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Description

[0001] The present invention relates to a generator rotor, and more particularly relates to a generator rotor that is especially suitable for a wind turbine. The present invention further relates to a method for assembly of a generator rotor.

BACKGROUND ART

[0002] Generators having a rotor carrying permanent magnets are known. They are generally deemed to be reliable and require less maintenance than other generator topologies.

[0003] Modern wind turbines are commonly used to supply electricity into the electrical grid. Wind turbines of this kind generally comprise a rotor with a rotor hub and a plurality of blades. The rotor is set into rotation under the influence of the wind on the blades. The rotation of the rotor shaft either directly drives the generator rotor ("directly driven") or through the use of a gearbox. For offshore wind turbines, direct drive systems employing permanent magnets are usually chosen.

[0004] Such a direct drive wind turbine generator may have e.g. a diameter of 6 - 8 meters and a length of e.g. 2 - 3 meters. Hundreds of magnets may need to be screwed or glued to the circumference of the rotor. It will be clear that this manufacturing process can be cumbersome.

[0005] Furthermore, if one or more magnets is damaged and needs to be replaced, the access to these magnets can be complicated (especially with large size generators), such that maintenance can become very expensive.

[0006] This size and type of generator is not limited to the technical field of wind turbines only. Generators of considerable dimensions may also be found e.g. in steam turbines and water turbines.

[0007] DE 10 2005 042 543 discloses a synchronous machine with permanent magnets arranged on a magnet wheel. The wheel comprises cut-out portions in which pole pieces are provided.

SUMMARY OF THE INVENTION

[0008] In a first aspect, the present invention provides a generator rotor according to claim 1.

[0009] In this aspect of the invention, a generator rotor is provided that can be assembled relatively easily. The permanent magnets do not need to be attached one by one and there is no need to perforate the rotor rim.

[0010] In case that the stator is arranged around the rotor with permanent magnets, the permanent magnet modules will be positioned on an outer circumference of the rotor rim. The axial strips that connect the plurality of rotor rings will thus be attached at the inner circumference of the rotor rim. In case the rotor is arranged around the stator, the permanent magnet modules will be positioned on the inner circumference of the rotor rim (and the axial strips on the outer circumference).

[0011] In some embodiments, the permanent magnet modules may comprise a single row of magnets. In other embodiments, the permanent magnet module may comprise at least two rows of magnets.

[0012] In some embodiments, the fasteners are fixed in blind holes in the base of the permanent magnet module. No holes need to be provided in the permanent magnet material which may be more cost-effective.

[0013] In some embodiments, the axial strips may be fixed to the bottom of the rings by welding. In alternative embodiments, the strips may be attached to the inner circumference of the rings by gluing, riveting, bolts or otherwise.

[0014] In some embodiments, the permanent magnets may be covered with a non-magnetic material, such as a resin or stainless steel. A cover may serve to protect the magnets against corrosion, but a cover may also induce parasitic currents and/or decrease thermal dissipation.

[0015] In some embodiments, the permanent magnet modules may have a length substantially corresponding to half of the length of the generator. Two permanent magnet modules may be arranged behind each other. In other embodiments, the permanent magnet modules may have a length corresponding substantially to the length of the generator. In yet further embodiments, the permanent magnet modules may have a length substantially corresponding to another fraction of the length of the generator. Also, in some embodiments, the axial strips may have the length of the generator. In other embodiments, the axial strips may have a fraction (e.g. half) of the length of the generator.

[0016] In another aspect, the invention provides a method of assembling comprising providing a plurality of rotor rings, providing a plurality of strips, and attaching the rotor rings to the strips by welding at one of an inner or outer circumference of the rotor rings, and leaving gaps between the rotor rings, positioning a permanent magnet module on the other of the inner or outer circumference of the rotor rings, and attaching the module to the strips with a plurality of bolts, the bolts extending in the gaps between the rotor rings.

[0017] Additional objects, advantages and features of embodiments of the invention will become apparent to those skilled in the art upon examination of the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Particular embodiments of the present invention will be described in the following by way of non-limiting examples, with reference to the appended drawings, in which:

Figures 1a-1c illustrate a first embodiment of a generator rotor according to the present invention;

Figure 2 illustrates a front view of an example of a permanent magnet module that may be used in embodiments of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] Figure 1a illustrates a rotor rim formed by the outer circumference of a plurality of rotor rings 10a, 10b, 10c and 10d. The rings are attached to each other by a plurality of strips 30 that extend axially from the front ring 10a to the rear ring 10d.

[0020] Gaps 15 are maintained between neighbouring rotor rings 10. A plurality of permanent magnet modules 20 are provided on the outer circumference of the rotor rim. In this embodiment, each permanent magnet module comprises a base 21 upon which a single row of magnets 22 is arranged.

[0021] The permanent magnets may be covered with a thin plate of stainless steel and/or by e.g. an epoxy resin 26. In alternative embodiments, the permanent magnets may not be covered at all. These embodiments may provide good cooling of the magnets, using the free space between them. With a cover, the permanent magnets may be more protected from their environment and it may e.g. reduce the likelihood and degree of corrosion. However, a cover may decrease thermal dissipation and may also cause parasitic currents in the cover. For this reason, generally non-magnetic materials may be used.

[0022] In this example, a plurality of bolts 35 extend through holes in the strips 30 into the base 21 of the permanent magnet modules. This way, the permanent magnets are securely fixed to the outer circumference of the rotor rim without having to fix every single magnet separately. Additionally, if blind holes in the base of the permanent magnet modules are used, none of the permanent magnets needs to be machined with e.g. a bolt hole.

[0023] In this aspect of the invention, a generator rotor is thus provided that can be assembled relatively easily. The permanent magnets do not need to be attached one by one and there is no need to perforate the rotor rim.

[0024] In the example of figure 1a, each permanent magnet module carries a single row of permanent magnets. In alternative embodiments, on the top surface of the base, multiple rows of permanent magnets may be provided. The width of the permanent magnet modules and the number of rows of magnets may be varied. Having a higher number of magnets per module reduces the number of modules and may simplify the assembly procedure. On the other hand, smaller modules may be more easily manufactured.

[0025] Figures 1b and 1c show two different views of the same embodiment.

[0026] It will be clear that e.g. the number of rotor rings may be varied in accordance with circumstances. Additionally, it will be clear that the width of the strips does not necessarily need to be the same as the width of the permanent magnet modules.

[0027] In general, if the strips are sufficiently narrow, they may be straight, i.e. do not need to be curved to adapt to the form of the rotor rim.

[0028] Not shown in figures 1 a and 1 b is the central rotor structure, supporting the rotor rim 10. Such a rotor structure may take many suitable forms and may comprise e.g. a hub with a plurality of radially and optionally axially extending spokes supporting the rotor rim, or a more solid rotor comprising e.g. a relatively thick annular structure. Within the scope of the present invention, any central rotor structure supporting the plurality of rings that from the rotor rim may be used.

[0029] Similarly, in configurations wherein the rotor is arranged surrounding the stator, the support structure around the rotor rim may also take any suitable form.

[0030] Since the permanent magnet module are fixed to the rotor rim through their base, friction between fasteners and permanent magnets can substantially be avoided in embodiments of the invention, both in operation and during assembly.

[0031] Figure 2a illustrates a front view of a permanent magnet module in accordance with an embodiment of the present invention. The permanent magnet modules comprise a base 21 and a row of permanent magnets 22. In this embodiment, the permanent magnets 22 may be mounted on the base 21 using sets of screws 28. Additionally, the magnets may be glued to the base. Furthermore, belts 27 are attached at a front of the module, extend on top of the permanent magnets towards the rear and are attached at a rear of the module (see also figure 2b) to thereby bind the permanent magnets to the base. In alternative embodiments, only one or two of these ways to fix the magnet on the base may be used: in a specific example, the magnets may be glued to the base and the belts are merely provided for if and when the glue degrades during the lifetime of the generator. In another example, the magnets may be glued to the base without any additional fastening mechanism. Friction between magnets and fasteners may thus be avoided.

[0032] To more easily and precisely position a magnet on top of the base, the top surface of the base may comprise two upstanding guides 29 between which magnets can be placed.

[0033] Figure 2b illustrates a row of magnets 221 - 232 as seen in an axial cross-section. Belts 27 may be fixed with a pin (or other fastener) 27b at the front and at the rear of the permanent magnet module.

[0034] The permanent magnet modules may have a length that substantially corresponds to the axial length of the generator; each permanent magnet module thus spans substantially the entire length of the generator. In other embodiments, the length of a module may be substantially half of the axial length of the generator; two permanent magnet modules span the length of the generator. In these cases, one module may be inserted from the front and one module may be inserted from the rear during e.g. maintenance. In further embodiments, the length of a module may be substantially equal to another

fraction of the length of the generator.

[0035] Similarly, the axial strips do not necessarily span the entire length of the generator. Instead in some embodiments, a number of axial strips are positioned behind each other to together span the length of the generator.

[0036] Although only a number of particular embodiments and examples of the invention have been disclosed herein, it will be understood by those skilled in the art that other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof are possible. Furthermore, the present invention covers all possible combinations of the particular embodiments described. Thus, the scope of the present invention should not be limited by particular embodiments, but should be determined only by a fair reading of the claims that follow.

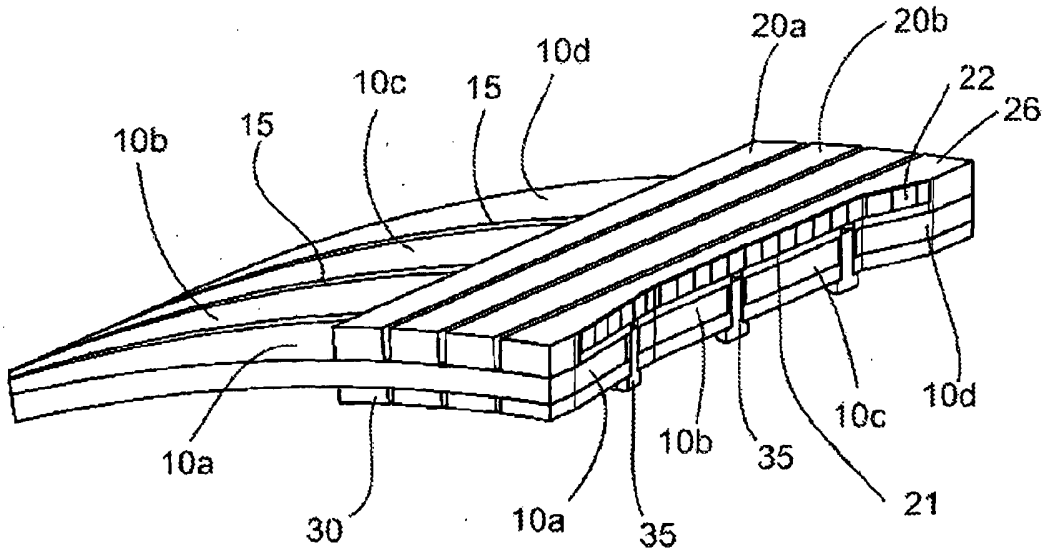

Figure 1a

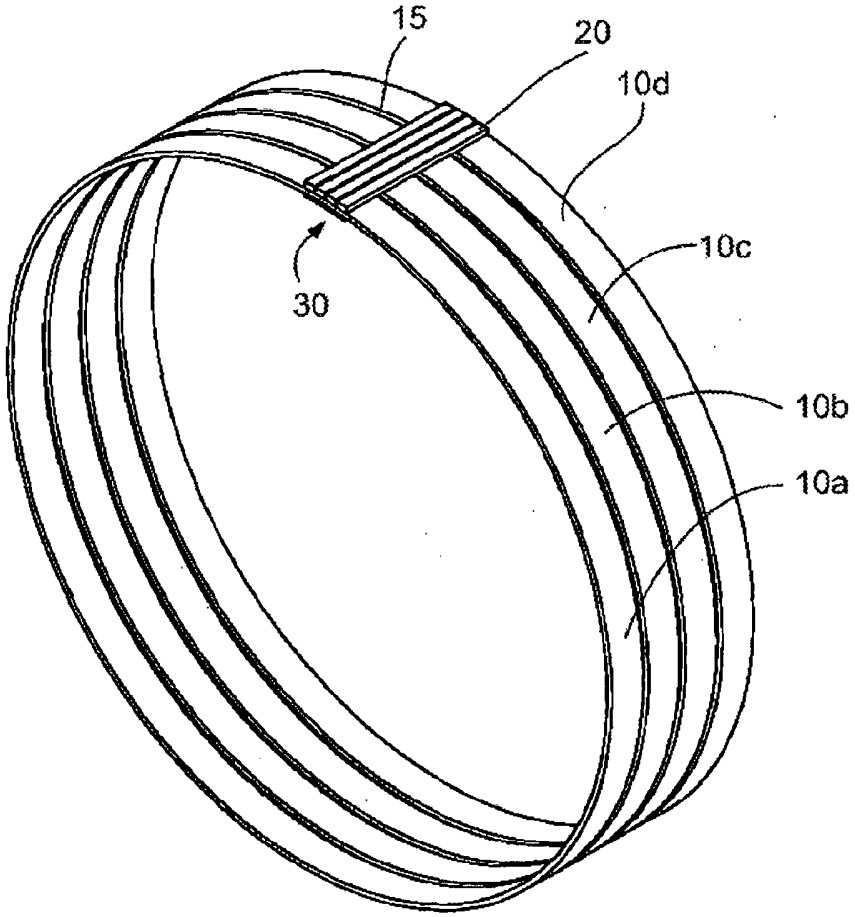

Figure 1b

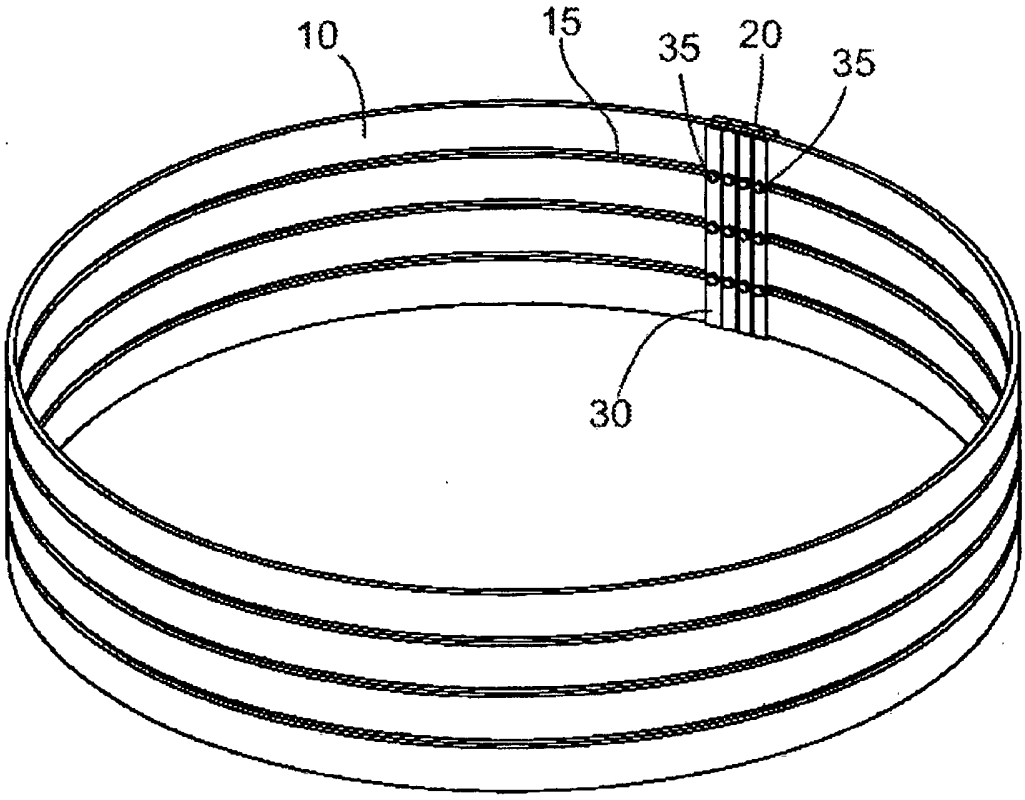

Figure 1c

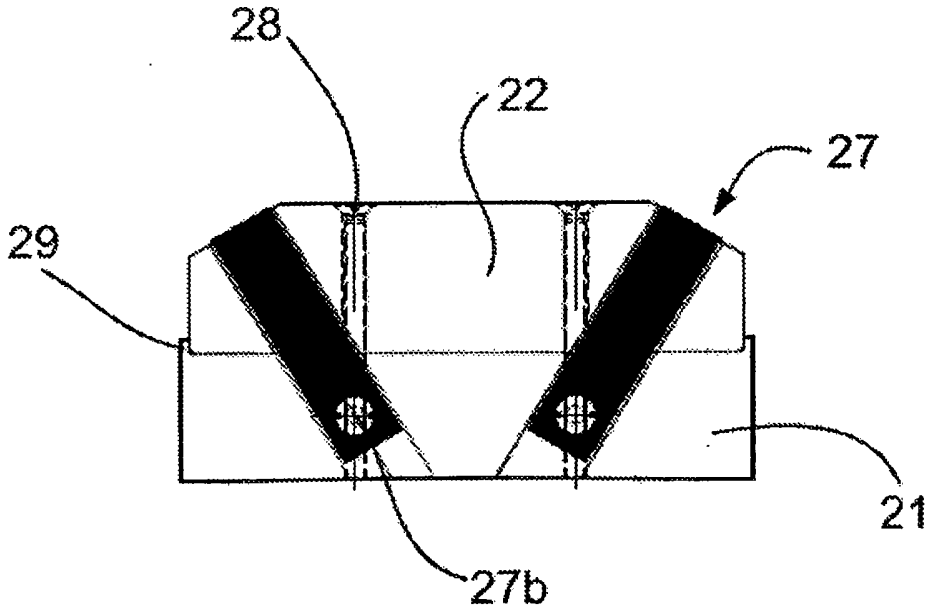

Figure 2a

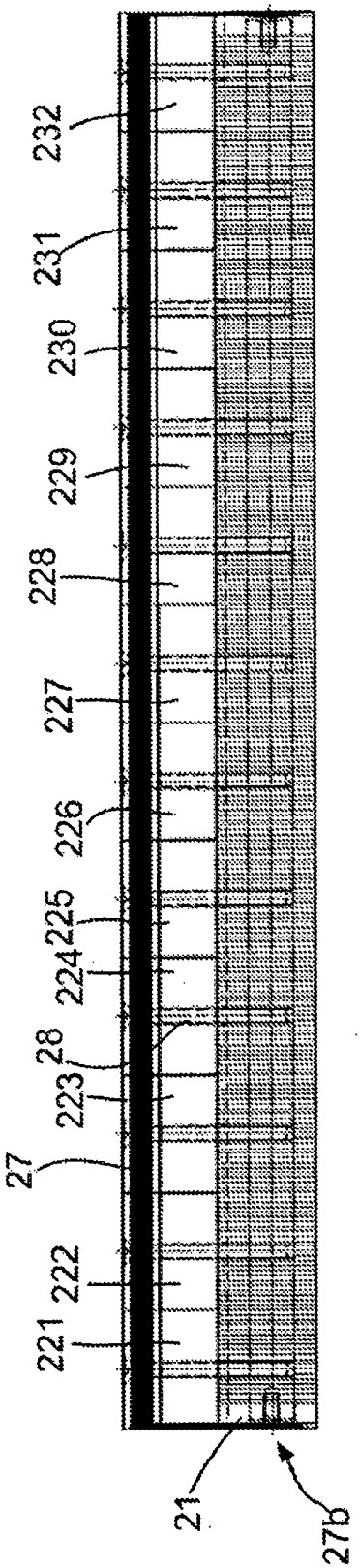

Figure 2b

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 102005042543 **[0007]**

Krav:

1. Generatorrotor omfattende en rotorkrans, hvor rotorkransen omfatter en flerhed af rotorringe (10a, 10b, 10c og 10d) adskilt ved hjælp af et mellemrum (15) mellem dem, og som er fastgjort til hinanden via en flerhed af aksiale bånd (30) fastgjort til den indre og ydre omkreds af ringene (10a, 10b, 10c og 10d), og en flerhed af permanente magnetmoduler (20) omfattende et fundament (21) og en eller flere rækker af magneter (22) monteret på en øverste overflade af nævnte fundament (21) og anbragt på den anden af den indre og ydre omkreds af nævnte ringe (10a, 10b, 10c og 10d), hvor de permanente magnetmoduler (20) er fastgjort til båndene (30) ved en flerhed af fastgørelseselementer (35) der strækker sig gennem hullerne (15) mellem rotorringene (10a, 10b, 10c og 10d).

2. Generatorrotor ifølge krav 1, hvor hver permanent magnetmodul (20) omfatter en enkelt række af magneter (22).

3. Generatorrotor ifølge krav 1, hvor hver permanent magnetmodul (20) omfatter mindst to række af magneter (22).

4. Generatorrotor ifølge hvilket som helst af kravene 1 - 3, hvor fastgørelsesorganerne (35) er fastgjort i blinde huller i basen af det permanente magnetmodul (20).

5. Generatorrotor ifølge hvilket som helst af kravene 1 - 4, hvor de aksiale bånd (30) er fastgjort til den indre omkreds af ringene (10a, 10b, 10c og 10d) ved svejsning.

6. Generatorrotor ifølge hvilket som helst af kravene 1 - 5 , hvor de permanente magneter (22) er dækket med et ikke-magnetisk materiale (26).

7. Generatorrotor ifølge hvilket som helst af kravene 1 - 6, hvor fastgørelsesorganerne (35) er bolte.

8. Generatorrotor ifølge hvilket som helst af kravene 1 - 7 , hvor de permanente magnetmoduler (20) har en længde i det væsentlige svarer til længden af generatoren.

9. Generatorrotor ifølge hvilket som helst af kravene 1 - 8, hvor de permanente magnetmoduler (20) har en længde, der i det væsentlige svarer til halvdelen af længden af generatoren.

10. Direkte drevet vindmølle omfattende en generator med en Generatorrotor ifølge hvilket som helst af kravene 1 - 9 .

11. Fremgangsmåde til samling omfattende tilvejebringelse af en flerhed af roterringe (10a, 10b, 10c og 10d); og kendetegnet ved tilvejebringelse af en flerhed af bånd, og fastgøring af rotorringene til båndene (30) ved svejsning ved en af den indre eller ydre omkreds af rotorringene (10a, 10b, 10c og 10d), og efterlade mellemrum (15) mellem rotorringene; positionere et permanent magnetmodul (20) på den anden, af den indre eller ydre omkreds af rotorringene (10a, 10b, 10c , 10d); og fastgørelse af modulet (20) til båndene (30) med en flerhed af bolte (35), hvor boltene udstrækker sig fra mellemrummene mellem rotorringene (10a , 10b, 10c og 10d).