Assessment of Open Magnetic Fusion for Space Propulsion

(prepared by Richard Fisackerly, Roger Walker)

Background

In an effort to address the current limitations, in terms of mission capability, of today's propulsion technologies there is a great deal of work being performed both in Europe and around the world on alternative methods of propulsion. One concept which is still at a relatively early stage of development is the direct use of energy from fusion reactions to drive a spacecraft. Theoretical research in this field has been performed for many decades, focussing on a variety of aspects of fusion propulsion from the detailed investigation of fusion reactions themselves to the consideration of the mission characteristics of a constant thrust fusion vehicle. Only relatively recently however has work begun to focus on the detailed design of a space-propulsion-specific reactor and the impact of these designs on the potential performance and mission capability of such engines.

Some concept evaluation work has been performed at a variety of different levels into concepts which employ closed chamber, toroidal confinement reactors (such as those favoured for terrestrial fusion applications), open confinement systems and inertial confinement devices. These studies have been able to draw upon the growing base of practical experience with toroidal reactors and the more recent experimental work into the behaviour of plasmas in open confinement systems e.g. gas dynamic mirror (GDM), field reversed configuration (FRC). The preliminary results of this work have shown that open magnetic configurations have a number of advantages in terms of their use in space, and as such some engineering design approaches (e.g. Integrated Design Environment Algorithms) have been developed to gain a more comprehensive understanding of the behaviour and performance of these devices.

Objectives

The main objectives of this study are:

1. To evaluate the current status of practical research into fusion confinement systems, specifically open magnetic configurations, and identify new concepts where possible.
2. To identify, using existing fusion concept evaluation processes or by developing improved methods, which concepts offer the greatest potential for space propulsion applications.
3. To briefly consider how the development and use of fusion propulsion technology might affect space research and exploration in Europe and worldwide (i.e. what specific opportunities and missions might fusion propulsion provide).
4. To identify how space institutes and industry in Europe might contribute to the development of fusion technology specifically for application to space propulsion, including the outline plan of a research and experimental programme in the context of international collaboration.

References

[1] Carpenter, S.A., Brennan, K.M. and Gatti, R.C., (1998c), 'Fourth Design Principle for Application of Fusion Power to Space Propulsion', Cleveland, Ohio, July 13-15 1998, AIAA – 98 – 3593

[2] Slough, J., (2001), ‘Performance Capability and Mission Analysis for a Pulsed High Density FRC Fusion Rocket’, Salt Lake City, Utah, July 8-11 2001, AIAA – 2001 – 3674

[3] Kammash, T. and Lee, M., (1995), ‘Gasdynamic Fusion Propulsion System for Space Exploration’, in: *Journal of Propulsion and Power*, Vol. 11 **(3)** 1995, pp.544-553