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Experimental Study on the Performance of Lenz Vertical Axis Wind Turbine

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Abstract—*Lenz type wind turbine is a type of vertical axis wind turbine used for converting wind power into rotational speed of shaft and hence power generation. It is a drag and lift type device, consisting of three blades. The blades have less convex surface , thus they experience more drag compared to lift for power generation .It can accept wind from any direction and provide high starting torque .The Lenz rotor used in this project is a single-stage three-bladed vertical axis rotor , which was tested on a centrifugal blower. This model has been tested without deflector and with deflector. The rotational speed of the rotor has been measured by the B.Tech students in the presence of static deflector kept at angles of 30°, 45°and 60°. The maximum coefficient of performance has been found to be 45.4% when the deflector is kept at 45 degree angle at wind speed of 7.56 km/h and the maximum power is 276.38 watt when the deflector is kept at vane angle of 30 degree at 443 rpm with free stream wind velocity of 16.5 m/s ..*

1. INTRODUCTION

The energy that can be extracted from the wind is directly proportional to the cube of wind speed. thus an understanding of the wind (velocity, direction, and variation) is critical to all aspects of wind energy generation , from the identification of suitable sites to predictions of the economic viability of wind farm projects, to the design of wind of wind turbine themselves, all is dependent on a characteristics of wind . The most striking characteristic of the wind is its random nature. The wind is highly variable, both in space and time. This is important because extractable energy from wind varies with the cube of wind velocity. Generally more wind is witnessed on the tops of the hills and mountains than low level areas. Even more locally, wind velocities are altered by obstacles such as trees or buildings. On the whole, it is important that we understand, the wind carries some energy with it , out of which some part is harnessed by the wind turbine which can be effectively use in small household as an alternate source of renewable energy.

2. INTRODUCTION TO LENZ TYPE VAWT

There are so many researches being carried out on vertical axis wind turbine design like the savonius type. Edward Lenz found a design which uses the principal of venture-meter. After constructing the model he named it as Lenz VAWT the Fig. of which is given in fig.1.

A lot of research is yet to be done in Lenz VAWT. In this paper we put forward our effort in constructing a Lenz VAWT with modified higher aspect ratio than unity and then testing it under various parameters. The model is a drag and lift type device, and due to presence of convex surface the blades experience more drag than lift. Since the model consists of minimal convex surface oriented in the direction of motion the blades experience least amount backward torque as possible due to presence of convex surface. Fig. 2 shows our 3D rendered model without deflector.

Our work is mainly focused on improvement of the performance and efficiency of the turbine under low wind speed condition. Accordingly we carried out our experimental procedure for different wind speeds and different static deflector vane angles.

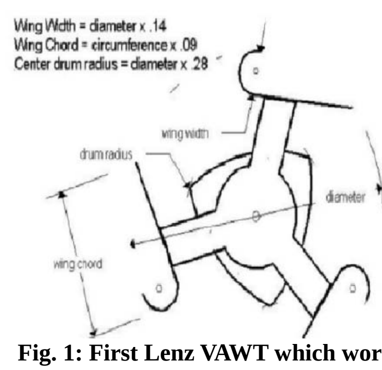

Fig. 1: First Lenz VAWT which works on venture-meter principal.

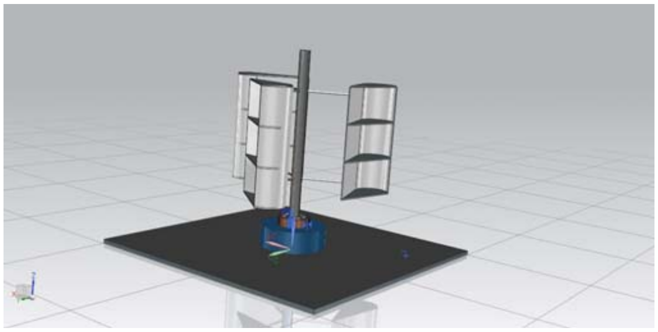

Fig. 2: 3D rendered Lenz VAWT with modified aspect ratio

Fig. 2: 3D rendered Lenz VAWT with modified aspect ratio and with deflector

3. DESIGN PROCEDURE

For the base, a mild Steel plate was taken, after that a circular cast iron base was tightly fitted with a ball bearing in the inner hole. 6 additional steel shafts were welded with the main steel shaft, which was inserted into the inner hole of the bearing.

The 3 blade were cut from the Aluminum sheet and the holes were drilled on it for fixing them on the additional shaft by the mean of bolts. In order to make the hole diameter of the blade, the blade on the shaft were arranged temporarily. The arrangement consist of 3 blades at an angle 120^o to each other, bending of blade was done with the help of roller dice. After arranging the blades on the shaft at the required position all the bolts were tightened to the additional shaft and finally the shaft in the ball bearing was fixed on the base.

4. FABRICATION PROCEDURE FOR DEFLECTOR VANE

For augmenting six deflector vanes in the model. new bigger base plate was introduced which was made of galvanized iron, after that six mild steel plates are cut off for making deflectors vanes of height equal to that of the blades, by the process of rolling the plates are rolled to bent the plates for making deflector vanes .Six extensions are welded with the base plate and in each extensions three holes is drilled by using radial drilling machine. This holes are made for fixing the deflector vane and the base plate by the mean of bolts. The model is shown in Fig. 3.

5. EXPERIMENTAL METHODOLOGY

The Firstly we made the setup for testing rotor without the deflectors. The velocity of air coming from centrifugal blower is measured with the help of anemometer. The readings was taken from range 2.0 to 16.5meter per second. The blower was started by switching on power supply and the experiment was started by opening the valve slowly .After few seconds when the rotor reached in stable rotating position the rpm of the rotor was recorded with the help of tachometer and after each reading the valve was slowly open further and the same procedure was repeated again.

For taking readings of wind velocity of centrifugal blower and rpm of the rotor with deflector vanes .we have placed six deflector vanes at different angles around the rotor to manipulate the flow of wind. At first we have placed the deflector at angle 30°and then the blower was started by switching on power supply .the velocity of wind was measured with the help of anemometer and after that rpm of the rotor was measured through tachometer. Same procedure is repeated for 45° and 60° of deflector vanes again

The readings were taken until the wind had the power to rotate the rotor. In this way one set of readings. The calculations to calculate different parameters were performed which are also known in the tables.

After calculating all the parameters the graph were drawn to see performance characteristics of the lenzrotor without any deflection plates.

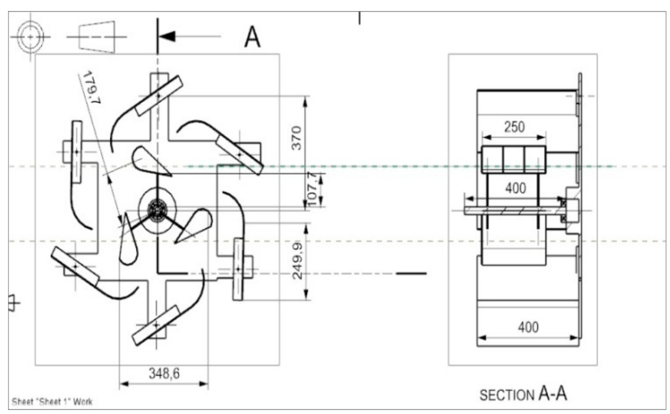

Fig. 3: Drafted drawing with dimensions of vanes

6. CALCULATION PROCEDURE

With the help of the anemometer the free stream velocity of air $V\infty=V1$ is calculated and the velocity of air is calculated by flow measurement instrument or by water water head with rotor in front of the blower.

1. The velocity is multiplied with correction factor of 0.85 to get the actual air velocity.

2. The maximum power available to the rotor is calculated with the help of the relation

$$P_{max} = 0.5\rho A V_\infty^3.$$

3. Power obtained at the rotor shaft is calculated using relation.

$$P_{actual} = 0.5\rho A V_1^2 R\omega$$

4. Power coefficient is the ratio of actual to maximum available power.

$$C_p = (P_{actual})/(P_{max})$$

5. Tip speed ratio is calculated using the tip speed of the blade and the free stream velocity of the air with the following relation.

$$\lambda = U/V_\infty$$

6. Torque coefficient is the ratio of the actual torque to maximum available torque.

$$C_t = T/(0.5\rho A V_\infty^2 R) = C_p/\lambda$$

7. RESULTS

The Model has been fabricated. Observing and comparing the blade speed for various wind speed and for deflector vane angle of 30°, 45° and 60°.

The maximum coefficient of performance was found to be 47.1% at 45°vane angle and a wind speed of 7.56km/h.

The maximum power generated by the Rotor was found to be 276.38 watt with deflector vane angle of 30° at 443 RPM, free stream wind velocity of 16.5 m/s. The Coefficient of performance was 8.16% during this condition.

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