Improvement and DOE for a VAWT

David Ryan, Kacper Zielinski, Patrick Mukuna, Connor Hannan

Aim of the Project

The aim of the project is to design new components which will improve the functionality, stability and efficiency of the Vertical Axis Wind Turbine (VAWT). Another aim of the project is to create a Design Of Experiment (DOE) using the Minitab software and identify the best configuration of variables which will provide with the highest RPM.

Objectives

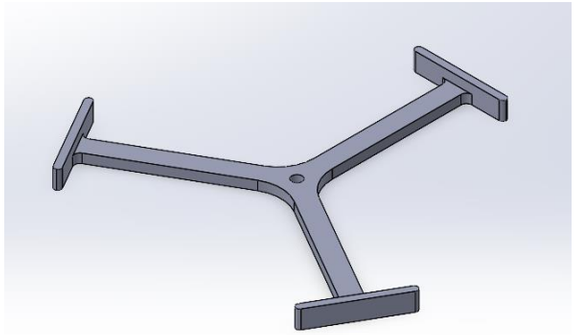
- Research about VAWT's and their existing designs to implement new improvements on the rig.
- Create concept designs of possible improvements and identify which one will be the best.
- Manufacture new components using the manual machining workshop along with the CNC machines.
- Research about DOE in Minitab, identifying what its purpose is and how to implement for the VAWT rig.
- Identify the best possible configuration for the VAWT rig.

Background

- A VAWT (vertical-axis wind turbine) is a type of wind turbine where the rotor, shaft and gearbox are arranged in a vertical position instead of horizontally as a typical wind turbine would be. Such a design allows it to harness wind from any direction without needing to adjust its position. This type of wind turbine simplifies maintenance and it's easier to set up than horizontal wind turbines.
- Vertical axis wind turbines are more suited to small scale/ residential use as they produce less noise.
- Darrius type VAWT are the most efficient of all designs. The profile resembles a airplane wing were its round at the front and then tapers off to a point at the rear, similar to a tear drop shape.

Design of the Wind Turbine

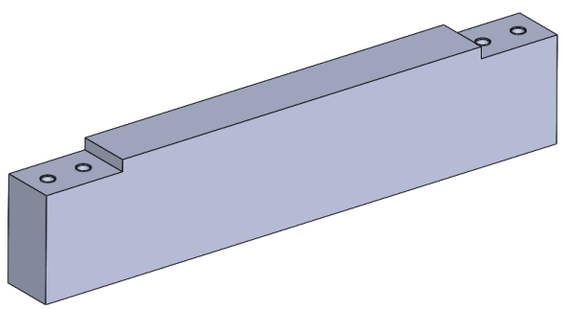
The existing wind turbine had a bent centre shaft, and the way of changing the angle of the blades was pretty much guesswork as it wasn't accurate. Hence, the current design was implemented with a new centre shaft and angle control system known as the 'Angle plate'. There were new sets of blades which were designed and 3D printed to ensure geometric similarity. Lastly, a fan mount was designed to ensure the stability of the fan and be able to relocate it to simulate high and low speeds affecting the wind turbine.



Angle plate CAD model

Shaft CAD model

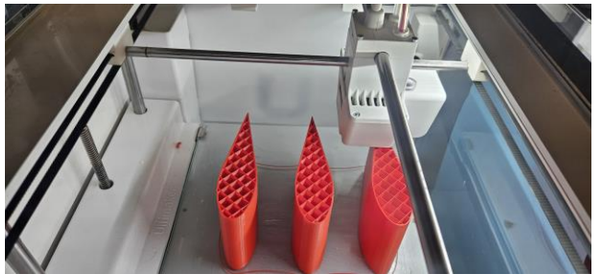
Fan mount upright CAD model



Fan mount base CAD model

Manufacture

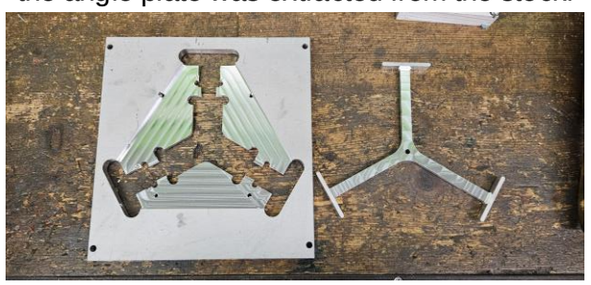
The manufacture of the Wind turbine was completed using a combination of 3D printing, CNC machining and manual milling machine. The blades were 3D printed to reduce their mass and to speed up the manufacture process.



The angle plate component was initially planned to be made using CNC on the spinner, but the deadline was coming to an end. Hence, it was decided to 3D print the part and use it during experimentation as a substitute for when the spinner was available, and the angle plate was able to be machined.

The fan mount base and fan mount uprights were manufactured using the manual milling machine. A combination of endmills and drills were used to bring both parts to length, cut slots, and drill holes.

The following is the final product from the machining done on the spinner. The machining was done from one side only and the angle plate was extracted from the stock.



Design of Experiment

Design of experiment is a tool used in experiments where there is many variables each resulting in a different output. When the experiment is run, the result is inputted, and the software compares the results for each run. Different graphs and tables are then produced that can be used to compare the variables used and their impact in the experimentation.

Conclusion

The designs made improved the stability, efficiency and accuracy of testing of the turbine. This was done by manufacturing a new shaft and designing and 3D printing a new set of blades with an improved, more accurate and repeatable way of changing the angle of the blades. When the results of the experiment were input into the DoE it told us that the height of the blades had the greatest impact on the output and the angle of the blades had little effect on the output

Acknowledgements

We would like to thank our supervisor, Dr Richard McEvoy for his initial guidance and then a massive thanks to Emma Kelly for stepping in when Richard became sick and helping us with our project and report. We would also like to thank Jennifer Hennessy for her help with understanding on how to use Minitab and setting up a design of experiment. We would also like to acknowledge all other lecturers that gave us advice such as Ciaran, John and Miroslaw.