Simulation, Optimization, and Validation of a Closed Wing Airplane

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A systematic design and analysis process was conducted for a closed wing airplane configuration. A closed wing configuration consists of two staggered wings connected at the tips. The closed wing configuration offers the possibility of improved efficiency by reducing or eliminating wing tip vortices, which have been calculated to account for 40% of an airplane's drag. A closed wing airplane was designed using parameters from previous research. The wing tip front profile shape was optimized through Vortex Lattice Method (VLM) computer simulation testing. Simulation results exhibited a 36% drag reduction compared to the same wing configuration without wing tips and demonstrated no indication of wing tip vortices. Based on the flow visualization and drag reduction, the closed wing design was effective in negating the wing tip vortices. The closed wing model was constructed according to the simulated design. An open wing Cessna model of the same scale was acquired for comparison purposes. Wind tunnel flow visualization using a smoke stream showed significant vortices on the Cessna wing tips. No indication of wing tip vortices was found on the closed wing tip area. In the wind tunnel, the closed wing airplane achieved a 50% higher maximum lift to drag ratio and a 149% greater cruise lift to drag ratio. Flight tests were conducted, and the closed wing airplane demonstrated excellent stability and safe stall characteristics. Data shows that the closed wing airplane is a viable airplane design and has a significantly higher aerodynamic efficiency than existing airplane designs.

Awards Won:
Second Award of $2,000
Shanghai STEM Cloud Center: STEMCloud Award of $1800 in Engineering Mechanics
NASA: Top Award of $5,000