Design and Fabrication of Horizontal Axis Wind Turbine

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ABSTRACT

Wind energy is one of the promising renewable energy, used to generate electric power. The search for environmental friendly, sustainable energy has promoted in this industrial world. The present global technological society is depended on the availability of energy. The development of industry, agriculture and transportation, etc. is totally depended on the availability of power. The cost of energy is increasing day by day due to the increase in the demand of power and depletion of the conventional energy resources, which are used in the generation of electricity. So, it is very essential to make use of the non- conventional sources of energy like wind energy, solar energy, tidal energy, etc. Wind is considered to be one of the most promising resources in the renewable energy portfolio. Wind energy is used to generate electrical power by rotating the rotor shaft by the conversion of kinetic energy of wind into rotational energy of the shaft. The objective of this work is to develop a domestic wind turbine which works at low wind speeds and which can be made available to the common man at a very low price. Polyvinyl chloride, which is easily available, has been utilized to fabricate the blades. In the design process, basic aerofoil section is considered with various forces acting on the blades are calculated theoretically and the design is optimized to get the optimum power output. The rotational speed of the wind turbine is maximized by using a gear ratio. A DC dynamo which acts as generator is used to extract power.

Keywords: Renewable sources, Horizontal Axis Wind Turbine, wind Energy, hub, blade, fabrication, Gear Ratio, Dynamo.

INTRODUCTION

Wind energy, like most earthly energy resources, comes from solar power. Solar radiation causes the regions of unequal heating over land masses and oceans. This creates regions of high and low pressures and this causes the flow of air called wind. There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Supply of energy is, therefore, far less than the actual demand.

Adequate availability of inexpensive energy is the most important demand of today. Economic growth and industrialization both are dependent on the availability of energy. But today the problem is that world energy sources are fast depleting and these fast depleting energy resources have put the world in a grip of energy crisis. This is the time to take steps to conserve the conventional sources and also find the alternative sources of energy such as solar energy, wind energy, tidal energy, geothermal energy etc. to generate the power. Wind energy is one of the prominent renewable energy sources on earth. Wind power utilization for electricity production has a huge resource and proven itself to be capable of producing a substantial share of the electricity consumption. The fuel of this electricity production is wind and it is the most important constraint for turbine design, as it creates loads the turbine has to withstand. Therefore, accurate knowledge about the wind is needed for planning, design and operation of wind turbines. This paper provides the process of fabricating the blades of a wind turbine with a desired output suitable for domestic purposes. Wind power produces no emissions and is not depleted overtime. A single one megawatt (1MW) wind turbine running for one year can displace over 1,500 tons of carbon dioxide, 6.5 tons of sulfur dioxide, 3.2 tons of nitrogen oxides and 60 pounds of mercury (based on the US average utility generation fuel mix).Wind plants can provide a steady flow of income to landowners, while increasing property tax revenues for local communities.

It can take many forms, including large wind farms, distributed generation and single end user systems. It also reduces the import of fossil fuels and lessens the dependence on foreign governments that supply these fuels. Also wind energy is better than other forms of unconventional energy sources because it is available throughout the day and at all seasons.

Horizontal Axis Wind Turbine

The analysis is carried out on Horizontal Axis Wind Turbine (HAWT) meant for domestic purposes. Components of this turbine are mentioned below.

Blades: The blades are made up of Poly Vinyl Chloride (PVC). Eight inch diameter PVC pipe is used to fabricate the appropriate wing-shaped curvature. A jig saw is used to cut the PVC pipe. The final blade dimensions are shown in Figure 1.

The leading edge is rounded and the trailing edge is tapered for each blade so that the shape would approach that of an airplane wing.

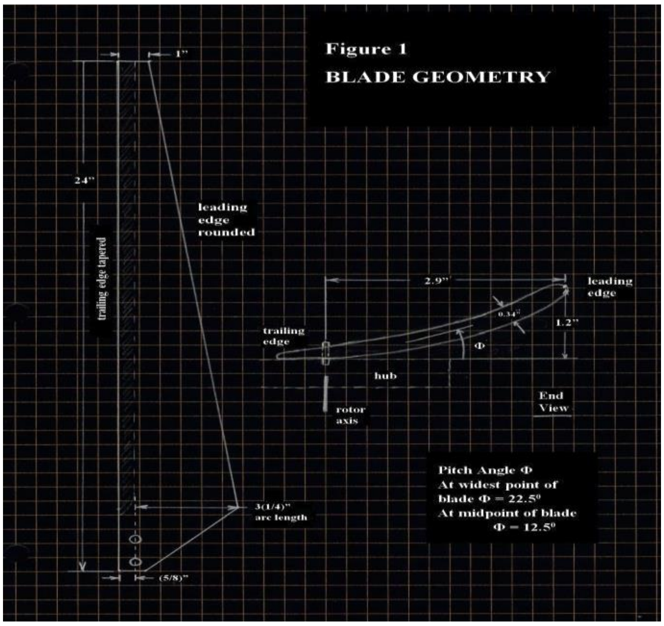

Figure 1. Geometry of the turbine blade

Figure.2. Dynamo acting as generator

DESIGN CALCULATIONS

The power in the wind, Pw = 1/2ñAV3

Where V is the velocity of wind at the blades, ñ is the density of the air; A is the area of the blade.

Maximum extractable power from wind, Pmax = 16/27(1/2ñAV3)

Actual power developed by a propeller type wind turbine shows that power coefficient is strongly reliant on tip speed ratio. Tip- speed ratio (TSR) is the ratio of the speed of the rotating blade tip to the speed of the free stream wind.

As tip speed ratio of our wind turbine is expected to be 2.5 times that of incoming velocity, whereas for a high speed wind turbine it attains a value of 8.

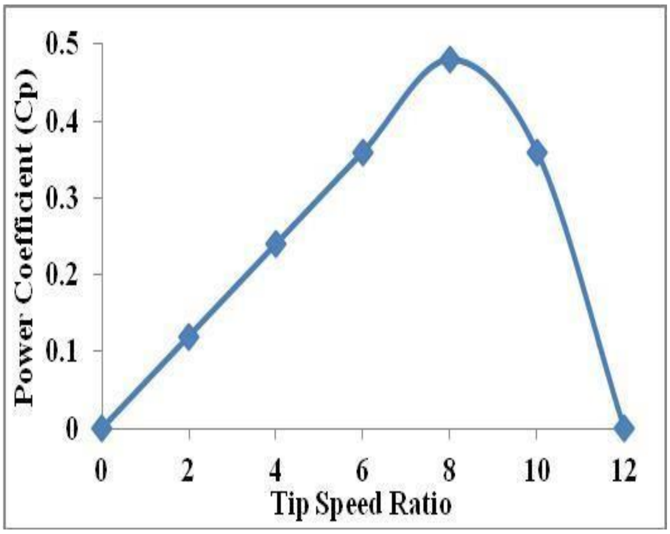

Figure 3. TSR versus Cp for wind turbines.

All wind power cannot be captured by rotor or air would be completely still behind rotor and not allow more wind to pass through. Theoretical limit of rotor efficiency is 59%
Most modern wind turbines are in the 35 – 45% range.

RESULTS AND DISCUSSIONS

Winds speeds vary day by day. Readings are taken by connecting the output of the dynamo with a multimeter with a purpose of measuring voltage. We took the readings on two consecutive days. The first day the average wind speed was found to be 15 kmph (4.17 m/s) measured using a Global Positioning System (GPS) tracker. With wind speed as equal to 4.17 m/s, the wind turbine spun at an average speed of 350 RPM. This rotational

S.No.	Wind Speed (m/s)	Wind blade rotational speed (R.P.M)	Voltage (V)
1	4.17	350	12.6

Table 1: Rotation of wind turbine blade corresponding to wind speed

On the second day the average wind speed was found to be 9 to 10 kmph (2.5 to 2.8 m/s), With wind speed as equal to 4.17 m/s, the wind turbine spun at an average speed of 350 RPM. This rotational speed is increased by three times i.e. 1050 RPM by using a bevel gear with a gear ratio 1:3 read from a tachometer and the multimeter read 12.6 V. It is expected to find a very low cut-in speed so that we could capture as much of our small quantities of available wind as possible. The ability to consistently produce 12 volts at around 15 kmph. 12 volts is necessary to push the power into the 12 V battery. The following reading has been observed in practical conditions.

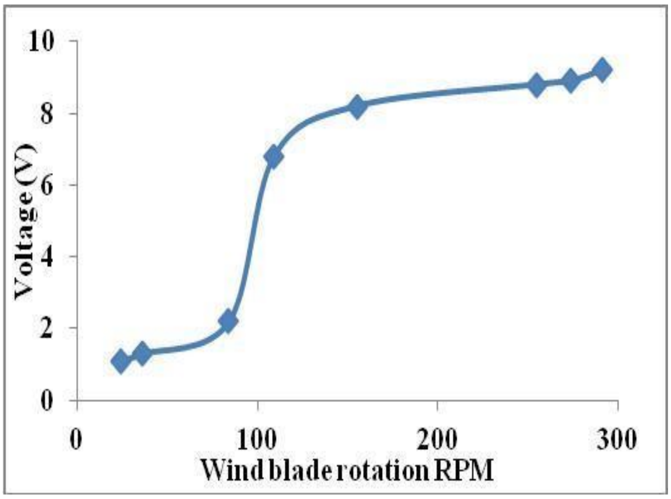

Figure 4. Wind blade rotation Vs voltage.

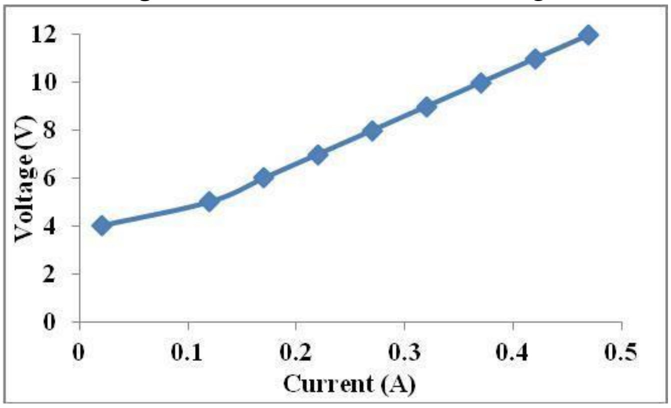

Figure 5. V-I Characteristics.

A voltmeter is connected in parallel and an ammeter is connected in series to measure voltage and current obtained from the wind turbine. Readings with smaller magnitude starting from zero in the voltmeter did not provide us a constant output. Hence we started noting the readings which withstands for a prolonged period of time. From the fig 10, it is observed that as the voltage increases current increases. Hence there exists proportionality between the current and voltage.

CONCLUSIONS

The analysis is yielding with the following conclusions. Rotates the turbine at low wind speeds. Manufacture of blades is simple and easy. It produces high torque and does not require starting thrust. More force is developed from wind energy. More mechanical work is developed by the turbine. Low cost as manufacture of blade is simple.

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