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Analysis Effect Ratio of Rotation Rotors and Tip Speed Ratio (TSR) On The Variations of Distance Rotors Counter Rotating Wind Turbine (CRWT)

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Analysis Effect Ratio of Rotation Rotors and Tip Speed Ratio (TSR) On The Variations of Distance Rotors Counter Rotating Wind Turbine (CRWT)

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Abstract. One important issue global is climate changes. The reduce climate changes one of them issue of the wind energy utilization is the energy conversion from wind energy. Conversion efficiency of the wind energy usable into productive power. Enhanced technology wind energy development CRWT. The purpose of this paper analysis of the effect ratio of rotation rotors and Tip Speed Ratio (TSR) on the variations rotor distance rotors CRWT. This research was carried out the development of previous research with airfoil series S826 blade modeling from NREL. This research used Gambit Software and solver using ANSYS (FLUENT CFD), used turbulent model $k - \varepsilon$ realizable. Results of this research the variations parameters CRWT, distance 0.5-0.1 and show performance maximum wind turbine the rear rotor shows an increase power of the turbine ratio of rotation rotors and TSR.

1. Introduction

Wind is energy clean source in the word. Energy wind is very important, because it can replace fossil energy sources. Wind energy is a renewable energy. Wind energy is converted into electrical energy through wind rotor rotation. one of the developments in wind conversion technology is CRWT. Energy conversion efficiency of wind turbine needs to improvement. The energy conversion efficiency of a wind turbine is usually characterized by its power maximum coefficient, which is the ratio of the power extracted from the wind to the power available in the wind. This research improved wind energy is CRWT (Counter Rotating Wind Turbine). CRWT have two rotors rotating in opposite direction and have on the same axis has been proposed as a new concept to enhance the maximum power coefficient of the wind turbine. Newman (1983) using momentum theory with actuator disk theory, maximum power coefficient of a wind turbine having two rotors (CRWT) without any losses increased to about 64%. Recently, based on this result, the CRWT research extensive to obtain more power from the wind energy than that obtainable from a conventional wind turbine having a single rotor.

The development of CRWT has been done both through numerical and experimental modeling of the aerodynamic parameters of turbine rotors to optimize the wind power of a generating system. Yuta (2012) research was carried out using experimental method and CFD (CFX) turbulent model SST with improved rotor front blade profile and blade angle optimization, diameter ratio 1.19 and distance ratio 0.08. The research gets the best results on the blade angle. Rosberg (2014) research CRWT design with RANS simulation. Variation in diameter ratio 0.25 and rotor distance 02 with uniform inflow.

This study shows an increase in turbine power coefficient of 7% higher than SRWT. Riszal, (2016) says that, from the study of the aerodynamics of CRWT with variations in distance between the front rotor and the rear rotor that is the best aerodynamic performance at a distance of 0.25 (maximum power coefficient of CRWT). From several studies that have been carried out show the influence of wind speed makes the rotation speed of the two rotors increase. Therefore, the CRWT study must be carried out either experiment or in simulation. The current study involves numerical modelling and CFD in CRWT system. research CRWT have two rotors have ratio same diameter and variation of distance is 0.5, 0,75 and 1. There is also make parameters ratio rotor rotation and tip speed ratio (TSR).

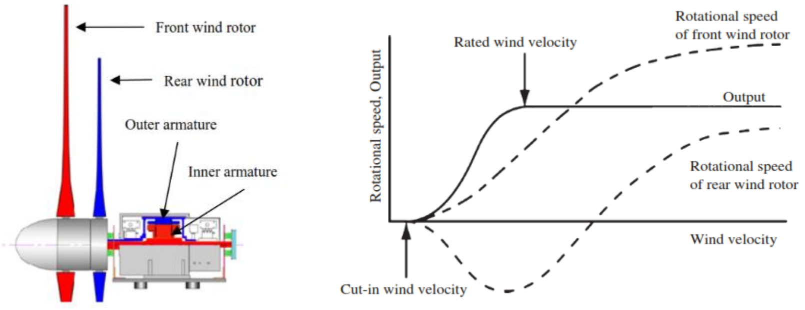

Figure 1. Wind turbine dual rotor (counter rotating)

Modelling of CRWT used Gambit software (geometry and mesh building intelligent toolkit). Gambit Software used to make models CRWT system, meshing, definition boundary layer so that it can be simulated and simulation of modelling CRWT system used ANSYS FLUENT 15.
The purpose of this study was to determine the effect of rotor rotation ratio and tip speed ratio (TSR) on the variation of Counter Rotating Wind Turbine (CRWT) rotors on the performance of wind turbines to converted output power maximum of each rotor rotation variation to TSR.

2. Method

In this study using the HAWT (Horizontal Axis Wind Turbine) model with a number of blades 3. The S626 airfoil model used in this research is NREL (National Renewable Energy Laboratory). Rotor diameter is 0.944 m. In this study, validation with SRWT (Single Rotor Wind Turbine) was carried out from the research development NORCOWE (Norwegian Center For Offshore Wind Energy). CRWT validation with SRWT with the development of CRWT through numerical analysis using turbulent model realizable k ε shows close results with the results of experiments conducted by Bartl and Sætran (2016) in the Blind Test (BT 4). In this simulation used computer speck processor Intel Core i7 3770CPU, RAM 24GB, VGA AMD Radeon HD 5700 2GB.

Three stages in CFD simulation:

2.1 Preprocessing

Preprocessing is a step in making and analyzing a CFD model. Technically with the making of the model then making the appropriate meshing, applying boundary conditions and fluid properties.

2.2 Solving

Solving or solver where at this stage, the core program searches for a numerical solution computationally by calculating the conditions that are applied at the time of preprocessing (numerical method).

2.3 Post processing

At this stage, the final step in CFD analysis. This is done in this step by interpreting CFD simulation results in the form of images, curves, graphics and animation.

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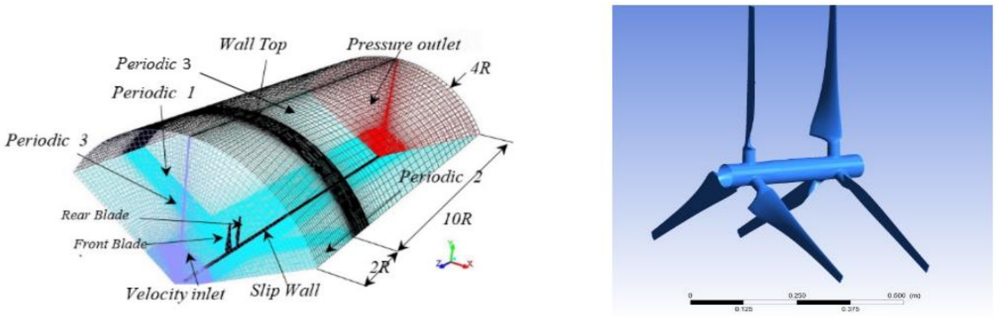

Figure 2. Domain CRWT computation

Table 1. Blade parameters CRWT

ρ =1.22 kg/m3 n =1395 Rpm
A =0.699897 m2 ω =146.08 rad/s
D =0.944 m U =68.951 m/s

V, m/s	TSR	Pa, Watt	Cp_Exp
6.892	10.00	30.72704	0.18850
7.66	9.00	62.67155	0.29761
8.62	8.00	110.1034	0.37913
9.85	7.00	181.9976	0.43500
11.5	6.00	305.1261	0.45000
13.8	5.00	509.8555	0.43675
17.25	4.00	861.1368	0.37739
23	3.00	963.8486	0.17356

D_1 (m)	D_2 (m)	Z/D_1	Z (m)	R_{tip} (m)	*Solidity*
0.944	0.944	0.5	0.1888	0.472	0.091778
0.944	0.944	0.75	0.2360	0.472	0.091778
0.944	0.944	1	0.2832	0.472	0.091778

Table 2. Parameters ratio of rotations rotors

n_1 (rpm)	n_2 (rpm)	n_2/n_1
	291.2	0.4
728	436.8	0.6
	582.4	0.8

3. Result

In Figure 3. shows ratio of rotation rotors and TSR at a distance of 0.5 can be analyzed that at round 0.4 tends to be better for each TSR than SRWT except for TSR = 10, for rotation ratio 0.6 in TSR = 7 and down tends to be better than SRWT but at TSR above TSR = 7 tends to be lower than SRWT and rotation ratio is 0.8 at TSR = 6 and lower than SRWT. TSR above 6 results under SRWT. Here it can be seen that the CP max Value of the variation of rotation ratio 0.8 has the highest value of 0.5303 or 16.93% in TSR 5. While the ratio of rotation 0.4 has CP max of 0.4814 or 6.15% at TSR = 6. While at the ratio of rotation 0.6 has CP max is 0.5160 or 13.78% at TSR = 6.

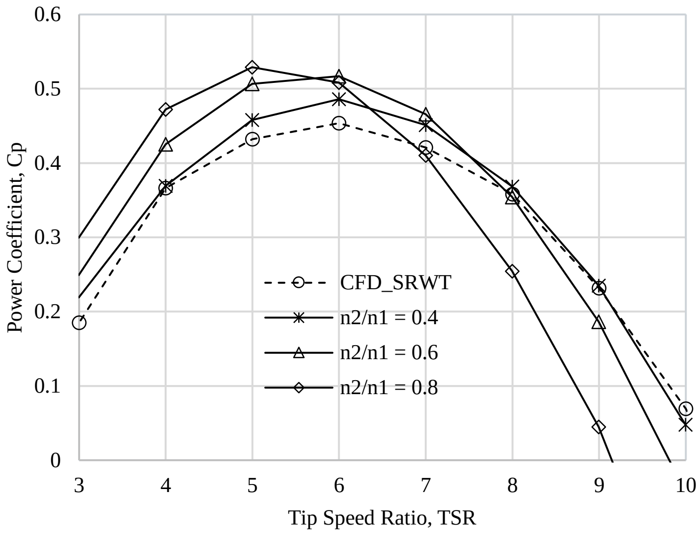

Figure 3. The relationship of power coefficient to TSR on the distance ratio Z / D1 = 0.5 and ratio of diameter D1 / D2 = 1.0 with variation Ratio of Rotation Rotors

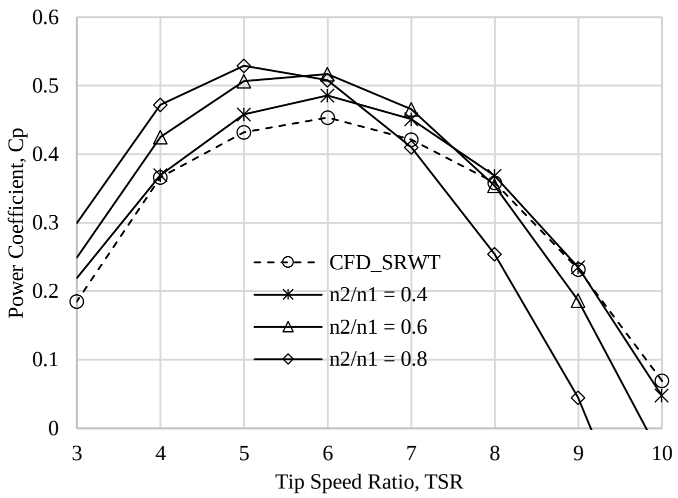

Figure 4. The relationship of power coefficient to TSR on the distance ratio Z / D1 = 0.75 and ratio of diameter D1 / D2 = 1.0 with variation Ratio of Rotation Rotors

Furthermore, it was examined at distance ratio of 0.75 as in Figure 04 with variations in TSR and ratio of rotation rotors. Figure 04 shows that the results obtained are not far away at a distance ratio of 03. The results from a distance of 0.75 at ratio of rotation rotors 0.8 which has a CP max value of 0.5289 or 16.63% at TSR = 5. While ratio of rotation rotors 0.4 and 0.6 has a CP max value is 0.4858 and 0.5170 or 7% and 13.99%. Here also at low TSR at high speed rotation it is seen that CRWT is better than SRWT.

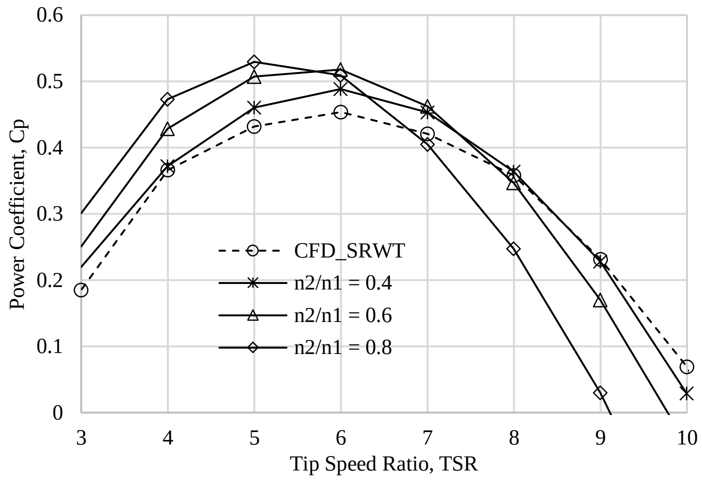

Figure 5. The relationship of power coefficient to TSR on the distance ratio Z / D1 = 1 and ratio of diameter D1 / D2 = 1.0 with variation Ratio of Rotation Rotors

In figure 5. explained about the variation of distance 1 can be analyzed that there are advantages of CRWT compared to SRWT. In figure CP max value variation ratio of rotation rotors 0.8 with CP max 0.5301 or 16.88 at TSR = 5. Next, at variation ratio of rotation rotors 0.4 and 0.6, CP max are 0.4827 and 0.5198 or 6.43% and 14.61% of SRWT on TSR = 6.

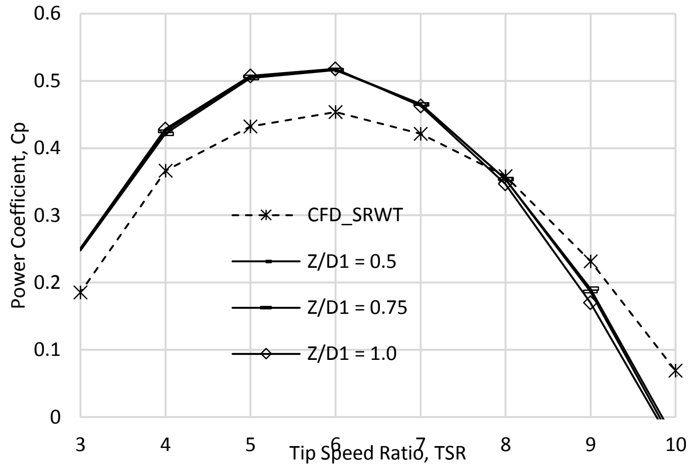

Figure 6. The relationship of power coefficient to TSR on the Diameter ratio $D_1/D_2 = 1$ and variation ratio of rotation rotors $n_2/n_1 = 0.6$ with at each distance ratio

Figure 6. shows that the comparison of the simulation results of the double rotor power coefficients in each distance to TSR ratio with a rotor rotation ratio of 0.6. Can be seen as a whole the maximum power coefficient value at TSR = 6. While the TSR = 1 to TSR = 7 indicates that the predicted results of the double rotor power coefficient are higher than the single rotor. Whereas in TSR = 8 to TSR = 10 shows the prediction of the double rotor power coefficient is lower than the single rotor. This can be explained by the low TSR flow angle passing through the blade according to the design conditions so that the maximum rotor performance. Whereas in a high TSR, the angle of flow through the blade is quite large and separation occurs which results in the rotor decreasing lift (lift) and increasing drag force. There is an increase in drag force or a decrease in lift force resulting in a decrease in rotor torque so that the output power decreases. Then for the comparison of each distance the maximum CP can be found at a distance of 1.0 with a rotor rotation ratio of 0.6 and TSR = 6. The D1/D2 = 1 CRWT, if the distance is widened then the rear rotor performance, performance drops, while the front performance rises.

4. Conclusions
The results analysis showing the performance of CRWT based on the CP max to the variation of the distance ratio is best in the variation ratio of rotation rotors 0.8 at TSR = 5, but if the CRWT performance is seen from the total CP max in the range of TSR = 3 to TSR = 10 then the best rotation ratio in the variation ratio of rotation rotors 0.6. this is due to the influence of the inflow angles on the front and rear rotors. and there is a flow separation that can affect the power produced especially on the rear rotor on the CRWT system. flow separation affects the drag force will increase. While the lift force will decrease.

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