

Overview of Construction and First Commissioning Results of JT-60SA Superconducting Magnets

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Abstract— JT-60SA (JT-60 Super Advanced) is a full-superconducting tokamak, constructed in Ibaraki Japan. The operation of JT-60SA is being carried out under Japan and European Union broader approach project. The superconducting magnet system of JT-60SA has 18 toroidal field (TF) coils, 4 modules of a central solenoid (CS), and 6 coils of equilibrium field (EF) coils. The TF coils are D-shaped coils lined up on the circumference, and CS and EF coils are circular coils put inside and outside of TF coils, respectively. Height and diameter of the superconducting magnet system of JT-60SA are more than 8 m and 10 m, and the total weight is about 700 tons. Maximum operating current and magnetic field are 25.7 kA and 5.65 T for TF coils, 20 kA and 8.9 T for CS, 20 kA and 6.2 T for EF coils, respectively. The stored energy of the 18 TF coils reaches 1.06 GJ. TF coils were procured by European Union, and CS and EF coils were procured by Japan. NbTi Cable-In-Conduit Conductor (CICC) is used for TF coils and EF coils, and Nb₃Sn CICC is used for CS. High-temperature superconductor current leads (HTSCLs), which are used for the current feeding system to reduce the heat load of cryogenic system, were manufactured by KIT (Germany), and HTSCLs were installed to the current feeding equipment called coil terminal box. Superconducting magnets are cooled with 4.5K supercritical helium. The helium refrigerator and supercritical helium supply system were manufactured by EU. A helium distribution system, including cryogenic piping system, valve boxes were procured in Japan. Previous tokamak system called JT-60U had been operated until 2008, then JT-60U magnet system was removed from tokamak building. In 2012, disassembling of the previous system was completed and the construction of JT-60SA started. The first installation of the superconducting magnet was conducted in 2013, and the last superconducting magnet was assembled in 2019. The cool-down of the magnet system started in October 2020, and energization tests were performed from January to March 2021. It was achieved that the TF coils were operated stably at the rated current of 25.7 kA during 35min. For the CS and the EF coils, an individual energization test was performed. The operating current of CS and EF coils reached 5 kA, one-fourth of the rated current of 20 kA. During rapid ramp-up and ramp-down test operated in maximum voltage of 5 kV, a current short circuit was generated and stainless-steel cylinder of SHe boundary melt by arcing. Then vacuum condition of the cryostat was lost, and the refrigerator stopped. As a result, commissioning was halted and is now under repair. Repairing will be finished at the end of this year. In 2022, the cool-down will restart, and the energization test will be resumed. This presentation will report the overview of construction, the result of first commissioning, current works, and future commissioning plan.

Keywords (Index Terms) — Tokamak Fusion, JT60-SA, superconducting magnet.