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Thermal-hydraulic Characteristics Study of Superconducting Magnets of SST-1

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Steady-state Superconducting Tokamak (SST-1) magnet system consists of NbTi/Cu based CICC (Cable-In-Conduit Conductor) wound Toroidal (TF) and Poloidal (PF) coils. The TF coils are wound in double pancakes (DP), whereas the PF coils are in DP as well as layered winding scheme. These coils are cooled down up to 5 K using force flow circulation of helium. The void fraction of helium within the square CICC (14.8 mm x 14.8 mm, 1.5 mm thick) is about 40%. There are 192 parallel hydraulic paths in the TF coils of lengths about 48 m each. The hydraulic path lengths of PF coils vary from 67 m –130 m.
Experience from several SST-1 cool down campaigns revealed that the PF coils have much higher hydraulic resistance, a factor of three as compared to its ideal expected value with reference to the TF coils. In order to improve the understanding on this issue, cool down trial of PF coils of similar hydraulic path lengths; have been attempted with better control by dividing them in separate groups. The specific experimental campaign carried out to study the thermo-hydraulic behaviour of the SST-1 coils and to investigate the cause of the higher hydraulic resistances within the PF coils. The experiment conducted to measure the hydraulic resistance at room temperature and at subsequent possible lower temperatures. This dedicated experiment revealed that even at lower temperature of 5 K, the pressure drops within the PF coils winding packs are almost three times higher than the ideally expected values. Due to these facts, the simultaneous cooling down of the TF coils and PF coils have not been possible as the cryogenic plant has limited pressure head available in the range of 0.5–0.6 bar. Thermal hydraulic analyses of TF and PF coils have also been attempted to understand the pressure drop experimental data. In this paper, we report the thermal hydraulic behaviour of the TF and PF coils and its comparison with theoretical analysis.

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