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(54) Benævnelse: **Fiberkomponent-konstruktionsdel og fremgangsmåde til fremstilling af samme**

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Description

The present invention relates to a fibre-composite component from a wound fibrous material impregnated with artificial resin, and to a method for manufacturing the same.

Document US 4273601 discloses the features of the preamble of Claims 1 and 7.

The present invention is based on the object of providing an at least substantially wound fibre-composite component having in the circumferential and longitudinal directions thereof an adapted distribution of rigidity and material.

According to the invention, this object is achieved by a fibre-composite component according to Claim 1.

Furthermore, this object is achieved by a method for manufacturing a fibre-composite component, according to Claim 7.

In the fibre-composite component, the fibrous material of the first fibrous material layer is expediently oriented at an angle in the range of 0° to approx. 10° in relation to the longitudinal direction of the fibre-composite component. This layer is wound so as to have a slight gradient, preferably so as to be overlapping.

Alternatively or additionally, the fibrous material of the second fibrous material layer is cross-wound at an angle of approx. ± 45° or approx. ± 90° in relation to the longitudinal direction of the fibre-composite component. These are preferred values for the angle. In principle, the angle may assume an arbitrary value.

According to one particular embodiment of the invention, a third fibrous material layer lies on top of the first or second fibrous material layer, fibrous material therein being configured and wound in an analogous manner to that of the first fibrous material layer. Here, analogous is not necessarily to mean that the fibrous material of the third fibrous material layer is configured and wound in an identical manner.

According to a further particular embodiment of the invention, at least one further fibrous material layer lies on top of the first, second, or third fibrous material layer, having at least one localized reinforcement applied thereon, the fibrous material therein being configured and wound in an analogous manner to that of the second fibrous material layer. Analogous here likewise is not necessarily to mean that the fibrous material of the further fibrous material layer, or the fibrous materials of the further fibrous material layers, respectively, is/are configured and wound in an identical manner.

In particular, it may be provided that the fibre-composite component is a blade connector for a rotor blade of a wind-energy plant.

In the method according to the invention, the fibrous material of the first fibrous material layer is wound, preferably in an overlapping manner, preferably at an angle in the range of 0° to approx. 10° in relation to the longitudinal direction of the fibre-composite component.

Alternatively or additionally, it may be provided that the fibrous material of the second fibrous material layer is cross-wound at an angle of approx. ± 45° or approx. ± 90° in relation to the longitudinal direction of the fibre-composite component. These are preferred values for the angle. In principle, the angle may assume an arbitrary value.

According to one particular embodiment of the invention, the method furthermore comprises that the layer thickness of the third fibrous material layer in the circumferential direction of the fibre-composite component is at least almost constant and varies in the longitudinal direction of the fibre-composite component.
A further particular embodiment of the invention of the method furthermore comprises winding at least one further fibrous material layer onto the first or second

fibrous material layer having at least one localized reinforcement applied thereon, wherein the fibrous material is a roving and is wound in such a manner that the layer thickness of the fibrous material layer in the circumferential and longitudinal direction of the fibre-composite component is at least almost constant.

A further particular embodiment of the method in turn further comprises winding at least one further fibrous material layer onto the third fibrous material layer having at least one localized reinforcement applied thereon, wherein the fibrous material is a roving and is wound in such a manner that the layer thickness of the fibrous material layer in the circumferential and longitudinal direction of the fibre-composite component is at least almost constant.

Finally, the fibre-composite component preferably is a blade connector for a rotor blade of a wind-energy plant.

The invention is based on the surprising finding that the production of a fibre-composite component having in the circumferential and longitudinal directions thereof an adapted distribution of rigidity and material is enabled by a special winding method. In particular, a fibre-composite component can thereby be produced in the winding process, which fibre-composite component on one side has a preferably rotationally symmetrical connection region (mounting or flange in which the introduction of force is distributed across the circumference), wherein the connection region may be established or completed, respectively, by downstream processing, such as boring etc., for example, and on the other side has a region with regions for the concentrated introduction of force, which are not uniformly distributed across the circumference and which run by way of local connection elements, such as, for example, screws, bolts, etc., or adhesive additions in regions which are primarily disposed in a parallel manner to the component axis. In other words, a transition from said connection region to said region having regions with a concentrated introduction of force may be established. The region having regions with a concentrated introduction of force may be embodied so as to be rotationally symmetrical or so as to be adapted to a component which adjoins thereto, for example so as to be elliptical or so as to approximate a profiled shape or parts thereof.

Further features and advantages of the invention are derived from the appended claims and the following description in which exemplary embodiments are explained in detail by means of the schematic drawings. In the drawings:

Figs. 1 to 3 show phases of a method according to one particular embodiment of the present invention;

Fig. 4 shows a perspective view of a fibre-composite component according to one particular embodiment of the invention;

Fig. 5 shows a perspective view of a fibre-composite component according to a further particular embodiment of the invention in the context of rotor-blade components of a wind-energy plant; and

Fig. 6 shows a perspective view of a fibre-composite component according to a further particular embodiment of the present invention.

Fig. 1 shows a shaped winding body or a forming core 10, respectively, being wound with a fibrous material, here a resin-impregnated fibrous tape 12. Such fibrous tapes may be manufactured as fibrous structures having an almost unlimited fibre orientation. In the present case, the fibrous tape is composed of a proportion of fibres in the longitudinal direction of the tape, and of a further proportion which is almost transverse to the direction of the fibrous tape. Two or more directions, which preferably are symmetrical to the transverse direction of the fibrous tape, are possible. The fibre proportion of each direction depends on the requirements of rigidity and strength which are placed on the fibre-composite component 14. The fibrous tape 12 is wound onto the shaped winding body 10 at a slight gradient, that is to say at an angle in the range of 0° to 10° to the longitudinal direction of the fibre-composite component, which is identified by an arrow, wherein the fibrous tapes are mutually overlapping. The transmission of force from one fibrous tape 12 to the other is performed in an interlaminary manner by way of the resin and fibre composite.

By way of changing the amount of indexing and reversing the direction of indexing at the reversal points during winding of the fibrous tape 12 onto the shaped winding body 10, almost unlimited consistent distribution of tape strength may be produced. The shaped winding body 10 thus in the circumferential direction will in each case be almost identically populated, but may be adapted in the longitudinal direction. In other words, a first fibrous material layer of which the layer thickness in the circumferential direction of the fibre-composite component 14 is at least almost constant and in the longitudinal direction of the fibre-composite component 14 is variable results.

During the winding operation described above, fibrous tapes having various orientations may be employed. Moreover, in Fig. 1 the thickness d of the fibre-composite component across the length l thereof is shown with the exemplary illustration of reversal points.

As is shown in Fig. 2a, after a certain layer thickness, which depends on the geometry of the fibre-composite component and other requirements, has been applied, one or a plurality of winding(s) having impregnated fibre strands, so-called rovings 15 (individual threads) or having a tape of a plurality of rovings arranged in parallel is/are applied so as to achieve adequate consolidation of the fibre-composite component. These rovings 15 are preferably wound at an angle of ± 45° (for stabilizing the layer construction) and 90° (for consolidating) in a second fibrous material layer. In the case of winding angles of up to approx. 60°, reversal of the indexing direction without complex aids is only possible by way of the end sides. This proportion of the population results in a population which in the longitudinal direction and the circumferential direction is homogenous (see Figs. 2a and 2b). In other words, a longitudinal thickness of the second fibrous material layer which is at least almost constant in the circumferential direction and the longitudinal direction of the fibre-composite component results (see also the illustration of the thickness d of the second fibrous material layer across the length l of the fibre-composite material).

Thereafter, either at least one further fibrous material layer as shown in Fig. 1 may be applied (not shown), or reinforcement tapes 22 for distributing the load may be applied in a targeted manner in certain regions (see Fig. 3), depending on requirements. These reinforcement tapes 22 lie in the direction of the desired load distribution and are composed of fibres in the longitudinal direction of the tape. To the right in Fig. 3 is the region for later concentrated introduction of force (concentrated in the circumferential direction), for example by way of adhesive bonding, bolting, etc., while to the left in Fig. 3 there is the later connection region or clamping region, respectively, (introduction of force distributed in the circumferential direction). Moreover, at the bottom left in Fig. 3, the mentioned thickness d, that is to say of all applied fibrous material layers, depending on the length l of the fibre-composite component 14 is shown. Additional localized reinforcement tapes or reinforcements, respectively, exist in the longitudinal direction and transverse direction.

Once the reinforcement tapes have been applied, it may be meaningful to apply one or a plurality of fibrous material layer(s) for consolidation (not shown), as is shown in Figs. 2a and 2b.

Thereafter, depending on the desired layer construction, the method steps shown in Figs. 1 to 3 may be completely or partially repeated once or a plurality of times.

At the end, the shaped winding body 10 is removed, such that the completed fibre-composite component results.

Fig. 4 shows a completely wound fibre-composite component 14 according to the present invention, which, explaining the length 2l, is embodied as a “double component” and is subdivided into two individual components by way of later mechanical separation in the central region. In other words, two fibre-composite components are simultaneously manufactured in that a shaped winding body 10 having an extended length is manufactured, or two mutually opposed and mutually twisted cores, so as to correspond to the requirements placed on fibre-composite components, are initially manufactured as a “double component”, which is thereafter separated in the middle. This offers the advantage of fewer material offcuts accumulating, since winding otherwise has to take place with excess length.

Fig. 5 shows a fibre-composite component according to one particular embodiment of the invention, specifically a rotor blade connector 16 for a rotor blade for a wind-energy plant, having further rotor blade components 18 and 20.

Finally, it may be derived from Fig. 6 that the fibre-composite component 14 according to one particular embodiment of the present invention may also be produced in a non-rotationally symmetrical manner, using a method according to one particular embodiment of the present invention.

According to one further particular embodiment of the invention, it may be provided that the steps shown in Figs. 1 and 2 are not carried out successively but completely or partially simultaneously (for example by two independently controlled indexing slides).

As has been shown by the above implementations, a defined wall-thickness profile from the flange (rotor blade connector) in the direction of the rotor blade may be produced at least according to particular embodiments of the method according to the invention.

The features of the invention which have been disclosed in the above description, in the drawings, and in the claims may be relevant to the implementation of the invention in its various embodiments both individually as well as in arbitrary combination with one another.

List of reference signs

10	Shaped winding body or forming core, respectively
12	Fibrous tape
14	Fibre-composite component
15	Roving
16	Rotor blade connector
18, 20	Rotor blade components
22	Reinforcement tapes
d	Thickness of the fibre-composite component, or the fibrous material layer (fibre-composite layer)
l	Length of the fibre-composite component

Patentkrav

1. Fiberkomponent-konstruktionsdel (14) af viklet fibermateriale, som er imprægneret med kunstharpiks, og hvor fibermaterialet i det mindste er anbragt i to ovenpå hinanden liggende fibermaterialelag, og hvor det for et i det følgende som først nævnte fibermaterialelag omtalt fibermaterialelag gælder, at fibermaterialet er et fiberlag, et fibervæv eller en fibermåtte, som er således viklet, at dets lagtykkelse i fiberkomponent-konstruktionsdelen (14) mindst er næsten konstant, men varierer i fiberkomponent-konstruktionsdelens (14) længderetning, som et på oversiden beliggende og på undersiden beliggende efterfølgende andet fibermaterialelag udgøres af fibermateriale i en Roving (15), som er således viklet, at lagets lagtykkelse i omkreds- og længderetningen af fiberkomponent-konstruktionsdelen (14) i det mindste er næsten konstant, **kendetegnet ved, at** der på det første eller andet eller et tredje viklet fibermaterialelag i mindst ét område er forsynet med en lokal forstærkning med henblik på fordeling af belastning, og at forstærkningen er et forstærkningsbånd (22), som består af i deres længderetning anbragte fibre.

2. Fiberkomponent-konstruktionsdel (14) ifølge krav 1, **kendetegnet ved, at** fibermaterialet i det første fibermaterialelag er orienteret i en vinkel, som ligger i området 0° til ca. 10° i forhold til fiberkomponent-konstruktionsdelens (14) længderetning.

3. Fiberkomponent-konstruktionsdel (14) ifølge krav 1 eller 2, **kendetegnet ved, at** fibermaterialet i det andet fibermaterialelag på "krydsagtig" måde er viklet i en vinkel på ca. ± 45° eller ca. ± 90° i forhold til fiberkomponent-konstruktionsdelens (14) længderetning.

4. Fiberkomponent-konstruktionsdel (14) ifølge et af kravene 1 til 3, **kendetegnet ved, at** det tredje fibermaterialelag er anbragt på det første eller andet fibermaterialelag, og hvor fibermaterialet er beskaffent og viklet analogt med fibermaterialet i det første fibermaterialelag.

5. Fiberkomponent-konstruktionsdel (14) ifølge et af de foregående krav, **kendetegnet ved, at** mindst ét yderligere fibermaterialelag er anbragt på det første, andet eller tredje fibermaterialelag med derpå påført mindst ene lokale forstærkning, og hvor fibermaterialet er beskaffent og viklet analogt med fibermaterialet i det andet fibermaterialelag.

6. Fiberkomponent-konstruktionsdel (14) ifølge et af de foregående krav, **kendetegnet ved, at** den er en bladtilslutning til et rotorblad i et vindenergianlæg.

7. Fremgangsmåde til fremstilling af en fiberkomponent-konstruktionsdel (14) af viklet kunstharpiksimprægneret fibermateriale, især ifølge et af de foregående krav, hvilken fremgangsmåde omfatter de trin:

- at man vikler et fibermateriale i form af et fiberlag, et fibervæv eller en fibermåtte i et første fibermaterialelag på et formviklingslegeme (10) på en sådan måde, at lagtykkelsen af det første fibermaterialelag i fiberkomponent-konstruktionsdelens (14) omkredsretning i det mindste er næsten konstant, men varierer i fiberkomponent-konstruktionsdelens (14) længderetning,

- at man vikler et fibermateriale, som er en Roving (15) – i et andet fibermaterialelag på det første fibermaterialelag, og dette så at lagtykkelsen af det andet fibermaterialelag i omkreds- og længderetningen af fiberkomponent-konstruktionsdelen (14) i det mindste er næsten konstant,

- eller at man anordner det første og andet fibermaterialelag omvendt, **kendetegnet ved, at** det første eller andet eller et tredje viklet fibermaterialelag, i mindst ét område påføres en lokal forstærkning til fordeling af belastningen, og at forstærkningen er et forstærkningsbånd (22), som består af fibre, der forløber i forstærkningsbåndets længderetning.

8. Fremgangsmåde ifølge krav 7, **kendetegnet ved, at** fibermaterialet i det første fibermaterialelag vikles med en vinkel i området 0° til ca. 10° med fiberkomponent-konstruktionsdelens (14) længderetning – og fortrinsvis overlappende.

9. Fremgangsmåde ifølge krav 7 eller 8, **kendetegnet ved, at** fibermaterialet i det andet fibermaterialelag vikles "krydsagtigt" under en vinkel på ca. ± 45° eller ca. ± 90° med fiberkomponent-konstruktionsdelens (14) længderetning.

10. Fremgangsmåde ifølge et af kravene 7 til 9, **kendetegnet ved, at** lagtykkelsen af det tredje fibermaterialelag i fiberkomponent-konstruktionsdelens (14) omkredsretning er i det mindste næsten konstant, men i fiberkomponent-konstruktionsdelens (14) længderetning varierer.

11. Fremgangsmåde ifølge et af kravene 7 til 9, **kendetegnet ved, at** den yderligere omfatter:

- at man vikler mindst ét yderligere fibermaterialelag på det første og andet fibermaterialelag med derpå påført mindst ene lokale forstærkning, og at fibermaterialet er en Roving og således viklet, at lagtykkelsen af fibermaterialelaget i fiberkomponent-konstruktionsdelens (14) omkreds- og længderetning er i det mindste næsten konstant.

12. Fremgangsmåde ifølge krav 10, **kendetegnet ved, at** det yderligere omfatter:

- at man vikler et yderligere fibermaterialelag på det tredje fibermaterialelag med derpå påført mindst ene lokale forstærkning, og at fibermaterialet er en Roving og vikles således, at fibermaterialelagets lagtykkelse i omkreds- og længderetningen af fiberkomponent-konstruktionsdelen (14) i det mindste er næsten konstant.

13. Fremgangsmåde ifølge et af kravene 7 til 12, **kendetegnet ved, at** fiberkomponent-konstruktionsdelen (14) er en bladtilslutning til et rotorblad i et vindenergianlæg.

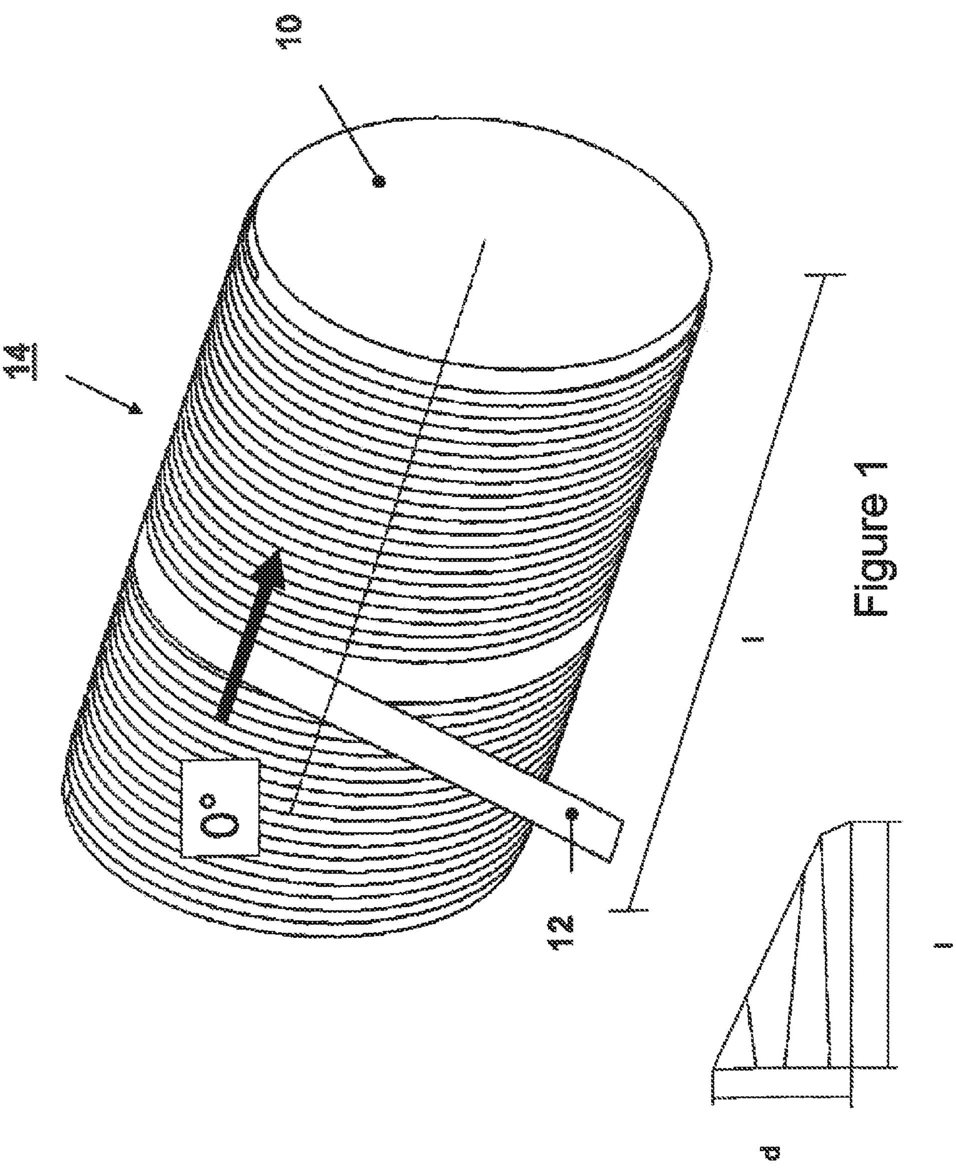

Figure 1

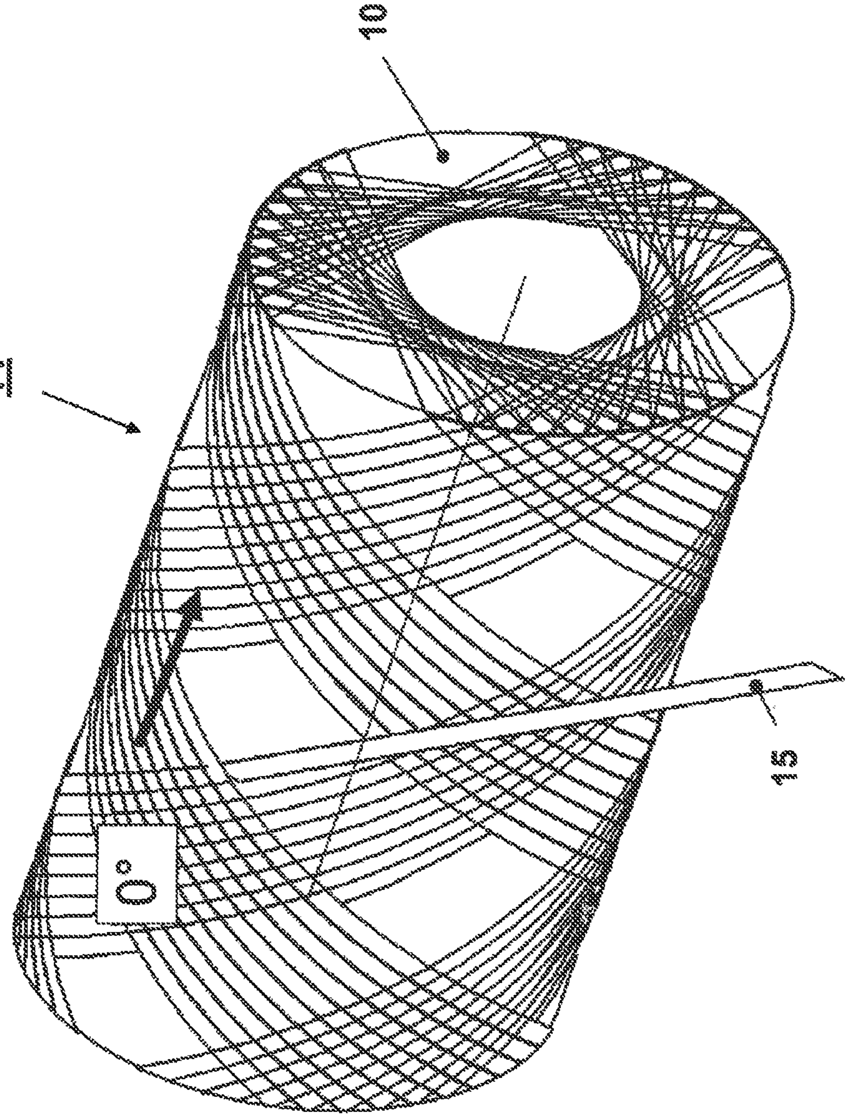

Figure 2a

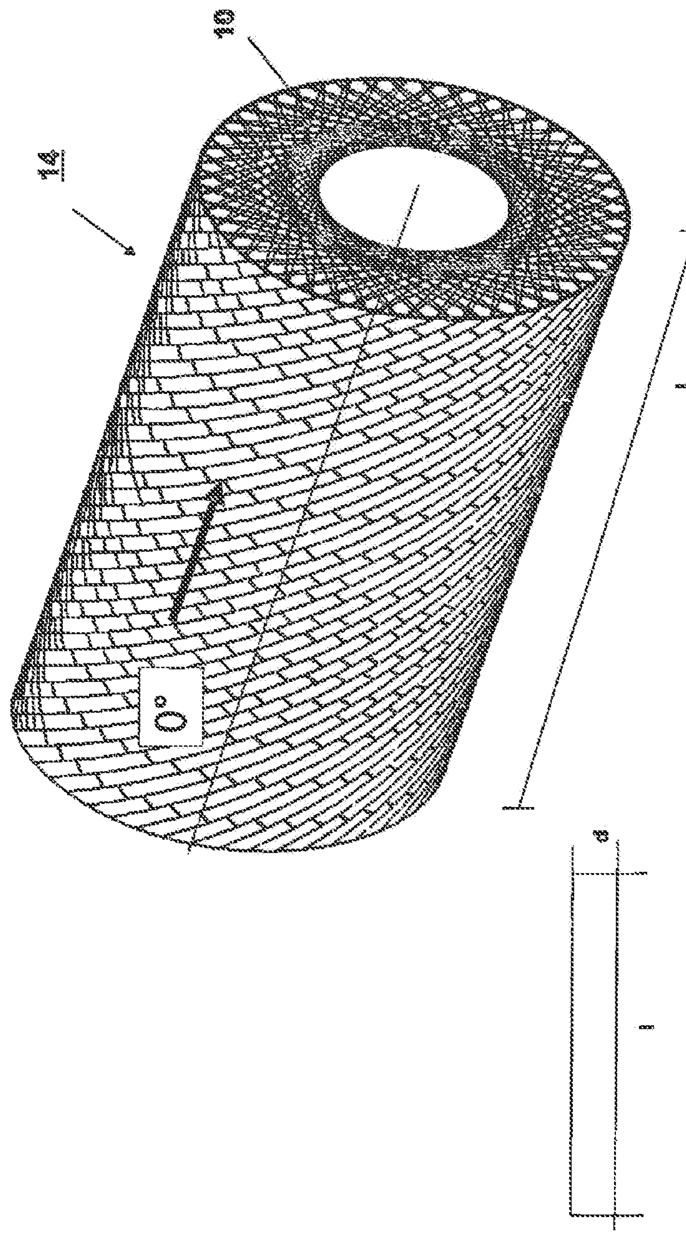

Figure 2b

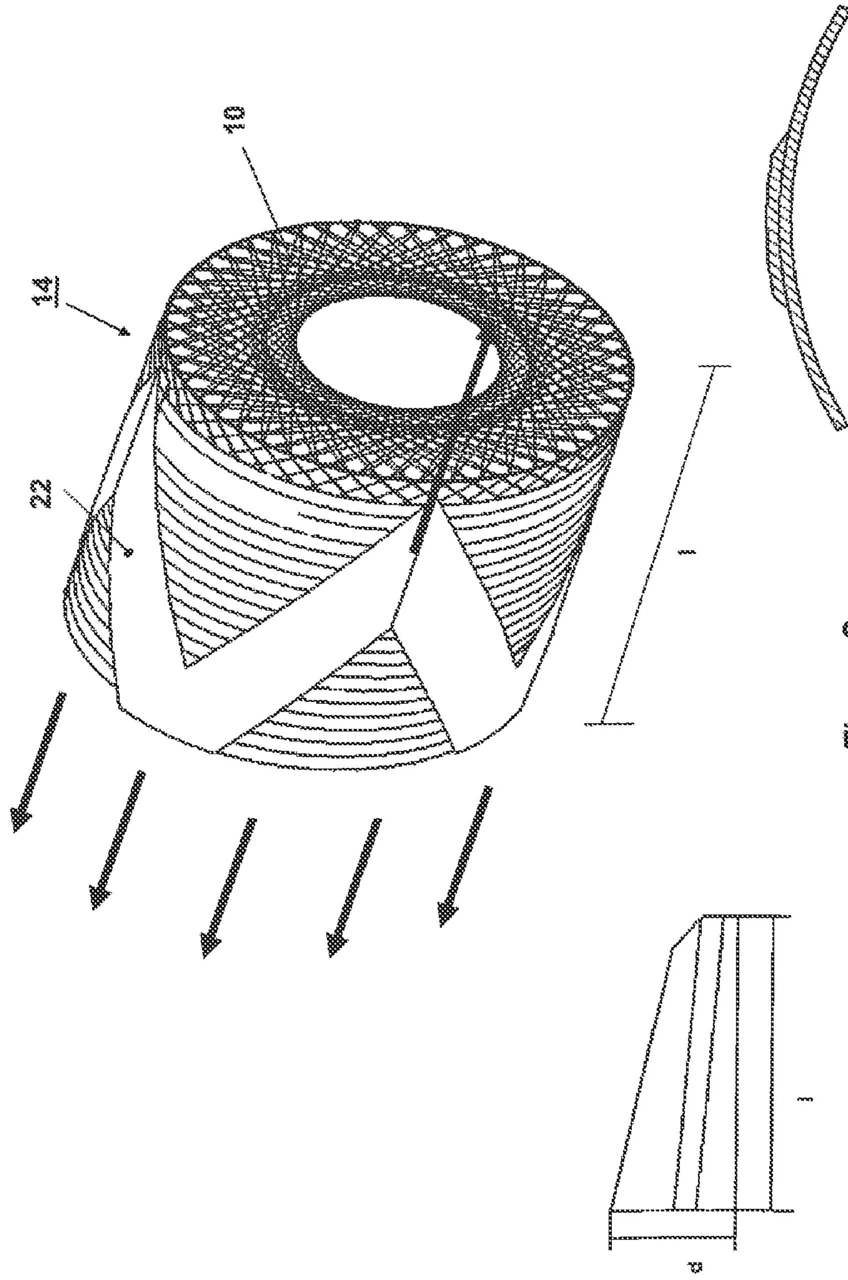

Figure 3

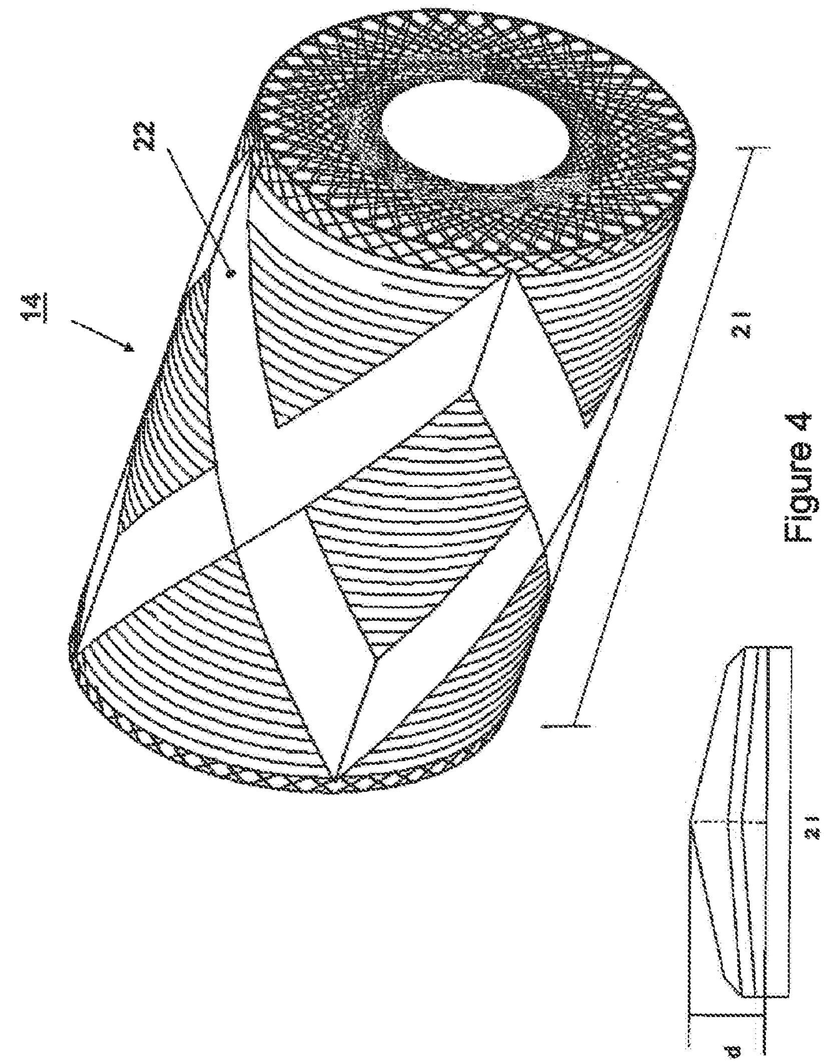

Figure 4

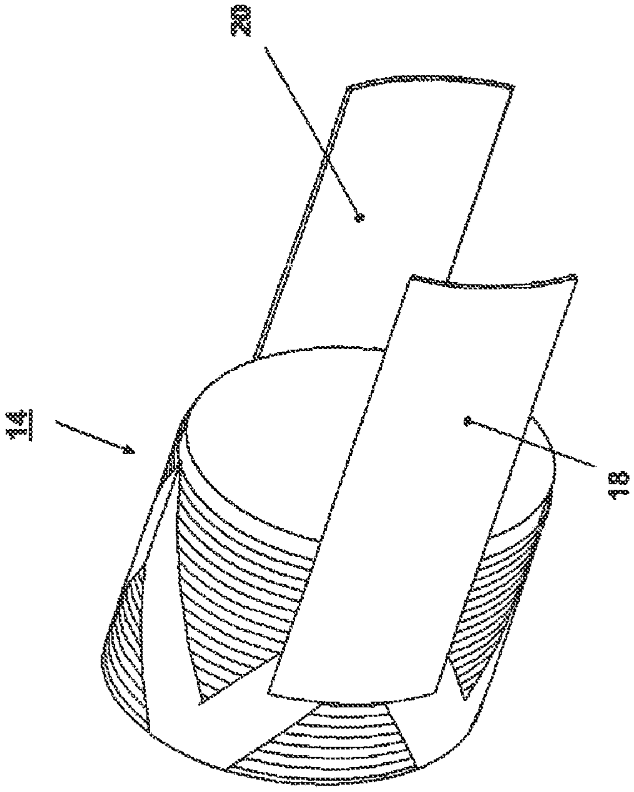

Figure 5

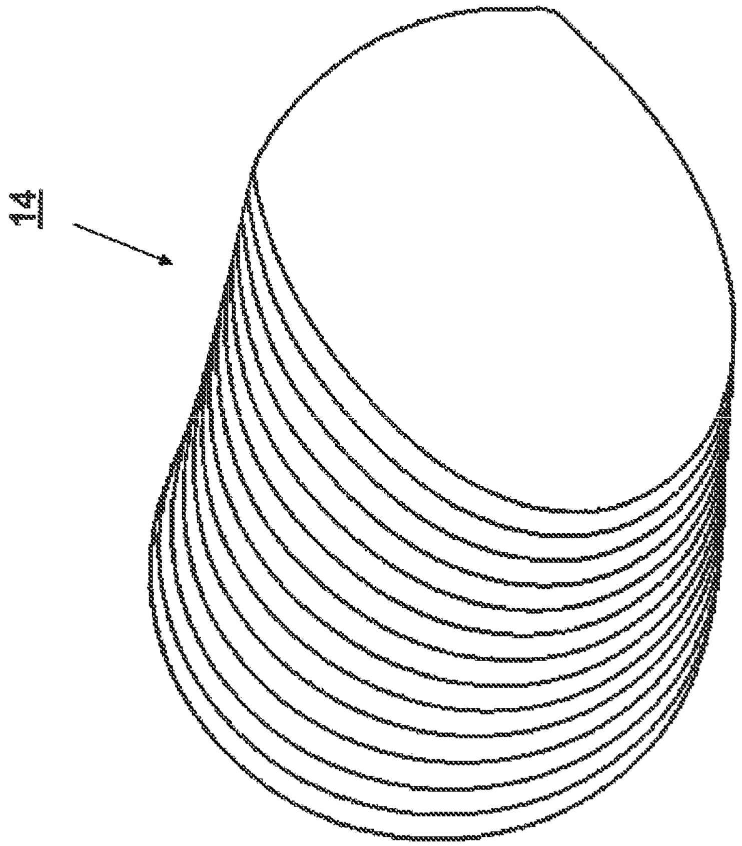

Figure 6