Load Control for Wind Turbines Using Microjets

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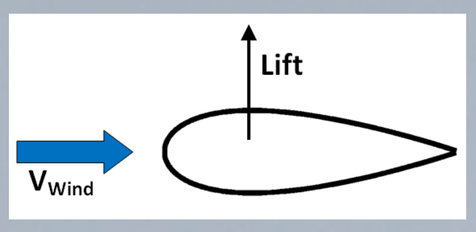
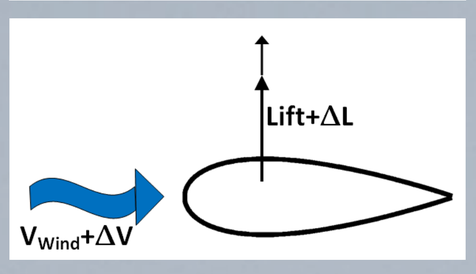
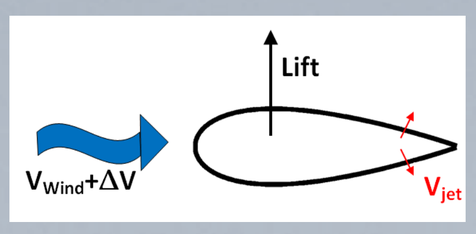
Microjet Concept



A steady wind produces a steady lift.



A gust of wind causes a change in the lift.

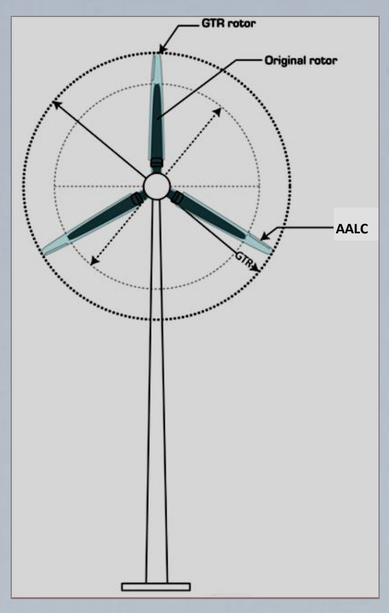


Engaging Microjets will counteract the change in the lift.

Need for Active Aerodynamic Load Control (AALC)

- Lowers Cost of Energy
  - Decreases wear and tear on blades, gear boxes, and tower
  - Less maintenance costs
  - Longer lifespan
  - Lighter blades = lower capital cost
- Grow the Rotor (GTR)
  - 10% larger blades can be used with the same gear box when AALC is used.
  - This results in 10-15% higher energy capture

(Image from Sandia National Labs: Berg, D.E., et al. 2009)



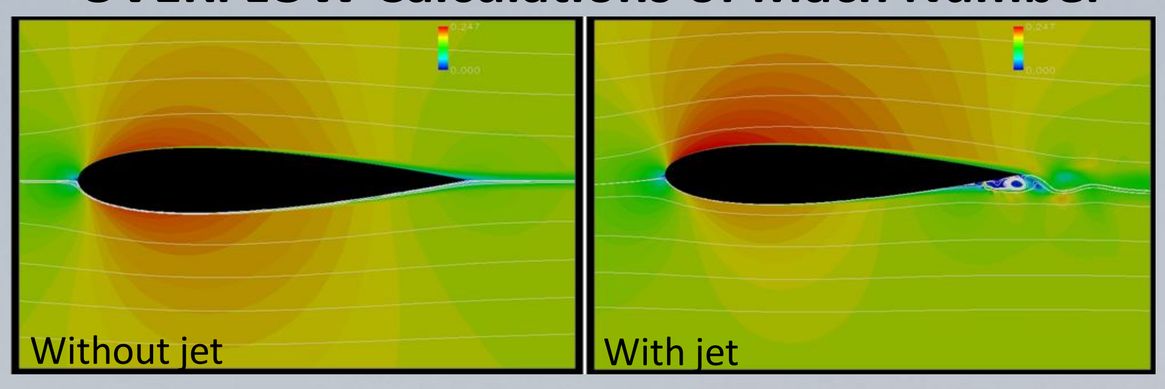
Computational Studies

Computational Fluid Dynamics(CFD) calculations are done using OVERFLOW to determine the characteristics of the airflow around an airfoil. A microjet placed near trailing edge changes the Kutta condition and entrains flow from the opposite side of the airfoil which affects the lift accordingly. This effect can be seen in the images to the right which compare a NACA 0018 airfoil without a microjet (left) to one with a microjet which has the same jet velocity as the freestream velocity (right).

Model Specifics:

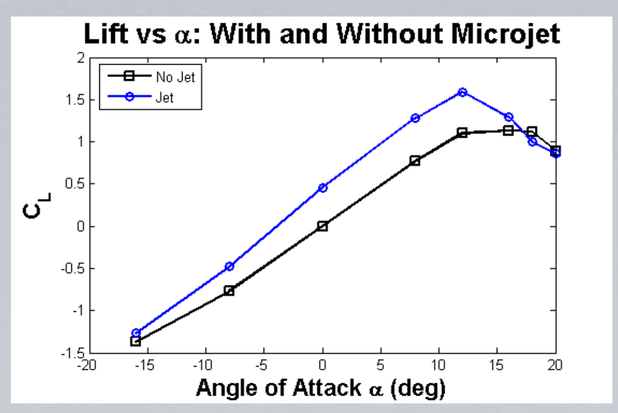
- NACA 0018
- $Re=6.6x10^5$
- Ma=0.176
- Jet at 90%c on pressure side
- Jet width h=0.006c
- $C_\mu=0.012$
- $\rho V_{jet}/\ \rho V_{inf}=1$

OVERFLOW Calculations of Mach Number



Effects of Microjet and Angle of Attack

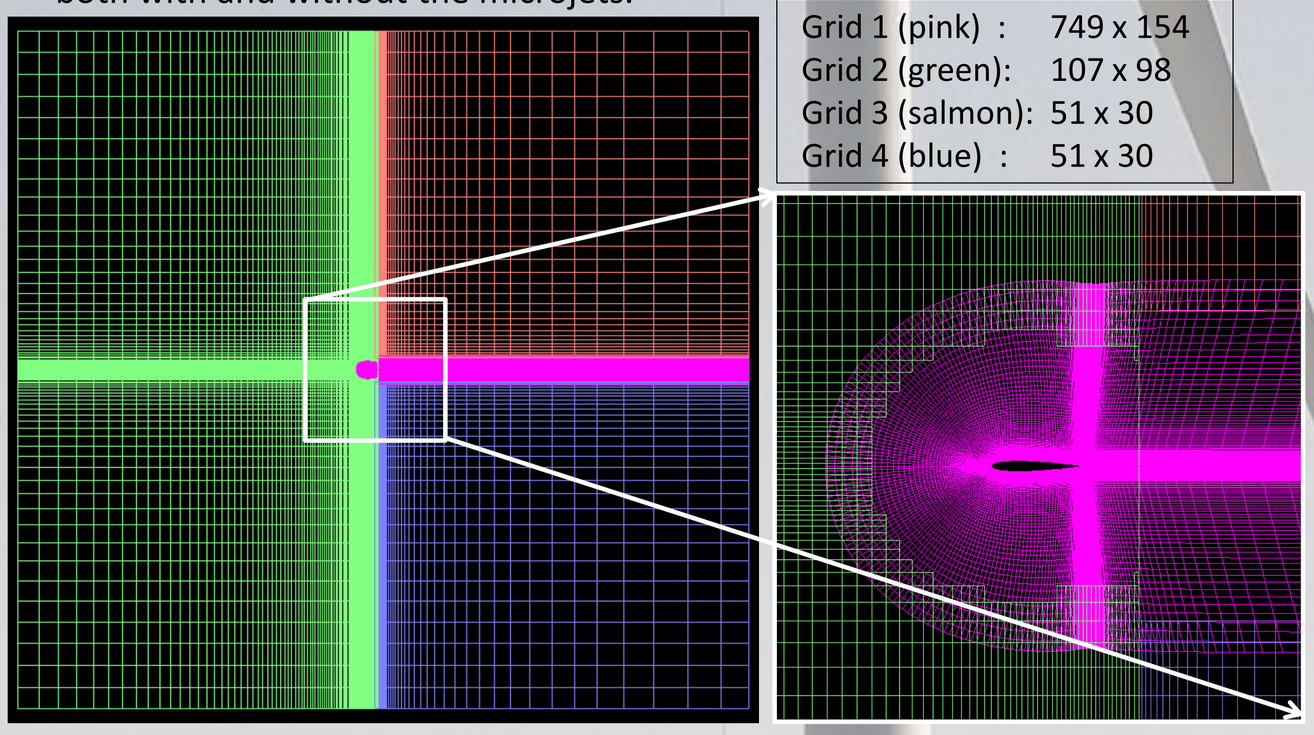
When a jet is active on the pressure side of the airfoil, the lift is increased over a wide range of angle of attack.

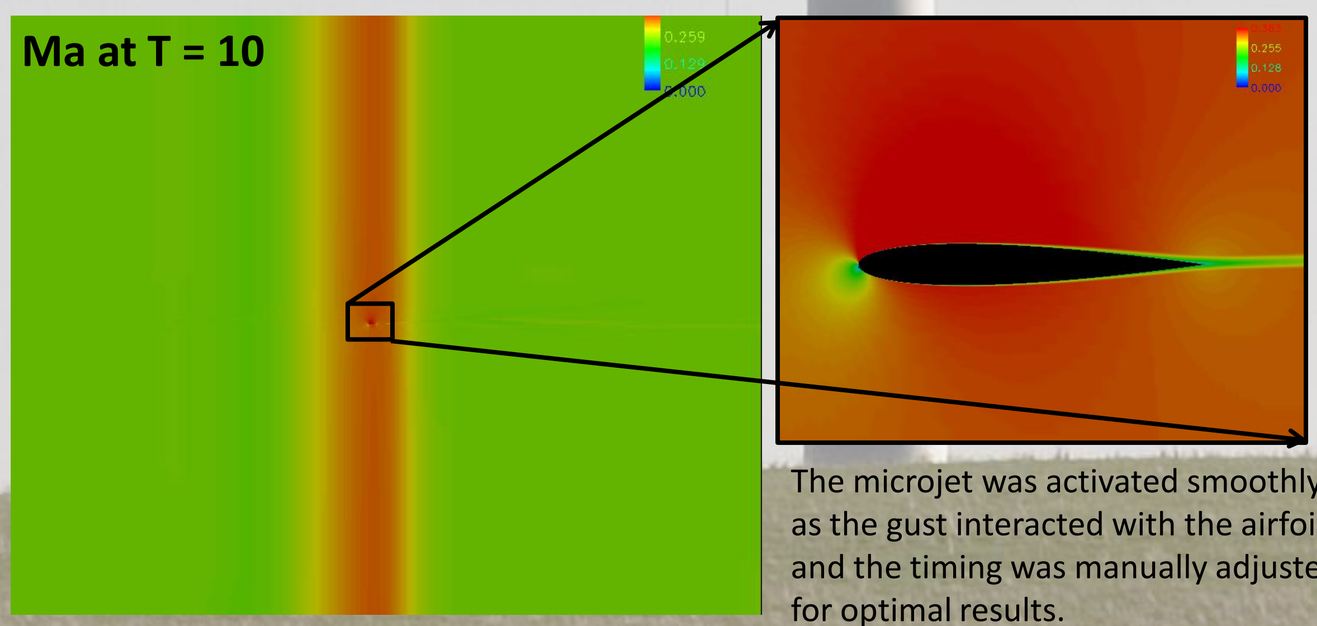


Gust Simulation

Ongoing work includes adding airflow disturbances, such as a gust that is created using the "unsteady jet" boundary condition in OVERFLOW along the left side of the green grid. The aerodynamic response to the gust is observed both with and without the microjets.

Grid 1 (pink) :	749 x 154
Grid 2 (green):	107 x 98
Grid 3 (salmon):	51 x 30
Grid 4 (blue) :	51 x 30



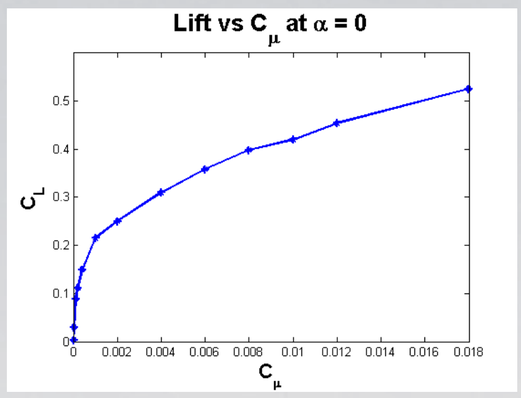


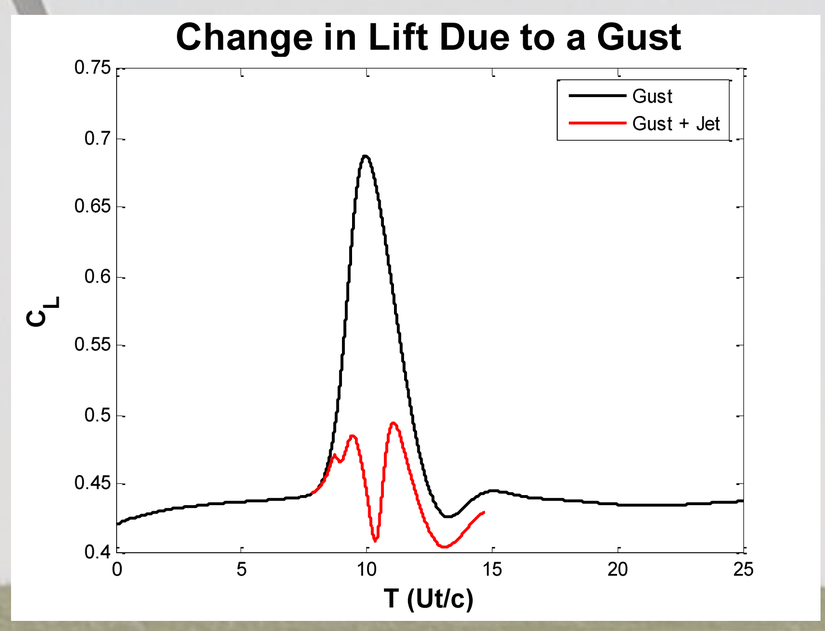
The microjet was activated smoothly as the gust interacted with the airfoil, and the timing was manually adjusted for optimal results.

Effects of Changing C_μ

The momentum coefficient, C_μ, is defined as the ratio of the jet momentum to the free stream momentum. This was changed by varying the jet velocity and keeping the jet width at h=0.006c. This graph shows that the effects on the lift can be controlled by the jet velocity.

$$C_\mu = \frac{v_{jet}^2 * h_{jet}}{1/2 * v_\infty^2 * c}$$





Microjet activation counteracts the effect of a gust convecting with the free stream past a NACA 0012 airfoil.

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Background Photo: H. Shiu