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Design and Analysis of Vertical Axis Wind Turbine

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Abstract: *Energy can neither be created nor destroyed. In the present world energy scenario, the demand for renewable energy sources finds a huge demand over the conventional type. Day to day as there is an alarm for the fossil fuels getting exhausted, depending on renewable energy sources is the most viable solution to fulfil the necessary energy requirements. Renewable energy sources such as solar, wind, ocean, and geothermal are a few kinds of them. In the present paper, a Vertical Axis Wind Turbine is designed and analysis is carried out to find the flow simulation.*

Background. *Solar energy and wind energy sources are best suited for the rural as well as any other applications around the globe. The application of these renewable energy sources is best suited for electricity or power generation. In 2019, around 11% of global primary energy came from renewable technologies. Most sources around the globe use both solar and wind energy*.

Materials and Methods*: In this research work design of a vertical axis wind turbine and simulation is carried out to evaluate the performance of the wind turbine. The methodology involved studying the different profiles of wind turbines, designing using CAD software, and finally performing the flow simulation using Ansys software.*

Results*: The obtained results are compared with the experiment data*

Conclusion: *The design found to give the optimum performance*

Key Word*:* ***Renewable energy, Fossil Fuels, Solar energy, Wind Energy, Power***

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I. Introduction

Energy is the most vital need in today’s world. Wind Energy is used to drive the wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of nonrenewable power sources. Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Wind power gives variable power which is very consistent from year to year but which has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply.

As the proportion of wind power in a region increases, a need to upgrade the grid and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighbouring areas, using vehicle-to-grid strategies or reducing demand when wind production is low, can in many cases overcome these problems. In addition, weather forecasting permits the electric power network to be readied for the predictable variations in production that occur.

Prevalence of Wind Power in India:

Wind power generation capacity in India has significantly increased in the last few years and as of 31 January 2017 the installed capacity of wind power was 28,871.59 MW, mainly spread across the South, West and North regions. By year end 2015 India had the fourth largest installed wind power capacity in the world. The development of wind power in India began in 1986 with the first wind farms being set up in coastal areas of Maharashtra, Gujarat and Tamil Nadu with 55 kW Vestas wind turbines. These demonstration projects were supported by the Ministry of New and Renewable Energy (MNRE).

1.1Types of Wind Turbines:

Wind turbines can rotate about either a horizontal or a vertical axis. Horizontal Wind Turbines are both older and more common. They can also include blades (transparent or not) or be bladeless. Vertical designs produce less power and are less common but are highly efficient and more eco-friendly when compared to Horizontal Wind turbines.

1.1.1 Horizontal Axis Wind Turbines:

Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

1.1.2 Vertical Axis Wind Turbines:

Vertical-axis wind turbines (VAWTs) are a type of wind turbine where the main rotor shaft is set transverse to the wind (but not necessarily vertically) while the main components are located at the base of the turbine. This arrangement allows the generator and gearbox to be located close to the ground, facilitating service and repair. VAWTs do not need to be pointed into the wind, which removes the need for wind-sensing and orientation mechanisms. A VAWT tipped sideways, with the axis perpendicular to the wind streamlines, functions similarly. A more general term that includes this option is "transverse axis wind turbine" or "cross-flow wind turbine. Drag-type VAWTs such as the Savonius rotor typically operate at lower tip speed ratios than lift-based VAWTs such as Darrieus rotors and cycle turbines.

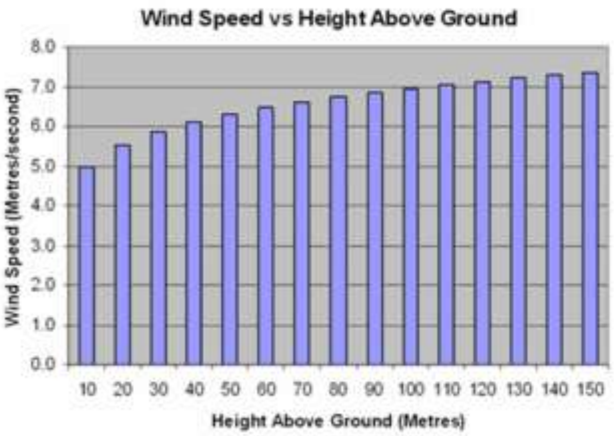

Fig 4.8: Variation of Wind with Altitudes

II. Material And Methods

The method involved in this research work can be given by the following steps;

1. Design of Vertical Axis Wind Turbine
2. Analysis of the Wind Turbine.

2.1 Design of Vertical Axis Wind Turbine Blades

The vertical axis wind turbine was designed and modelled used solid works CAD software

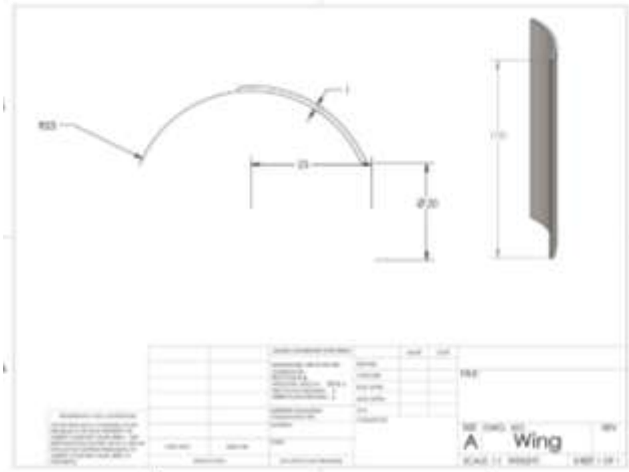

Figure1: 2D drawing of the turbine blade

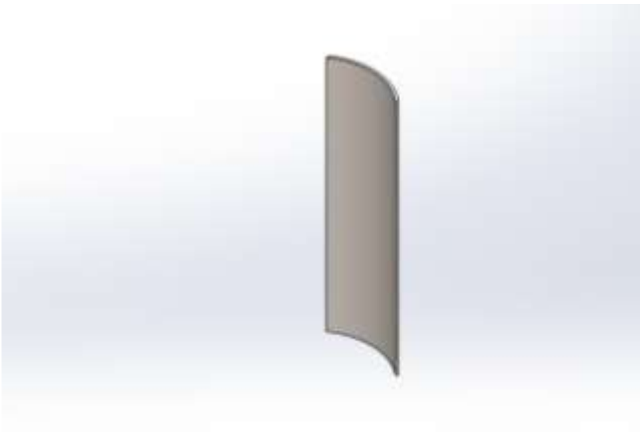

Figure2: 3D Model of the vertical axis wind turbine blade

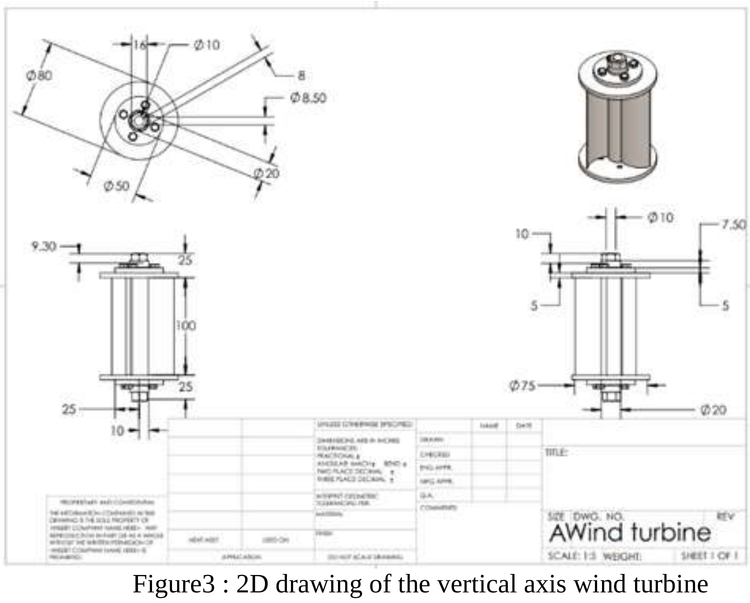

Figure3 : 2D drawing of the vertical axis wind turbine

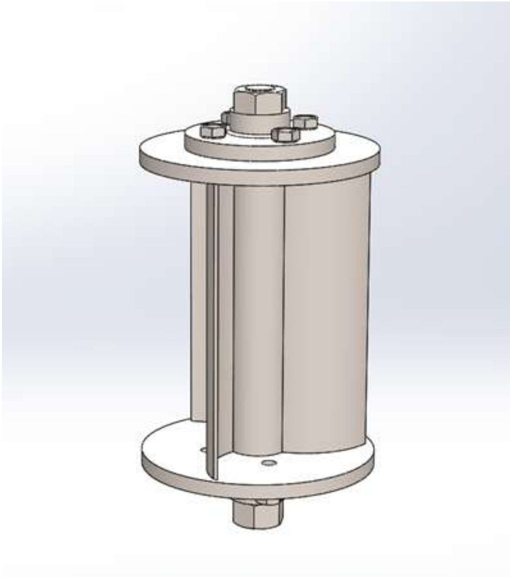

Figure 4: 3D Model of the vertical axis wind turbine

2.2 Wind Power Generation Unit Calculations:
Kinetic Energy of Wind: The kinetic energy is calculated from the formula;

P=1/2*ρ*A*V3
(P=Power, ρ=density, A= swift area, V= velocity of wind)
p = 1/2 * 1.125 *0.04575 * 53
= 3.21 kg m^2 /s^3

Multimeter Reading:

I = 0.2 amps/min
Power (P) = V*I
=12*0.2
Power (P) =2.4 W/min (if Wind Flow is continuous and V =5 m/s)

III. Result

After the design, the simulation of the Vertical Axis Wind Turbine is carried out using ANSYS software.

The boundary conditions used for the simulation are;

Boundary Conditions:
Fluid - Air
Fluid Properties
Density:
1.2047 (kg/m^3)
Dynamic Viscosity: 1.8205E-5 (kg/m.s)
Kinematic Viscosity: 1.5111E-5 (m^2/s)
Specific Heat: cp 1.0061E+3 (J/kg.K)
Conductivity: k 0.025596 (W/m.K)
Prandtl number: 0.71559
Thermal Diffusivity: 2.1117E-5 (m^2/s)
Thermal Expansion Coefficient: 3.4112E-3 (1/K)
Inlet
Velocity- 20 m/s
Mass Flow rate- 1 kg/s
Temperature- 298 K
Outlet
Atmospheric pressure-1 bar

3.1 Velocity Plot of the wind turbine -
The above figure shows that the fluid traveling at 20 m/s in the Z direction. The design entraps the fluid allowing the turbine to rotate, represented by the clustering of the flow lines near the blade.

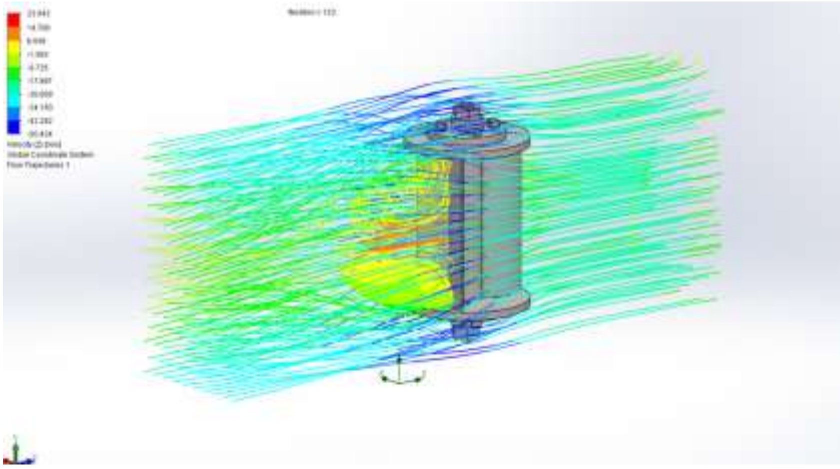

Figure 5: Simulation results showing the velocity distribution

3.2 Pressure Plot -
The yellow lines represent the pressure (102763.55 Pa) of the fluid at the inlet. As the fluid passes through the design, there is a pressure drop to 100859.56 Pa, represented by blue lines at the outlet

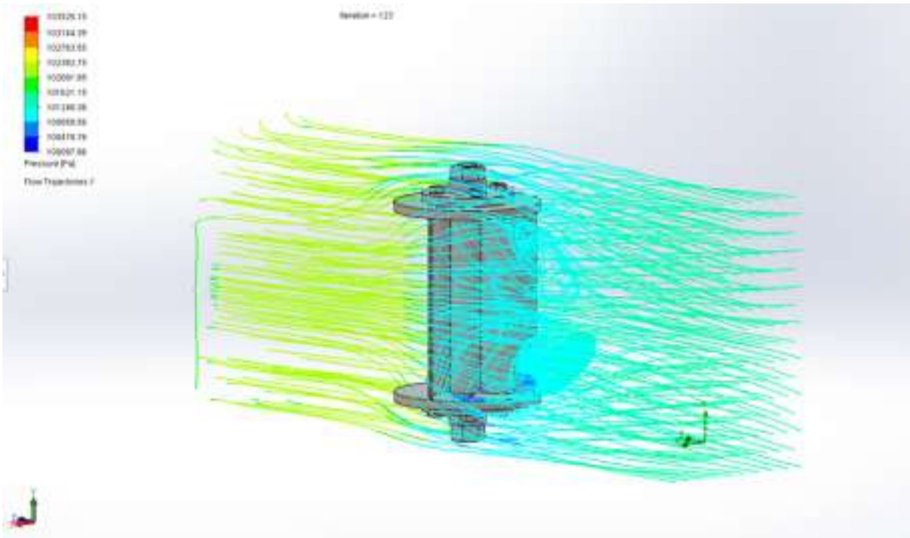

Figure 6: Simulation results showing the pressure distribution

3.3 Temperature Plot-

The temperature of the fluid is 298 K, represented by the red lines. The heat in the fluid is absorbed more by the top and bottom parts of the assembly, represented by the yellow lines.

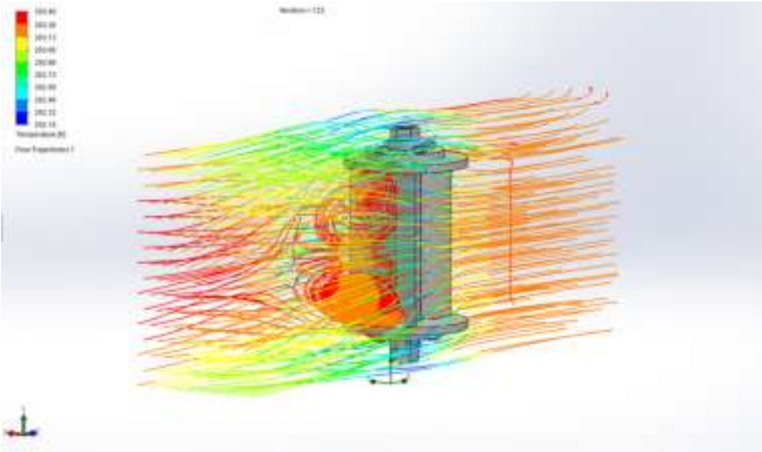

Figure 7: Simulation results showing the temperature variation across the blades.

3.4 Density Plot-

The fluid density at the inlet is 1.21 kg/m3, represented by the red lines. As the fluid passes through the rotating blades, the density of the fluid drops to 1.19 kg/m3, represented by the green lines.

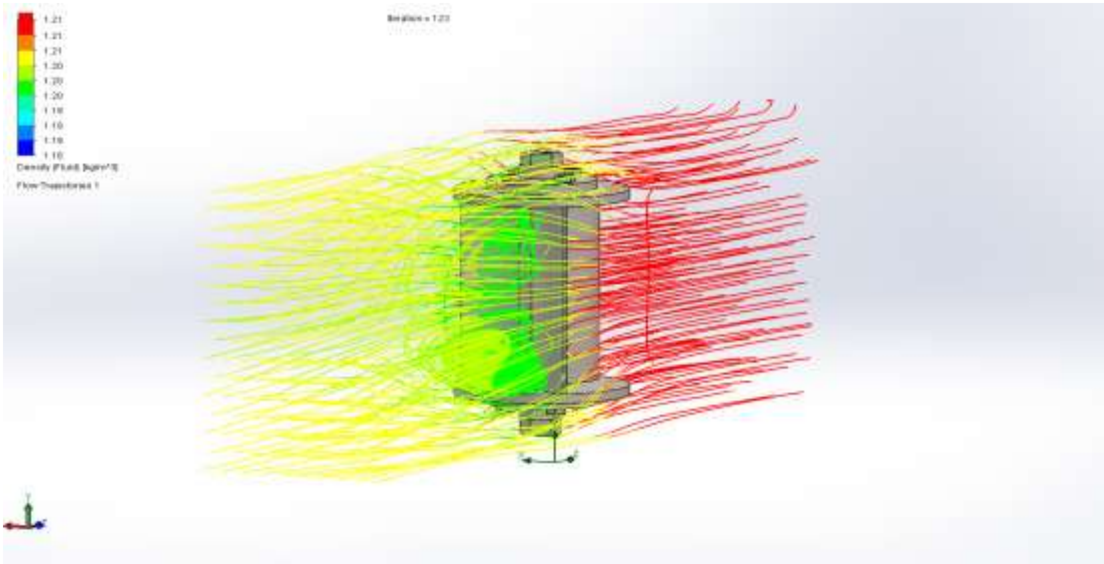

Figure 8: Simulation results showing the density variation

IV. Conclusion

- From the research project, it is concluded the Vertical Axis Wind Turbine is giving the optimum performance compared to the other types.
- The calculated power is found to be 2.4 W/min.
- The density of air is dropped from 1.21 kg/m^3 to 1.19 kg/m^3.

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