Reducing HAWT Blade Failure due to Fatigue Through Varied Aerodynamic Design

BEng Renewable Energy Engineering

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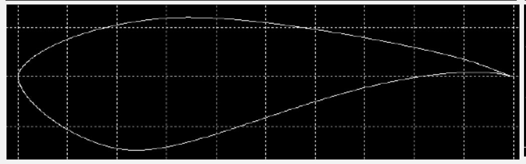
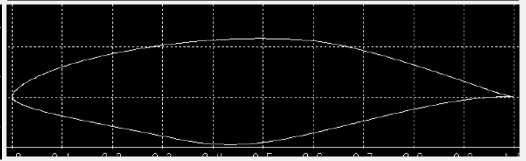
Introduction

The project aimed to investigate the effects of changing the geometric properties of HAWT blade aerofoils on the aerodynamic forces. Specifically targeting those which contribute to fatigue without contributing to power output. Minimising these forces should help reduce the likelihood of blade failure by fatigue, while maintaining a high overall turbine power coefficient.

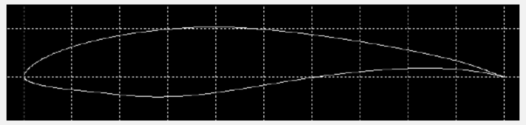
S815 - Thick, High Camber.



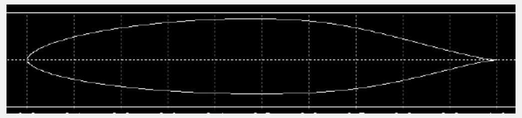
S827 - Thick, Medium Camber.



S826 - Thin, High Camber.



S829 - Thin, Low Camber.

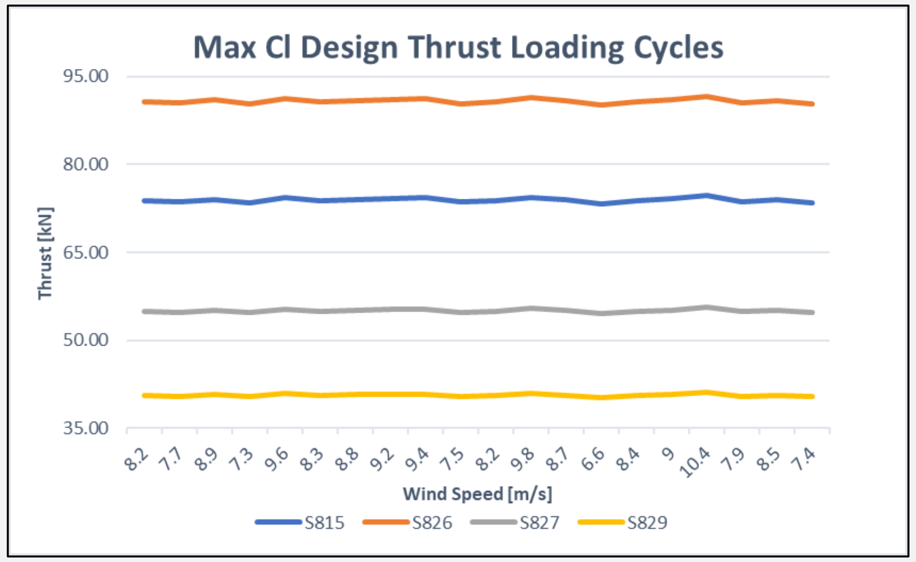


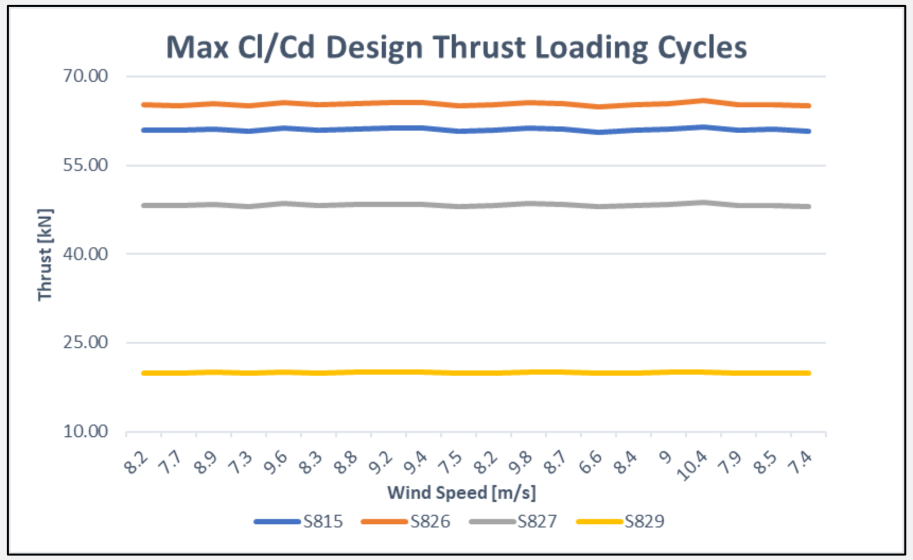
Project Method

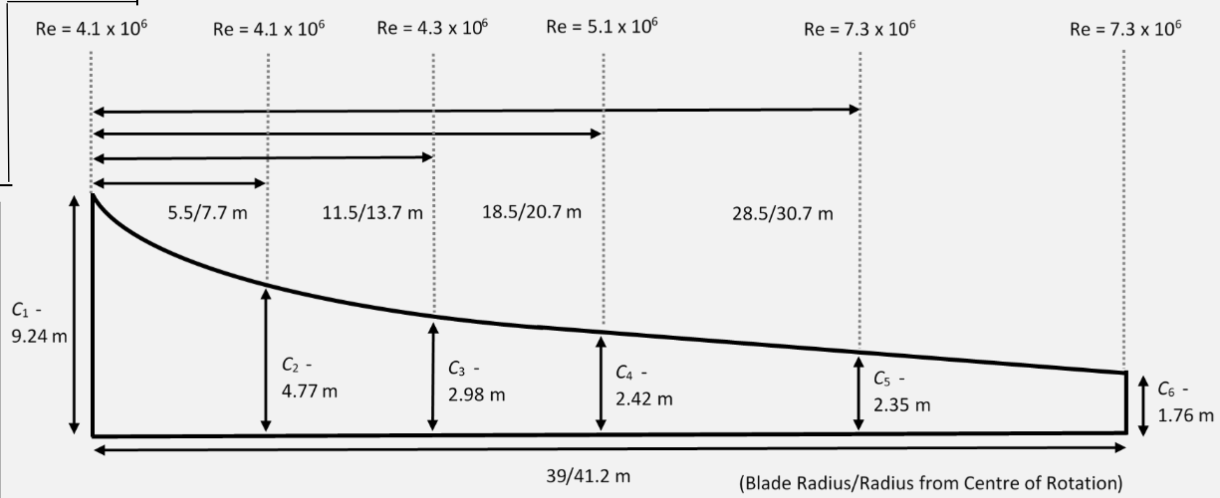
- Iterations were used to calculate values for chord and Reynolds number at several points across the span.
- Chords were plotted to give design dimensions which were optimised for the mean lift coefficient of the 4 aerofoils.
- XFOIL was used to simulate air flow around the aerofoils and compute coefficients.
- Typical wind conditions were simulated based on the reference turbines wind class: II_A.
- Blade was divided into sections and Blade Element Momentum Theory was used to calculate the aerodynamic forces at each section.

Assumptions

- BEM assumes 2D air flow and that the flow in one BEM section does not affect neighbouring sections.
- Tangential and Axial Induction Factors assume initial conditions.

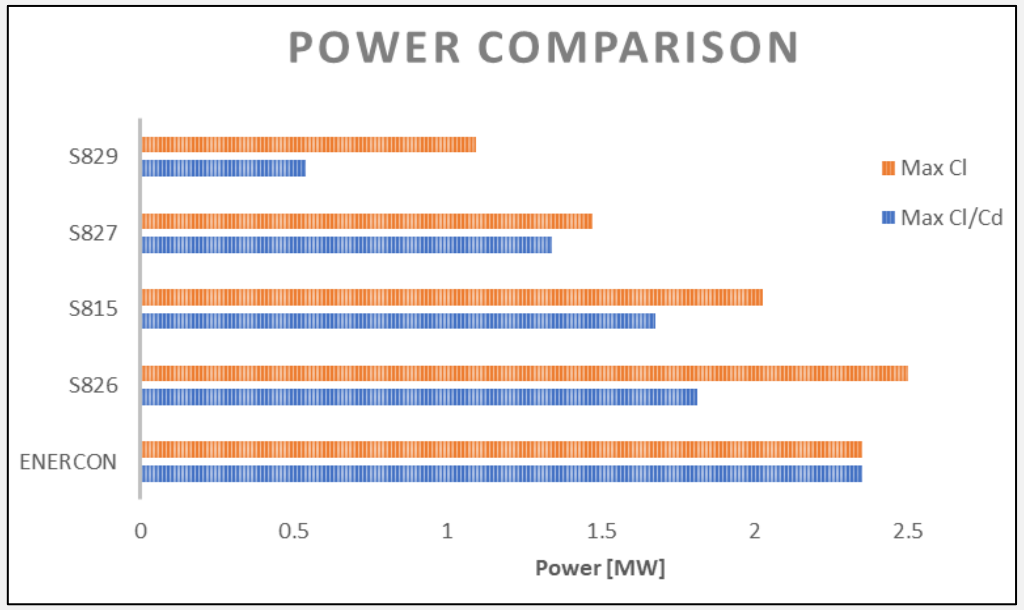






Project Objectives

- Research and concept solution ideas to overcome issue.
- Determine the optimum solution.
- Perform detailed designs in accordance with the project specification and reference turbine design parameters.
- Simulate design performances in working conditions, observing the effects on loads responsible for fatigue.
- Make comparisons against a current reference HAWT blade.
- Comment on solution effects on turbine efficiency and power output.



Conclusions & Recommendations

- Reduced likelihood of fatigue corresponds to a reduction in power output.
- All designs have a similar power to thrust force ratio.
- Scale models of each design profile could be manufactured using typical structural internals.
- Design thrust and torque forces could be converted into stress cycles which could be run to give expected lifetime of each design.
- More in depth profit analysis may be carried out for each design and the best design optimized further.