Conceptual Design of a Novel Power-Augmented Marine Current Turbine

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Abstract: Ocean or marine field become one of the main concerns of renewable source in the world with the emergence of marine technology. Since water density is 800 times denser than the density of air and the power of the flow is proportional to the cube of the fluid velocity, therefore same amount of energy generated in wind turbine can be produced by water even with lower flow velocity. Many researchers started to design and fabricate the marine current turbine in order to convert tidal stream into electricity. Tidal energy offers us a promising future. Nearly half or more than 50% of marine current turbines are designed in horizontal axis and ducted. For example, Marine Current Turbine Ltd (UK) had come out of many turbines such as SeaGen U, SeaGen F and so on, all of them are horizontal axis, huge and weighty. Though vertical-axis turbines are generally less efficient than horizontal-axis turbines, they do have some distinct advantages: vertical-axis turbines can have a rectangular cross section, which allows them to be more efficiently packed in arrays than section horizontal-axis turbines. Another benefit is the ability to generate power from any flow direction that is perpendicular to the axis, which is extremely advantageous in a tidal flow. Besides, there are some marine turbines that were enclosed by the diffuser or duct, such as Rotech tidal turbine (RTT), which functioned to channel the flow in order to increase water flow velocity. Shape of the diffuser and the additional support structure to the diffuser are the challenges faced during fabrication and installation. In this paper, a conceptual design of a novel power-augmented marine current turbine which utilizes the concept of cross-axis wind turbine and augmented guide vane is proposed. The conceptual marine current turbine system is designed by intercepting the two guide vanes in between three individual turbines and also two diffusers at the outer part of the system. The conceptual design of this cross-axis turbine with helical blade is similar to the Gorlov helical turbine but there are some differences in the radial blades which are designed as 8 degrees upper and lower respectively to the horizontal axis of the connector hub. The two layers radial blade-rotors are offset by 60 degrees. The NACA 0015 airfoil profile is used as turbine blade in this design. The augmented guide vane could channel the water stream and increase the flow velocity when strikes to the turbine blade. Turbine is designed based on the concept of cross-axis wind turbine (CAWT) which gives the advantages of better self-starting at low velocity and the greater torque at high velocity. A 3D model was constructed and simulated by using the computational fluid dynamics software, ANSYS-Fluent. In the simulation, the velocity of water flow and the rotational speed of turbine were increased with the integration of the guide-vane and diffuser features. It is estimated that this conceptual design turbine will achieve 60% increase in energy gain.

Keywords: Renewable Energy; Ocean Engineering; Marine Current Turbine; Innovative Design