CFD Analysis of a Wind Turbine Experimental Test Rig

Liam Flynn K00264849

Aim of the Project

The aim of the project was to complete a CFD analysis of a wind turbine vane within the wind tunnel previously designed.

The project objectives were;

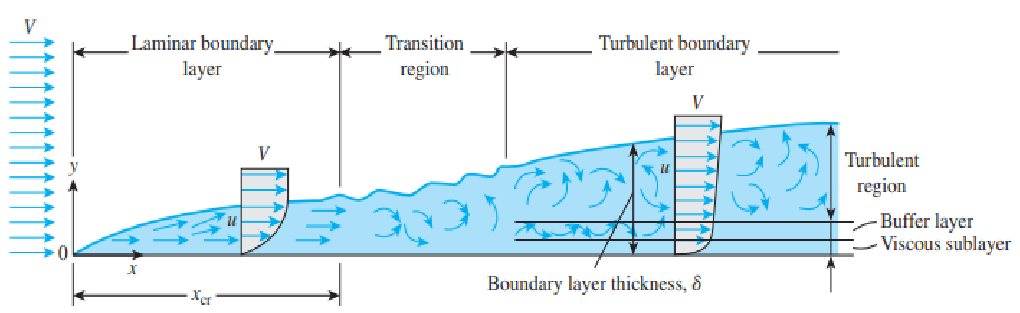
- Create a CFD model of the wind tunnel in SolidWorks
- Set boundary conditions to mimic those of an actual test
- Run a CFD analysis on a wind turbine vane and determine lift and drag generated
- Compare the results to those obtained from a physical test
- Create a report to detail the process and display the results

Background

CFD is used to analyse fluid flow without the use of costly physical test rigs. It is a software package used by many industry sectors for the likes of car design, turbine blade design, aircraft wings and fuselages etc.

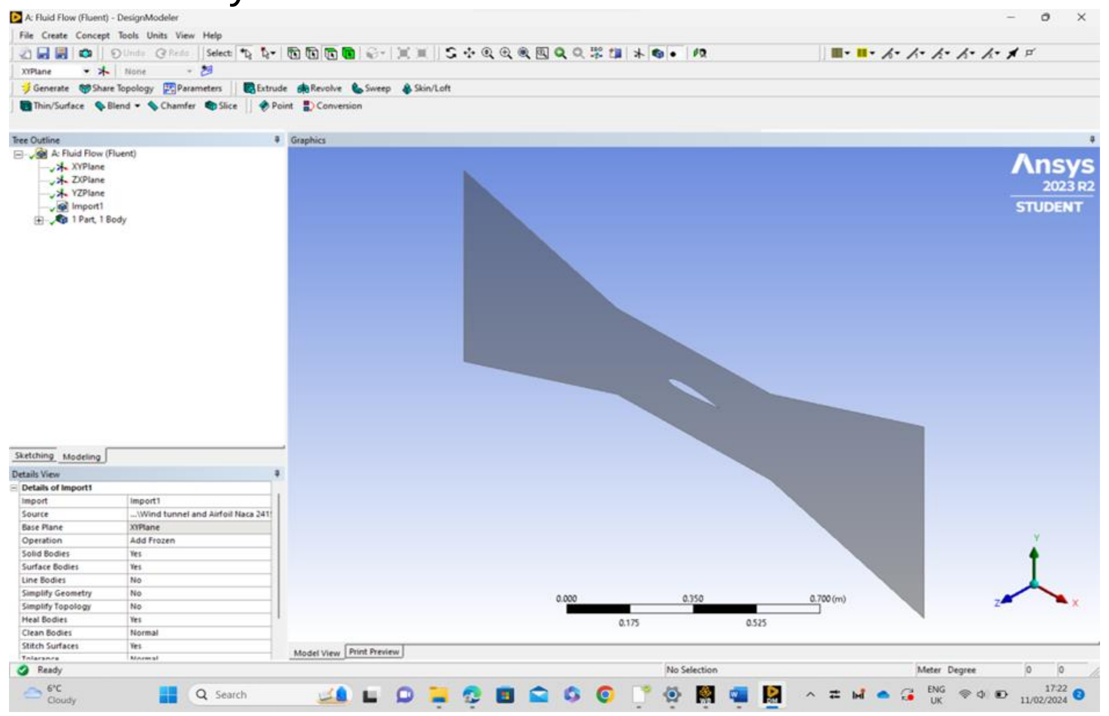
Different aspects of fluid flow theory needed to be understood before the analyses could begin. These included understanding velocity boundary layers as seen below, Reynolds number, Navier stokes eqns. etc.

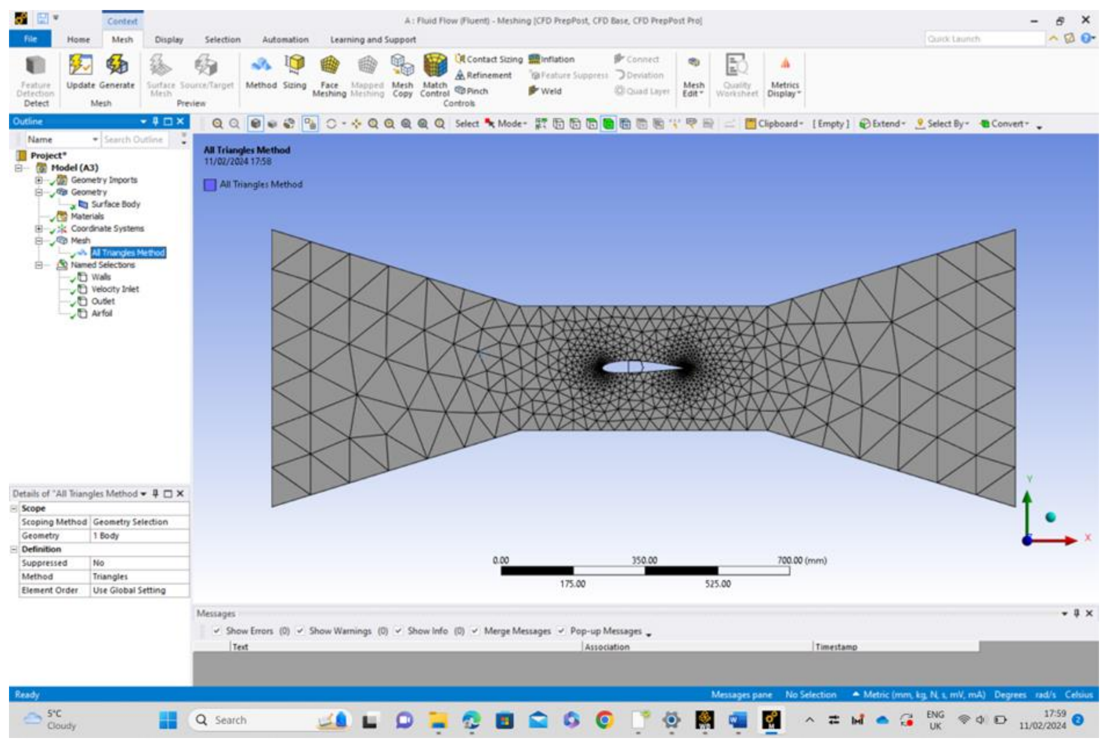
The understanding of these equations and factors of fluid flow is necessary to be able to determine whether the results of the analyses are reliable and accurate.

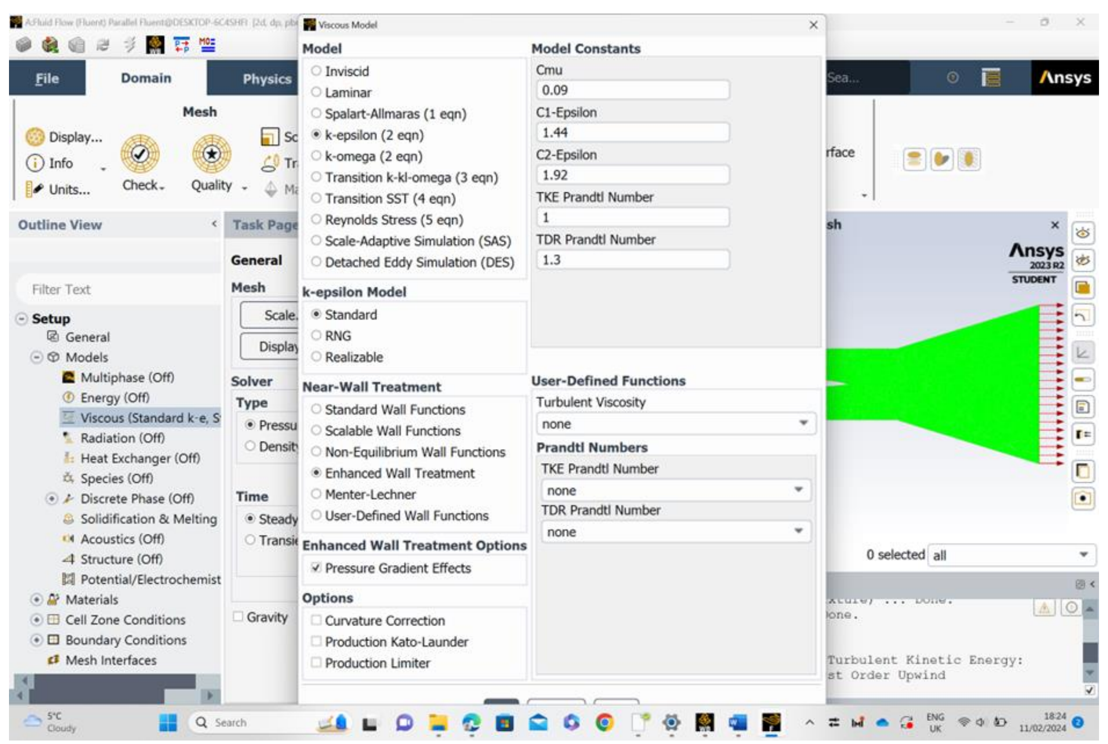


Setup of Analyses

Seen below is the setup of the analyses within ANSYS Fluent. The images show the creation of the refined mesh and the importing of the surface into ANSYS. Along with the tab showing all of the conditions applied to the analyses.



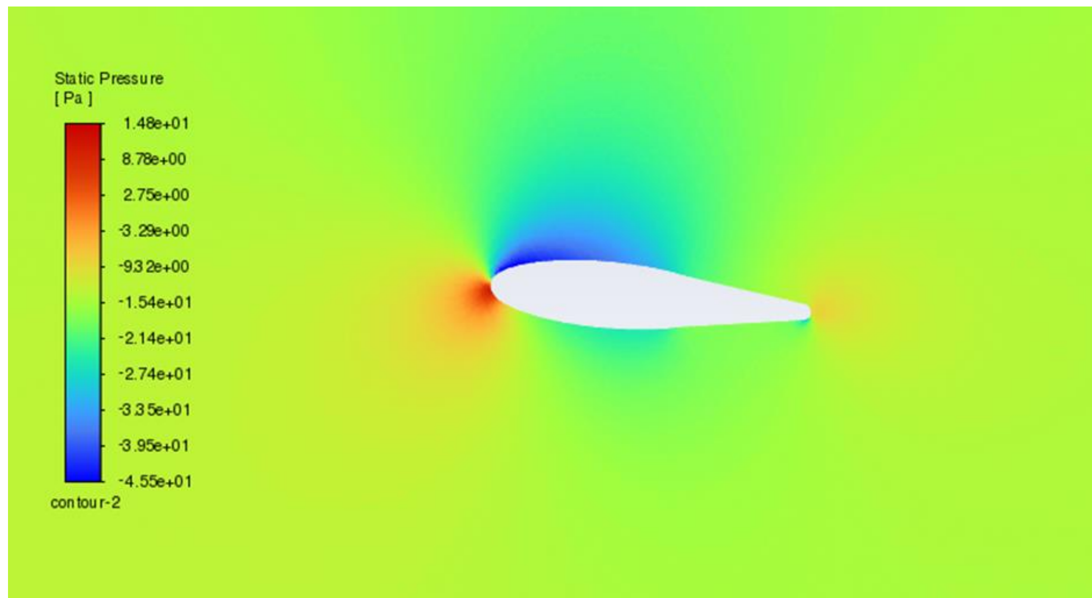


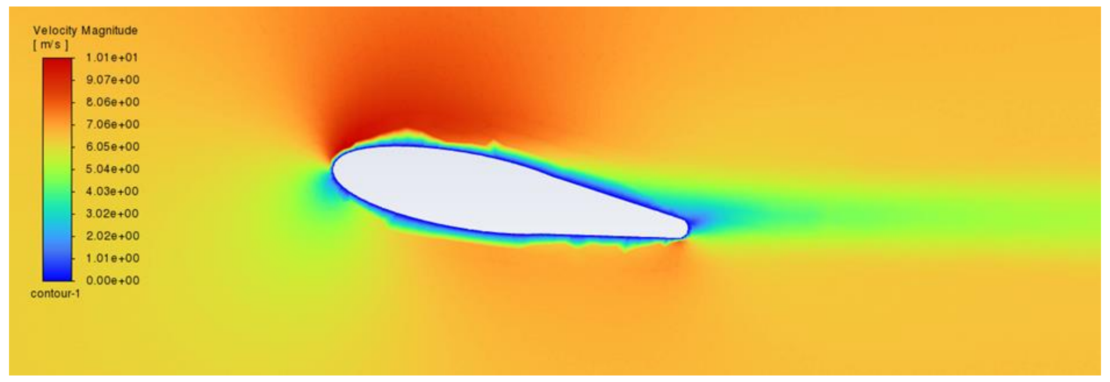


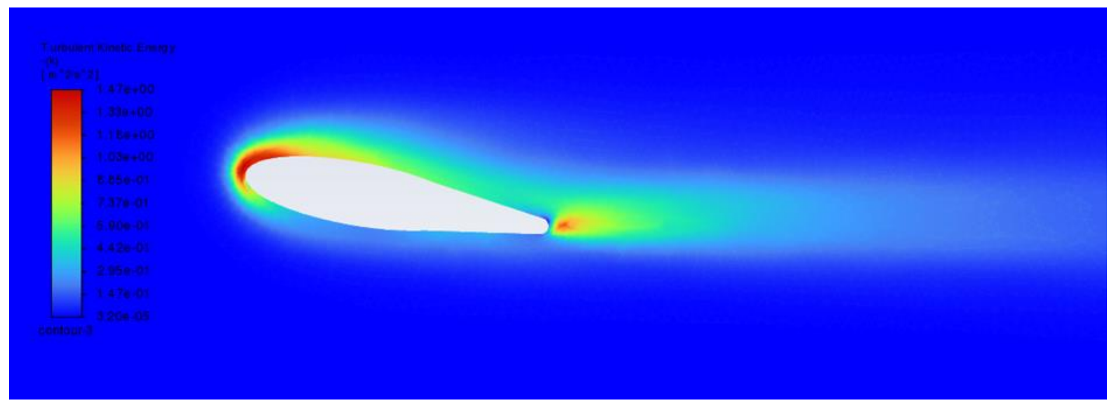
CFD results

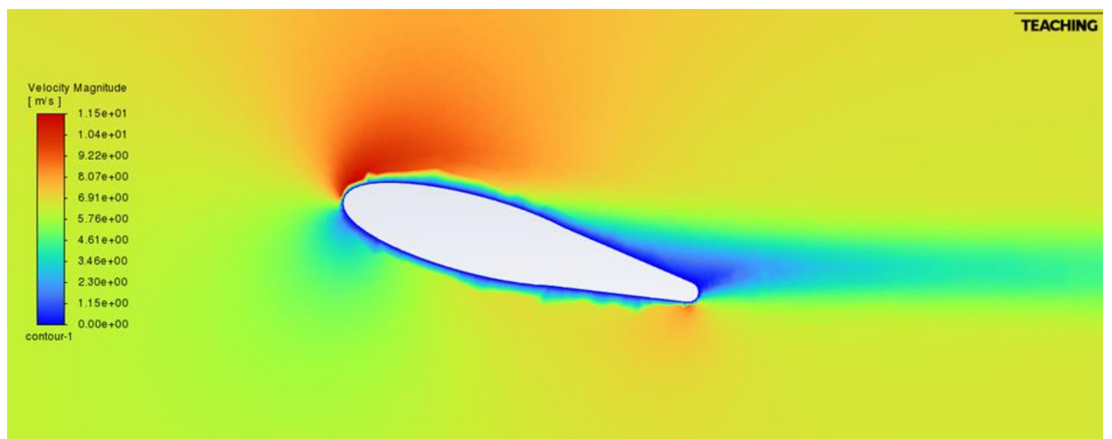
CFD Analysis Results

Below are the results from the CFD analyses conducted on the wind tunnel as a two-dimensional surface. The results show pressure difference across the aerofoil along with turbulent and velocity drag formation









Conclusions

- The wind tunnel test rig maintained a laminar flow throughout the test section meaning the design was a success.
- The CFD tests returned representative values when compared to existing research.
- The NACA-0018 aerofoil developed larger lift forces with more aggressive angles of attack.
- From five degrees angle of attack up to fifteen degrees the lift force generated increased by a factor of 2.7
- The maximum lift force generated by the NACA-0018 aerofoil was 24.32 newtons.
- The minimum lift force generated by the NACA-0018 aerofoil was 0.004 newtons.
- It was found that the NACA-2415 reference aerofoil developed 3.49 newtons of lift force at zero degrees angle of attack.
- As the angle of attack of the NACA-0018 aerofoil increased the pressure in the test section decreased.