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High Temperature Superconductors for Fusion Nuclear Science Spherical Tokamak

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Princeton Plasma Physics Laboratory is currently leading the design studies of Fusion Nuclear Science Facility and pilot plants based on the most promising magnetic confinement configurations including the low aspect ratio Spherical Tokamaks. An innovative magnet design approach is needed to close the gap between rapid advances in High Temperature Superconductor (HTS) and the maximal fusion energy extraction from ITER-like burning plasma development. Significant performance improvement in HTS cables utilizing a stack of REBCO tapes as well as the high current density Bi-2212 round wires provides targeted magnet R&D opportunities to support the design consideration of low aspect ratio spherical tokamak pilot plants. We present conductor design options based on recent test results of high current HTS cables and discuss the optimal winding pack layout for the TF and CS coils within the design space allocated for the 3-m HTS ST-FNSF magnet system. The rectangular shaped high current density CORC cable made of YBCO tapes will be analyzed to validate feasibility of TF coil winding pack design for the ST FNSF. For the CS coil, a series of pancake YBCO coils with metal insulations, or solenoids consist of Bi-2212 round wires can be shown to meet the physics requirements of magnetic flux swing in facilitating initial plasma operation. Irradiation limit of magnet materials for the next step fusion reactors will also be discussed.

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