ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 5 – No.1, January 2018

DESIGN, FABRICATION AND ANALYSIS OF FIBONACCI SPIRAL HORIZONTAL AXIS WIND TURBINE

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ABSTRACT

The present study is focused on the ever advancing field of wind energy (HAWT). Objective is to design, fabricate a wind turbine with the help of Fibonacci spiral. The profile of the blades was conical helix. An attempt has been made to use such turbines in urban areas while reducing the installation height. 3D model of the blades were designed on solid works to study the static simulation. Study showed that such turbines can yield RPM at low wind speeds 5 m/s. Results showed that the modified spiral wind turbine is ideal for urban locations due to its property to withstand wind turbulence. The results showed that the minimum speed required to function the turbine is 5 m/sec. The maximum efficiency on theory basis was found to be 71.38 % .The turbines exhibits high response towards varying wind speed. The minimum speed of wind require to rotate the blade is 5 m/sec. For optimum performance of the wind turbine the speed of the wind must lie in between 18 to 25 m/sec.

KEYWORDS

HAWTs, Archimedes spiral, wind turbine, simulation, solid works.

1. INTRODUCTION

There are basically two types of wind turbines Horizontal axis wind turbines (HAWTs) and vertical axis wind turbines (VAWTs), out of which HAWTs are commonly manufactured. It works on simple principle of conversion of kinetic energy of wind into the mechanical energy of the turbine followed by further converting it into electrical energy with the help of a generator. In case of horizontal axis wind turbines the axis of rotation is horizontal with respect to the ground and approximately parallel to the wind stream.

2. LITERATURE REVIEW

A new windmill design loosely base on Archimedes's screw principle, aims to hinge this however. A Dutch start-up apply named The Archimedes's has re-worked the concept of windmill move away from the traditional concept of using the pressure differential between the front and rear of the device.

The aerodynamic characteristics of Archimedes Spiral Wind Turbine for small scale wind turbine system were investigated experimentally with respect to the angle of attack in the case of counter clockwise direction and clockwise direction. The flow characteristics around the blade tip were visualized using PIV technique and scale down wind turbine model. And power coefficient and aerodynamic p to move the rotors. Over were investigated using real spiral model. In order to provide the aerodynamic characteristics, Particle Image Velocimetry (PIV) has been used to measure instantaneous velocity field near the wind turbine blade. The signature of tip vortices generated from each blade is clearly observed for the range of 0° to 120° phase angle. The spatial distance \ between the tip vortices generated from each blade is quite uniform in cases of small angle of attack. Additionally, the aerodynamic power generation was investigated for several wind speed condition and angle of attack change using real Archimedes spiral wind turbine blade. As wind speed grow up, the effect on the angle of attack change seems to be decreased.

Another, research describes aerodynamic characteristics of small-scale wind turbine blade, called Archimedes spiral wind turbine blade. Numerical approaches on the prediction of aerodynamic performance of the blade have been conducted. Both steady and unsteady state numerical simulations using ANSYS CFX are performed on the several cases of rotating speeds. Large scale tip vortex is captured and graphically addressed in this research. In order to proving the results of numerical simulation, Particle Image Velocimetry (PIV) has been used to measure the aerodynamic characteristics of the Archimedes spiral wind turbine blade. Detail velocity vector fields around the blade are obtained and compared to those predicted by the steady and unsteady state CFD analysis. Mean velocity profiles are in a good agreement between experiment and unsteady state CFD analysis, the trajectory and magnitude of tip vortices generated by the blade are identified from the PIV results.

3. DESIGNING AND FABRICATION OF THE BLADES

It is a spiral blade wind turbine which works on the principle of conservation of momentum like other wind turbines, but the difference in their blades which is capable to extract maximum electricity from the wind by converting mechanical energy into electricity.

ISSN (O): 2393-8609

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3.1 Design of Blades- Spiral (Fibonacci Spiral)

The Fibonacci spiral: an approximation of the golden spiral created by drawing circular arcs connecting the opposite corners of squares in the Fibonacci tiling; this one uses squares of sizes 1, 1, 2, 3, 5, 8, 13 and 21.

3.2 Specifications

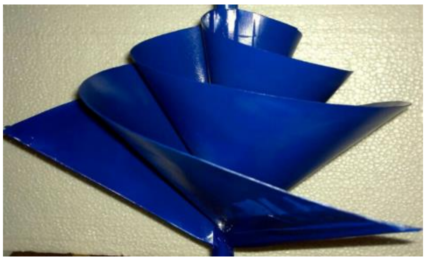


Fig 1: Fabricated turbine blades

Blade diameter- 205mm

Rotor diameter- 350mm

Shaft diameter- 1.5mm

Shaft length- 480mm

Blade thickness- 1mm

Length of turbine- 280mm

Angle of inclination- 60 degree (from the axis)

Frame dimensions- shorter arm- 230mm

Longer arm- 480mm

Supporting frame rod- 800mm

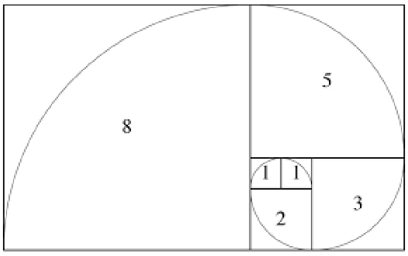


Fig 2: Fibonacci spiral

3.3 Profile of Blades- Conical Helix

A spiral blade has the characteristics of both. The blade is constructed from flat sheets, can work under a large margin of error, produces very low noise (<42 Db) and is lightweight. All are characteristics of a resistance type rotor. In contrast, the conical spiral rotor tip speed ratio is greater than 1, and its efficiency is extremely high, characteristic of the lift type.

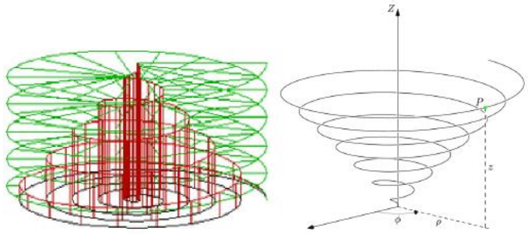


Fig 3: An Archimedean spiral, a helix and a conical spiral

The Archimedes rotor blade is a flat surface elongated to give it depth and, therefore it's shape perceived to have volume. From a sheet of paper one can obtain the spatial form of an Archimedes rotor blade by turning and simultaneously stretching out a cutout of the plane between a circle with radius R and a flat spiral.

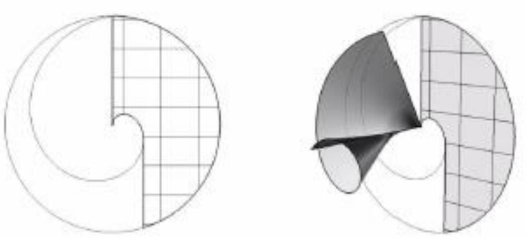
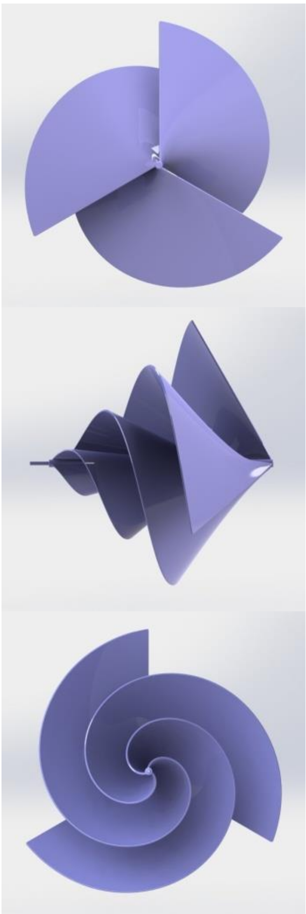


Fig 4: Semi-circle is twisted to gain spiral shape

4.4 Isometric and orthographic view of Turbine



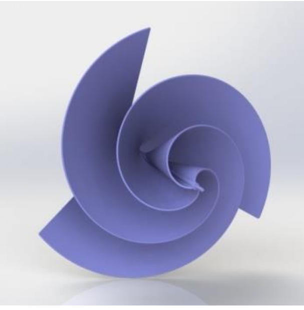


Fig 5: Isometric and orthographic view of Turbine

4. STATIC SIMULATION

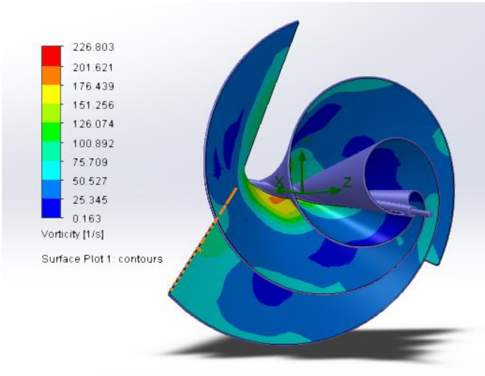


Fig 6: Vorticity

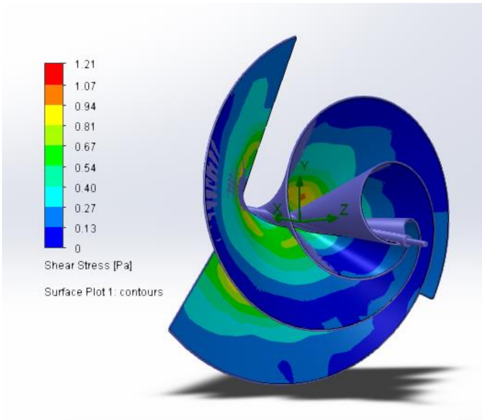


Fig 7: Shear Stress Distribution

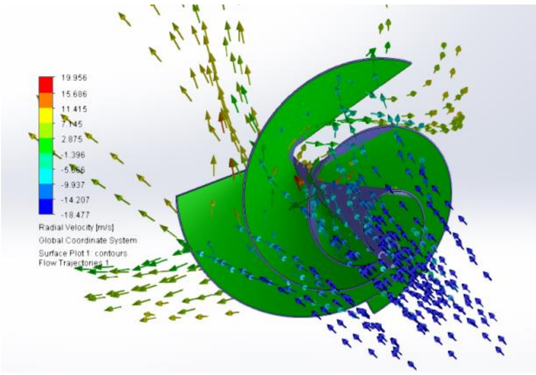


Fig 8: Radial velocity

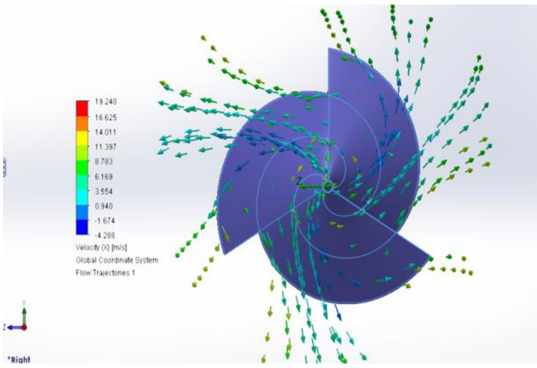


Fig 9: Front turbulence

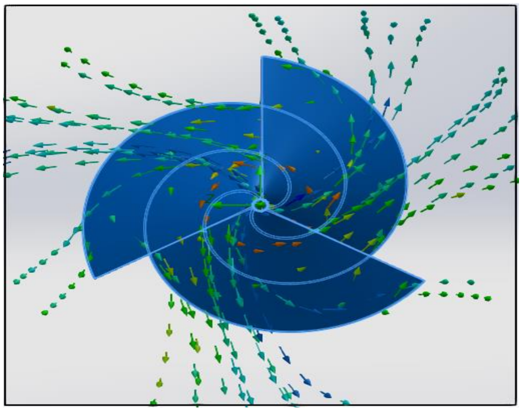


Fig 10: Front view turbulence

5. CALCULATIONS

The power available from wind for a vertical axis wind turbine can be found from the following formula:

$P = \frac{1}{2}\rho s v^3$ (1)

Power available in wind:

$P_1 = 1/2\, eAV_1^3$ (in watt) (2)

Power Extracted from wind:

$P_2 = eAV^2 (V_1 - V_2)$ (in watt) (3)

Where,

e = Density of Air (1.27Kg/m3 at 1 atm)

A = area of Rotor

V_1 = velocity of Air before impact

v = Average Velocity during impact

V_2 = Velocity after attack

Efficiency (η) =Extracted power From Wind (P_2)/Power available in Wind (P_1)

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

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Table 1. Velocity efficiency table

S No.	Velocity of air before impact , V_1 (m/s)	Velocity of air during impact, V (m/s)	Velocity of air after impact V_2 (m/s)	Efficiency of the turbine (η) %
1	19	12	2	71.38
2	17	11	3	68.95
3	15	8	3	45.45
4	11	6	3.5	35.16

Table 2. Power extracted table

S No.	Normal wind speed (m/s)	Available wind power (Watts)	Extracted power from wind (Watts)
1	19	340.00	243.07
2	17	243.08	168.21
3	15	167.56	76.26
4	11	66.08	23.23

Table 3. Air velocity V/s voltage table

S No.	Air velocity (m/s)	Voltage (V)
1	5	0.8
2	11	1.8
3	15	4.5
4	19	11.6

6. CONCLUSIONS

Now, a day's different types of wind turbine are used for the electricity generation, but spiral blade wind turbine is best in among them because it having maximum efficiency and also have ability to extract 80% power from the available power in wind. New generation Spiral blade wind turbine is compact in shape, having low working speed on smaller heights and much more economical than other wind turbines. The results showed that the minimum speed required to function the turbine is 5 m/sec. The maximum efficiency on theory basis was found to be 71.38 % .The turbines exhibits high response towards varying wind speed. The turbine smoothly works under the drag and stresses impeded on turbine's body and blade. Spiral blade wind turbine can be used for generation of electricity in urban areas and large scale industry purposes. If the velocity of the wind is increased, the blade speed increases and thus increases the efficiency of the turbine. The minimum speed of wind require to rotate the blade is 5 m/sec. For optimum performance of the wind turbine the speed of the wind must lie in between 18 to 25 m/sec.

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