3-6 Superconducting Magnet Technology in ITER
—Development of the Largest Superconducting Magnet in the World—

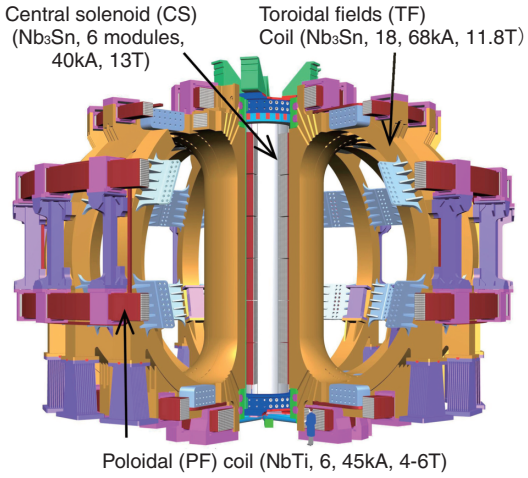

Fig.3-13 ITER superconducting magnet system

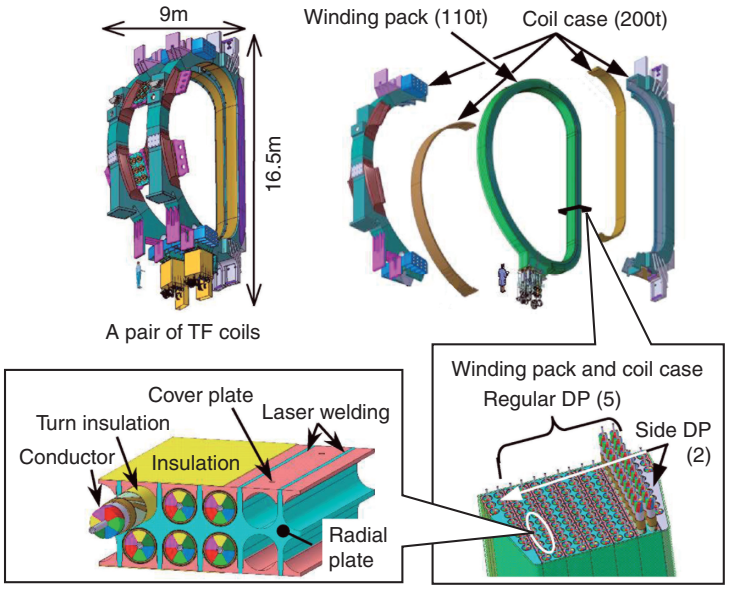

Fig.3-14 Configuration of TF coil

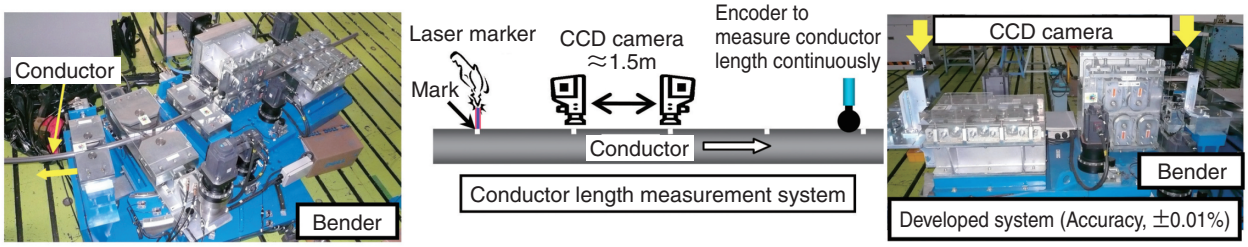

Fig.3-15 High accuracy winding system

In ITER, a joint project by China, EU, India, Korea, Japan, Russia and the US, large superconducting magnets (Fig.3-13) generating a field of more than 10 T are necessary. Japan is responsible for procuring 9 Toroidal Field (TF) coils (Fig.3-14), which are the largest superconducting coils in the world, as well as 25% of the TF conductors, whose procurement was the first contract signed in the ITER project.

In the TF coil, a winding pack (WP) is supported by a coil case, enabling it to sustain a huge electromagnetic force of 50MN/m. A WP consists of 7 double-pancakes (DP), which are fabricated as follows: (1) a 4.6km conductor is wound into a D-shape with accuracy of ±0.02% for the conductor length of each coil; (2) the conductor is heat-treated at 650℃ for 200h to generate Nb_3Sn; (3) the conductor wrapped in electrical insulation is inserted into a groove in the radial plate (RP), which provides a high degree of rigidity to support each conductor against a large electromagnetic force of 800kN/m; (4) the conductor is fixed in an RP groove by welding cover plates to the RP; and (5) the DPs are electrically insulated from each other.

A high degree of accuracy is required in the shaping of the winding. Each TF coil winding also must be made in 4 months. A highly accurate automatic winding system is a key technology to meet these requirements. We developed a highly accurate, automatic bender (Fig.3-15) that comprises a major part of the winding machine. The deformation of a conductor cross section due to bending is reduced to less than 0.2mm by optimizing the interval between the rollers. In order to measure the length of a conductor with great precision, we developed a new system in which the distance between marks scribed by a laser marker is measured with 2 CCD cameras (Fig.3-15). We have achieved a very high degree of accuracy of ±0.01% in measuring the length of a conductor and a winding speed of 3m/min. These results demonstrate the feasibility of our TF coil winding process.

Reference

Koizumi, N. et al., Critical Issues for the Manufacture of the ITER TF Coil Winding Pack, Fusion Engineering and Design, vol.84, issues 2-6, 2009, p.210-214.