WB3-4-INV

Development of Large-Current HTS Conductors for the Next-Generation Helical Fusion Experimental Device

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The Large Helical Device (LHD) has been successfully operated at National Institute for Fusion Science. Deuterium experiments, having achieved the ion temperature of 10 keV, proves the effective plasma confinement by the heliotron magnetic configuration. The design study of the LHD-type helical fusion reactor FFHR-d1 has also progressed. Presently, extension of the LHD project is proposed and discussed, with the main target showing the steady-state discharge capability under high heating power. In parallel, discussion for the post-LHD project has also been initiated, as one of the candidates is to build a new device employing a similar but more optimized heliotron magnetic configuration with magnetic field produced by the High-Temperature Superconducting (HTS) magnet system. A large-current capacity HTS conductor is required, and three candidates are now being developed: STARS, FAIR, and WISE. Firstly, the STARS conductor has been developed since 2005 to be applied to FFHR-d1. The REBCO tapes are simply stacked, imbedded into a copper stabilizer and stainless steel (SS) reinforcement jacket. A 3-m long 100-kA-class conductor sample, having a SS jacket sustained by bolts, was formerly fabricated and tested successfully. A bridge-type mechanical lap joint technique with low joint resistance has also been developed to make the “joint-winding” feasible. A 20-kA-class conductor is now being developed to meet the new target by selecting a suitable welding method for the SS jacket. Secondly, The FAIR conductor has a stack of REBCO tapes imbedded in a circular aluminum-alloy jacket. The stacked tapes are twisted together with the aluminum-alloy jacket, which is welded by Friction Stir Welding (FSW). A number of ~1-m long short samples, having different pitch length of twisting, are fabricated and tested, presently in liquid nitrogen. Thirdly, the WISE conductor is formed by inserting a stack of REBCO tapes into a flexible metal tube. Then, after the coil winding, the winding package is impregnated by filling a low-melting temperature metal. The advantage of this conductor is its flexibility during the winding process. Two prototype coil samples were fabricated and tested in liquid nitrogen. In this presentation, the design concepts and progresses of these large-current HTS conductors are reviewed.

Keywords: Large-current HTS conductor, LHD, helical / heliotron, fusion magnet