Experimental detection of MHD flow reversals in sub channels of a liquid metal test blanket for ITER

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ABSTRACT

In thermonuclear fusion reactors, like ITER, a plasma formed by tritium and deuterium is confined at very high temperature by strong magnetic fields to a toroidal chamber, in order to avoid direct contact with the surrounding solid structure. The latter one consists of so-called blanket modules filled by liquid lead lithium alloy, which absorbs the neutron energy and allows generating from lithium the fuel component tritium. The electrically conducting fluid is circulated through the modules for tritium removal and purification of the liquid breeder, and interacts with the strong magnetic field that confines the fusion plasma, giving rise to significant electromagnetic interaction. A reliable design of such fusion blankets requires detailed knowledge of the magnetohydrodynamic (MHD) flow behaviour. However, full capability to simulate numerically the global MHD flow and pressure distributions in the current blanket concept is not achieved yet due to the complexity of the geometry and the strong electromagnetic flow coupling [1].

In order to determine the flow distribution in the breeder units, liquid-metal magnetohydrodynamic experiments in a scaled mock-up of a lead lithium blanket module have been performed. Experiments are carried-out in the strong dipole magnet of the MEKKA laboratory at the Karlsruhe Institute of Technology. The experimental mock-up consists of four breeder units with feeding and draining manifolds. Each breeder unit is subdivided in six sub channels by five walls simulating cooling plates. A uniform convective removal of the generated tritium can be enhanced by a homogeneous partitioning of the flow in all the sub channels. A detailed parametric study has been performed by varying the strength of the magnetic field, expressed by the non-dimensional Hartmann number *Ha*, and the flow rate, given in terms of Reynolds number *Re*. It has been found that depending on the combination of these characteristic numbers the flow may be more or less uniform in the sub channels as foreseen in the design. However, there exist combinations of parameter for which the flow in some sub channels becomes stagnant or even reversed. These flow conditions should be avoided in engineering application. Results show that the occurrence of flow reversals is mainly determined by an inertial – electromagnetic balance of forces [2].

REFERENCES

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