International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

REVIEW ON SAVONIUS TYPE VERTICAL AXIS WIND TURBINE

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ABSTRACT

In recent era, research and development activities in the field of renewable energy, especially wind and solar, have been considerably increased, due to the worldwide energy crisis and high global emission. The horizontal axis wind turbine cannot be used for household purpose. So, Savonius vertical axis wind turbine can be better option as it operates in low wind condition also. The choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation..

Keywords: Vertical Axis Wind Turbine, Savonius, Renewable Energy, Magnetic levitation structure.

I.INTRODUCTION

A wind turbine, which is installed on top of a tower, collects kinetic energy from the wind and converts it to electricity that is compatible with a home's electrical System. The wind turbine typically **lowers our electricity bill by 50 to 90 percent**. Homes use approximately 9,400 kilowatt-hours (kWh) of electricity per year (about 780 kWh per month). Depending upon the average wind speed in the area, a wind turbine rated in the range of **50 watt to 15 kilowatts** would be required to make a significant contribution to meet this demand. A small turbine can **cost about Rs 20,000/-**, depending upon size, application and service. They are designed for a long life (up to 20 years) and operate completely automatically.

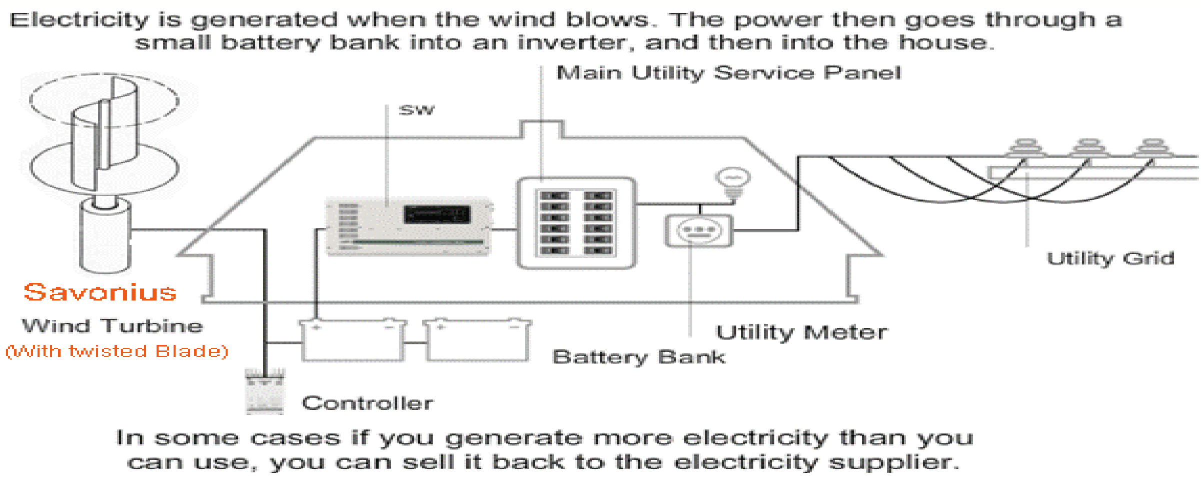

Fig. Residential Wind Turbine [4]

II.LITERATURE SURVEY

Relating to the current stated work a literature survey was carried out. The summary of the reviewed papers is given below.

1. Mohammed Hadi Ali Lecturer University of Mustansiriya presented research paper on "Experimental Study for savonius Wind Turbine of Two and Three Blades at Low Wind Speed". The experiment's procedure was carried out and tested in the wind tunnel and the required measurement were obtained to study the performance of the two blades and three blades savonius wind turbine and makes the comparison between them to see which one is better in performance than the other. The performance [the dimensionless parameters torque coefficient (C_t) and power coefficient (C_p)] was evaluated as function of the dimensionless parameter the tip speed ratio (λ) at low wind speeds in terms of starting acceleration and maximum no-load speed.

2. Prof. Vaibhav Bankar and Ashwin Dhote presented research paper on "Design, Analysis and Fabrication of Savonius Vertical Axis Wind Turbine".

Following are the same conclusions drawn from this Research:

[1] At least 10% power of the consumption can be fulfilling by this set up.

[2] Multi stage generator is the double generation concept with the same size rotor.

[3] Gear arrangement can increase the number of rpm in case of low wind speed.

[4] This turbine is generally suitable for 8 to 10m of height above ground level. Because at ground level velocity of air is very less.

[5] Combination of alternator with gear arrangement can be used to increase output but unnecessarily it will increase the cost of machine.

[6] Considering the all-weather point of view the material use should be non-corrosive.

[7] The alternate option for turbine blade material is reinforced glass fibre because of its more elastic nature but it is costlier than aluminium alloy.

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ISSN: 2319-8354

[8] The cost of the machine should be as minimum as possible. So that it will be economical for everyone to purchase.

3. Magedi Moh. M. Saad, a, Norzelawati Asmuin presented research paper on "Comparison of horizontal axis wind turbines and vertical axis wind turbine". This paper gives a comparison between the horizontal axis wind turbines, or HAWTS, and the vertical axis wind turbines, or VAWTS. The two types of wind turbines are used for different purpose. Both types of turbines, whether VAWTs or HAWTs, are used for generating electrical power from the wind. This work has compared both types, and also presented the advantages and disadvantages of both types. Each type has its applications. It depends on the wind speed and place to be fixed on. Any way the horizontal axis with propeller blades is the most common one, since its efficiency is about 60%.

III.VERTICAL AXIS WIND TURBINE

Vertical axis wind turbines, as shortened to VAWTs, have the main rotor shaft arranged vertically. The main advantage of this arrangement is that the wind turbine does not need to be pointed into the wind. This is an advantage on sites where the wind direction is highly variable or has turbulent winds.

With a vertical axis, the generator and other primary components can be placed near the ground, so the tower does not need to support it, also makes maintenance easier. The main drawback of a VAWT generally creates drag when rotating into the wind.

It is difficult to mount vertical-axis turbines on towers, meaning they are often installed nearer to the base on which they rest, such as the ground or a building rooftop. The wind speed is slower at a lower altitude, so less wind energy is available for a given size turbine. Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration, including noise and bearing wear which may increase the maintenance or shorten its service life. However, when a turbine is mounted on a rooftop, the building generally redirects wind over the roof and this can double the wind speed at the turbine. If the height of the rooftop mounted turbine tower is approximately 50% of the building height, this is near the optimum for maximum wind energy and minimum wind turbulence.

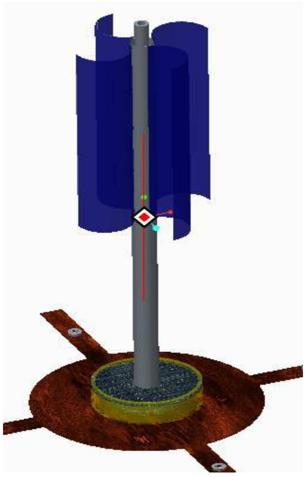

Fig. Savonius Vertical Axis Wind Turbine [6]

IV.WORKING OF SAVONIUS WIND TURBINE

Operating principle of the Savonius or so called " S" rotor is rather simple and is very similar to the one observed on simple cup anemometers. Drag force created by cup or semi-cylinder like surfaces (scoop) produces the torque on the main holding shaft thus creating power that could be utilized for multiple purposes. In the case of a Savonius rotor, it is shown that a geometrical characteristic such as a separation gap between scoops, overlap ratio and aspect ratio are found to be a most important for optimum performance of the rotor.
We therefore define those parameters through the following relations:
Aspect ratio: AR = Hs / Ds
Overlap ratio: OL = a / Dc
Separation gap: GP = - b / Dc
Where, Hs = Height of savonius rotor.
Ds = Diameter of savonius rotor.
a = Savonius rotor overlap.
Dc = Diameter of savonius rotor semi cylinder.
B = Savonius rotor separation gap.

Savonius wind turbine consists of two, three or six half cylinders facing opposite directions in such a way as to have almost on S-shaped cross section. These two semi-circular drums are mounted on a vertical axis perpendicular to wind direction with a gap at the axis between the two drums. Irrespective of the wind direction the rotor rotates such as to make the convex side of the buckets head into the wind. Instead of having each two edges together to make an S shaped the overlap to leave a wide space between the two inner edges, so that each of these edges is near the central axis of opposite cylinder. The main action of the wind is very simple; the force of the wind is greater on the cupped face than on rounded face. The wind curving around the back side of cupped face exerts a reduced pressure much as the wind does over the top of air-foil and this help for rotation. The wide slot between the two inner edges of the half cylinders lets the air whip around inside the forward moving cupped face, thus pushing both in the direction of the rotation.

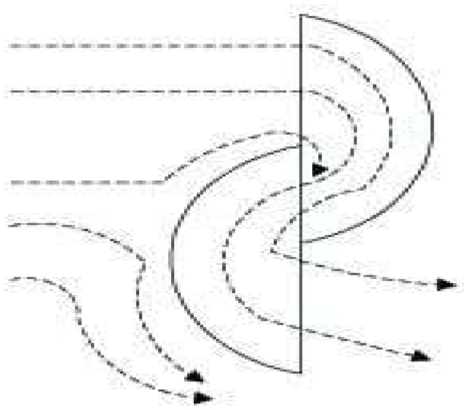

Fig. Attack of wind on cupped surface [5]

V.SAVONIUS WIND TURBINE ADVANTAGES

Savonius wind turbines are making an impression in the alternative energy scene these days for their unique design and new applications. Vertical Axis Wind Turbines (VAWT's) are enjoying a revival of popularity, as they offer a number of advantages over more conventional Horizontal Axis Wind Generators (HAWT's). Vertical wind turbines are not a new concept; since the Persians were using them thousands of years ago. VAWT's are different from traditional HAWT's because their main axis is perpendicular to the ground. Vertical wind turbines have a unique spinning rotor which is directly connected to a solid monopole or a vertical shaft. The rotor is connected through a gearbox to a generator which produces electricity.

- **Savonius wind turbine Operate in Any Wind Direction: -** Savonius wind turbines, unlike other wind conversion devices, do not have to be positioned so that the rotors are facing in a moving wind current. The rotors can face in any direction, and still collect wind energy for conversion into mechanical energy. This is because Savonius wind turbines are able to detect and catch the wind in any direction, no matter which way the wind is blowing.
- Savonius wind turbines have a higher airfoil pitch angle, giving improved aerodynamics while decreasing drag at low and high pressures.
- Low height useful where laws do not permit structures to be placed high. Does not need a free standing tower so is much less expensive and stronger in high winds that are close to the ground.
- Can be easier to maintain if the moving parts are located near the ground. Mesas, hilltops, ridgelines and passes can have faster winds near the ground because the wind is forced up a slope or funneled into a pass and into the path of VAWTs situated close to the ground.

VI.IMPORTANT CHARACTERISTICS OF DRAG FORCES

1) Drag Force increases with the Area Facing the Wind:-

Drag force increases in proportion to the **swept area** of an object facing the wind. In savonius maximum drag force is required to incident on cupped face than on the round face.

2) Drag Increases with the Square of the Wind Speed:

Both lift and drag increase with the square of the wind speed.

3) Drag Increases with the density of air:-

Both lift and drag increase in proportion to with the density of air. Cold air will thus give more drag than hot air. We can find the density of air at different temperatures in the Reference manual.

4) Drag Force Formula:-

The drag force for a given object can be found using the formula below:

$F_d = C_d$ x 0.5 x A x v^2

Where,

F_d = The drag force measured in N (Newton).

C_d = The drag coefficient, measured in N/m^2, i.e. the drag force per square meter swept area of the object shape. This value is usually found through (very expensive) wind tunnel measurements.

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ISSN: 2319-8354

A = Swept area of the object in m^2,

VII.CALCULATION OF WIND POWER

1) The power output of a **wind generator** is proportional to the area swept by the rotor - i.e. double the swept area and the power output will also double.

2) The power output of a wind generator is proportional to the **cube** of the wind speed - i.e. double the wind speed and the power output will increase by a factor of **eight** (2 x 2 x 2)!

Power available in wind

P_a=1/2 mv^2, (where, m= ρ x A x V)

P_a= =1/2 x ρ x A x v^2

Power that Rotor extract from Wind

P_w= = C_p x Pa x N_g **x** N_d

P_w= 0.5 x C_p x N_g **x** N_d **x** ρ x A x v^3

Where,

P = power in watts (746 watts = 1 hp) (1,000 watts = 1 kilowatt)

ρ = air density (about 1.225 kg/m3 at sea level, less higher up)

A = rotor swept area, exposed to the wind (m^2)

C_p = Coefficient of performance (.59 {Betz limit} is the maximum theoretically possible, 0.45 for a good design)

V = wind speed in meters/sec (20 mph = 9 m/s)

N_g = generator efficiency (50% for car alternator, 80% or possibly more for a permanent magnet generator or grid-connected induction generator)

N_d = bearings efficiency (depends, could be as high as 95% if good)

VIII.FUTURE ENHANCEMENTS

From the past experiences, it is evident that wind turbines can compete with conventional sources in niche markets, and lower costs make them affordable options in increasingly large markets. **Magnetic Levitation weight reduction structure** can be used for vertical Axis wind turbine. It includes frame, a fixed permanent magnet, revolving permanent magnet, blade hub, and a generator. The fixed permanent magnet fixed to the frame has a first repulsive surface. The axle is connected to the frame. The revolving permanent magnet fixed to the axle has a second repulsive surface in relation to first repulsive surface of the fixed permanent magnet. Both the first and second repulsive surfaces repel with each other. The blade hub and the generator are connected to the axle. When the revolving permanent magnet is rotated, the axle functions a balance center.

IX.CONCLUSION

The field of wind power utilization is not fully tapped at the present time. As we are degrading our fossil fuels at high rate. It is important for us to look for alternatives and certainly the VERTICAL AXIS WIND TURBINE (VAWT) is a key process for harnessing this renewable energy. At present, HAWT technology is more mature than VAWT technology because of strong US and European research efforts, ready adaptability of certain aerodynamic and structural analysis techniques for propeller and helicopter rotors and an existing foundation of HAWT design philosophy from early nineteenth century. Nevertheless, VAWT technology can show equal or superior promise if more funding is given for further R&D activities. The two categories of wind turbines, VAWT and HAWT, represent viable embodiments of wind energy technology, each with understandable pros and cons when considered for any given applications.

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