3-1 Start of Manufacture of the Superconductors for the ITER Magnets
—Development of Exacting Quality Assurance Techniques—

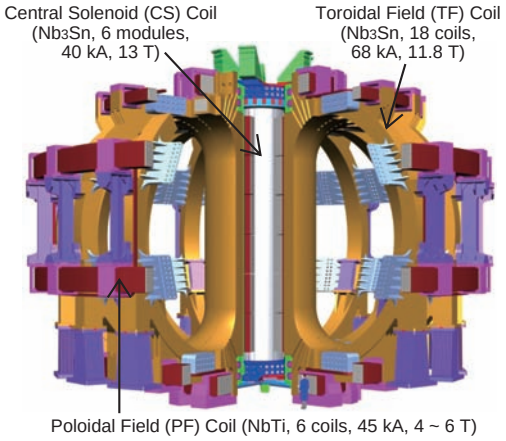

Fig.3-2 ITER superconducting magnet system
The system consists of 18 toroidal field (TF) Coils, 6 central solenoid coils and 6 poloidal field coils.

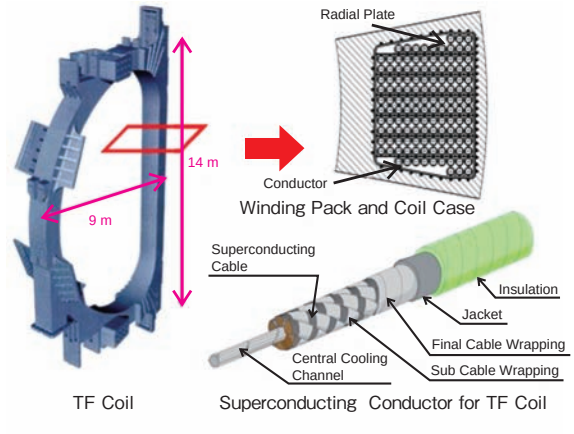

Fig.3-3 Structure of TF coils and their superconductor
A circular, multistage superconducting cable, consisting of around 1000 superconducting strands, is inserted into a circular stainless steel jacket. The superconductor is subsequently inserted into the groove of a radial plate.

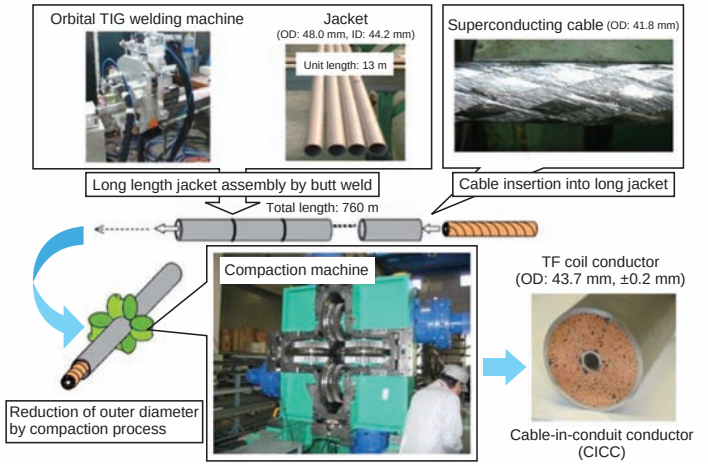

Fig.3-4 Fabrication process of the TF conductor
Jackets with a length of 13 m are butt-welded by an automatic welding machine to create a jacket whose total length is 760 m. The superconducting cable is inserted into the jacket. The jacket is then compacted to a diameter of 43.7 mm.

The ITER device being constructed by Japan, China, the EU, India, Korea, Russia and the US, will have a field of 10 T in order to confine and control a very high temperature plasma. Huge superconducting coils are necessary for this purpose (Fig.3-2). The height, width and weight of a toroidal field (TF) coil, which generate the magnetic field, are 14 m, 9 m and about 300 tons, respectively (Fig.3-3). Japan is procuring 9 TF coils and 25% of all TF superconductors, and is the first to begin manufacturing the TF conductors.

A circular superconducting cable, consisting of around 1000 superconducting strands, is inserted into a circular stainless steel jacket (Fig.3-4). The jacket is composed of tubes, each 13 m in length, that are butt-welded by an automatic welding machine to create a single length of 760 m. The gap between the cable and the jacket is approximately 2 mm. The pulling force on the cable is approximately 4 tons. Following cable insertion, the jacket is compacted to the specified diameter in a single step. After welding, a helium leak test, radiographic inspection and a dye penetrant test are carried out on the welds. Following the compaction, outer diameter tolerances of 0.2 mm, corresponding to 0.5% of the outer diameter (43.7 mm), are confirmed through continuous laser measurement. The conductor is wound as a one-layer solenoid with a diameter of 4 m, and a helium leak test is carried out in a vacuum tank. Demanding specifications have required the development of exacting quality assurance techniques. These techniques were confirmed as valid during the fabrication of a 760 m Cu dummy conductor, as a result of which we have started fabrication of actual superconductors at the rate of approximately one conductor per month.

Reference

Nabara, Y., Takahashi, Y. et al., Procurement of Nb_3Sn Superconducting Conductors in ITER, Journal of Plasma and Fusion Research SERIES, vol.9, 2010, p.270-275.