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IMPROVING EFFICEINCY OF WIND POWER GENERATION WITH JET WIND TURBINE

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Abstract

It is becoming necessary to fully understand how to improve wind turbine efficiency, as energy consumption and cost reaches record-breaking levels. The cost of oil and non-renewable resources is skyrocketing, and the depletion of these resources will require a sustainable and environmentally friendly energy source. An improvement to wind turbine efficiency will allow the limits of today to be surpassed, and someday be able to extract all of the energy from the wind with only a few improvements in technology [1]. One such method of improving turbine efficiency is a Diffuser augmented wind turbine (DAWT) as an improvement to the conventional horizontal axis wind turbine (HAWT). DAWTs are simply a HAWT with a trumpet-bell-shaped diffuser surrounding the rotor blades and extending aft. A DAWT is claimed to have a greater efficiency than conventional HAWTs, even possibly higher than the Betz limit, because the diffuser allows for a greater pressure drop across the rotor blade. DAWTs offer additional advantages in addition to increased augmentation, including minimal tip speed losses, and small rotor diameter that increases RPM [2].

Introduction

Wind as an Energy Resource

Renewable energy has become an important topic in recent years because of how fossil fuels affect the environment and how they're being used faster than they are created. One major form of renewable energy is wind. Wind power is growing at a rate of 30% annually, so increasing the potential of the windmill is very important [3].

The working of wind mill is very simple as the air comes in the structure the working blades rotates which is connected to main rotor shaft by the supporting arms the main rotor is coupled to a generator from where we can get the output. The power in the wind can be extracted by allowing it to blow past moving wings that exert torque on a rotor. The amount of power transferred is directly proportional to the density of the air, the area swept out by the rotor, and the cube of the wind speed. The mass flow of air that travels through the swept area of a wind turbine varies with the wind speed and air density. The kinetic energy of a given mass varies with the square of its velocity. Because the mass flow increases linearly with the wind speed, the wind energy available to a wind turbine increases as the cube of the wind speed. As the wind turbine extracts energy from the air flow, the air is slowed down, which causes it to spread out and diverts it around the wind turbine to some extent [4].

The current design of the windmill turbine has three large blades that spin slowly, which spins a shaft, which is connected to a gearbox to increase the rotational speed. Some torque is lost through the use of a gearbox. By increasing the rotational speed of the wind turbine, the gearbox and its torque losses can be eliminated from the design. Using higher density and smaller turbine blades allows for higher rotational speeds and a lower cut-in speed than the current low density three blade designs [2].

This concept of a jet wind turbine was first implemented by the FloDesign Inc., a company dealing with renewable energy production, which is headquartered in the United States of America. FloDesign had modeled a prototype of a jet wind turbine and has tested it under various conditions. Tests were first conducted in the United States and subsequently it was found out that a jet wind turbine has more efficiency than a traditional wind turbine and that it has structural advantages over it as well [2].

Drawbacks of Traditional Wind Turbines

The jet turbine design, which draws on technology developed for jet engines, circumvents a fundamental limit to conventional wind turbines. Typically, as wind approaches a turbine, almost half of the air is forced around the blades rather than through them and the energy in that deflected wind is lost. At best, traditional wind turbines capture only 59.3 percent of the energy in wind, a value called the Betz limit [2].

Present day wind turbines only capture 50% of the air flow, cannot stand high winds, have high building standards, require many trucks to deliver parts for 1 turbine and have to be built tall and away from habitable areas. Due to their large size, the large turbines force air around it instead of through it and during high winds they are usually turned off or break due to their huge slow spinning blades [1].

Principle of Jet Wind Turbine

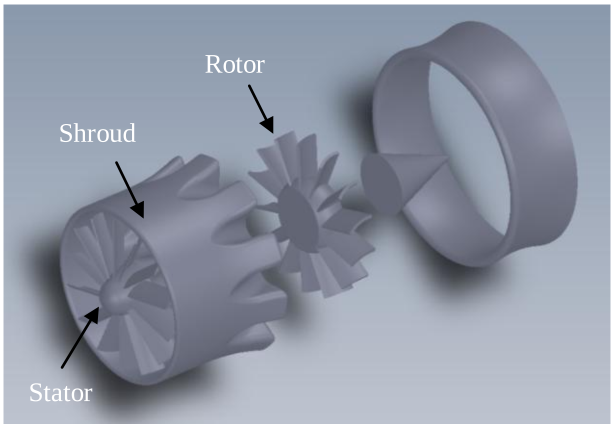

Figure 1: SolidWorks model of Jet Wind Turbine

From the front, the wind turbine looks something like the air intake of a jet engine. As air approaches, it first encounters a set of fixed blades, called the stator, which redirect it onto a set of movable blades--the rotor. The air turns the rotor and emerges on the other side, moving more slowly now than the air flowing outside the turbine. The shroud is shaped so that it guides this relatively fast-moving outside air into the area just behind the rotors. It mixes with the slow moving air, at different angles. The fast-moving air speeds up the slow-moving air, creating an area of low pressure behind the turbine blades that sucks more air through them. Thus a vortex is created at the back of rotor. Due to this, the rotor starts spinning at a faster rate and thus it produces more power [2].

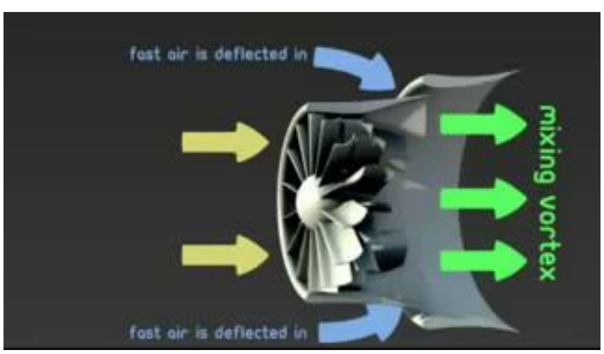

Figure 2. Principle of Jet Wind Turbine [2]

Power Output Calculations

The specifications of our turbine are as follows:
Rotor blades of 10’’ x 6’’
i.e. a rotor blade of 10 inches diameter and 6 mm pitch
Thus, the rotor blade diameter becomes 10 x 25 = 250 mm
Considering wind velocity = 10 m/sec

The power output of any wind turbine is calculated as,
$Pt = \frac{1}{2} * \rho * A * V^3 * Cp$ [3]

Assuming density of air = 1.2 kg/m³
Also, Cp = power coefficient. It considers all the losses in aero turbine, gearing, mechanical coupling and the losses in the generator.

Power output of conventional turbine:

Power, $P = \frac{1}{2} * \rho * A * V^3 * Cp$ [3]

For conventional turbine the value of Cp = 0.35
For a rotor diameter of 250mm, swept area = $(\pi/4) * 0.25^2 = 0.049 m^2$
Thus power produced, $P = \frac{1}{2} * 1.2 * 0.049 * 10^3 * 0.35 = 10.29$ watts

Power output of jet wind turbine:

Power, $P = \frac{1}{2} * \rho * A * V^3 * Cp$ [3]

For jet wind turbine value of Cp = 0.45
For a rotor diameter of 250mm, swept area = $(\pi/4) * 0.25^2 = 0.049 m^2$
Thus power produced, $P = \frac{1}{2} * 1.2 * 0.049 * 10^3 * 0.45 = 13.23$ watts

Thus, by above calculations, we can say that for same specifications, jet wind turbine produces more power than conventional wind turbine.

The power output for various wind velocities is tabulated as follows:

Table 1. Power output comparison

Air velocity (m/s)	Conventional turbine power output	Jet wind turbine power output (watts)	% Increase

	(watts)		
5	1.286	1.653	28.53
7	3.52	4.53	28.69
10	10.29	13.23	28.57
15	34.72	44.65	28.60
20	82.32	105.84	28.57
25	160.78	206.71	28.56
30	277.83	357.21	28.57

From above table, we can conclude that jet wind turbine with our specifications is 28.5% more efficient than conventional wind turbine.

Observations

In the jet wind turbine when the air is approached to stator, it acts as a nozzle that the velocity of wind increases and pressure decreases. Due to this, velocity of airfoil increases rotor spins and produce much power and decreasing pressure results in suction of wind.

With the specifications, which we have used to fabricate the model, earlier we used 10 stators and 4 rotor blades. But due to the 10 stators, the area at the front for passing the air was too less which was restricting the flow. It also resulted into less power generation than desired.

So, the only option available for us was to increase the frontal area, so that maximum air can pass through the turbine. For this, we reduced the number of stators to 4, and we got sufficient open area at front.

For the testing and operation of turbine, we used a moderate capacity blower which gave the air speed of around 9 to 10 m/sec. A dynamo connected to turbine blades at the back-side, gave power output indication on millimeter in terms of voltage and current. The observations were recorded as follows:

Table 2. Readings recorded after observation

Sr. No.	Voltage (volts)	Current (amperes)	Power = V*I
1	10.4	2.2	22.88
2	11.2	2.8	31.36
3	12.5	3	37.5
4	14.8	3.15	46.62
5	15.7	4.2	65.94

Result

Thus, based on the specifications of our turbine i.e. 250mm rotor diameter with 4 stators and 9 to 10 m/sec air speed the average power produced by jet wind turbine is 40 watts.

Conclusion

As electricity is a need of world it is also important thing in our daily life and wind is the cost free source of energy. From the calculations as well as the observations result we can say that, the concept of Jet Wind Turbine is more efficient than conventional turbine and produces 3 to 4 times more power. The efficiency of Jet Wind turbine increases due to its aerodynamic blade shape along with stator that guides wind to increase velocity and decrease the pressure to generate power. Thus the concept of Jet Wind Turbine is simple adequate to remove many drawbacks of conventional wind turbine.

References

[1] Concept of wind turbine based on jet engine; www.howstuffwork.com.

[2] Official Website of Flodesign Inc.; flodesign.org/news/flodesign-vs-flodesign-wind-turbine-fdwt

[3] G.D. Rai, "Non Conventional Energy Sources"

[4] E. H. Lysen: Introduction to Wind Energy, basic and advanced introduction to wind energy, SWD, Netherlands, (1982).

[5] Vishal Salunkhe, Satish G Bahaley; "Design and analysis of Jet Wind Turbine Blades"; International Journal of Mechanical Engineering and Robotic Research, Vol.2, No.3, July 2003

[6]Wind energy conversion systems; www.powertechnology.com.

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Biographies

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