Venus Wind Turbine Optimization

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Project Background

Venus is the second planet closest to the Sun and is often considered Earth's "sister" due to its size. However, Venus's environment is harsh and caustic. It has an average surface temperature of 460 C, a pressure of 9300 kPa, an air density of 67 $\frac{kg}{m^3}$, and an average wind velocity of 0.7 $\frac{m}{s}$. Wind velocity was obtained from multiple rover missions sent to Venus in the 1970s and 80s, shown in Figure 1 below.

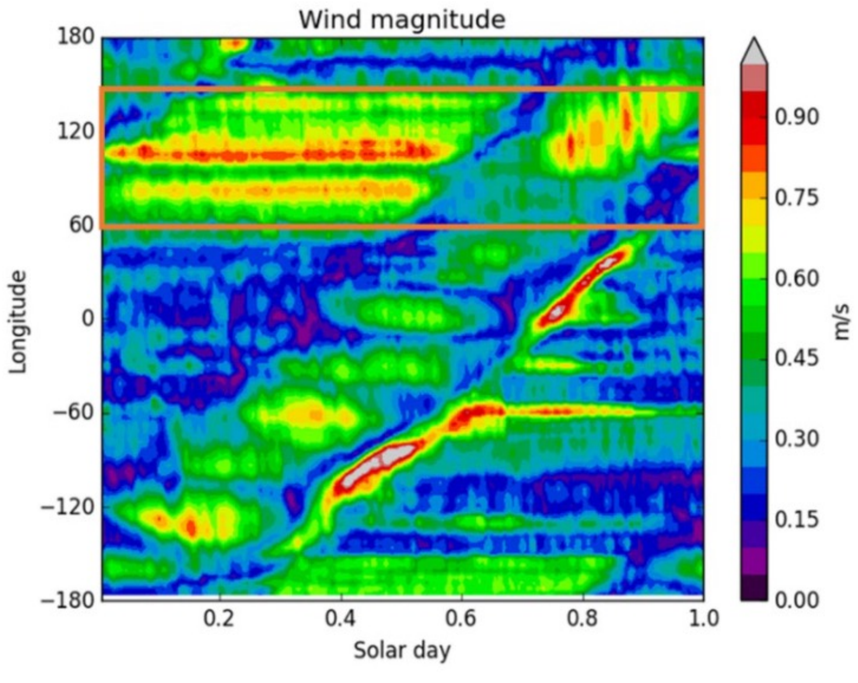


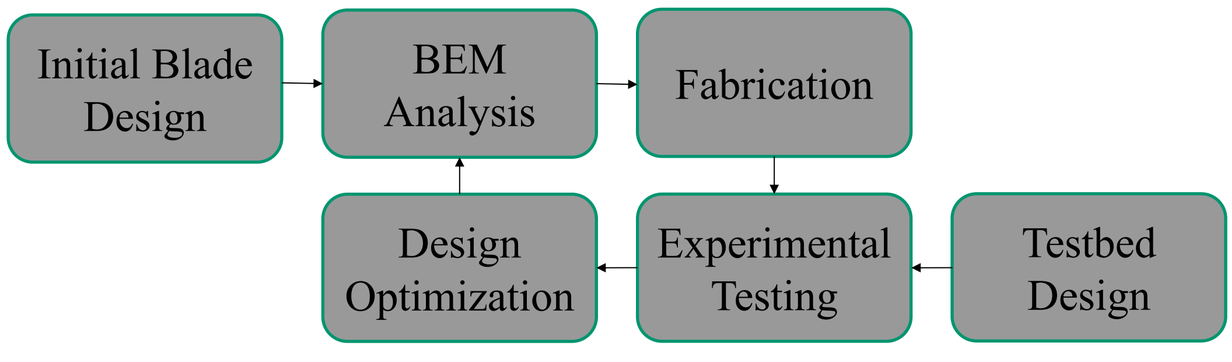
Figure 1 – Venus Wind Speeds

Project Goal

- Design and fabricate a prototype of a three-bladed horizontal wind turbine.
- Design a program to characterize the behavior and power generation of blade design
- Design and construct a modular testing platform to verify computational results

System-Level Requirements

No.	Attribute	Requirements
1	Power Generation	15 Watts
2	Efficiency	0.35-0.45
3	Turbine Diameter	2 m



Turbine Blade Design Approach

Blade Element Momentum Theory was applied to design the blade through a set of airfoils that satisfies the requirements of fluid properties and wind speed range. A 3-bladed system was then produced with 6061 aluminum for testing.

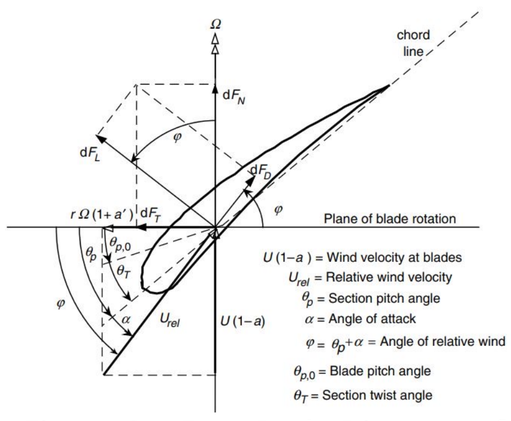


Figure 2 – Free Body Diagram of turbine airfoil

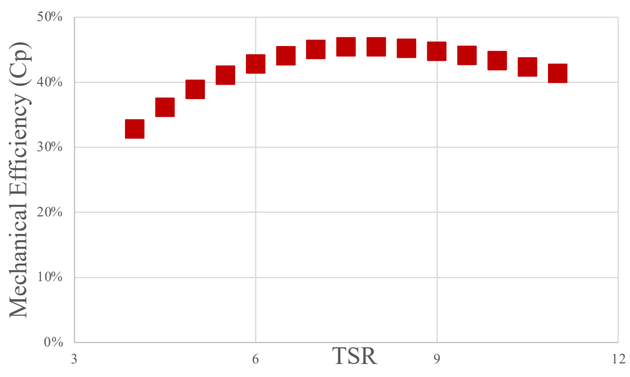


Figure 3 – Theoretical mechanical efficiency with respect to TSR at 0.7 m/s



Figure 4 – 1/4th Scale Aluminum Turbine Blade

Testing Platform and Sensors

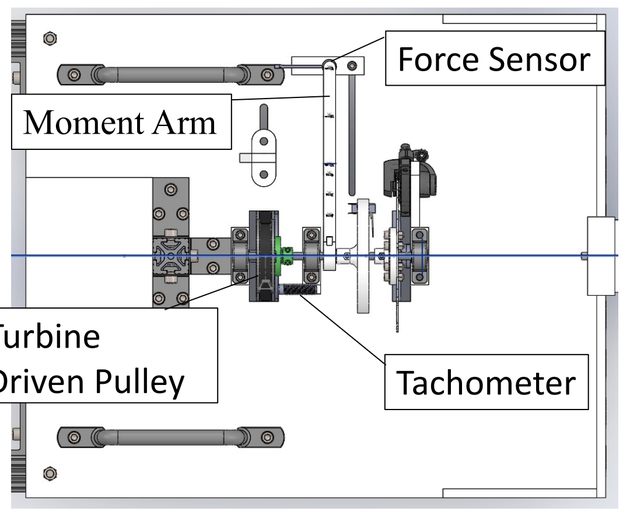


Figure 5 – Top view of test platform

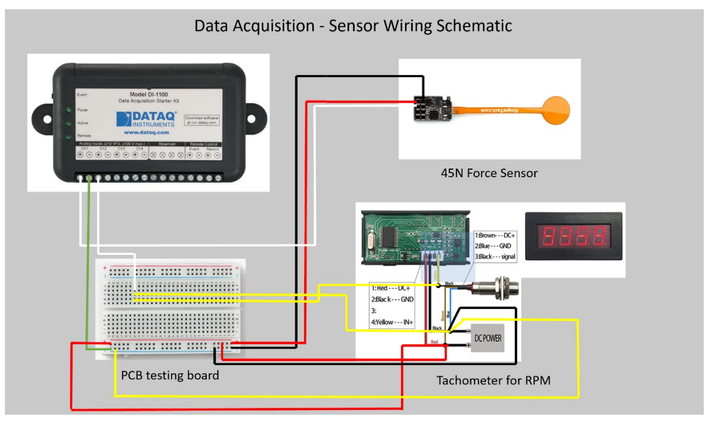


Figure 6 – Schematic of the Data Acquisition Unit and sensors required for testing

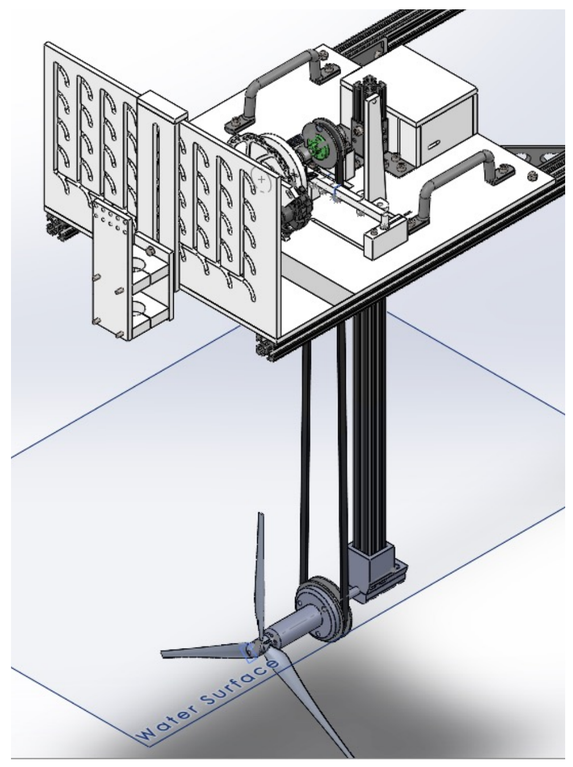


Figure 7 – CAD model of Testing Platform

Results and Conclusion



Figure 8 – 1/4th scale turbine blades and hub

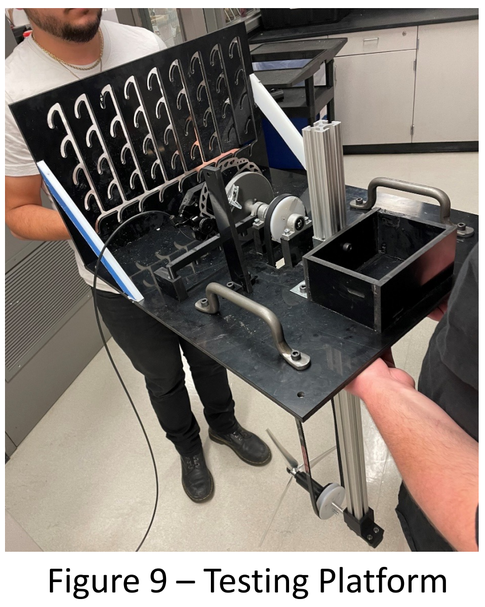
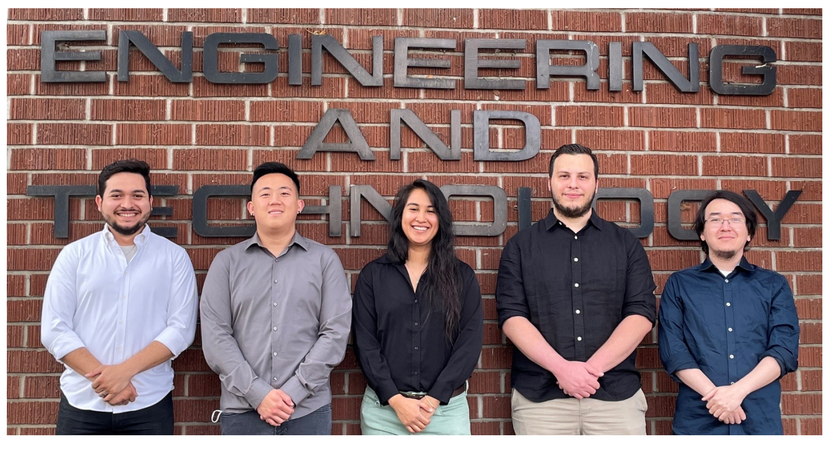


Figure 9 – Testing Platform

- Testing platform structure and components fabricated and assembled
- Various anomalies postponed system results
- The next step is to test the wind turbine in water to verify theoretical values



Cal State LA 2022 Venus Wind Turbine Optimization Senior Design Team