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Design and Development of Active Flow Effectors

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RCEU 2022 Project Proposal

Project Title

Design and Development of Active Flow Effectors

Faculty Information

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Previous participation in RCEU: Yes

Project Summary:

The goal of the proposed work is to design, develop and wind tunnel test deployable flow effectors. Focus will be given on investigating the 3D effects of deployable flow effectors at high angles of attack. Aircraft performance is limited by the inability of the wings to produce lift at high angles of attack due to flow separation. Boundary layer separation leads to aircraft stall inflicting severe aerodynamic performance penalties. It is true that conventional flow effectors (widely known as vortex generators) have been used to increase near-wall momentum through momentum transfer from the free stream to the near-wall region. Although they have received a great deal of attention in the aerospace community and they have been integrated in many devices involving fluid flow (aircraft wings, wind turbine blades, propellers, marine rudders, etc.), passive flow effectors are limited by their functional abilities and are only effective over a small operational range. Flow separation of the boundary layer can be suppressed at high angles of attack static flow effectors but they cause a permanently increased drag over the whole flight cycle reducing the cruise efficiency. Operating deployable flow effectors that are not only effective at controlling the boundary layer separation, but also minimize the parasitic drag, fuel consumption and actuation complexity, is of major importance to future aviation that requires improved aerodynamic performance and low carbon footprints.

Fig.1: Vortex generators: Preventing stall at high and low speeds. The figure is taken from flickr.

Objectives & Tasks: The aim of this project is conduct an experimental study and investigate the 3D effects of deployable flow effectors and their ability to control boundary layer separation while reducing the parasitic drag. **Task I:** Design the flow effectors and conduct a low fidelity computational analysis to derive an optimal design of flow effectors **Task II:** 3D print the qualified designs, design an actuation system to deploy the effectors and wind tunnel test to validate the performance.

The RCEU student's tasks in the project include:

i.) Familiarization with the design and performance of active flow effectors.
ii.) Design optimization of flow effectors
iii.) 3D printing and proper installation of flow effectors.

iv.) Wind tunnel testing

Student Prerequisites

The student will be required to have the following skills:

i.) Basic understanding of fundamental aerodynamics concepts and related sciences
ii.) Sufficient knowledge and experience in MATLAB, Solid-edge, Ansys Fluent
iii.) 3D printing skills
iv.) Completed MAE 330/331 courses and a minimum GPA of 3.5

Student Duties and Deliverable

This project requires the student to use analytical and observation skills in a laboratory setting. One big aspect of the project will entail the use of software to simulate and manipulate data. In weekly meetings, the student will give progress reports to the mentor and discuss current progress. A final report will be submitted during the 10^{th} week for the mentor to evaluate. Provided is a tentative 10-week project schedule:

Week 1: Introduction to both lab, equipment, and background.
Week 2: Review literature on active/passive flow effectors.
Weeks 3-4: Design and computationally measure the effector's efficiency.
Weeks 5-7: Develop a first prototype and test it
Weeks 8-9: Integrate to a wing and wind tunnel test it.
Week 10: Analysis and documentation of the results

Mentor Supervision and Interaction

The research mentor will have regular interactions with the RCEU student during the project period. Undergraduate students will also interact with graduate research assistants to facilitate a more productive environment. The instructor/research mentor will confer with the student in regularly scheduled, weekly meetings to supervise, mentor, evaluate progress and assess student's general project development and work product.