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Author: Mr. Richard Hatcher
Propulsion Research Center, University of Alabama in Huntsville, United States, rbh0008@uah.edu

Mr. Milos Stanic
Propulsion Research Center, University of Alabama in Huntsville, United States, torden85@gmail.com
Dr. Jason Cassibry
Propulsion Research Center, University of Alabama in Huntsville, United States, cassibj@uah.edu
Mr. John Loverich
Tech-X Corporation, United States, loverich@txcorp.com
Mr. Madhusudhan Kundrapu
Tech-X Corporation, United States, madhusnk@txcorp.com

PROJECT ICARUS: ANALYSIS OF MAGNETIC NOZZLE DESIGN FOR A PULSED-FUSION PROPULSION SYSTEM

Abstract

Pulsed fusion propulsion is one of the most promising advanced propulsion concepts, as large values of specific impulse (105 to 106 s), specific power (MW/kg) and relatively high thrust (few kN) are potentially available. However, mechanisms for the confinement and direction of thrust remain very much under-explored. One of the first proposed solutions for directing the thrust of a pulsed fusion propulsion system was presented in Project Daedalus (Bond, Martin et al., 1976) and similar concepts were used in other fusion propulsion studies (Thio et al., 1999; Adams et al., 2003). The concept involves a number of superconducting magnetic coils placed in a parabolic arrangement around the fusion chamber, such that the fusion reaction occurs in the focus of the paraboloid. During each cycle the expanding plasma compresses the initial magnetic field, transferring momentum to the craft and slowing the plasma down. After the plasma stagnates, the field returns to its initial state and the plasma is ejected through the open side of the nozzle. This work is the first in-depth computational study of pulsed magnetic nozzle systems. The study carries out a series of high-detail, 2D simulations using state-of-the-art magnetohydrodynamic code Nautilus, developed by Tech-X Corporation, Boulder, CO, USA. We explore several axes of the parameter space, varying the number of coils, strength of the magnetic field and initial energy of the expanding plasma in order to examine the validity of the nozzle concept. We attempt to recover the intensity of recuperating currents in the coils, which are crucial for the operation of the whole concept as recuperation currents supply the power for the following cycle. Exhaust velocities, thrust and nozzle efficiencies are also to be addressed as vital thruster performance parameters. This is a submission of the Project Icarus Study Group.