CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

S0318

Project Title

Comparison of the Effect of Fixed and Natural Boundary Layer Transition on Airfoil Drag at Low Reynolds Numbers

Abstract

Objectives/Goals

This project is on testing whether or not a turbulent boundary layer can be beneficial in reducing overall drag on an airfoil at low Reynolds numbers.

Methods/Materials

Desktop/Laptop (Windows) computer with a fluid simulator XFOIL installed from the original MIT site. The code itself is developed by Mark Drela. XFOIL was used to modify or trip the boundary layer on an e222 airfoil (downloaded from Airfoil Tools) and the resulting output polar file analyzed by a text editor and Office Excel. This was done in six total configurations: 3 low Reynolds numbers (Re) and two trip types (Re = 200000, 300000, 400000, and tripped top & bottom surface or just top).

A wind tunnel was also made out of garage materials for visualization. These included a ShopVac, 3/4 inch plywood, two 2x4s, black spray paint, pipe clamps, flexible hose, and a valve. Dry ice was put inside the vacuum for airflow visualization.

Results

At Re = 200000 and 300000, drag was reduced for both the top & bottom and just top surface transitions. The LSB was also qualitatively noted to be reduced by looking at the pressure outputs. Drag was not reduced at Re = 400000 because of excess friction drag, which XFOIL can also predict.

Conclusions/Discussion

Since at 2 out of 3 Reynolds numbers the drag was still reduced using a turbulent boundary layer, the project concludes that a turbulent boundary layer can reduce drag by eliminating LSBs at certain Reynolds numbers. Friction drag is too high at higher Reynolds numbers so the turbulent boundary layer then becomes detrimental and increases overall drag.

Summary Statement

I showed how modifying fluid flow over an airfoil (2D section of a wing) could be beneficial in reducing drag on drones or airplanes in certain conditions.

Help Received

I received help from Dr. Raymond Chow from the Department of Mechanical and Aeronautical Engineering at UC Davis and Capt. John Rousseau of the Navy in understanding basic aerodynamics and how to use XFOIL. My AP Research teacher Dr. Nikki Malhotra helped me to access research papers. I