Patented Hydro-kinetic undershot paddle wheel with in-blade articulated U-gravity boosters for low speed water flow

An object of at least some embodiments of the present invention is to provide a gravity boosted generator that is less likely to fall off from a surface of a Hydro-kinetic turbine blade, as well as a Hydro-kinetic turbine blade and a Hydro-kinetic turbine power generating apparatus having the gravity boosted generator.

A gravity boosted generator, according to at least some embodiments of the present invention, for a Hydro-kinetic turbine blade to be mounted to a Hydro-kinetic turbine blade, comprises: a platform portion to be mounted to a surface of the Hydro-kinetic turbine blade; and at least one fin disposed upright on the platform portion. The platform portion has a cross section having a curved convex shape, at least along a blade span wise direction of the Hydro-kinetic turbine blade.

During operation of a Hydro-kinetic turbine power generating apparatus, the Hydro-kinetic turbine blade deforms flexural due to bending deformation caused by an aerodynamic load. Thus, a great stress is applied to the platform portion mounted to the surface of the Hydro-kinetic turbine blade.

In this regard, with the above configuration (1), the platform portion of the gravity boosted generator has a cross section of a curved convex shape along the blade spanwise direction of the Hydro-kinetic turbine blade, and thereby the platform portion is deformable in accordance with bending deformation of the Hydro-kinetic turbine blade, and thereby it is possible to disperse stress generated at the platform portion. Thus, it is possible to reduce a risk of falling off of the gravity boosted generator from the surface of the Hydro-kinetic turbine blade.

(2) In some embodiments, in the above configuration (1), the platform portion has a cross section having a curved convex shape, along a chordwise direction of the Hydro-kinetic turbine blade.

With the above configuration (2), even if the Hydro-kinetic turbine blade should torsionally deform during operation of the Hydro-kinetic turbine power generating apparatus, the platform portion can deform in accordance with the

torsion deformation of the Hydro-kinetic turbine blade and thus it is possible to disperse stress applied to the platform portion. Thus, it is possible to reduce a risk that the gravity boosted generator falls off from the surface of the Hydro-kinetic turbine blade even further.

(3) In some embodiments, in the above configuration (1) or (2), the platform portion has a cross section having a curved convex shape within a region excluding a connection part at which the at least one fin connects to the platform portion, along any direction orthogonal to the surface of the Hydro-kinetic turbine blade.

With the above configuration (3), the platform portion deforms in accordance with complicated deformation of the Hydro-kinetic turbine blade, and thereby it is possible to disperse stress applied to the platform portion. Thus, it is possible to reduce a risk that the gravity boosted generator falls off from the surface of the Hydro-kinetic turbine blade even further.

(4) In some embodiments, in any of the above configurations (1) to (3), the platform portion has a circular shape or an oval shape in a top view.

With the above configuration (4), it is possible to disperse stress applied to the platform portion due to deformation of the Hydro-kinetic turbine blade effectively, and to reduce a risk that the gravity boosted generator falls off from the surface of the Hydro-kinetic turbine blade even further.

(5) In some embodiments, in any of the above configurations (1) to (4), the platform portion has a back surface to face the surface of the Hydro-kinetic turbine blade, and the back surface has a larger curvature along the chordwise direction than a curvature of the surface of the Hydro-kinetic turbine blade at a mounting position of the platform portion along the chordwise direction.

With the above configuration (5), it is possible to improve an adhesion property of the platform portion to the surface of the Hydro-kinetic turbine blade, and to reduce a risk of falling off of the gravity boosted generator even further.

(6) In an embodiment, in the above configuration (5), the back surface of the platform portion has a larger curvature along the chordwise direction than a curvature of the surface of the Hydro-kinetic turbine blade along the chordwise direction at a maximum chord-length position of the Hydro-kinetic turbine blade.

At the side of the blade root of the Hydro-kinetic turbine blade, it is desirable to improve the maximum lift coefficient Clmax to make up for shortage of an actual chord length with respect to the optimum blade chord length. For this purpose, an effective approach is to mount the gravity boosted generator to a region in the vicinity of the maximum chord-length position to suppress separation of a flow along the surface of the Hydro-kinetic turbine blade.

With the above configuration (6), even if the gravity boosted generator is to be mounted to a region in the vicinity of the maximum chord-length position of the Hydro-kinetic turbine blade (a region having a larger curvature on the surface of the blade body along the chordwise direction than at the side of the blade tip) to improve the maximum lift coefficient, it is possible to ensure an adhesive property of the platform portion to the surface of the Hydro-kinetic turbine blade appropriately.

(7) In some embodiments, in the above configuration (5) or (6), the gravity boosted generator further comprises an adhesive-agent layer for filling at least a gap between the back surface of the platform portion and the surface of the Hydro-kinetic turbine blade, and fixing the platform portion to the surface of the Hydro-kinetic turbine blade.

According to the above configuration (7), with the adhesive-agent layer formed in a gap between the back surface of the platform portion and the surface of the Hydro-kinetic turbine blade, it is possible to enhance an adhesion property of the platform portion to the surface of the Hydro-kinetic turbine blade, and to expect the adhesive-agent layer to achieve an effect to mitigate stress, which makes it possible to reduce the risk of falling off of the gravity boosted generator even further.

(8) In some embodiments, in any one of the above configurations (1) to (7), the at least one fin has a root portion which is to be connected to the platform portion and which has a fillet.

With the above configuration (8), it is possible to reduce stress concentration at a connection part between the root portion of the fin and the platform portion, and enhance the strength of the gravity boosted generator.

(9) In some embodiments, in any one of the above configurations (1) to (8), the at least one fin comprises a pair of fins disposed on the platform portion.

A plurality of fins may be disposed along the blade spanwise direction to constitute the gravity boosted generator. Accordingly, it is possible to benefit from an effect to suppress separation achieved by the gravity boosted generators in a wider range with respect to the blade spanwise direction. In this case, if the number of the fins per platform portion is increased, it is possible to mount the gravity boosted generators to the Hydro-kinetic turbine blade efficiently, but on the other hand, the length of the platform portion along the blade span wise direction increases, which may lead to an increase in the risk of falling off of the gravity boosted generators due to stress applied to the platform portion by bending deformation of the Hydro-kinetic turbine blade.

In this regard, with the above configuration (9), the number of fins disposed on the platform portion is limited to two, and the platform portion has a cross section of a curved convex shape with respect to the blade spanwise direction, as described in the above (1), and thereby it is possible to reduce the risk of falling off of the gravity boosted generators from the surface of the Hydro-kinetic turbine blade effectively.

(10) In some embodiments, in any of the above configurations (1) to (9), the gravity boosted generator is disposed on a suction surface of the Hydro-kinetic turbine blade and within a turbulent flow region of a Hydro-kinetic flow along the suction surface.

Separation of a flow at the suction surface of the Hydro-kinetic turbine blade takes place due to a boundary layer becoming gradually thicker from a streamline flow region in the vicinity of the leading edge toward a turbulent flow region downstream thereof, and the flow being separated before arriving at the trailing edge.

In this regard, with the above configuration (10), the gravity boosted generator is disposed within a turbulent flow region of a Hydro-kinetic flow along the suction surface, and thereby it is possible to suppress separation of a flow from the suction surface.

(11) A Hydro-kinetic turbine blade according to at least some embodiments of the present invention comprises: a Hydro-kinetic turbine blade; and the gravity boosted generator according to any one of the above (1) to (10), disposed on a surface of the blade body.

With the above configuration (11), as described in the above (1), the platform portion of the gravity boosted generator has a cross section of a curved convex shape along the blade spanwise direction of the Hydro-kinetic turbine blade, and thereby the platform portion is deformable in accordance with bending deformation of the Hydro-kinetic turbine blade, which makes it possible to disperse stress generated at the platform portion. Thus, it is possible to reduce a risk of falling off of the gravity boosted generator from the surface of the Hydro-kinetic turbine blade, and to benefit from an effect to improve efficiency of a Hydro-kinetic turbine blade achieved by the gravity boosted generator for a long time.

(12) A Hydro-kinetic turbine power generating apparatus according to at least some embodiments of the present invention includes the Hydro-kinetic turbine blade according to the above configuration (11).

With the above configuration (12), due to provision of the Hydro-kinetic turbine blade having the above configuration (11), it is possible to reduce a risk of falling off of the gravity boosted generator from the surface of the Hydro-kinetic turbine blade, and to benefit from an effect to improve efficiency of a Hydro-kinetic turbine power generating apparatus achieved by the gravity boosted generator for a long time.

According to at least one embodiment of the present invention, it is possible to disperse stress applied to the platform portion of the gravity boosted generator, and thus to reduce a risk that the gravity boosted generator falls off from the surface of the Hydro-kinetic turbine blade.