Effect of Conventional Multistage Savonius wind Turbines on the Performance of the Turbine at Low Wind Velocity

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Abstract--- This paper presents a model for the evaluation of the optimal design of Savonius vertical wind turbine by CFD analysis and experimental tests, through analyzing the stage number, number of blades and tip speed ratio. For this purpose, a full validation campaign has been carried out through a systematic comparison of numerical simulations with wind tunnel experiments data and other references for grid dependency and correlation coefficient. In this case, results show that the correlation coefficient (0.936) better than the correlation coefficient (0.93) in reference [17]. Also, grid dependency was included and described by average y+ values between 1-5.The experiments were done for all Savonius wind turbine models by using a subsonic wind tunnel under open type test section with airflow speed was 3 m/s and different tip speed ratio TSR. The results show that the power coefficient Cp increases when TSR increases to a certain value then decreases for all models. The torque coefficient CT decreases when TSR increases for all models. Savonius wind turbine performance with two blades rotor good agreement was obtained between experimental and numerical results gave better results than other models at low wind speed. The maximum experimental Cp and CT for two brackets rotor are 0.23 at TSR 0.685 and 0.402 at TSR 0.175 respectively.

Keywords--- Savonius Wind Turbine, Multistage, Multi Blades, Two Stage, Low Wind Velocity.

Nomenclature

A	swept area of turbine (m^2)	PAV	available power in the wind (W)
Cp	power coefficient	PT	power produced from turbine (W)
CT	torque coefficient	P	static pressure
CTs	static torque coefficient	T	dynamic torque (N.m)
d	Blade chord length (mm)	Ta	ambient temperature (K)
D	rotor diameter (mm)	Tor	torque (N.m)
Do	end plate diameter (mm)	Ts	static torque (N.m)
e	overlap distance (mm)	TSR	tip speed ratio
F	force (N)	$\vec{u}$	relative velocity of fluid
H	blade height (mm)	V	free stream velocity (m/s)
H1	Stage one height (mm)	RANS	Reynolds Averaged Navier-Stokes
H2	Stage two height (mm)	SST	Shear Stress Transport
n	number of experimental results	VAWT	Vertical axis wind turbine
R	radius of turbine rotor	WT	Wind Turbine
R^2	correlation coefficient	$\vec{\Omega}$	rotational speed (rpm)
Rg	gas constant (287 J/kg.K)	μ	viscosity(Pa.s)
$\vec{r}$	position vector	ρ	air density (kg/m^3)
rp	radius of pulley (mm)	ω	angular velocity (rad/s)
Patm	atmospheric pressure (Pa)	Sui	Centrifugal and Coriolis force
		τij	Average shear stress

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