A Fully Self-Developed Open-Source 17 kW High-Temperature Superconducting Applied-Field Magnetoplasmadynamic Thruster for Efficient Deep Space Exploration

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A self-developed, open-source High-Temperature Superconducting (HTS) Applied-Field Magnetoplasmadynamic Thruster (AF-MPDT) platform for deep-space propulsion combines potential for high Isp (2,000–10,000 s) with thrust (0.1–100 N), bridging the gap between chemical & electric propulsion. Key innovations: 1. 0.5T HTS YBCO Magnet: We first synthesized HTS YBCO using custom-designed equipment. Later we designed a 0.5T double-pancake HTS magnet that operates at -197°C using 30 meters of ReBCO tapes, generating an adjustable applied magnetic field. 2. Compact Cathode-Anode Assembly: We lathed-machined cathodes from CuW, LaB6, CuCrZr, graphite & LaW to compare erosion & performance, then carefully optimized geometry & insulation through simulation & testing. 3. Self-Built High-Vacuum Chamber: Over ten months, we completed seven major iterations of the vacuum chamber design, evolving from a quartz & aluminum structure to a 304 stainless-steel system. We machined & welded essential components, resolving all leak points. We used a two-stage pumping system to achieve pressures below 10?³ Pa, along with a precise pendulum-based thrust measurement system. 4. Adaptive Nozzle System: A variable nozzle with a ring-based adjustment mechanism designed for real-time changes in nozzle geometry, allowing for faster design iteration & performance optimization. 5. Integrated Control System: The system integrates Jetson & Arduino-based control, pressure gauge monitoring, HTS magnet quench protection, and the ignition & voltage regulation systems. This AF-MPDT platform offers a cost-effective, scalable solution to space propulsion challenges. Open-sourcing work ensures that its use extends to researchers worldwide, fostering collaboration in space propulsion research.

Awards Won:

Third Award of $1,200

Adam R. Scripps Foundation: Cash Award

Midjourney: Eight awards of $2,500

Society Alumni Special Award: Society for Science Alumni Special Award