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(54) LIGHTWEIGHT NACELLE FOR TURBINES AND METHODS FOR MAKING SAME

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(57) **ABSTRACT**

A lightweight nacelle includes a plurality of wound carbon fibers embedded in an epoxy matrix around a hollow region. The nacelle is made by a process that includes winding the plurality of carbon fibers around a mandrel.

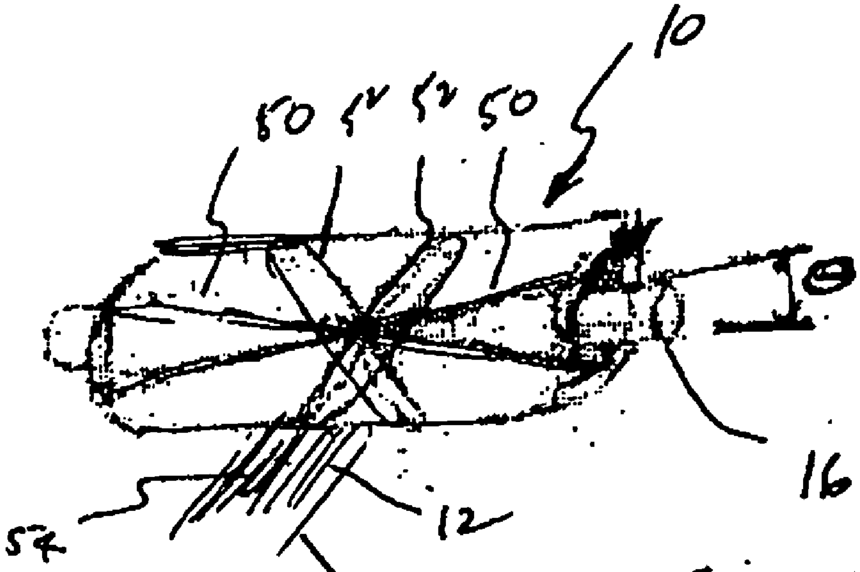

Fig. 1

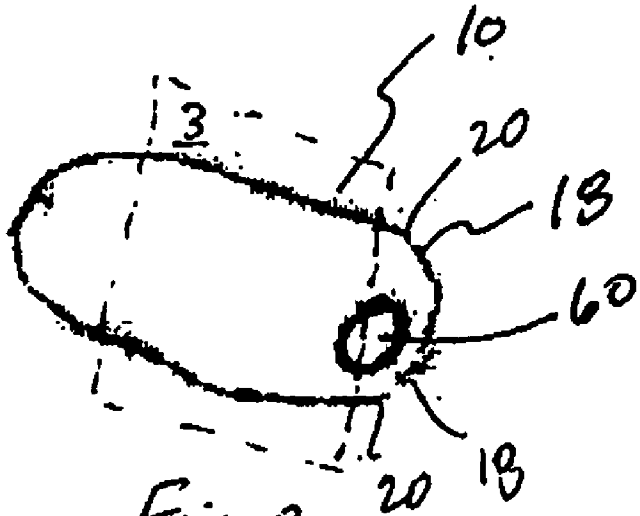

Fig. 2

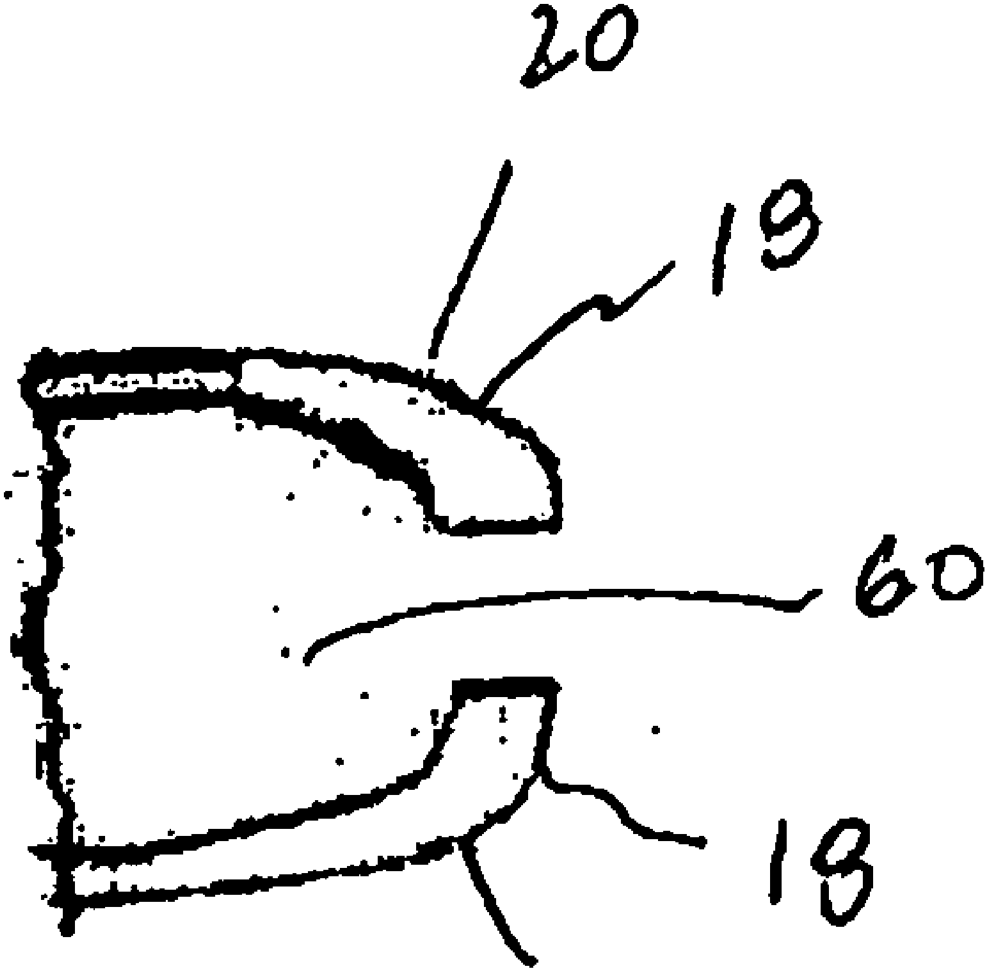

Fig. 3

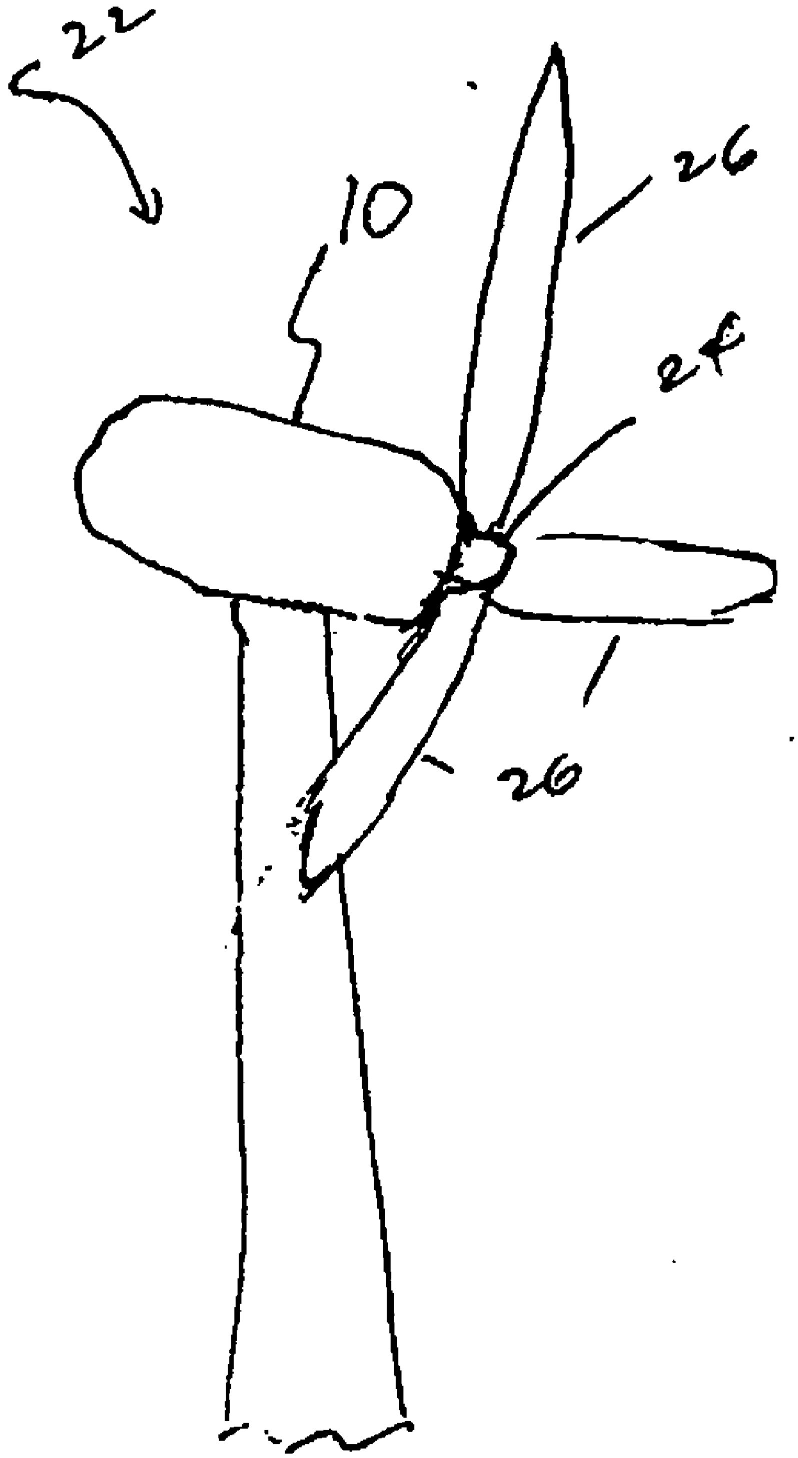

Fig. 4

LIGHTWEIGHT NACELLE FOR TURBINES AND METHODS FOR MAKING SAME

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to methods for manufacturing of nacelles for turbines and for nacelles made by such methods. Configurations of the present invention are applicable to many different types of turbines, and are particularly advantageous for wind turbines.

[0002] At least one known nacelle configuration introduces substantial weight at the top of each wind turbine tower. The high weight at the top of the wind tower tends to increase cost and decrease reliability and life of wind turbines. In addition, this nacelle configuration includes a large cutout to accommodate a power shaft. This cutout introduces flexibility to the structure and requires local reinforcing and/or stiffening members.

BRIEF DESCRIPTION OF THE INVENTION

[0003] One aspect of the present invention therefore provides a lightweight nacelle that includes a plurality of wound carbon fibers embedded in an epoxy matrix around a hollow region, and having rounded corners.

[0004] Another aspect of the present invention provides a method for making a nacelle that includes winding a plurality of carbon fibers embedded in an epoxy matrix around a mandrel.

[0005] It will thus become apparent that configurations of the present invention provide a low-cost, structurally efficient nacelle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a pictorial schematic drawing representing the winding of carbon fibers embedded in an epoxy matrix as in some configurations of the present invention.

[0007] FIG. **2** is a pictorial drawing of a nacelle representative of some configurations of the present invention.

[0008] FIG. **3** is a partial planar cross-section of the nacelle of FIG. **2** taken in plane **3** of FIG. **2**.

[0009] FIG. **4** is a configuration of wind turbine using the nacelle of FIGS. **2** and **3**.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Some configurations of the present invention utilize an automated process in which a composite pre-impregnated tape/tow winding is used to fabricate a pitch-based carbon fiber epoxy nacelle for turbine engines. Pitch-based carbon fibers are inexpensive and readily available in a wide variety of strengths and stiffness, thereby allowing the structural response of the nacelle to be tuned to any of various preselected design criteria.

[0011] In some configurations of the present invention and referring to FIG. **1**, carbon fibers embedded in a low-cost epoxy matrix in either tape or tow format are wound around a mandrel. Suitable carbon fibers include, but are not necessarily limited to, pre-impregnated pitch-based carbon fibers. Fiber architecture can be tuned for predetermined strength and stiffness requirements. For example, the fibers can be wound +/−10-degree orientation for axial strength and stiffness (0-degrees is not possible with the winding process due to the winding poles), ±/−45-degree orientation for torsional stiffness and strength, and 90-degree orientation for lateral strength and stiffness. A thicker, dome (i.e., pole) region is a byproduct of some configurations of the present invention and provides natural reinforcement for the shaft cutout. Also, in some configurations of the present invention, rounded corners result from limitations in composite material winding. These rounded corners are also advantageous because they result in aerodynamic surfaces that are less likely to produce flow separation or vortex trails, which are vibration drivers, in high wind gusts. The winding can be performed using an automated process to produce a lighter weight, higher quality, nacelle structure due to well-controlled manufacturing conditions.

[0012] Thus, and referring to FIG. **1**, some configurations of the present invention comprise a lightweight nacelle **10**. Nacelle **10** itself comprise a plurality of carbon fibers **12** embedded in an epoxy matrix **14** and wound around a mandrel **16**, which is subsequently removed to leave behind a hollow region **60** (best seen in FIGS. **2** and **3**). Mandrel **16** may comprise an inflatable elastomeric to facilitate removal. Wound carbon fibers **12** in some configurations are pre-impregnated, pitch-based carbon fibers, which may be selected to satisfy predetermined strength requirements, stiffness requirements, or both.

[0013] Carbon fibers **12** in some configurations include fibers oriented to provide axial strength and stiffness. For example, in some configurations, fibers **12** include fibers **50** that are wound in a $\theta=\pm 10$ degree orientation. In some configurations, carbon fibers **12** include fibers oriented to provide torsional stiffness and strength, which may, for example, include fibers **52** wound in a $\theta=\pm 45$ degree orientation. And in some configurations, fibers **12** include fibers **54** oriented to provide lateral strength and stiffness. For example, nacelle **10** may include fibers **12** wound at a 90 degree orientation.

[0014] In many configurations and referring to FIGS. **2** and **3**, nacelle **10** has a thickened dome region **18** and rounded corners **20**.

[0015] Referring to FIG. **4**, nacelle **10** configurations of the present invention are particularly suitable for use in wind turbines **22** which have a rotor **24** having a least one blade **26**, and a generator (not shown, but inside nacelle **10**). In many configurations, three blades **26** are provided for aerodynamic efficiency.

[0016] In some configurations, a method for making a nacelle **10** is provided that comprises winding a plurality of carbon fibers **12** embedded in an epoxy matrix **14** around a mandrel **16**. The plurality of carbon fibers **12** can comprise pre-impregnated, pitch-based carbon fibers. In some configurations, the method further includes preselecting the fibers in accordance with predetermined strength requirements, stiffness requirements, or both.

[0017] The winding a plurality of carbon fibers **12** in some configurations further comprises orienting and winding fibers to provide axial strength and stiffness. For example, orienting and winding the fibers to provide axial strength and stiffness can comprise winding the fibers in a ±10 degree orientation.

[0018] Winding a plurality of fibers **12** in some configurations comprises orienting and winding fibers to provide torsional stiffness and strength. For example, orienting and winding fibers to provide torsional stiffness and strength can comprise winding the fibers in a ±45 degree orientation.

[0019] Winding a plurality of fibers **12** ins some configurations comprises orienting and winding fibers to provide lateral strength and stiffness. For example, orienting and winding fibers to provide lateral strength and stiffness can include winding fibers in a 90 degree orientation.

[0020] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.

What is claimed is:

1. A lightweight nacelle comprising a plurality of wound carbon fibers embedded in an epoxy matrix around a hollow region, and having rounded corners.

2. A nacelle in accordance with claim 1 wherein said wound carbon fibers are pre-impregnated, pitch-based carbon fibers.

3. A nacelle in accordance with claim 2 wherein said fibers are selected for predetermined strength requirements, stiffness requirements, or both.

4. A nacelle in accordance with claim 2 wherein said fibers include fibers oriented to provide axial strength and stiffness.

5. A nacelle in accordance with claim 4 wherein said fibers include fibers wound in a +/−10 degree orientation.

6. A nacelle in accordance with claim 2 wherein said fibers include fibers oriented to provide torsional stiffness and strength.

7. A nacelle in accordance with claim 6 wherein said fibers include fibers wound in +/−45 degree orientation.

8. A nacelle in accordance with claim 2 wherein said fibers include fibers oriented to provide lateral strength and stiffness.

9. A nacelle in accordance with claim 6 wherein said fibers include fibers wound at a 90 degree orientation.

10. A nacelle in accordance with claim 1 having a thickened dome region and rounded corners.

11. A wind turbine having a nacelle in accordance with claim 1, a rotor having a least one blade, and a generator.

12. A method for making a nacelle comprising winding a plurality of carbon fibers embedded in an epoxy matrix around a mandrel.

13. A method in accordance with claim 12 wherein said winding a plurality of carbon fibers comprises winding a plurality of pre-impregnated, pitch-based carbon fibers.

14. A method in accordance with claim 13 further comprising preselecting said fibers in accordance with predetermined strength requirements, stiffness requirements, or both.

15. A method in accordance with claim 13 wherein said winding a plurality of carbon fibers comprises orienting and winding fibers to provide axial strength and stiffness.

16. A method in accordance with claim 15 wherein said orienting and winding said fibers to provide axial strength and stiffness comprises winding said fibers in a +/−10 degree orientation.

17. A method in accordance with claim 13 wherein said winding a plurality of fibers comprises orienting and winding fibers to provide torsional stiffness and strength.

18. A method in accordance with claim 17 wherein said orienting and winding fibers to provide torsional stiffness and strength comprises winding said fibers in a +/−45 degree orientation.

19. A method in accordance with claim 13 wherein said winding a plurality of fibers comprises orienting and winding fibers to provide lateral strength and stiffness.

20. A method in accordance with claim 19 wherein said orienting and winding fibers to provide lateral strength and stiffness include winding said fibers in a 90 degree orientation.

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