Seminar

Institute for Plasma Research

Title: MHD flow studies in a single and multichannel rectangular ducts in presence of flow obstacles

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Abstract

The Lead-lithium (Pb-Li) eutectic is considered as a most promising liquid breeder material for liquid metal (LM) blankets because of its favorable properties of tritium breeding, neutron multiplication, and heat removal. However, LM blankets have feasibility issues associated with Magneto-hydrodynamic (MHD) interactions between the flowing electrically conducting liquid metal and strong plasma - confining magnetic field, leading to high MHD pressure drop in the blanket module [**1**] and altered velocity profile inside the flow channels. As of today, various liquid metal MHD studies have been reported for various flow configurations, such as bends, pipes, expansions, inclined channels, and parallel flow channels, to characterize flow behavior and assess its impact on blanket performance. However, studies on MHD flows in the presence of internal obstructions are limited. In liquid breeder blankets, internal components such as neutron diagnostic pipes [2], helium pipes for tritium extraction [3], and water cooling pipes [4] are unavoidable. These components act as flow obstructions and can significantly alter the MHD flow behavior within the channels, thereby necessitating detailed 3D MHD analysis to assess the impact of such obstacles on flow characteristics.

The 3D MHD simulation has been performed under a lab scale conditions, considering a Pb-Li mass flow rate of 5kg/s and a uniform transverse magnetic field of 1T magnetic field. The analysis has been performed for both a single rectangular channel and multichannel flow model geometries, with and without the presence of hollow pipe acting as an obstacle in the Pb-Li flow path. The simulation results of velocity, pressure and flow distribution will be discussed in detail. The present work aims to advance the understanding of liquid metal MHD flows in the presence of internal obstructions, thereby contributing to the design optimization and performance assessment of liquid breeder blankets for fusion reactor applications.

References

[1] Mohamed Abdou, et al. FED, 100 (2015) 2-43**.**
[2] H.L. Swami, et al. FED, 121 (2017) 174-181.
[3] [3] S. Ranjithkumar, et al. FED, 109-111 (2016) 1581-1586.
[4] [4**]** L.V. Boccaccini, et al. FED, 179 (2022) 113116.