



SENIOR DESIGN ORGANIZATION SYNOPSIS – FALL 2013

Design, Analysis and Multi-Objective Constrained Optimization of Multi-Winglets

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There has been a constant struggle for aircraft designer and aerodynamicists to find an optimum balance between lift and drag. One area of interest in wing design is the challenge of properly channeling the vortices and trailing vortices. These turbulent vortices are due to the pressure leakage from the lower surface of the wing to the upper surface. These vortices increase induced drag, which increases fuel consumption, and reduces the lift-to-drag ratio. For these reasons, winglets are used to redirect the airflow and, therefore, reduce the strength of the trailing tip vortices.

Single winglets reduce drag; however, a study of soaring birds by biologists has shown that multiple individually controlled winglets reduce drag significantly greater than single winglets. It has also shown that not only is the drag reduced by the presence of multiple winglets, but also by an optimization of the individual winglet's angle of attack, sweep angle and dihedral angle.

The goal of this project is to optimize a multi-winglet configuration that will maximize the ratio of lift-to-drag ratio. The optimization will be carried out at the cruise section of the flight profile, as this is where the majority of the fuel is consumed. The winglet geometry will be controlled by a set of design variables, each of which can be modified to obtain a new winglet configuration. For the optimization, an initial population of about 50 designs will be created each with different values for the design parameters. Following that, a 3D computational grid will be generated for the model. A CFD analysis will be carried out in ANSYS Fluent to obtain the lift-and-drag ratios for each design. These design parameters and lift-and-drag coefficient will be used to carry Response Surface Approximation in a software package called ModeFRONTIER. From this response surface, an optimal Pareto design will be chosen and validated by both computational methods and wind tunnel testing.

The end result of this project is to increase the lift-to-drag ratio by 2% from the existing blended winglets. This process will enable the group to be more familiar with and be able to contrast and compare the various designs from European manufacturers such as Airbus, and local American based manufacturers such as Boeing. The process of designing a better and more efficient multi-winglet will give the group opportunities to interact with other engineers, notably in the aerospace Industry.