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NEW ADVANCED MATERIALS FOR ENERGY PRODUCTION: THE ARC FUSION REACTOR AND MHD PHENOMENA IN THE FLIBE BREEDER

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ABSTRACT

For decades, nuclear fusion energy has been pursued by scientist worldwide. This is because fusion energy devices have the potential produce huge amounts of clean carbon-free energy. Different designs for fusion reactors have been proposed and some have been built. At the Plasma Science and Fusion Center (PSFC) of the Massachusetts Institute of Technology (MIT), an innovative design was created: ARC, the Affordable Robust Compact reactor. ARC achieves its compactness partially due to the presence of High Temperature Superconductors (HTS) for the magnetic confinement and the use of molten salt Lithium-Fluoride, Beryllium-Fluoride (FLIBE) as coolant, neutron shield, and tritium breeder. FLIBE has the characteristic of extremely high boiling point (about 1700 K) which guarantees a single-phase flow. As an electrical conducting fluid, MHD flows can be encountered in FLiBe. The flow inside breeding blanket channels can be very complex and results in high pressure drops, especially when the channels are also made by electrically conducting materials. The evaluation of fluid velocity profile, pressure drop and prediction of thermal heat fluxes are of considerable interest for the blanket design. For this purpose, thermal-MHD simulations can be run. Those simulations evaluate 3D transient problems in which the quantities describing the problem have to be estimated at each discretized point of the geometry domain. After a brief introduction of ARC and the fundamentals of MHD, the paper will present the numerical approach adopted and the implementation of thermal-MHD coupled code on Open-FOAM and COMSOL, as well as a stability discussion. The results of such simulations are presented, with sections dedicated to comparison between codes and analitycal results for a simple class of problem: square ducts.

Keywords: fusion energy, advanced materials, FLIBE, ARC reactor.