Sounding Rocket Roll Control Through DBD Plasma Actuated Boundary Layer Control

Spencer Sumanik, Dr. Jason Etele

Dielectric Barrier Discharge (DBD) plasma actuators alter the velocity of the fluid around them through ionization of the gas and the presence of an electric field. The induced flow, or electric wind, is directed tangential to the surface on which the plasma actuator is mounted. This changes the boundary layer profile over the surface by adding momentum to the lower regions of the boundary layer. This analysis examines the change in pressure distribution on a rocket fin as a result of plasma actuators oriented in the up-stream direction. The pressure distribution on the surface can be integrated to find the force applied to the fin. Two-dimensional computational fluid dynamic simulations are used to determine the location of the plasma actuator where the pressure differential is largest by simulating the plasma actuator at multiple chord-wise locations across the fin, between 25\% and 90\% chord in 5\% chord increments. The location with the largest resultant force is examined through a velocity range of 10 and 90 m/s. The simulations show that the plasma actuator produces the most force when mounted between 30\% and 50\% chord. The maximum normal force experienced by a sounding rocket, as a result of the plasma actuation is approximately 23 mN decreasing as the rocket decelerates. This force produces an angular velocity of the 0.29 rad/s or 2.8 RPM of roll on a single stage sounding rocket that is 272 cm long with a radius of 7.6 cm. The three-dimensional simulations are observed to have similar pressure distributions over the plasma actuator as the two dimensional cases.

Bio: Spencer Sumanik knew he wanted to be an engineer from a young age while launching rockets off the antenna of an old truck. He gained his Bachelors of applied science in mechanical engineering at University of British Columbia Okanagan specializing in fluid dynamics and heat transfer. Spencer is now researching plasma actuated rocket control for his Masters of applied science in aerospace engineering at Carleton University and has had the privilege to present this research at the AIAA Hypersonics conference in Xiamen China.