Journal of Offshore Structure and Technology
ISSN: 2349-8986 (online)
Volume 1, Issue 2
www.stmjournals.com

Anthropogenic Wind Mill

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Abstract
Electricity can also be generated from artificially generated wind using blower. A prototype model can be developed which generates constant power from artificially generated constant flow of wind. Artificially generated air is flown through wind mill which is coupled to an alternator in such a way that constant electricity is generated. This wind mill is called the anthropogenic wind mill (AWM). Anthropogenic is basically a Greek word which means "artificial." This project tries to give that mass flow rate at inlet and outlet are approximately the same, but velocity of air at the outlet is four times of velocity at the inlet.

Keywords: *AWM, KE, CFM, WE*

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INTRODUCTION

Conventional energy source are the burning issue of 21st century. To tap the absolute potential of non-conventional energy source, we must make every effort quite seriously with cooperation and support from scientific community. Among all the options of non-conventional energy sources, wind energy is the cleanest and endless source of energy [1].

This work relates to wind energy in particular, a method for harnessing wind energy to provide power to a load, said method comprising the steps supplying power to a motor; sucking air into a duct; increasing the velocity of the sucked air; converting kinetic energy of the moving air to mechanical energy; converting the mechanical energy to electrical energy, supplying part of the generated electrical energy to the motor; and supplying electrical energy to a load [2].

This paper takes care of deficiency in the prior art and boosts the kinetic energy of the available natural wind in order to have a more efficient device for power generation. Anthropogenic wind mill device does not require any fuel. Only while starting the device, we need electricity for four to five minutes after which the supply can be stopped, and then it runs on its own.

ANTHROPOGENIC WIND MILL MODEL

Figure 1 shows the block diagram of the anthropogenic wind mill as the smart assembly of all equipment. At the front of this wind mill unit air, blower is used which initiates air supply to wind mill at sufficient speed. As per the working principle of blower, it throws air out at high speed; naturally a low-pressure area is developed in the casing of the blower. To fill this vacuum, high pressure air from surrounding area reaches there. As blower is operational continuously, this process also happens on continuous basis with a specific speed. But this speed is not sufficient. To run the wind mill, some auxiliary equipment is used [3].

An air jet is such equipment. Due to its conical shape it not only helps in increasing air pressure and consequently air speed but also gives specific shape to the controllable jet of air. This air jet attachment is fixed at the blower outlet. The combined air from the blower and the air jet is then introduced into the air duct. The swift flow of air pushes the air column which already exists inside the duct. This creates a low-pressure area at the opening of air duct. To reduce deficit of air, high-pressure air from the atmosphere rushes there with great speed [4].

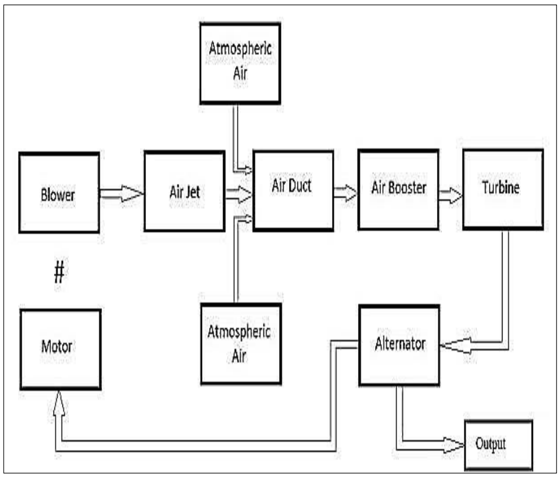

Fig.1: *Block Diagram of Anthropogenic Wind Mill.*

WORKING OF ANTHROPOGENIC WIND MILL

Air current in the atmosphere is a combined effect of solar energy and gravitational force. Heating air at ground level is only contribution of Sun in the entire process, while cold and hot air currents are generated due to gravity only. On this same principle, anthropogenic wind mill converts static energy into kinetic energy with the help of collective effort of electrical energy and gravitational force. As per working principle of today's wind mill, kinetic energy of wind is converted into mechanical energy with the help of wind mill unit and then mechanical energy is converted into electrical energy by the generator as shown in Figure 2. More is the speed of wind that kinetic energy available is converted into power. How much energy a wind mill can generate is determined with the help of this formula [5]:

Wind energy = 1/2 × air density × area of circle in which turbine blades rotate × (air velocity)^3

The direct relation of wind energy on wind speed is evident. Here, if we double the velocity, the energy output rises eight times, so, for the successful harnessing of wind energy. How much control over wind speed is necessary is very well underlined. Then subsequent question that will be asked is whether it is possible to exercise such control over wind speed or to maintain consistency or increase the same as desired. And every one delights the anthropogenic wind mill. In this whole process, the energy generated by wind mill is sufficiently and viably higher than the energy spent on generating air of specific pressure and specific velocity required for wind mill operation. By changing the parameters of equipment, amount of energy can be easily manipulated as per requirement. An important thing to be noted is that part of enhanced electricity output is again fed as an input to run the wind mill unit sufficiently without depending further upon external source of power supply.

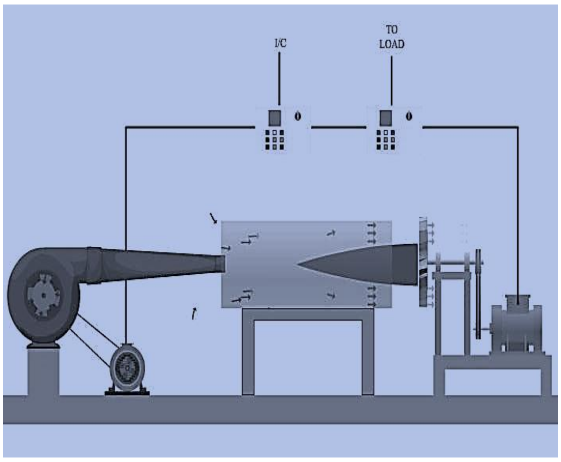

Fig. 2: *Prototype Model of Anthropogenic Wind Mill.*

EXPERIMENTAL SETUP

Wind is a clean source of renewable energy that does not produce air or water pollution. And since the wind is free, once a turbine is erectedoperational costs are nearly zero. Mass production and technology advances are making turbines cheaper, and many governments offer tax incentives to spur wind-energy development.

A wind turbine is a device that converts kinetic energy from the wind into mechanical energy – a process known as wind power [6]. If mechanical energy is used to produce electricity, the device may be called a wind turbine or wind power plant. If mechanical energy is used to drive machinery, such as for grinding grain or pumping water, the device is called a windmill.

Anthropogenic is basically a Greek word which means "artificial." So the name given is "anthropogenic wind mill." Anthropogenic wind mill is a smart assembly of equipment which are electric motor-operated blower, wind jet, air duct, air-speed booster, and electric generator. Figure 3 shows an anthropogenic wind mill.

Fig. 3: *Anthropogenic Wind Mill.*

Main Parts of a wind mill are:
1. Electric motor operated blower
2. Wind jet
3. Air duct
4. Air-speed booster and alternator are discussed in detail in the following section.

A. Electric Motor-Operated Blower

Blower is a mechanical device which takes air from inlet and discharges it through the outlet. It takes some amount of mass of air from one side (inlet) and discharges the exactly same amount of air to the other side (outlet). An electric operated blower is shown in Figure 4. Air blower is used which initiates the air supply at sufficient speed to wind mill. As per working principle of blower, it throws air out at high speed and naturally the low-pressure area is developed in the casing of the blower. To fill this vacuum, high-pressure air from the surrounding area reaches there. As blower is in operation continuously, this process also happens on continuous basis with specific speed [7].

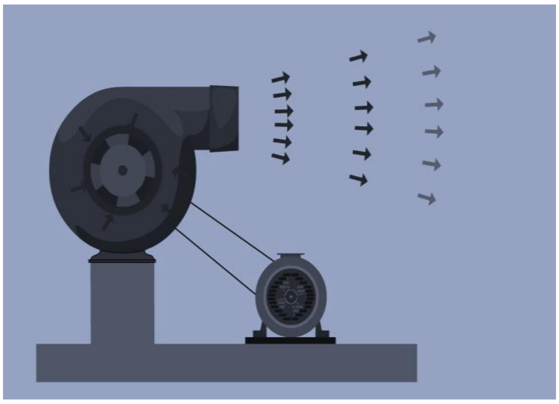

Fig. 4: *Electric Motor Operated Blower.*

B. Wind Jet

Wind jet or air jet equipment having conical shape helps in increasing air pressure. It increases air speed and gives specific shape and controllable jet of air. The position of air jet is after the blower outlet. Figure 5 shows structure of wind jet.

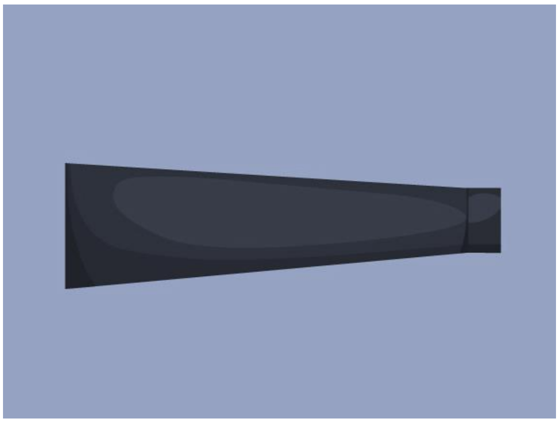

Fig. 5: *Wind Jet.*

C. Air Duct

The combined air which is obtained from blower and air jet is then introduced into the air duct. The air column which already exists inside the duct is pushed due to the swift flow of air from the duct inlet. This creates a low-pressure area at the opening of the air duct. To reduce deficit of air, high pressure air from atmosphere rushes there with great speed.

The speed of air flowing through angular area of duct depends upon the air received from the air jet. Now, due to summation effect the amount of total air flowing through the duct rises significantly. Figure 6 shows the air duct.

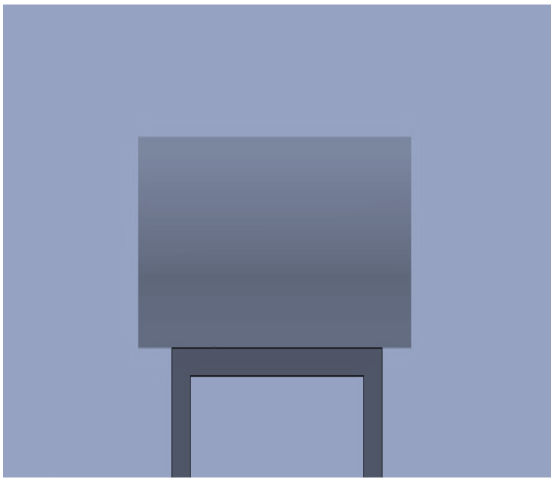

Fig. 6: *Air Duct.*

D. Air Speed Booster and Alternator
The air booster throws out the speed air from duct on to the turbines with great control and increased velocity. An alternator is an electromechanical device that converts mechanical energy to electrical energy in the form of alternating current. Wind turbines pick up motion and power generated by converting this mechanical energy into electrical energy with the help of generator. Figure 7 shows assembly of air-speed booster and electric generator.

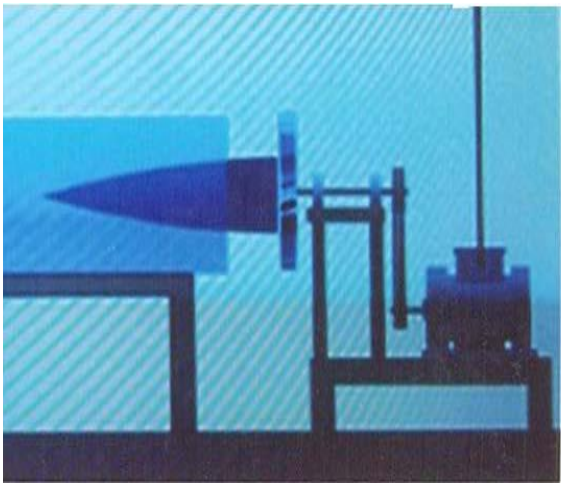

Fig. 7: *Air Speed Booster and Alternator.*

CALCULATION OF BLOWER

Notations

A_{in} = Inlet area of blower (m^2)
A_{out} = Outlet area of blower (m^2)
V_{in} = Velocity of flow at inlet (m/s)
V_{out} = Velocity of flow at outlet (m/s)
ρ = Density of air (kg/m^3)
Q_{in} = Volume flow rate at inlet (m^3/s)
Q_{out} = Volume flow rate at outlet (m^3/s)
$(K.E)_{out}$ = Kinetic energy rate at outlet(J/s)

Following data are used for calculation of power required to drive the blower.
CFM = Cubic feet per minute
Volume flow rate = 35000 CFM
Static pressure = 3inches of WC
Fan efficiency = 60%
Efficiency of motor = 90%

The power required to drive the blower can be calculated using the formula [8]:
Motor Hp = CFM × static pressure (inches of WC)/6362 × fan efficiency
Type of impeller used is backward inclined curved

= 27.507 Hp

As the efficiency of motor is 90%, by considering efficiency of motor the additional power required is:

0.1 × 27.507 = 2.75 Hp

Hence the total motor Hp required is:
Total motor Hp = 27.507 + 2.75
= 30.2577 Hp

The standard motor available in the market is 30 Hp which is closer to the experimental setup requirement; hence we have selected 30 Hp

Inlet and outlet diameters of the blower are primary variables which can be designed as per the energy output desired. The parameters are given in Table 1.

Table 1: *General Parameters of Blower.*

S. No.	Description	Size (m)	Corresponding area (m^2)
1	Blower inlet diameter	0.925	0.67
2	Blower outlet diameter	0.455	0.16

Experimental Results Obtained from Blower

The inlet area of the blower is 0.67 m^2 which is considerably large to measure readings with anemometer so to obtain the total mass flow rate at inlet of the blower, the authors have divided the total area of suction into number of concentric rings (areas are given in Table 2) and the mass flow rate at each ring has been measured at various locations and then added the entire mass flow rate to calculate the total mass flow rate at inlet.

Table 2: *Ring Area.*

Ring	R1	R2	R3	R4	R5	R6
Area (in m^2)	0.01	0.05	0.09	0.13	0.16	0.20

Two cases are considered below for measurement of flow at inlet of blower.

Case 1: Velocity and Volume Flow Rate at Inlet

When nozzle is absent: Velocity of flow rate at inlet without nozzle for six rings and for four different locations. Flow rates are measured using anemometer at different locations as shown in Table 3.

Fig. 8: *Blower Inlet without Nozzle.*

Table 3: *Velocity of Flow Rate at Inlet without Nozzle.*

Ring/Position	Different location velocity of flow (in m/s)				
	1	2	3	4	Avg.
R1	32.5	32.5	31.7	32.4	32.52
R2	30	31	30.7	30.2	30.47
R3	30	29.3	28.7	30	29.5
R4	27.5	27.4	26.2	27.3	27.1
R5	25.2	26	24.5	24.4	25.025
R6	20.5	22.3	21.4	20.6	21.2
	Average velocity at inlet = 25.545 m/s				

Volume flow rate Q = Area of cross section × Velocity of flow
= A × V

Flow rate through ring 1 = Area of ring 1 × Velocity of flow at ring 1
$= A_1 \times V_1$
$= 0.01863 \times 32.52$
$= 0.60572\ m^3/s$

Following the same step, volume flow rates are calculated for other rings. Table 4shows the volume flow rate at inlet without nozzle for all rings.

Case 2: Velocity and Volume Flow Rate through Blower Inlet when Nozzle is Present

In another case, velocity and volume of flow rate is measured when nozzle is present. Table 5 shows velocity of flow rate for six rings at four different locations.

Table 4: *Volume Flow Rate at Inlet without Nozzle.*

Ring	Area	Velocity of flow (m/s)Avg.	Volume flow rate (m^3/s)
R1	0.01863	32.52	0.60572
R2	0.05588	30.47	1.70266
R3	0.09313	29.5	2.74745
R4	0.13036	27.1	3.5327
R5	0.16766	25.025	4.1957
R6	0.20489	21.2	4.3436
			Total volume flow rate = 17.127

Table 5: *Velocity of Flow Rate at Inlet with Nozzle.*

Ring/Position	Different location velocity of flow(in m/s)				
	1	2	3	4	Avg.
R1	20.2	20	19.8	19.7	19.9
R2	19.5	19.3	19.2	19	19.2
R3	18.8	18.5	18.4	18.1	18.4
R4	17.9	17.5	17.3	17	17.4
R5	16.6	16.4	16.2	16	16.3
R6	15.8	15.6	15.4	15	15.4
Total	Average velocity at inlet = 17.76 m/s				

Fig. 9: *Blower Inlet with Nozzle.*

Flow rate through ring 1 = Area of ring 1 × Velocity of flow at ring 1
$= A_1 \times V_1$
$= 0.01863 \times 23.15$
$= 0.4312\ m^3/s$

Mass flow rate of air at
inlet = $m_{air} = A_{ring} \times V_{ring} \times \rho_{air}$
$= 0.67 \times 17.76 \times 1.083$
$= 12.88$ kg/s

Following the same step, volume flow rates are calculated for other rings. Table 6 shows the volume flow rate at inlet with nozzle for all rings.

Table 6: *Volume Flow Rate at Inlet with Nozzle.*

Ring	Area	Velocity of flow (m/s) Avg.	Volume flow rate (m^3/s)
R1	0.01863	23.15	0.4312
R2	0.05588	22.07	1.2333
R3	0.09313	21.3	1.9837
R4	0.13036	19.5	2.542
R5	0.16766	18.325	3.0724
R6	0.20489	15.525	3.1809
			Total volume flow rate = 12.44

Velocity and volume flow rate through blower inlet when nozzle is present is given in Table 6. Blower is a mechanical device which takes air from inlet and discharges it through the outlet.

It takes some amount of mass of air from one side (inlet) and discharges the exactly same amount of mass of air to the other side (outlet). As there is no accumulation of mass or addition of mass, the flow is considered to be incompressible.

By applying continuity equation,
Volume flow rate at inlet = volume flow rate at outlet.

$$Q_{in} = Q_{out}$$
$$A_{in} \times V_{in} = A_{out} \times V_{out}$$

Therefore,
Velocity of flow at
outlet = $V_{out} = A_{in} \times V_{in}/A_{out}$
$= 0.67 \times 17.76/0.16$
$= 74.37$ m/s
The kinetic energy rate available at outlet,
$$(K.E)_{out} = 1/2 \times \rho \times A_{out} \times V_{out}^3$$
where,
ρ = Density of air
A_{out} = Outlet area of blower
V_{out} = Velocity of flow at outlet.

Wind energy = ½ × air density × area of circle in which turbine blades rotate × (air velocity)^3
$= ½ \times 1.18 \times 0.16 \times 74.37^3$
$= 38829.8165$ J/s
Wind energy = 38829.8165/746
= 52 Hp

Static pressure at outlet of blower is equal to the atmospheric pressure. The kinetic energy rate available at outlet is greater than the energy consumed by the motor to drive the blower (30 Hp).

Calculation of Anthropogenic Wind Mill

Table 7: *Parameters of Wind Mill.*

Description	Size	Cross-sectional area
Blower inlet diameter(di)	0.925 m	0.67 m^2
Blower outlet diameter(do)	0.455 m	0.16 m^2
Duct diameter(D)	2.875 m	6.49 m^2
Air booster diameter(db)	2.3 m	4.15 m^2
Annular area at suction(Ai)	$6.49\ m^2 - 0.16\ m^2 = 6.33\ m^2$	
Annular area at outlet(Ao)	$6.49\ m^2 - 4.15\ m^2 = 2.34\ m^2$	

By the practical experiment, we found that inlet velocity of air entering through annular area of the duct is 20% of the blower outlet velocity.
Velocity at Ai = 0.2×74.37
$= 14.874$ m/s
With this, we can calculate mass flow rate sucked into the duct through annular area
$$m = \varrho \times Ai \times V$$
$$m = 1.23 \times 6.33 \times 14.874$$
$$m = 115.80 \text{ kg/s}$$
Total mass flow rate of air passing through the air duct is summation of mass flow rates passing through air jet of blower and mass flow rate sucked into the duct through annular area.
m total = 12.88 kg/s + 115.80 kg/s
= 128.68 kg/s
With this total mass flow rate, we can calculate air velocity passing through outlet annular area of the duct
m total $= \varrho \times A_o \times V$
$128.68 = 1.23 \times 2.34 \times V$
$V = 128.68/(1.23 \times 2.34)$
$= 44.70$ m/s

Kinetic energy in the air at outlet of the air duct:

KE = ½ × m total × V^2

= ½ × 128.68 × 44.70^2 = 128557.1106 J/s

Rated power output can be calculated as:

= ½ × swept area of the turbine × air density × v^3

= ½ × 2.24 × 1.23 × 44.70^3 = 123039.825 J/s

Considering betz's limit available kinetic energy is 60% of the rated power output

= 0.6 × 123039.825 = 73823.8948 J/s

Considering overall efficiency of the anthropogenic wind mill is just 40%

= 0.4 × 73823.8948 = 29529.5579 J/s

= 29529.5579/746

= 39.5 Hp

RESULTS AND DISCUSSION

Table 8: *Results and Discussion.*

S. No.	Parameters	Calculated values
1	Total motor Hp	30.2 Hp
2	Total volume flow rate(without nozzle)	17.127 m^3/s
3	Total volume flow rate(with nozzle)	12.44 m^3/s
4	Wind energy	52 Hp
5	Kinetic energy	128557.110 J/s
6	Output power	39.5 Hp

Results are compared and it shows that the blower operated wind mill system is the best method to extract energy. It is suggested that this scheme is more suitable in practice and to meet the future power demand.

CONCLUSIONS

This work scientifically and experimentally proves that the amount of energy recovered in blower system is feasibly larger than the amount of energy spent on converting static pressure into kinetic energy. Here, we practically conclude that the kinetic energy rate available at outlet of duct is greater than the energy consumed by the motor to drive the blower (30 Hp). Hence, output power available is more than the rated input power required to drive the air blower. It is observed that with certain changes in blower design, more efficient model can be developed and this may be a better option for generation of electricity using artificial wind in future. This will fill the gap between supply and demand.

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