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(54) SCREW TURBINE AND METHOD OF POWER GENERATION

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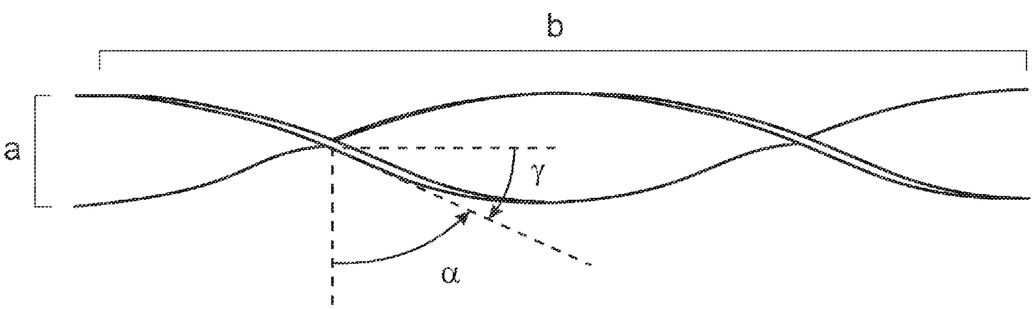
(57) ABSTRACT

A screw turbine comprising a helical turbine blade mounted for axial rotation, a mount associated with the helical turbine blade and mounting the helical turbine blade for axial rotation, and a generator associated with the helical turbine blade which converts energy imparted to the helical turbine blade to electricity, wherein the diameter of the helical turbine blade is less than the lead of the helical turbine blade and wherein said screw turbine is adapted to permit lateral exchange of fluid in use.



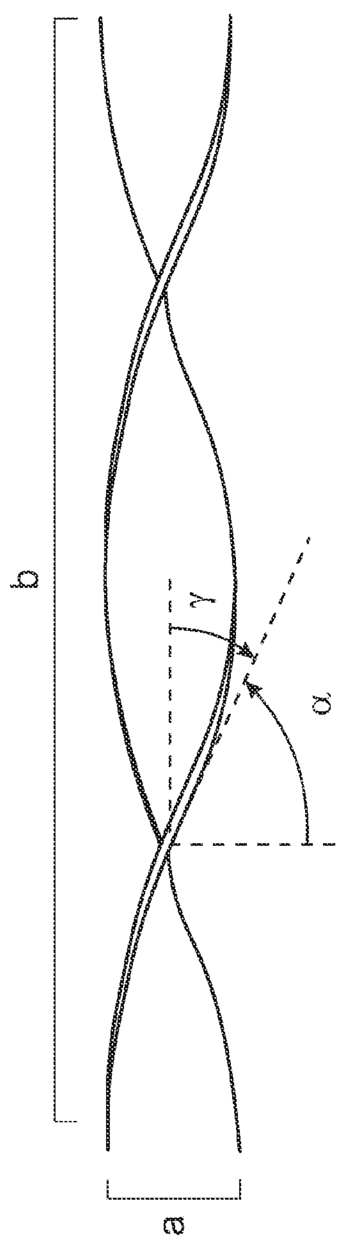


FIG. 1

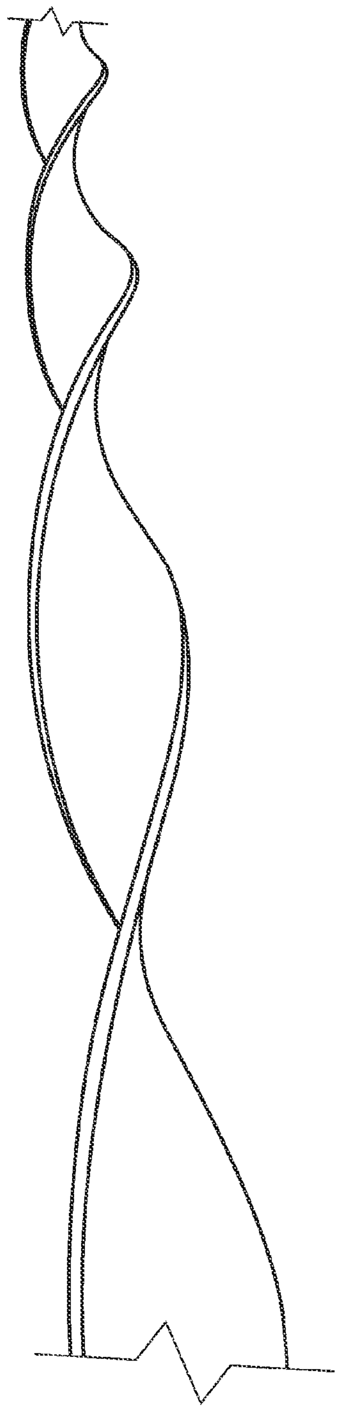


FIG. 2

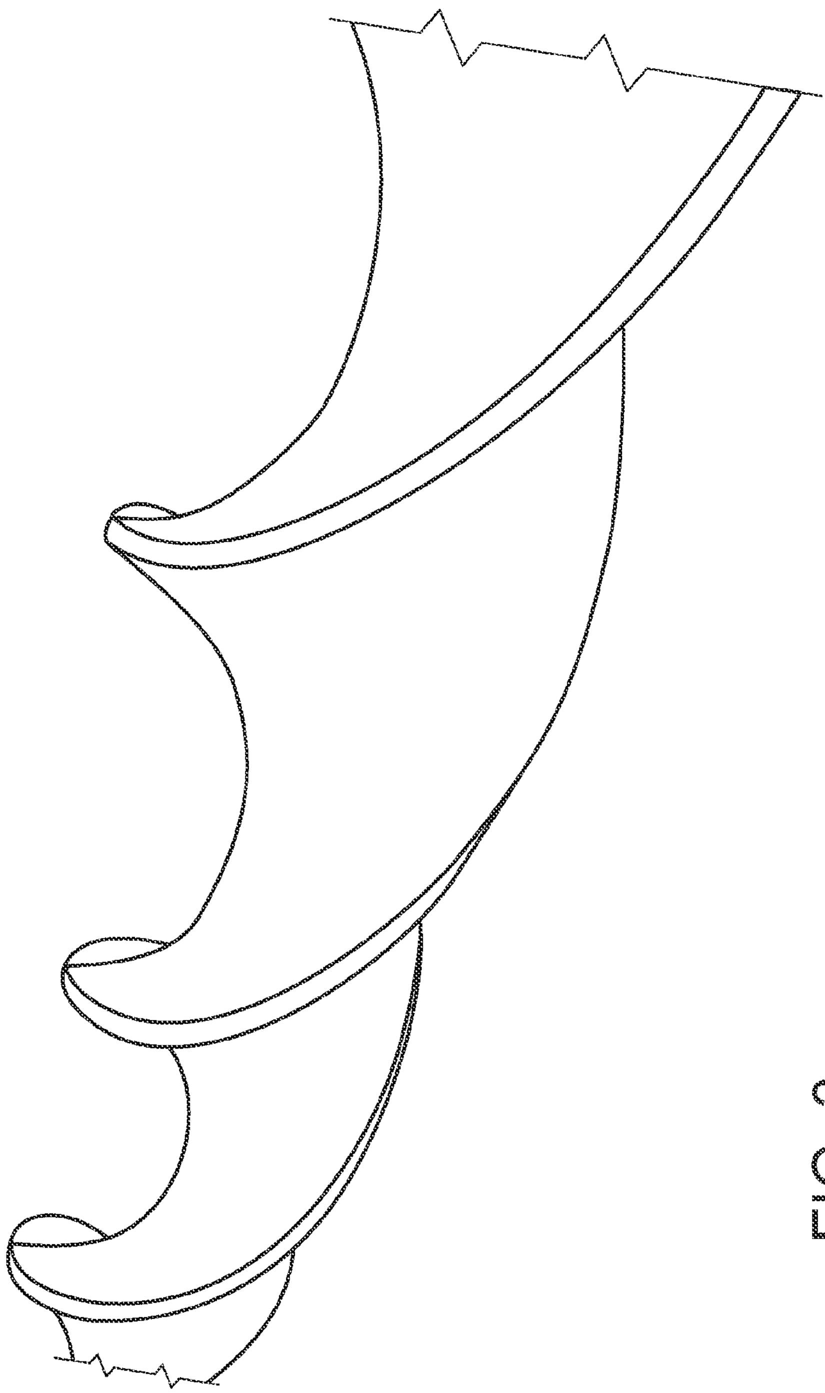


FIG. 3

SCREW TURBINE AND METHOD OF POWER GENERATION

[0001] CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0002] This patent application is a continuation of PCT/AU2011/000983, filed Aug. 3, 2011, which claims priority to Australian Application No. 2010903459, filed Aug. 3, 2010, the entire teachings and disclosure of which are incorporated herein by reference thereto.

FIELD OF THE INVENTION

[0003] The present invention relates to a screw turbine and method of power generation which employs same. Particularly, the invention relates to an Archimedean screw turbine including a helical turbine blade which has a relatively small helix angle and which, in use, advantageously does not require or employ an outer sheath that houses it.

BACKGROUND TO THE INVENTION

[0004] Various forms of turbines are known. These include, for example, cross-flow turbines, Kaplan turbines and Archimedean screw turbines.

[0005] In the cross-flow turbine a cylindrical water wheel or runner with a horizontal shaft is provided. The wheel or runner includes a number of blades arranged radially and tangentially. The blade edges may be sharpened to reduce resistance to the flow of water. Unlike most water turbines, which have axial or radial flows, in a cross-flow turbine the water passes through the turbine transversely, or across the turbine blades. As with a water wheel, the water is admitted at the turbine's edge. After passing the runner, it leaves on the opposite side. Going through the runner twice provides additional efficiency. When the water leaves the runner, it also helps clean the runner of small debris and pollution. The cross-flow turbine is a low-speed machine that is well suited for locations with a low head but high flow.

[0006] The Kaplan turbine is a propeller-type water turbine which has adjustable blades. It was developed in 1913 by Viktor Kaplan, who combined automatically adjusted propeller blades with automatically adjusted wicket gates to achieve efficiency over a wide range of flows and water levels. The Kaplan turbine is an inward flow reaction turbine. As such, the working fluid changes pressure as it moves through the turbine and gives up its energy. The design combines radial and axial features.

[0007] The Archimedean screw turbine was developed based on the principle of the Archimedes screw. The Archimedes screw is a type of water pump which has been known for centuries. To pump water from the bottom to the top, the pump needs to be twisted, either manually or through some other mechanism, such as a windmill. The Archimedean screw turbine is basically an inverted Archimedes screw which utilises water to drive the screw and conversion of the energy through a generator.

[0008] The big advantage of these turbines over others used for small hydro schemes is that they work well when there is a low head of water. As such, they may be used over an existing weir, or in outflow pipes and generally don't need much pipe work making the civil engineering component of the scheme much smaller. Debris in the river just passes through (at least up to a point), so there's no need for trash screens.

[0009] The efficiency of turbines, particularly wind turbines, is predicated by Betz law. This is a theory on the maximum possible energy that may be derived from a hydraulic wind engine, developed in 1919 by German physicist Albert Betz. According to this law, no turbine can capture more than 59.3% of the kinetic energy of wind. That is, the more one gears the propeller to resist the wind in order to generate more power, the more the propeller slows down and the less power is generated. Betz law may similarly apply to water turbines, although it is thought that there are some additional factors in play in this environment. Particularly, it is thought that higher efficiency may be obtained in water turbines compared with wind turbines as water is not compressible. Therefore, some energy may also be imparted in the form of pressure, in addition to the kinetic energy of the water. Even so, there are limits to the efficiency that may be obtained using existing water turbines.

[0010] The present invention aims to provide an alternative form of water turbine, in the form of an Archimedean screw turbine, which may provide improved efficiency under certain conditions compared with existing examples of water turbines.

SUMMARY OF THE INVENTION

[0011] According to one aspect of the invention there is provided a screw turbine comprising:

- **[0012]** a helical turbine blade mounted for axial rotation;
- **[0013]** a mount associated with the helical turbine blade and mounting the helical turbine blade for axial rotation; and
- **[0014]** a generator associated with the helical turbine blade which converts energy imparted to the helical turbine blade to electricity,
- **[0015]** wherein the diameter of the helical turbine blade is less than the lead of the helical turbine blade and wherein the screw turbine is adapted to permit lateral exchange of fluid in use.

[0016] As used herein the term "lead" is intended to mean the distance between consecutive contours of the helical turbine blade measured parallel to the axis of the blade. This is identified as distance "b" in FIG. **1**.

[0017] As used herein the term "lateral exchange" is intended to mean that fluid that has lost energy (i.e. has slowed) by transfer to rotation of the helical turbine blade is radially emitted from the helical turbine blade such that it is replaced by fluid having a higher energy. For example, if the screw turbine is submerged in moving water, water that has transferred energy to rotation of the helical turbine blade (i.e. has slowed) may be radially emitted and replaced with faster flowing water.

[0018] It is considered that the screw turbine of the invention may surprisingly give good results, particularly in applications involving low flow rates. It is thought that the screw turbine of the invention may provide for a proportional increase, or close thereto, in power generated as the length of the helical turbine blade increases. That is, it may be possible to provide turbines that overcome the Betz limit historically considered relevant to such systems.

[0019] In a preferred embodiment, the helical turbine blade of the screw turbine is unsheathed in use to permit lateral exchange of fluid. It is envisaged that this may also be achieved by providing sufficient spacing between the helical turbine blade and an outer sheathing surrounding it, or by providing such an outer sheathing with sufficient venting to allow fluid to be radially emitted.

[0020] The relationship between the diameter and lead of the helical turbine blade is not particularly limited, with the proviso that the diameter of the helical turbine blade is less than the lead of the helical turbine blade. That is, the "twist" of the helical turbine blade is relatively gentle. In a preferred embodiment, the ratio of diameter and lead of the helical turbine blade is about 1:8.

[0021] The helical turbine blade may preferably have a lead angle of from 50-75°, for example of about 60-75°. In certain embodiments, though, the lead angle may be as high as 80°. Such angles, corresponding with a relatively small helix angle, provide blades with a relatively gentle twist.

[0022] In one particular embodiment which is preferred in order to facilitate lateral exchange of the fluid, the helical turbine blade is an axleless helix. Although, it is considered that helical turbine blades that include an axle may also be useful in accordance with the invention.

[0023] As used herein, the term "axleless helix" is intended to mean that the blade does not include a central axle around which the blade is mounted (i.e. as with conventional Archimedes screws), but is constituted by a strip of material with twists along its length. This is best represented in FIGS. **2** and **3**.

[0024] The helical turbine blade may be mounted by any suitable means. For example, the blade may be mounted on a structure that is constructed in a body of water (i.e. secured within the river bed), or may be mounted at the distal end of an arm secured to and extending from, for example, a river bank or shore. The form of mounting will be somewhat dependent on particular environment involved. The blade must be mounted for rotation, for example through a coupling provided with bearings which facilitates rotation of the blade about its longitudinal axis.

[0025] The helical turbine blade may be coupled to a generator in the usual manner. For example, a drive shaft associated with the blade may be engaged with gearing that engages the generator to produce electricity. In such a case, it will be preferred that the gearing operate at low revolutions (revs) and high torque. That is, it will be preferred that there be a relatively high gearing ratio. This may be dependent on the particular circumstances of use.

[0026] According to another aspect of the invention there is provided a helical turbine blade for a screw turbine, the helical turbine blade comprising an axleless helix, the diameter of the axleless helix being less than the lead of the axleless helix.

[0027] As with the previous aspect of the invention, the ratio of diameter and lead of the helical turbine blade is preferably about 1:8. The helical turbine blade preferably has a lead angle of from 50-75°, for example of about 60-75°, but may be as high as 80°.

[0028] The helical turbine blade may be formed from any suitable material, for example steel or comparable material. It may be formed from a composite material.

[0029] According to a further aspect of the invention there is provided a method of power generation comprising:

- **[0030]** submerging a screw turbine provided with a helical turbine blade in a body of moving water; and
- **[0031]** converting energy imparted to the helical turbine blade to mechanical or electrical power,
- **[0032]** wherein the screw turbine is adapted to permit lateral exchange of water as the helical turbine blade is rotated by the moving water.

[0033] Preferably, the screw turbine is submerged unsheathed to permit lateral exchange of water as the helical turbine blade is rotated by the moving water. Other possible embodiments are disclosed above, but are not considered preferable.

[0034] Generally, the energy imparted to the helical turbine blade is converted to electricity through a generator. However, in certain embodiments it is envisaged that the energy may be converted to mechanical energy and used for alternative purposes.

[0035] As with other aspects of the invention, the diameter of the helical turbine blade is generally less than the lead of the helical turbine blade. For example, the helical turbine blade may comprise an axleless helix, the diameter of the axleless helix being less than the lead of the axleless helix.

[0036] Again, the ratio of diameter and lead of the helical turbine blade is preferably about 1:8. The helical turbine blade may have a lead angle of from about 50-75°, for example of about 60-75°.

DETAILED DESCRIPTION OF THE INVENTION

[0037] The invention will now be described in more detail with reference to the accompanying drawings. It should be appreciated that the following is provided by way of exemplification only and should not be construed as limiting on the invention in any way. In the drawings:

[0038] FIG. **1** illustrates a side view of a helical turbine blade; and

[0039] FIGS. **2** and **3** illustrate perspective views of a helical turbine blade.

[0040] Referring to the figures, the helical turbine blade takes the form of an axleless helix. Effectively, the helical turbine blade is constituted by a strip of material, for example steel or other suitable material, which is twisted along its length. The twists are relatively gentle, and therefore the helix angle y relatively small. Consequently, the lead angle a is relatively large. This is particularly the case compared with conventional screw turbines, the blades of which are generally provided with a much greater degree of raking.

[0041] The diameter "a" of the helical turbine blade is less than the lead "b" of the blade. As exemplified, the ratio of diameter to lead is just over 1:8. This configuration in combination with the omission of an axle is thought to facilitate better lateral exchange of fluid in use.

[0042] Generally, the helical turbine blade is submerged in moving water without any sheathing. With reference to the figures, it will be appreciated that in doing so, water will power the blade forcing it to rotate, lose energy and speed and be radially emitted from the blade allowing faster water to take its place. Therefore, as the length of the helical turbine blade increases, it is envisaged that the power generated will proportionally increase.

[0043] It is considered that the helical turbine blade and the screw turbine employing it will be useful in slow flowing rivers and other environments with relatively small currents. For example, the screw turbine may be a viable alternative to the hydroelectric schemes proposed for the Amazon River. Taking this example, the invention may provide substantial advantages including the ability to provide power while maintaining tribal land that is threatened by the proposed scheme (i.e. the building of a series of massive dams throughout the Amazon Basin).

[0044] The helical turbine blade is not rotated quickly or aggressively, and therefore works on relatively low efficiency, due to the fact that the helix angle is small (opposite to a propeller). However, due to the potential for greater length than generally seen in existing turbines, the medium (i.e. water) has a chance to act on a relatively large surface area which then increases the total amount of power transferred to the rotation.

[0045] Unless the context requires otherwise or specifically stated to the contrary, integers, steps or elements of the invention recited herein as singular integers, steps or elements clearly encompass both singular and plural forms of the recited integers, steps or elements.

[0046] Throughout this specification, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated step or element or integer or group of steps or elements or integers, but not the exclusion of any other step or element or integer or group of steps, elements or integers. Thus, in the context of this specification, the term "comprising" is used in an inclusive sense and thus should be understood as meaning "including principally, but not necessarily solely".

[0047] It will be appreciated that the foregoing description has been given by way of illustrative example of the invention and that all such modifications and variations thereto as would be apparent to persons of skill in the art are deemed to fall within the broad scope and ambit of the invention as herein set forth.

1. A screw turbine comprising:

a helical turbine blade mounted for axial rotation;

a mount associated with the helical turbine blade and mounting the helical turbine blade for axial rotation; and

a generator associated with the helical turbine blade which converts energy imparted to the helical turbine blade to electricity,

wherein the diameter of the helical turbine blade is less than the lead of the helical turbine blade and wherein said screw turbine is adapted to permit lateral exchange of fluid in use.

2. A screw turbine according to claim, **1**, wherein said helical turbine blade of said screw turbine is unsheathed in use to permit lateral exchange of fluid.

3. A screw turbine according to claim **1**, wherein a ratio of diameter and lead of said helical turbine blade is 1:8.

4. A screw turbine according to claim **1**, wherein said helical turbine blade has a lead angle of from about 50-75°, for example of about 60-75°.

5. A screw turbine according to claim **1**, wherein the helical turbine blade is an axleless helix.

6. A screw turbine according to claim **1**, wherein said at least one mount includes a coupling provided with bearings which facilitates rotation of the helical turbine blade about its longitudinal axis.

7. A screw turbine according to claim **1**, wherein a drive shaft associated with the blade is engaged with gearing that engages the generator to produce electricity, the gearing preferably operating at low revolutions (revs) and high torque.

8. A helical turbine blade for a screw turbine, said helical turbine blade comprising an axleless helix, the diameter of said axleless helix being less than the lead of said axleless helix.

9. A helical turbine blade according to claim **8**, wherein a ratio of diameter and lead of said helical turbine blade is 1:8.

10. A helical turbine blade according to claim **8**, wherein said helical turbine blade has a lead angle of from about 50-75°, for example of about 60-75°.

11. A method of power generation comprising:

submerging a screw turbine provided with a helical turbine blade in a body of moving water; and

converting energy imparted to the helical turbine blade to mechanical or electrical power,

wherein said screw turbine is adapted to permit lateral exchange of water as said helical turbine blade is rotated by said moving water.

12. A method of power generation according to claim **11**, wherein said screw turbine is submerged unsheathed to permit lateral exchange of water as said helical turbine blade is rotated by said moving water.

13. A method according to claim **11**, wherein said energy imparted to the helical turbine blade is converted to electricity through a generator.

14. A method according to claim **11**, wherein the diameter of the helical turbine blade is less than the lead of the helical turbine blade, preferably said helical turbine blade comprises an axleless helix, the diameter of said axleless helix being less than the lead of said axleless helix.

15. A method according to claim **11**, wherein a ratio of diameter and lead of said helical turbine blade is about 1:8.

16. A method according to claim **11**, wherein said helical turbine blade has a lead angle of from about 50-75°, for example of about 60-75°

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