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(73) Patenthaver: **Siemens Gamesa Renewable Energy A/S, Borupvej 16, 7330 Brande, Danmark**

(72) Opfinder: **Pedersen, David Stien, Birkevej 4, 9000 Ålborg, Danmark**

(74) Fuldmægtig i Danmark: **Novagraaf Brevets, Bâtiment O2, 2 rue Sarah Bernhardt CS90017, F-92665 Asnières-sur-Seine cedex, Frankrig**

(54) Benævnelse: **FREMGANGSMÅDE TIL FREMSTILLING AF RODSEGMENTAFSNIT TIL ET RODSEGMENT AF ET TURBINEROTORBLAD, FREMGANGSMÅDE TIL FREMSTILLING AF RODSEGMENTET OG FREMGANGSMÅDE TIL FREMSTILLING AF TURBINEROTORBLADET**

(56) Fremdragne publikationer:
WO-A1-2014/072120
DE-A1- 102018 100 941
US-A1- 2013 276 962

DESCRIPTION

Description

[0001] The invention relates to a method for manufacturing root segment sections for a root segment of a turbine blade, a method for manufacturing a root segment of a turbine blade and a method for manufacturing a turbine blade, in particular a wind turbine blade.

[0002] It is known to manufacture root segment sections for a root segment of a wind turbine blade for a wind turbine separately by means of forming the root segment sections from multiple layers of fabric in a desired round shape and casting them. The root segment sections are thereafter joined together by means of casting to obtain the substantially cylindrical root segment. This method of manufacturing is time-consuming and cost-intensive.

[0003] DE 10 2018 100 941 A1 describes a method according to the preamble of claim 1.

[0004] It is an object of the invention to provide a method for manufacturing root segment sections for a root segment of a turbine blade, as well as a method for manufacturing the root segment and a method for manufacturing the turbine blade, which are simple, precise, time-efficient and cost-effective.

[0005] This object is solved by the subject-matter of the claims. In particular, the object is solved by a method for manufacturing root segment sections for a root segment of a turbine blade according to claim 1, a method for manufacturing a root segment of a turbine blade according to claim 12 and a method for manufacturing a turbine blade according to claim 14. Further details of the invention unfold from the other claims as well as the description and the drawings. Thereby, the features and details described in connection with the method for manufacturing root segment sections for a root segment of a turbine blade of the invention apply in connection with the method for manufacturing the root segment and the method for manufacturing the turbine blade, so that regarding the disclosure of the individual aspects of the invention it is or can be referred to one another.

[0006] According to a first aspect of the invention, the object is solved by means of a method for manufacturing tapered root segment sections for a root segment of a turbine blade, in particular a wind turbine blade, wherein the method comprises the steps as defined in claim 1.

[0007] Thereby, multiple tapered root segment section may be provided with high preciseness and in a time-efficient and cost-effective manner, because these multiple tapered root segment sections are casted, meaning applying the adhesive and curing, at once and afterwards simply cut from the cured multilayered structure instead of separately manufacturing tapered root segment sections as known from the state of the art.

[0008] The tapered root segment sections may in particular have a round shape, i.e. be rounded and moreover in particular have a partially circular or elliptical shape such that when they are casted together form the root segment. Accordingly, the winding core may have a cylindrical shape and a circular or elliptical cross section. Thereby, a cylindrically shaped root segment of the turbine blade, in particular the wind turbine blade, may be manufactured. The root segment then has a cylindrical shape. The cross section of the root segment may have a circular or an elliptical shape.

[0009] The winding of the multiple layers of fabric is controlled, either manually or automatically, such that the tapered shape of the multilayered structure is built up. For this purpose, the layer of fabric wound around the winding core, which may also be referred to as a panel, may be moved relative to the winding core during the winding. Also, a roll from which the panel is supplied may be moved relative to the winding core. Alternatively, or additionally, the winding core itself may be moved relative to the panel and/or the roll, such that the tapered shape of the multilayered structure is built up. In particular, the multiple layers of fabric may be wound around the winding core in a way such that the multilayered structure from the fabric has a shape tapered perpendicular to the direction of the winding.

[0010] The adhesive may be a resin, such as an epoxy resin, or contain a resin, such as an epoxy resin, or a mix of different resins. The curing of the adhesive applied to the fabric of the multilayered structure wound around the winding core may be performed by heating the multilayered structure or by applying a self-curing adhesive.

[0011] The purpose of the winding core is to provide the shape of the cured multilayered structure. That is why the winding core is separated from the cured multilayered structure after the multilayered structure is cured. The cutting of the cured multilayered structure into the tapered root segment sections may be performed either by cutting through the cured multilayered structure such that separate tapered root segment sections are obtained or alternatively by cutting into but not through the cured multilayered structure such that tapered root segment sections are obtained, which however are still connected to one another at least in a part which is not cut through. It is important, that the tapered root segment sections may be pulled apart from one another for a large part such that a distance between them is created when they are later joined together once again to form the root segment, which will be explained later.

[0012] The fabric may contain glass fibers, carbon fibers and/or aramid fibers, for example, or any other fibers or mix of fibers. The winding core may be a hollow winding core, for example.

[0013] Preferably, the cured multilayered structure is cut into the tapered root segment sections in a direction transverse, in particular at a degree in the range of 70 ° to 110 °, to a circumference or direction of circumference of the cured multilayered structure, i.e. not along the circumference.

[0014] Moreover, preferably, the cured multilayered structure is cut into at least four root segment sections.

[0015] The winding of the multiple layers of the fabric on the winding core is performed in a way such that two adjacent multilayered structure portions of the multilayered structure from the fabric are obtained, each of the two adjacent multilayered structure portions having a shape tapered in an opposing direction. In particular, the adjacent multilayered structure portions may be adjacent multilayered structure halves of the multilayered structure. Also, the multilayered structure portions may be adjacent to one another such that they are connected with each other by means of the multiple layers of fabric.

[0016] Also, preferably, the cured multilayered structure is cut along a circumference between the two adjacent multilayered structure portions having the shapes tapered in the opposing directions. Thereby, effectively two portions are provided by means of only winding process on the winding core and thus twice as many tapered root segment sections may be provided very efficiently.

[0017] Further it is preferred, that the winding core has the shape of a truncated cone. The truncated cone shape enables for a simple providing and controlling of a precisely tapered shape of the multilayered structure.

[0018] It is also preferred, that the winding core has the shape of a double truncated cone. This means that the winding core has two adjacent truncated cones as a shape. Thereby, it is easily possible to provide two adjacent multilayered structure portions of the multilayered structure.

[0019] Moreover, it is preferred, that the shape of the double truncated cone of the winding core is a shape in which deck areas of two truncated cones of the double truncated cone are congruent with each other. A truncated cone as a geometrical shape has a deck area and opposite of that deck area a base area. The base area is larger than the deck area. When the deck areas of the truncated cones of the double truncated cone shape of the winding core are congruent with each other, or in other words are equal, than the winding process may be performed particularly easy and fast. That is because a double truncated cone shape with congruent deck areas has a V-shaped recess in between the truncated cones and thus the multiple layers of fabric may very easily be built up in that V-shaped recess.

[0020] It is also preferred, that the winding core is cut along a circumference between the two winding core portions, each of which has the shape of the truncated cone. By means of cutting the winding core in such a way, the winding core may be separated from the cured multilayered structure with ease.

[0021] Further it is preferred, that the adhesive is applied to the fabric (a) by means of immersing the multiple layers of fabric into a bath prior to winding them around the winding core, and/or (b) by means of vacuum infusing the adhesive into the multilayered structure

wound around the winding core. In the first case, the fabric is wound in a wet condition (wet from the adhesive) onto the winding core, whereas in the second case, the fabric is wound in a dry condition onto the winding core. This means, that the adhesive may be applied to the fabric prior to and/or after the winding.

[0022] Preferably, the winding core has a smooth outer winding surface. The outer winding surface is the winding surface of the winding core onto which the multiple layers of fabric are wound. Thereby, the cured multilayered structure may be easily separated from the winding core.

[0023] Further preferably, a release agent is applied on an outer winding surface of the winding core prior to winding the multiple layers of the fabric around the winding core. The release agent facilitates easy removal of the cured multilayered structure from the winding core.

[0024] According to a second aspect of the invention, the object is solved by a method for manufacturing a root segment of a turbine blade, in particular a wind turbine blade, comprising the steps of:

1. (a) manufacturing multiple tapered root segment sections for the root segment of the turbine blade using the method according to the first aspect of the invention,
2. (b) arranging the multiple tapered root segment sections in a round shape, in particular a cylindrical shape, and
3. (c) casting the arranged multiple tapered root segment sections to obtain the root segment.

[0025] Preferably, the multiple tapered root segment sections are arranged at a distance from one another or with a gap in between each other in the round shape. This accounts for the deformation of the tapered root segment sections in the course of the casting process, in which high pressures are applied onto the tapered root segment sections.

[0026] According to a third aspect of the invention, the object is solved by a method for manufacturing a turbine blade, in particular a wind turbine blade, comprising the steps of:

1. (a) manufacturing a root segment of the turbine blade using the method according to the second aspect of the invention,
2. (b) arranging multiple layers of fabric on an outer side and an inner side of the root segment and connecting them to a portion of the turbine blade, and
3. (c) casting the multiple layers of fabric with the root segment and the portion of the turbine blade to obtain the turbine blade.

[0027] Further advantages, features and details of the invention unfold from the following description, in which by reference to the drawings of FIGS. 1 to 9 embodiments of the present invention are described in detail. Thereby, the features from the claims as well as the features mentioned in the description can be essential for the invention as taken alone or in an arbitrary combination. In the drawings, there is schematically shown:

FIG. 1
: a schematic side view on a method for manufacturing tapered root segment sections according to a first embodiment of the invention,

FIG. 2
: a schematic front view on the method of FIG. 1,

FIG. 3
: a schematic front view on the method for manufacturing tapered root segment sections according to a second embodiment of the invention,

FIG. 4
: a schematic front view on the method for manufacturing tapered root segment sections according to a third embodiment of the invention,

FIG. 5
: a schematic front view on the method for manufacturing tapered root segment sections according to a fourth embodiment of the invention,

FIG. 6
: a schematic front view on the method for manufacturing tapered root segment sections according to a fifth embodiment of the invention,

FIG. 7
: a schematic side perspective view on a cured multilayered structure separated from a winding core and manufactured by means of the method according to FIG. 3,

FIG. 8
: a schematic side perspective view on a tapered root segment section, and

FIG. 9
: a schematic sectional view through a wind turbine blade manufactured according an embodiment of a method for manufacturing a turbine blade according to the invention.

[0028] Same objects in FIGS. 1 to 9 are denominated with the same reference number. If there is more than one object of the same kind in one of the figures, the objects are numbered in ascending order with the ascending number of the object being separated from its reference number by a dot. The specific dimensions of features and parts in the figures are exemplary and may be enlarged for ease of reference only.

[0029] FIGURE 1 shows a schematic side view on a method for manufacturing tapered root segment sections 19 according to a first embodiment of the invention.

[0030] A panel 15 of a fabric 11 is being unwound from a roll 14 of the fabric 11 and transferred via pulleys 22.1, 22.2 through a bath 20 containing adhesive 21. The adhesive 21

attaches to the panel 15 of the fabric 11 and is transferred via pulley 22.3 to a winding core 30. The panel 15 is wound onto the winding core 30 as multiple layers 16 of fabric 11.

[0031] FIGURE 2 shows a schematic front view on the method of FIG. 1. From FIG. 2 it can be taken, that the winding core 30 is hollow and has the shape of a truncated cone C. The panel 15 of fabric 11 is wound from the roll 14 onto the winding core 30 in a way such that it is moved along the arrows placed next to the panel 15, indicating that the layers 16 of fabric 11 are consecutively built up on the winding core 30 such that a multilayered structure 17 made from the fabric 11 is provided on the outer winding surface G of the winding core 30. During the wounding, the winding core 30 is rotated around its winding core axis Z as indicated by the arrow placed next and circling the winding core axis Z.

[0032] The multilayered structure 17 may be cured together with the winding core 30 by applying heat to it, for example, or using a self-curing adhesive.

[0033] The multilayered structure 17 has a tapered shape, wherein the tapering runs perpendicular to a direction of the winding. The multilayered structure 17 has an outer side A and an inner side B arranged on the outer winding surface G, wherein the inner side B arranged on the winding core 30 is tapered towards the outer side A.

[0034] FIGURE 3 shows a schematic front view on the method for manufacturing tapered root segment sections 19 according to a second embodiment of the invention.

[0035] In contrast to the first embodiment of the invention according to FIG. 2, in FIG. 3 the winding core 30 has the shape of a double truncated cone D. In particular, the shape of the double truncated cone D is such that deck areas E.1, E.2 of the two truncated cones C.1, C.2 of the double truncated cone D are congruent with each other. Each of the deck areas E.1, E.2 is opposite to the base area F.1, F.2 of its respective truncated cone C.1, C.2.

[0036] The winding process itself is not shown in the FIG. 3 or any of the further figures anymore. However, due to the shape of a double truncated cone D, there is a V-shaped recess provided in the winding core 30, such that the multilayered structure 17 is built up having a triangular shape. There is a first cutting line H, along which the multilayered structure 17 may be cut such as to provide two multilayered structure portions 18.1, 18.2, in particular halves. The first cutting line H runs along the circumference of the multilayered structure 17. Further, the winding core 30 may be cut along first cutting line H so as to split the winding core 30 into two winding core portions 31 enabling easy separation of the multilayered structure portions 18.1, 18.2 from the winding core 30. The first cutting line H also runs along the circumference of the winding core 30.

[0037] Because the outer winding surface G in the second embodiment of the invention is larger than in the first embodiment of the invention, a panel 15 of larger width may be used for winding the layers 16 of fabric 11 onto the winding core 30, whereby the winding process is accelerated.

[0038] FIGURE 4 shows a schematic front view on the method for manufacturing tapered root segment sections 19 according to a third embodiment of the invention.

[0039] In contrast to the second embodiment of the invention according to FIG. 3, in FIG. 4 the V-shaped recess is smaller. Hence, the multilayered structure 17 is built onto the winding core 30 in a diamond like shape.

[0040] FIGURE 5 shows a schematic front view on the method for manufacturing tapered root segment sections 19 according to a fourth embodiment of the invention.

[0041] In contrast to the embodiments of the invention according to FIG. 2 to 4, in FIG. 5 the winding core 30 has the shape of a cylinder. The multilayered structure 30 is built up in a triangular shape but on top of the straight outer winding surface G of the winding core 30, so that the winding process is more challenging to provide a tapered shape of desired preciseness compared to the embodiments of FIG. 2 and 3 but an easier to manufacture shape of the winding core 30 may be used.

[0042] FIGURE 6 shows a schematic front view on the method for manufacturing tapered root segment sections 19 according to a fifth embodiment of the invention.

[0043] In contrast the embodiment of the invention according to FIG. 3, in FIG. 6 the winding core 30 the shape of the double truncated cone D such that base areas F.1, F.2 of the two truncated cones C.1, C.2 of the double truncated cone D are congruent with each other.

[0044] FIGURE 7 shows a schematic side perspective view on a cured multilayered structure 17 separated from a winding core 30 and manufactured by means of the method according to FIG. 3.

[0045] The cured multilayered structure 17 is cut along first cutting line H into the two multilayered structure portions 18.1, 18.2, being halves of the cured multilayered structure 17. Further, the cured multilayered structure 17 is cut along the shown second cutting lines K.1, K.2, K.3 running perpendicular to the first cutting line H. Thereby, multiple tapered root segment sections 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8 are provided.

[0046] FIGURE 8 shows a schematic side perspective view on a tapered root segment section 19.

[0047] The tapered root segment section 19, as cut from the cured multilayered structure 17 of FIG. 7, is tapered along its length and has a rounded shape. In particular, the tapered root segment section 19 has a partially circular or elliptical shape transverse, in particular perpendicular, to its length. Thereby, multiple of the tapered root segment sections 19 may be arranged at a distance from one another, when they are cut through from one another, or with a gap in between each other, when they are cut into, and casted such that they form a

cylindrical root segment having a circular or elliptical cross section.

[0048] FIGURE 9 shows a schematic sectional view through a wind turbine blade 40 manufactured according an embodiment of a method for manufacturing a turbine blade 40 according to the invention.

[0049] The root segment 10 has the tapered root segment sections 19 casted together with multiple layers of fabric 11 arranged on them with further portions 41.1, 41.2 of the turbine blade 40.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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Patent documents cited in the description

- DE102018100941A1 [0003]

PATENTKRAV

1. Fremgangsmåde til fremstilling af tilspidsede rodsegmentafsnit (19) til et rodsegment (10) på et turbinerotorblad (40), især et vindmøllerotorblad, hvilken fremgangsmåde omfatter følgende trin:

(a) vikling af en flerhed af lag (16) af et stof (11) om en viklingskerne (30) på en sådan måde, at der tilvejebringes en flerlagsstruktur (17) fra stoffet (11) med en form, der er tilspidset på tværs af en retning af viklingen,

(b) påføring af klæbemiddel (21) på stoffet (11),

(c) hærdning af klæbemidlet (21), der er påført stoffet (11) i flerlagsstrukturen (17) viklet om viklingskernen (30) på en sådan måde, at der tilvejebringes en hærdet flerlagsstruktur (17),

(d) adskillelse af den hærdede flerlagsstruktur (17) fra viklingskernen (30), og

(e) opskæring af den hærdede flerlagsstruktur (17) i de tilspidsede rodsegmentafsnit (19),

kendetegnet ved, at

viklingen af flerheden af lag (16) af stoffet (11) på viklingskernen (30) udføres på en sådan måde, at der tilvejebringes to til hinanden stødende flerlagsstrukturafsnit (18) af flerlagsstrukturen (17) fra stoffet (11), hvor hvert af de to til hinanden stødende flerlagsstrukturafsnit (18) har en form, der er tilspidset i en modsat retning.

2. Fremgangsmåde ifølge krav 1,

kendetegnet ved, at

den hærdede flerlagsstruktur (17) opskæres i de tilspidsede rodsegmentafsnit (19) i en retning på tværs af en omkreds af den hærdede flerlagsstruktur (17).

3. Fremgangsmåde ifølge krav 1 eller 2,

kendetegnet ved, at

den hærdede flerlagsstruktur (17) opskæres i mindst fire rodsegmentafsnit (19).

4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav,

kendetegnet ved, at

den hærdede flerlagsstruktur (17) opskæres langs en omkreds mellem de to til hinanden stødende flerlagsstrukturafsnit (18) med formerne tilspidset i de modsatte retninger.

5. Fremgangsmåde ifølge et hvilket som helst af de foregående krav,

kendetegnet ved, at

viklingskernen (30) har form af en keglestub (C).

6. Fremgangsmåde ifølge et hvilket som helst af de foregående krav,

kendetegnet ved, at

viklingskernen (30) har form af en dobbelt keglestub (D).

7. Fremgangsmåde ifølge krav 6,

kendetegnet ved, at

formen på viklingskernens (30) dobbelte keglestub (D) er en form, i hvilken dækområder (E) af to keglestubbe (C) af den dobbelte keglestub (D) kongruerer med hinanden.

8. Fremgangsmåde ifølge krav 7,

kendetegnet ved, at

viklingskernen (30) opskæres langs en omkreds mellem de to viklingskerneafsnit (31), hvoraf hvert har form af keglestubben (C).

9. Fremgangsmåde ifølge et hvilket som helst af de foregående krav,

kendetegnet ved, at

klæbemidlet (21) påføres stoffet (11) gennem

(a) nedsænkning af flerheden af lag af stof (16) i et bad (20), inden de vikles om viklingskernen (30), og/eller

(b) tilførsel, ved hjælp af vakuum, af klæbemidlet (21) ind i flerlagsstrukturen (17), der er viklet om viklingskernen (30).

10. Fremgangsmåde ifølge et hvilket som helst af de foregående krav,

kendetegnet ved, at

viklingskernen (30) har en glat ydre viklingsoverflade (G).

11. Fremgangsmåde ifølge et hvilket som helst af de foregående krav,

kendetegnet ved, at

et slipmiddel påføres en ydre viklingsoverflade (G) på viklingskernen (30), inden flerheden af lag (16) af stoffet (11) vikles om viklingskernen (30).

12. Fremgangsmåde til fremstilling af et rodsegment (10) af et turbinerotorblad (40), især et vindmøllerotorblad, hvilken fremgangsmåde omfatter følgende trin:

(a) fremstilling af en flerhed af tilspidsede rodsegmentafsnit (19) til turbinerotorbladets (40) rodsegment (10) ved anvendelse af en fremgangsmåde ifølge et hvilket som helst af de foregående krav,

(b) anbringelse af flerheden af tilspidsede rodsegmentafsnit (19) i en rund form, og

(c) støbning af den anbragte flerhed af tilspidsede rodsegmentafsnit (19) for at tilvejebringe rodsegmentet (10).

13. Fremgangsmåde ifølge krav 12,

kendetegnet ved, at

flerheden af tilspidsede rodsegmentafsnit (19) anbringes i en afstand fra hinanden eller med et mellemrum mellem hinanden i den runde form.

14. Fremgangsmåde til fremstilling af et turbinerotorblad (40), især et vindmøllerotorblad, hvilken fremgangsmåde omfatter følgende trin:

(a) fremstilling af et rodsegment (10) af turbinerotorbladet (40) ved anvendelse af en fremgangsmåde ifølge krav 13 eller 14,

(b) anbringelse af en flerhed af lag af stof (11) på en ydre side (A) og en indre side (B) af rodsegmentet (10) og forbindelse af dem til et afsnit (41) af turbinerotorbladet (40), og

(c) støbning af flerheden af lag af stof (11) med rodsegmentet (10) og afsnittet (41) af turbinerotorbladet (40) for at tilvejebringe turbinerotorbladet (40).

DRAWINGS

Drawing

FIG 1

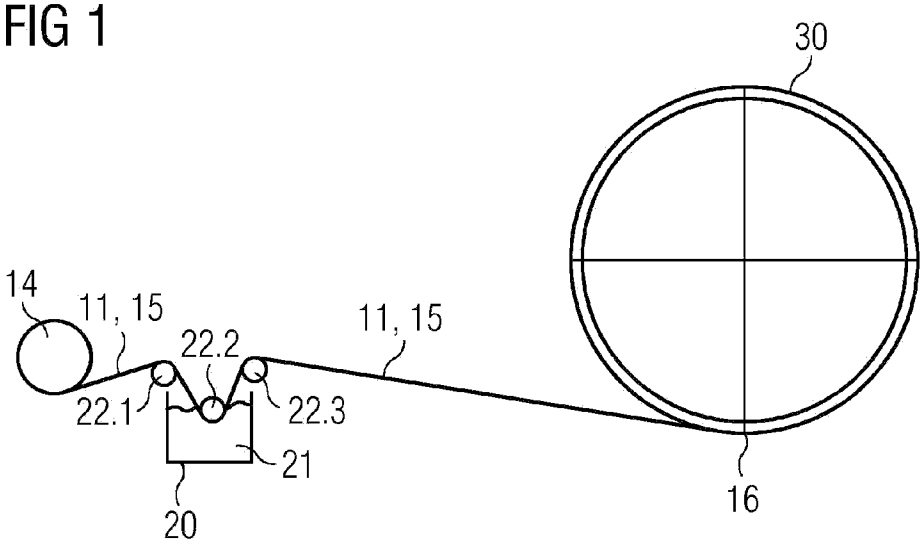


FIG 2

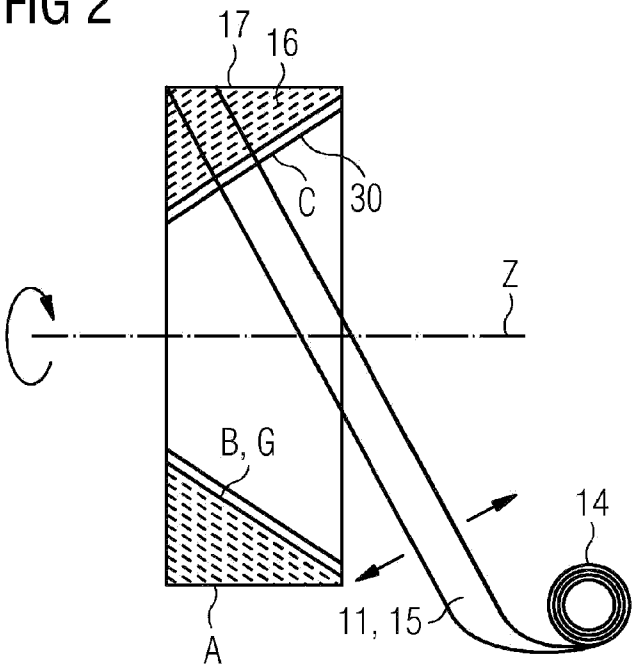


FIG 3

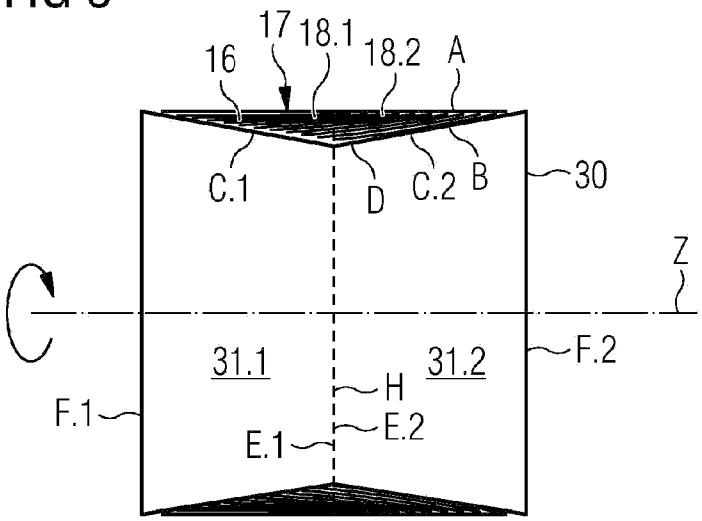
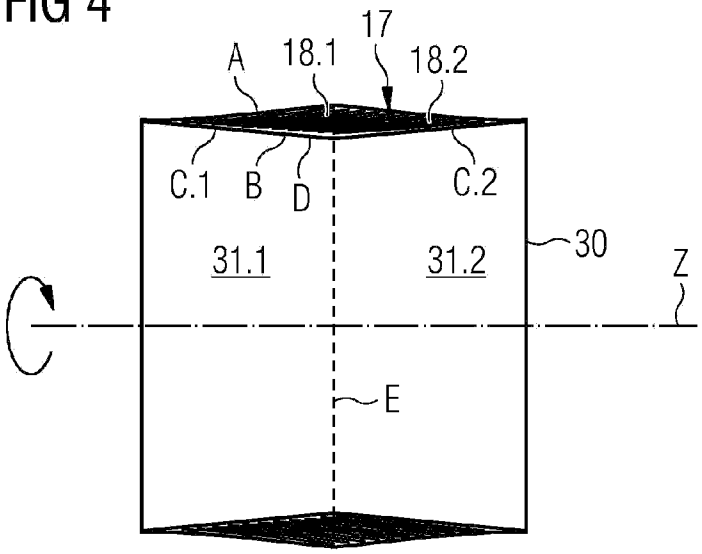

16
17
18.1
18.2
A
C.1
D
C.2
B
30
Z
31.1
31.2
F.2
H
F.1
E.2
E.1

FIG 4


17
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18.1
18.2
C.1
B
D
C.2
30
31.1
31.2
Z
E

FIG 5

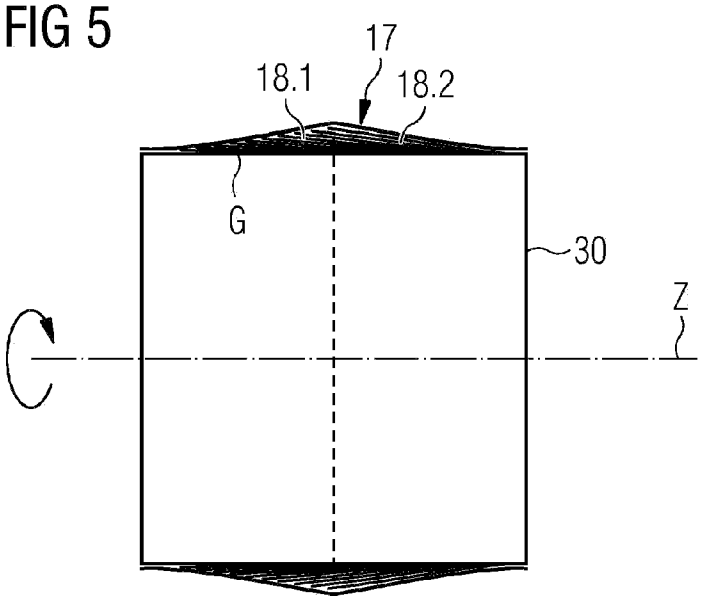

FIG 6

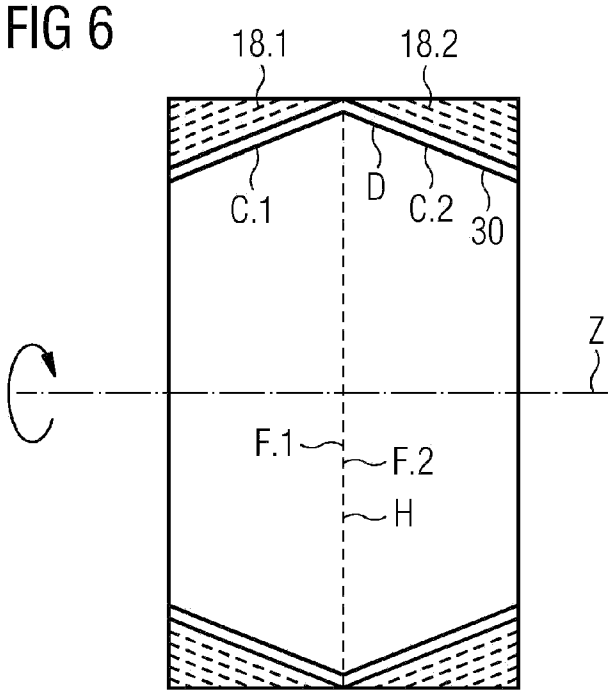

FIG 7

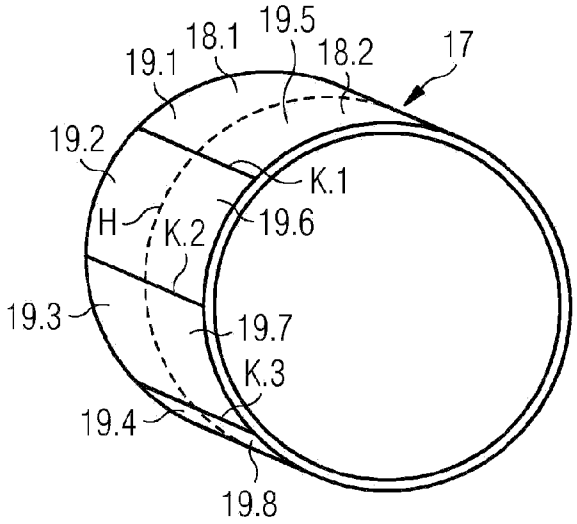

FIG 8

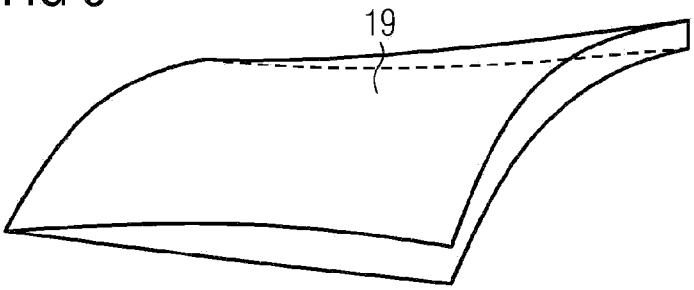

FIG 9