DESIGN AND EXPERIMENTAL TESTING OF PVC BLADED SMALL SCALE WIND MILL

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Abstract : Exhausting fossil resources and increasing demand of electricity ,has led to the number of researches on different forms of energy resources[1,2,3] .The cost of energy is increasing day by day due to increase in demand of power .So it is very essential to make use of the non-conventional sources of energy like wind, solar, tidal etc. Among that wind energy is considered to be one of the most promising resources in the renewable energy portfolio to fulfill the energy demands. The objective of this paper is to design and demonstrate that PVC blade profile has better power capacity for small wind turbine. In most of the previous experiments due to direct and continuous exposure to sun light the blades becomes weak. In our paper the PVC material is laminated to prevent from robust and break. It is specially designed as micro wind turbine for areas like domestic region. It can be installed in houses which plays a vital role in reducing utilization of conventional energy.

Keywords: Design, PVC blade, Wind mill, Renewable energy.

1. INTRODUCTION

Nowadays wind turbine industry is becoming one of the best choices for energy production among all renewable energy choices. In recent years this industry has been much more interesting than other power industries which have huge environmental effects. In financial aspects, wind industry shows a very dramatic progress which is expected to compete with fossil fuel energy generation in following years[4]. The utilization of the energy in the wind requires the development of devices called wind mill which convert that energy into more useful forms. This is typically accomplished by first mechanically converting the linear velocity of the wind into a rotational motion by means of a windmill and then converting the rotational energy of the windmill blades into electrical energy by using a generator or alternator[5]. Wind energy has great promise but due to the unreliable nature of wind, grid-integration of wind power becomes very difficult. If the generated power could be economically stored at large levels, this challenge could be overcome. However, the technology for grid scale storage is not yet available. The problem with the power grid and lack of storage capacity could be alleviated by a more distributed system of smaller wind energy generators. Small wind turbines offer a promising alternative for many remote electrical uses where there is a good wind resource. There are various small wind mill designs already exist which are simple and cost effective, but the design based on wind turbine blades attracts the researchers to develop most economical and efficient wind mill.

Regarding the importance of turbine blade in its energy generation lots of researches have been developed to make the blade more efficient. Nicolette Arnalda Cencelli optimized a designed blade. In this research some airfoils were designed by XFOIL software for different sections. Results showed new airfoils can increase the output power[6]. Liu *et al.* and Xudong *et al.* worked on rotor blade chord and twist distributions. BEM analysis and CFD methods were used to determine the effect of design changes[7],[8]. Ozge Polat and Ismail H. Tuncer worked on aerodynamic shape optimization based on Genetic Algorithm and Blade Element Momentum theory. Optimization studies were performed to maximize power production of specific wind speed, rotor speed, and rotor diameter. In this research, XFOIL was used to provide sectional aerodynamic loads[9]. Pourrajabian *et al.* worked on the influence of the air density variation with altitude on the performance of a small horizontal axis wind turbine blade[10]. Sharifi and Nobari optimized pitch angle, along wind turbine blade, based on an aerodynamic code. This aerodynamic code could accurately predict the aerodynamics of horizontal axis wind turbines[11]. However the design of wind mill blade based on the materials suitable for small scale domestic purpose making them as cost effective is less available in literature.

This paper is about construction and performance testing small wind power system that uses PVC blade and low cost components aimed for domestic electrification.

2. DESIGN OF WIND TURBINE

Components of the wind turbine are mentioned below:

2.1 BLADE:

The blades of wind turbine are made from Poly Vinyl Chloride (PVC) pipe because it is easy to find, relatively cheap, easy to work with, and performance is more than acceptable for a small basic wind turbine generator. There are three blades and length of each blade is put up 4 ft. 5 inch diameter PVC pipe is used to fabricate the appropriate wing-shaped curvature. A cutting machine is used to cut the PVC pipe. The leading edge is grounded and the trailing edge is flat for each blade so that the shape would approach similar to that of an airplane wing. The final blade dimensions are shown in Fig 1. A steel sheet is fixed in the flat corner of the blade which creates weight difference between the two edges making the blades to lift easier and fast rotation can be achieved. In addition, the PVC blades are laminated in order to increase their life time against the environmental effects such as sun light, dust, humidity, rain, etc. Snapshot of blades is shown in figure1.

Table 1: Dimension of blade

Parameters	Dimensions
Blade Diameter	5 inch
Blade Length	4 feet

Figure 1: Blades

2.2 ROTOR HUB:

A flywheel is used as the hub for the rotor. A circular metal disc made up of iron is used as rotor hub. It is crucial that the blades may cause oscillations which can lead to a blade tearing away from the hub. To ensure the blade symmetry, the tip-to-tip spacing is measured precisely before drilling the final attachment holes through the blades. The snapshot of rotor hub with blade arrangement is shown in Figure 2.

Figure 2: Rotor hub with blade arrangement

Table 2: Dimension of Hub

Parameters	Dimensions
Hub Thickness	6mm
Shaft Hole Diameter	19mm

2.3 TRANSMISSION SYSTEM:

The transmission system is used to transmit the power developed at the blades to the dynamo. Transmission linkage consists of blades as power developing elements which is connected to the hub. The hub is connected to gear set. Then the gear set is connected to the generator. The elements of the transmission are the hub and the gear set. The gear set converts the high torque low rpm into high rpm low torque which is in the ratio 1:3. The snapshot of transmission system is shown in figure 3.

Figure 3: Transmission system

2.4 MAIN SHAFT:

Main shaft is connected to the hub at one end through the gear set and to the generator at another end through a 19 mm bearing for ensuring smooth rotation. They support the main shaft to rotate freely when blades rotate. The snapshot of mainshaft is shown in figure 4.

Figure 4: Main shaft

2.5 GENERATOR:

A generator rated at 1500 RPM and 100 W is used for generating power. The dc power output from DC generator is directly fed to the load. Blocking diode of 8 A is used to flow current in one direction and to break the current from being overcharge. Lead-acid sealed battery with rating 12V, 26Ah is used to store the power generated from wind generator. The snapshot of generator is shown in figure 5.

Figure 5: Generator

2.6 YAW CONTROL:

The yaw system of wind turbine is the component responsible for the orientation of the wind turbine rotor towards the wind. Aluminum sheet is used for the fabrication of Yaw control. The snapshot of yaw control is shown in figure 6.

Figure 6: Yaw control

2.7 BASE:

It acts as a main support for the entire wind turbine unit. It is made of iron. It has rectangular shape, supported by single leg. The leg holds the rectangular plate on which the tower is placed. It is made up of rigid materials to provide very good support which can with stand high wind speeds. Base is welded with bolts and nuts which are fixed to provide the extra support. The snapshot of base is shown in figure 7.

Figure 7: Base

2.8 TOWER

A 10 feet, 3 inch diameter iron pipe protected against corrosion that was divided into two parts as 8 feet plus 2 feet for ease of easy dismantling under trouble shooting time is installed in the terrace. The tower is well concreted, after proper leveling checked using level meter, such that it can withstand any level of wind speed. This tower now is used to support the entire wind turbine unit and also to capture the upper wind. The snapshot of tower is shown in figure 8.

Figure 8: Tower

2.9 COVERING CASE

A covering case is provided using steel sheet in order to protect the entire wind turbine unit from environmental effects. The snapshot of covering case is shown in figure 9.

Figure 9: Covering Case

3. RESULTS AND DISCUSSIONS

The fully assembled PVC bladed small scale wind mill is shown in Figure 10.

Figure10: PVC bladed small scale wind mill

Testing is done in the terrace of our college campus. Winds speeds vary day by day. Readings are taken by connecting the output of the generator with a high precision multimeter with a purpose of measuring voltage. We took the readings on two days of different wind speed. On the first day the average wind speed was found to be 3.17 m/s measured using an anemometer. With wind speed as equal to 3.17 m/s, the wind turbine spun at an average speed of 350 RPM. This rotational speed is increased by three times i.e. 1056 RPM by using the gear set with a gear ratio 1:3 read from a tachometer and the multimeter read 35 V under open circuit condition. On another day the average wind speed was found to be 2 to 2.5 m/s. With wind speed as equal to 2.5 m/s, the wind turbine spun at an average speed of 214 RPM. This rotational speed is increased by three times i.e. 643 RPM by using the gear set with a gear ratio 1:3 read from a tachometer and the multimeter read 20 V under open circuit condition. The plot between Blade rotation speed and Rotor speed is shown in Figure. Also the plot between Rotor speed and Generated voltage is shown in Figure. 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. We could find that with wind speed as equal to 2 m/s, which is very low, we get an output voltage of 12.8 V and 12 volts is necessary to push the power into the 12 V battery.

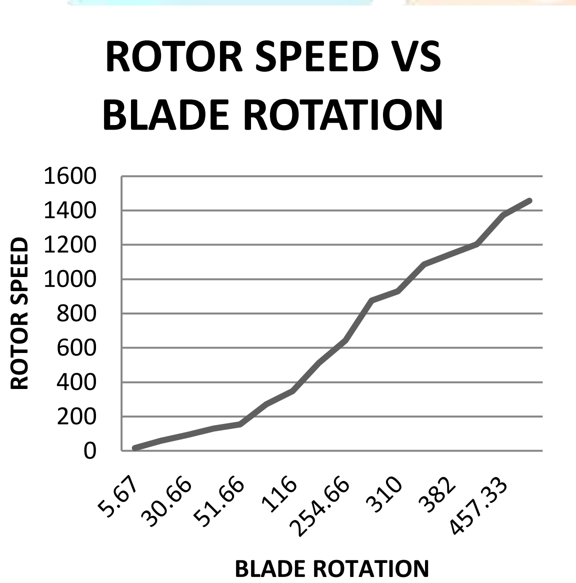

Figure 10: Rotor Speed vs Blade Rotation Speed

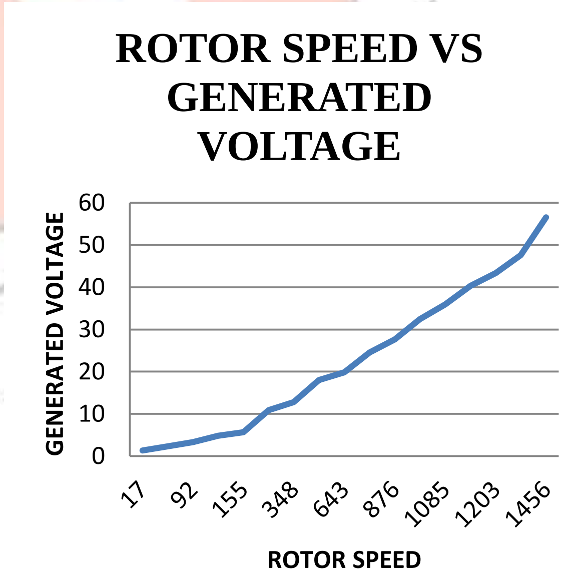

Figure 11: Rotor speed vs Generated voltage

4. CONCLUSIONS

This paper is about construction and performance testing small wind power system that uses PVC blade and low cost components aimed for domestic electrification. The PVC blade used for fabrication is laminated so that the blades do not get damaged due to environmental effect, thus making them to last longer. The metal plates attached to one end of the blade makes the weight difference and hence increase the lift capacity. Due to which we get a very low cut-in speed so that we could capture as much of our small quantities of available wind as possible. We could find that with wind speed as equal to 3.17 m/s, which is very low, we get an output voltage of 12.6 V which is more than enough to charge a 12 V battery.

The analysis is yielding with the following conclusions.

1. Rotates the turbine at low wind speeds.
2. Manufacture of blades is simple and easy.
3. It produces high torque and does not require starting thrust.
4. More force is developed from wind energy.
5. More mechanical work is developed by the turbine.
6. Low cost as manufacture of blade is simple.

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