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STEERING A HIGH VELOCITY REENTRY SPACECRAFT BY DIELECTRIC BARRIER DISCHARGE PLASMA ACTUATORS

Abstract

Dielectric Barrier Discharge (DBD) plasma actuators are simple actuators consisting of at least two flush mounted high voltage electrodes and a dielectric material separating them. They are widely used for airflow modifications in aeronautical applications, but to this date DBD plasma actuators have not been researched in detail for space-based systems. An opportunity arose to conduct a parametric study for spacecraft reentry steering application. Proven and currently used system for spacecraft steering during reentry is Reaction Control System (RCS). This system has two drawbacks, namely it is comprised of mechanical parts and it requires propellants for operation. Both of these drawbacks contribute to an increase in spacecraft mass and a decrease in its reliability. If RCS was replaced with system made of DBD actuators numerous benefits could be gained. Some of these benefits are: very low mass, cost and power consumption; extremely fast response; and an increased reliability due to lack of moving mechanical parts.

This study examined two objectives, namely the effects of interaction between an external flow with created ionic wind and the strength of various dielectric materials. Study consists of two analytical models. First model aims in estimating the influence of an external flow on the actuator force, which can be used for modification of boundary layer. Second model aims in estimating dielectric material strength when subjected to thermal cycles expected to occur on spacecraft surface during a lifetime of two years. Results show that DBD actuator system is capable of producing significant perturbations between spacecraft surface and natural shockwave. The made perturbations are in form of a compression wave. Interaction between newly created and natural waves creates a dis-balance of forces proficient for spacecraft reentry steering. Results also show that some dielectric materials are capable of withstanding thermal cycling loads. This paper presents first step, the feasibility study needed to qualify and apply this system to an operational spacecraft, much research on optimization is still needed.