Experimental power and thrust coefficients of a shrouded horizontal axis hydrokinetic turbine in yaw operation

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Abstract

Dataset includes power and thrust coefficients of a 19.8 cm diameter horizontal axis hydrokinetic model turbine in yaw operation. Tests were done at 0.7, 0.9, and 1.1 m/s water speeds for three turbine configurations: the unshrouded turbine and the turbine with two different shrouds. Experiments were done for yaw angles from 5° to 25° in 5° intervals. Output power of the turbine and its thrust force are measured experimentally in a water tunnel. Results are corrected using a theoretical model that accounts for free surface proximity and blockage effects of the water tunnel.

Keywords: Hydrokinetic turbine, shroud, yaw misalignment, performance, thrust coefficient

1 Water tunnel

Tests are carried out in the recirculating water tunnel facility at the University of Manitoba. The tunnel has a 61 cm wide by 183 cm long test section and allows maximum of 60 cm water height. A propeller pump provides water flow up to 1.1 m/s velocity at the test section for the full water height. Turbulence intensity of the flow at the test section is less than 3% for the maximum speed.

2 The model turbine

The model turbine has a rotor blade and allows use of shrouds. The rotor blade is a 19.8 cm diameter three bladed H0127 wind turbine blade of KidWind Project Inc. with a solidity of 0.13. Two shrouds are designed, manufactured, and used in the experiments. One is a duct of convergent-divergent profile referred to as the *shroud*. The other is a straight wall duct referred to as the *diffuser*. Schematics of profile and photos of the shroud and the diffuser are depicted in Figure 1 and the geometric characteristics are summarized in Table 1. Thickness of the diffuser wall is 9 mm.

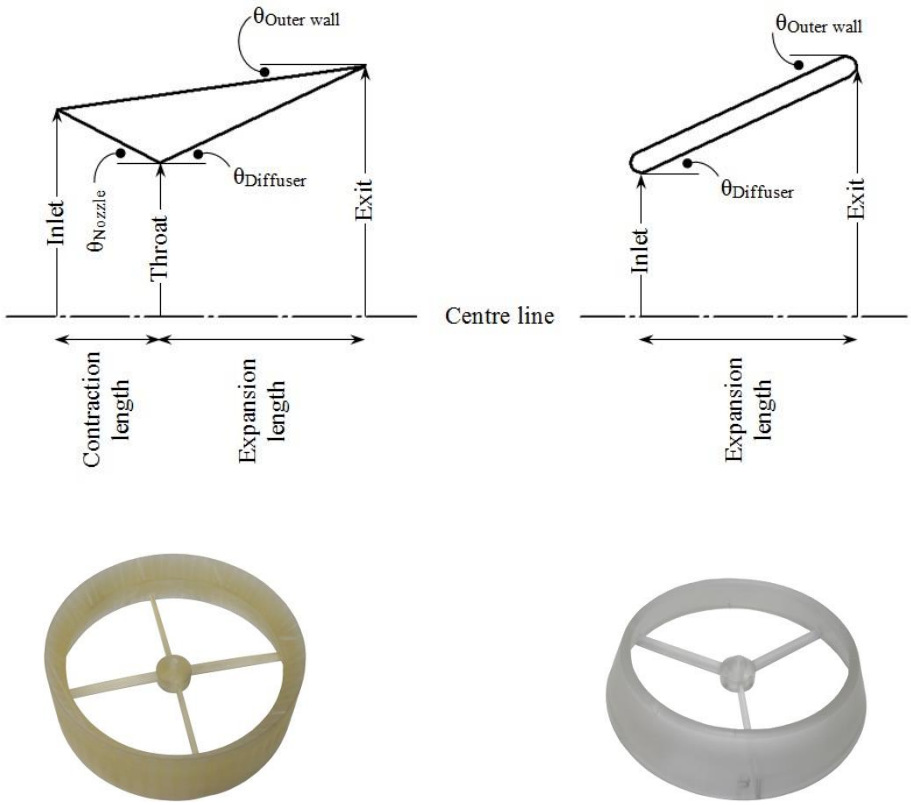

Figure 1: Schematic profile and photo of the shroud (left) and the diffuser (right)

Table 1: Dimensions of the shroud and the diffuser

Dimension	Shroud	Diffuser
Inlet diameter (cm)	22.6	20.1
Throat diameter (cm)	20.1	---
Exit diameter (cm)	25.0	25.0
Contraction length (cm)	2.5	---
Expansion length (cm)	5.2	5.2
Nozzle half angle (°)	27	---
Diffuser half angle (°)	25	25
Outer wall angle (°)	8	25

3 Dataset

The dataset contains experimental values of power and trust coefficients for the shrouded and unshrouded turbines for yaw angles from 5° to 25°. The first column in each cluster of data is TSR and the second column is the coefficients. Tip speed ratio, power and trust coefficients are calculated as follows:

$$TSR = \frac{R\omega}{V}$$

$$C_P = \frac{Q\omega}{1/2\,\rho A V^3}$$

$$C_T = \frac{T}{1/2\,\rho A V^2}$$

where Q and T are torque and thrust of the turbine and ω and V are respectively the angular velocity of the turbine shaft and the flow speed. The power and thrust coefficients are calculated based on the swept area of the rotor blade, A.