Venturi Wind Turbine

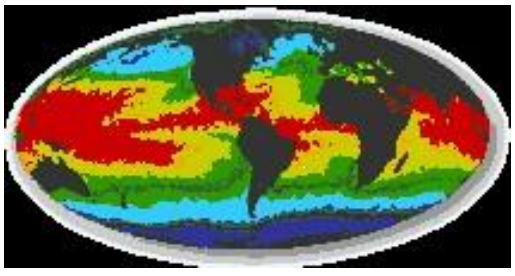
N. Aravindhan (Assoc.Prof), Ajith Kumar M, Akshy Ramaseshan N. P., Devarajan N

Abstract: **The Conventional power Generation from wind mill takes up large area and it requires higher wind speed. Our main objective is to reduce the area and to improve the Efficiency. We direct the wind through a funnel arrangement and pass it on to low level turbine with the help of a nozzle; it can produce power, even from a wind speed as low as 2mph.**

1. INTRODUCTION

All renewable energy (except tidal and geothermal power), and even the energy in fossil fuels, ultimately comes from the sun. The sun radiates 1.74 x 10 ^{17} kilowatt hours of energy to the earth per hour. In other words, the earth receives 1.74 x 10 ^{17} watts of power. But, about 1 to 2 per cent of the energy coming from the sun is converted into wind energy. That is about 50 to 100 times more than the energy converted into biomass by all plants on earth. Wind is one of the most abundant sources of energy, which is not utilized to its potential. The Conventional Wind farm is large in area, but the power produced is very less because of the methodology followed in the present. The basic drawback of conventional wind mill is that it requires minimum wind speed of 15mph to generate power. This restricts the conventional power generation only to the places where you get higher wind speeds. Our idea is to overcome the demerits of the conventional method. The Vision is to create power from even a wind speed of 2mph; the ideology we follow here is to direct the wind through a tunnel into a nozzle, where wind at high velocity can be acquired .Thus the wind even at lower speed can be used to harness the energy. The amount of energy which the wind transfers depends on the density of the air, the rotor area, and the wind speed. In our design we try to improve all the factors influencing in improving the efficiency of power generation. So, this design will be able to harness higher power rather than conventional in same working environment.

2. THE STUDY ON WIND



The major study that goes during wind power generation, is observing the characteristics of wind along the region. The wind is basically driven by the temperature differences caused by the sun. The regions around equator, at 0° latitude are heated more by the sun than the rest of the globe. Hot air is lighter than cold air and will rise into the sky until it reaches approximately 10 km (6 miles) altitude and will spread to the north and the South. Due to the rotation of globe, any movement on the Northern hemisphere is diverted to the right, if we look at it from our own position on the ground. The southern hemisphere is bent to the left. This apparent bending force is known as the Coriolis force. This phenomenon decides the direction of wind flow in a region. The typical chart on Prevailing Wind Directions:

Latitude	90-60°N	60-30°N	30-0°N	0-30°S	30-60°S	60-90°S
Direction	NE	SW	NE	SE	NW	SE

There are majorly two types of winds, Geostrophic Winds and Local Winds. Winds in the troposphere (11km from ground level) are said to be **geostrophic** winds and the wind which blows within the range of 100m from the ground level are Local winds.

These Local Winds are source of our wind power Generation. Local winds are always superimposed upon the larger scale wind systems, i.e. the wind direction is influenced by the sum of global and local effects. When larger scale winds are light, local winds may dominate the wind patterns. These Local winds depend on the concept of Sea Breeze which works by the below given information: Land masses are heated by the sun more quickly than the sea in the daytime. The air rises, flows out to the sea, and creates a low pressure at ground level which attracts the cool air from the sea. This is called a sea breeze. At nightfall there is often a period of calm when land and sea temperatures are equal. At night the wind blows in the opposite direction. The land breeze at night generally has lower wind speeds, because the temperature difference between land and sea is smaller at night. The monsoon known from South-East Asia is in reality a large-scale form of the sea breeze and land breeze, varying in its direction between seasons, because land masses are heated or cooled more quickly than the sea.

From the data's given above, we may come to a conclusion that Wind Power Generation is restricted to certain norms. But the design we are proposing might change the way of wind energy utilization.

3. WORKING PRINCIPLE OF VWT

- The harnessing of Power from Wind Energy is purely dependent on the Kinetic energy of the Wind. Hence, if we have to improve the efficiency of the Wind power generation System, then we have to increase the Velocity of the Wind.
- Thus the design we propose uses the wind with different velocities, captured from different directions. Those with low speed are captured in the lower deck and those with higher speed are captured in upper deck.

- Also, the shape of VWT enables to capture wind from 360 degree. And our design will be able to harness higher power rather than conventional will mill in the same working environment.
- The suction of air may be maintained using COANDA effect.
- During its course a vortex flow is created by the help of design parameters, this in turn increases pressure which helps for steady flow.
- The Kinetic Energy of the wind is increased with the help of a nozzle effect, which converts the Pressure Energy of the wind into Kinetic Energy.
- This Energy of the wind hits turbine blades, thus generating power from the wind. After the power generation, wind is led out into the atmosphere

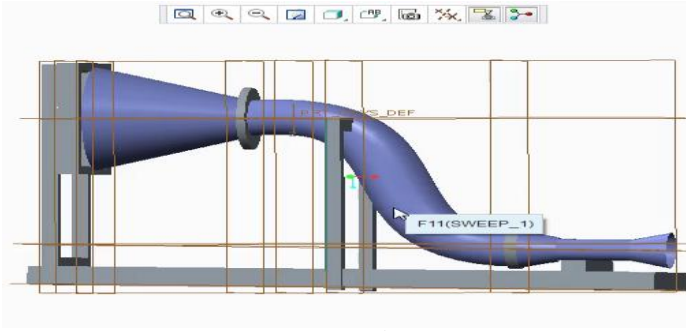


Fig: CREO Modeling for VWT

4. COANDA EFFECT:

- The airflow attaches itself to the nearby surface and remains attached even when the surface curves away from the initial airflow direction.
- When the flow of air in the atmosphere is not steady, then the air suction will be very helpful in providing flow inside the VWT.

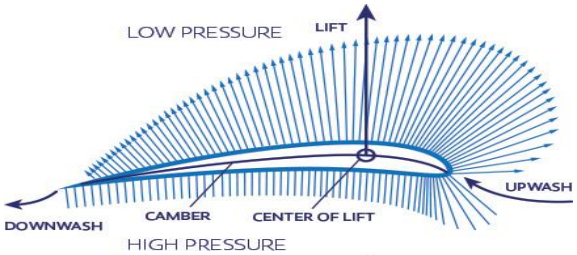


Fig: Aero foil Design and Coanda Effect.

- Bernoulli's Principle is also known as the venturi effect - it states that a high velocity flow gives a low static pressure.

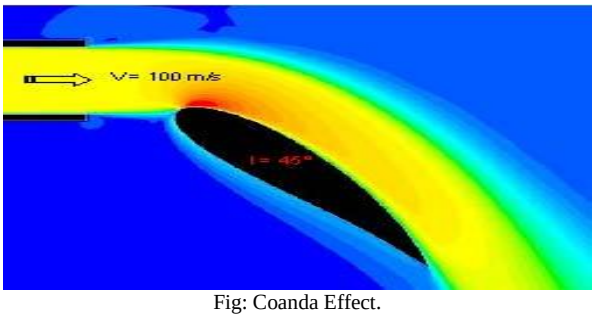
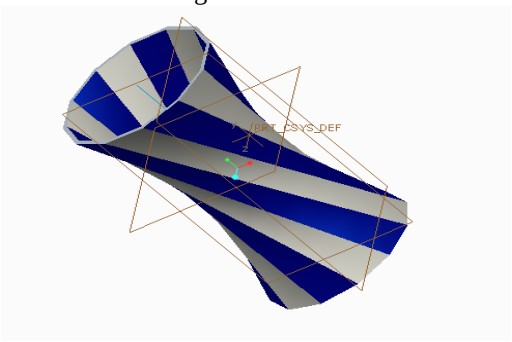


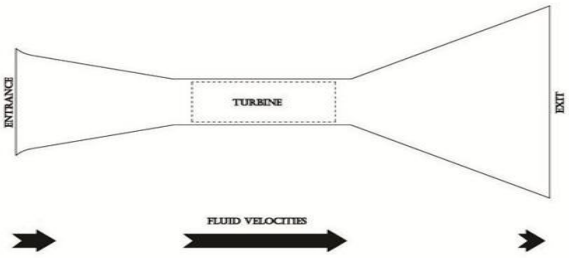
Fig: Coanda Effect.

5. VORTEX FLOW

- The Vortex helps in creating the high Pressure necessary to increase the pressure energy and to improve the efficiency.
- In general, a vortex is a region in a fluid in which the flow rotates around an axis line, which may be straight or curved.
- The, Vortex flow in our system is created in vertical flow section by artificially making the flow to rotate along its axis



6. NOZZLE EFFECT



- The Nozzle is generally a structure in which the flow area decreases or increases constantly from the inlet to outlet. Due, to this the velocity of the fluid flowing may tend to change.
- So, when the air comes from the flow pipe the air enters the nozzle on larger area side and leaves through the reduced area.
- By this we increase the Velocity with the help of a simple equation of mass flow rate.

$$\dot{m} = \rho \dot{V} = \frac{\dot{V}}{v} = \rho A \vec{V} = \frac{A \vec{V}}{v}$$

where: $\dot{m}$ is the mass flow rate $\left[\frac{kg}{s}\right]$

$\dot{V}$ is the volumetric flow rate $\left[\frac{m^3}{s}\right]$

ρ is the density $\left[\frac{kg}{m^3}\right]$, v is the specific volume $\left[\frac{m^3}{kg}\right]$

$\vec{V}$ is the velocity $\left[\frac{m}{s}\right]$ A is the flow area $\left[m^2\right]$

- Thus, from the above equation we come to know that when area decreases the velocity of air increases as the mass flow rate is constant.

7. FACTORS INFLUENCING WIND POWER

A wind turbine obtains its power input by converting the force of the wind into torque (turning force) acting on the rotor blades. The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, the wind speed and the flow loss.

DENSITY OF AIR: The kinetic energy of a moving body is proportional to its mass (or weight). The kinetic energy in the wind thus depends on the density of the air, i.e. its mass per unit of volume.

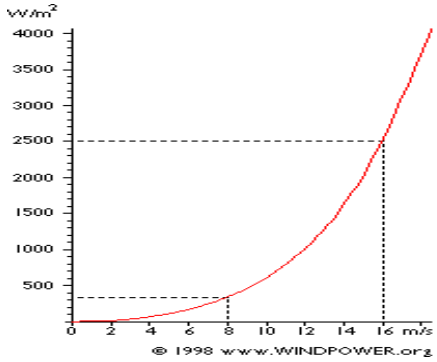
KINETIC ENERGY = ½ mv^2

m- Mass of the air v- Velocity of the air

Density, ρ = m/v Unit: kg/m^3

ROTOR AREA: The rotor area determines how much energy a wind turbine can harvest from the wind. The wind turbine rotor must obviously slow down the wind as it captures its kinetic energy and converts it into rotational energy. This means that the wind will be moving more slowly to the left of the rotor than to the right of the rotor. The graph to the left shows the air pressure plotted vertically, while the horizontal axis indicates the distance from the rotor plane. The wind is coming from the right, and the rotor is in the middle of the graph. As the wind approaches the rotor from the right, the air pressure increases gradually, since the rotor acts as a barrier to the wind. Note that the air pressure will drop immediately behind the rotor plane (to the left). It then gradually increases to the normal air pressure level in the area.

WIND SPEED: The wind speed is extremely important for the amount of energy a wind turbine can convert to electricity. The energy content of the wind varies with the cube (the third power) of the average wind speed, e.g. if the wind speed is twice as high it contains $2^3 = 2 \times 2 \times 2$ = eight times as much energy.



The graph shows that at a wind speed of 8 meters per second we get a power (amount of energy per second) of 314 Watts per square metre exposed to the wind (the wind is coming from a direction perpendicular to the swept rotor area). At 16 m/s we get eight times as much power, i.e. 2509 W/m^2.

FLOW LOSSES: This Loss is minimal, but it also influences the efficiency of power generation. The basic loss may occur in the curvature where the wind as to flow during its course.

MINOR HEAD LOSS:

$$h_m = K \frac{V^2}{2g}$$

g = acceleration due to gravity = 32.174 ft/s^2 = 9.806 m/s^2.

$\mathbf{h_m}$ = head loss due to a fitting and has units of ft or m of fluid. It is the energy loss due to a fitting per unit weight of fluid.

K = minor loss coefficient for valves, bends fittings.

For Long radius 90°, flanged	0.2

The Major Head loss occurs when the flow is along straight pipe.

MAJOR HEAD LOSS:

For Round Pipes:

$$h_f = \frac{4f\, l\, v^2}{2g\, d}$$

Where

h_f is the head loss due to friction [m]

l is the length of the pipe [m],

d is the hydraulic diameter of the pipe. For circular sections this equals the internal diameter of the pipe [m].

v is the velocity within the pipe

g is the acceleration due to gravity

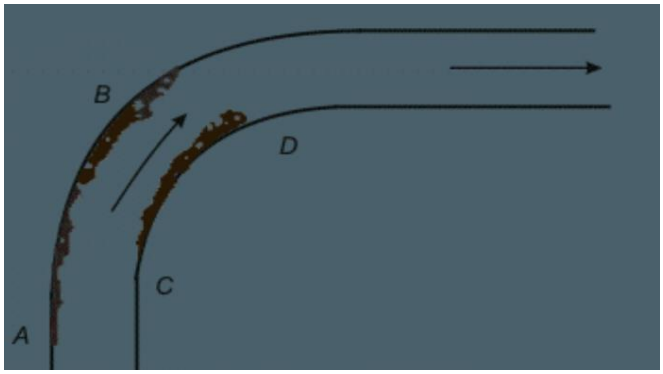
f is the coefficient of friction.

Losses in Bends:

- Bends are provided in pipes to change the direction of flow through it. An additional loss of head, apart from that of the fluid friction, takes place in the course of flow through pipe bend.
- Whenever a fluid flows in a curved path, there must be a force acting radially inwards on the fluid to

provide the inward acceleration, known as centripetal acceleration

- This results in an increase in pressure near the outer wall of the bend, starting at some point and rising to a maximum at some point B. There is also a reduction of pressure near the inner wall giving a minimum pressure at C and a subsequent rise from C to D.
- Therefore between A and B and between C and D the fluid experiences an adverse pressure gradient (the pressure increases in the direction of flow).
- This pressure variation can be controlled using coanda effect



8. POWER OF THE WIND:

Power of the Wind Formula

The power of the wind passing perpendicularly through a circular area is:

$$P = 1/2\ \rho\ v^3\ \pi\ r^2$$

Where **P** = the power of the wind measured in W (Watt).
ρ = (rho) = the density of dry air = 1.225 measured in kg/m 3 (kilogram per cubic metre, at average atmospheric pressure at sea level at 15° C).
v = the velocity of the wind measured in m/s (meters per second). **π = (pi) = 3.1415926535...**
r = the radius (i.e. half the diameter) of the rotor measured in m (meters).

9. VWT NOMENCLATURE

- The significant feature of VWT is intake system, pipe carrying accelerated wind and a diffuser system.
- It is based on hydro power generation principle VWT captures the winds kinetic energy and uses the pressure differential to increase the kinetic energy and makes it available to the turbine.
- The wind flow from multi collection funnel is concentrated in such a way that the resulting power output rises almost exponentially.
- Since the airflow is brought from the top of the turbine to the ground level were the turbine is placed, helps us to generate more power with smaller blades. This turbine is 50% shorter than traditional wind tower and with blades 84% as long.

10. KEY BENEFITS OF VWT

- This technology is very simple, this not only provide greater reduced cost, it also brings solution for to all the planning and developing issues.
- VWT forms an environmentally friendly, and will not face any kind of public resistance unlike the traditional wind farms which pose high health and higher development cost.
- *Low cut in speed:* VWT can generate power at a wind speed as low as 2mph.Therefore VWT can be used on very low speeds developing sites .This technology offers a wide range of use and higher level of availability.
- *REDUCED LAND USE :* Due to smaller and higher performance VWT farms uses less area than traditional wind farms .It remains unaffected by wakes and vortex effect that are caused by huge turbine blade rotation the aerodynamic exposure improves turbine spacing on large farms it uses 90% less space than traditional wind turbine.
- *VISUAL IMPACT:* VWT occupies less area as a result the visual impact of a VWT wind farms is considerably reduced. Noise impact and shadow flickers of traditional wind turbines which produces aerodynamic disturbance in the noise by rotation of blades create disturbance in quality of life of neighboring residents. VWT reduces the high energy and low frequency noise nuisance formed from the wind farm and eliminate the shadow flicker issue.
- *ICING:* Traditional wind turbines, in cold climate areas, suffer from icing which results in performance degradation or shutdowns. Because VW Turbine and blades are safely installed at or below ground level, inside the venture section of the tower, they will not be subjected to harsh temperature variations and no icing will occur.

- *RELIABITITY:* Since the VW Turbine and generator are safely placed at ground level, reliability will increase since they are not subjected to harsh environmental conditions. For example, bearings, shafts, blades, and gears are not exposed to broad temperature changes, humidity, airborne debris, and excessive winds. Our enclosed turbine-generator system will lead to reduced downtime, and result in more effective maintenance programs.

- *IMPACT ON BIRDS:* Since VWT does not contain larger sized rotating blades and occupies only smaller area, contributes significantly to reduce the negative impact on birds.

11. APPLICATIONS

VWT is a scalable technology which is equally suitable for use in major wind farms or micro-generation settings. It can be used for a broad range of applications including:

• Large to medium scale onshore wind farms
• Offshore wind farms
• Small wind applicable to commercial and residential buildings

. Installation of Water Spray:

It works on the principle of convergent /divergent nozzle as it provides the venturi effect at the point of diffusion as the tube gets narrows at the throat the velocity of the fluid increases and because of the venturi affect it pressure decreases, vacuum will occur in the diffuser throat where the suction line will be provided.

It's where, the water is sprayed thus the suction of air at throat sucks and delivers the cooling system

• Micro-wind power generation systems suitable for military applications and consumer products Not only can VWT wind turbines be installed on sites which are not suitable for traditional wind farms, but they can also be sited closer to urban centers of demand, and used in tandem with natural gas to form a hybrid power plant. Sheer Wind's VWT technology creates new markets not possible with traditional wind technology, such as micro-power systems, mobile power systems, and collapsible/inflatable towers for military/disaster needs. Micro-power generation includes garden wind lights (versus solar) and street wind lights. Residential/commercial buildings can use VWT for wind towers built in or added as a retrofit to the building structures with the generators installed in the basement. For ground vehicles, VWT systems can be built in commercial, passenger and military vehicles as an assist power system to maintain charge in batteries of electrical or hybrid vehicles

12. ADVANTAGES OVER TRADITIONAL TOWERS

Since the VWT turbine or generator is safely placed at ground level, there is increase in reliability since the parts are not subjected to harsh environmental conditions. Shafts, bearings, blades, and gears are not exposed to varying temperature changes, humidity and excessive winds. Our concept will lead to more efficient production. Since the turbine blade are not directly exposed to the environment. We can control the icing of blades to a major extent since it is not effected by harsh temperature conditions.

13. CONCLUSION

Thus it may be a better solution for increasing efficiency in commercial renewable power generation applications. It also has good architecture and can be installed for ground level applications.

Also, the shape of wind mill enables to capture wind from 360 degree. And our design will be able to harness higher power rather than conventional in same working environment.

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[9] www.mdpi.com/1996-1073/5/9/3425/pdf Wind Turbine Blade Design Peter J. Schubel * and Richard J. Crossley Faculty of Engineering, Division ofMaterials, Mechanics and Structures, University of Nottingham, University Park, Nottingham NG7 2RD, UK