TOBB UNIVERSITY OF ECONOMICS AND TECHNOLOGY
MECHANICAL ENGINEERING DEPARTMENT

DESİGN, ANALYSIS, MANUFACTURING AND TEST OF A VERTICAL AXIS WIND TURBINE (VAWT)

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Abstract

The main goal of the project is to design a ¼ scale 3-bladed H-Type Vertical Axis Wind Turbine (VAWT) that can generate 1000 Watt of power. In the design process; the aerodynamic analysis, structural analysis and modal analysis are done. After designing the VAWT, a prototype is manufactured and tested.

Aerodynamic Design

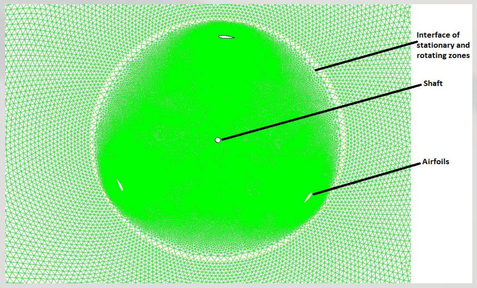
For the aerodynamic design calculations, momentum based multistream tube model is used.

Design Inputs

Power	: 1000 watt
Diameter	: 60 cm
TSR	: 4.5
Solidity	: 0.225
Wind Speed	: 10 m/s
No. of blades	: 3

Design Outputs

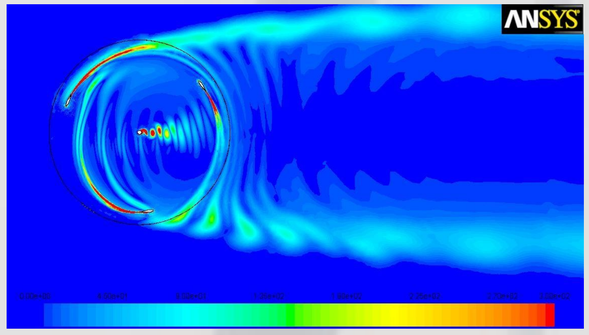
Airfoil	: NACA0018
Height	: 35 cm
Chord	: 4 cm



Zoomed view of used mesh

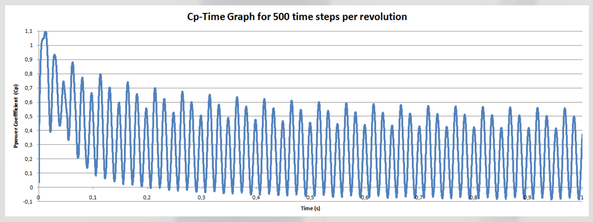
CFD Analysis

2-D CFD analysis are performed to predict the output power and aerodynamic forces over the blades. Sliding mesh tecnique is used in transient calculations with 0.0001s and 0.0002s time steps. Mesh involves 500.000 nodes. These analysis are performed for NACA0018 and FX 63-137 airfoils with different wind speeds.

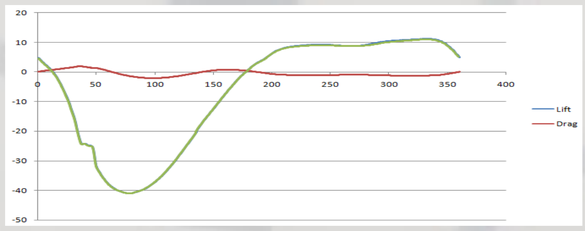


Vorticity contours at 10 m/s wind speed

Transient calculations are kept running until the solution is converged.

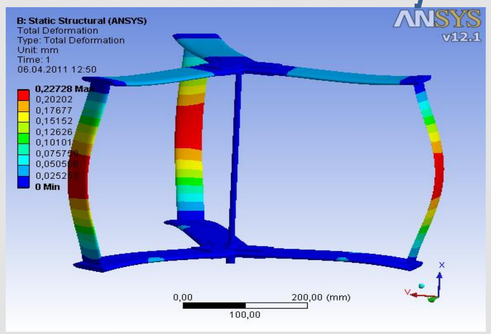


Cp-Time graph with 0.0001s time step



Aerodynamic forces over the blades

Static Structural Analysis

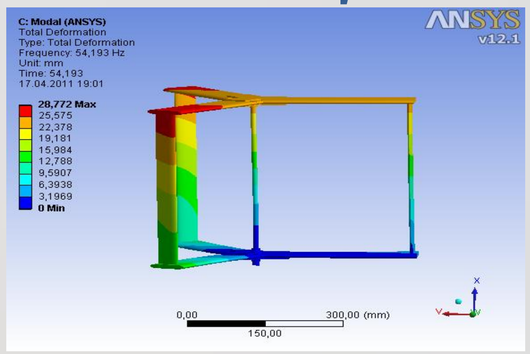


Total Deformation of VAWT

Max. Total Deformation	0,22 mm
Max. Equivalent (Von-Misses) Stress	151 Mpa
Max. Shear Stress	25 Mpa
Max. Principal Stress	200 Mpa

Structural analysis results

Modal Analysis



Mode 1

Mode	Natural Frequency	Vibration Type	Direction
1	54,193	Bending	around axis x
2	54,439	Bending	around axis y
3	98,983	Torsional	around axis z
4	245,62	Bending	around axis x and y
5	245.79	Bending	around axis x and y
6	291.33	Bending	around axis x and y

Mode Frequencies and Mode Types

Conclusions

- 2-D CFD analysis of the designing VAWT is performed to calculate the power and force values.
- Sliding mesh tecnique is used.
- 0.0001s and 0.0002s time steps are tried. According to the results 0.0001s time step is unnecessarily small and causes waste of time.
- Aerodynamic forces over the airfoil blades are calculated and plotted. This force is used as input to the structural analysis of the turbine blades.
- All these analysis performed for NACA0018 and FX 63-137 airfoils with different wind speeds.
- In structural part, the aerodynamic force is used as an input. However, as determined the centrifugal forces dominate the aerodynamic forces.
- Maximum total deformation occurs on the blades. In order to prevent or minimize this deformation, blades produced by carbon fiber material.
- With modal analysis, the natural frequency of the system is calculated and kept away from the rotating frequency to prevent collusion.
- A ¼ scale prototype is manufactured
- Wind Tunnel Test of the scaled model is done .

Picture of the manufactured VAWT