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Thu-Af-Po.06-03: Superconductor selection assessment for magnetizing coil magnets for a FFHR based on a RFP configuration

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The Fusion-Fission Hybrid Reactor (FFHR) concept has been envisioned since the early days of fusion research as a system in which fast neutrons produced by a high-temperature D-T plasma interact with a surrounding blanket containing fissile material and then a Li-based target. This process enables the production of plentiful tritium in quantities exceeding the requirements of the fusion core [1]. Such a surplus of tritium could also be used to fuel other fusion reactors without the need for a breeding blanket, thus streamlining their design and simplifying both their construction and operation.
For what concerns the FFHR fusion core, the Reversed Field Pinch (RFP) stands out as a compelling option. This toroidal plasma configuration relies on a self-generated toroidal magnetic field, with the plasma temperature increased, in principle, solely by ohmic heating [2]. These features make the RFP an attractive and potentially cost-effective choice for hybrid reactor designs.
Based on such a configuration, the study explores the suitability of various superconductors, among LTS (i.e. NbTi and Nb3Sn) and High-Temperature Superconductors. While HTS offer higher critical current densities and operational temperatures, their generally lower neutron irradiation resistance may limit their applicability in the high-flux environment of a quasi-continuous "double-swing"operation characteristic of a RFP configuration [3]. The investigation also considers the impact of transient stresses induced during the dwell phase and the need to maintain stable performance over extended operational periods.
This research aims to establish a comprehensive framework for superconductor selection tailored to FFHRs based on RFP configurations. The outcomes will inform material and design choices for future hybrid reactors, addressing the challenges of high neutron flux and demanding operational regimes, and advancing the feasibility of commercial fusion-fission hybrid systems.

[1] S. Murgo et al. "RFP-MSR Hybrid reactor model for actinides transmutation and tritium breeding", submitted to Nuclear Fusion, Poster presented to the 2023 IAEA FEC.
[2] L. Marrelli et al. "The Reversed Field Pinch", Nuclear Fusion, Vol. 61, n. 2, 2021.
[3] R. Piovan et al, "A continuously pulsed Reversed Field Pinch core for an ohmically heated hybrid reactor" , Fusion Engineering and Design, Volume 136, Part B, 2018.

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