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# A design, fabrication and experimental Investgation of venturi wind turbine

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## ABSTRACT

**Through the next several decades, renewable energy technologies , thanks to their continuously improving performance & cost, growing recognisation of their environmental , economic & social values will grow increasingly competitive with traditional energy technologies so that by the middle of the 21st century , renewable Energy In its various forms should be supplying half of the worlds energy needs.**

**Thinking towards power generation, increasing demand in energy facilitated the need of clean energy such as wind energy. Residences, building & commercial establishments need more power everyday and also continuous power through clean sources such as wind. Power generation in our country is very low at present. Industrially developed states like Maharashtra is suffering through major power shortages, and this is a signal of major crises. Even in cities like Mumbai , Pune & Nagpur peoples are suffering from power cuts. Important facilities such as wireless or radio sets require small amount of energy albeit continuously.**

**From this project, our intention is that residential societies should install such Venture wind turbine on the terrace to tackle with the power cuts & become independent up to certain amount. So we have begun it with our college. As our college is near a creek thus good location for a venture wind turbine. In this project wind turbine charges a 12 volt battery, run various 12 volt appliances & 60 volts bulbs. We have fabricated the small scale venture wind turbine on the basis of design calculations & made changes in design to track it with manufacturing constraints. The modification are made in the shape of the venture wind turbine & for different velocity ranging from 4m/s to 8m/s the effect on the torque generated is examined & compared with the conventional Venture wind turbine, with small change in the shape of the conventional venture wind turbine we observe the drastic change in the power generation by theoretical calculation & analysis by software.**

***Keywords—*** **Wind energy, Power, Venture & Analysis.**

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## I. Introduction

Wind power plants are established mostly in open grounds to get open air stream of air. An open air stream contains more potential energy than kinetic energy. This available kinetic energy was utilised by bare wind turbines to generate power. This paper focuses on concentration of wind on HAWT blade which results into increment of wind velocity hence kinetic energy. To accomplish this purpose the phenomenon venturi effect was used. A venturi has three regions i.e. contraction, throat and divergent section, which creates differences in cross section areas of a tube or pipe. This difference in cross section areas results in pressure difference in each region of venturi. Based on the Bernoulli and Venturi principles, the wind speeds will increase depending on the difference in cross sections. Since the only energy injected in the system is wind, and mass flow and energy balances, it is the pressure energy that is converted to additional kinetic energy [1]. This process allows the WTG installed in the Venturi section to have access to much larger kinetic energy of the wind, and thus be able to generate same or more power using smaller turbines[1].

The world's energy demands are ever increasing (figure 1), and so the demand for more reliable and efficient wind turbine systems are also increasing. The clean energy trend that started mainly in the United States and Europe is now spreading to countries all over the world with millions of watts of clean energy being supplied to large cities ( figure 2).

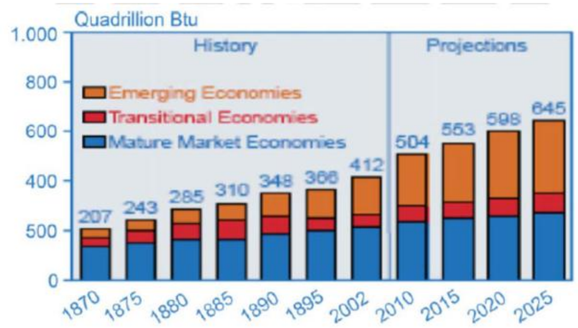



Fig. 1. World Energy Demand Growth[10]

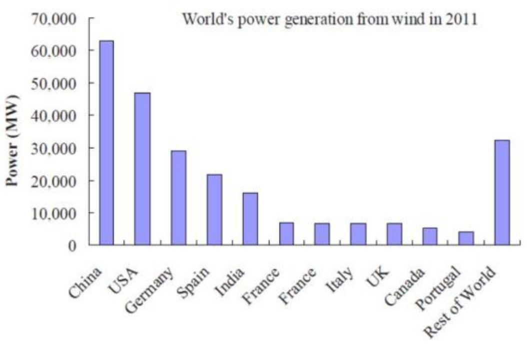



Fig. 2. Top Ten Wind Power Generating Countries by December, 2011[10]

## II. VENTURI EFFECT

The Venturi effect is named after Giovanni Battista Venturi (1746–1822), an Italian physicist. An equation for the drop in pressure due to the Venturi effect may be derived from a combination of Bernoulli's principle and the continuity equation.

$P + \frac{1}{2} mV2 + \rho g\, h = \text{constant}$

(1)

Using Bernoulli's equation in the special case of incompressible flows (such as the flow of water or other liquid, or low speed flow of gas), the theoretical pressure drop at the constriction is given by:

$P1 - P2 = \rho/2 * ((V)^2 2 - (V)^2 1)$

(2)

And,

$A1 * V1 = A2 * V2$

(3)

Where:

A = area, V = velocity,

ρ = density of fluid, g = acceleration constant,

h = height, P = fluid pressure.

The acceleration of the airflow was achieved with the use of a converging duct. This is illustrated in the diagram of Fig.1.

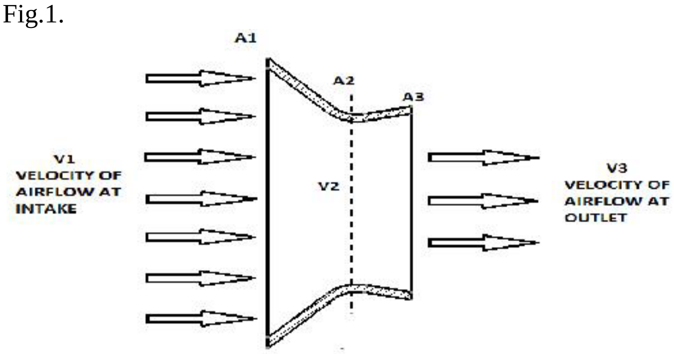



Fig.4: Illustration of the venturi maintaining continuity equation

Therefore,

$V2 = (A1 * V1)/A2$ (4)

$V2 = [(\pi/4) * (D1)^2 * V1] / (\pi/4) * (D1)^2$

(5)

For all wind turbines, wind power is proportional to wind speed cubed. Wind energy is the kinetic energy of the moving air. The kinetic energy of a mass m with the velocity V is,

$Ekin = \frac{1}{2}\, m\, V2$

(6)

The mass of air, m can be determined from the air density ρ and the air volume V according to,

$m = \rho\, V$

(7)

Then, $Ekin,\ wind = \frac{1}{2}\, \rho\, V\, V2$

(8)

Power is energy divided by time. Considering a small time, Δt, in which the air particles travel a distance s = v Δt to flow through. Multiplying the distance with the rotor area of the wind turbine, At, resulting in a volume of

$\Delta V = At\, V\, \Delta t$

(9)

Which drives the wind turbine for the small period of time. Then the wind power is given as,

$P\ wind = kin\ wind / \Delta t = \Delta V \rho V^2/2\, \Delta t = \rho A t V^3/2$

(10)

The wind power increases with the cube of the wind speed. According to the venturi effect as discussed earlier in this paper that high velocity zone is the throat area. Hence the turbine was mounted in this zone to utilize the high kinetic energy. Fig. 2 showing turbine blade inserted into throat area of venturi.

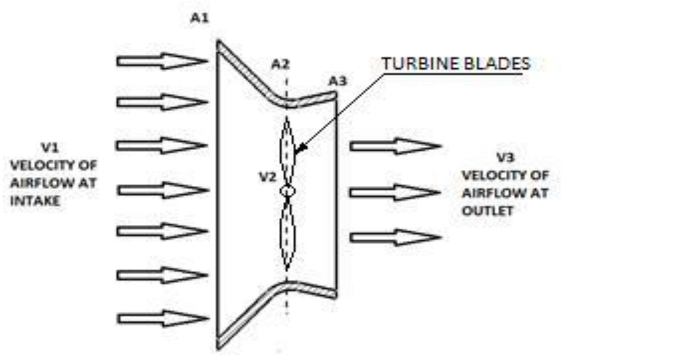



Fig.3: Turbine blade inserted into throat area of venturi

## III. VENTURI DESIGN AND MODELLING

The venturi is modelled in CATIA V5 as per the existing design by I.H. Al-Bahadly and A.F.T. Petersen [2] with modified curves.

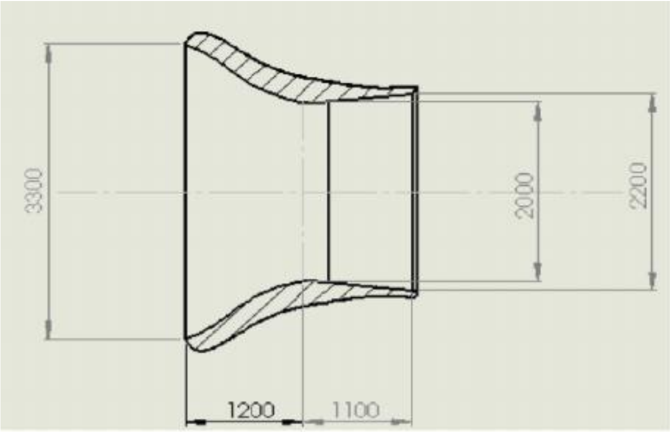



Fig.5: Turbine blade inserted into throat area of venturi [2]

The velocity of air at throat section is,

V2 = [ (π/4) * D12 * V1] / (π/4) * D12
 = [ (π/4) * 332 * 4] / (π/4) * 332
V2 = 10.89 m/s

The velocity of air at exit is,

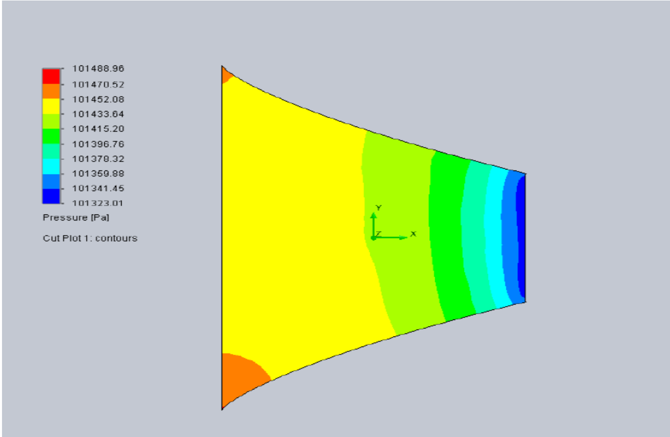
V3 = [ (π/4) * D22 * V2] / (π/4) * D22
 = [ (π/4) * 202 * 10.89] / (π/4) * 202
V2 = 9 m/s

## III. ANALYSIS OF VENTURI

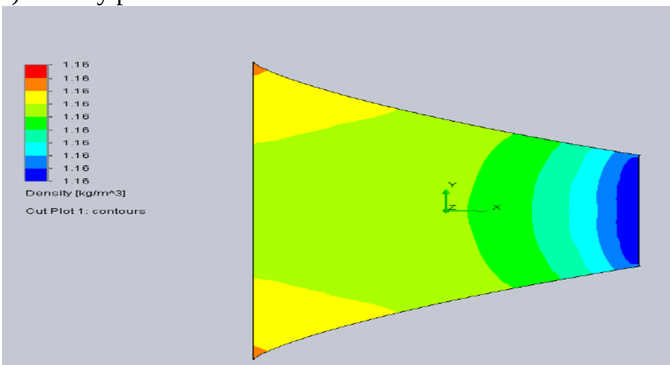
Solid work techniques are used to study the behavior of air flow through venturi with and without turbine. Conditions are considered as per International Standard Atmosphere (ISA) and Normal Temperature and Pressure (NTP) conditions. Inlet velocity was taken as 4 m/s in X direction. The Solid work analysis was carried out on venturi without turbine. Fig. 4 and 5 shows velocity, pressure zones. As stated earlier that the velocity would increase at throat section indicated by red color and its magnitude was shown by scale. Similarly in pressure profile, it decreases in throat area shown in fig. 5.

Solid work analysis on with turbine blades was carried to determine exact velocity available on turbine blades and their results are shown in fig. 6 and 7 with velocity and pressure plot respectively. In both the cases, a low pressure region was created in upper part of diffuser end which is responsible to draw more air from venturi. Its results increment in velocity throughout the venturi section.

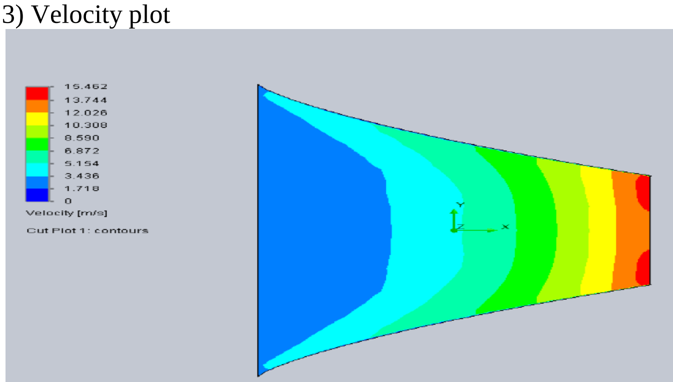
1) Pressure plot



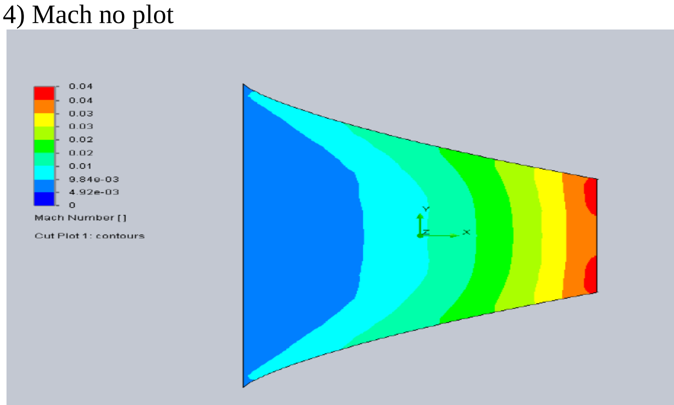

2) Density plot



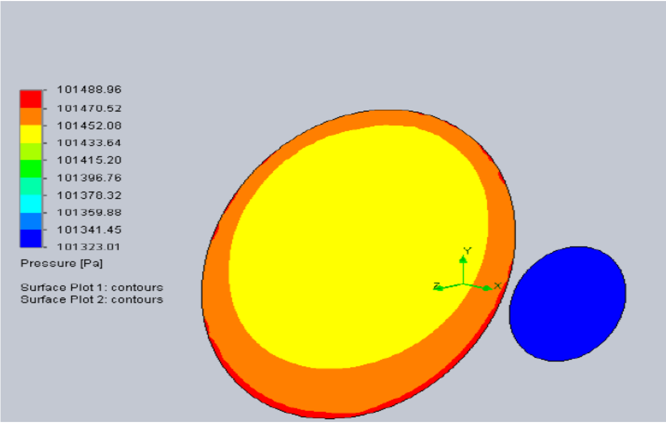

3) Velocity plot



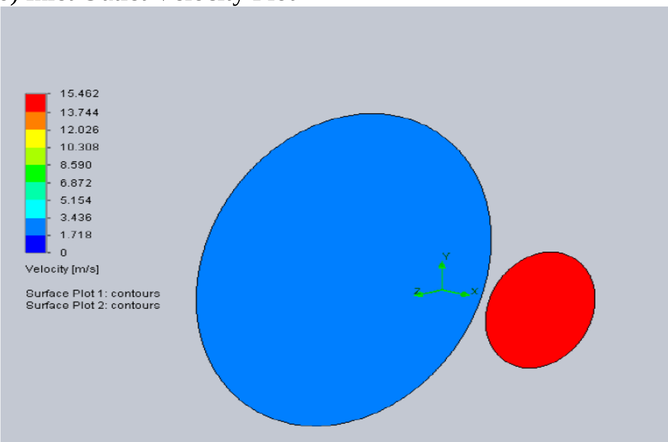

4) Mach no plot



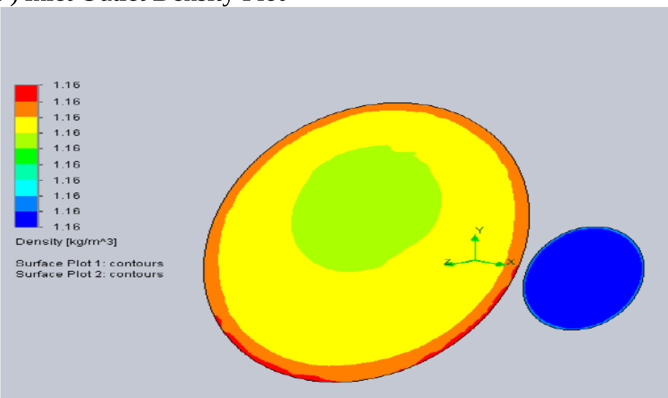
5) Inlet Outlet Pressure Plot



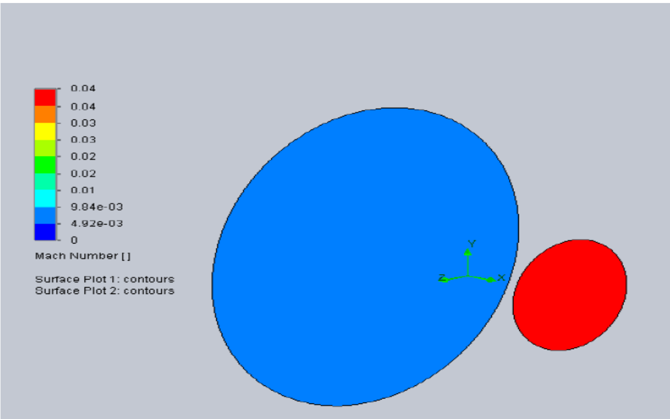

6) Inlet Outlet Velocity Plot




7) Inlet Outlet Density Plot




8) Inlet Outlet Mach No Plot




## IV. RESULT & DISCUSSION

Fig. 9 and 10 shows the velocity and pressure profiles respectively at a cross sectional area inside the *Venturi*. It was noted that the average velocity was raised to more than 7 m/s, while the maximum velocity was increased to

**V.** MORE THAN 9 M/S, SPEED RATIO OF MORE THAN 2.25

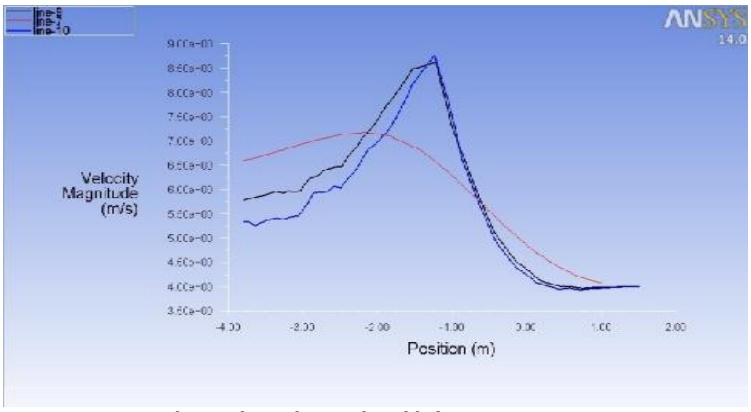



Fig.9: Velocity plot without turbine blades

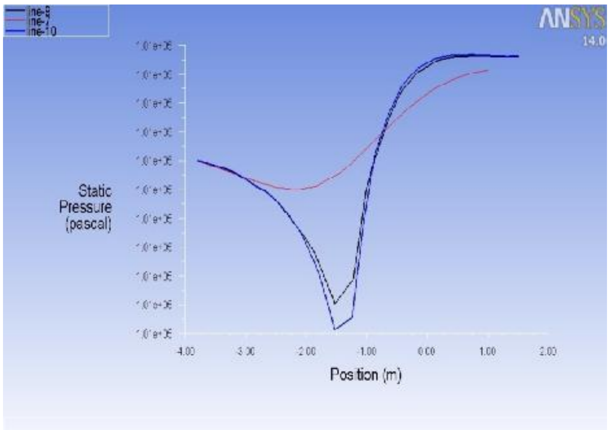



Fig.10: Static Pressure plot without turbine blades

The accurate result can be obtained by introducing the turbine blades into the venturi. Fig.11 and 12 shows velocity and pressure plots. Here the average velocity obtained was more than7 m/s and maximum was 9.75m/s

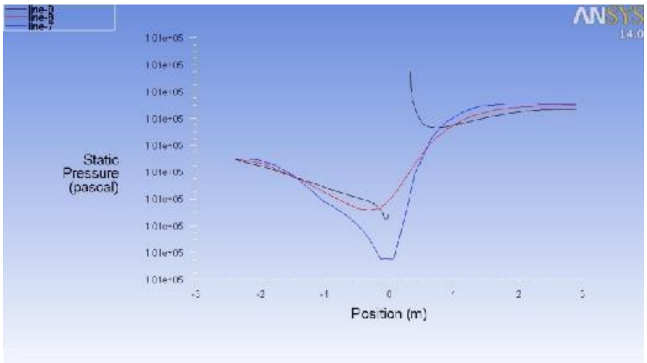



Fig12: Static pressure plot with turbine blades

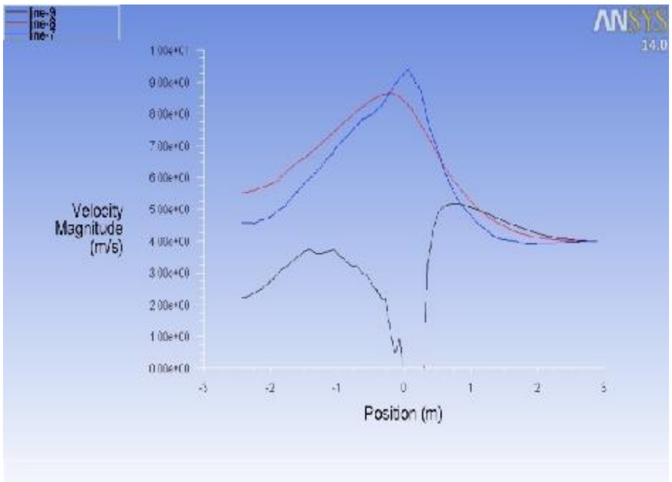



Fig.11: Velocity plot with turbine blades

## V.CONCLUSION

The exiting design of venturi was utilised for wind study. The results from solid work analysis are found nearly same as the analytical calculations. The result shows that the average velocity in the venturi section was found to be 1.75 times, whereas maximum velocity achieved was 2.5 times of inlet velocity of air. Since power is proportional to cubic power of wind speed, 60% increase in wind speed, means power output is increased by 5 times.

## ACKNOWLEDGEMENT

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