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Research and Development for Fusion Energy in QST

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One of promising candidates for electric generation is nuclear fusion because of the following attractions. Namely, the fuels of nuclear fusion are in abundant supply. The accident hazard in reaction is much less compared with fission. The emission of carbon dioxide is much less than existing thermal power generation with oil and coal.

To realize the nuclear fusion, National institutes for Quantum and Radiological Science and Technology (QST) in Japan has implemented the research and development (R&D) on the thermonuclear fusion that generates the power via the high-energy neutrons of 14 MeV generated by a reaction of deuterium and tritium plasmas. The JT-60, one of the large experimental fusion machines in the world, was completed to be constructed in 1985, where the fusion plasma has been experimentally researched. Through several modifications of the JT-60 machines, the plasma performance has been significantly improved. In the research in JT-60 for 23 years, the ion temperature reached 520 million kelvin of the Guinness record. The fusion triple product of ion density, ion temperature and confinement time of the plasma also reached 3.5×10^{21} kelvin/cm^3 at the plasma discharge time of 30 s. The achieved equivalent fusion gain (Q value) was 1.25, namely, output power by fusion reaction exceeded the input power for the fusion plasma generation. The JT-60 has shut down in 2008.

In addition to the domestic R&D's in Japan, the world-wide collaborative project of the fusion, International Thermonuclear Experimental Reactor (ITER) project was initiated in 1985. After ITER organization (IO) was established under the collaboration among Japan, Europe, USA, Russia, China, Korea, India in 2007, ITER started to be constructed in France to demonstrate a fusion output power of 500 MW at Q>10 for 500 seconds. The QST is delegated as Japanese implementing Agency for ITER and procures the in-kind components in ITER. The key components in ITER, i.e., TF coils, center solenoid (CS) coils, diverter, diagnostic device, plasma heating devices with neutral beams (NBI) and radio frequency (RF), remote handling system and tritium plant system has been developed and procured by QST.

In addition to the ITER project, satellite tokamak project started between EU and Japan as well as the Japanese national fusion program to contribute the early realization of fusion energy by addressing key physics and engineering issues for ITER and DEMO of prototype fusion reactor in Japan in 2007. In this project, JT-60 Super Advanced (JT-60 SA) started to be assembled in 2013 after the disassembly of the previous JT-60. The JT-60 SA is steadily being constructed as shown in Figure and planned to be operated in 2019. Long sustainment during 100 seconds with high integrated performance plasmas will be investigated by making the best use of powerful and versatile NBI&RF system, flexible plasma shaping, various kinds of in-vessel coils, and so forth.

In this talk, the latest activities of fusion energy development towards ITER and JT-60 SA are reported after the achievement of plasma performance in JT-60.

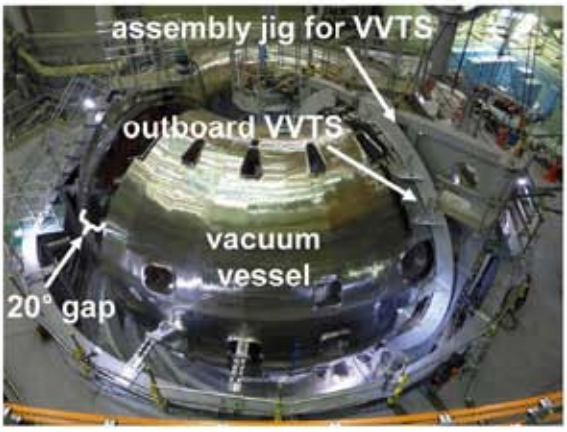

Figure Photograph of JT-60 SA under the construction.

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