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Japanese contributions to the procurement of the ITER superconducting magnet

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Abstract

Japan is expected to make a major contribution to the procurement of the ITER superconducting magnet system, including the TF coil windings and structures, and conductors for the TF coil and CS. JAEA has started preparation activities for the ITER construction in tight collaboration with industries. These activities include manufacturing studies to identify detailed fabrication processes and tools for critical components, and manufacturing demonstrations at full scale level based on the studies. So far, high-performance Nb_3Sn strands that satisfy the ITER requirements have been developed and full scale trial fabrications of new cryogenic materials, such as JJ1 and strengthened 316LN, have successfully been performed for TF coil case and radial plates. Results from these activities will provide a firm technical basis to achieve required performance of the magnets while maintaining both project schedule and cost.

Keywords: Fusion; ITER; Superconducting magnet; Structural materials; Model coil

1. Introduction

In the Engineering Design Activity (EDA) of the International Thermonuclear Experimental Reactor (ITER) performed from 1992 to 2001, two model coils, the Central Solenoid (CS) model coil [1] and Toroidal Field (TF) model coil [2], have been manufactured and tested. The design principles and manufacturing methods of the ITER superconducting (SC) magnets have been validated by the successful operation of the model coils and a technical basis for ITER construction has been established [3,4]. In 2005, Cadarache was selected as ITER site by the six Participant Teams (PTs), namely, Japan, China, EU, Korea, Russia and US, and India was accepted to be a new member. In addition, procurement sharing for the ITER construction was also agreed.

The ITER superconducting magnet system consists of 18 TF coils, 1 CS and 6 Poloidal Field (PF) coils [5]. The TF coils have a D-shape with a height of 14 m and a width of 9 m. The CS is composed of six identical modules, which are stacked into an assembly of 12 m

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height and supported by a pre-compression structure. The PF coils are ring coils located at the outside of the TF coils and the largest PF coil has an outer diameter of 25 m. Maximum fields are 11.8 T in the TF coil, 13 T in the CS, and below 6 T in the PF coils. The TF coils and CS use Nb_3Sn superconductor and PF coils use NbTi conductor.

Regarding the procurement of the superconducting magnet system, all six PTs will make contribution [6]. For example, TF conductors will be produced by the six PTs. The overview of the sharing is shown in Fig. 1. Among six PTs, Japan, EU and US will be responsible for major part of the superconducting magnets, and Japanese contribution will be the largest, including the following four areas: part of TF conductors, about half (9 out of 19) of TF coil winding packs, most of TF coil structures and all of CS conductor. Since 2004, Japan Atomic Energy Agency (JAEA) started preparation activities for procurement, including manufacturing studies to identify detailed fabrication processes and tools for critical components, such as TF coil winding and case, and manufacturing demonstrations at full scale level on Nb_3Sn strands and conductors and cryogenic structural materials, such as coil case segments and radial plates. Details are described in the following sections.

2. Conditions in procurement

In performing the preparation activities, several boundary conditions, which are imposed by the project, have been clarified as follows.

2.1. Cost

The construction cost for ITER has been defined in terms of ITER Unit Account (IUA), and the breakdown of each component has also been defined in IUA. For example, the SC magnet system corresponds to about 1/4 of the total cost, in which conductor cost is the largest, about half of the total magnet cost, and TF coil (winding and structures) is the second largest. Available resource, which is conversion from IUA to real currency in each PT, is therefore fixed. In order to maintain magnet manufacturing cost at this estimated level, continuously effort is being made to optimize the design by eliminating excessive margins, mitigating requirements (e.g. manufacturing tolerances) and simplifying manufacturing processes.

2.2. Construction schedule

The ITER project assumes about 2 years for regulatory process and 8 years for the construction until the first plasma is obtained, as shown in Fig. 2. The

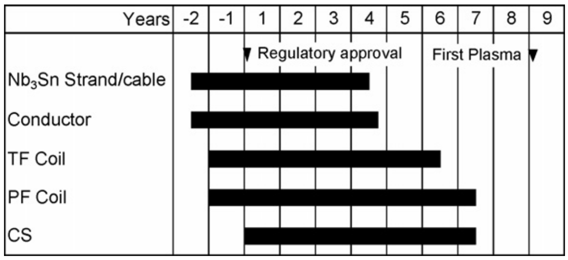

Fig. 2. ITER project schedule.

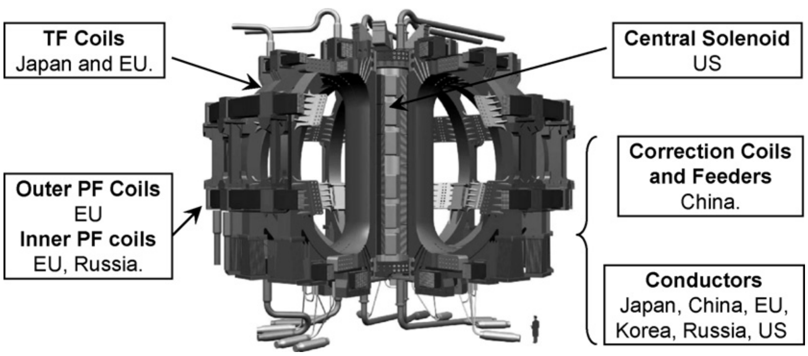

Fig. 1. ITER superconducting system and overview of the procurement sharing among participant teams.