Can Airfoil Camber Enhance the Performance of VAWTs?

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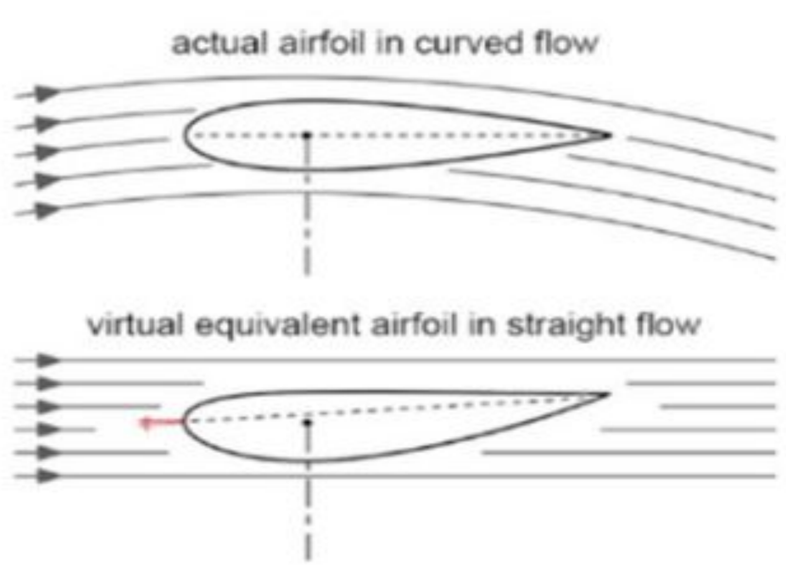
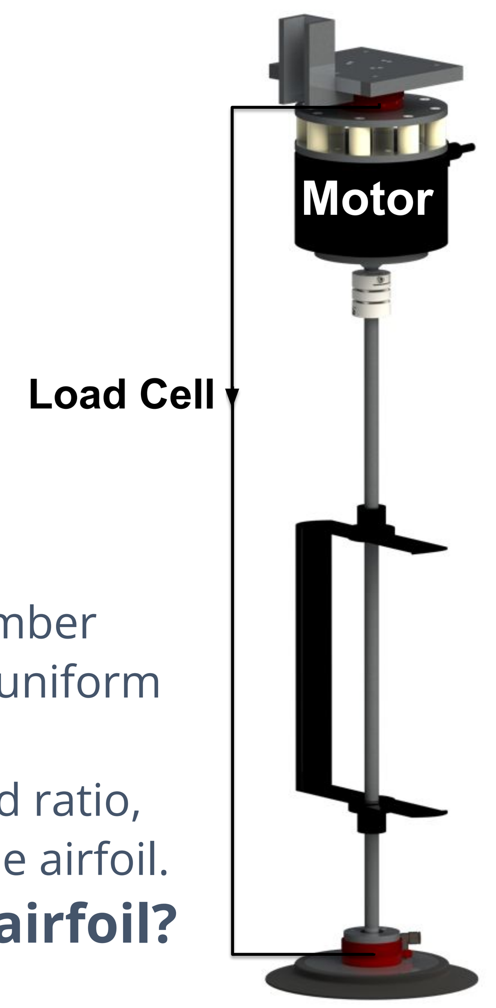
Abstract

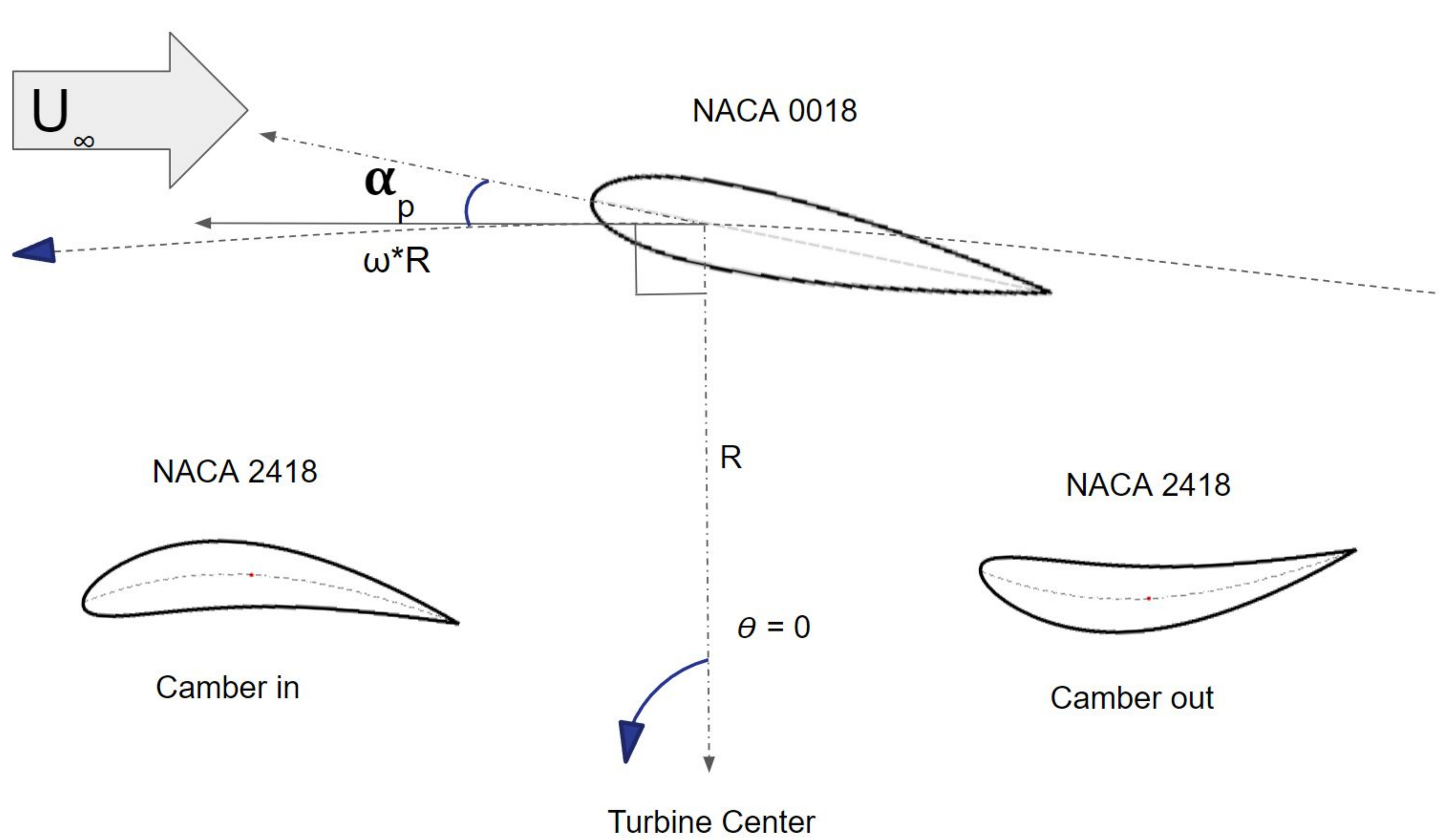




- The rotational flow field creates an induced camber component to a symmetrical airfoil due to nonuniform inflow direction acting on the camber line [1].
- The induced camber changes with the tip speed ratio, preset pitch angle, and geometric camber of the airfoil.

What if we add in the camber to the airfoil?

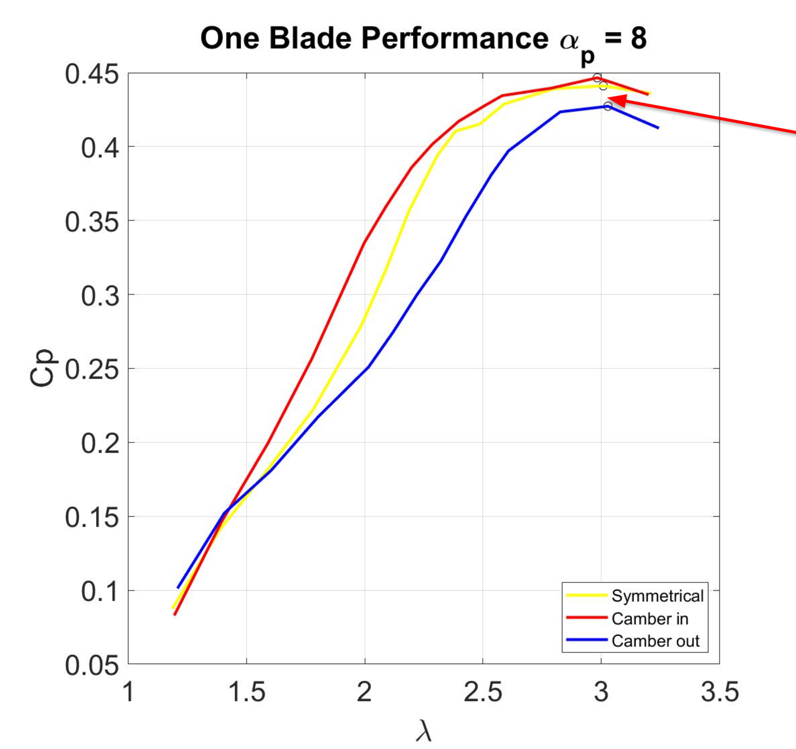
Nomenclature



Tip Speed Ratio:

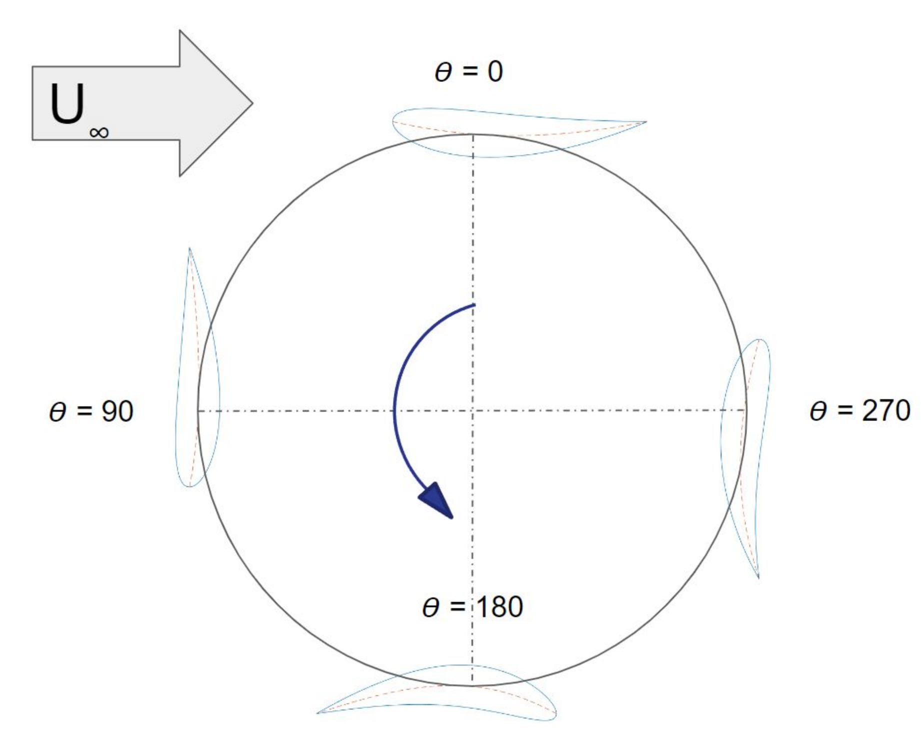
$$\lambda = \frac{\omega R}{U_\infty} \quad \frac{\textit{rotational speed}}{\textit{inflow speed}} \qquad C_p = \frac{\omega\tau}{\frac{1}{2}\rho U_\infty^3 2RL} \quad \frac{\textbf{Energy extracted}}{\textbf{Flow energy}}$$

Method



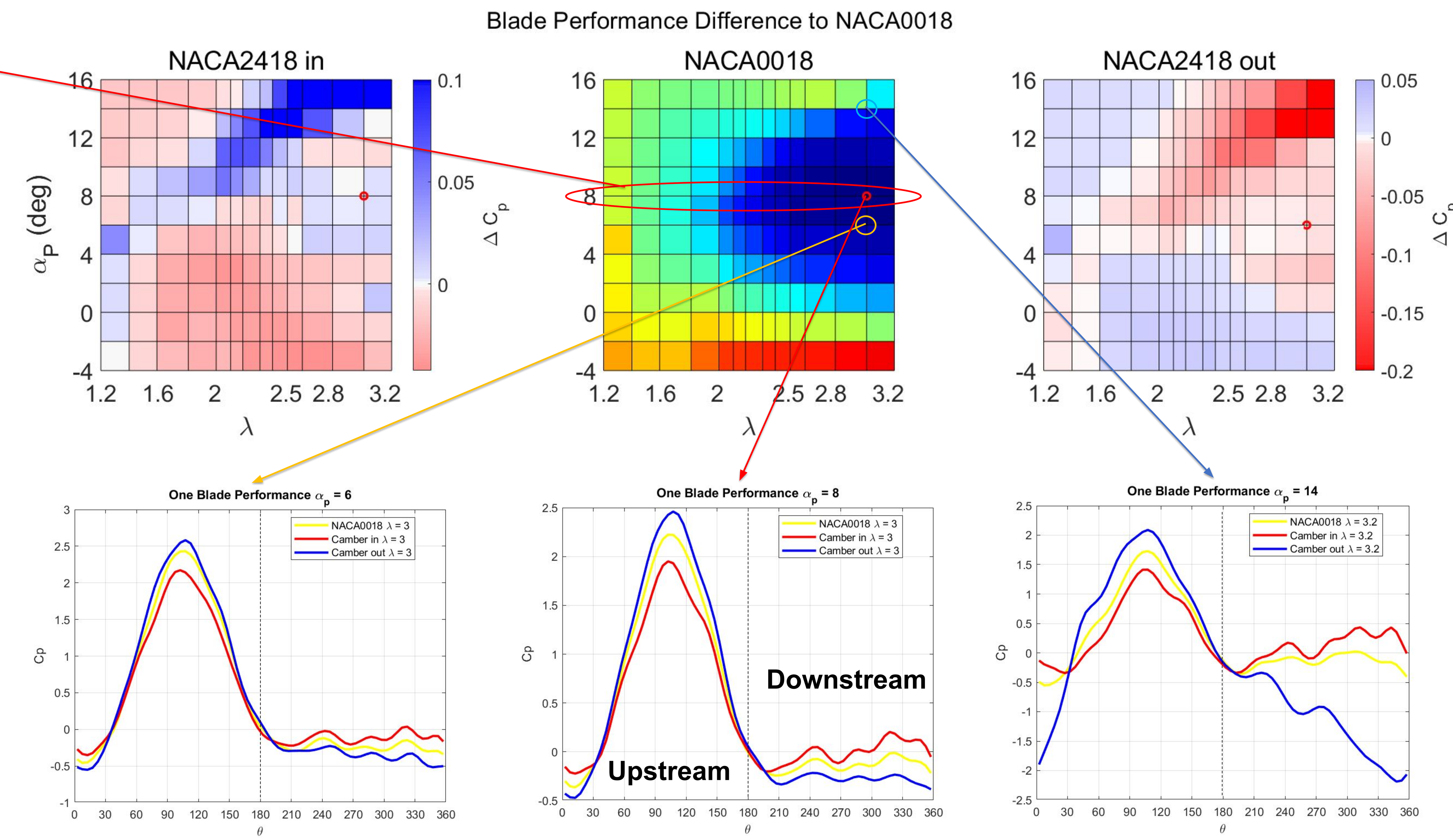
Experiment Conditions

- Airfoils: NACA0018, NACA2418 camber towards the center of the turbine, and NACA2418 camber away from the center of the turbine.
- NACA2418 were chosen based on having a 2% average virtual camber for the specific c/R ratio added to the NACA0018 airfoil from Migliore's method.
- The force and moments experienced by the turbine were measured through a set of load cells.
- The blade only performance data were obtained by subtracting out the force and torque disturbance from a disk only data set.
- Re_D = 281,000.



Virtual Airfoil of NACA0018 with Preset Pitch Angle of 6°

Results



Results:

- The optimal preset pitch angle and optimal tip speed ratio is not very sensitive to the camber profile.
- Camber in airfoil improves the performance at higher preset pitch angle and tip speed ratio, whereas camber out airfoil dampens the performance.
- Camber in airfoil has an improvement of 1.2% in peak time averaged performance compared to the symmetrical airfoil.
- Camber that enhances power output of the power stroke is not optimal due to detrimental power performance in the downstream region.
- Geometric camber does not allow for significant changes in turbine performance output as benefits in power extraction in the upstream are offset by the downstream portion of flow recovery in most cases.

Future Work & Reference

- Explore in the peak loading experienced by each airfoil throughout a turbine cycle. A reduction in the loading could be a huge benefit to the turbine design.
- Make connection from the blade performance to the virtual camber component of the airfoil.

- **Reference**: "Effects of flow curvature on the aerodynamics of Darrieus wind turbines"- Migliore P, 1980 [1]

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