PROPELLER

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to propellers that may be used, for example, for aircraft, watercraft, turbines, unmanned aerial vehicles and air circulation devices.

SUMMARY

[0001a] According to a first aspect of the invention there is provided a propeller for use with fluids, the propeller provided to propel an object or person or to move the fluid, the propeller comprising: a plurality of blades; a means for generating non-axial lift and non-axial fluid flow; a means for redirecting the non-axial fluid flow to axial fluid flow; a rotational axis coincident with a hub; the plurality of blades extending radially outward from the rotational axis and disposed around the rotational axis; each blade forming a loop and having an intake portion, an exhaust portion and a tip portion extending radially outward from the rotational axis; wherein the means for generating non-axial lift and non-axial fluid flow is the blades being configured wherein in a cross-sectional profile taken perpendicularly from the rotational axis through the tip portion of each of the plurality of blades, the distance from the rotational axis to the leading edge of the blade is greater than the distance from the rotational axis to the trailing edge of the blade in at least part of the tip portion, each of the plurality of blades has a roll angle value of 40 degrees to 50 degrees at a transition point from the intake portion to the tip portion, wherein the transition point occurs where the amount of non-axial lift produced by a given parameter section is greater than the axial lift produced; and wherein the means for redirecting the non-axial fluid flow to axial fluid flow includes a vertical angle between -45 degrees and 45 degrees throughout the blade.

[0002] Embodiments of the invention provide a propeller that has a plurality of blades and a means for generating non-axial lift, which creates non-axial fluid flow, and a means for redirecting non-axial fluid flow to create axial fluid movement or thrust. The propeller may include a hub or be of a rim or “hubless” form. The plurality of blades either extends outward from the hub or inward from the rim. Each blade may form a loop-type structure that may be open or closed, and having an intake portion, and exhaust portion and a tip portion extending radially outward from to the hub or inward from a rim or “hubless” form. The means for

generating non-axial lift and non-axial fluid flow to create axial thrust may be a configuration of the blades wherein in a cross-sectional-profile of each of the plurality of blades, the distance from the rotational axis to the leading edge of the blade is greater than the distance from the rotational axis to the trailing edge of the blade in at least part of the tip portion.

[0003] The blades may have an intake portion, an exhaust portion, and a tip portion that connects the intake and exhaust portions, but is not necessarily a discrete component. The propeller has an intake root and an exhaust root, which are at either the rim or hub, for example. The tip portion may include a roll angle of ninety degrees, wherein a roll angle of zero is at the intake root. The tip portion vertical angle and pitch angle may be positive throughout. In an exemplary embodiment the tip portion produces more non-axial lift than either the intake or the exhaust portion.

[0004] In an illustrative embodiment the transition from the intake portion to the tip portion occurs when the amount of non-axial lift produced by a given parameter section of the blade is greater than the axial lift produced.

[0004a] As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude further additives, components, integers or steps.

[0004b] Reference to any prior art in the specification is not an acknowledgment or suggestion that this prior art forms part of the common general knowledge in any jurisdiction or that this prior art could reasonably be expected to be understood, regarded as relevant, and/or combined with other pieces of prior art by a skilled person in the art.

DESCRIPTION OF THE DRAWINGS

[0005] For further detail regarding illustrative embodiments of the disclosed propeller, reference is made to the detailed description provided below, in conjunction with the following illustrations: All figures are of illustrative embodiments of the disclosed propeller.

[0006] FIGS. 1A-E depict various views of an illustrative propeller.

[0007] FIG. 2 depicts a parameter sections defining a propeller blade.

[0008] FIG. 3 depicts a blade parameter section geometry.

[0009] FIGS 4A-F depict measurements of rake for parameter sections in the intake portion, tip portion and exhaust portion of a propeller blade.

[00010] FIGS. 5A-F depict measurements for skew angle and vertical angle of parameter sections in the intake portion, tip portion and exhaust portion of a propeller blade.

[00011] FIG. 6 depicts an example fluid flow around propeller blades.

[00012] FIGS. 7A-D depict examples of alpha and radius values for selected parameter sections.

[00013] FIGS. 8A-H depict illustrative values or relative values of various parameters that define a parameter section or a blade.

[00014] FIGS. 9A-F depict pitch angles for selected parameter sections of the blades.

[00015] FIGS. 10A-B depict views of a turbofan.

[00016] FIG. 11 depicts an unmanned aerial vehicle.

[00017] FIGS. 12A-C depict roll angle for selected parameter sections.

[00018] FIGS. 13A-G depict a propeller without a hub and having a ring from which propeller blades extend.

[00019] FIGS. 14A-B depict a two blade propeller and a cross-section thereof.

[00020] FIGS. 15A-B depict a three blade propeller and a cross-section thereof.

[00021] FIGS. 16A-B depict a five blade propeller and a cross-section thereof.

[00022] FIGS. 17A-B depict a seven blade propeller and a cross-section thereof.

[00023] FIGS. 18A-F depict an illustrative embodiment of a propeller with a high rake.

[00024] FIGS. 19A-F depict a further illustrative embodiment of a propeller with a high rake for intake and exhaust.

[00025] FIGS. 20A-I depict an inboard propeller.

[00026] FIGS. 21A-F depict a propeller with a through hub exhaust.

DETAILED DESCRIPTION OF THE INVENTION

[00027] FIGS. 1A-E depict propeller 100 according to an illustrative embodiment. FIG. 1A depicts a perspective view of propeller 100. FIG. 1B depicts a side view of propeller 100, and FIG. 1C depicts the opposing side of propeller 100. FIGS. 1D and 1E depict a top (fore) view and bottom (aft) view, respectively, of Propeller 100. Propeller 100 includes a plurality of blades 102, 104, 106, each having, a tip portion 122, an intake portion 124 and an exhaust portion 126. In this illustrative embodiment, blades 102, 104 and 106 extend from a hub 128. Each of blades 102, 104, 106 has a median line 108, 110, 112, respectively. Blades 102, 104, 106 rotate about hub axis 103. For simplicity the term "hub" may be used to include any rotational axis, even if there is no physical hub.

[00028] The blades have a means for generating non-axial lift and non-axial fluid flow and a means for redirecting the non-axial fluid flow to axial fluid flow. In illustrative embodiments, the means for generating non-axial lift and non-axial fluid flow is the configuration of the tip portion of the blade, which will be described further below. In illustrative embodiments the means for redirecting the non-axial fluid flow to axial fluid flow is the configuration of the tip and intake portion, and may also include the exhaust portion, which will also be described in more detail below.

[00029] The term "propeller" as used herein may include rotary blade devices that can be used to displace fluid to propel an apparatus, or which are employed in a stationary device such as, for example, a cooling or other air circulating fan, which moves fluid such as air through or around it.

[00030] Propeller 100 has three blades 102, 104, 106 disposed at equal increments around hub 128. Disclosed embodiments of the propeller may have for example, two, three, four, five, six, seven or eight blades that rotate in the same plane. The number of blades will generally depend on the application of the propeller. For example, additional

blades may be beneficial for increases in the weight of a boat or airplane in which the propeller is employed to increase the area of the blades, thereby reducing the blade loading.

[00031] Blades 102, 104, 106 may be configured to rotate about an axis corresponding to hub axis 103, but in an apparatus in which there is no hub, such as in a configuration in which the blades extend inward from a rotating support. The rotation of the support may be generated by an electromagnetic field. Hub 128 may also be hollow, and may have openings in its surface, such as in a centrifugal fan.

[00032] FIG. 2 depicts a blade 200 having parameter sections 1-29, with parameter section 1 in the vicinity of the intake root 204, and parameter section 29 in the vicinity of exhaust root 206. Each parameter section represents a set of physical properties or measurements whose values determine the characteristics of the blade area. The parameter sections as a group determine the shape of blade 200 and its behavior. Parameter sections are equally spaced in an exemplary embodiment but may be selected at unequal intervals. FIG. 2 serves merely to illustrate how blade parameter sections may be laid out to define the blade geometry. Parameter sections represent the shape and orientation of blade 200 at a particular place along the blade. A smooth transition is formed between parameter sections to create a blade. As used herein "orientation" may include location. In the illustrative embodiment in FIG. 2, blade sections 1-29 are planar sections disposed along an irregular helical median line 202. "Irregular helix" is used herein to mean varying from a mathematical helix-defining formula or as a spiral in 3-D space wherein the angle between the tangent line at any point on the spiral and the propeller axis is not constant. The blade may have an irregular, non-helical median line at least in part, or the median line may be an irregular helix throughout.

[00033] Although 29 blade sections are shown in FIG. 2, more or fewer sections can be used to define a blade. Additionally, sections may exist within or partially within the hub that are not shown or fully shown. Blades may be defined by planar or cylindrical parameter sections.

[00034] Parameter sections 1-29 are defined, for example, by orientation variables, such as roll angle and vertical angle (alpha), and may include location variables; and shape variables, such as chord length, thickness, and camber. Additional illustrative orientation or location variable include rake, skew angle and radius. Some or more of the variables may

change through the blade or a blade portion and some may be constant throughout. Orientation variables may be measured with respect to an X-Y-Z coordinate system. The X-Y-Z coordinate system has the origin at the shaft centerline and a generating line normal to the shaft or hub axis 103. The X-Axis is along hub axis 103, positive downstream. The Y-Axis is up along the generating line and the Z-Axis is positive to port for a right handed propeller. A left handed propeller is created by switching the Z-Axis and making a left hand coordinate system.

[00035] Parameter sections may be located by their chord (nose-to-tail) midpoint, such as by using radius, rake and skew. Parameter sections may be oriented using the angles Phi, Psi and Alfa, as will be described further below.

[00036] FIG. 3 depicts blade parameter section geometry by reference to a cross-sectional profile of a blade, which could be a parameter section. An illustrative parameter section 300. Parameter section 300 is in the form of an asymmetrical airfoil. The airfoil is bounded by a curved blade surface line 302 and a generally flat blade surface line 304, with a rounded nose 306 at the leading edge 310 of the parameter section and a pointed or less rounded tail 308 at the trailing edge 312 of parameter section 300. Parameter sections may also be in the shape of a symmetrical airfoil. Additional parameter section shapes include, for example, a shape having parallel blade surface lines 302, 304. Blade surface lines 302, 304 may also be linear and at an angle to one another. The nose and tail edges may both be rounded, both be flat (perpendicular to one or both blade surface lines 302, 304) or one of either the nose or tail may be rounded and the other of the two flat. A blade formed of a sheet material, for example, would generally exhibit parallel blade surface lines 302, 304. In an illustrative example of a blade formed of a sheet, the leading edge of the blade is rounded and the trailing edge is flat or less rounded, though both intake and trailing edges could be rounded.

[00037] Illustrative shape variables for parameter sections are defined as follows;

[00038] Radius: The term radius is used to define both the shape of a parameter section and its orientation with respect to the X-Y-Z coordinate system. With regard to the parameter section shape, radius may refer to the curvature of the nose 306 of parameter section 300, for example, and thus will be referred to as a “nose radius.” Other points on

parameter section 300 may be used to calculate a radius. By way of example, parameter section leading edge radius may be calculated based on maximum thickness 316 and the length of chord 314.

[00039] Chord: The chord is the nose-to-tail line 314 of the parameter section.

[00040] Thickness: Various thickness measurements may define a parameter section such as, for example, the maximum thickness 316. A further illustrative example is the trailing edge thickness, which may be calculated as a percentage of maximum thickness 316. For example, the trailing edge thickness may be 8% of maximum thickness 316 of parameter section 300.

[00041] Camber: Camber 318 defines the curvature of a parameter section.

[00042] **Illustrative orientation variables include:**

[00043] Rake: Rake is the axial location of a parameter section chord midpoint.

[00044] By "axial location" it is meant in this instance, along the X-axis, which is coincident with the propeller rotational axis. Illustrative rake measurements are shown in FIGS. 4A-F for various parameter sections. Each of FIGS. 4A-F show coordinates X, Y and Z, wherein the X-axis is coincident with the propeller rotational axis, and the Y-axis and Z-axis are perpendicular to the X-axis, and the three axes are mutually perpendicular. Parameters are measured from the origin of the coordinate system. In an illustrative embodiment, the zero point of the coordinate system is along the propeller rotational axis, and is closer to the intake root than the exhaust root. Illustratively, values along the X-axis toward the intake root are negative and toward the exhaust root are positive. In general a coordinate system is located as desired and all parameters or geometry are measured from the origin of the selected coordinate system.

[00045] FIGS. 4A and 4B depict Rake for parameter sections 412, 414 on the intake portion 402 of blade 400. Parameter section 412 in FIG. 4A is toward tip portion 404 of blade 400. Parameter section 414 is toward intake root 406. Rake is measured along the propeller rotational axis or along a line parallel to the rotational axis. In the illustrative examples of FIGS. 4A, 4B, Rake is the distance from point A at X equals zero to the X coordinate value of point B, wherein point B is at the midpoint 410 of the chord of

parameter sections 412, 414. The X-coordinate value of point B is represented by B_x in FIGS. 4A-F. .

[00046] FIGS. 4C and 4D depict Rake for parameter sections 418, 420 on the tip portion 404 of blade 400. Parameter section 418 in FIG. 4C is at a first position in tip portion 404 of blade 400 wherein the roll value (described further below) is greater than zero and less than 90 degrees. Parameter section 420 in FIG. 4D is at a second position in tip portion 404 where the roll value is equal to or greater than 90 degrees. In the illustrative examples of FIGS. 4C, 4D, Rake is the distance from point A at X equals zero to the X coordinate value, B_x, of point B, wherein point B is at the midpoint 410 of the chord of parameter sections 418, 420. FIGS. 4E and 4F depict Rake for parameter sections 422, 424 on the exhaust portion 426 of blade 400. Parameter section 422 in FIG. 4E is toward tip portion 404 of blade 400. Parameter section 424 is toward exhaust root 428. In the illustrative examples of FIGS. 4E, 4F, Rake is the distance from point A at X equals zero to the X coordinate value of point B, wherein point B is at the midpoint 410 of the chord of parameter sections 422, 424.

[00047] Pitch Angle: Pitch Angle is the angle between the chord line of a parameter section and a plane perpendicular to the X-axis. Pitch angle may be calculated based on pitch distance and blade radius. Examples of pitch angle of parameter sections is provided in FIGS. 9A to 9F.

[00048] Radius: The orientation radius is the distance from the hub center 208 to the midpoint 320 of chord 314 of a parameter section. Chord 314 may also be referred to as the nose-to-tail line. The radius described in this paragraph will be referred to as the parameter section orientation radius to differentiate it from the nose radius or other parameter section shape radii, which are not measured with respect to the X-Y-Z coordinate system. Midpoint 320 of chord 314 is the point on the parameter section chord line through which the median line 202 would pass. This is illustrated in FIG. 2 by line R which extends from hub center 208 to the midpoint of the chord of parameter section 5. Note that the chord of parameter section 5 and its midpoint are not specifically shown in FIG. 2.

[00049] FIGS. 5A-F depict blade 400 viewed along the blade rotational axis X. FIGS. 5A-F identify representative parameter section radii and skew angle. FIG. 5A

depicts the radius of parameter section 412 in the intake portion 402 of blade 400. FIG. 5B shows the radius of parameter section 414, a parameter section in intake portion 402 of blade 400 further from intake root 406 than parameter section 412. FIGS. 5C and 5D depict radii for parameter section 418 and 420, respectively, wherein parameter section 418, 420 are in tip portion 404. FIGS. 5E and 5F depict radii for exhaust parameter section 422 and 424, respectively, both within exhaust portion 426. The position of parameter sections 412, 414, 418, 420, 422 and 424 as being in intake portion 402, tip portion 404, or exhaust portion 426 are provided only

Claimed is:

1. A propeller for use with fluids, the propeller provided to propel an object or person or to move the fluid, the propeller comprising:

a plurality of blades;

a means for generating non-axial lift and non-axial fluid flow;

a means for redirecting the non-axial fluid flow to axial fluid flow;

a rotational axis coincident with a hub;

the plurality of blades extending radially outward from the rotational axis and disposed around the rotational axis;

each blade forming a loop and having an intake portion, an exhaust portion and a tip portion extending radially outward from the rotational axis;

wherein the means for generating non-axial lift and non-axial fluid flow is the blades being configured wherein in a cross-sectional profile taken perpendicularly from the rotational axis through the tip portion of each of the plurality of blades, the distance from the rotational axis to the leading edge of the blade is greater than the distance from the rotational axis to the trailing edge of the blade in at least part of the tip portion, each of the plurality of blades has a roll angle value of 40 degrees to 50 degrees at a transition point from the intake portion to the tip portion, wherein the transition point occurs where the amount of non-axial lift produced by a given parameter section is greater than the axial lift produced; and

wherein the means for redirecting the non-axial fluid flow to axial fluid flow includes a vertical angle between -45 degrees and 45 degrees throughout the blade.

2. The propeller of claim 1 wherein the tip portion of the blades includes a blade section having a roll angle of ninety degrees.

3. The propeller of claim 1 wherein the blades have an irregular helical median line.

4. The propeller of claim 1 wherein the tip portion of the blades produces more non-axial lift than either the intake or the exhaust portion.

5. The propeller of claim 1 wherein the roll angle value of parameter sections of the blades in the tip portion transition from less than 90 degrees to greater than 90 degrees.

6. The propeller of claim 1 wherein the tip portion of the blades has a non-zero pitch angle throughout.

7. The propeller of claim 1 wherein non-axial lift of the blades is generated by 10 percent to 75 percent of the blade.

8. The propeller of claim 1 wherein the pitch angle of the blades is positive throughout the blade.

9. The propeller of claim 1 wherein the tip portion has an intake end and wherein throughout at least a portion of the tip portion of the blades before a 90 degree roll angle and toward the intake end of the tip portion, the distance (N) to a nose of a cross-section as measured perpendicularly from the rotational axis is greater than the distance (T) to a tail of the cross-section as measured perpendicularly from the rotational axis.

10. The propeller of claim 9 wherein average pitch angle of the exhaust portion of the blades is greater than average pitch angle of the intake portion.

11. The propeller of claim 1 wherein the blades have an intake root and an exhaust root, and wherein the intake root rake position of the intake root is less than the exhaust root rake position of the exhaust root resulting in a gap between the intake root and the exhaust root.

12. The propeller of claim 1 wherein the blades have an intake root and an exhaust root, and wherein the intake root of the blades is forward of the exhaust root and skew begins at zero and ends at a positive value.

13. The propeller of claim 1 wherein the blades have an intake root and an exhaust root, and wherein pitch angle of the exhaust portion of the blades at the exhaust root is greater than pitch angle of the intake blade at the intake root.

14. The propeller of claim 1 wherein the blades have a closed loop structure.

15. The propeller of claim 1 wherein the blades have an intake root and an exhaust root, and each parameter section has a roll angle in the intake portion ranging from zero at or near the intake root, increasing to the tip portion to about 90 degrees at a tip portion

blade section, and increasing through the exhaust portion to about 180 degrees at or near the exhaust root.

16. The propeller of claim 1 wherein roll angles of parameter sections of the blades from the intake root to the exhaust root are 0 to 180 degrees.

17. A device having a propeller according to claim 1 selected from the group consisting of, jet engines, propulsors, shrouded propellers, encased propellers, impellers, aircraft, watercraft, turbines, including wind turbines, cooling devices, heating devices, automobile engines, unmanned aerial vehicles, turbofans (hydrojets), air circulation devices, compressors, and pump jets.

18. The propeller of claim 1 wherein vertical angles throughout the tip portion of the blades are zero.

19. The propeller of claim 1 wherein the blades have an intake root and an exhaust root, and wherein pitch angle of the exhaust portion of the blade at the exhaust root is less than pitch angle of the intake portion at the intake root.

20. The propeller of claim 1 defined by planar parameter sections.

21. The propeller of claim 1 where the intake portion has a higher average pitch angle than an average pitch angle of the exhaust portion.

22. The propeller of claim 1 wherein rake values of the blades decrease from the intake root and in the intake portion of the blade and increase in the exhaust portion of the blade.