International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 01 | Jan 2020 www.irjet.net p-ISSN: 2395-0072

Manufacturing System of Hybrid Vertical Axis Wind Turbine

Monali Dhawas[1], Ankita Nikam[2], N.V. Yawale[3]

[1]*Student, Dept. of Electrical Engineering, DES'S COET, Dhamangaon Rly*
[2]*Student, Dept. of Electrical Engineering, DES'S COET, Dhamangaon Rly*
[3]Professor, *Dept. of Electrical Engineering, DES'S COET, Dhamangaon Rly*

---***---

Abstract - Vertical axis wind turbines (VAWTs) have with time been outrivaled by the today common and economically feasible horizontal axis wind turbines (HAWTs). However, VAWTs have several advantages such as the possibility to put the drive train at ground level, lower noise emissions and better scaling behavior which still make them interesting for research. This control strategy captures wind power from a vertical axis wind turbine (VAWT), and a back-to-back PWM converter is applied to control the output power from permanent magnet synchronous motor (PMSM) in order to make sure the wind power can be transmitted to the grid safely. Due to the characteristic of the traditional control method that the power factor is not the optimal by the side of motor, here a control method of unit power factor is present, so that the voltage and the current are controlled to the same phase by the side of motor as well as the voltage and the current are controlled to the opposite phase by the side of power grid in order to ensure the output reactive power is zero. The simulation results based on Simulink validates the effectiveness of the proposed control strategy.

Key Words: Control Strategy, Permanent Magnet Synchronous Motor, Vertical Axis Wind Turbine, Wind Energy.

1. INTRODUCTION

With populations increasing exponentially and our natural resources being strained by increases in demand, it is more important than ever to invest in renewable energy. Our consumption of fossil fuels as energy has been traced to be a leading cause in environmental issues. The byproduct of fossil fuel consumption is carbon dioxide, which has been named to be a primary constituent leading to Global Warming. The amount of carbon dioxide that someone or something produces is known as its "carbon footprint." The media has been focusing on this issue and many green movements have started to try and reduce our "carbon footprint." (Green Student U, 2008). Speed and density of flowing bodies determine the kinetic energy that can be converted into mechanical energy using turbine. Though the wind speed is much higher than the water speed, but water is about 835 times denser than wind. Worldwide, the total estimated power in ocean currents is about 5,000 GW, with power densities of up to 15kW/m2 [1]. Kinetic energy of water current can be converted into mechanical energy using a turbine. Turbine may be horizontal axis or vertical axis type. Vertical axis turbines are preferred due to their omni-directional characteristics. This shows three vertical axis turbines. Savonius type vertical axis turbine produce higher torque and have lower cut-in speed. A lift type Darrieus turbine (classified as vertical axis) can have blade tip speed many times the speed of the water current (i.e. the Tip Speed Ratio (TSR) is greater than 1).

It does researches on the power transmitted to the grid control strategy of a direct-driven permanent magnet synchronous wind power generator. It uses a method of rotor flux oriented vector control to regulate the PMSM, and the flux direction of the generator is seen as the direction of d-axis. And then, it controls the d-axis current to 0, so that the optimal wind energy can be captured by controlling the q-axis current. In this case, the power factor of the PMSM is less than 1 as well as the d-axis voltage is not zero. That means this control strategy will produce reactive power and increase the motor capacity.

It applies a control method of uncontrollable rectifier and controllable inverter as the circuit of power transmitted to the grid which has a lower cost of the system and a simpler control algorithms. However it cannot regulate the torque of the generator directly, meanwhile it will increase the stator harmonic currents of the generator.

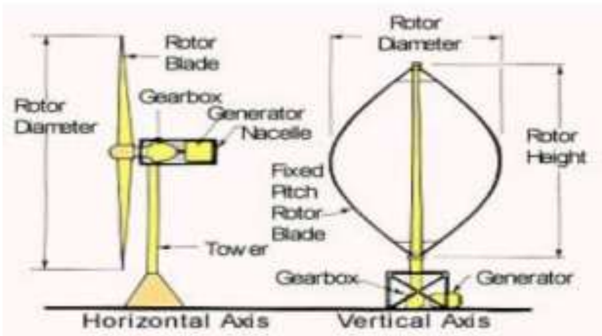

Fig. 1: HAWT Vs. VAWT Design

As shown in above fig.1 the difference between two axis. This paper is an extension of previous work at WPI in MQP papers that focused upon VAWTs. The research in this paper was intended to improve VAWT efficiency and maximize the energy generation from the wind's available power. This was done by considering alternate turbine designs adding a shroud around the wind turbine. The paper researched blade designs that performed the best with a 90° enclosure. The enclosure is a shroud that surrounds the turbine and allows wind to enter the area at a 90° angle. The enclosure was expected to increase the turbine's revolutions as compared to a turbine without an enclosure. The paper also entailed research into reducing the amount of vibration experienced by a roof caused by wind turbines. This was approached by variations of vibration dampening systems on the roof mounting system. To see how effective a VAWT system would be in Worcester, specifically WPI facilities, a software program called WAsP was used with wind speed data collected over the past couple of years.

2. RELATED WORK

2.1 VAWT

The other major classification for wind turbines are vertical axis wind turbines. These turbines spin on a vertical axis. Figure 2 is an example of a Darrieus vertical axis wind turbine. This turbine is an example of a commercially used vertical axis turbine. One of the major problems with vertical axis wind turbines is that an initial force is required to start the turbine's spinning. Another issue is that they are difficult to be designed for high altitudes. The blades on a vertical axis wind turbine can utilize an airfoil design like the VAWT, however a VAWT can also use blades that directly face the wind, as shown in fig. 3.

Fig. 2: Darrieus VAWT

Fig. 3: Three flat bladed VAWT

2.2 The Effects of Shrouds on Vertical Axis Wind Turbines (VAWT)

A previous Major Qualifying Paper (MQP) report by Julie Eagle (Eagle, 2012) addressed VAWT design, entitled Enclosed Vertical Axis Wind Turbines, shows preliminary research on how a protective shroud affects vertical axis wind turbines placed within it. The research confirms that a three bladed turbine design with air foil blades outperform and is more efficient at lower speeds then the equivalent flat blade design. This information is depicted in Figure 4.

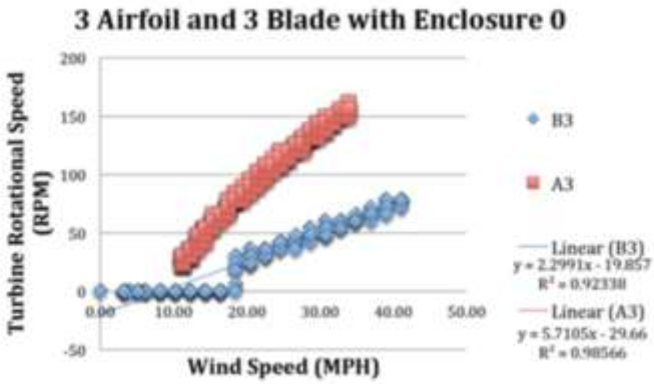

Fig. 4: Comparison Flat Blades vs. Air Foil Design (Without Enclosure)

The results from fig. 4 demonstrate poor potential for home rooftop wind turbine potential because the airfoil design (labeled as A3) has a cut in speed of 10 miles per hour. The flat bladed design (labeled as B3) takes even higher wind speeds to initiate spinning with a cut in wind speed of 20 miles per hour. The reason these results are poor for a rooftop wind turbine is because in Massachusetts the estimated wind speed that will approach a rooftop wind turbine is 6.24 miles per hour indicating that neither of these designs can be expected to generate significant amounts of energy throughout the year. The results also do not indicate their real performance because there was no load put on the turbine system, such as a generator. The wind speeds indicated to spin the turbine are much lower than actual wind speeds required to rotate a turbine with generator.

Further testing from the same paper (Eagle, 2012) compares the previous test with the same turbines, but with a protective shroud and a funnel that accelerates wind speed. These results are depicted in figure 5. The x-axis represents the wind speed that is produced by the wind tunnel and not the accelerated wind speed occurring within the enclosure.

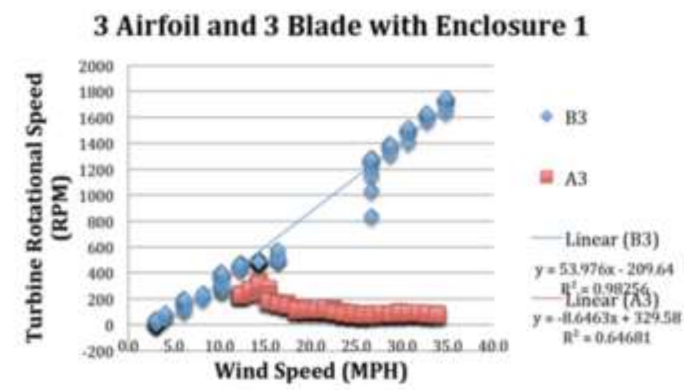

Fig. 5 Comparison Flat Blades VAWT vs. Air Foil Design (Enclosure 210)

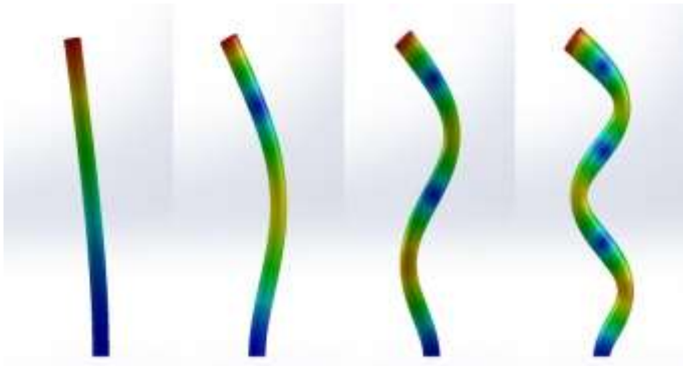

Fig. 6: Four Eigen Frequency Modes for An Unsupported Tubular Tower (Attached to the Ground with the First Mode at the Far Left)

The results in fig. 4 and 5 from Julie Eagles report, primarily indicate that funneling wind into an enclosure increases the rotation rate of the turbines significantly. This leads to a promising potential for vertical axis rooftop wind turbines. An unexpected result from this test is that the flat bladed design (B3) performed better than the airfoil design (A3) in this test. This is very surprising because without the funnel and shroud the airfoil design performed better than the flat bladed design.

Similarly during the test shown in fig. 4 the airfoil design had a cut in speed around 10 miles per hour in the test depicted in fig. 5 However, the design peaked at about 15 miles per hour and had a decrease in its rotation rate as speed increased thereafter. This still leaves these VAWTs at below performance levels for the wind speed expected on roof tops in the Worcester area. The flat bladed design performed better than expected and outperformed the airfoil design in this test. The decrease in speed was at about 2.5 miles per hour which is below the expected wind speed the product would encounter. The results are also encouraging because at 6.24 miles per hour the flat bladed design had a similar rotation rate to the airfoil designs without a shroud at over 35 miles per hour. Again, this is without a load attached so we can expect when attaching a load that the rotation rate will decrease as a resistance is applied.

3. METHODOLOGY

An eigen frequency is a frequency at which a construction tends to oscillate in the absence of driving or damping forces. If the eigen frequency coincide with a forced frequency, a so called dynamic load, the amplitude of vibration escalates and a so called resonance occurs. A construction has several different eigen frequencies, different modes, where for each frequency the construction is moving in a different way. In figure 6 the first four mode shapes for an unsupported cylindrical tower attached to the ground can be seen. Eigen frequencies of a structure depend on material, shape, height, mass as well as motion constraints such as guy wires.

As shown in above fig. 6, Instability due to eigen frequencies are of concern regarding wind turbines as well as most other tall structures. Different components of a wind turbine can have their own eigen frequency and besides the tower which is the main subject of this work, the T1-turbines mode shapes due to the elasticity of the struts has been examined and for the driveshaft. It was found that by careful dimensioning it is possible to obtain a large resonance free operational rotational speed range regarding the struts. The aerodynamic damping of the eigen modes of interest was also found to be good. In it was found that by using a directly-driven generator the shaft can be made considerably 20 smaller. Furthermore, the Sandia National Laboratories VAWT research of the 1970-80s includes work on guyed VAWTs, for example vibration and damping issues of the guy wires. Sandia studies a Darrieus turbine supported entirely by guy wires attached to the top, whereas the VAWT studied in this work is only partly guy wire supported.

3.1 Manufacturing of Turbine Blades and Rod.

The vertical shaft that held the turbine was manufactured out of quarter inch stainless steel with press fits designed to attach to the generator and the anemometer. It also had two set screws which kept the shaft connected to both instruments as well as a set screw in the middle to lock turbine in place. The split Savonius blade was manufactured in the Stratysys Dimension FDM Rapid Prototyping 3d printer. The top and bottom pieces were cut out of 3/8th inch acrylic and then glued together. The adjustable angle wind turbine was mostly manufactured in the 3-d printer. The metal rods used to lock the adjustable blade to the top and bottom pieces were glued together with epoxy.

4. CONCLUSION

In this paper, the control strategy of the power transmitted to the grid based on the vertical axis wind-driven generator, which uses a method of back-to-back PWM control for the power system. An unit power factor control is applied by the side of motor in order to make sure that it can capture the optimal wind energy, as well as the output reactive power is zero. By the side of grid, the control strategy can make sure that the output electrical connects to the grid safely and the output reactive power is zero.

REFERENCES

[1] Jay Verma, Yogesh , Tiwari, Anup Mishra, Nirbhaya *Singh ,"Performance, Analysis and Simulation of* Wind Energy Conversion System Connected with *grid". IJRTE, ISSN: 2277*-3878 Volume-2, Issue-6, January2014.

[2] *D Mary,Shinosh Mathew,Sreejith K,,"Model*ing and Simulation of Grid Connected Wind Energy *System.",IJSCE,ISSN: 2231*-2307, Volume-3, Issue-1, and March 2013.

[3] A. Bharathi sankar, Dr. R. Seyezhai, *"MATLAB* Simulation of Power Electronic Converter for PMSG Based Wind Energy Conversion *System",IJIREEICE,Vo*l.1,Isuue.8,November 2013

[4] *Gaurav Singh Bhandari,Dr.M.Kowaslya,"Power* Electronics Converter for Grid Intregrated Vriable *Speed Wind Turbine",IJDR,Vol.4,Issue.3,March 2014*

[5] Rajveer Mittal, K.S.Sandhu, *D K. Jain,"Grid Voltage* Control of Inverter Interfaced Wind Energy *Conversion System",* IJESD, Vol.2, Issue.5, October 2011.

[6] H. Polinder, F. F. A. van der Pijl, G. J. de Vilder, P. J. Tavner, "Comparison of direct-drive and geared generator concepts for wind turbines," IEEE Trans. On energy conversion, vol. 21, no. 3, pp. 725-733, Sept. 2006.

[7] T. F. Chan, L. L. Lai, "Permanenet-magnet machines for distributed generation: a review," in proc. 2007 IEEE power engineering annual meeting, pp. 1-6.

[8] *M. De Broe, S. Drouilhet, and V. Gevorgian, "A peak* power tracker for small wind turbines in battery charging *applications,"* IEEE Trans. Energy Convers., vol. 14, no. 4, pp. 1630–1635, Dec. 1999.

[9] *R. Datta and V. T. Ranganathan, "A method of* tracking the peak power points for a variable speed wind energy *conversion system,"* IEEE Trans. Energy Convers., vol. 18, no 1, pp. 163–168, Mar. 1999.

[10] *K. Tan and S. Islam, "Optimal control strategies in* energy conversion of PMSG wind turbine system *without mechanical sensors,"* IEEE Trans. Energy Convers., vol. 19, no. 2, pp. 392–399, Jun. 2004.