Flow analysis of the vertical axis Savonius current turbine (VASCT) performance for Myring blade n = 1 using CFD aproach

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Abstract. The flow visualization of vertical axis Savonius current turbine has been investigated numerically by using Myring formula n of 1. Computational Fluid Dynamics or CFD approach has been carried out by using Gambit for geometry and ANSYS 17.0 running to solve the incompressible U-RANS. This work has been done by comparing the performance between Myring and conventional Savonius. The y+ in the first layer of blade surface has been made between 30 and 100 with y+ in about 52. The turbulence model will be chosen the Realizable k-epsilon (RKE) for this turbine case. The numerical obtain the torque and power coefficient and the power coefficient called the turbine performance. The numerical simulation has been validated by experimental results towards torque coefficient. The results have indicated that the Myring formula n = 1 have the best performance compared this one by decreasing the pressure in attached flow area.

1. Introduction

Indonesia is still dominant to use the fossil fuel to do combustion producing the emission gas disturbing environment. The best way decrease the emission by developing the renewable energy. The one of renewable is done like hydropower for low current.

The formation of blade will the influence of the performance of turbine. Savonius research has developed quickly by using numerical study. The 2D simulation has been done to see the performance of the Savonius turbine. The Myring formula has been done for wind turbine by varying n from 0 to 3. The best performance has shown at n of 1 by the improvement of turbine performance in about 10.98% compared by Conventional [1]. Sheldahl et al. [2] and patel et al [3] have discused about the overlap ratio of the Savonius conventional. The improvement of turbine performance is obtained at overlap ratio 0.1 – 0.15 for Sheldahl et al [2] and 0.2 for patel et al [3]. This study will be performed the myring equation n=1 to see the influence of the turbine performance. The type of turbulence model in this study is chosen Realizable k-epsilon (RKE) [4]. The influence of cylinder has been carried out by placing the side of returning and advancing [5,6,7,8]. A cylinder placed advancing has been done by varying diameter (ds/D) and the best performance at ds/D = 0.7 [5]. A cylinder placed in front of advancing is done by varying the diameter and stagger angle and the best performance is occured at the ds/D of 0.5 [6]. For a cylinder installed the side of advancing has performed by changing of the distance and the best performance has shown at x/D of 0.5 [7]. Various of stagger angle by placing a cylinder the side of returning shows that the best performance is obtained at stagger angle 60 degree [8].

This work will be performed comparison the conventional and myring blade with n=1 by using numerical simulation. The geometry of domain simulation will be used Gambit 2.2.30 software and export to ANSYS 17.0. The aim of this work is to determine the performance of turbine by using the conventional blade and myring blade for n=1. The results of numerical are the visualization of velocity contour, pressure contour and pressure distribution.

2. Methodology

This work will be done comparison the conventional and myring blade for n = 1. The layer on the surface has 20 layers near wall. Figure 1 shows the conventional and the myring blade for n = 1. Myring blade equation is represented as in equation 1.

$$y = b[1 - \left(\frac{x}{a}\right)^2]^{\frac{1}{n}} \tag{1}$$

$$TSR = \frac{\omega . R}{U} \tag{2}$$

$$C_m = \frac{4T}{\rho U^2 D^2 H} \tag{3}$$

$$C_p = TSR \, . \, C_m \tag{4}$$

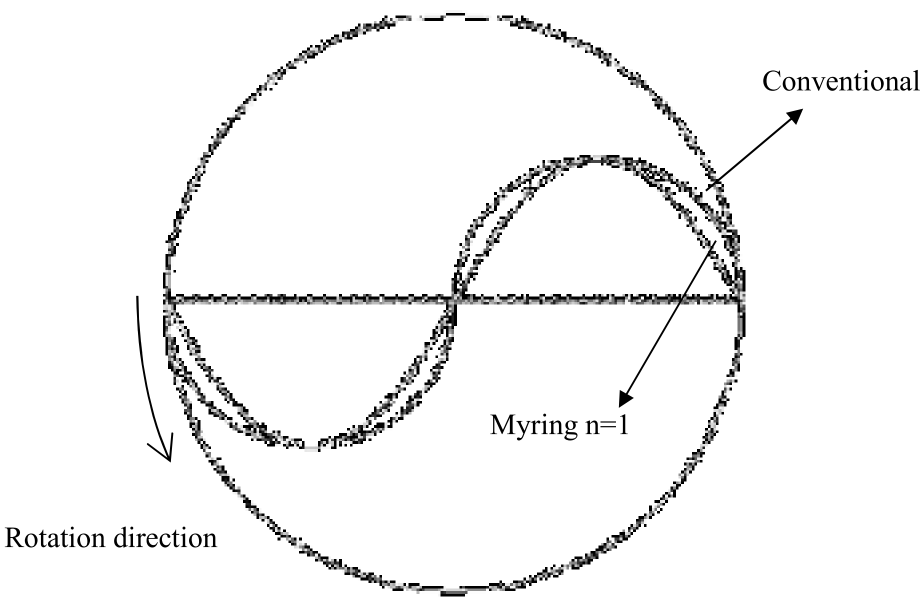

Figure 1. Schematic of Savonius Rotation for Conventional and Myring n = 1

Blade shape for bucket is shown as in Figure 1, for conventional blade n = 2 and myring blade n = 1 based on the equation (1) with the diameter of blade 400 mm. The TSR, torque coefficient (Ct), power coefficient (Cp) are obtained from the equation (2), (3) and (4), respectively.

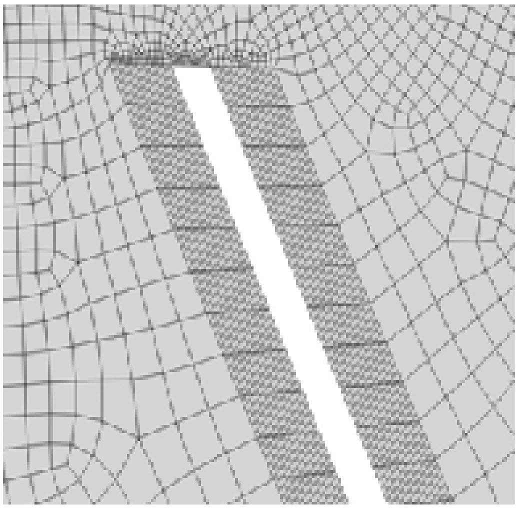

Figure 2. The first layer on the blade surface

The domain consist of upperside as wall and lowerside as wall, inlet as the velocity inlet, outlet as the pressure outlet, turbine blade as moving mesh and rotation. Domain has two zones namely rotating and stationary. The domain simulation can be represented in Figure 3.

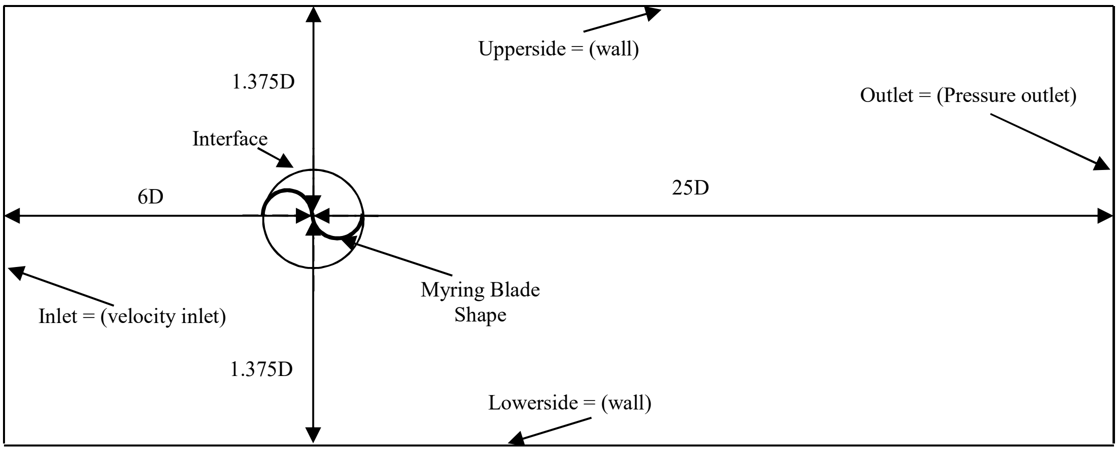

Figure 3. The domain simulation

Table 1. The calculation of input data for RPM and TSS

TSR	RPM	TSS
0.4	4.200	0.03968254
0.6	6.300	0.02645503
0.8	8.400	0.01984127
1.0	10.500	0.01587302
1.2	12.600	0.01322751

Angular velocity (rad/s) is calculated from TSR equation and varying TSR=0.4, 0.6, 0.8, 1.0 and 1.2. The angular velocity (ω) convert to Revolution per minute (RPM) for inputing data to moving mesh in rotating zone. The calculation of the TSS and RPM can be displayed in Table. 1. The blade rotation will be conducted every 1° to acquire high accuracy. The water is used for both the zone in this simulation.

3. Results and discussion

3.1. Velocity contour at blade angle of 30 degree

The velocity contour has been performed at blade angle 30° as represented in figure 4. The velocity contour for the onventional blade and myring n=1 s shown in Figure 4(a) and 4(b), respectively. The stagnation flow always is occurred on returning blade for the both of blade. The attached flow show that the myring blade n=1 has the velocity higher than this one that can be seen in figure 4. The vortex from advancing and returning can be seen at the both of turbine. The further analysis can be seen in Figure 5 about pressure contour.

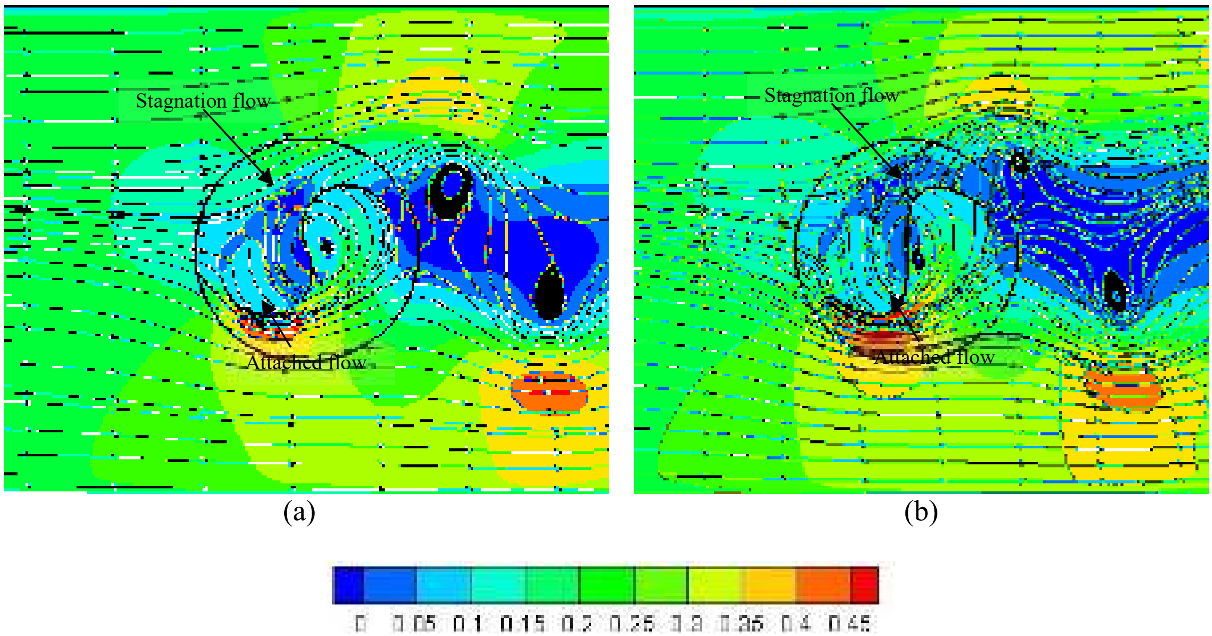

Figure 4. The velocity contour (a) Conventional blade and (b) Myring n=1

3.2. Pressure contour at blade angle of 30 degree

The pressure contour has been performed also at blade angle 30° as represented in Figure 5. The pressure contour for the onventional blade and myring n=1 is shown in Figure 5(a) and 5(b), respectively. The stagnation flow always is occurred on returning blade for the both of blade by decreasing the velocity until zero or the higest pressure on surface. The myring blade n=1 has the pressure lower than this one that can be seen in Figure 5 at attached flow. Therefore, the torque increase by decreasing the pressure at the attached flow area and than, the power would increase.

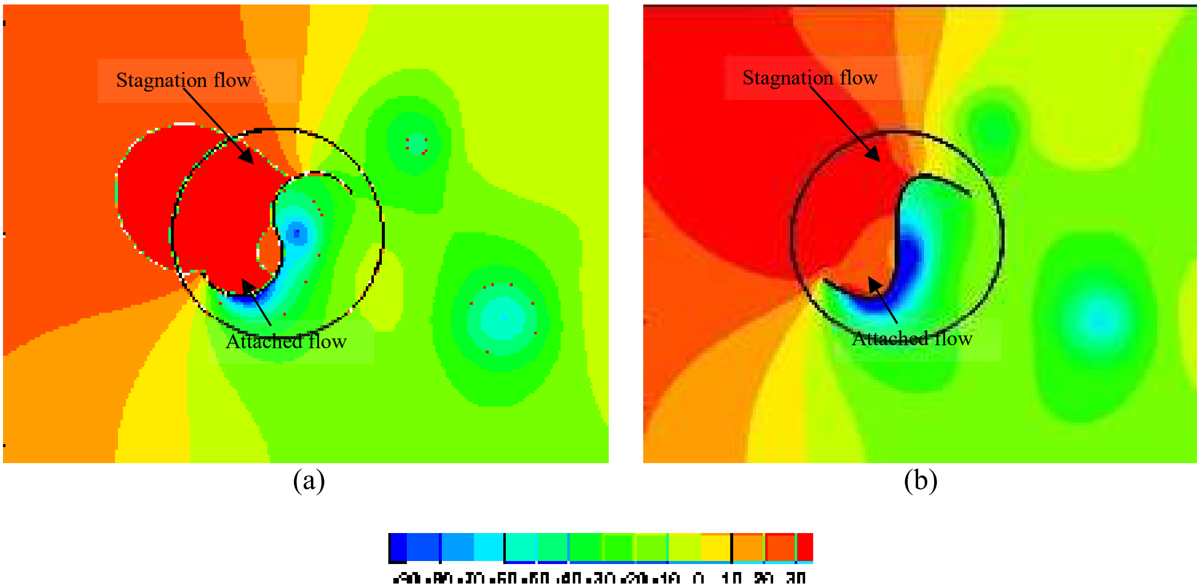

Figure 5. The pressure contour (a) Conventional blade and (b) Myring n=1

4. Conclusion
The discussion results above, the Myring equation with n = 1 has given effect to the Savonius performance. The pressure on surface of myring blade n=1 in attached flow area will decrease and improve the performance of turbine.

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5. References
[1] W. Tian, B. Song and Z. Mao 2014 Numerical investigation of a Savonius wind turbine with elliptical blades Proceedings of the CSEE, vol. 34, pp. 796–802.
[2] Sheldahl R E, Feltz L V and Blackwell B F 1978 Wind Tunnel Performance Data for Two- and Three-Bucket Savonius Rotors *Journal of Energy* **2** 160-4
[3] Patel C R, Patel V K, Prabhu S V and Eldho T I 2013 Investigation of Overlap Ratio for Savonius Type Vertical Axis Hydro Turbine *International Journal of Soft Computing and Engineering* **3** 379 – 83.
[4] Ariwiyono N, Setiawan P A, Husodo A W, Subekti A, Juniani A I, So'im S, Lukitadi P P S, Indarti R and Hamzah F 2019 A Numerical Study Of The Turbulence Model Influence On A Savonius Wind Turbine Performance By Means Of Moving Mesh Journal of Mechanical Engineering Research and Developments (JMERD) 42(3): 91-93.
[5] Setiawan P A, Yuwono T and Widodo A 2018 Numerical simulation on improvement of a Savonius vertical axis water turbine performance to advancing blade side with a circular cylinder diameter variations *IOP Conf. Ser.: Earth Environ. Sci.* **200** 012029.
[6] Setiawan P A, Yuwono T and Widodo A 2019 Effect of a circular cylinder in front of advancing blade on the Savonius water turbine by using transient simulation International Journal of Mechanical and Mechatronics 19(01), 151-159.
[7] Setiawan P A, Yuwono T and Widodo A, Julianto E and Santoso M 2019 Numerical study of a circular cylinder effect on the vertical axis Savonius water turbine performance at the side of the advancing blade with horizontal distance variations International Journal of Renewable Energy Research, 9(2) 978-985.

[8] Setiawan P A, Yuwono T and Widodo A 2019 Numerical Study of the Stagger Angle Effect of a Circular Cylinder Installed in Front of Returning Blade Toward the Vertical Axis Savonius Water Turbine Performance IOP Conf. Series: Journal of Physics: Conf. Series 1179 012107.