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(Review Article)

A Review on Performance Tests of Helical Savonius and It's Utilization

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Abstract

One of the most promising renewable energy resources for power generation is wind energy, and it has been growing rapidly. The most classification of wind turbines is by its axis of orientation 1) Horizontal Axis Wind Turbines (HAWT) and 2) Vertical Axis Wind Turbines (VAWT). HAWTs are most commonly used for medium to large power production. Maintenance in HAWT is difficult. On other hand VAWTs are smaller in size and they are easily installed near to the ground. They have low maintenance cost, simple in construction. VAWTs are used for domestic areas and residential areas. VAWTs can also be used with street lights.

Keywords: Renewable Energy, VAWTs, Helical savonius, Field Performance.

1. Introduction

The savonius wind rotor was invented in 1922 by the Finnish engineer Sigurd Johannes Savonius. It is a vertical axis wind rotor with simple geometry. In its most common shape it is made of two semi-cylindrical blades, asymmetrically positioned with respect to the vertical axis of rotation, it is also called as conventional savonius. In some recent years the global market of Small wind turbines rising due to increasing fossil fuel prices, limited fossil fuels and increasing pollution. That reasons leads us to do more research related to Renewable Energies. As the Small Vertical Axis Wind Turbine (SVAWT) Technology encourages the Indian market to do research and manufacturing in this field. Helical savonius is one of them, due to its self-starting ability, Omni-directional, high starting torque, less tower height and low starting wind speed of 2m/s. They also have good starting characteristics. Its Operating speed increases as Rotor size increases leads to produce more power from 200W to 10KW. Due to wide range of power producing capacities, these wind turbines can be use on top of urban buildings. Keeping all the things in mind A number of researchers have tested many models of helical Savonius rotor and they have numerically and experimentally examined the effects of various design parameters of helical Savonius wind rotor such as the rotor aspect ratio, the overlap ratio, the twist angle, the number of buckets, the presence or absence of rotor end plates, and the influence of Reynolds numbers.

2. Literature Review

M.A. Kamoji et al [1]. In this paper they discuss the helical savonius with 90° twist angle and then performance of helical Savonius rotor with shaft between the end plates and helical Savonius rotor without shaft between the end plates. They consider different overlap ratios as 0.0, 0.1, and 0.16 and aspect ratios as 0.88, 0.93 and 1.17, then calculate different parameters as coefficient static torque, maximum coefficient of power and coefficient of torque, they compared it for helical savonius with shaft and helical savonius without shaft.

First they did experiment for overlap ratio, it is found out that overlap ratio with 0.0 has maximum coefficient of power without shaft. Then further they check for aspect ratio as 0.88, 0.93 and 1.17 having constant overlap ratio of 0.0. From this test 0.88 is aspect ratio has higher coefficient of power.

Further the check helical savonius with overlap ratio of 0.0 and having aspect ratio of 0.88 for different Reynolds number, and then the data is compared with conventional savonius. After that taking two different Reynolds No as Re=1, 20,000 and Re=1, 50,000 they plotted various graphs for,

- Coefficient of power V/s Tip speed ratio :
- Coefficient of torque V/s Tip speed ratio :
- Coefficient of static torque V/s Rotor angle :

They found that as Reynolds number increases then coefficient of power increase, so they take different Reynolds Number for study as 57700, 86600, 115500, 144000, 173000 and 202000. It is also considered as wind velocities of 4m/s, 6m/s, 8m/s, 10m/s, 12m/s and 14m/s. These results are compared with the results of the conventional Savonius rotor available in the literature they refer.

A. Damak et al [2]. This paper in study, the performance test of modified Savonius rotor with twist angle of 180° taken with aspect ratio of 1.57 and overlap ratio of 0.0 with Reynolds number as 79794, 99578, 116064 and 147059. The other experimental test of helical savonius rotor at overlap ratio 0.0 and different Reynolds number is taken 79794, 99578, 116064 and 147059 with corresponding velocities 6m/s, 7.5m/s, 8.8m/s and 11.1m/s. so, maximum coefficient power achieve 0.25 And tip speed ratio in the range of 0.4-0.45 at the Reynolds number of 147059 but it is for 90° twist angle. Hence, the coefficient of power increases with increases in Reynolds number. It is also found that overlap ratio 0.24 has better coefficient of power rather than overlap ratio 0f 0.0.There is change in power coefficients depending on the speed ratio λ at different Reynolds numbers equal to Re = 79,794, Re = 99,578, Re = 116,064 and Re = 147,059. So there is direct relation between change in overlap ratio and the Reynolds number on the performance of helical savonius. This investigation of helical savonius rotor compared with conventional savonius rotor values with same parameters, it found out that helical geometry gives better performance value over conventional one. Results conclude that change in overlap ratios for given Reynolds numbers then this directly effect on the global characteristic of the helical Savonius rotor.

Jae-Hoon Lee et al [3]. In this paper they have discuss about effect of twist angle on the performance of helical savonius wind turbine. They conduct two analysis 1) experimental test analysis and 2) numerical based analysis. The measured power coefficient (C_p) at different tip speed ratios (TSRs) and torque coefficient (C_t) for different blade angle are 0°, 45°, 90° and 135°. These results are compared to numerical based analysis. But, overall results for both condition are showed that maximum power coefficient achieved at Tip speed ratios of 0.4 to 0.8 for the twist angle 45° are almost same. Now they conduct experiment with same conditions for twist angle of 90° and 135°, then results are opposite that power get decreased. They also conduct experiment on helical savonius rotor with aspect ratios of 0.88, 0.93 and 1.17, for twist angle of 90°. But, the performance of aspect ratio 0.88 is better than others, further they calculate the power coefficient for two bladed rotor and three blade rotor with0.88 aspect ratio. So, the generated power coefficient for two blade rotor is better than the three blade rotor.

T. Micha Premkumar et.al [4]. In this paper, they have tested the helical savonius with end plates and without End plates, for low wind velocities at a 3m/s to 6m/s. They have taken 6 different values for without end plate and 6 for with end plates but all wind velocities are different from each other. By considering these wind velocities they measure the various parameters like coefficient of power, coefficient of torque and tip speed ratio. The first experiment is about savonius without end plates for different wind velocities range between 3m/s to 6m/s and all parameters are calculated coefficient of power, coefficient of torque and tip speed ratios. By this test wind velocity of 5.117m/s achieves maximum coefficient of power, hence as wind velocity increases then correspondingly coefficient of power increases, but coefficient of torques decreases simultaneously. Same test conducted for savonius with end plates and calculated all parameter, with different wind velocities apart from the value they have taken in without end plates. When wind velocity is considered 5.1293m/s then maximum coefficient of power is 0.0540 achieved But coefficient of torque is reduces. So, above results are compared with each other found out helical savonius with end plate has high coefficient of power. They also discuss the torque value for different blade angles from 0° to 360°**.**

Keum Soo Jeon et al [5]. In this paper they have discuss about the experiment that they have conduct to find Aerodynamic performance and Effects on helical savonius. They use 4 different types of end plates with various shape and size for experiments (shown in figure 1). The helical savonius they have used is having Twist angle of 180°.They studied Maskell's Blockage correction method, which is for Straight savonius but later someone suggest that this method is also applicable to helical savonius. The practical experiments are conducted in subsonic open-circuit type wind Tunnel. The end plates were fabricated from an acrylic plate of 5mm thickness, aspect ratio H/D remains constant for each blades. The experiments were performed at air speeds ranging from 6 m/s to 12 m/s. Through this experiment it is found out that savonius rotor with circular end plate is 36% more efficient than no end plate.

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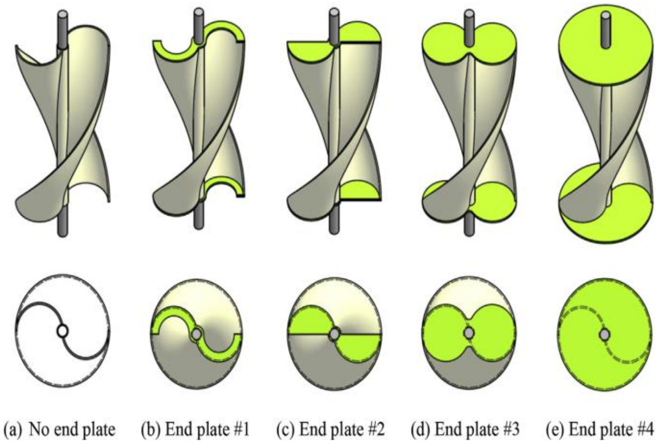

Figure 1: Different shapes of end plates [5]

Renato Ricci et.al [6]. In this paper they created a lamppost having vertical axis wind rotor and solar panel. The experiment is conduct at University "Politecnica delle Marche" (UNIPVPM). They use discrete vortex method rather than CFD and P.I.V. first they make prototype having scale 1:1 single stage rotor. Prototype is consisting of single stage blade or multistage, end-plate and supporting posts. They studied the influence of all the parts for the lamppost. They conduct series of experiment with blade angle (0°, 90° and 105°), position of posts and end plates. For example test of lamppost having blade angle 0° with end-plates and without support. They consider all possibilities as given example, and it is find out that, the blade having angle 105° is more efficient than other 2 angles. The absence of Overlap ratio decreases the power coefficient by 17%. The end plates had an improving effect for the helical rotor with a step of 105°**.** The supporting posts affect negatively on the performance test but for helical rotor with 105° it's small. The best results were obtained for a helical rotor with a step of 105°, with end plates and open gap, in this condition a Cpmax of 0.251 at λ=0:899 was measured

Qing'an Li et al [7]. In this paper they have study the effect of blades number in savonius rotor. They have taken constant velocity of 8m/s, with this velocity they conduct experiment for 2, 3, 4, 5 blades. Hence we find that as blade number increases the coefficient of power decreases. So savonius rotor blade having 2 blades is more efficient than savonius rotor with 5 blades.

3. Equations

The equations which are written below are mostly common formulas for certain papers.

$$Re = \frac{\rho U D}{\mu} \tag{1}$$

$$TSR = \frac{\omega D}{2U} \tag{2}$$

$$T = \frac{(M-S)(r_{shaft}+r_{rope})g}{1000} \tag{3}$$

$$Ct = \frac{4T}{\rho U^2 D^2 H} \tag{4}$$

$$Cts = \frac{4Ts}{\rho U^2 D^2 H} \tag{5}$$

$$Cp = TSR \ x \ Ct \tag{6}$$

$$B = \frac{HD}{H_w W} \tag{7}$$

$$Cp = \frac{2P}{A_p V^2} \tag{8}$$

$$Cm = \frac{4M}{\rho V^2 D^2 H} \tag{9}$$

$$U = \omega R \tag{10}$$

$$\lambda = \frac{U}{V} \tag{11}$$

$$A_R = \frac{H}{D} \tag{12}$$

$$Re = \frac{\rho V_\infty H}{\mu} \tag{13}$$

$$D = \frac{2(D \ x \ H)}{D+H} \tag{14}$$

$$TSR = \frac{2\pi Rn}{60 V_\infty} \tag{15}$$

$$Cp = \frac{T\omega}{0.5\rho A V_\infty^3} \tag{16}$$

$$C_T = \frac{T}{0.5\rho A V_\infty^3} \tag{17}$$

$$\alpha = \frac{H}{D} \tag{18}$$

$$\beta = \frac{e}{D} \tag{19}$$

$$Cts = \frac{Ts}{qSR} \tag{20}$$

$$Ct = \frac{T}{qSR} \tag{21}$$

$$Cp = \frac{P}{qSR} = \lambda \ x \ Ct \tag{22}$$

$$\lambda = \frac{\Omega R}{U} \tag{23}$$

$$ER = \frac{A_E}{A_C} \tag{24}$$

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4. Conclusions

We conclude from this paper that Overlap ratio, Aspect ratio and wind speed affects drastically on the performance of helical savonius. Overlap ratio 0.24 and aspect ratio 0.88 are the best parameters considered as better solution. Helical savonius with blade angle 180° have positive static torque and Savonius rotor with 2 blades have better performance.

Nomenclature

Re	Reynolds Number.
U	Free stream Wind Velocity. (m/s)
ρ	Density of air. (kg/m^3)
D	Rotor Diameter. (m)
R	Rotor radius. (m)
μ	Absolute viscosity of air. (Pa s)
TSR	Tip speed ratio.
ω	Angular velocity of rotor. (rad/s)
T	Torque. (N-m)
M	Mass. (gms)
S	Spring balance reading. (g)
r_{shaft}	Diameter of the string. (mm)
r_{rope}	Radius of the shaft. (mm)
Ct	Coefficient of torque.
H	Rotor height. (m)
Cts	Coefficient of static torque.
Ts	Static torque. (N-m)
B	Blockage ratio.
H_w	Height of wind tunnel exit. (m)
P	Power. (W)
V	Speed of air. (m/s)
Cm	Coefficient of torque
Cp	Coefficient of power
Λ	Tip speed ratio.
A_R	Aspect ratio.
V_∞	Velocity at the tunnel free stream.
D_h	Hydraulic diameter.
α	Aspect ratio.
β	Overlap ratio.
e	Gap between two adjust blade.
q	Dynamic pressure.
Ω	Angular speed.
ER	End plate area ratio.
A_E	End plate area.
A_C	Cross-sectional area.

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