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FTP/P7-26: First Results from Tests of High Temperature Superconductor Magnets on Tokamak

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It has long been known that high temperature superconductors (HTS) could have an important role to play in the future of tokamak fusion research. Here we report on first results of the use of HTS in a tokamak magnet and on the progress in design and construction of the first fully-HTS tokamak. In the experiment, the two copper vertical field coils of the small tokamak GOLEM were replaced by two coils each with 6 turns of HTS (Re)BCO tape. Liquid nitrogen was used to cool the coils to below the critical temperature at which HTS becomes superconducting. Little effect on the HTS critical current has been observed for perpendicular field up to 0.5T and superconductivity has been achieved at ˜90.5K during bench tests. There had been concerns that the plasma pulses and pulsed magnetic fields might cause a "quench"in the HTS, i.e. a sudden and potentially damaging transition from superconductor to normal conductor. However, many plasma pulses were fired without any quenches even when disruptions occurred with corresponding induced electrical fields. In addition, experiments without plasma have been performed to study properties of the HTS in a tokamak environment, i.e. critical current and its dependence on magnetic and electrical fields generated in a tokamak both in DC and pulsed operations, maximum current ramp-up speed, performance of the HTS tape after number of artificially induced quenches etc. No quench has been observed at DC currents up to 200A (1.2kA-turns through the coil). In short pulses, current up to 1kA through the tape (6kA-turns) has been achieved with no subsequent degradation of the HTS performance with a current ramp rate up to 0.6MA/s. In future experiments, increases in both the plasma current and pulse duration are planned. Considerable experience has been gained during design and fabrication of the cryostat, coils, isolation and insulation, feeds and cryosystems, and GOLEM is now routinely operated with HTS coils. The construction of a small fully-HTS low aspect ratio tokamak has started at the Tokamak Solutions UK premises in the Culham Science Centre. It is planned to operate a small tokamak with A=2 and circular cross section in steady state with plasma currents of 10-20kA driven by Electron Bernstein Wave current drive. In parallel, the design and manufacture of a high-field (5T) HTS TF coil for a spherical tokamak is carried out.

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