DESIGN AND FABRICATION OF HORIZONTAL AND VERTICAL WIND TURBINE

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Abstract : **Wind energy is one of the major forms of renewable energy resources found abundantly which is widely used as an alternate energy. Wind power is sustainable and the production of electricity using wind energy is increasing day by day due to lack of availability of fossil fuels. The wind energy can be converted into electricity by using a wind turbine, which is of two types-vertical axis wind turbine (VAWT) and horizontal axis wind turbine (HAWT). The vertical axis wind turbine is mainly used for domestic applications where the volume of production is low and efficiency is optimal while the horizontal axis wind turbine is widely for larger volume of production and requires huge investment and efficiency is also higher. In this project, an effort has been made to combine the vertical axis wind turbine (VAWT) and horizontal axis wind turbine (HAWT) on the same tower, which in turn reduces the space requirements. The combined vertical and horizontal axis wind turbine also reduces the cost for larger volume of electricity generation. A prototype of the horizontal and vertical axis wind turbine has been designed and fabricated. It is observed that around the premises of G Pullaiah College of Engineering and technology , the winds are strong & persistent. This situation motivated to select the present work. A system to store the energy generated from the windmill by using a dynamo is designed and developed. The system is tested for its power coefficient at different situations which resulted in a satisfactory output.**

Keywords: Renewable energy, vertical axis wind turbine (VAWT) , horizontal axis wind turbine (HAWT), Wind energy.

I. INTRODUCTION

Energy is an important issue in the present scenario of the world and there is always a need for the renewable energy for sustainable growth. The rapid expansion of industrial sectors leads to the increases of energy consumption. With the rising demand of energy, conventional energy is becoming more expensive and scarce. The need to generate power from renewable sources to reduce the demand for fossil fuels and the damage of their resulting carbon dioxide emissions is now well understood. So there is an obvious need for alternative sources of energy. Renewable energy sources include wind energy, solar energy, tidal energy, geothermal energy and biomass energy.

Wind energy is the oldest source of energy and currently accounts for approximately 40% of total primary energy consumption. Many of the developing countries have adopted wind turbine technology that converts into electrical energy. Wind is among the most popular sources of alternative energy because it is pollution free and available almost any time of the day, especially in the coastal regions. As a sustainable energy resource, electrical power generation from the wind is increasingly important in national and international energy policy in response to climate change. The disadvantages of wind energy are high installation cost and the necessity of strong winds to produce electricity. Wind energy is converted into electrical energy by wind turbine. In wind turbine the kinetic energy of wind is converted into mechanical energy of turbine. A generator is connected to the turbine with the help of gears to produce electrical energy.

II. METHODOLOGY OF THE PRESENT WORK

- The wind energy industry so far has been supported by market incentives backed by government policies fostering sustainable energy resources.
- Large scale wind facilities approaching the output rating of conventional power plants, control of the quality is required to reduce the adverse effects on their integration into the network.
- To study widely HAWT and VAWT from available literature.
- To identify different suitable wind mill design for combining.
- To conduct study for performance analysis of identified wind mill design.
- Based on the outcomes of experimental study, to develop best possible model for efficient wind mill.
- To transfer the power from rotor to generator smoothly and to minimize the noise. It economical and do not affects the nature. To produce electricity in any wind direction by using the yaw mechanism to minimize the risk for human and birds because blades moves at relatively low speeds.
- Particularly suitable for areas with extreme weather conditions, like in the mountains.
- To utilize the available wind resources and to reduce the usage of non reneweable energy resources. Wind energy is the fastest growing renewable energy resource.

III. WORK DESCRIPTION

We have undertaken the project which demonstrates the electrical power generation by wind energy being the non-conventional form of energy. A blower is used to supply the wind to the turbine blades which in turn rotates the alternator to produce the electricity. The project has been completed in 7 different steps which described in the subsequent sections.

Step-1:

In our project we are using iron rod (MS) as a shaft. We adjoin this rod with one spring for flexible rotation of rod. The turbine blades are mounted on this shaft.

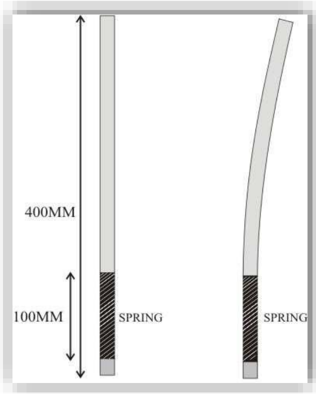


Fig-1 Mild Steel Shaft

Step-2:

We used PVC transparent pipe in our project for showing clear working. First we insert one bearing in the rod from top side of spring and then use PVC sheet covering as a first support.

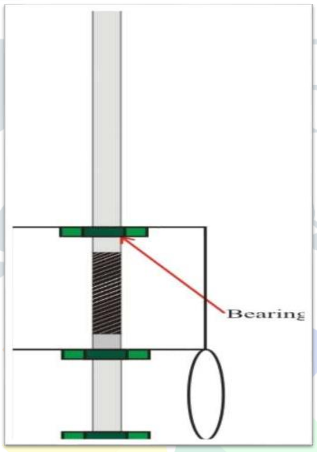


Fig-2 PVC Pipe Housing Bearing

Step-3:

Then we fixed one bevel gear mechanism for transmitting vertical rotation to horizontal rotating.

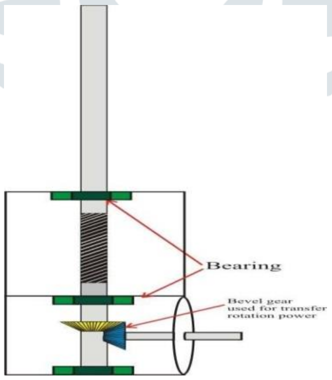


Fig-3 Bevel Gear Mechanism

Step-4:

Then we fixed one dynamo with horizontal shaft with the help of a gear train as shown in fig.4

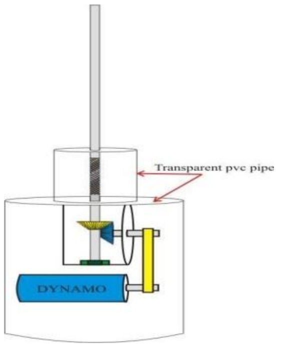


Fig-4 Power Transmission Schematic

Step-5:

Two types of blades one is partial helical and other one is circular in shape are used for quantifying the effect of the blade shape on power generation.

1. We used a rectangle PVC sheet. We curve this sheet with help of heater and give special shape as shown in fig.5

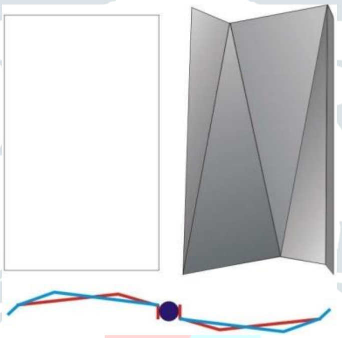


Fig-5 Partial Helical Blade

2. In second type of the blade we used circular blower which is shown in fig.

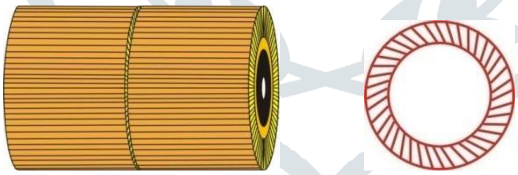
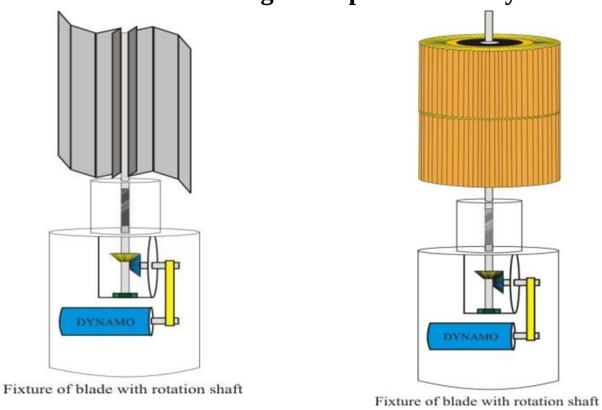


Fig-6 Circular Blade

Step-6:

Then we attach our blades with vertical rod so that the power can be transmitted to the shaft through blade by wind energy.

Fig-7 complete Assembly



Step-7:

We attach one multi meter with dynamo for checking dynamo output. As per our project design our generator give 3-12v output (output may be vary according to the wind speed)

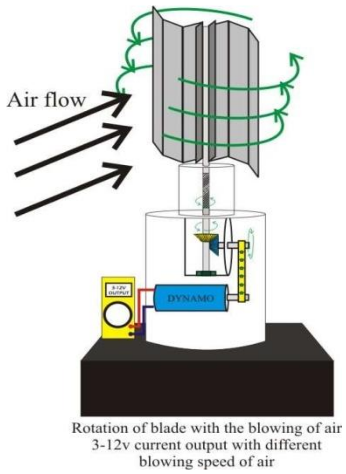


Fig-8 Energy Flow Diagram (Helical Blade)

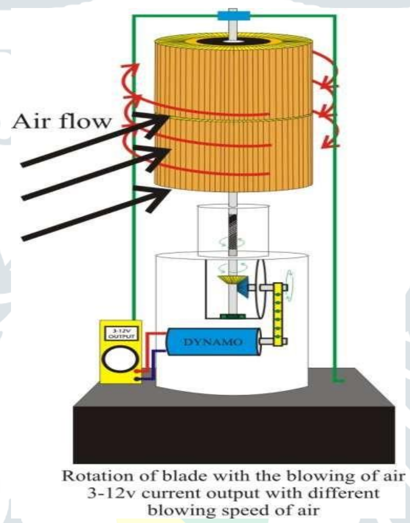


Fig-9 Energy Flow Diagram (Circular Blade)

IV. CALCULATIONS FOR VERTICAL WIND TURBINE

Table 1: Experimental Readings for VAWT with PVC Blades

Room Temperature (T, C)	Inlet Velocity of Wind V_i m/s	Exit Velocity of wind V_o m/s	Power Available P_a , W	Power Extracted by mill P_e, W	Thermal Power Coefficient (C_{pth})
27	15.6	5.8	565.429	312	0.552

Table 2: Experimental Readings for VAWT with Aluminum Blades

Room Temperature (T, C)	Inlet Velocity of Wind V_i m/s	Exit Velocity of wind V_o m/s	Power Available P_a , W	Power Extracted by mill P_e, W	Thermal Power Coefficient (C_{pth})
27	15.6	11.2	565.429	219.9	0.388

Vertical Wind turbine tested with PVC blades at the end of wind tunnel

Inlet velocity of turbine V_1 = 15.6 m/sec

Outlet velocity of turbine V_2 = 5.8 m/sec

Speed of wind turbine N = 900 rpm

Angular velocity(ω) = $\frac{2\pi N}{60} = \frac{2 \times \pi \times 900}{60}$ (Rad/sec)

ω = 94.2477 (Rad/sec)

Tip speed ratio **(λ) =** $\frac{\boldsymbol{\omega \times D}}{\boldsymbol{2V}}$

D= diameter of rotor = 0.436 m
V = inlet velocity of turbine =15.6 m/sec
λ =$(94.277 \times 0.436)/(2 \times 15.6)$
λ = 1.31

Power developed by the wind (P_W) = 0.5×ρ×A×V_1^3 (watts)

P = density of air = 1.12 (kg/m^3)

A = area of rotor = D × H

D = diameter of rotor = 0.436m

H = height of blade = 0.57 m

A = 0.436 × 0.57= 0.24852 m^2

V_1 = inlet let velocity of the wind = 15.6 m/sec

P_W = 0.5 × 1.12 × 0.24852×15.6^3=528.35watts

Power developed by the wind

(P_T)=0.25×ρ×A×(V_1+V_2)×(V_1^2-V_2^2) (watts)

= 0.25× 1.12 × 0.24852 × (15.6 + 5.8) × (15.6^2 – 5.8^2)

P_T = 312.30 watts

Power co- efficient (C_P) = $\frac{Pt}{Pw} = \frac{312.30}{528.35}$

C_P = 0.591

Torque (T_B) = $\frac{Pt \times 60}{2 \times \pi \times N} = \frac{271.78 \times 60}{2 \times \pi \times 900}$

T_B= 2.88 (N-m)

Torque co- efficient (C_T) = $\frac{Tb}{0.25\ \rho ADV^2}$

= $\frac{2.883}{0.25 \times 1.12 \text{x} 0.24852 \times 0.436 \times 15.6^2}$

C_T =0.3905

Actual power output from turbine is P_T = V × I(watts) Voltage,

V = 27,

Current, I = 0.9amperes obtained directly by using the instruments.
P_T== 27× 0.9 = 24.33watts

The remaining power losses are due to gears and generator.

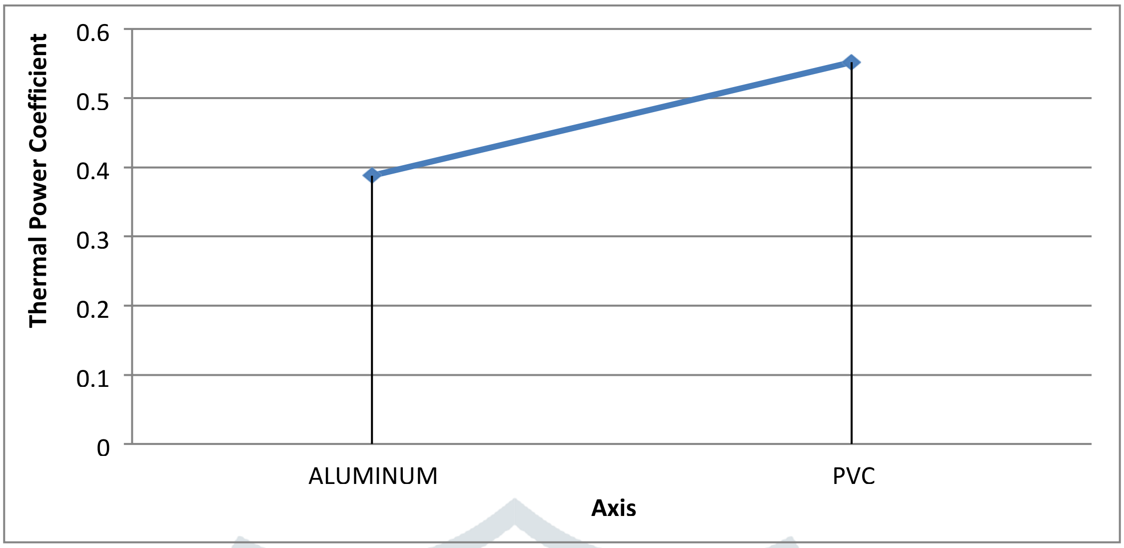


Fig10: comparison of Thermal Power coefficient for VAWT **CALCULATIONS FOR HORIZONTAL WIND TURBINE**

TABLE 3: EXPERIMENTAL READINGS FOR HAWT WITH ALUMINIUM BLADES (WITHOUT FINS) AT ROOM TEMPERATURE (27^{0}C)

Angle of Orientation In degrees	Inlet Velocity Of Wind Vi m/s	Exit Velocity Of wind Vo m/s	Power Available Pa , W	Power Extracted by mill Pe, W	Thermal Power Coefficient (Cpth)
0	17	16	459	50.9	0.11
45	17	12.6	459	180.2	0.39
90	17	14	459	134.8	0.29

Table 4: Experimental Readings for HAWT with Aluminium Blades (With Fins) at room temperature (27^{0}C)

Angle of Orientation In degrees	Inlet Velocity Of Wind Vi m/s	Exit Velocity Of wind Vo m/s	Power Available Pa , W	Power Extracted by Mill Pe, W	Thermal Power Coefficient (Cpth)
0	17	15	459	81.43	0.177
45	17	10	459	202.9	0.44
90	17	12	459	167.19	0.36

Horizontal Wind turbine tested with Al blades in front of wind tunnel at a distance of 30 inches (762mm)

At $\Theta = 90^o$

- To calculate density of air

$\rho = P/RT = (1.01325*10^5)/(287*300) = 1.1768\ kg/m^3$

ρ is the density of air

P is the atmospheric pressure in the bar.

T is the room temperature=27 ^{o}

- Power available $p_a = 0.5*\rho*A*V^3 = (1/8)*\rho*\pi*D^2*V^3$ i

$= (1/8)*1.176*\pi*0.45^2*17^3$

$= 459$ watts

P is the density of air

A is the swept area of windmill in m^2

V_i is the inlet velocity of windmill in m/s

- Power obtainable from the wind $P_e = 0.25 \times \rho \times A \times (V_i+V_o) \times (V^2-V^2)$(watts)

  $= 0.25*1.176*(\pi/4)*0.45^2*(17+12.8)*(17^2-12.8^2)$

  =180 watts

V_i is the inlet velocity of wind at the swept area in m/s

V_o is the exit velocity of wind from the rotor in m/s

- Power Coefficient C_{pth} = Power producible / Power available

  $= P_e / P_a$

  = 180/459

  = 0.39

Combined power outputs

Power input to horizontal turbine p_{ih}= 459 Watts Power input to vertical turbine p_{iv} = 528.35 Watts

Combined power input p_i = 459+528.35 = 987.35 Watts

Power output to horizontal turbine p_{oh}= 174 Watts Power output to vertical turbine p_{ov} = 312.30 Watts

Combined power output p_o = 174+312.30 = 486 Watts Power Coefficient C_{pth} = Power output/ Power input

$= P_o / P_i$

= 486.30/987

= 0.4925

Table 5: Percent Increase in Thermal Coefficient of HAWT using Aluminium Blades with fins

Type Of blades	Inlet Velocity Of Wind V_i m/s	Exit Velocity Of wind V_o m/s	Power Available Pa , W	Power Extracted by mill Pe, W	Thermal Power Coefficient (Cpth)	Percent of Thermal Coefficient Improved (%)
Without fins	17	12.6	459	180.2	0.39	
With fins	17	10	459	202.9	0.44	12.82

Percentage of Thermal Coefficient Improved is 12.82

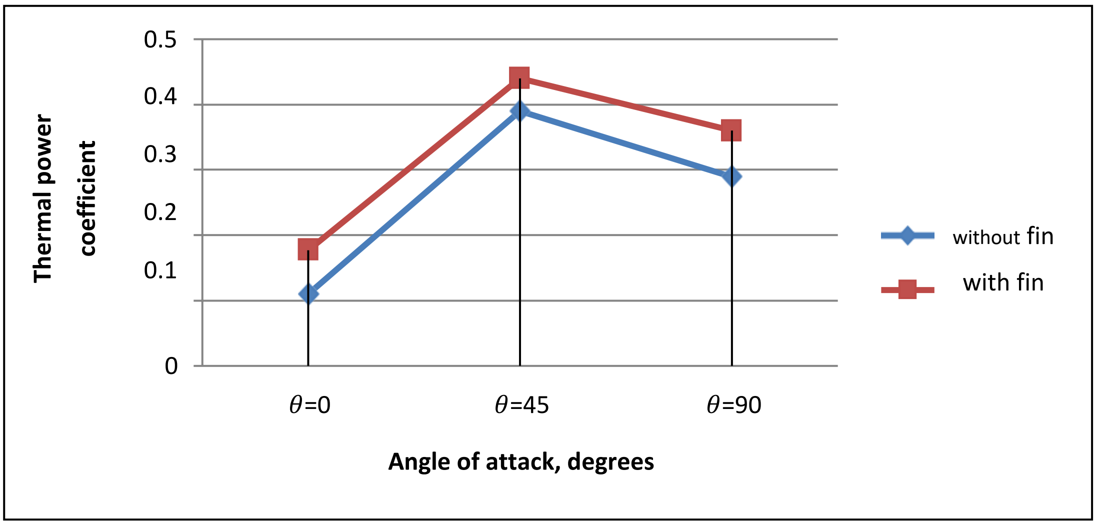


Fig 11: Graph comparing Thermal Power coefficient for HAWT

V. CONCLUSION

The present work is focused on the design and fabrication of dual axis wind turbine (combined HAWT AND VAWT).In this project a Dual axis wind turbine is done for various wind parameters when the wind turbine is tested at the outlet end of wind tunnel. The power coefficient has been experimentally determined for HAWT and VAWT individually. The combined thermal power coefficient has been determined. The following conclusions have been drawn from the project.

1. The combined actual power output from the Dual axis wind turbine is more compared to individual power outputs.
2. The theoretical power developed by the turbine is better when wind turbine is tested at the outlet end of wind tunnel. Because as in the calculations, the outlet velocity of the wind is reduced due to some air losses then the theoretical power developed by the wind turbine is increased.
3. The actual power output from PVC bladed vertical axis turbine is more compared to power output from turbine with Aluminium blades.
4. The space for installation has been drastically reduced for the given TPC.
5. The turbine works at any altitude of the wind and wide range of wind speeds without interruption.

VI. REFERENCES

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