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DEVELOPMENT OF ADAPTABLE ELECTRODELESS PLASMA PROPULSION SYSTEMS USING EVOLUTIONARY TOPOLOGY OPTIMISATION AND PARTICLE IN CELL SIMULATION

Abstract

The space industry continues to pursue efficient, lightweight propulsion systems, increasing the desirability of complex optimisation methodologies that leverage accelerating computational resources and additive manufacturing technology. Engaging in this pursuit, this paper comprises research on the novel application of self-adaptive evolutionary algorithms to optimise the field topologies of electrodeless plasma propulsion systems. A method that could be used for rapid development of structurally unique propulsion systems, customised and optimised for any satellite design. Case study systems are simulated variants of a small scale 100W ambipolar thruster for nano satellites and the magnetic reconnection thruster, devices currently undergoing experimentation at the University of Sydney. Experimental data was used to quantify the notable specific impulse and mass improvements of evolved variants over original systems.

Magnetostatic or electrostatic field designs were evolved and then analysed within a 2D axisymmetric finite element magnetics solver (FEMM), rewarding increasingly complex structures that reduce plume divergence, minimise ion detachment, and increase specific impulse. Resulting designs often had previously impractical geometric complexity, yet using modern additive manufacturing they can now be printed as a substrate for current carrying copper wire, or directly printed as permanent magnets. Measures of success required for genotype selection and recombination are based on simplified theoretical assumptions, therefore it is necessary to verify candidates by utilising particle in cell simulations employing self-similarity scaling (V-Sim). The plasma discharge simulation code provided by the Tech-X corporation was experimentally validated on the aforementioned ambipolar and magnetic reconnection thrusters.