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Material Solutions for Flow Channel Inserts for Liquid Metal Blankets

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Flow Channel Inserts (FCI) are key components, originally proposed in European blanket conceptual designs, required in liquid metal-cooled and/or -bred fusion reactor blankets such as the Dual Coolant Lead-Lithium (DCLL) or Helium-Cooled Lead-Lithium (HCLL) concepts. The FCI minimizes the magnetohydrodynamic (MHD) pressure drop and enables higher outlet temperatures for liquid metal than temperature limits for the structural alloys. The primary functions of the FCI are to electrically insulate the flowing liquid metal from the conductive metal structures and to thermally insulate the structures from the high temperature liquid. The FCI must also provide structural integrity, allow adequate tritium breeding while operating in a harsh radiation, temperature gradient, and chemical environment.

Two FCI materials concepts are currently considered: SiC-based composites and metal-encapsulated insulators. SiC-based composites, in particular the continuous SiC fiber-reinforced SiC-matrix (SiC/SiC) composites, are the prime candidate due to the superior high temperature capability and anticipated radiation tolerance. These composites in the common two-dimensional fabric lay-up architectures have been shown to satisfy the general requirements for FCI in as-manufactured and fission neutron-irradiated conditions. However, a few critical design-limiting issues and uncertainties remain with regard to the use as an FCI in a fusion nuclear environment. The metal-encapsulated insulator concept is a potential near-term alternative to the SiC-based FCI concept. Although the concept presents more limitations on the operating temperature and neutron tolerance, proper choice of both the insulating and encapsulating materials may allow operations in less aggressive conditions. These FCI concepts are discussed in terms of the development status, design limiting issues, potential solutions, and the path-forward for technology development and qualification.

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Eligible for student paper award?

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