Department of
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Vertical Axis Wind Turbine

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Project Overview

The objective of this project was to use carbon fiber NACA 0015 airfoils to build a lightweight and stiff Vertical Axis Wind Turbine (VAWT) that could perform well in gusty environments. The team successfully built and tested a quarter-scale VAWT that generated lift and sustained lift-generated rotation in low wind speeds. The project aimed for a 30% efficiency, and achieved an actual efficiency of 24.6%.

Specifications and Metrics

The metrics and specifications were determined to meet the efficiency and deflection goals requested by our customer, Dr. Meredith Metzger.

Table 1: *Metrics*

Metric Description	Desired Value	Measured Value
Height of Blades	29 in	29 in
Turbine Diameter	24 in	24 in
Turbine Torque	0.11 Nm	0.125 Nm
Maximum Moment of Inertia	0.07 kg-m^2	0.021 kg-m^2
Maximum Deflection	25.4 mm	22 mm
Tip Speed Ratio	3.4	3.45
Coefficient of Power, Cp (Mechanical Efficiency)	0.3 (30%)	0.246 (24.6%)

Testing Methods

Torque Test: A brake was manufactured to hold weights perpendicular to the turbine shaft. The brake load the turbine could withstand was plotted vs. the speed of the turbine. This torque vs. speed curve was used to determine the efficiency of the turbine.

Deflection test: A high speed camera was used to measure the max deflection of the blades at 5 m/s in front of the wind tunnel to ensure the maximum deflection was within the strength factor of safety of the blades.

Sponsors

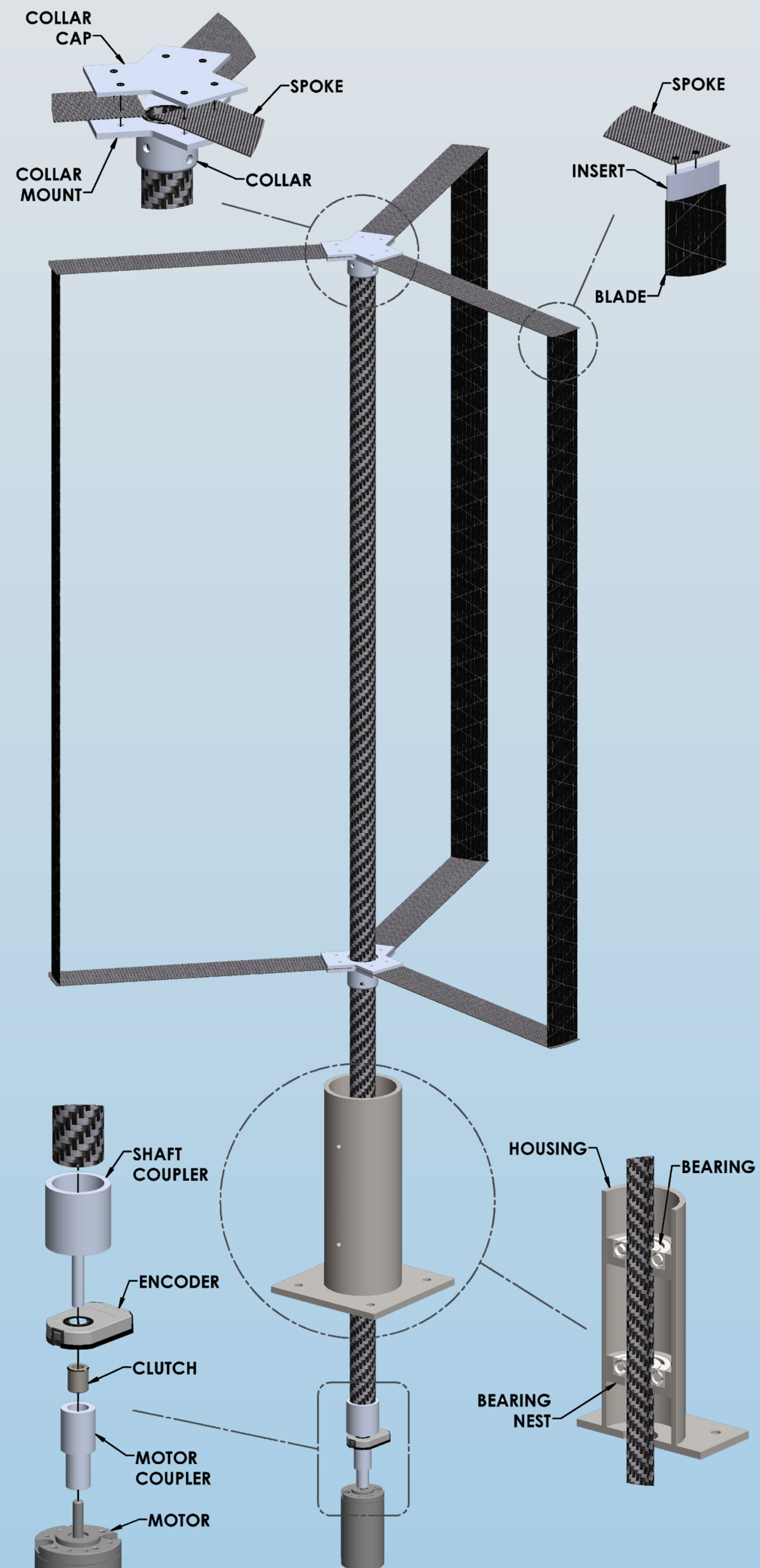
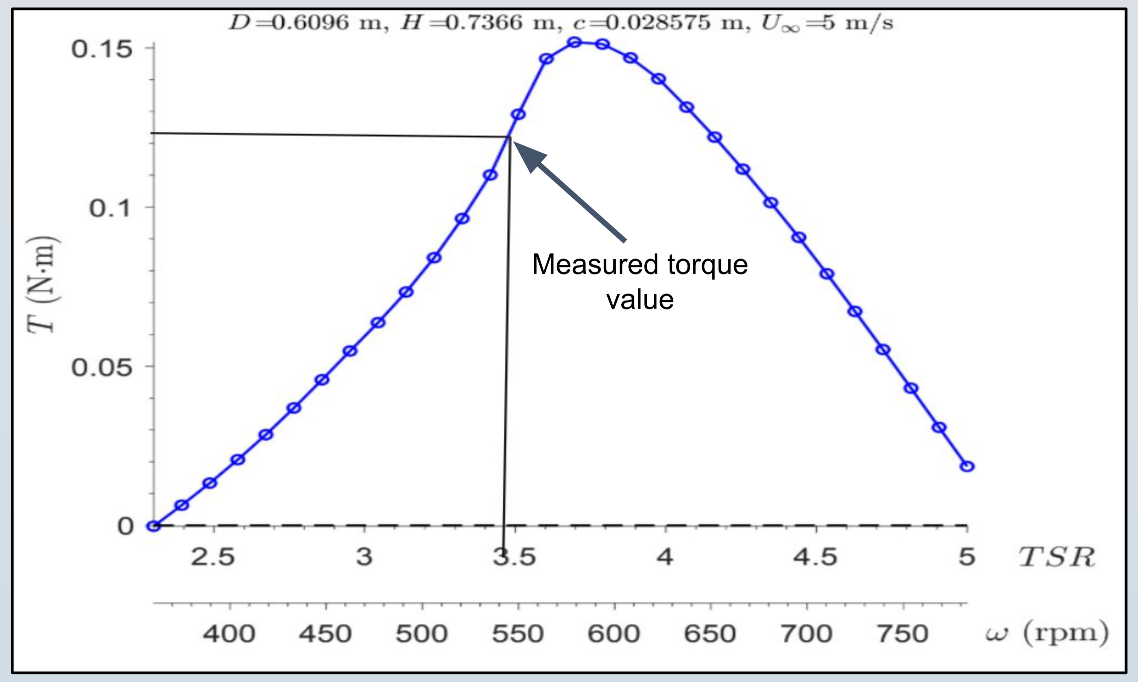


Figure 1: *Turbine Assembly.*

Results and Analysis

Torque Test: The tip speed ratio (TSR) and the coefficient of power results are shown in *Table 1* and were determined by comparing the measured torque to the rotational speed (*Figure 2*). Our Coefficient of power was 18% lower than our goal.



$$Cp = \frac{2T\omega}{\rho V^3 DH}$$

T = torque (N/m)
ω = rotational speed (rad/s)
ρ = air density (kg/m^3)
V = air speed (m/s)
D = turbine diameter (m)
H = height of blades (m)

Figure 2: *(Left)Torque vs. Rotational Speed (analytical and measured), (Right) Coefficient of Power Equation (mechanical efficiency)*

Deflection Test: Two forms of analysis were performed to determine blade deflection at different rotations per minute (RPM): Numerical analysis using MATLAB and computational analysis using Abaqus. Actual deflection was determined during testing, and the compared results can be seen in Figure 3.

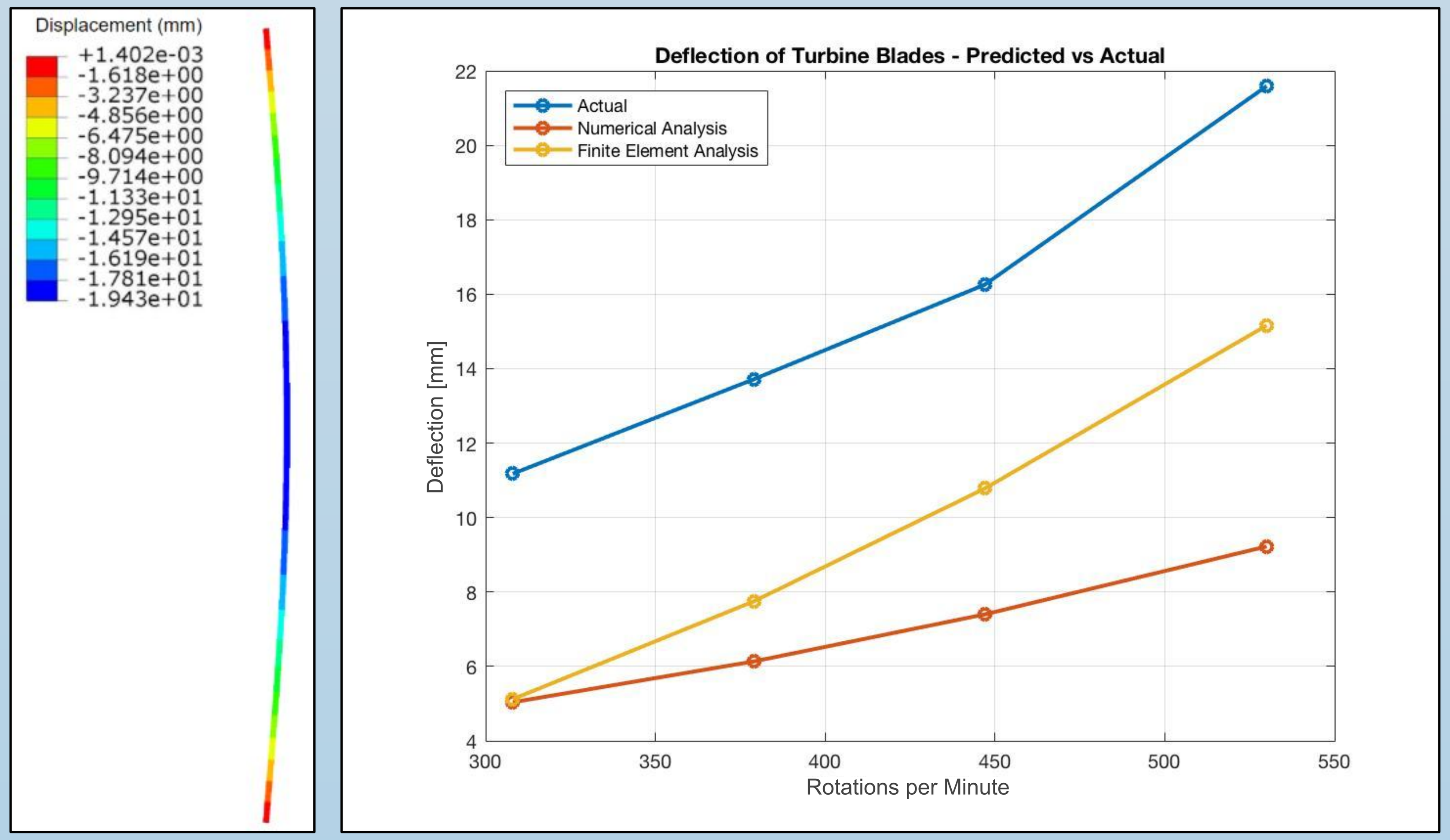


Figure 3: *(Left) Deflection as predicted by FEA analysis at 600 RPM, (Right) Predicted vs actual blade deflection.*

Conclusion

The vertical axis wind turbine with the geometry tested can generate lift proving the turbine can generate power. The overall goal of 30% efficiency was not fully reached because of oscillations in the wind turbine system. We believe stabilizing the structure and placing the bearings farther apart will decrease the oscillation and improve the efficiency.