A Biomimetic Non-Planar Approach to Reducing Induced Drag from Trailing Vortices

Brooks-Da Silva, Candace

Aviation-generated emissions from hydrocarbon fuel combustion account for approximately 3.5% of the world's greenhouse gas emissions. Current wingtip devices seek to lower induced drag from trailing vortices that negatively impact fuel consumption; however, efficiency and flight phase inflexibility remain issues. Although morphing multi-winglet designs have recently attracted attention, thus far research has focused on testing simple designs, few configuration shapes and angle proportions, all under limited angles of attack. This work designed, synthesized and characterized a novel biomimetic non-planar multi-winglet premised on nine strategies supported by aviation theory. A subsonic open-circuit closed test-section wind tunnel and force sensor apparatus were constructed to test 154 unique scenarios of configuration shape (V-Shaped "above wing" Dihedral, V-Shaped "below wing" Anhedral, Downward Sloping, Upward Sloping, Multi-Horizontal, Multi-Vertical, Staggered High, Staggered Low), angle proportion (Small, Medium, Large) and angle of attack (0°, 3°, 6°, 9°, 12°, 15°, 18°) plus controls. Mathematical analyses showed significant and considerable multi-winglet lift-to-drag performance improvement over controls: multi-winglet configurations exceeded controls in six of seven angle of attack tests. A novel configuration shape, "Staggered Low-Medium" produced the largest lift-to-drag ratio overall (257.2% more than Control-8's largest) plus was "best overall" with the highest lift-to-drag ratio in three tests. This work is an important initial step in designing an efficient morphing multi-winglet able to reduce trailing vortex-induced drag and aviation-generated emissions by matching moment-by-moment configuration and angle proportion changes to aircraft flight phase.

Awards Won:
Second Award of $2,000
NASA: All-expense paid four week trip and scholarship to the Bessie Lawrence International Summer Science Institute