Performance Testing & Analysis of H-rotor Vertical Axis Wind Turbine

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***Abstract:** Wind turbines are widely regarded as an alternative source for electric power generation. Current wind turbines are classified into horizontal axis wind turbine (HAWT) and vertical axis wind turbine (VAWT) categories. Vertical axis wind turbines are better for the applications in the built environment due to their ability to capture wind from different directions. This paper presents an experimental results from a small scale three bladed H-rotor VAWT. The study was carried out for a small scale H-rotor wind turbine, model setup was placed on the roof of the building at energy centre, MANIT Bhopal. In this study numerical calculations were carried out for power coefficient Cp, Mechanical Power P_m, power extracted by wind turbine P_a, and the rotor speed N of the wind turbine with different wind speed.*

***Keywords:** VAWT, Wind Energy, Power Coefficient, Wind Speed.*

1. INTRODUCTION

With the raise of energy storage and environmental pollution, the increase and use of renewable energy become more significant. The wind energy as a class of renewable energy is forthcoming to the surrounding environment and has huge amount of resources The large scale development of wind energy, which dates back its origin from the energy crisis of 1973, seems to be full maturity. The cost of electricity produced from the wind has stabilized at levels progressively decreasing.

Wind turbines are classified in two categories depending on their axis of rotation, horizontal axis wind turbine (HAWT) and vertical axis wind turbine (VAWT). The most common VAWT is the Darrieus invented in 1931[1], which looks like a giant egg in whisk.In the 80s, several wind farms with commercial Darrieus turbines were operated in California[2] and the biggest turbine of that time had rated power of 4 MW[3]. However, the Darrieus turbine suffered from structural problems as well as poor energy market. Consequently most turbines were dismantled and the research effort was closed [3-5]. The original Darrieus also includes a turbine with straight blades. Peter Musgrove et al [3] further investigated this concept in the 70s and 80s [6]. Subsequently the straight bladed Darrieus turbine, also called H-rotor, has been developed by several other researchers. It is now available in small scale commercially.

There are many potential advantages with H-rotor. The vertical axis rotation helps the generator to be placed at ground level. The turbine it accepts wind from every direction and need not a yaw mechanism. In addition the noise level is expected to be relatively low due to low blade tip speed [7]. Furthermore the few rotating parts simplify the structure and decrease the need for maintenance

2. EXPERIMENT SETUP

A. Turbine Specifications

In table 1 the most important parameters are presented, excluding electrical parameters. The turbine have 3 blades each having length of 47.5 cm and diameter of 51.2 cm.. The blades are made of Aluminum to keep weight minimum for at low cost.

Table 1. Different Component Specifications for Wind Turbine

S. No.	Component	Specification
1	Number of Blades	3
2	Swept Area	0.2451 m^2
3	Blade Length	0.475 m.
4	Chord Length	0.235 m.
5	Turbine radius	0.256 m.
6	Tower height	1.20 m.

B. Base

The Base is made of steel and stands 4 feet high . The base supports the torque and moments produced from wind turbine. The base also supports the wind turbine at the time of high wind speed.

C. Connectng Arms

The connecting arms provide a means to mount the blades to the center mounts and thus the center shaft. It is made of Steel.

D. Shaft

The shaft is made of steel so that it doesn’t bend or twist due to torque generated by rotation of blades (by high velocity winds).

E. Gear Box

The gear box in a wind turbine converts the slow rotation of the turbine into much faster rotation of the electrical generator. It converts the mechanical power generated by wind turbine into the electrical power generated by the electrical generator; this power transmission is dependant to the gear ratio. The gear ratio for our wind turbine is 5:2 (turbine to the generator)

3. CALCULATED PARAMETERS FOR H-ROTOR VAWT

The performance testing of the H-rotor type VAWT model was done at rooftop of Energy Center, MANIT Bhopal, India. Wind data for various wind speed were recorded using digital anemometer installed in the center. The rotor speed was measured by the digital tachometer.

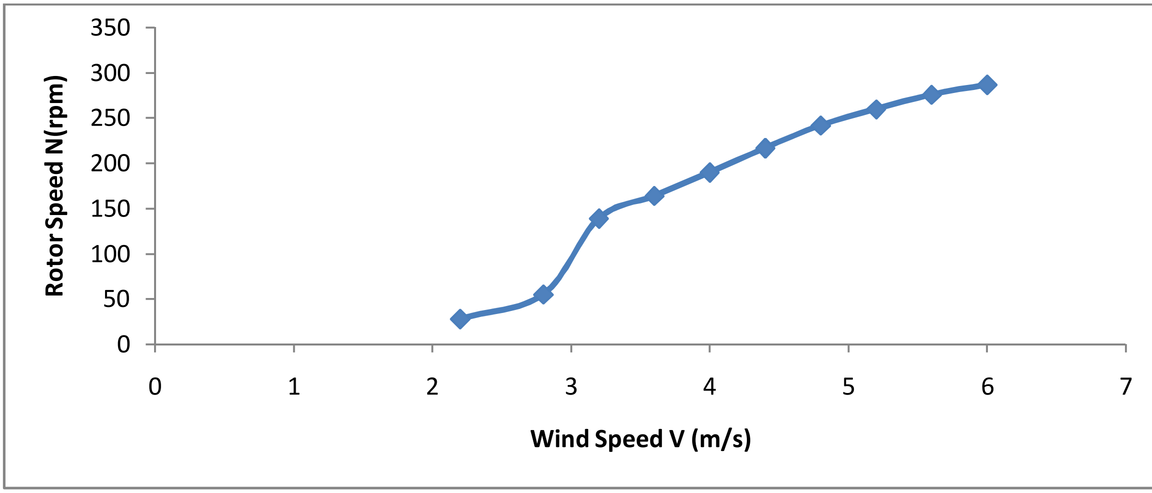
Based on these primary data, computational study was done to obtain the performance efficiency of the model. Table. 2 shows the calculated results for wind parameters.

Table 2. Calculated Parameters for H-rotor Wind turbine

Wind Speed, V (m/s)	Rotor Speed, N (rpm)	Calculated parameters			
		Tip Speed Ratio, TSR	Mechanical power, P_m (watts)	Power in the wind P_a (watt)	Power coefficient, C_p
2.2	28	0.340	0.264	1.586	0.166
2.8	55	0.526	0.842	3.269	0.257
3.2	139	1.164	1.110	4.881	0.227
3.6	164	1.221	1.659	6.949	0.238
4.0	190	1.272	2.372	9.533	0.248
4.4	217	1.321	3.278	12.689	0.258
4.8	242	1.351	4.343	16.473	0.263
5.2	260	1.340	5.487	20.944	0.261
5.6	276	1.321	6.878	26.159	0.262
6.0	287	1.282	8.065	32.175	0.250

4. RESULT

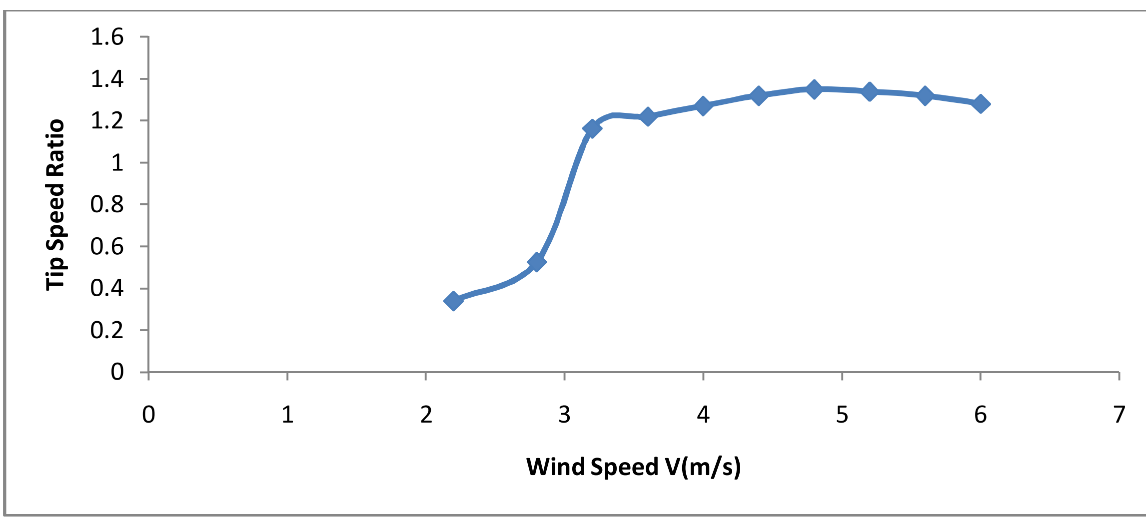
A. Rotor Speed: The rotor speed was recorded using a tachometer; there was a sudden jump in rotor speed at around 3m/s, which gives us a cut-in value for our wind turbine.



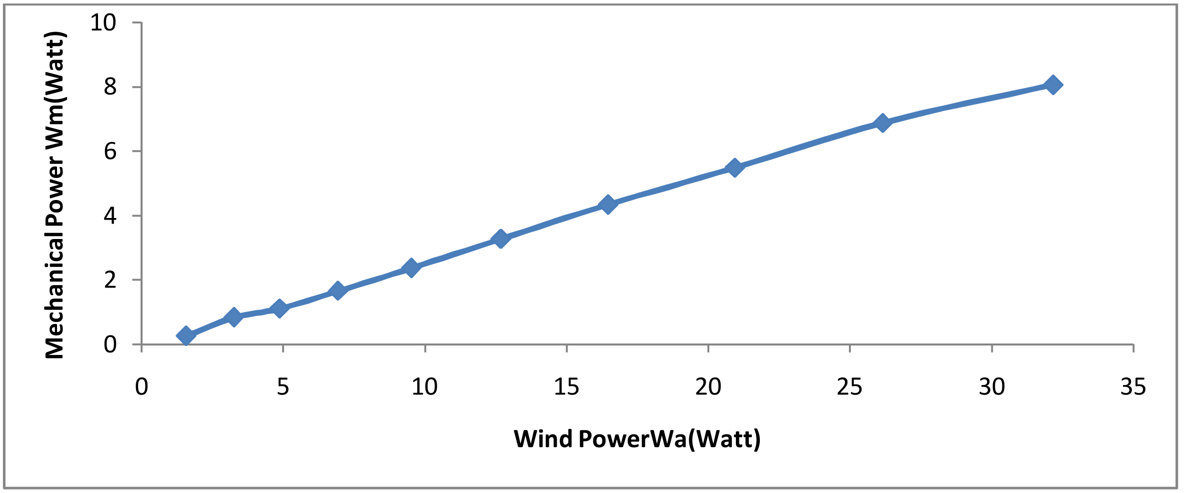
B. Tip Speed Ratio: The tip speed ratio was calculated by using formula

TSR= Rω/V

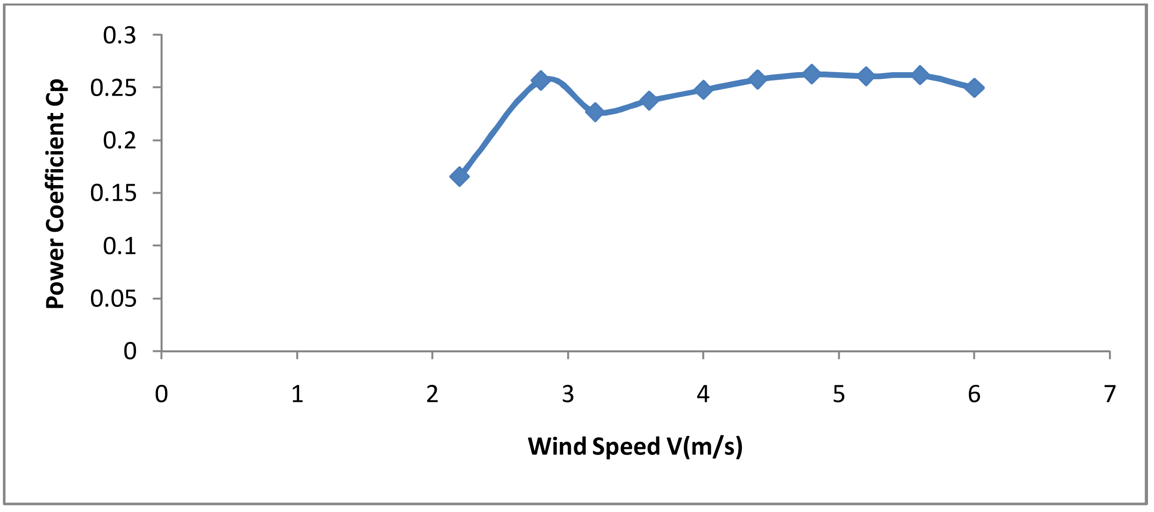
It is a measure of the gearing ratio of rotor, R is the Rotor radius of wind turbine in meter, ω is the angular speed measured in radian and V is the wind velocity in m/s



C. Mechanical Power Vs Wind Power: The slope between Mechanical power and Wind power give us the value of Power coefficient, as the wind speed increases the slope is increasing, which shows that with increasing wind speed power coefficient increases, after a certain value this becomes almost constant, from graph we can approximate that power coefficient for our wind turbine is 0.25.



D. Power coefficient: With Increasing wind speed wind speed increase till a certain value, the maximum power coefficient is 0.263 at 4.8 m/s.



5. CONCLUSION

This article has presented were carried out for power coefficient Cp, Mechanical Power P_m, power extracted by wind turbine P_a, and the rotor speed N of the wind turbine with different wind speed. With the above results it is concluded that with the increase in wind speed the power coefficient is about 0.263. Moreover, materials used in manufacturing of turbine also play an important role in determining the performance of a wind turbine. The rotor speed changes drastically at 2.8m/s wind speed which shows cut in speed .

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