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HIGH TEMPERATURE SUPERCONDUCTING MAGNET BASED ELECTRIC PROPULSION DERIVED FROM FUSION ENERGY TECHNOLOGY

Abstract

High temperature superconductors enable compact, ultra-high magnetic field strength electromagnets with reduced cooling requirements. These high performance electromagnets have the potential to enhance many different space applications, in particular propellantless and plasma propulsion of various forms.

An enabling benefit of superconducting magnets is their ability to contain high plasma densities safely for extended periods. Pulsed power electric propulsion concepts such as the Magdrive, and high thrust applied field magnetoplasmadynamic approaches have been shown to benefit from high field strength superconducting magnets, although a number of practical challenges need to be resolved before space based demonstrations. Longer term, delivery of the first compact modular nuclear fission reactors into orbit will stimulate customers seeking high capacity efficient power transfer mechanisms (eg superconductors) as well as those developing electric propulsion able to operate at megawatt power levels, widening the market for superconducting systems in and beyond Earth orbit.

Two system design studies on fusion energy derived superconducting magnet technology have been conducted to (a) raise the TRL of compact superconducting electric propulsion system for low Earth orbit active debris removal applications, and (b) explore a magnet-only in-space demonstration mission on a small satellite platform. High thrust and high Isp requirements have been identified by a potential client and can uniquely be met by a single, superconductivity enabled propulsion system.

The paper discusses system study results focused on the thermal management and power supply challenges faced when integrating superconducting coil, power supply and coolers into a spacecraft. We will cover mass, power and volume budgets; mechanical, thermal and electrical interfaces; component suppliers; system operating scenarios for different mission phases; results from component level testing and model validation. Work is ongoing under UK government space technology development funding to combine propulsion systems evaluation with superconducting magnet qualification and system breadboarding work: the near term goal to demonstrate sustained high temperature superconductor operation in space. This will be the first major step of a roadmap leading to a flight demonstration of the superconducting electric propulsion technology this decade.