Prandtl Propeller Modeling and Evaluation

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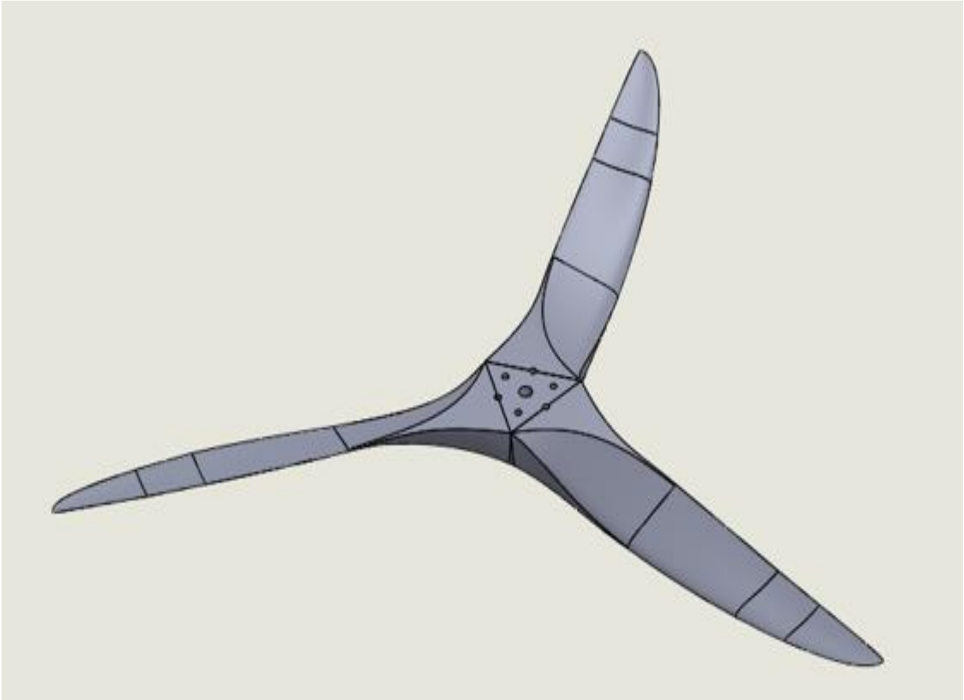
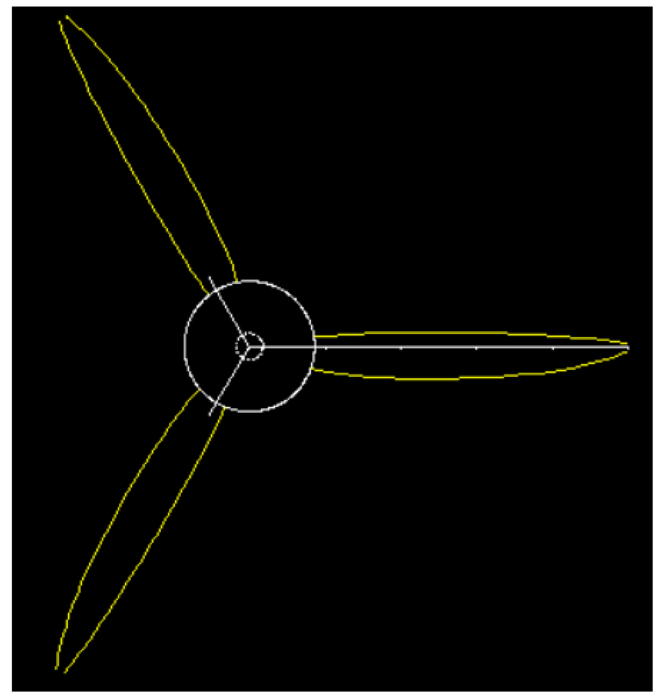
Overview

The propeller has been used since the dawn of flight and has been modelled and designed using the same methods for nearly a century.

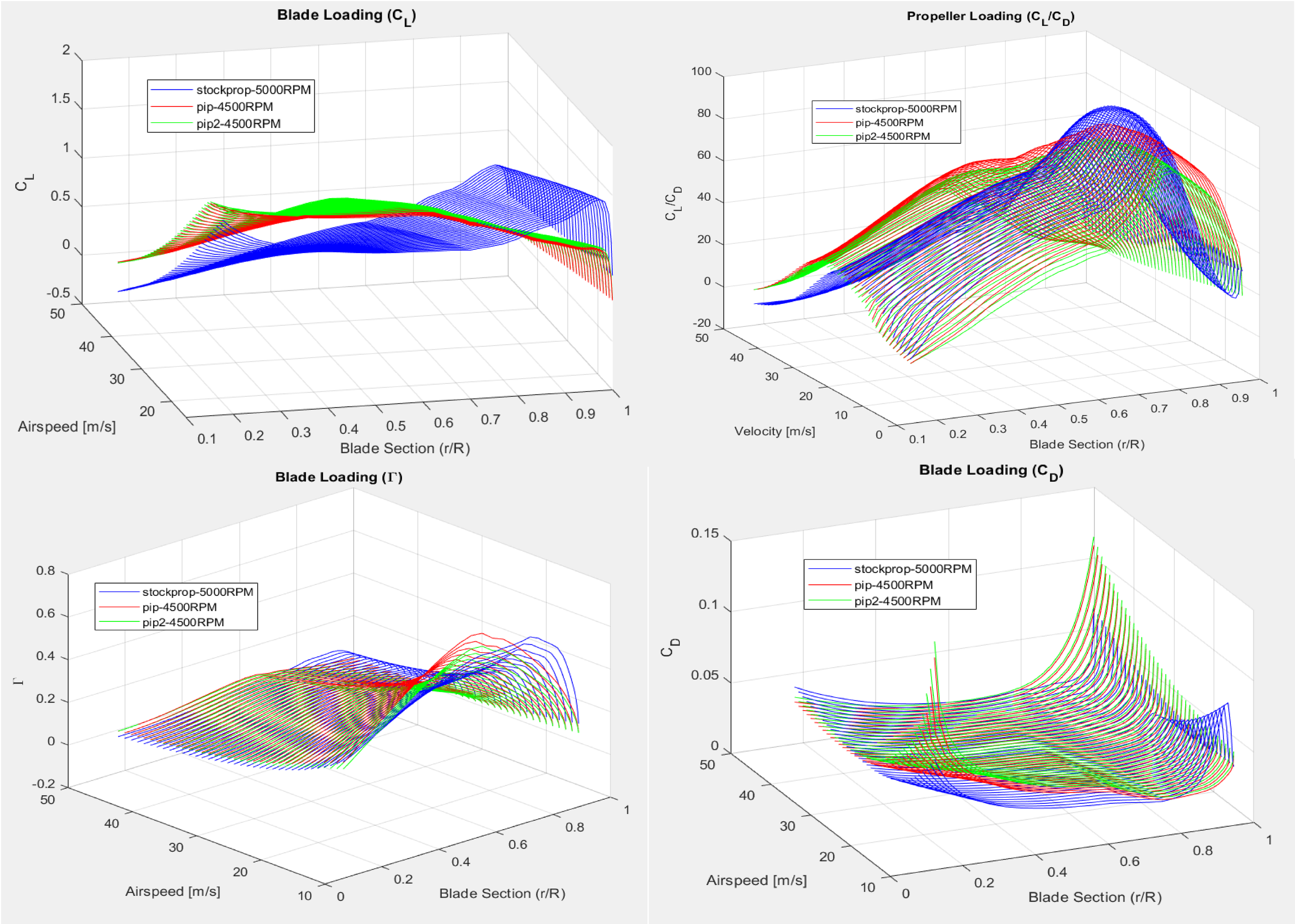
- Traditionally design uses the Minimum Induced Loss (MIL) method, which says that maximizes the local efficiency along the length of the propeller blade will result in the best overall efficiency.
- The Prandtl design challenges MIL attempting to optimize for other conditions





Modelling Techniques

- Blade Element Momentum Theory (BEMT) is a common method that is used in propeller design, which assumes that a blade is a collection of 2D airfoil profiles, and the local pitch is determined based on desired angle of attack and the angle between the axial and tangential velocities that the propeller section is travelling. The advantage to using BEMT is that the propeller designer tailors the propeller blade to meet the design goals.
- Actuator Disk Theory, which is used to analyze overall propeller performance. This treats the propeller as an infinitely thin disk that has a difference in pressure on either side, which represents the thrust generated by the propeller.



Processes

Using MATLAB®(The MathWorks Inc., Natick, Massachusetts), propeller models are made, one using the traditional MIL method and another that applies a Prandtl Twist to the propeller blade. Using the open source programs XFOIL and XROTOR, the propeller can be modelled and analyzed to determine the performance in a variety of operating conditions. The primary focus is to analyze the performance in greater detail to explain previous results. Analysis includes thrust, power, and torque coefficients, along with changes in inflow angles and angles of attack along the propeller blade.

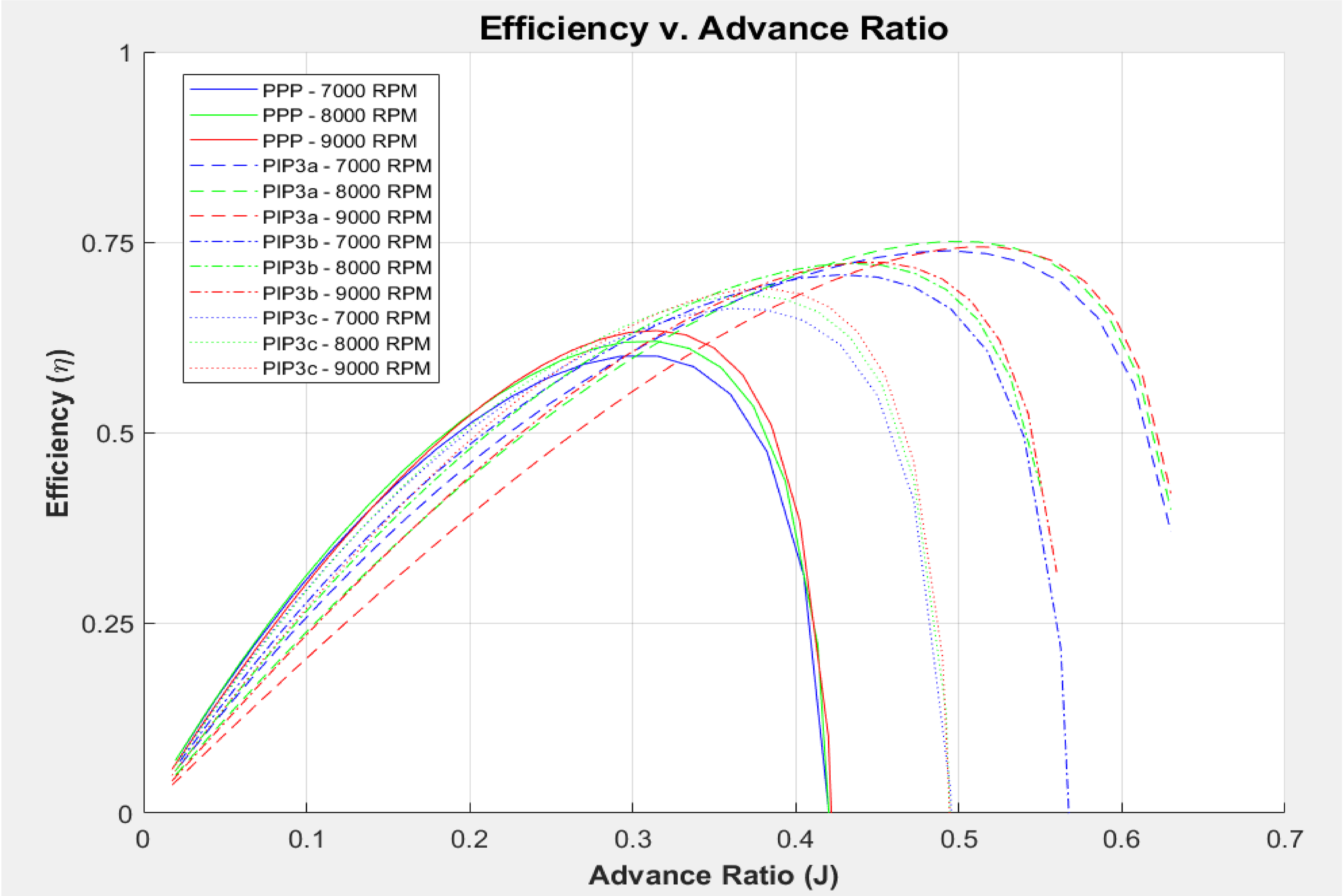
Results

Current results show redesigned propeller efficiencies are improved at higher velocities.

- Higher blade design angle of attack results in both higher lift, until stall, and higher drag. For propeller designs, to create more lift, it generally means we must cerate more drag.
- Prandtl Propeller design increases blade design angles which can cause poorer performance at lower velocities because they will have a high angle of attack, which can be beyond stall conditions.

Next Steps

- A more in-depth analysis of the propeller performance in a variety of operating conditions.
- Increasing model accuracy.



Acknowledgements
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