Numerical Analysis of a Ducted High-Solidity Tidal Turbine

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Abstract

This piece of research elaborates a CFD model utilised to investigate the hydrodynamic performance concerning a ducted high-solidity tidal turbine. The model achieved good comparison with experimentation data for a three-bladed HATT. Accordingly, the model was implemented for the analysis of a ducted high-solidity turbine, in aligned and yawed flows.

1 Introduction

Efforts to increase the efficiency of energy-generating turbines have been in development since their introduction to the global market. On the forefront of the pertinent research is the effort of increasing the mass flow through the turbine, along with constraining the wake to facilitate further turbine installations.

2 Physical Model Parameters

2.1 Three-Bladed Horizontal-Axis Turbine

In an effort to attain a validated CFD model for tidal turbine applications, a simulation was established to replicate the experimentation undertaken by Mycek et al. [1], where identical blade, nacelle, and mast geometry were utilised within the model domain, onto which a tetrahedral mesh was imprinted, as shown in Figure 1.

2.1.1 Eight-Bladed Ducted Turbine

In continuation to the validated CFD model, the settings were then implemented for the analysis of an eight-bladed ducted tidal turbine developed by OpenHydro, shown in Figure 2.

3Results & Discussion

3.1 Power Coefficient

Performance curves depicting the variation in the power coefficient of the three-bladed turbine as a function of TSR were compared, as illustrated in Figure 3. A discrepancy of 6.44 % was indicated between the two data profiles within the TSR range of 2.05 – 8.01, with a discrepancy of 4.88 % within a TSR range of 3.58 – 6.182.

Performance curves depicting the variation in the power coefficient of the eight-bladed ducted turbine as a function of TSR was analysed. The results present a maximum power output of 1.91 MW, which was deduced to be a suitable value for a 2 MW concept turbine.

Figure 1 – Three-Bladed Turbine

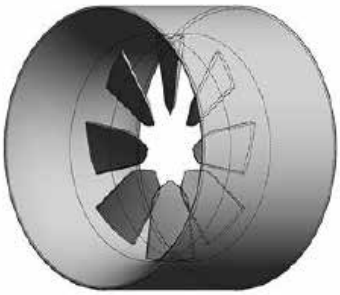

Figure 2 – Eight-Bladed Ducted Turbine

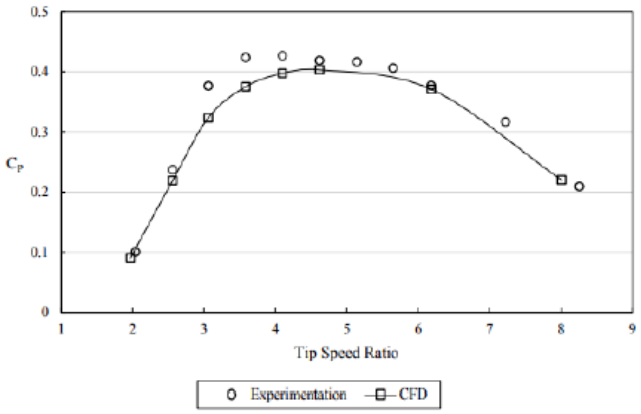

Figure 3 – Power Coefficient with TSR for Three-Bladed Turbine

References

[1] P. Mycek, B. Gaurier, G. Germain, G. Pinon and E. Rivoalen, "Experimental Study of the Turbulence Intensity Effects on Marine Current Turbines Behaviour. Part I: One Single Turbine," Renewable Energy, vol. 66, pp. 729-746, 2014.