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EQUIVALENT CIRCUIT OF VACUUM ARC THRUSTER WITH MULTI-LAYER ELECTRODES

Abstract

Vacuum arc thrusters (VAT) are pulse thrusters in space with low thrust and efficiency but require less volume and power than continuous thrusters. The VAT is composed of an anode, a cathode, and an insulator layer between the electrodes, along with a thin graphite coating above the insulator layer. When a power supply applies a high voltage between the anode and cathode, the current flows through and vaporizes the thin graphite, generating an arc. The arc ablates the cathode and produces thrust.

In this experiment, the vacuum arc thruster with a parallel electrode array is developed. The VAT with a parallel electrode array uses a trigger discharge unit to induce the main discharge units. The aim of this experiment is to study the equivalent circuit of the VAT with a parallel electrode array by changing the discharge capacitor and discharge voltage. The equivalent circuit can be analyzed by calculating the damping factor ζ. ζ=$\alpha\omega$ α=R2L ω=1LC where R represents resistance, L represents inductance, and C represents capacitance. In the first step, this experiment measures the period of the discharge waveform, and the capacitance value in the circuit is known. Therefore, the inductance of the equivalent circuit of the thruster can be calculated by approximating the damped frequency as the natural frequency. In the second step, this work uses Python to iterate and find the resistance by minimizing the discrepancy between the experimental result and the response of underdamped oscillation in the least-squares sense. In the third step, to calculate the resistance and inductance without the approximation, this study uses Powell's method to solve the two-dimensional optimization of a nondifferentiable function, least-square error, which is a function of the resistance and the inductance. This calculation makes the results more precise.

Finally, this experiment aims to change the thruster discharge waveform from an underdamped response to an overdamped one. This is achieved by placing an additional series resistor or inductor before the discharge capacitor to change the type of discharge waveform.