Conceptual Design of a Novel Power-Augmented Hydrokinetic Run-of-River Turbine

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Abstract: Other than the water stream from ocean, river stream is also being considered as a viable source of renewable energy. Many researchers has approached and started the studies of river stream in order to harness the maximum power from the rivers. River stream offers promising energy especially to the rural areas which are surrounded by rivers. From previous studies, it shows that majority of the hydrokinetic run-of-river turbine systems are designed in vertical and horizontal axis. Besides, some of the vertical and horizontal axis turbines are also enclosed by the duct or diffuser in order to guide the river stream and increase the flow velocity. However, the design of the shape of diffuser faced the challenges during fabrication phase and additional supporting structures are needed during installation, causing the increases in the overall cost. In this paper, the authors would like to propose a conceptual design of a novel power-augmented hydrokinetic run-of-river turbine which utilizes the concept of cross-axis wind turbine and simple augmented guide vane. This conceptual design of hydrokinetic turbine able to capture the advantages of both the horizontal and vertical axis turbines. Helical blade design was chosen for this conceptual design due to its ability to capture the skewed flow created by the difference in velocity of upper and lower faces of turbine. When the vertical-axis turbine rotates, the angle of attack of each blade varies cyclically. The cyclical variation of the angle of attack creates cyclical blade loading, which increases the fatigue experienced by blades. Most of the cyclical loading can be alleviated by using helical instead of straight blades. 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 turbine system is designed by intercepting the two guide vanes in between three individual turbines and also two diffuser-vanes as the outer part of the system. The NACA 0015 airfoil profile is used as turbine blade in this design. The construction costs of cross-axis concept turbine and the helical blades are relatively low (about 30%) compared with the huge ducted and diffuser turbine. 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; Hydrokinetic River Turbine; Innovative Design; Hydro Turbine; Green Technology