Inductive Pulsed Plasma Thruster Model with Time-Evolution of Energy and State Properties

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A model for pulsed inductive plasma acceleration is presented that consists of a set of circuit equations coupled to both a one-dimensional equation of motion and an equation governing the partitioning of energy. The latter two equations are obtained for the plasma current sheet by treating it as a single element of finite volume and integrating the governing equations over that volume. The integrated terms are replaced where necessary by physically-equivalent quantities that are calculated through the solution of other parts of the governing equation set. The model improves upon previous one-dimensional performance models by permitting the time-evolution of the energy and state properties of the plasma, the latter allowing for the tailoring of the model to different gases that may be chosen as propellants. The time evolution of the various energy modes in the system and the associated plasma properties, calculated for argon propellant, are presented to demonstrate the efficacy of the model. The model produces a result where efficiency is maximized at a given value of the electrodynamic scaling term known as the dynamic impedance parameter. Qualitatively and quantitatively, the model compares favorably with performance measured for two separate inductive pulsed plasma thrusters, with disagreements attributable to simplifying assumptions employed in the generation of the model solution.