Medium Ionization through Plasma Induction for Improved Aerodynamic Efficiency

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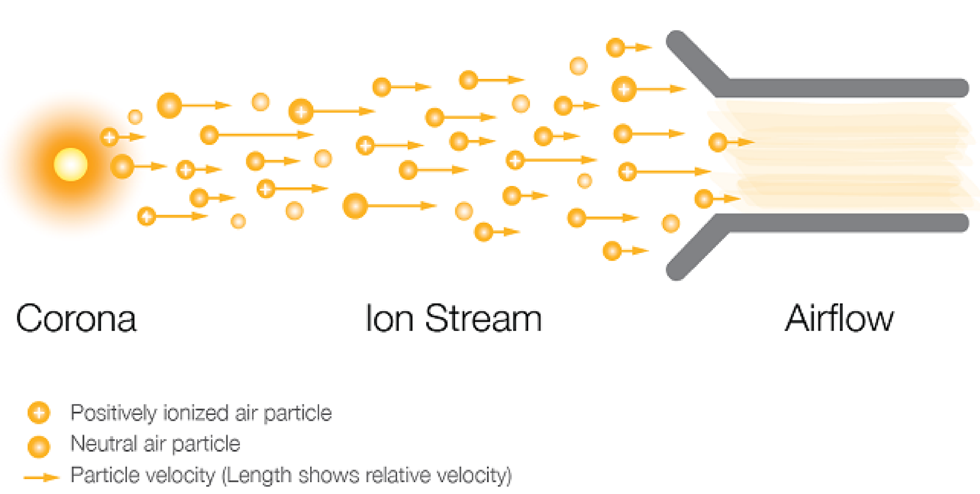
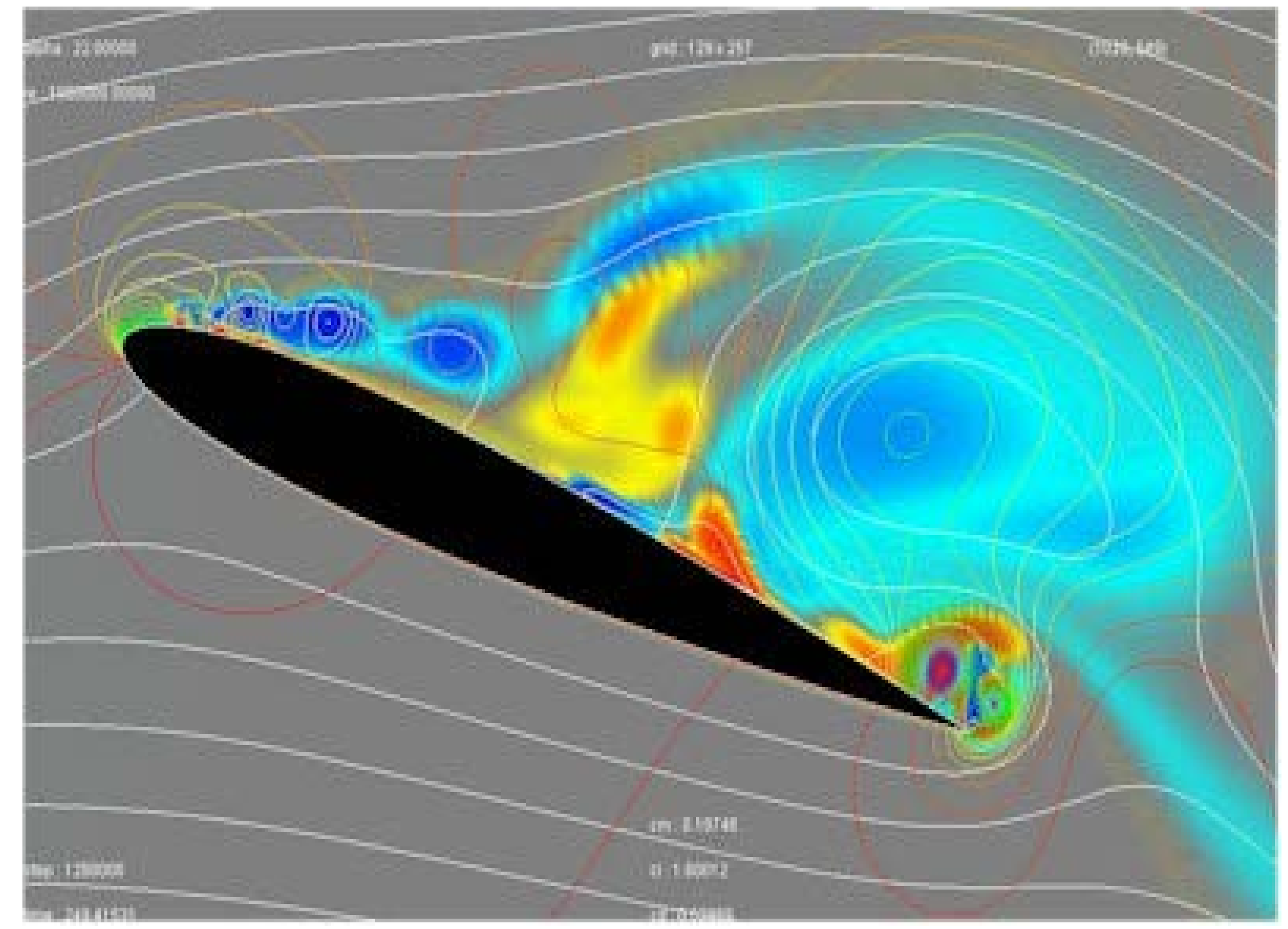
OBJECTIVE

Project DRIFT (Drag Reducing Ionized Flow Technology) aimed to improve aerodynamic performance and efficiency by ionizing the air that flows over an aircraft's wing in subsonic, compressible regimes. To do so, viscous skin friction and resulting drag were reduced via the effects of corona discharge, an electrically induced phenomenon that alters the properties of the medium in which it resides. The corona discharge created a flow with unique ionized properties that led to the ability to control aerodynamic characteristics. Similar projects have been pursued by the National Aeronautics and Space Administration (NASA), as well as several other reputable organizations, and served as a research base for this project.

BACKGROUND

The premise of air ionization at subsonic velocities is focused on controlling the flow to maintain laminar characteristics. By ionizing air, energy is added into the flow that restricts its streamlines to remain within the laminar regime. By preventing flow from becoming turbulent, viscous drag forces caused within the boundary layer on the surface are reduced, making total drag across the surface dominated by induced drag. This drag is a direct product of the lift of an airfoil, and does not significantly vary between turbulent and laminar flows. This method is the basis for drag reduction of this project. Corona discharge describes the phenomenon of an electrical discharge through a fluid near a highly charged surface. The charged surface creates an electric field that is strong enough to create a conductive region. This conductive region causes breakdown of fluid particles, turning each into an ion. This sea of ions is known as plasma and the region is considered partially conductive. The strength of the electric field decreases with distance from the surface, and thus, the effect diminishes further away from the charged body. When a corona manifests in air, it can be seen with a bluish/purple glow caused by photon emission of the ionized particles.





METHODOLOGY & TESTING

Through experimental research and iterative designs, Project DRIFT developed an effective method of reducing the drag on a wing by utilizing corona discharge. First, the effect of the corona was optimized through a case study of varying parameters including chord and span-wise node spacing, node shape, voltage level, and current type. Then, instrumented airfoils were built to begin performance testing through a wide sweep of test conditions.

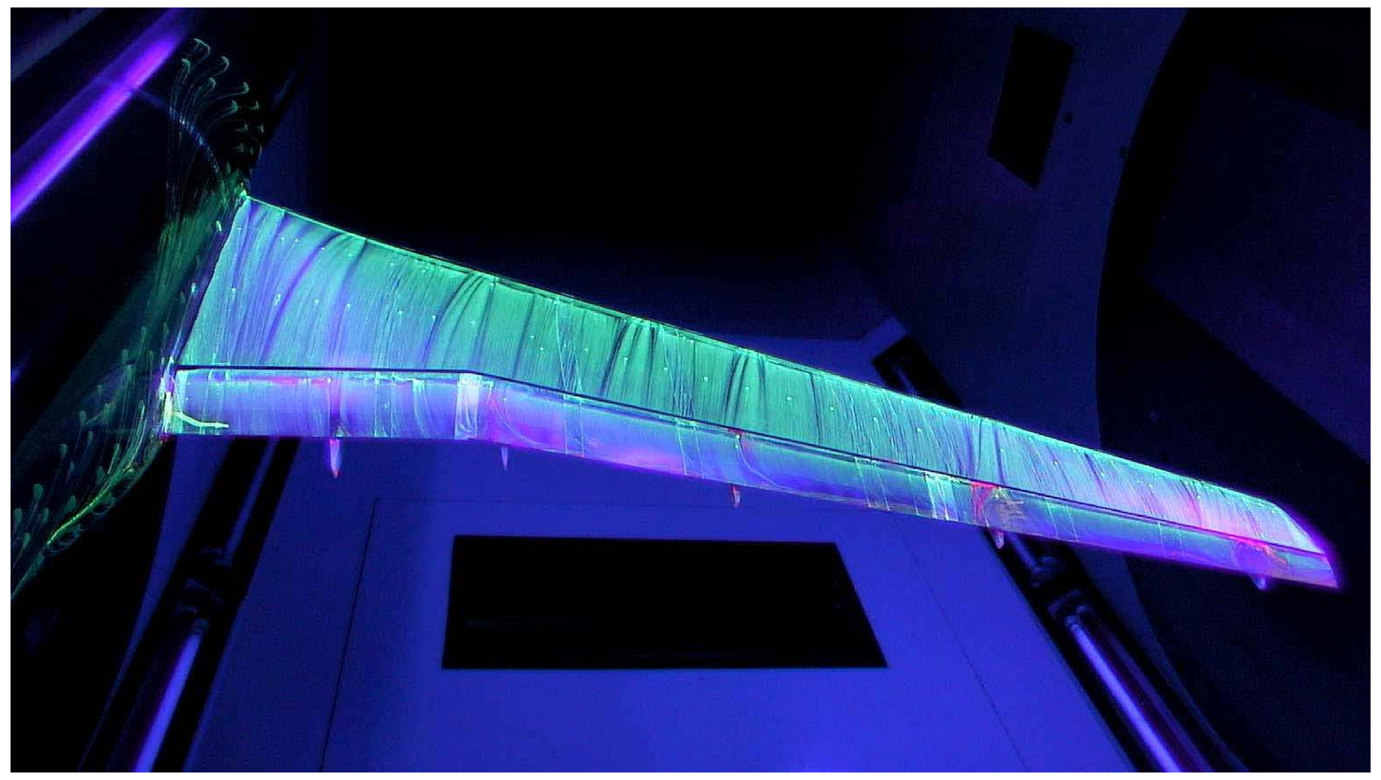
A standard NACA 0012 airfoil was molded from soaked balsa wood wrapped around a foam core. The corona was developed by implanted electrodes on the surface of the foil that provided 15000 volts of electricity to the airflow. Impacts of the phenomenon were observed via flow visualization techniques such as smoke visualization and compared against a non-ionized airfoil. Additionally, pressure port measurements and a force balance allowed for pressure, lift, drag, and induced moment measurements to analyze the impact of the corona. This allowed for data to be captured regarding the momentum addition to the flow field in order to delay separation.

RESULTS

Tests were conducted over a range of initial flow conditions that included multiple angles of attack and freestream velocities. Angles of incidence ranged from -15 degrees to +15 degrees in increments of 5 degrees. This sweep allowed for analysis at a variety of flight conditions up to and beyond the expected stall angle of most conventional aircraft. The values obtained during testing were compared to computed values produced through Computational Fluid Dynamics (CFD) via programs such as Pointwise and Fluent. To account for the addition of the induced voltages, a body force was placed on the model to represent the added momentum to the flow due to the corona.

CONTINUED RESEARCH

As a fundamental component in the Aerospace industry, aerodynamic performance and efficiency is the leading contributor to research and development. Between the commercial, private, and military sectors of aerospace, a wide array of research has been dedicated to improving aircraft performance for optimization in areas such as fuel consumption, range, and power. Continued research within medium ionization and plasma induction presents promise for innovation of these realms as high energy actuators and diodes are utilized in design. DRIFT hopes to continue its endeavor of ground breaking research within plasma dynamics and aero-efficiency through continued testing and further exploring the principles of ionization to transform flow over a wing.



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