Research Area and Activities of JT-60SA and the Present Status of its Construction

JT-60SAの研究領域とそれへ向けての検討状況および建設の状況

Hiroshi Shirai and the JT-60SA Team
白井浩、JT-60SAチーム

Japan Atomic Energy Agency
801-1 Mukoyama, Naka, Ibaraki 311-0193, Japan
日本原子力研究開発機構　〒311-0193　茨城県那珂市向山801-1

Construction of JT-60 Super Advanced (JT-60SA), a superconducting tokamak, is steadily proceeding toward the first plasma in March 2019. Components such as toroidal and poloidal field coils, vacuum vessel, cryostat, power supplies and so forth are being manufactured in EU and Japan. Since January 2013, assembly work in the torus hall of Naka Fusion Institute has been going on schedule. In parallel, research collaboration in the research community of EU and JA has been further developed with updated version of JT-60SA Research Plan, which is open to public.

1. Objective of the Project

Mission of the project of JT-60SA (JT-60 Super Advanced), a superconducting tokamak, is to contribute to the early realization of fusion energy by (i) conducting supportive researches for ITER to accomplish its technical targets, (ii) conducting complementary researches to ITER necessary for design and construct DEMO, and (iii) training domestic scientists and technicians, especially those in younger generation, who are expected to play leading roles in research and development of ITER and DEMO [1-3].

JT-60SA tokamak, upgrade of JT-60 tokamak using normal conducting coils, controls high-temperature and high-pressure deuterium plasmas in breakeven condition for long duration (typically 100 s). It has powerful heating and current drive tool using NBI (positive- and negative ion source) and ECRF, several kinds of MHD stability control coils and flexible plasma shaping capability to produce high-elongation and high-trianglularity plasmas. Thus JT-60SA is a powerful device for exploring and optimizing operation scenario of ITER and DEMO.

2. Framework of the Project and Structure of Collaboration

JT-60SA Project is conducted under the Satellite Tokamak Programme of the Broader Approach (BA) Agreement and the Japanese national programme. The exploitation opportunities of JT-60SA are equally shared between the national programme and the Satellite Tokamak Programme. Implementation of JT-60SA Project is directed and supervised by the BA Steering Committee, some of the members of which come from the Japanese Government and EURATOM. Overall JT-60SA Project is managed by the Integrated Project Team (IPT) consist of the Project Team, EU Home Team and JA Home Team.

Research Plan of JT-60SA has been intensively discussed involving the research community of EU and JA. Coordination of discussion is ensured through the Fusion Energy Forum with researchers from JAEA, Universities, etc. in Japan as well as those from F4E and EUROfusion in EU. In the eight research areas, i.e. (i) operation regime development, (ii) MHD stability and control, (iii) transport and confinement, (iv) high energy particle behavior, (v) pedestal and edge physics, (vi) divertor, scrape off layer and plasma-material interaction, (vii) fusion engineering, and (viii) theoretical models and simulation codes, proposals from EU and JA researchers have been elaborated and put together as "JT-60SA Research Plan (SARP)". The latest SARP (ver.3.1) [4] written by 331 authors was made open to public in December 2013. SARP will be updated on a periodic basis in the future.

3. Status of Construction

Upgrade of the former JT-60 tokamak with normal conducting coils to JT-60SA tokamak with superconducting coils needs manufacture and replacement of lots of facilities and components. Their procurement is shared by EU and Japan. Present status of major activities are shown below. Some facilities used by JT-60 tokamak are reused, with refurbishment and repair to some degree; e.g. central substation, three motor generators, auxiliary heating (NBI and RF) facilities and so forth, in order to restrain overall construction cost.

Disassembly of the former JT-60 was completed in October 2012. Assembly of JT-60SA started in January 2013. Up to date, 25 procurement arrangements (PAs) in total (JA: 14 PAs, EU: 11 PAs) , which covers 93% of the total value of the BA Satellite Tokamak Programme, have been established and thereunder fabrication of components, their acceptance and installment in Naka have been steadily progressing toward the first plasma in March 2019.

(i) Procurement by EU

19 Toroidal Field coils (TFC) in total including one spare TFC are procured by EU by cross-border linkage among different companies. 6 rectangular steel-jacketed NbTi cable-in-conduit conductors (CICC) are used for each TFC. 80 conductors have been already produced and tested. Winding activities and their impregnation are carried out in France and Italy. Impregnated winding packs will be put together with TF casings manufactured in Italy. Then they will be sent to France to conduct cold test to validate their performance. After the cold test, the outer inter-coil structure is fix to the TFC for reinforcement. The first set of TFCs is expected to be delivered to Naka by the end of 2015. In parallel the gravity supports for TFC, the high temperature superconducting current leads for TFC and Poloidal Field Coil (PFC) are also being manufactured and will be delivered to Naka.

Several kinds of power supplies have been also procured by EU. The first design report of power supply for superconducting magnets (TFC, PFC, etc.) will be completed in November 2014. The fabrication of Quench Protection Circuit (QPC) for TFC and PFC was completed and delivered to Naka at the end of September 2014. Their installation will start in November 2014. The power supply (PS) for Resistive Wall Mode (RWM) stabilization coils is also under deliberation. The signature of the RWM PS PA is expected in November 2014.

Cryostat of JT-60SA is made up of three parts; i.e. cryostat base (CB), cryostat vessel body cylindrical section (CVBCS) and the top lid of the CVB. The CB procured by Spain was installed in the torus hall in March 2013. The fabrication CVBCS started in 2014 and will be delivered to Naka in mid. 2016.

Detailed design and manufacturing of the cryogenic system was completed and their delivery will start in November 2014.

(ii) Procurement by JA

Poloidal field coil system of JT-60SA is made up of 6 Equilibrium Field (EF) coils and 4 Central Solenoid (CS). The former uses circular NbTi CICC and the latter circular Nb3Sn CICC. They are manufactured inside Naka site. Fabrication of EF4, EF5 and EF6 coils was completed and temporally installed on the CB in January 2014. As for the other three EF coils, the manufacturing of EF1 and EF2 coils started in June 2014. The manufacturing of CS winding is also progressing.

Vacuum Vessel (VV) of JT-60SA is made up of ten VV sectors (seven 40-degree sectors, two 30-degree sectors and one 20-degree sector). Inboard side and outboard side of each sector were separately manufactured in the factory. After they were delivered to Naka site, they were welded to make a complete sector. After the assembly frame was installed in the torus hall in May 2014. A pair of 40-degree VV sectors were put onto the CB. They were directly welded at the end of September 2014. The second pair of 40-degree VV sectors put on CB is being welded as shown in Fig. 1.

Design and manufacturing work of components such as thermal shields, gravity support for VV, ports, port bellows are also ongoing.

Auxiliary heating system for long duration of plasma operation has also been developed. The dual frequency gyrotron (110 and 138 GHz) has achieved significant progress with 1 MW power for 100 sec. As for the negative ion source NBI, the pulse duration and the current density have been remarkably improved up to 100 sec with 120-130 A/m^2.

Fig.1. Welding Work of VV sectors in torus hall

References

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