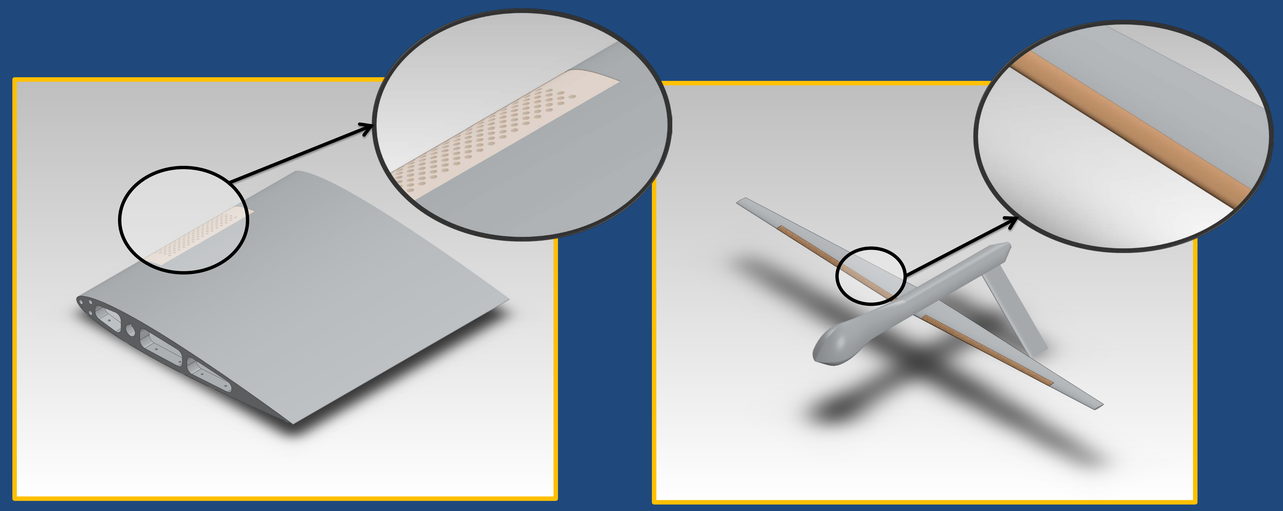
WEST VIRGINIA UNIVERSITY

Mechanical and Aerospace Engineering

RESEARCH

Dynamic Roughness as a Means for Aerodynamic Flow Control

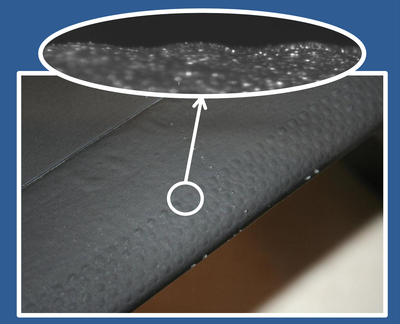


Example of the use of Dynamic Roughness near the leading edge of an airfoil to eliminate the leading edge separation bubble as well as alter the leading edge vortex of a pitching airfoil.

Development of a Smart Skin is being conducted to produce an installable surface that will produce controllable actuation, amplitude, and frequency with low power consumption.

Project Goals

The purpose of this research is to evaluate the effectiveness of **Dynamic Roughness (DR)** as an aerodynamic flow control device. Specifically, the ability of DR to eliminate the leading edge separation bubble as well as the ability to alter the leading edge vortex on a rapidly pitching wing. This research involves both computational simulations as well as experimental work.



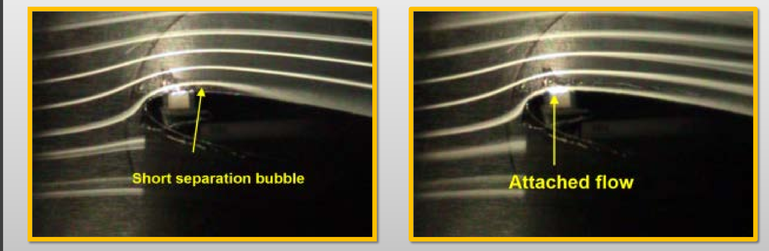
DR consists of small, sub-boundary layer perturbations on the surface of an airfoil that are actuated in a time dependent manner. The roughness amplitude and frequency of actuation can be altered for specific flow conditions. Therefore, DR is a tunable flow control device.

DR has the potential to impact a wide range of aerodynamic areas including unmanned aerial vehicles (UAVs), high performance aircraft, helicopter rotors, and turbo machine blades.

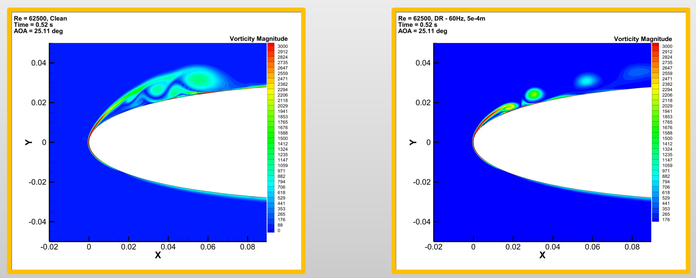
Current DR Research

Currently, there are multiple research topics being investigated concerning DR:

- **Control of laminar flow separation**
- **Alteration of leading edge vortex**
- **Maneuver control**
- **Dynamic alteration of the local pressure distribution**
- **Smart skin development**



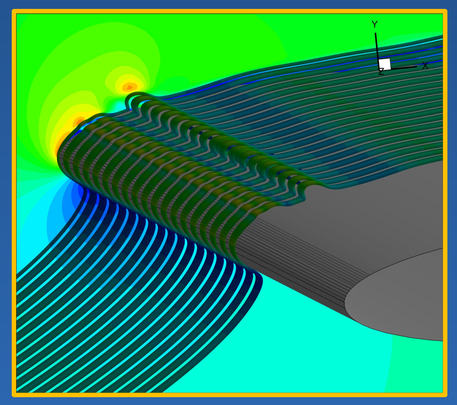
Airfoil at 9° AOA without DR and with DR, respectively.



CFD results of rapidly pitching airfoil without DR and with DR, respectively.

Future Development

Fabrication of an experimental model for wind tunnel tests is currently underway. Wind tunnel tests will consist of smoke flow visualization as well as Particle Image Velocimetry (PIV).



Further computational studies will be performed to investigate three-dimensional effects as well as to study the relationship among flow conditions (Re, Pitch Rate), DR properties (DR location, amplitude, frequency), and effectiveness of flow control.

Research Possibilities

There has been renewed interest in aircraft that mimic biological flyers, specifically the aerodynamics of flapping flight. DR shows great promise as a maneuvering mechanism as well as a vortex control device on such small aircraft.

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