Abstract

Parasitic drag is a restrictive force for all vehicles moving through a fluid medium. In many industries and applications, even incremental reductions in drag could result in large savings in fuel, time, and even thermal management. In turbulent flows, skin friction drag is of particular concern. The main source of turbulent skin friction drag is thought to be due to low-velocity streaks in the near-wall region of the boundary layer and by hairpin vortices which carry high-velocity flows further down into the boundary layer, resulting in higher local wall shear stress and higher drag. Computational work by Du and Karniadakis suggests that these two phenomena may be minimized using a force in the form of a span-wise traveling wave. Reductions in skin friction drag of over 50% were predicted. Several attempts have been made to reproduce this wave and the resultant reduction in drag in experiments. An actively-deformed skin design was examined by Rediniotis and Lagoudas, but this experiment’s results were invalidated due to an irregularity in skin movement that invalidated results. Preliminary tests by Wilkinson using oscillating surface plasma failed to create an adequate effect and created a mean-flow region that complicated comparison to computational results. Still, this concept’s large predicted reductions in drag provide an incentive for further investigation. This study deals with several wind tunnel tests undertaken in the fall of 2015 at the 3’x4’ wind tunnel at Texas A&M University. A NACA 0012 infinite wing with a Re of 1.6 million was tested with embedded discrete plasma actuators in two different configurations. Hot film velocity measurements of the boundary layer were taken with and without the pulsed plasma actuators engaged. Velocity data indicated the presence of a near-wall low-velocity region in lieu of the aforementioned low-velocity streaks, consistent with the results of Du and Karniadakis. Calculations of wall shear stress and friction coefficient indicated up to a 66% local reduction in drag. Baseline boundary layer measurements showed good agreement with existing computational and experimental data at similar Reynolds Numbers. Overall wing drag measurements using a pyramidal balance integral to the tunnel test section showed some signs of overall drag reduction, but were less conclusive than local drag reduction.

Christopher Russo is an MS candidate in the Aerospace Engineering Department working under the supervision of Professors Rediniotis & Bowersox. His research interests are in the areas of Wind Tunnel Testing and High-Speed Flows. He will be employed as a Systems Engineer in the International Space Station Ops Planning group in Mission Control for Lockheed Martin at NASA Johnson Space Center in Houston, Texas.