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Extended Abstract

Numerical Study Darrieus – Savonius Turbine As a Low Speed Marine Current Energy Converter

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Abstract* – The use of clean energy without gas emissions has been developed at this time such as using kinetic energy from marine current with turbine. Types of turbines are Darrieus and Savonius turbine. Savonius turbine is suitable for the characteristics of low speed marine current, while Darrieus Turbine has high power coefficient. Therefore, the combination of the two turbine is studied to know the performance of Darrieus – Savonius turbine that will be carried out simulation with CFD. Simulation is using Fluent Software. Unsteady simulation performed different speed ratio and based on RANS turbulent calculations using sliding mesh approach. Model turbulent is STT based k – omega and using hybrid grid/mesh.

***Key words:* Turbine Darrieus-Savonius, CFD, renewable energy**

INTRODUCTION

Renewable energy has developed by many counties, such as using kinetic energy from marine current convert to electricity. Turbine is a device used to convert the energy. Based on the alignment of the rotor axis with respect to water flow, two generic classes exist. They are horizontal and vertical axis turbine.

This study research is about the combination of two vertical axis turbine, the Darrieus turbine and Savonius turbine. The Darrieus turbine is not suitable at low speed current because this turbine is difficult to rotate. However, the advantage of this turbine is generating high power. Savonius turbine type is capable of rotating at low speed current. This turbine can rotate at a speed current of 0.3 m/s [1], but it generates lower power compared to the other vertical axis turbine. Therefore, two turbines are combined so this turbine (Darrieus-Savonius Turbine) is not only suitable for low speed current but also generate more power.

METHOD

The purpose of this study was to determine the performance of the turbines. The coefficient of torque (Cm) and coefficient of power (Cp) are parameter to measure the efficiency of the turbine. Cp and Cm will calculate every tip speed ratio, where TSP is the ratio the rotational speed of the tip of a blade and the actual velocity of the water. Cm, Cp and TSR which is defined in Equation (1), (2) and (3)

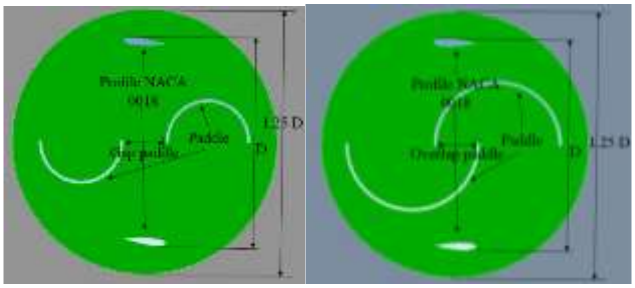
$$Cm = \frac{T}{\frac{1}{4}\rho ADU^2} \quad (1) \qquad Cp = \frac{P}{\frac{1}{2}\rho AU^3} \quad (2) \qquad TSP = \frac{\omega D}{2U} \quad (3)$$

The analysis will be carried on from these parameter.

All simulation was performed with a constant current speed of 0.269 m/s. This value is the average speed of ocean current during 2014-2015 that measured in the western part of island Giliyang, Madura.

CFD simulation in this study used 2D model with full scale and unsteady state simulation. Darrieus Savonius Turbine operates in open field conditions, so it is necessary consider a large domain, to avoid solid blockade. In a smaller domain, the boundary condition can influence the results.

This study provides two turbine models as shown in Fig 1. Consideration in choosing design model A or B is NACA profile inserted between two paddle Savonius turbine, so fluid flow is not impeded. The model A has smaller diameter than the paddle, so there is a gap between paddle to be placed on naca profile, while model B, has an overlab paddle to be placed on NACA profile.



(Model A) (Model B)

Fig 1. Two model turbine Darrieus-Savonius

Table 1. Main geometrical features of the analyzed rotor

Denomination	Value
Rotor Diameter (D) [mm]	2000
Rotating zone diameter	1.2 D
Rotor height (H) [m]	1
Blade section	Naca 0018
Blade chord (c) [mm]	400
Number of blade	2
Puddle Savonius Diameter [mm]	400 (model A) and 600 (model b)
Number of puddle	2

A finite volume CFD solver is used in this study that implement RANS equation. The fluid density is incompressible. By studying the effect of time step size on coefficient pressure using 0.04, 0.05, 0.06, 0.07, 0.08 and 0.09 second, it is observed that is the change in torque coefficient is not exceed 5%. In addition, same study carried out using 40, 50, 60, and 70 maximum number of iteration; the change in torque coefficient is not exceeding 1%.

The size of time step is set to be 0.07 s by performing the computations on 7 times revolutions of the turbine with 70 maximum number of iteration. Residual convergence for each physical time step has been set to 10^{-4}. Solution for grid independence with total number of mesh about 447,110 elements and minimum cell size is $9.35x10^{-03}$. The first cell height was maintained $y^{+} < 5$, used around the walls of the turbine. The turbulent model use of SST based k-ω.

RESULT AND DISCUSSION

Based on simulation result, turbine Model B is better than Model A in which the torque coefficient of Model B has a peak value of 0.174 at TSR = 1.2 while Model A has torque coefficient of 0.136 at TSR = 0.8. As well as the value of coefficient power, the Model B is better than the Model A. As a validation of this computational model is compared with experimental result published of Darrieus-Savonius water turbine, Kapwan et al 2014 [2]. Fig 2 and 3 present a comparison of the parameter turbine model A, B, exp. Kapwan and solo Savonius turbine.

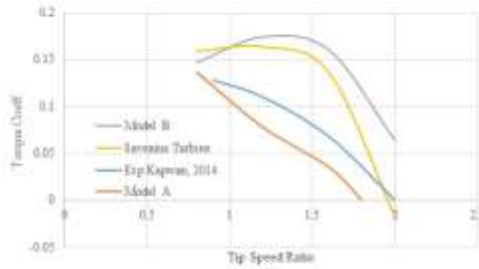


Fig 2. Torque coefficients as a function of tip speed ratio for Model A, B and Exp Kapwan, 2014

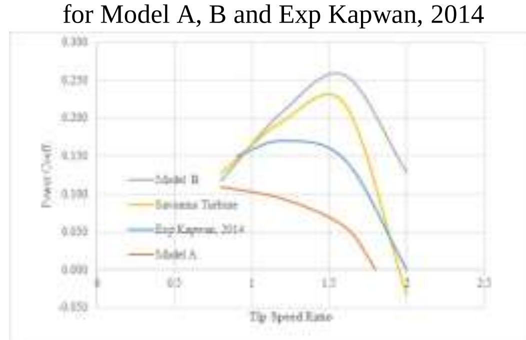


Fig 3. Power coefficient as a function of tip speed ratio for Model A, B and Exp Kapwan, 2014

CONCLUSION

Darrieus Savonius Turbine model B can be considered used as energy converter, because it has better performance than Model A or Savonius turbine. Darrieus-Savonius turbine has 34 percent performance better than solo Savonius turbine.

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