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Development of Flapping Panel Vertical Axis Wind Turbine

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Abstract - In a developing nation like India, electricity has become one of the most important basic needs nowadays. Coal and gasoline based power generation capacity stands at 71% in India, which contributes to a considerable part of air pollution. There are various renewable energy sources which are pollution free, one among them is the wind energy. So the main objective of the project is to facilitate pollution free power generation for individual purpose. In order to understand the problem and working, a flapping panel vertical axis wind turbine was designed. The main advantage of using a vertical axis wind turbine is that it need not pointed towards the wind and also vertical axis wind turbine is more comfortable to erect for domestic purposes. The flapping panel wind turbine is designed using solidworks software and analysed using Ansys Fluent. By making use of the wind, the flapping panels attached to the shaft rotate and the rotor is connected to the permanent magnet electricity generator (PMG). The PMG converts the Kinetic energy of the rotor shaft into electrical energy. The PMG we have used has the capacity of producing maximum power at 1200rpm. On calculating theoretically, the power output is found to be 8W for the rotation of 76.39 rpm and for 1200rpm the power output is calculated to be 125W. The entire wind turbine setup is compact in size and can be easily mounted and erected.

Index Terms*: Renewable energy, Flapping Panel, Permanent Magnet Generator,

I. INTRODUCTION

A wind turbine converts the wind's kinetic energy into electrical energy. Wind turbines are manufactured in a wide range of vertical and horizontal axis. The smallest turbines are used for applications such as battery charging for boats, buses and many automobiles; whereas Large Turbines are used for domestic purposes. Wind farms which are commonly called as Turbine arrays are one of the important sources of renewable energy, so many countries are nowadays using this as an alternate sources for most of the fossil fuels. Survey says that compare to all the other Turbines, Wind Turbine is the most essential power generation technique which is much needed for the world, since it does not emit any toxic gases into the atmosphere that creates pollution[1]. This is the reason for the demands in wind turbine exist than that of Hydel, Geo-Thermal, Thermal Power Plant.

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II. PROBLEM IDENTIFICATION

The power demand is increasing everyday due to the enormous growth in population. The majority of the power supply is produced through coal and thermal based power plants, which accounts for a considerable part of the pollution. Hence there were alternatives like the wind energy, solar energy, etc.., which are renewable and pollution free[2]. But the cost of initial investment to harvest these renewable sources of energy is very high. So, it is not accessible to a average person.

A. Design Objectives

- The main aim is to generate pollution free electricity from renewable sources.
- To design a wind turbine, that does not depend on the direction of the wind.
- To generate electricity from slower and higher wind speeds.

III. DESIGN – AN OVERVIEW

A. Design calculation

The basic principle of wind turbine is to convert kinetic energy in to mechanical energy and further converted to electrical energy with the help of Permanent Magnet Generatror[3].The kinetic energy for the turbine is calculated by using the formulas

$$K.E = \frac{1}{2} mv^2$$

Where m, mass = volume * density => m= ρAv
V is the velocity of wind in m/s. The power of the wind turbine can be calculated by, $P = \frac{1}{2}\rho A V^3$
For 100 Watt power, calculating the design parameters of turbine, P= 100 watts. $P = \frac{1}{2}\rho A V^3$
V, assuming wind velocity 5 m/s
ρ, Density of air (1.225 kg/m^3)

$$P = \frac{1}{2}\rho A V^3$$

$100 = \frac{1}{2}\, 1.125A\, (5)^3$
On solving the above equation,
A= 1.5m^2
A = D X H (m^2)
D= diameter of the blade
Taking diameter as 1 meter, height of turbine can be calculated as, H= A/D = 1.5/1 = 1.5m
H =1.5m; D=1m

Design of shaft:
Length of shaft = 650m
Diameter of shaft = 20mm
Shear stress = 32Mpa
Torque $T = (\pi/16)d^3\tau$
Torque T = 50.265 KN-mm

Turbine design calculations

Power $=1/2\rho A\ u^3\eta$

Power = 8W

Speed of rotation

N= (Velocity x 60) / (radius x 2π)

Speed of rotation N= (4 x 60) / (0.5 x 2 π)

Speed of rotation N = 76.39 rpm

Angular Velocity ω =u / R

Angular velocity ω = 4/ 0.5

Angular Velocity ω = 8 rad/s

Resultant blade velocity V_R= 5.76 m/s

IV. MODELLING OF FLAPPING FOIL

The shaft is modelled according to the dimensions using “solidworks” software. The frame is the important part to keep the blades in place. This frame is designed or modelled according to the required dimensions using “solidworks” software.The Ball Bearingis used for holding rotatingblades with help of bearing and other parts[4,5]. The Ball bearing is modelled according to the specified design using the “solidworks” software. The frame is kept as base and all other parts such as shaft, bearings, blades and connecting rod and blade tip pin are assembled according to the required model. The assembled flapping blade is shown in figure 1.

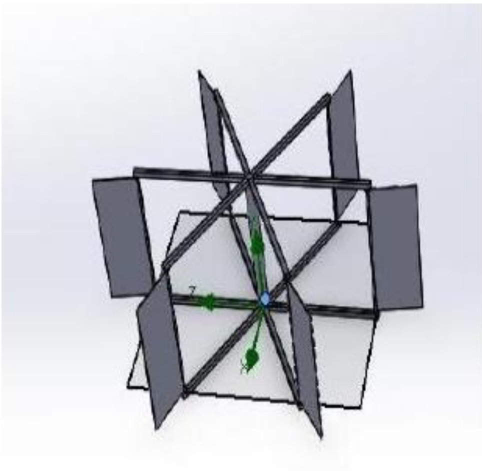

Figure:1 Assembling of Turbine blades and frame

V. METHODOLOGY

A. Software used for designing – Solidworks

Initially Solid Works is developed for creating models and assemblies. In mainly uses a typical parametric approach for creating a model. To draw a 3D model, the first step is to create a 2D sketch and later it can be extruded into a 3D one. For creating a 2D sketch various tools like lines, arcs, splines, and etc are used. In order to define the size and geometry of the sketch, dimensions are added to the sketch. Various relation tools like tangent, parallel, perpendicular, concentric are used so define the attributes[6].

In an assembly, the most important technique using is mating. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. Finally, drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, then as per the need dimensions and tolerances can be added easily to the drawing.

B. **Software used for Analysis – Ansys**

Ansys is an American based software development company, which develops engineering simulation software. Ansys software is used to design products and to test the properties like durability, temperature distribution, fluid movements, and electromagnetic properties. The following procedures are carried out while performing analysis ie. Pre-processor, and post processor. Ansys provides Computational fluid dynamics software so as to do fluid flow analysis. It is also used to non-parallel fluid flow analysis. The basic ANSYS products in the fluid flow analysis are Fluent and CFX. ANSYS –CFX is typical software exclusively used for flow analysis to determine the turbulence in Pipe lines as well as heat transfer applications for engineering purposes. Various areas where CFX are used are combustion, aerodynamics, hydrodynamics, reacting flows, heat transfer, and etc. The results can be taken in the form of graph that shows fluid flow, particle flow, heat transfer, combustion, and etc. In analysis part the boundary conditions are fixed for atmospheric condition[7,8].

The range varies from combustion process in a furnace to aerodynamic, from bubble columns to oil platforms, from blood flow to semiconductor manufacturing and from clean room design to wastewater treatment plants. Fluent spans an expansive range, including special models, with capabilities to model in-cylinder combustion, aero-acoustics, and turbo machinery and multiphase systems. Fluent is the high performance and cost effective tool used to solve complex models.

VI. ANALYSIS

A. Velocity flow analysis

The velocity flow analysis has been made for the blade considering the average velocity between o to 5m/s. The contour of Velocity and velocity magnitude is shown in figure 2 and 3 respectively.

B. Pressure flow analysis

The pressure flow analysis for the blade is performed using the ansys fluent software, for the boundary condition of $1.015\ X\ 10^5$ Pascal and temperature 310K. The velocity magnitude, pressure magnitude and strain rate are shown in Figure 4,5 and 6.

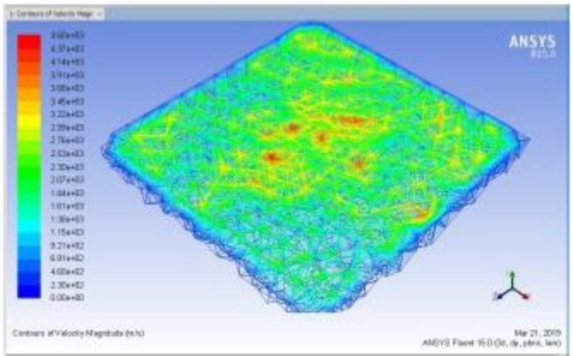

Figure:2. Contour of Velocity magnitude

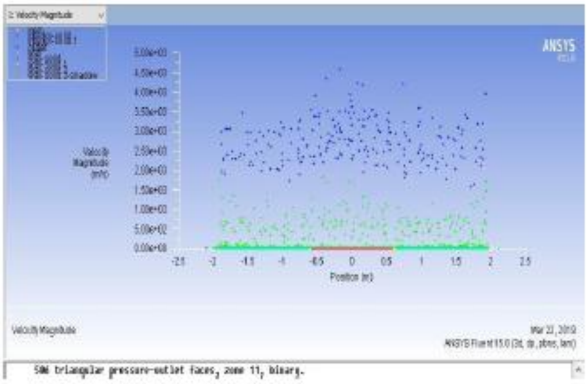

Figure:3. Velocity Magnitude graph

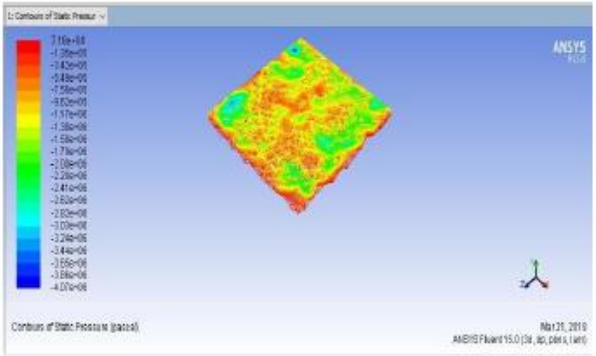

Figure:4. Contour of pressure magnitude

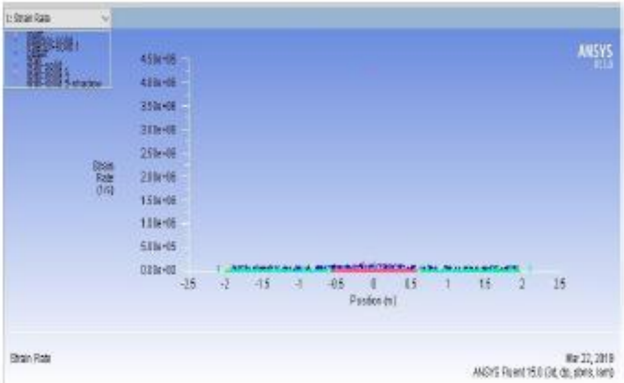

Figure:5. Strain rate

VII. FABRICATION OF THE FLAPPING PANEL VERTICAL AXIS WIND TURBINE

A. Materials Used - Mild Steel

In recent trends mild steel is preferred for many applications because of its cost effectiveness as well as its crystal structure provides more strength as well as it is good in ductility properties. Its tensile strength is relatively low so it can be easily hardened by using carburizing process.. It contains 0.05–0.25% carbon as in table 1 makes it malleable and ductile. The mechanical properties are shown in table 2.

Table: 1 Chemical Composition

Element	Content
Carbon, C	0.25 – 0.290%
Copper, Cu	0.20%
Iron, Fe	98.0%

Table:2 Mechanical Properties

Specification	value
Brinell Hardness	126
Rockwell hardness no.	71
Vickers hardness	131
Ultimate Tensile strength	440MPa
Yield tensile	370MPa
Elongation	15.0 %
Area Reduction	40.0 %
Youngs Modulus	205 GPa
Bulk Modulus	140 GPa
Poissons Ratio	0.290
Modulus of Shear	80.0GPa

B. Fabrication of parts

Centre shaft

- The shaft is made up of mild steel.
- It is machined by Lathe and Milling machine for Plain turning and Key slot.
- Length of the shaft is 500mm and diameter is 43mm.

Turbine Blade

- Blade is made up of Reinforced fibre.
- It is a rectangular fibre plate.
- Dimension of the blade is 450mm long, 200 mm wide and 3mm thickness respectively.
- The blade is fitted in the blade tip pin.
- Blade tip pin is also made up of mild steel.
- It is a circular rod 40mm long.
- It is used to keep the blades in required place.

Roller Bearing

- Roller bearings are used to support the blade motion whenever necessary.
- It permits rotary motion of the blade without any friction.

Plummer block

- Plummer blocks are to support the connecting rods and the shafts.
- It permits Rotary motion of the shaft without any friction.

Final assembly of the turbine

Thus the blades, frame, shaft and connecting rods are fabricated and assembled together as shown in figure .

Figure 6. Final assembly of the turbine

VIII. CONCLUSION

The unique characteristics of flapping panel turbine is that it starts rotating even at low speeds and independent to the direction of the wind which makes this VWAT a better turbine when compared to others and also with its power obtained at any cause of rotation makes it perfect one for power generation.

The flapping blades adapts to the direction of the wind direction, which makes the flapping action in accordance to the need and thus results in major advantage of rotation. In Darrieus turbine the blade has the capability of self-starting while working in low Reynolds number as well as at moderate value. The pitch angle of the blade plays a vital role on the behavior of self starting while comparing to other parameters, for a low speed wind starting higher values of the blade pitch angle are preferred.

Hence through these techniques, the VAWT is made to work at normal conditions of wind at 4 m/s and it produces an actual power of 8W at 76 rpm.

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