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Effect of rotor blade position on Vertical Axis Wind Turbine performance

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Abstract

The need for sustainable energy sources becomes greater each year due to the continued depletion of fossil fuels and the resulting energy crisis. For the past decade there has been a call for immediate and concrete solutions to the climatic challenges the world is currently facing. An answer to the need for a sustainable, low cost energy solution is potentially in the form of wind turbines, which are receiving increased political support. In this paper a numerical study is presented with the aim of evaluating the performance output of three Vertical Axis Wind Turbine (VAWT) configurations. Here using Computational Fluid Dynamics (CFD) a two-dimensional Multi Reference Frame (MRF) approach has been used to perform steady state simulations. For this purpose an inlet velocity of 4m/s has been used along with rotor blade tip speed ratios (λ) in the range of 0 to 0.6. The effects of varying rotor blade position on the global and local flow fields have been quantified as shown in Figure.1.

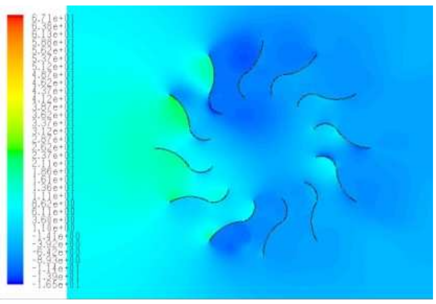

Figure.1 'Pressure field (Pa) with rotor at 0°, λ=0.4'

From this figure it can be seen that the pressure distribution across the wind turbine is non uniform and features large pockets of high and low pressure. The regions of the turbine that are in direct contact with the air stream (windward) feature the highest pressure. It is also evident that each blade has both a pressure and a suction side.

The torque contribution made by each rotor blade for each rotor position is presented in Figure.2. This contribution has been non-dimensionalised relative to overall rotor torque output (T/T_{AVG}).

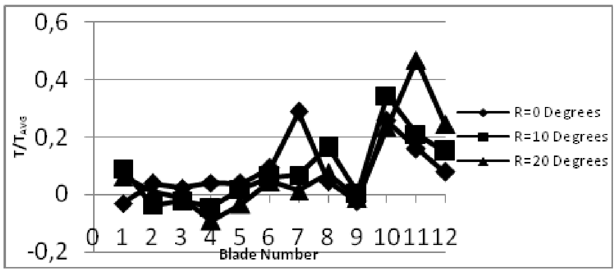

Figure.2 'Variation of rotor blade torque (T/T_{AVG}) contribution at R=0,10 and 20˚'

Here, the rotor blade passage between blades 11 and 12 generates maximum torque when the rotor is at 20˚. Furthermore, it has been found that within a typical rotor blade passage, maximum torque is obtained at a unique rotor angle.

The power curves for all three configurations are depicted in Figure.3 and show the variation of power coefficient with respect to TSR. From the data obtained it can be concluded that the VAWT power curve characteristics vary with relative rotor blade position. For positions 10˚ and 20˚ peak power is generated at a tip speed ratio of 0.4 whereas position 0˚ generates maximum power at 0.6. A maximum power coefficient of 0.26 is present when the rotor is positioned at 0˚ and operating at a tip speed ratio of 0.6.

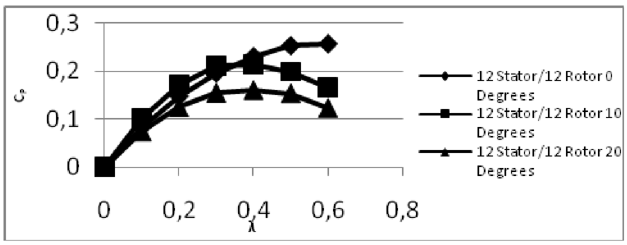

Figure.3 'Variation of power output with respect to λ'

Key words

Vertical axis wind turbine, Computational Fluid Dynamics, Performance, Pressure field, Torque.