Design and Numerical Analysis of a Novel Co-Flow Jet System to Improve the Lift, Range, and Fuel Efficiency of a Commercial Airline Wing

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The aviation industry accounts for 11% of all transportation-related greenhouse gas emissions in the United States, producing 158 million metric tons of carbon dioxide each year. While a smaller percentage compared to the automotive industry, the aviation industry emits directly into the climatically sensitive upper-troposphere, impacting the environment more directly. Accounting for changes in lift, range, and fuel efficiency, this research modified the existing wing of the Boeing 777-300 through the implementation of the novel Co-Flow Jet (CFJ) airfoil to engineer a more environmentally sustainable wing design. The CFJ airfoil is a low energy system that is embedded inside a pre-existing airfoil design that runs a slipstream along the boundary layer that flows across the top of the wing. This energizes the boundary layer through the creation of vortical structures, generating greater lift while decreasing the drag to negative levels, generating thrust. The NASA standard RAE-2822 airfoil was modified with the CFJ and then compared with the baseline RAE-2822 in a CFD environment. This data was then compared with the mathematical predictions of the CFJ-modified Boeing 777-300 in terms of overall efficiency and lift-coefficients, using a variety of jet stream velocities, angles of attack, and atmospheric conditions. An increase of 18.0% in the lift coefficient correlated to a 20.5% fuel usage reduction while increasing the range by 23.5% (3321 km). These increases in fuel efficiency and overall range allow for discussion of including hybrid or fully-electric engines as replacements for the current engines on board modern airliners.

Awards Won:

Fourth Award of $500

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