Wind Turbine Prototype for Offshore Power Generation

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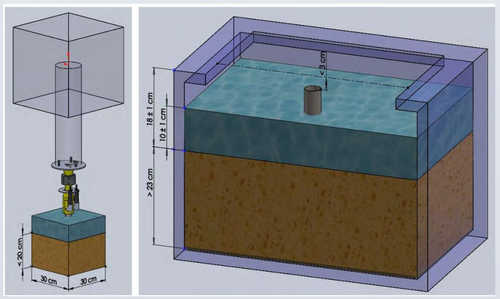
Scope of Project

- Build and prepare a functional wind turbine prototype based on 2022-2023 CWC (Collegiate Wind Competition) rules and standards.
- Reach needed milestones for next year's team to compete.
- Invite and recruit a structured UVU Windmill Team to compete every year following the 2023-24 competition.

Design Requirements of the CWC

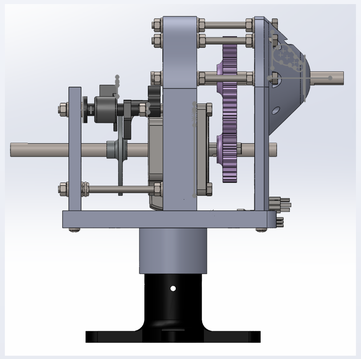
- Wind tunnel speeds of 5 – 22 m/s
- Blades and Turbine components must be within 45 cm x 45 cm x 45 cm cube
- Turbine must anchor into 15 cm x 25 cm x 25cm sand cube submerged below 10cm of water
- Power generation must not exceed 48 volts
- Must be able to control braking of turbine



Objectives

- Redesign of housing to allow for a more compact and enclosed design
- Reduction of weighted components to allow for functionality and efficiency
- Incorporating last Years Moons 80BLC D/C motor into new design
- Build foundation to withstand wind speeds of 22 m/s with displacement less than 25mm
- Design a blade that can withstand 22 m/s
- Optimize the blade to fit in the 45 cm cube
- Design modular controller to change to each need
- Integrate braking systems that are required for competition

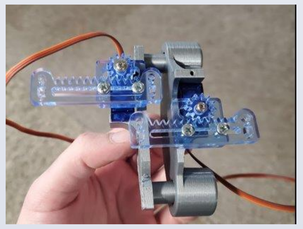
Methods and Materials



Turbine Housing

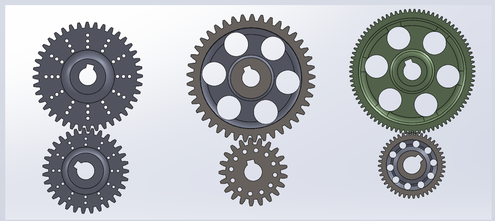
- Geared configuration
- Sectioned Structal supports for drive train and power generator
- Non-Ferrous internal components

Original Vs Custom shaft



Drive Shaft and Secondary brake

- Two drive shafts were machined of 304 stainless steel by A&M machining
- Centered Machined shafts for true alignment
- Sliding disk design for even pressure distribution during braking
- Two 6-volt actuators for braking during low power generation.



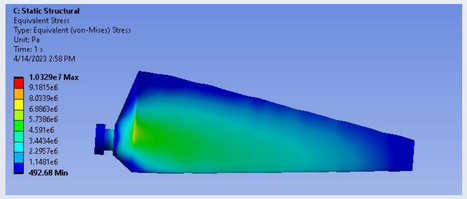
Spur Gear Development

- Gear ratio ranges 1:1.25 to 1:89
- Weight reduction for increased efficiency
- Printed using Vat Photopolymerization

Blade Design and Development:

- CFD simulation using QBlade to determine which airfoil design would provide the most torque and least amount of thrust
  - Torque to overcome resistance of generator
  - Thrust to reduce force creating a moment force on the tower

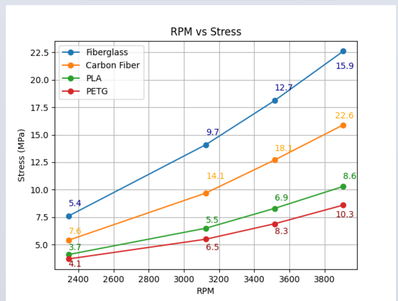
Selected Airfoil - NASA/AMES Airfoil Design



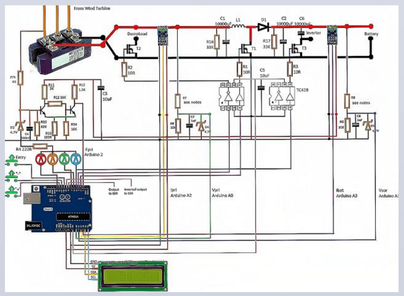
ANSYS Static Structural Analysis

- 3D FEA in ANSYS used to simulate maximum rotational and normal stresses applied to turbine blades during competition
- Material selection comparing PLA, PETG, Fiberglass, and Carbon Fiber
- PLA was selected for blade material

Blade Material Analysis

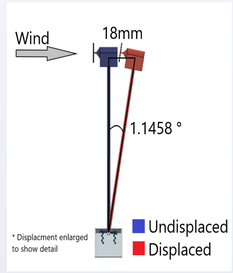


Turbine Controller



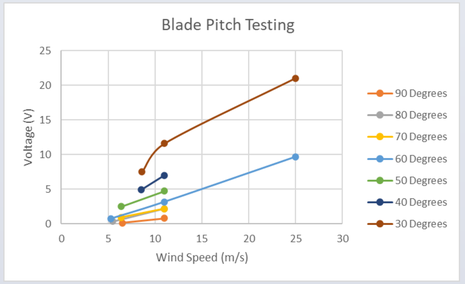
- Controller was designed using arduino IDE

Foundation



Results

- Power generation was within expectations
- Cut in speeds were around 5-9 m/s
- Ideal blade pitch angles were identified at 30 & 60 degrees.
- Prototype braking works but still needs to be created out of a ferrous metal to function properly.
- Foundation resisted wind speeds of 22 m/s with only 18mm of displacement



Accomplishments and Conclusion

Accomplished Objectives:

- Built and prepared a functional wind turbine prototype
- Recruited a team leader for the next year

Next Year Team Objectives:

- Refine housing design to be more aerodynamic
- Reduce cut in speed
- Make any changes to accommodate new rules and standards for 2024 CWC
- Meet all deadlines for reports and applications for CWC

References

Collegiate wind competition rules and requirements. Energy.gov. (n.d.). Retrieved April 16, 2023, from https://www.energy.gov/eere/collegiatewindcompetition/articles/collegiate-wind-competition-rules-and-requirements

Acknowledgements

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