EFFECT OF WIND VELOCITY ON POWER OF WIND TURBINE: A REVIEW

Harkamal Preet Singh
Assistant Professor, Department of Mechanical Engineering, PU SSGRC Hoshiarpur, Punjab (India)

ABSTRACT

Wind energy as a clean, widely distributed and environment friendly gas produces no emission and uses less space during operation. For planning a successful wind turbine one must familiar with the required location for installing wind turbine generator for adding a new source of property value in rural areas that have a hard time attracting new industry. With increase in efficiency of a wind turbine, more power can be generated and thus decreasing the need for expensive power generators that cause pollution. With this cost of power for the common people can be reduced. Wind velocity has great importance in increasing the power. In other word wind velocity have direct effect on efficiency

Keywords: Components, installation, power, wind energy, wind speed.

I. INTRODUCTION

For pumping water and milling grain windmills have been used for many centuries. After the invention of engine and development in the field of electrical, windmill disappear in beginning of this century. But, now with the increase in cost of fuel and pollution with fuel, the wind energy got a great attention. A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be used for practical use. Around the world, wind turbines of all sizes have become a familiar sight. Today, in the world wind turbines are producing great amounts of electricity. A wind turbine can be in different size from small 1 kW structures to large machines rated at 1.5 MW depending upon the requirement [1]. As we know, winds are produced by movements of air masses in the atmosphere mainly due to temperature differences. Temperature gradient exists due to non – uniform solar heating. The polar region is more irradiated than the equatorial ones. Consequently, the warmer and lighter air of the equatorial region rises to the outer layers of the atmosphere and moves towards the poles, being replaced at the lower layers by a return flow of cooler air coming from the Polar Regions. This air circulation is also affected by the Coriolis forces associated with the rotation of the Earth. In fact, these forces deflect the upper flow towards the east and the lower flow towards the west. Actually, the effects of differential heating dwindle for latitudes greater than 30oN and 30oS, where westerly winds predominate due to the rotation of the Earth. These large-scale air flows that take place in the entire atmosphere constitute the geostrophic winds. The lower layer of the atmosphere is known as surface layer and extends to a height of 100 m. In this layer, winds are delayed by frictional forces and obstacles altering not only their speed but also their direction. This is the origin of turbulent flows, which cause wind speed variations over a wide range of amplitudes and

frequencies. Additionally, the presence of seas and large lakes causes air masses circulation similar in nature to the geostrophic winds. All these air movements are called local winds.

This paper is organized as follows. The working principle is discussed in Section II. In section III, component of wind turbine and in section IV selection of location for wind turbine discussed. Wind energy and power in section V advantage and disadvantages are discussed in Section VI and conclusion is done in Section VII.

II. WORKING PRINCIPLE

Since a long time, wind is a source of energy that used for different applications. The Babylonians and the Chinese have used wind power for the pumping of water for irrigation of crops some 4,000 years back [5].And in addition to this, sailing boats were harnessing wind power long before that. It has been recorded that wind power was used in Europe in the middle Ages for other activities like grinding of corn. In fact, this is what has been attributed to the start of the term windmill. To understand the concept of wind power, it is better to first understand the science behind wind formation. With the sun heating the atmosphere unevenly, some patches of land become warmer than others; and this is where warm patches of air rise. With this, other air starts blowing to replace them and start a wind blowing. The energy produced from the wind is used by building a tall tower which has a large propeller on its top. The propeller starts turning round with wind energy, which in turn turns a generator to produce electricity. Many of these towers are built together to form a 'wind farm' for the production of electricity. The production of electricity is increased by using more towers to turn more wind with larger propellers. It is basically better to build win farms having strong and steady winds like coastal areas, open plains, tops of rounded hills and gaps in mountains. It is required to have at least an average wind speed of about 25km/h to generate electricity with wind power [5].Small wind generators are used in boats and caravans to charge their batteries. Large propellers are used to extract maximum energy from wind power. To copes with varying speed of wind blades of turbine are angled to fine and coarse pitch. It is possible to turn the generator and propeller to face the wind, to get maximum wind power. There are some windmills with vertical turbines which do not have to be turned to face the wind. Towers are usually tall as the higher the propellers reach the stronger is the wind there. With this feature, the land beneath the tower is not wasted, and can be used for farming. When wind blows on blades to make them turn, wind energy is produced. These blades in turn a shaft in the nacelle, which goes into a gearbox to increase the rotation speed of the generator. The rotational energy is converted into electrical energy with magnetic fields. This energy goes into a transformer to convert the 700V energy into the required voltage for distribution, 33,000V. This energy is transmitted around the country with the help of national grid. Wind power is not only used in large scale wind farms for national electrical grids but is also used in small individual turbines for providing electricity to rural residences and locations that are not reachable by grids. With wind power being renewable, widely distributed and clean, it reduces toxins and greenhouse gas emissions in the atmosphere [5] As the heat distributed by sun is non uniform, so some patches of air become warmer than others. These warm patches of air rise due to decrease in density, other patches of air blows in to replace them - and we feel a wind blowing. We can use the energy in the wind by building a tall tower, with a large propeller on the top. The wind blows the propeller round, which turns a generator to produce electricity. We tend to build many of these towers together, to make a "wind farm" and produce more electricity. The more towers, the more wind, and the larger the propellers, the more electricity we can make. It's only worth building wind farms in places that have strong, steady winds, although boats and caravans increasingly have

small wind generators to help keep their batteries charged. Some designs use vertical turbines, which don't need to be turned to face the wind. The towers are tall, to get the propellers as high as possible, up to where the wind is stronger. This means that the land beneath can still be used for farming [3]

III. COMPONENENTS OF WIND TURBINE

The basic components of a typical wind energy system are shown on "Fig 1".These includes:

- A rotor, consisting of blades with aerodynamic surfaces. When the wind blows over the blades, the rotor turns, causing the generator or alternator in the turbine to rotate and produce electricity.
- A gearbox, which matches the rotor speed to that of the generator/alternator. The smallest turbines (under 10 kW) usually do not require a gearbox.
- An enclosure, or nacelle, which protects the gearbox, generator and other components of the turbine from the elements.
- A tail vane or yaw system, which aligns the turbine with the wind.

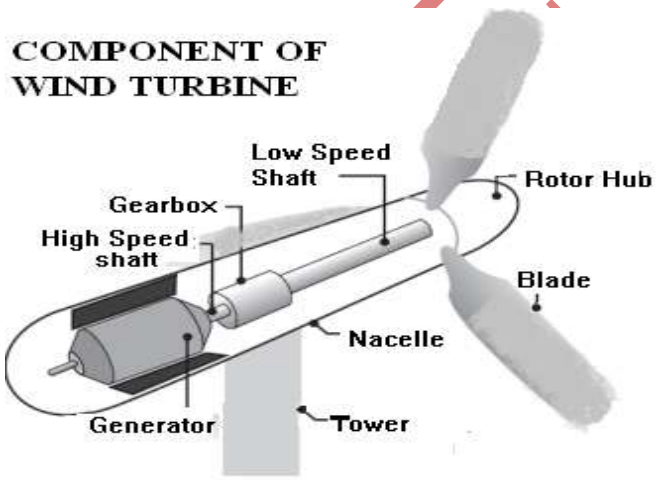

Figure 1- Wind Turbine Components

IV. SELECTION OF LOCATION FOR WIND TURBINE

Selection of suitable location for wind energy system is a very important task to accomplish. It limits the energy conversion if there are trees, houses obstruct the wind. Also keep the following in mind while selecting location of wind turbine:

- On the top of hill winds tend to have higher velocities, on a shoreline, and in places where land is clear from trees and other obstacle because it affects the air density and thus the power in the wind and hence the useful electric power output.
- Remember that trees grow over the years.
- One must inform to neighbors of your plans to avoid conflict later on.
- Keep turbine as far away from neighbors as possible may be beyond 250-300m.
- While deciding the location one must aware of distance of road or railway track from the site.

- The velocity of wind is the critical parameter. The power in the wind, through a given cross sectional area for a uniform wind Velocity is Pw = WV3 (W is const.) From the relation above it is clear that due to cubic dependence on velocity of wind, a small increase in V power of wind markedly affected.
- If the surface is bare rock it may mean lower hub heights hence lower structure cost, if trees or grass are present, all of which tends to destructure the wind.
- Check with local government for any other by laws and regulations about zoing.

Wind speeds tend to be higher on the top of a ridge or hill, and for that reason it is a good idea to locate wind turbines at hilly locations. Just remember to keep your turbine away from high turbulence. Do not expect your wind turbine to generate the same amount of power all the time. The wind speed at a single location may vary considerably, and this can have a significant impact on the power production from a wind turbine. Even if the wind speed varies by only 10%, the power production from a wind turbine can vary by up to 25%.

V. WIND ENERGY AND POWER

The power in the wind can be computed by using the concept of kinetics i.e. it works on the principal of conversion of kinetic energy into mechanical energy. The kinetic energy of an object with total mass M and velocity V is given by the expression

$$KE=1/2*M*V^2 \quad (1)$$

To find out the KE of molecules of wind, let's have a large parcel of wind and has shape of a collection wind molecules passing through the plane of wind turbine blades which sweeps area A with thickness t passing through the plane over a given time and volume of this parcel is

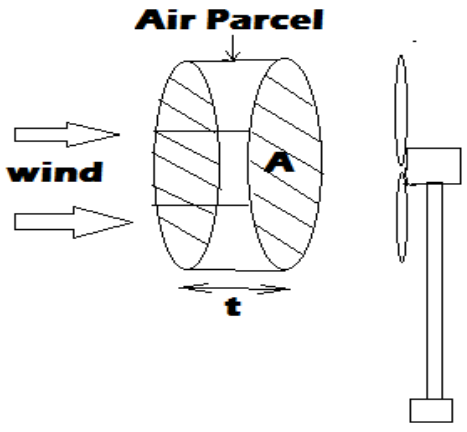

Figure 2- Wind energy conversion

Vol = A*t

And density, ρ = M/Vol

we get, M = ρ *Vol

Now let V represent velocity of wind parcel. And time T is required to move through the plane of blades, then distance travelled is, t=V*T

KE = ½*ρ *A* V^3*T And Power, P = Kinetic energy/Time taken

P= KE/T= (½*ρ *A* V^3*T)/T

So Power = ½*ρ *A* V^3

And for power per unit area divide the above expression by cross sectional area A then we get

$P/A = ½*\rho * V^3$

From the above expression we come to conclusion that power is proportional to the cube of the wind speed and when we divide the power by cross sectional area then the expression on right side of power equation is independent of size of the rotor of turbine. In other words it depends only on density and wind speed.[2]

VI. ADVANTAGES AND DISADVANTEGES

Most people know that on burning of coal harmful particulate emissions are released that cause asthma and other breathing problems. In the form of emission sulfur dioxide are released which cause acid rain. Coal is one of the primary contributors of the carbon dioxide that causes mercury contamination of our lakes and global warming. Natural gas is a better option than coal, but it still produces considerable air pollution and contributes to global warming. Nuclear energy produces no particulate emissions, but it creates dangerous radioactive wastes which will require thousands of years of careful storage. All three sources--coal, gas, and nuclear power--are limited fuels. Today, they compose the bulk of our electric generation sources. Wind, on the other hand, is a completely renewable fuel source. As long as the sun shines, the winds will blow. And wind power produces no health risks and no air pollution. It is a renewable source of energy. Wind power systems are non-polluting so it has no adverse influence on the environment. Wind energy system avoids fuel provision and transport. On a small scale up to a few kilowatt system is less costly. On a large scale costs can be competitive conventional electricity and lower costs could be achieved by mass production. They are always facing some problems like no wind no energy. Energy transfer depends upon surface area. They can be installed in more locations - on roofs, along highways, in parking lots etc. wind energy system can be scaled more easily - from milliwatts to megawatts. They have low maintenance downtime - mechanisms at or near ground level. Wind energy system produces less noise.

VII. CONCLUSIONS

Wind turbines can safely and efficiently turn wind into useable energy. With awareness about wind energy and site selection hundreds of rural landowners throughout the Midwest have learned how to harvest the wind. Many of these people have been operating small turbines on their farms for years. Many others are just beginning to investigate the large wind turbines. As they would with any investment, these landowners must carefully weigh the benefits and risks and research just what a wind turbine on their property would involve. As a nation, we have decided that living more sustain ably with less pollution is a priority. When we account for the social costs of energy production, wind energy is the clear winner. We cannot afford to wait to do the right thing anymore. Wind power is an energy technology for today and the 21st century that we can all feel good about. And also conclude that wind machines intended for generating substantial amounts of power should have large rotors and be located in areas of high wind speed.

REFERENCES

[1] http://www.ecomall.com/greenshopping/windindustry.htm

[2] http://www.ocgi.okstate.edu/owpi/educoutreach/library/lesson1_windenergycalc.pdf

[3] Bianchi,F.D.; de Battista,H.; Mantz,R.J., "Wind turbine control systems Principles,Modelling and Gain Scheduling Design" 2007, XIX, 207p.105 illus, Hardcover ISBN 978-1-84628-492-2.

[4] The University of Texas School of Law and the Oil, Gas and Energy Resources Law Section of the State Bar of Texas, *Current Issues in Texas Wind Energy Law 2007*

[5] http://www.thinksolarenergy.net/84/introduction-to-producing-wind-energy/renewable-energy/

[6] National Renewable Energy Laboratory, Wind Energy Update, p. 2; and U.S. Department of Energy,

[7] U.S. Department of Energy, "Wind Powering America: Installed U.S. Wind Capacity," and Global Wind Energy Council, *Global Wind 2007 Report*

[8] T. Anderson, A. Doig, D. Rees and S. Khennas: Rural energy services – A handbook for sustainable energy development. ITDG Publishing, 1999.

[9] Harkamal Preet Singh, " Wind Energy: An alternate energy source in future"3rd National conference on emerging trends in Mechanical and Electrical Engineering (NCETMEE-12) at Integral University, Lucknow 12-13 June 2012.

[10] Harjit Singh, Dr. Anish Sachdeva, Dr. R.K. Garg, Harkamal Preet Singh, " Wind Energy: A future energy source"3rd International conference on production and industrial engineering CPIC – 2013 at NIT Jalandhar 29-31 March 2013.

[11] http://www.globalspec.com/reference/81079/203279/chapter-2-the-wind-and-wind -turbines.

[12] Andrew Swift and Jamie Chapman, "A Primer on Wind Energy: Meteorology, Technology, Economics and Transmission," presented at the University of Texas School of Law 2007 Wind Energy Institute Conference, Austin, Texas, February 2007,

[13] National Renewable Energy Laboratory, Wind energy updates by Larry Flowers (Golden, Colorado, January 23, 2008),

[14] Presentation by Patrick A. Nye, American Shoreline, Inc., at the University of Texas School of Law 2007 Wind Energy Institute Conference, Austin, Texas, February 26-27, 2007,

[15] http://www.ukessays.com/essays/chemistry/the-word-novel.php

[16] http://www.thinksolarenergy.net/84/introduction-to-producing-wind-energy/renewable-energy/

[17] Electric Reliability Council of Texas, Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study, (Austin, Texas, April 2, 2008)