Kanälen (11) eines Formwerkzeugs (10) einer beliebigen gewünschten Form, um Rippen eines Formstücks zu bilden, wobei die Kanäle (11) in verschiedenen Richtungen verlaufen, wobei das Verfahren durch folgende Schritte gekennzeichnet ist: Bereitstellung mehrerer Faserauflegeköpfe (22); unter Bereitstellung einer Relativbewegung zwischen dem Formwerkzeug (10) und den Köpfen (22) in verschiedenen Richtungen gleichzeitiges Anordnen der Fasermittel (33) in einer Anzahl der Kanäle (11) des Formwerkzeugs (10) mit Hilfe dieser Köpfe (22) und Wiederholen des Schrittes der Relativbewegung und des Anordnens so oft wie nötig, um die Fasermittel (33) in einer gewünschten Dicke in den Kanälen (11) anzuordnen.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Kanäle (11) des Formwerkzeugs (10) in drei verschiedene Richtungen in Bezug zueinander verlaufen und wobei der Schritt des Bereitstellens der Relativbewegung und des Anordnens das Anordnen der Fasermittel (33) in denjenigen Kanälen (11) umfasst, die in eine erste Richtung verlaufen, dann das Anordnen der Fasermittel in denjenigen Kanälen (11), die in eine zweite Richtung verlaufen, und dann das Anordnen der Fasermittel in denjenigen Kanälen (11), die in eine dritte Richtung verlaufen, wobei der Schritt des Bereitstellens der Relativbewegung und des Anordnens das Bewegen der Köpfe (22) in eine Richtung in Bezug zum Formwerkzeug (10) umfasst oder das Bewegen des Formwerkzeugs in eine erste Richtung in Bezug zu den Köpfen, oder wobei der Schritt des Bereitstellens der Relativbewegung und des Anordnens das gleichzeitige Bewegen der Köpfe (22) in zwei verschiedene Richtungen umfasst, die senkrecht zueinander verlaufen.

3. Verfahren nach Anspruch 2, gekennzeichnet durch den zusätzlichen Schritt des Anordnens des Formwerkzeugs (10) auf einer Welle (52), und wobei der Schritt des Bereitstellens der Relativbewegung und des Anordnens das Drehen des Formwerkzeugs (10) in Bezug zu den Köpfen (22) und das Bewegen der Köpfe oder des Formwerkzeugs in einer Richtung umfasst, die parallel zu einer Rotationsachse der Welle (52) liegt.


5. Verfahren nach Anspruch 2, das zur Ausführung des Schrittes des Anordnens der Fasermittel (33) durch den Schritt des Verwendens einer Anzahl der Faserauflegeköpfe (22) gekennzeichnet ist, die der höchsten Anzahl der Kanäle (11) in jedweder gegebenen Richtung des Formwerkzeugs (10) entsprechen.

6. Anordnung mit mehreren Faserauflegeköpfen zum gleichzeitigen Anordnen von Fasern in mehreren Kanälen (11) eines Formwerkzeugs (10), um Rippen an einem Formstück zu bilden, wobei die Kanäle (11) in verschiedenen Richtungen verlaufen, wobei jeder der Köpfe (22) gekennzeichnet ist durch:

- ein einzelnes motorbetriebenes Rad (37) zum
Anordnung mit Faserauflegeköpfen nach Anspruch 9.

Ein programmierbarer Controller (53) zum Steuern des Faserauflegekopfes (22) und des Formwerkzeugs (10) umfassen kann, wobei das Mittel (20) zum Aufrechterhalten der Betriebsparameter der Köpfe und der Relativbewegung zwischen dem Formwerkzeug (10) und den Köpfen (22) ist.

Revendications

1. Procédé pour mettre en place des moyens fibreux dans plusieurs canaux (11) d’un moule (10) ayant une forme quelconque voulue afin de former des nervures d’un élément de structure, lesdits canaux (11) s’étendant dans différentes directions, ledit procédé caractérisé par les étapes consistant à :

- agencer de multiples têtes de placement de fibres (22) ;
- tout en produisant un mouvement relatif entre le moule (10) et lesdites têtes (22) dans plusieurs directions différentes, mettre simultanément en place lesdits moyens fibreux (33) dans plusieurs desdits canaux (11) dudit moule (10) au moyen desdites têtes (22) ; et
- répéter ladite étape de production d’un mouvement relatif et de mise en place aussi souvent que nécessaire afin d’obtenir dans lesdits canaux (11) une épaisseur voulue desdits moyens fibreux (33).

2. Procédé selon la revendication 1, caractérisé en ce que lesdits canaux (11) dudit moule (10) s’étendent dans trois directions différentes les unes par rapport aux autres, et dans lequel ladite étape de production d’un mouvement relatif et de mise en place comprend la mise en place desdits moyens fibreux (33) dans les canaux (11) s’étendant dans une première direction, puis la mise en place desdits moyens fibreux dans les canaux (11) s’étendant dans une deuxième direction, et ensuite la mise en place desdits moyens fibreux dans les canaux (11) s’étendant dans une troisième direction, dans lequel ladite étape de production d’un mouvement relatif et de mise en place comprend le déplacement desdites têtes (22) dans une direction par rapport audit moule (10), ou le déplacement dudit moule dans une première direction par rapport auxdites têtes, dans lequel ladite étape de production d’un mouvement relatif et de mise en place comprend le déplacement desdites têtes (22) simultanément dans deux directions différentes qui s’étendent perpendiculaires l’une à l’autre.

3. Procédé selon la revendication 2, caractérisé par l’étape supplémentaire consistant à disposer ledit moule (10) sur un mandrin (52), et dans lequel ladite étape de production d’un mouvement relatif et de mise en place comprend la rotation dudit moule (10) par rapport auxdites têtes (22) et le déplacement desdites têtes ou ledit moule dans une direction pa-
4. Procédé selon la revendication 2, caractérisé en ce que l’étape de mise en place desdits moyens fibreux (33) comprend le guidage desdits moyens fibreux dans lesdits canaux (11) et leur compactage à l’intérieur ; et également caractérisé par l’étape supplémentaire consistant à découper lesdits moyens fibreux (33) lorsque l’extrémité d’un canal (11) est atteinte après ladite étape de mise en place, ou peu après l’avoir atteinte, et/ou par l’étape supplémentaire consistant à chauffer ou initialiser un durcissement desdits moyens fibreux (33) avant ladite étape de mise en place desdits moyens fibreux dans lesdits canaux (11), et/ou par l’étape supplémentaire consistant à évaser lesdits moyens fibreux (33) pendant une étape ultérieure consistant à mettre en place ceux-ci par rapport à la mise en place précédente des moyens fibreux et avant l’extrémité d’un canal (11), et/ou par l’étape supplémentaire consistant à extraire de manière continue lesdits moyens fibreux (33) de leurs moyens d’alimentation (26).

5. Procédé selon la revendication 2, lequel, pour réaliser ladite étape de mise en place desdits moyens fibreux (33), est caractérisé par l’étape consistant à utiliser plusieurs desdites têtes de placement de fibres (22) qui correspondent au plus grand nombre desdits canaux (11) dans une direction donnée quelconque dudit moule (10).

6. Agencement de multiples têtes de placement de fibres pour mettre en place des étoupes de fibres simultanément dans plusieurs canaux (11) d’un moule (10), afin de former des nervures d’un élément de structure, lesdits canaux (11) s’étendant dans des directions différentes, chacune desdites têtes (22) étant caractérisée par :

   - une seule roue entraînée par un moteur (37) pour extraire de manière continue des étoupes de fibres de leurs moyens d’alimentation (26) et pour acheminer lesdites étoupes de fibres à travers ladite tête de placement de fibres (22), lesdites étoupes de fibres étant disposées autour d’une partie d’une circonférence de ladite roue (37) ;
   - des galets de guidage pour guider lesdites étoupes de fibres à travers ladite tête de placement de fibres (22) ; et
   - des moyens (45 à 47) pour compacter lesdites étoupes de fibres dans lesdits canaux (11) ladite roue (37) acheminant lesdites étoupes de fibres jusqu’auxdits moyens de compactage.

7. Agencement de têtes de placement de fibres selon la revendication 6, caractérisé en ce que lesdits moyens d’alimentation (26) sont de préférence une broche respective pour ladite tête (22), et également caractérisé par au moins un galet de guidage supplémentaire pour guider lesdits moyens fibreux (33) dans lesdits canaux (11) dudit moule, dans lequel lesdits moyens de compactage comprennent un galet de compactage (45), un ensemble piston pneumatique et moteur à électro-aimant (47) permettant en outre de commander un mouvement et une pression devant être exercés par ledit galet de guidage supplémentaire et ledit galet de compactage (45) sur lesdits moyens fibreux (33), et par des moyens destinés à commander la vitesse de ladite roue (37) de telle sorte que ladite roue maintient une tension appropriée sur lesdits moyens fibreux (33).

8. Agencement de têtes de placement de fibres selon la revendication 7, caractérisé par au moins des premiers moyens de tension (36, 43) pour régler une tension sur lesdits moyens fibreux (33) lorsque ceux-ci se déplacent à travers ladite tête (22), et de préférence également par des moyens de chauffage ou de durcissement (49) pour lesdits moyens fibreux (33), et des moyens de coupe (50) pour découper lesdits moyens fibreux après leur mise en place dans un canal (11), lesdits moyens de coupe étant disposés en amont dudit galet de compactage (45) et adjacents à celui-ci.

9. Agencement de têtes de placement de fibres selon la revendication 6, également caractérisé par :

   - des moyens (20) pour assurer un mouvement relatif entre ledit moule (10) et lesdites têtes (22) ; et
   - des moyens (53) pour commander automatiquement lesdites têtes (22) et ledit mouvement relatif.

10. Agencement de têtes de placement de fibres selon la revendication 9, caractérisé en ce que lesdits moyens (20) pour produire un mouvement relatif sont un portique sur lequel lesdites têtes (22) sont montées de manière mobile, et qui peuvent inclure un mandrin rotatif (52) pour recevoir ledit moule (10) sur celui-ci, dans lequel lesdits moyens (53) pour commander automatiquement lesdites têtes (22) sont une unité de commande programmable (53) pour commander des paramètres de fonctionnement, lesdites têtes et dudit mouvement relatif entre ledit moule (10) et lesdites têtes (22).
REFERENCES CITED IN THE DESCRIPTION

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