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Design and Analysis of Aero foil Geometry of Wind Turbine Blade

Shahshank Patil, Umang Patel, Krupal Patel,Uzair Pathan,Prof. Dharmendra Sapariya

Department Of Mechanical Engineering
Indus Institute Of Technology & Engineering, Ahmedabad, India

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Abstract *Recently there is a resurgence of interests on different types of renewable energy technologies, including VAWT, because of growing environmental concerns and the demand for more enhanced energy security the basic theoretical advantages of VAWTs are: they are Omni-directional i.e. they accept the wind from any direction. Design of blade is also an important factor for the performance of a wind turbine. So this project mainly concentrates on blade airfoil design in such a way to have high lift force and low drag force. A model of wind turbine is created using SOLIDWORKS software. After file is converted into .stl file we 3d printed our prototype made of PLA material.*

***Key Words*: Shaft, blades, DC Motor, Flow Analysis, Static Analysis**

1. INTRODUCTION

Wind Energy is the result of Solar Energy. The temperature difference generated between the Equatorial surfaces and Polar Regions of Earth, due to the difference in concentration of intensities of Solar Radiations resulting the temperature difference which sets up the large scale 'Wind Currents' in the atmosphere. If we utilize even 1% of these daily wind energy input, equivalent to 0.01% of the incoming solar energy, it sums up to the "World's Daily Energy Consumption".

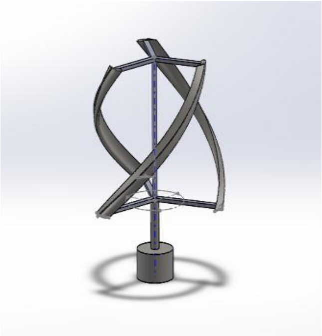
1.1 Prime Mover: Wind Turbine

Wind Turbine Conversion Systems are basically differentiated on basis of their axis of operation, either Vertical or Horizontal Axis Wind Turbine and later they are classified on the basis of their designs and capacities.

1.2 Critical aspects of Resolution

For designing the Aerofoil section, materials also need to be judiciously chosen because wind turbines operate under a variety of forces and weather conditions be used. Other font types may be used if needed for special purposes. . Fiberglass composites or Fiber-reinforced plastics are another possible material for VAWT aerofoils. These composites have low density, sound mechanical properties, non-corrosive and versatility in fabrication methods.

2. Design



The Parameters of the wind turbines are the following:-

- Turbine height (h cm)
- Rotor diameter (d cm)
- Blade length (l cm)
- Blades number (n)
- Wind speed (v m/s)

Table -1: Technical Specification Of designed VAWT (Analysis Purpose)

Blade Length	60 cm
Aerofoil	NACA 0012h & symmetric
Upper Diameter	75.28 cm
Lower Diameter	55.78 cm
Chord Length	10.5 cm
Solidity	0.4
No. Of Rotor Blade	3

Prototype

Table 2: Technical Specification

Height Of Rotor	20 cm
Upper Diameter	18 cm
Lower Diameter	24 cm
Aerofoil	NACA 0012h And symmetric
Chord Length	3 cm
Cut In Speed	4 m/s
Solidity	0.47
Material	PLA

Power Calculation:
The Parameters of the wind turbines are the following:-

- Turbine height (h cm)
- Rotor diameter (d cm)
- Blade length (l cm)
- Blades number (n)
- Wind speed (v m/s)

Swept Area (S) = $2l * \sum_{k=0}^{m} d * \sin\theta * \cos\theta$ [6]

$$= 2*0.20*0.24*\sin\left(\frac{\pi}{3}\right)*\cos\left(\frac{\pi}{3}\right)$$

$$= 0.02076\ m^2$$

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

$$= 0.5*1.8*.02076*125$$

$$= 2.37\ W$$ [6]

Results (Prototype):

Wind Speed	Voltage	Current	Power
6.2	0.4	0.125	0.05
7.1	0.57	0.122	0.07
8	0.62	0.2	0.1302
9	0.7	0.25	0.175

3. Analysis

The designed parameters are used to prepare 3d model in Solidworks. and different analysis Are also done in Solidworks. After analysis following results are obtained.

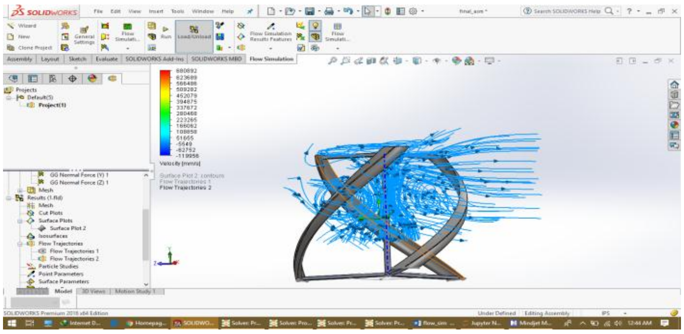


Figure 1flow trajectory

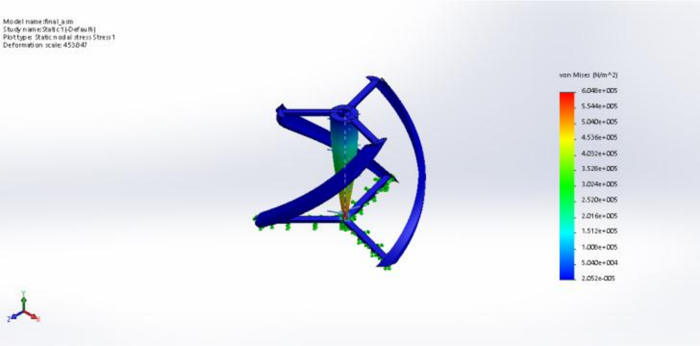


Figure 2 static analysis

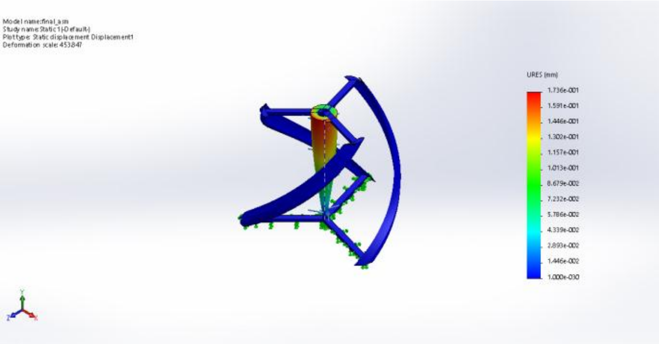


Figure 3 Displacement

Figure 4 Centrifugal forces at 100 rpm

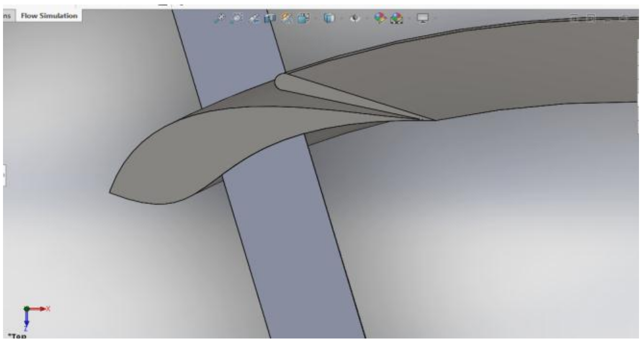


Figure 5 aerofoil NACA 0012H & symmetric

For the prediction of VAWT performance, the three major Aerodynamic models include momentum models, vortex models, and computational fluid dynamics (CFD) models. Each of the three models is based on the simple idea of being able to determine the relative velocity and, in turn, the tangential force component of the individual blades at various azimuthal locations.

Due to the flexibility of CFD, it has been gaining popularity for analyzing the complex; unsteady aerodynamics involved in the study of wind turbines and has demonstrated an ability to generate results that compare favorably with experimental data. Unlike other models, CFD has shown no problems predicting the performance of either high or low- solidity wind turbines or for various tip speed ratios. However, it is important to note that predicting the performance of a wind turbine using CFD typically requires large computational domains with sliding interfaces and additional turbulence modeling to capture unsteady affects; therefore, CFD can be computationally expensive.

After reviewing the available models and recent research efforts, CFD was chosen as the appropriate tool for predicting the performance of a VAWT because of its flexibility and accuracy. Due to the possibility of local optimization, and the requirement. for floating -point optimization for geometric flexibility, a parallel stochastic differential evolution algorithm was chosen for the optimization. The NACA 4-series family of wing sections was chosen as the geometry to be parameterized for the optimization, allowing either symmetric or cambered Aerofoil shapes to be generated.
What separates this approach from all previous work is the consideration of both symmetric and cambered Aerofoil geometries, along with a full two-dimensional, unsteady simulation for a three-bladed wind turbine for various design points.

For decades, the researchers on VAWTs and aerodynamicists have keenly investigated for various parameters for design and development of large-scale vertical axis wind turbines. The prime motivation for this was anticipation that, for multi-megawatt machines, the economics of the vertical axis wind turbine would be more favorable than that of its horizontal counterpart. In addition, the apparent simplicity of their mechanical design and their omnidirectional capability augured well for their placement in large offshore wind farms.'

'Although, as mentioned above, there was an apparent simplicity of mechanical design, the aerodynamic environment and operation of the blades is indeed complex, for the turbine operation relies on the apparent unsteady flow past the Aerofoil. As a consequence of this and a lack of detailed knowledge, little was known as to the manner in which the choice of Aerofoil section or blade geometry should be made. Several research programs were addressing this problem and included detailed pressure measurements on wind turbines, two-dimensional dynamic stall of typical turbine sections, and Aerofoil design procedures.'

Analysis Environment
Software Product: Flow Simulation 2016 SP1.0. Build: 3296
CPU Type: Intel(R) Core(TM) i5-4210U CPU @ 1.70GHz
CPU Speed: 1701 MHz
RAM: 8095 MB/134217727 MB
Operating System: (Build 17134)
Analysis Mesh
Total Cell count: 3177
Fluid Cells: 2566
Solid Cells: 611
Partial Cells: 575
Trimmed Cells: 0
Analysis Time
Calculation Time: 100 s
Number of Iterations: 160

Name	Unit	Value	Progress	Criteria	Delta	Use in convergence
GG Force (X) 1	N	-1.536	0	0	1.34757487	Off
GG Force (Y) 1	N	-16.689	0	0	16.3315086	Off
GG Force (Z) 1	N	1.552	0	0	0.485111218	Off
GG Max Shear Stress (X) 1	MPa	0.000013	0	0	2.28906202e-006	Off
GG Max Shear Stress (Y) 1	MPa	6.023803e-007	0	0	1.8337095e-007	Off
GG Max Shear Stress (Z) 1	MPa	9.055533e-006	0	0	1.37051936e-006	Off
GG Torque (X) 1	N*mm	2728	0	0	776.294282	Off
GG Torque (Y) 1	N*mm	-68	0	0	82.9506601	Off

GG Torque (Z) 1	N*mm	-1737	0	0	991.091281	Off

Engineering Database
Gases: Air
Path: Gases Pre-Defined
Specific heat ratio (Cp/Cv): 1.399
Molecular mass: 29.0 kg/k moll

3. CONCLUSIONS

The concept of curved blades used specifically for this project work is quiet efficient at the moment, but the limitation is that the starting gradually decreases compared to rest of designs. And as in VAWT's to every single position of blade the azimuthal angle varies and due to which the flow of wind gets distorted to easily. So in order to maintain the streamlines of the flow it is necessary to deflect it appropriately. So we developed a whole new concept of Blade curvature based on the Vortex geometry and Fibonacci spiral information.
Output voltage rising as wind velocity increases and is maximum were 9m/s is analyzed by V/V and V/C characteristics , for the wind velocity near to the 9.0m/s, current generated by the turbine (coupled generator) increases About 0.25 amp. The Concept Of Vortex For This Project Is Quiet Efficient.

As Lift Is Directly Proportional To Aerofoil Thickness, Higher Aerodynamic Performance Is Achieved By Adopting Combine NACA 0012H And Symmetric Aerofoil.

Appendices

Software: Solidworks 2016

3d Printer: 3 Face Tech

DC Motor

Stand: PVC Pipes

Blower

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REFERENCES

[1] Carlos Simão Ferreira and Ben Geurts, Delft University of Technology - DUWind, Delft, The Netherlands(05,2014), Aerofoil optimization for vertical-axis wind turbines
[2] Travis J. Carrigan, Brian H. Dennis, Zhen X. Han, and Bo P.Wang(01,2012), Aerodynamic Shape Optimization of a Vertical-Axis Wind Turbine Using Differential Evolution
[3] The Darrieus Wind Turbine Aerofoil Configuration Manual (A Subcontract Report)
[4] Mathematical Model To Calculate The Performance Of Low Power Vertical Axis Wind Turbine

Web Link
[5] Solidworks Tutorial **(**CL/CD Calculation In Solidwork2 2012 - Part 3 Airfoil Simulation setup)
[6] Aerofoil (http://airfoiltools.com/airfoil/naca4digit)

[7] https://ultimaker.com/en/resources/19639-vertical-axis-wind-turbine