An Experimental and Numerical Investigation on Darrieus Vertical Axis Wind Turbine Types at Low Wind Speed

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Abstract-- **This paper presents a model for the evaluation of the optimal design of Darrieus vertical axis wind turbine by CFD analysis and experimental tests, through analyzing six models of Darrieus wind turbines, number of blades and tip speed ratio. For this purpose, a full investigation campaign has been carried out through a systematic comparison of numerical simulations with wind tunnel experiments data. The airfoil profile used in the turbine blades was DU06W200 and constant geometry dimensions to turbines. The experiments were done for all Darrieus wind turbine models by using a subsonic wind tunnel under open type test section with airflow speed range (3-7.65) m/s and different tip speed ratio TSR. The results show that Darrieus WT straight type can be self-starting at the wind velocity 3 m/s, where other types cannot be starting at less than wind speed 5 m/s. The rotational speed (N) increases for all models with the wind velocity increase. The power coefficient (CP) increases when the TSR increases at experimental results for all models. The performance of Darrieus WT with 2 blades rotor is better than other models. At low wind velocity (3 m/s) the value of CP (0.2495), the CT (0.174), the rotational speed (198 rpm) and can be self-starting at this wind velocity.**

Index Term-- **Darrieus wind turbine; Straight-type; Twisted-type; Helical-type; Airfoil profile DU06W200; low wind velocity.**

Nomenclature

As	swept area of turbine (m^2)	T	dynamic torque (N.m)
Cp	power coefficient	Ta	ambient temperature (K)
CT	torque coefficient	Tor	torque (N.m)
c	blade chord length (mm)	TSR	tip speed ratio
R	rotor radius (mm)	$\vec{u}$	relative velocity of fluid
e	overlap distance (mm)	RANS	Reynolds Averaged Navier-Stokes
F	force (N)	SST	Shear Stress Transport
H	blade height (mm)	VAWT	Vertical axis wind turbine
Rg	gas constant (287 J/kg.K)	WT	Wind Turbine
$\vec{r}$	position vector	$\vec{\Omega}$	rotational speed (rpm)
rp	radius of pulley (mm)	μ	viscosity (Pa.s)
Patm	atmospheric pressure (Pa)	ρ	air density (kg/m^3)
PAV	available power in the wind (W)	ω	angular velocity (rad/s)
PT	power produced from turbine (W)	Sui	Centrifugal and Coriolis force
P	static pressure	τij	Average shear stress

1. Introduction

In the latest years, wind energy has become one of the most important technology in economic renewable energy. Today, wind turbines use proven and tested technology for generating electrical power and provide a secure and sustainable energy supply. To compete with others it had to cope with the least affirmative conditions to maximum positive conditions. The usual challenge for the turbines is performing at low wind speed. Wind power has many advantages, that makes it's the fastest-growing energy source in the world. Wind energy doesn't pollute the air like a power plant [1,2]. Darrieus is a lift-type VAWT, it can be a rotation at tip speed ratio greater than one, the torque generated by Darrieus wind turbine is less than Savonius wind turbine but it rotates fastest. Darrieus wind turbine is much better to use in generating electricity. Darrieus turbine generates very large centrifugal forces act on the turbine, there are many types of Darrieus turbines such as H-rotor, Eggbeater, Helical blades, twisted blades ... etc. [3].

The effect of the blade geometrical section on the energy performance and aerodynamic forces working on a small straight-Darrieus type vertical axis wind turbine studied