Final Report: Field Reversed Configurations—Critical Issue Scoping: Reactor Plasma Physics

DOE grant #DE-FG03-97ER54430
(University of Washington, project 62-0977)

Loren Steinhauer

March 2000

The role of the University of Washington (UW) component of the *FRC Critical Issues* study is program is to offer support on the plasma physics modelling aspect of the engineering systems study conducted at the University of Wisconsin under the direction of John Santarius. The Redmond Plasma Physics Laboratory, affiliated with the UW, is the site of the leading FRC experiment and theory programs in the world. The primary areas where plasma modelling has been needed for the critical issues study are (1) quasi-analytic description of FRC equilibria, and (2) properties of rotating magnetic field current drive in FRCs. The following is a brief summary of the various FRC plasma characteristics that were supplied to the engineering team at Wisconsin.

(1) FRC equilibrium description

A quasi-analytical description of 2D (r,z) FRC equilibria was constructed. These are not true equilibria but are accurate enough for the purpose of understanding how the FRC interacts with the reactor engineering aspects. These *quasi-equilibria* are an extension of the familiar "rigid rotor" equilibria (a 1D concept) by: (a) admitting a more flexible radial structure; and (b) introducing a "reasonable" axial structure. Missing from these equilibria is flow, which may be an important feature of relaxed FRCs but should have a modest effect on the bulk equilibrium properties.

The properties of these quasi-equilibria have been characterized in terms of several key parameters: radial size parameter; elongation; separatrix beta; and edge layer relative thickness parameter. Reasonable values and ranges for these parameters based on experience with FRC experiments were identified.

In addition to the equilibrium properties, the confinement scaling properties of FRCs were also characterized. Since the underlying physics of FRC transport is not yet well understood, these properties are based on extrapolations from published empirical confinement times for FRC experiments.

(2) Current drive

Experiments are currently in progress on the STX and TCS facilities at Redmond Plasma Physics Laboratory (University of Washington) to investigate the current drive characteristics of rotating magnetic field (RMF) current drive. Heretofore the understanding of RMF is based on low-temperature experiments in "rotamak" devices. There is also an emerging body of RMF theory, largely through studies by Steinhauer and others at Washington. The main element of RMF current drive needed for the reactor

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

engineering study is the power consumed by the current drive system. This was analyzed, accounting both for the power consumption due to the plasma resistivity and by losses in the RMF antennas.

Publications and Presentations from the Critical Issues Study

Publications to date

J.F. Santarius, G.A. Emmert, H.Y. Khater, E.A. Mogahed, C.N. Nguyen, L.C. Steinhauer, and G.H. Miley, "*Field-Reversed Configuration Power Plant Critical Issues*," in Proceedings ANS Topical Meeting on the Technology of Fusion Energy, 8-11 June 1998, Nashville, TN.

G.H. Miley, J.F. Santarius, and L.C. Steinhauer, "On Design and Development Issues for the FRC and Related Alternate Confinement Concepts," presented at the IAEA Technical Committee Meeting on Fusion Power Plant Design, 24-27 March 1998, IKAEA, Culham, UK.

Presentations

J.F. Santarius, "*FRC Power Plants—a Fusion Development Perspective*," in Proceedings of the US-Japan Workshop on Physics of High-Beta Fusion Plasmas, Seattle, 18-20 March 1998.

Loren Steinhauer, "*FRC Plasma-Liquid Wall Physics Interface Issues*," presented at the APEX/ALPS meeting on Plasma Interface Issues, Albuquerque, 27-31 July 1998.

J.F. Santarius, "*Field-Reversed Configuration Engineering Issues for Designs with Liquid Walls*," APEX/ALPS Meeting, Albuquerque, 27-31 July 1998.

Additional papers in preparation

C.N. Nguyen et al., "*Systems Analysis of a D-T Field-Reversed Configuration Power Plant.*"

E.A. Mogahed et al., "*Engineering Design of a D-T Field-Reversed Configuration Fusion Core.*"

S.V. Ryzhkov et al., "*Systems Analysis of a D-^{3}He Field-Reversed Configuration Power Plant.*"