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Development and Testing of Hybrid HTS Conductor for TF and CS Coils

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In future tokamak reactors higher magnetic field will be required to confine the plasma for a longer time to achieve higher confinement density. It is anticipated that higher magnetic field for future tokamak will be provided by high temperature superconducting coils, with good stability and low cryogenic requirements. Second-generation REBCO (2G HTS) high temperature superconductors (@77 K), such as GdBCO, offer high critical current densities and withstand higher magnetic fields compared to conventional low-temperature superconductors (@4 K). A Hybrid High-Temperature Superconductor (HHTS) was developed by soldering five HTS strips (GdBCO, 0.15 mm thick, 4 mm wide) with no insulation (NI) into a copper stabilizer. Five NI-HTS strips without stabilizers were also tested at room temperature and in liquid nitrogen (LN_2). Experimental results showed that the standalone HTS tapes achieved a maximum stable current of 270 A in LN2 at a voltage of 0.08 V, corresponding to a critical electric field (Ec) of 14μV/mm. In contrast, the HHTS configuration carried a significantly higher current of 740 A at only 0.2 V, with an electric field of 6.8 μV/mm. Numerical simulations using the H-formulation were conducted across the HHTS cross-section, exploring current levels from 500 A to 1000 A and stabilizer widths of 7 mm, 9 mm, and 12 mm. The results indicate stable current conduction up to 1000 A. The copper matrix provides stability during interruption in cooling system, and the electric field in the HHTS allows operation at higher currents. The copper matrix within the conductor enhances stability during cooling interruptions, while the electric field in the hybrid conductor enables operation at higher currents. This configuration provides stable operation at 500 A and above, offering advantages in voltage control and cooling efficiency. Such conductors can be used for the Toroidal Field (TF) coils of Tokamak where long pulse stable current is required.
A small central solenoid (SC) has been manufactured by winding and soldering the 10 layers of HTS strips at copper cylinder (used as a stabilizer). The testing of the pulse current will be performed and results will be reported.

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