

Kinetic Energy Recovery System from the flow of exhaust in buildings and industries

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Abstract— Wind energy is capable of meeting a fraction of energy needs around the globe. Wind Energy is harnessed by means of windmills that make use of natural resources. Contrary to this, our system makes use of wind originating due to manmade sources to generate energy. KERS or Kinetic Energy recovery system converts the lost fraction of energy in the form of heat/wind to useful energy. Based on the high speed possessed by the exhaust air flow in industries and buildings, a wind turbine can be put in place to extract the energy.

Index Terms— Horizontal Axis Wind turbine, Vertical Axis Wind Turbine, Exhaust Air, Centrifugal action

1 INTRODUCTION

A large industrial centrifugal fan is installed at the top of a building or exhaust tower in an industry. The air flows through a channel due to drawing in action of the fan. This is pushed by the fan towards the turbine, via the channel cover that has a mesh or net in order to prevent dust from accumulating on the surface of the blades of windmill causing slow rotations. The spinning action of turbine from incident airflow is a function of speed of the fan and discharge. Centrifugal action creates suction effect that causes air to fill into the evacuated region causing ventilation. The air is concentrated on the windmill using a case that also protects the structure from any foreign objects. Finally conversion of mechanical energy in the form of rotation to electricity is achieved with the help of an alternator.

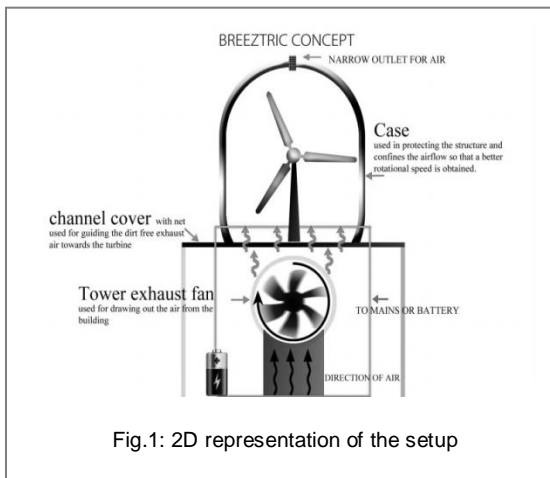


Fig.1: 2D representation of the setup

General VAWT characteristic speed curve shows as the wind speed increases the RPM reaches the rated value.

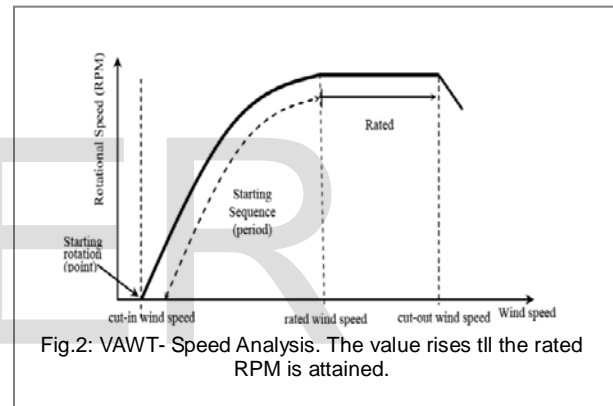


Fig.2: VAWT- Speed Analysis. The value rises till the rated RPM is attained.

Since the speed of air is almost constant, no external devices are required for regulating voltage and power output. In our case the turbine is designed to run at a constant speed. The wind speed can be determined by making use of anemometers. The system is further connected to a charge controller. Charge controller limits the rate at which current is added or drawn from the battery. It prevents against overcharging and thereby prevents the dangers of over voltage. It is then connected to an inverter.

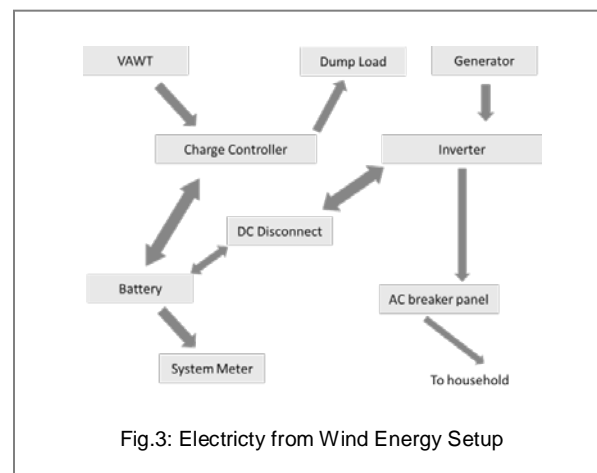


Fig.3: Electricity from Wind Energy Setup

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This is used for converting DC to AC power. The output can be determined by making use of Multi meter before being fed into the mains. The AC breaker panel is for safeguarding the power supply to the household.

2 DESIGN AND IMPLEMENTATION

2.1 Theory

Predominantly there are 2 kinds of wind turbines: Horizontal Axis (HAWT) and Vertical Axis (VAWT). Horizontal Axis turbines are comparatively more efficient. However there were several design constraints that had to be accounted for.

- 1) If a horizontal axis wind turbine is used, there has to be a long shaft that needs to support the rotor assembly. A VAWT takes less space.
- 2) The system should be lighter and compact. Thus it should be more resilient to instability. The best way is through use of tin sheets as rotors and good quality fibre as directional scoops.
- 3) The system must bear the high stress due to centrifugal action and hence the blades of a VAWT can fulfil this at a lower cost due to their orientation and design. A HAWT would have required a more expensive design due to stronger blades.
- 4) Stress results in vibrations and noise. In VAWT the vibration and noise factor is reduced by introducing blades to the existing number.

2.2 Experimental Setup

Thus we selected VAWT for our experiment. We tested our Vertical Axis Wind turbine model (1:5) using PVC pipes for rotor blades. The blades are in the form of longitudinal structures representing semi-circular cross section. We also used a 4 bolt bearing and wooden bases for rotating drums. The nature of discharge in case of the blower is analogous to that of the centrifugal fan. In VAWT the base is circular. It becomes important to ensure that rotating drum diameter is sufficiently large to house the alternator. All we need to do is mount the alternator with the turbine assembly

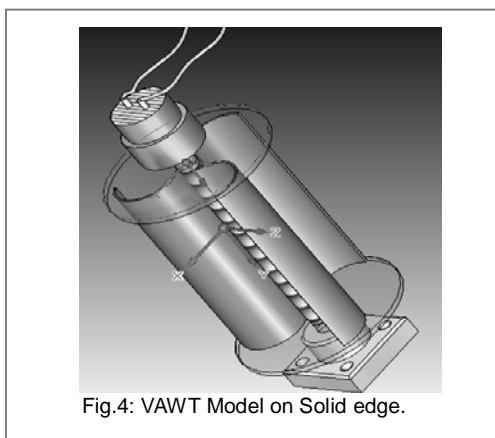


Fig.4: VAWT Model on Solid edge.

In our model we have used a DC Motor that works similar to an alternator and generates electricity when the motor spindle rotates

The turbine orientation is such that the air flow is perpendicular to the axis about which turbine spins.

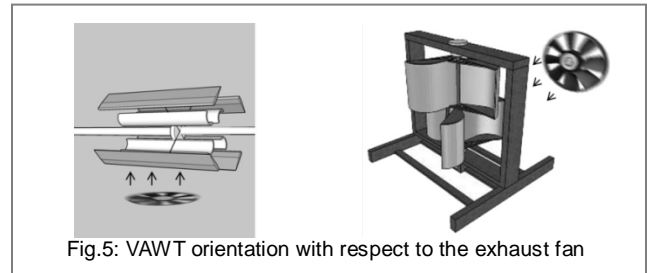


Fig.5: VAWT orientation with respect to the exhaust fan

We tested the model in our lab before a centrifugal blower. The blower has different valve opening positions that determine the exhaust flow.

The following parameters and equations govern the speed of rotation of the turbine and the power output.

- ρ_a = Density of air at 287K
- H_a = Height of air column
- H_m = Height of mercury column
- Q_a = Discharge at room temperature
- C_d = Coefficient of discharge
- τ = Torque
- d_1, d_2 = Inlet, Throat Diameters
- N = RPM of rotor

The blades are fixed on the orbital path of each other. In ordinary situations a small amount of power is required to start the rotation. However the wind velocity in this case is high and no external power is required. Given below are the equations to

$$\rho_a = P / RT_r = (101325) / (287 \times 301) = 1.17 \text{ kg/m}^3$$

$$H_a = (\rho_w \times h_m) / \rho_a$$

$$H_m = (\rho_m \times h_m) / \rho_a$$

$$Q = C_d a_2 \sqrt{(2gH_m) / (1 - (d_2 / d_1)^4)} \text{ m}^3/\text{s}$$

$$\text{Blower output} = (\rho_a Q_a H_a g) / 1000$$

$$\text{Power of wind} = 0.55 \rho_a V^3 \text{ (A=Area of Blower)}$$

$$\text{Power of turbine} = 0.5 C_p A V^3$$

$$A_s = 0.1196 \text{ m}^2$$

$$P_{\text{turbine}} = \tau \omega$$

$$\tau = (P_{\text{turbine}} \times 60) / (2\pi N)$$

2.3 Result

The test was successful under the available butterfly valve positions of the centrifugal blower. The speed of the turbine were recorded using a digital tachometer. The results correspond to 30°, 60° and 90° valve positions. The power output increased with discharge and efficiency of the system also improved. As swept area is an important parameter that affects

power output, it can be concluded a turbine of larger size can generate more power.

TABLE 1
EXPERIMENTAL OBSERVATION FOR TURBINE POWER

Valve position in degrees	Rotor RPM -N	Discharge Q_a in m^3/s	Blower Output In KW	Velocity in m/sec	Power of turbine in KW
30	28	0.1764	0.302	30.866	0.276
60	143	0.377	0.679	40.440	0.676
90	310	0.472	0.861	43.77	0.853

TABLE 2
EXPERIMENTAL OBSERVATIONS FOR SYSTEM EFFICIENCY

Valve position in degrees	H_a in metres	H_m in metres	Discharge Q_a in m^3/s	Blower Output In KW	Efficiency in %
30	150.43	93	0.1764	0.302	35.95
60	156.87	430.08	0.377	0.679	65.95
90	158.57	672.46	0.472	0.861	78.27

Table 2: Efficiency with respect to the discharge values



Fig.6: VAWT Model on Solid edge.

2.4 Simulation

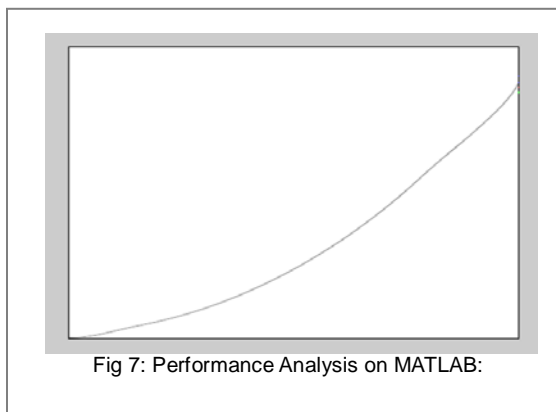


Fig 7: Performance Analysis on MATLAB:

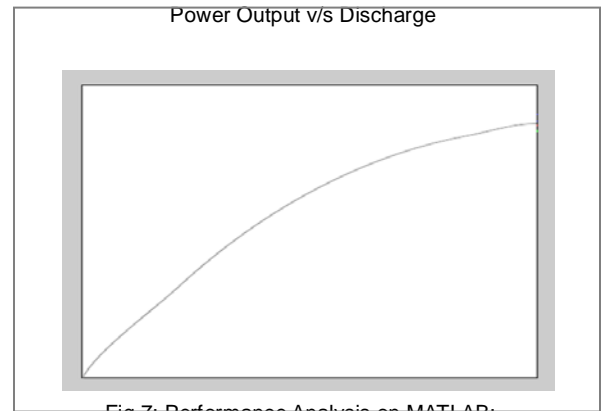


Fig 7: Performance Analysis on MATLAB:
Efficiency v/s Discharge

3 CONCLUSION

Wind flow due to exhaust fan is cleaner compared to natural wind. Using a VAWT for recovering energy from exhaust can help reduce carbon footprint of a concerned building or industry. Industrial fans run for longer durations in petrochemical, semiconductor industries, power plants and corporate warehouses for cooling by extracting the heat and maintain suitable working conditions. The power produced can thus be that can be stored or fed back into the mains.

REFERENCES

- [1]. H. Beri and Y. Yao, "Double Multiple Streamtube Model and Numerical Analysis of Vertical Axis Wind Turbine," Energy and Power Engineering, Vol. 3 No. 3, 2011, pp. 262-270. doi: 10.4236/epe.2011.33033.
- [2].EWEC, Wind energy review. (2009)
- [3].Kira Grogg, The Physics of Wind Turbines Carleton College, 2005, p.8
- [4].Neeraj Mittal, Investigation of Performance Characteristics of a Novel Vertical Axis Wind Turbine- September 2001
- [5].G. F. Homicz, "Numerical Simulation of VAWT. Stochastic Aerodynamic Loads Produced by Atmospheric Turbulence: VAWT-SAL Code," Technical Report SAND91-1124, Sandia National Laboratories, Albuquerque, 1991.
- [6].H. M. Dreess, "Self-Starting Windmill Energy Conversion System," US Patent No. 4180367, 1979.