IN-SITU EXPERIMENT OF CROSS-FLOW SAVONIUS HYDROKINETIC TURBINE WITH A DEFLECTOR

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ABSTRACT

The crossflow type Savonius turbine is capable to rotate at low current velocity conditions. The drawback of this turbine lies on its efficiency. This study aims to test its performance before implementation in the field. The research method used is an in-situ experimental study in Umbulan, Pasuruan. Turbine model T1 AR 1.145 without deflector is used, when TSR reaches a value of 0.824, it gets a CQ value of 0.327 and a CP value of 0.269. In the same model with deflector, when TSR reaches a value of 1.1, the CQ value is 0.251, and the CP value is 0.276. It can be concluded that this turbine is suitable for area with low current velocity.

keyword: Hydrokinetic energy, savonius turbine, crossflow, deflector, in-situ experiment, low current velocity

Introduction

Ocean energy can be defined as energy obtained from the sea [1]. Of the many types of marine energy, ocean currents have become the primadona to be developed into power plants because of their relatively stable and predictable nature [2]. The energy conversion technology of seawater currents is usually identical to that of turbines. Based on the configuration of the turbine axis and the flow through it, ocean current turbines can be divided into crossflow turbines, horizontal axis turbines, and vertical axis turbines [3], [4]. Crossflow turbines advantages are rotating at low seawater current speeds [5].

One of the most popular crossflow type ocean current turbines is the Savonius. Over the years, research to investigate the Savonius ocean current turbine's performance has been carried out on experimentally [6], numerically using Computational Fluid Dynamics (CFD) methods [7], or both of them [8]. Results of this research according to the conditions of the study area. The majority of the maximum value of the Coefficient of Power (CP) ranges from 0.15 to 0.30. Meanwhile, the Tip-Speed Ratio (TSR) ranges from 0.6 to 0.9 [9].

Based on the research results conducted by Talukdar, et al. (2018) [10], the blade on the Savonius ocean current turbine with a semicircular profile has better performance when compared to an elliptical profile. On the other hand, Hamzah et al. (2018) [11] found that 3-blade turbines were more optimal than the two to six blades studied due to a blade arc angle of 70°.

In this study, a blade with a design inspired by the trademark owned by Water Rotors [12] will be using used with a shape resembling a shark's fin capable of producing power up to 300% better than the Savonius ocean current turbine in general. The purpose of this study was to test the performance of the study turbine before entering the implementation phase. The performances referred to be here, include Coefficients of Power (CP), Coefficients of Torque (CQ), and Tip-Speed Ratio (TSR).

Methodology

The experimental model consists of Model T1. Turbine model T1 is a model with an increased diameter of 1.3 times the diameter of the validation model so that it has an AR value of 1,427.

The particulars of the experimental model in this study are given in full in Table 1 and Figure 1.

Table 1. Experiment model

Model	Dimension (cm)			
	a	d	D	L
T1	23	11,2	45,4	52

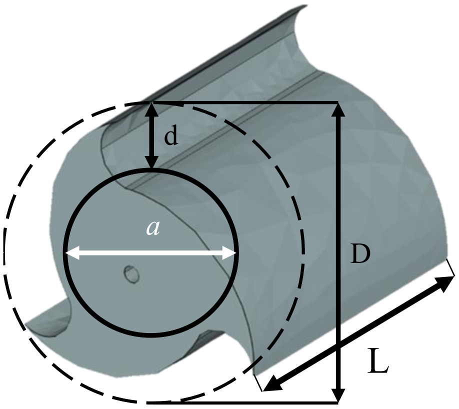

Figure 1. Illustration of a study model with its dimensional parameters

The test location point for the selected experimental model is 25.2 m from the front of the floodgate. This point is appropriate because it is far from the sluice gate to avoid any reflected currents after the water hits the sluice gate and avoid water spills that come out on the left side of the channel. Measurement of water flow velocity before passing through the turbine is carried out as far as 7 meters from the front of the turbine to avoid current reflections that may form after hitting the turbine. At the same time, measurement of the speed of water flow after passing through the turbine would carry on behind the turbine as far as 5.2 m.

Result and Discussion

Result

Turbine models with an Aspect Ratio (AR) of 1.145 and 1.427 will each go through a running process for 120 seconds after the turbine rotates in a stable state. The running process would vary the load received by the turbine during the testing process. Performance measuring instrument equip model experiment consists of a torque measuring device in a single system, including a spring balance on the slack side and a spring balance on the tight side.

Figure 2 shows that from the two tests carried out, including the turbine Model T1 AR of 1.145. Closely related to the increase in the different results of the scales read on the digital scale monitor, accompanied by an increase in the turbine's rotational speed. The speed of water flow through the turbine is always very fluctuating, as can be observed in Figure 2. It is known that the speed of water flow strongly influences the turbine's rotational speed through the turbine. Switch back to the data obtained from the tests performed. The first data is in the form of the difference in readings of the scales that show on the digital scale monitor after processing, the Coefficient of Torque (CQ) obtain. On the other hand, the second data is the turbine rotational speed process to obtain a Tip-Speed Ratio (TSR).

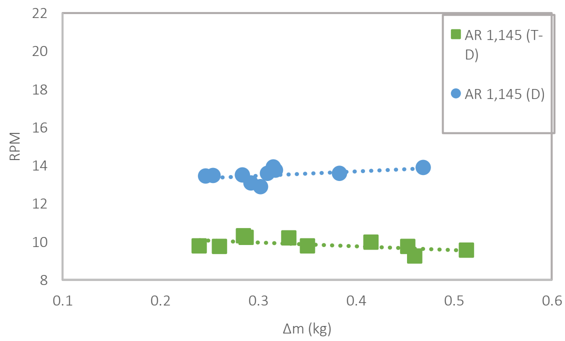

Figure 2. The curve of the relationship between the difference between the readings of the scales and the RPM

Coefficient of Torque (CQ)

Parameters of the turbine's ability to generate power and can be written into the equation:

$$C_Q = \frac{\tau}{{}^1\!/_2\, \rho\, A\, |V|^2 R} \tag{1}$$

Where ρ is the density of the fluid (kg/m3), A is the projected turbine area (m2), V is the inlet flow velocity (m/s), and R is the turbine radius (m).

Tip-Speed Ratio (TSR)

The ratio between the tangential velocity of the blade tip and the flow through it so that can express into the equation:

$$TSR = \frac{R\,\omega}{V} \tag{2}$$

Where ω is the turbine rotational speed (rad/s).

Coefficient of Power (CP)

The power parameter converted by the current ocean turbine from the seawater flow through it and expressed into the equation:

$$C_P = C_Q \times TSR \quad (3)$$

Discussion

In Fig. 3, it can be seen that deflector has an apparent influence on the performance of the crossflow type Savonius ocean current turbine in the form of TSR and CQ. In the test without using a deflector, it shows that the T1 AR Model is 1.145. When the TSR value is 0.824, the CQ value is 0.327. Remember that the water flow velocity measurement is in front of the deflector and not passing through the deflector. The turbine performance after being applied by a deflector and before cannot compare directly. The increase in performance from the deflector application observed by increasing the TSR value generated by the turbine. The deflector application shows that the Model T1 AR 1.145 when the TSR value is 1.1, the CQ value is 0.251.

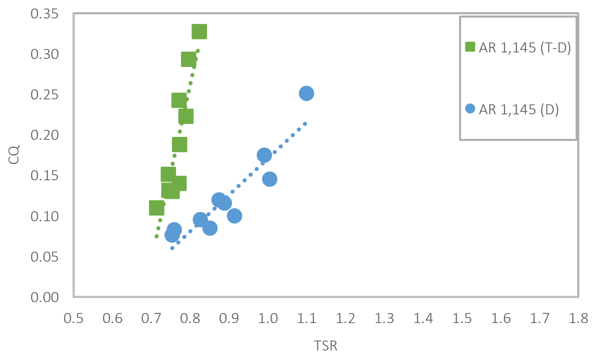

Figure 3. Relationship curve between TSR and Coefficient of Torque (C_Q)

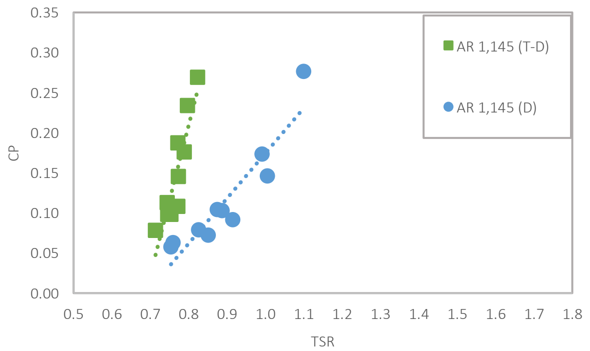

Figure 4. Relationship curve between TSR and Coefficient of Power (C_P)

From Fig. 4, it can also be seen that AR has an apparent effect not only on the Coefficient of Torque (CQ) of the crossflow type Savonius ocean current turbine but also on the Coefficient of Power (CP). The test without using a deflector shows that the Model T1 AR 1.145 when the TSR value is 0.824, the CP value is 0.269. Likewise, in the deflector application, it can be noted that the Model T1 AR 1.145 when the TSR value is 1.1, the CP value is 0.276. Therefore, from the Coefficient of Power (CP), it can be concluded that the turbine model with a larger diameter (smaller AR) can produce an immense CP value with a more considerable TSR values.

Conclusion

Deflector has a significant effect on turbine performance. In Model T1 with AR 1.145 for testing without deflector, when TSR reaches a value of 0.824, it gets a Coefficient of Torque (CQ) value of 0.327 and a Coefficient of Power (CP) value of 0.269. For testing with a deflector on the same model, when the TSR reaches a value of 1.1, the Coefficient of Torque (CQ) value is 0.251, and the Coefficient of Power (CP) value is 0.276. Therefore, this turbine is suitable for location with low current velocity.

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