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Trolley Mounted Micro Power Wind Mill

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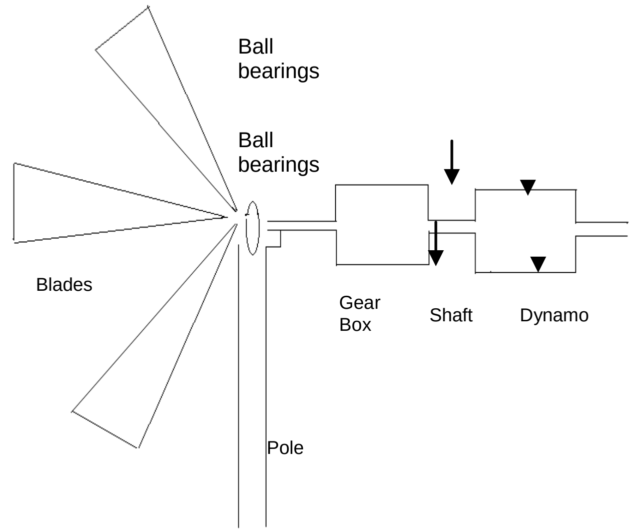
Abstract

A small trolley mounted wind mill was fabricated by us as a student (NS) project at Jain University Campus Bangalore rural..It is a horizontal axis wind turbine (HAWT) one set made of three wooden aerodynamically shaped wind blades and a home made generator, the other one is made of fibre glass wind blades and a commercial electric generator exclusively made for wind turbines.All the theories/fabrication/assemble details ,power out put obtained from both with the natural wind in Bangalore on roof top of Engineering College JU and also using a wind blower are given in this paper.

Introduction

In earlier days around 18th century wind mills particularly in Europe/USA/China were used for drawing water from the wells , ponds, lakes etc for irrigation purposes [Ref 1]. A simplest form of a wind mill consists of few wind blades made of wood or metals of about one meter long ,10 cm width tapered attached to a shaft. As the wind blades rotate the shaft with a long pole is connected vertically to an eccentric arrangement like a 'governor' in a steam rail engine that was mechanized to lift water to the ground. After the advent of electricity in 19th century the electric pumps replaced the wind mills for drawing water from the well. But around 1970s when the oil crisis hit the world the wind mill mechanism was made use of/converted/modified to generate electricity[Ref 2]. Electricity is generated according to Faraday's law of electromagnetism which states that ' when ever there is a rate of change of magnetic field and a conductor in a closed circuit emf is generated'. According to statistics approximately 48,000 MW of electricity is generated using wind mills alone in India (source MNRE). M/s. Suzlon , Enercon are the leading wind mills manufacturing companies producing electricity in Mega Watts and connected to the grid. But there is a need for micro-power electrical energy generated systems say even 40 - 500 watts which can be installed over roof top of a house in remote areas, hill tops , forest areas ,farm lands where drawing electricity from the sub station is rather difficult. Hence such an applied oriented work has been taken up ,fabrication of wind mill (shown schematically in Fig 1.) as a student project at an M.Phil level. There is no dispute about the electricity generated by conventional non -renewable energy sources like Thermal , Hydro and Nuclear but the source materials like coal and nuclear fuels are fast depleting and hydro is seasonal. It is an amazing fact that to run /generate 1 MW of electricity per day per thermal unit about 10,000 tonnes of coal is required and in the case of uranium about 1 Kg is required per day. Hence there is a need for alternate electrical energy generating plants. Solar and wind energy have come handy and the details of wind mill and solar energy are explained very well else where[Ref 3,4] . When ever light rays fall on a photovoltaic cells like Si , GeAs where one layer is 'p' type the other one is 'n' type of the same semiconducting material with an insulating layer in between them , DC voltage is developed across the two semiconducting layers. As the Sun's rays are abundant it is easy to obtain electricity from the solar cells ,even easy to assemble and keep it on the roof top of a building. Normally 100 watts of energy can be obtained per square meter area of a conventional solar cells and the cost is about Rs10,000/= per 100 watts. But solar energy cannot be generated during rainy seasons and also from sun set to sun rise time. The advantage with wind energy is it is round the clock round the year but designing fabricating, assembling, installing a wind mill is somewhat complicated and the cost is more .



1. Three wind blades and a tail,2 A Pole, 3 Gear Box, 4 Dynamo,5.Storage Batteries and 6.End effect Flood light/0.5 HP domestic pump

Brief description of the working principle of the wind mill.

Whenever there is a good breeze the wind blades rotate in the direction of the wind as a tail is attached to it and also a yaw bearing. But in our set up no tail is attached .Yaw bearing requires external electrical power input and no yaw bearing in our set up. Our wind turbine is a trolley mounted one. To increase the speed of rotation of the blades its shaft is attached to a step up gear box. The output of the gear box shaft is attached to a dynamo (also called generator) [Ref 3,6]. The final electrical output through proper wiring/storage batteries etc can be connected to the flood lights/0.5 H P domestic water pump. The basic physics principles/theories of a wind turbine involved are explained in the next section . The average wind speed in Bangalore is 2-3 m/s , but sometimes it goes up to even 10 m/s at outskirts The wind speed is fairly high at Chickbagalur Karnataka State.

Theories of turbine power

According to Betz theory [Ref 3,5], the kinetic energy of an air mass 'm' moving with a velocity 'V_w' can be expressed as

$K.E = (1/2)m\,(V_w)^2$ ------------------- **(1)**

This amount of energy strikes the propeller / wind blade. The amount of air passing in unit time through an area 'A' with a velocity 'V_w' is equal to 'AV_w' and its mass 'm'

$m = \rho A V_w$----------------------- **(2)**

where

A = the area swept by the propellers

V_w = velocity of the wind (wind speed)

ρ = Density of air (= 1.225Kg/M^3)

$K.E = (½)\,\rho A V_w\,(V_w)^2$

$= (½)\,\rho A\,(Vw)^3$ ----------------------- **(3)**

Hereafter V_w will be = V

$K.E = (½)\,\rho A\,V^3$ Watts ……………..(4)

Eq (3) gives the maximum wind power (this is NOT the electrical power out put) that can be extracted by a wind turbine under ideal conditions . If the area swept by the propeller of diameter 'D',it can be shown that the available wind power

$P = (\rho)\pi/4)D^2V^3$

$P = (1/8)\,\rho\pi\,D^2\,V^3$ ……………….. (5)

From this equation it is clear that wind machines intended for generating substantial amounts of power must have lengthy rotors (propeller) and be located in areas of high wind speeds.

$$\text{Power coefficient} = \frac{\text{Power of wind rotor}}{\text{Power available with the wind}}$$

The maximum theoretical power co-efficient = 0.593 obtained by taking into consideration of all the factors .

Conversion of wind energy into electrical energy

As given in the earlier section the basic principle of electricity generation is mainly based on Faraday's law of Electro Magnetic Induction

$e = \mu\, n\, A\, B\, d(\Phi)/dt$ .... (6)

where,

e = emf linked with the circuit

μ= Permeability of the medium

A= Area of the coil

B= Magnetic field

$d(\Phi)/dt$ = Rate of change of magnetic flux.

From the equations of **5** and **6** it is clear that the wind machines intended for generating substantial amounts of electrical power must have large rotors (propeller) so that the torque will be high, powerful magnets, more number of copper coils (number of turns) and be located in areas of high wind speeds with long poles as the wind speed is more at higher altitudes. As a student project it may not be possible to have very lengthy rotor and erect at a very high altitude . Hence we scaled down all the dimensions so as to generate at least 40 watts of electricity.

Fabrication details

Wind turbine made of wooden blades

This section describes a detailed description of the wind mill (wind turbine) that was mostly fabricated/ some out sourced and assembled by us as a project work by ourselves with the help of workshop facilities of Jain University.

Wind Blades :- An aerodynamically shaped three wooden blades each of length 60 cm, width 7 cm with the tip end 2 cm and thickness of the top around 2cm and the bottom edge 2mm.

Gear box:-It is made of Teflon material of thickness 10mm , it is a four stage gear box with each stage 1:5 i.e ,if wind blades rotate say at 100 rpm the final output will be 100x 625 rpm.

Dynamo :-It is a hand made dynamo with Nd-Fe magnet of torroid shape the outer diameter 72 mm and inner diameter 10 mm and magnetic field at the rim is 3000 Gauss and at a distance of 2mm from the rim it was measured to be 1000 Gauss. We used multi-poles (8 pole) [Ref6] ,wound copper coil of 200 turns on a cubic plastic bobbin (13x 13x20 mm) and inserted CRGO E-cores into the bobbin to enhance the emf by approximately 13 times.

Wind turbine made of fibre glass blades

Though we wanted to try with different materials of wind blades , due to lack of time we had to outsource three fibre glass blades the dimension details are given in Table I and the schematic diagram of the blade is shown in Fig 2. The blades were fitted it to an acrylic circular disc of 20cm diameter and 12mm thickness and connected the blades set up directly to a commercially available dynamo exclusively made for wind turbines.

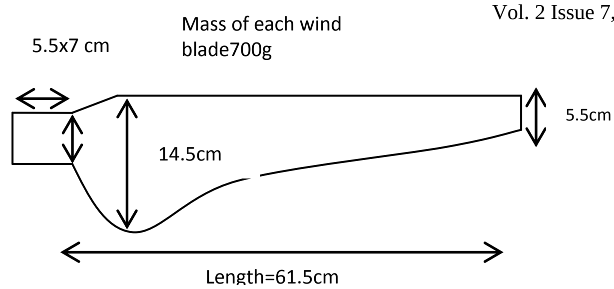


Fig2. Schematic diagram of the fibre glass wind blade

Table 1:Detailsof the wind blades

Type of blade	Blade dimension	Weight of each blade
Wooden	Full length =50cm Broad end =18.07mm Tail end thickness (Top)=18.07mm Thickness (bottom edge)= 3.08mm	170g
Fibre glass	Full length= 61.5cm Broad end =9.39mm Tail end thickness (top)=9.39mm Thickness (Bottom edge)=4.0mm	150g

Experimental Results and discussions

Experiment carried out with wooden blades in natural wind speed

The experiment was conducted on the roof top of the Mechanical Engineering building of Jain University .With the natural wind the wind blades rotated at 100 RPM as recorded by a Digital Tachometer but the electrical output was hardly 1.0 volt. More over the torque of the blades with the moderate wind speed was not sufficient to rotate the gears and so we performed the experiment with out the gear box.

Experiment carried out with fibre glass blades in natural wind speed

Though we wanted to try with different material of wind blades and dynamo , due to paucity of time we had to outsource the fibre glass blades and fitted it to an acrylic circular disc of 20cm diameter and 12mm thickness and connected the blades set up directly to the outsourced dynamo. The entire set up is a trolley mounted one.

The experiment with fibre glass wind blade set up was conducted on the roof top of Jain University, Engineering Block, Even with a natural wind the blades rotated at an amazing speed of 400 rpm and the output was 12 Volt. But a 12 Volt 1 Amp auto lamp glew dimly. Probably 400 rpm was not sufficient . The voltage was measured using a multimeter.

Experiment carried out using wind tunnel (blower)

As the wind speed was very low on many days when the experiment was performed it was decided to carry out the experiment in font of a wind blower. Such an experiment carried out in front of a wind tunnel has also been reported in the literature [Ref7] . Our set up was kept in front of a big wind tunnel generating very high wind speed ,the fibre glass wind blades rotated at a speed of 900 rpm and the voltage obtained was 15 Volt and a 15 watts rated auto lamp **glew very brightly.** Similarly the experiment was performed for the wooden blade set up also , but the out put was not much. All the experimental results recorded both with the natural wind and wind blower are tabulated in Tables 2.. Details of the magnets and their field strength used for the home made dynamo are given in Table 3.

Table 2 -Voltage output of both fibre glass and wooden blades under different conditions**.**

Material of the wind blade	Performed at	Rpm of the blades	Output	Result
3 Wooden	Under natural wind	400	Approximately 1Volt	No bulb glew
3 Fibre glass blades	Under natural wind	400 to 700 rpm	6 to 12 Volt	A 12Watt bulb glew faintly
3 Fibre glass blades	In front of the wind blower	800 to 1000 rpm	12 to 15 Volt	A 15 Watt bulb glew brightly

Table 3:Details of the magnets abd magnetic field measured ,which is used in dynamo

Sl number	Shape of the magnet	Measured magnetic field in GAUSS
1	Torroid	At 0cm=3000 2mm=1800 5mm=700
2	Cylindrical	At 0 mm=5000 2mm= 3000 5mm=1700
3	Studded disc shaped	AT 0mm=2800 2mm=2000 5mm=1500

Conclusions

As seen from Table No II it is clear that an auto lamp rated 15 watts glowing brightly. Of the two wind blades we used the electrical power out put from the fibre glass blade was far better than that of the wooden blades set up.. We expected at least 60 watts power out put but any inner technical details of the dynamo are known though the firm claimed 24 Volt out put even for 250 RPM , may be a better dynamo could have yielded higher out put. But one advantage with this dynamo is not much of torque is required to rotate the shaft where as auto mobile dynamos require large torque. In the case of wooden blades with home made dynamo the reason for not getting higher electrical out put was that even though the blades rotated with a greater RPM the poles were kept at a distance of 5 mm from the rim of the torroidal magnet and the magnetic field tapered to 1000 gauss and also the permeability of the CRGO 'E' core was only 13.00. If the poles are kept very close say 2mm to the magnet because of strong magnetic attraction between the magnet and the CRGO 'E' core the magnet could not be rotated. If a very high permeability material of 1000 Henry/m be used the electrical power out put will be more even for a magnetic field of 1000 Gauss as per equation (6). There is a μ metal of 5% Si and 95% Fe [Ref 8] has that much of permeability value. But this material is not available in the market in small quantities and bulk material is very expensive. We have learnt that in some Central Government labs are making such materials and after procuring it try it out in our set up and we are sure the electrical out put may be around 100 watts even with a wind speed of 5 m/s. In our set up we have not used any external electrical in put like powering the rotor, energise the dynamo , power to yaw etc , and what ever out put we got it is only from the natural wind.

References

[1]Ushiyama Izumi,*Wind Engineering* **16** 1992(1-9)

[2]Geozinne F and Eilering F *Wind Engineering* **8** 1984 (152-159)

[3]G D Rai *Non Conventional Energy Sources* Fourth Edition Khanna Publishers 2010

[4]Powell Richard W *Solar Energy* **26** 1981 (77-80)

[5]Hau Erich Wind Turbines – Fundamentals, Technologies, Application, Economics 2nd Edition , Springer 2005

[6]Thyagarajan T et al Engineering Basics-Electrical , Electronics and Computer Engineering Third Edition New Age International Publishers 2005

[7]Ahamet Z Sachin etal *Int.J Energy.Res* **25** 2001 (501-506)

[8] Hand Book of Chemistry and Physics ,88th edition 2007-2008 (12-108) CRC Press Taylor and Francis

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