Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
Wissenschaftliche Berichte
FZKA 7312

Magnetohydrodynamic Flow in a Mock-Up of a HCLL Blanket. Part I Numerical Analysis

C. Mistrangelo

Institut für Kern- und Energietechnik
Programm Kernfusion

September 2008

Forschungszentrum Karlsruhe

in der Helmholtz Gemeinschaft

Wissenschaftliche Berichte

FZKA 7312

Magnetohydrodynamic flow in a mock-up of a HCLL blanket. Part I Numerical analysis

C. Mistrangelo

Institut für Kern- und Energietechnik
Programm Kernfusion

Forschungszentrum Karlsruhe GmbH, Karlsruhe
2008

Forschungszentrum Karlsruhe GmbH
Postfach 3640, 76021 Karlsruhe

Mitglied der Hermann von Helmholtz-Gemeinschaft
Deutscher Forschungszentren (HGF)

ISSN 0947-8620

urn:nbn:de:0005-073129

Magnetohydrodynamic flow in a mock-up of a HCLL blanket

Abstract

A modular *Helium Cooled Lead Lithium* (HCLL) blanket concept has been proposed to be tested in the first phase of ITER operation as part of the Test Blanket Module (TBM) program of the European Union. In this blanket concept helium is used to cool the breeder zones through cooling plates immersed in the liquid metal as well as the whole structure (first wall and grid plates). The liquid breeder circulates in the rectangular gaps formed by the cooling plates inside the breeder units and only a small velocity ($1 - 1.5$ mm/s) is required to direct it towards external facilities for tritium removal and purification of the liquid metal. The interaction of the moving lead lithium with the strong magnetic field that confines the plasma induces electric currents, which create electromagnetic forces. These latter modify the velocity and pressure distributions compared to those in hydrodynamic flows. Since all the walls, cooling and grid plates, are electrically conducting, an exchange of electric currents through common walls of adjacent fluid domains may lead to an electric flow coupling and its effects on the flow and pressure distribution have to be investigated. The detailed knowledge of the established magnetohydrodynamic (MHD) flow is required to asses the reliability of this blanket design.

In the present report results from a numerical study of MHD flows in four breeder units with internal cooling plates are discussed. The geometric features are chosen according to the characteristics of the experimental test section that is inserted in the liquid metal loop of the MEKKA laboratory at the Forschungszentrum Karlsruhe for the 2007-2008 experimental campaign. The analysis focuses on the effects of electric coupling between adjacent breeder units. Results have been obtained for a pure toroidal magnetic field and for cases where the field has a certain inclination with respect to the toroidal direction.

In the case of a pure toroidal magnetic field, velocity jets develop close to the grid plates and a small increase of the velocity is also observed near the cooling plates. The electric coupling between breeder units is weak since currents do not cross the grid plates, but they flow preferentially in tangential direction within the walls separating the boxes. Instead, inside the breeder units, the narrow ducts formed by the cooling plates are strongly coupled.

It has been found that the presence of a poloidal component of the confining magnetic field yields a stronger electric coupling between the breeder units and more complex current paths can be identified.

This MHD study has been initiated to advance our understanding of the proposed HCLL blanket concept, to identify the main MHD issues for this design and to define further R&D areas to be investigated as part of the ongoing experimental program at the Forschungszentrum Karlsruhe.