Economic Windmill by Using Venturi Effect

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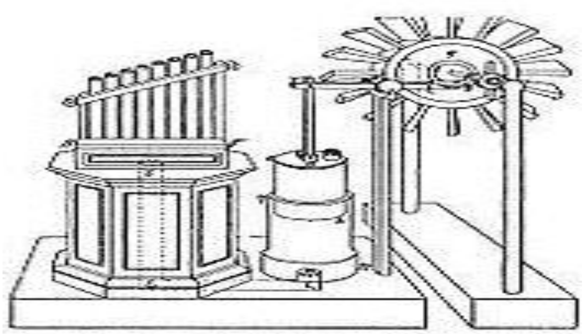
Abstract- **Today electricity plays a vital role in all fields .The main scope of our project is to overcome the difficulties in existing windmills. The propeller rotation depends on the velocity of wind flow in the environment. But in our project, the propeller rotation is increased four times for the wind velocity in the surroundings. In fluid dynamics, a fluid's velocity must increase as it passes through a constriction in accord with the principle of continuity, while its static pressure must decrease in accord with the principle of conservation of mechanical energy. Thus any gain in kinetic energy a fluid may accrue due to its increased velocity through a constriction is balanced by a drop in pressure. Thus, the power is generated.**

INTRODUCTION

1.WINDMILL

A windmill is a mill that converts the energy of wind into rotational energy by means of vanes called sails or blades. Centuries ago, windmills usually were used to mill grain, pump water, or both. Thus they often were gristmills, wind pumps, or both. The majority of modern windmills take the form of wind turbines used to generate electricity, or wind pumps used to pump water, either for land drainage or to extract groundwater.



The wind wheel of the Greek engineer Heron of Alexandria in the first century AD is the earliest known instance of using a wind-driven wheel to power a machine.

TYPES OF WIND MILL

1.Horizontal windmills

These windmills were used to grind grain or draw up water, and were quite different from the later European vertical windmills. Windmills were in widespread use across the Middle East and Central Asia, and later spread to China and India from there.

2.Vertical windmills

ECONOMIC WINDMILL

The study also found that having each VAWT spin in the opposite direction of its neighbor allowed them to spin faster because the opposing spins reduced the drag on each turbine , which upped their efficiency even more.

So we are choose the vertical axis wind mill. Then some modification are created our new ideas. In this type of wind mill is newly added to a venturi effect. And total area is enclosed. There is opposing force on the wind blade is neglected. And propeller rotation speed is four times efficient to the other wind mills. Then steering system is fully neglected in this type of wind mill.

DIMENSIONS OF ECO-FRIENDLY WIND MILL

1.Main nozzle
Top length – 250mm
Bottom length – 200mm
Radius of arc – 365mm
Side length – 250mm
Height – 350mm

2.Venturi effect
1. Convergent nozzle
Diameter – 200mm, Height – 150mm, Radius – 100mm
Angle – 0.349 rad = 20 degree

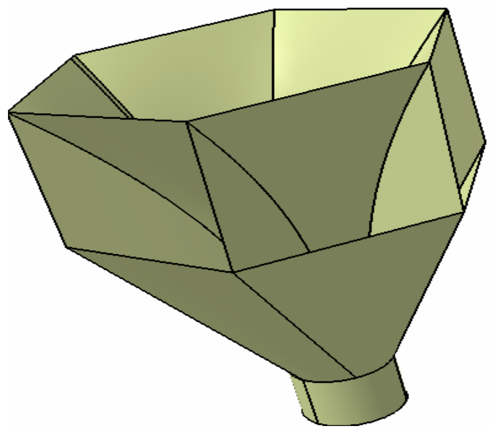
3.Throat part
Diameter – 100mm
Height – 150mm
Length – 314mm

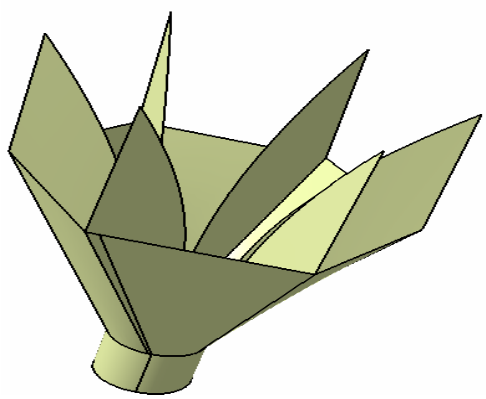
4. Outlet diffuser
Diameter(D) – 200mm
Height – 100mm
Length – 141.5mm
Angle – 0.105 rad = 6 degree

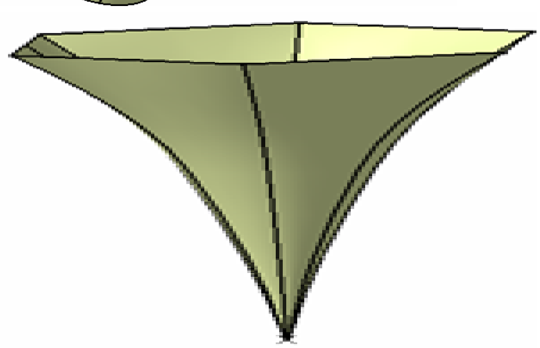
3. Angular dimensions
1.angle of convergent part = 20°-30°
2.angle of divergent part = 5°-10°
3.throat diameter = throat length
4.air collector diameter =diameter of exit section of divergent part
5.area ratio(n) = $(d/D)^2$ = 0.05 to 0.55

CONSTRUCTIONAL DETAILS OF ECONOMIC WINDMILL

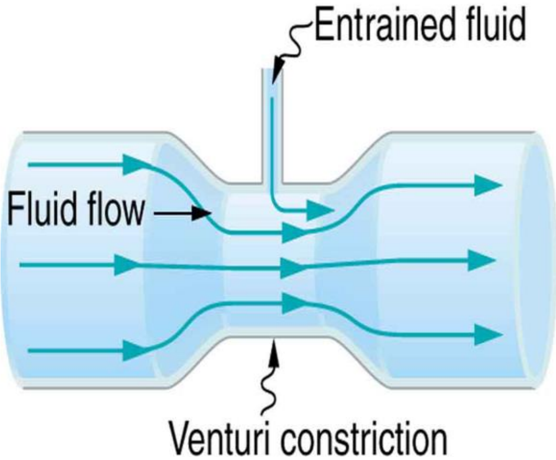
1. STRUCTURAL COMPONENT
1.Main nozzle – sheet metal
2.Convergent nozzle – sheet metal
3. Throat part – sheet metal
4.diffuser – sheet metal
5.propeller – sheet metal
6.Electric generator – 40W
.





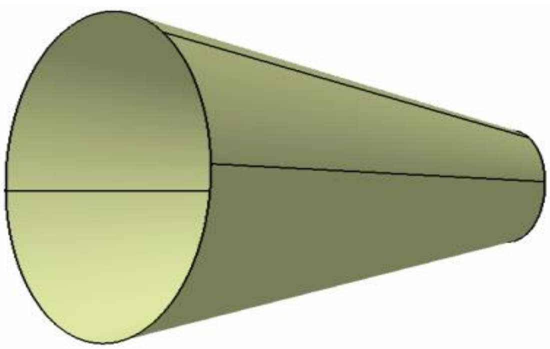


2. Venturi effect



a)Convergent nozzle

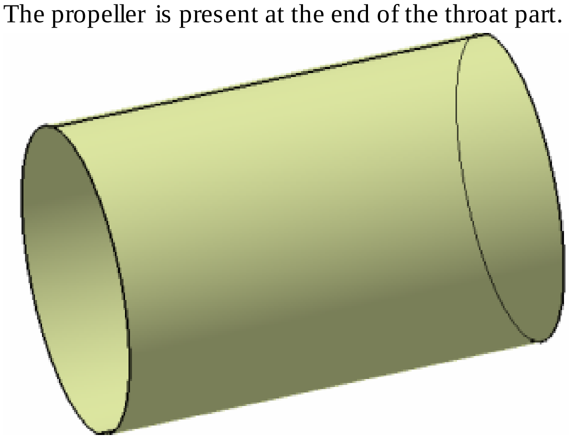
the velocity increases with the corresponding drop in pressure.



b)Throat part

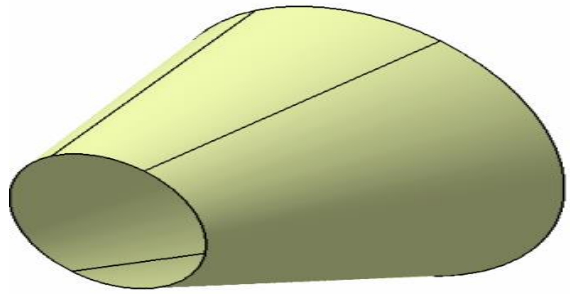
It is used to maintain the high velocity air from the outlet of convergent nozzle constantly till the diffuser.

The propeller is present at the end of the throat part.



c)Outlet diffuser

It is used to decrease the wind velocity before releasing the wind to the environment.



WORKING PRINCIPLE

When the wind blows, it enters the main nozzle. The function of main nozzle is to collect the air from any direction. Though the direction of wind changes, the main nozzle collects it and sends it to the collector tank.After passing through the main nozzle, the velocity of air is slightly increased. It flows to the throat part through convergent nozzle.

In convergent nozzle, the velocity of the air is increased rapidly. In throat part, due to venturi effect pressure is reduced and the velocity is increased.I The high velocity air makes the propeller rotates. Which in turn rotates the propeller shaft and goes out through diffuser. The diffuser reduces the velocity of the wind.

Propeller is connected to the generator. Hence, the electricity is produced in the generator. This electric power is stored in the battery(lead-acid).Lead-acid batteries are the most dependable form of energy storage, since they can go through thousands of cycles, charging and discharging, without much deterioration.

BY USING VENTURI EFFECT

- The venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section of pipe

- The venturi effect is a jet effect; as with a funnel the velocity of the fluid increases as the cross sectional area decreases, with the static pressure correspondingly decreasing.

DESIGN & CALCULATION

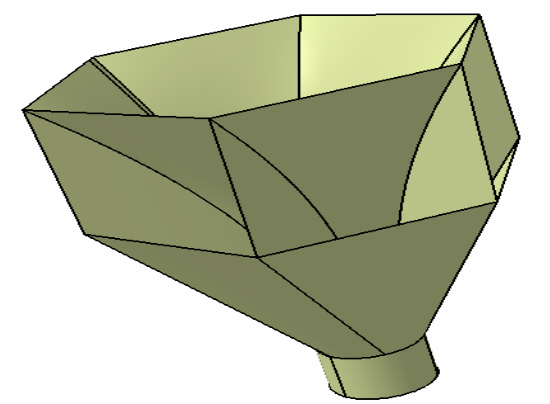
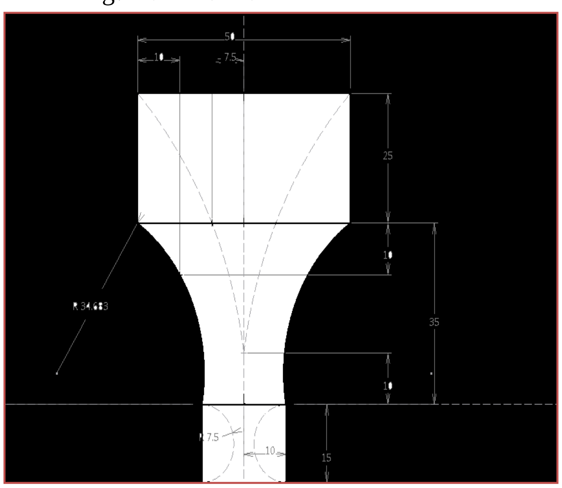
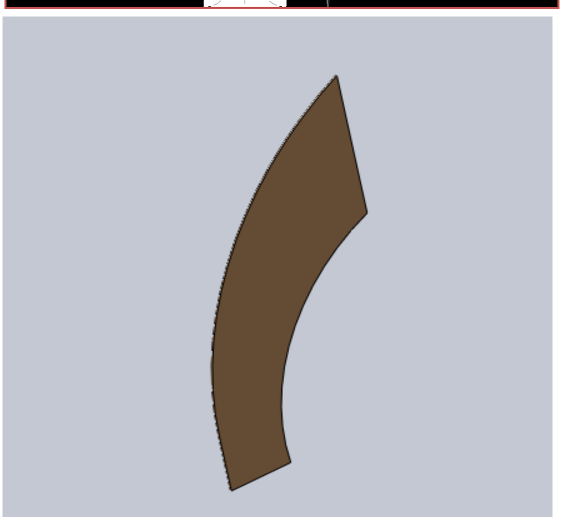
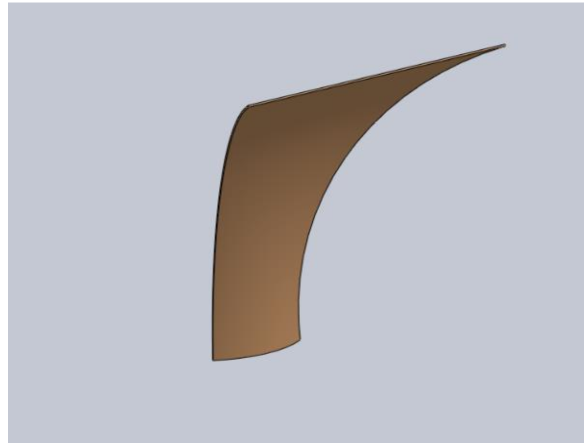


Fig: main nozzle



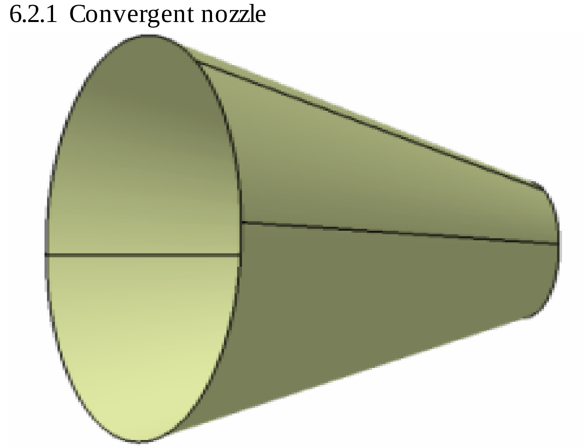




Top length – 250mm
Bottom length – 200mm
Radius of arc – 365mm
Side length – 250mm
Height – 350mm

6.2 venturi effect
1. Convegent nozzle
2. Throat part
3. Outlet diffuser

6.2.1 Convergent nozzle



1. Diameter – 200mm
2. Height – 150mm
3. Radius – 100mm

FOMULAE:

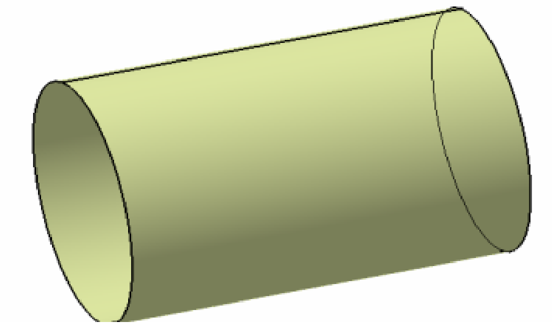
$L=\sqrt{R^2+H^2}$

$L=165.5mm.$

$\theta=(R/L)\times 360^{\circ}$

$\theta=152.5^{\circ}$

6.2.2 Throat part



1. Diameter – 100mm
2. Height – 150mm

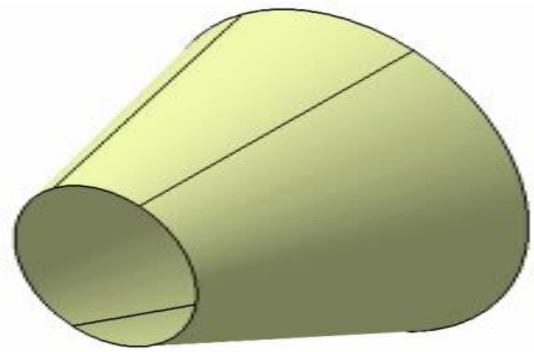
FORMULAE:

$L=3.14\times D$

$L=3.14\times 100$

$L=314$mm.

6.2.3 Outlet diffuser



1. Diameter – 200mm
2. Height – 100mm

FORMULAE:

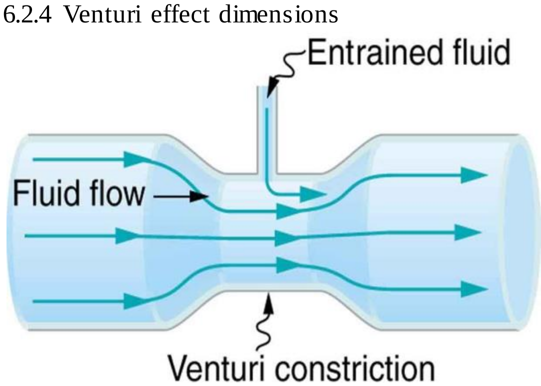
$L=\sqrt{R^2+H^2}$

$L=141.5$mm.

$\theta=(R/L)\times 360^\circ$

$\theta=254.42^\circ$

6.2.4 Venturi effect dimensions



1. Angle of convergent part = 20° - 30°
2. Angle of divergent part = 5° -10°
3. Throat diameter = throat length
4. Area ratio (n) = $(d/D)^2$ = 0.05 to 0.55
5. Air collector diameter = diameter of exit section of divergent part

6.3 analysis calculations (theoretical)

6.3.1 Available power

1. Available wind power

P = (½) mUm2 Watts

Where

Density = 1.225 kg/m^3 (at sea level)

U_m = 4.474 mile/hour = 2m/s(assume)

(2.237mile/hour = 1m/s ; 1mile/hour = 1.61Km/hour)

Conventional wind mill *(small-sized horizontal axis wind turbine)*:

(C_{pmax} = 0.59(based on bet'z limit)

(Betz Limit with

Values of 0.35-0.45 common even in the best Designed wind turbines)

U_m = 2 m/s (at low speed)

$= (1/2)\times\pi\times\rho\times r^2\times Um^3$ ($m=\rho Av$)

$= (1/2)\times 1.225\times\pi\times r^2\times U_m^3$

$= (1/2)\times\pi\times 1.225\times 0.216^2\times 7.2^3$

P_a = 33.51W (not including C_p value)

P_a = 13.41W (including C_p value)

m = mass flow rate (kg/s)

Um = wind speed (km/hour)

A = area of the propeller

Data:

Convergent part diameter (d1) = 200mm = 0.2m

Divergent part diameter (d2) = 100mm = 0.1m

Pressure at inlet (at sea level) = 1.0133bar = 1.0133×105n/m2 (international standard atmosphere)

Temperature at inlet (at sea level) = 288.2K (international standard atmosphere)

Density of air (at sea level) = 1.225Kg/m3 (international standard atmosphere)

Ratio of specific heats = 1.4 (perfect gas)

1. Max mass flow rate

[Mmax (T0)1/2]/ [A*P0] = (2/r+1)(r+1)/2(r-1)

For SI units,(R = 287Nm/Kg-K & r = 1.4

[Mmax (T0)1/2]/ [A*P0] =0.0404

Mmax= {0.0404×[(π/4)×0.12]×1.0133×105}/{(288.2)1/2}

Mmax= 1.894Kg/s

2. Mass flow rate

M = ρi×Ai×ci = ρt×At×ct = ρe×Ae×ce

= 1.225×2×(π/4)×0.22 (at low speed)

M= 0.0769Kg/s

3. Pressure, velocity at throat
T01= T1+(c12/2cp) = 288.2 + 22/(2×1005)
T01 = 288.202K
T1/ T01 = 288.2/288.2019 = 0.999
Refer isentropic flow (gas tables),
M1=0.05 ; p1`/p01 = 0.998 ; A1/A01 = 11.592
P01= 0.998/1.0133 = 1.0153bar
A1/A01 = 11.592; A02 =A 01
A2/A02 = 2.8988
Refer isentropic flow,
P2/ P02= 0.973; P01 = P02
P2 = 0.9878bar
A1 c1 = A2 c2
A1= 0.0314m2
A2= 7.85×10-3m2
Then,
C2= 0.0314×2×7.85×10-3
C2= 8m/s
Um = 8 m/s
= (1/2) ×π×1.225×r2×Um3
= (1/2)×1.225×π×28.83×0.09752
Pa = 436.96W (no considering any losses)

2.performance of wind mill [practical]
Coefficient of performance:
Kp = power delivered by the rotor/maximum power available in the wind.
Kp = P/Pmax
p = 10 W
Pmax = 13.33 W
Kp = 10/13.33
Kp = 0.75

1. Available wind power (HAWM)
P = (½)mU_m^2 Watts
Where,
Density = 1.225 kg/m^3(at sea level)
U_m = 4.474 mile/hour = 2m/s(assume)
(2.237mile/hour = 1m/s ; 1mile/hour = 1.61Km/hour)
m = 0.0769Kg/s

a)High speed
P = (½)mU_m^2 Watts
= 0.5×0.769× U_m^2
= 16.55 w

b) Medium speed
P = (½)mU_m^2 Watts
= 0.5×0.769× U_m^2
= 10.78 w

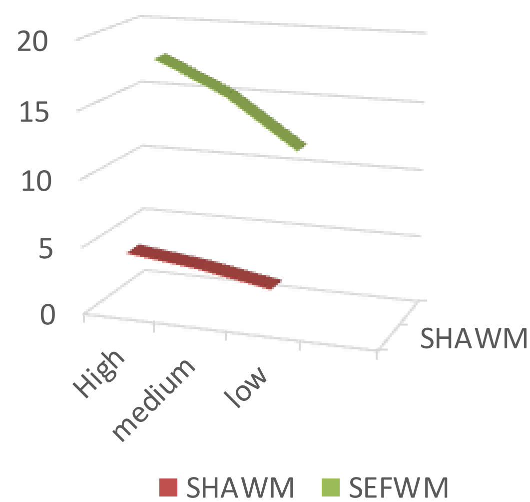
c) low speed
P = (½)mU_m^2 Watts
= 0.5×0.769× U_m^2
= 4.79 w

2.Available wind power (EFWM)

a)High speed
P = (½)mU_m^2 Watts
= 0.5×0.769× U_m^2
= 958.55 w.

b) Medium speed
P = (½)mU_m^2 Watts
= 0.5×0.769× U_m^2
= 617.386 w

c) low speed
P = (½)mU_m^2 Watts
= 0.5×0.769× U_m^2
= 274.49 w



CONCLUSION

The main scope of our project is to overcome the difficulties in existing windmills. Some of the difficulties of existing windmills. The propeller rotation depends on the velocity of wind flow in the environment. But in our project, the propeller rotation is increased four times for the wind velocity in the surroundings. So, save electricity and save life.

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