Recent technological progress for Advanced Tokamak Research in JT-60U and JFT-2M

N. Hosogane, the JT-60 team and JFT-2M team

Japan Atomic Energy Research Institute, Naka Fusion Research Establishment
Naka-machi, Naka-gun, Ibaraki-ken, 311-0193, Japam

Japan Atomic Energy Research Institute has been investigating an advanced tokamak concept for ITER, and will lead it to an economically and environmentally acceptable future fusion reactor. In JT-60U, to develop such a reactor with high output density, advanced tokamak operations based on high β plasmas with a high bootstrap current fraction have been studied. In JFT-2M, on the other hand, “advanced material test experiment”(AMTEX), which investigates the feasibility of ferromagnetic ferritic steel with low activation property to tokamaks as a future reactor material, has been conducted from a viewpoint of reducing radioactive wastes of fusion reactors.

From 2003 experimental campaign, JT-60U proceeded to a new stage of steady state study with long discharges exceeding time scales of current diffusion and wall saturation. For this purpose, the tokamak discharge duration was extended from 15 s to 65 s by modifying the control systems of power supplies. Also, to sustain high performance plasmas in the steady state with NBI and RF systems, intensive efforts have been made to extend their injection pulse lengths to 30 s or more.

(1) Positive ion based NBI system

This system was extended to 30 s at 14 MW only by modifying the control system. The pulse length is mainly limited by temperature rise at the injection port without water cooling.

(2) Negative ion based NBI system

The electric field at the beam extractor was corrected so as to compensate the deflection of the beamlets caused by repulsion between beamlets. In addition, pumping outlets were added at either side of the accelerating grids to reduce bombardment of electrons stripped from negative ions due to collisions with neutrals. These reduced the temperature rise at the injection port by 70% and the heat load to the grounded grid by 25%, showing a good prospect to the achievement of 30 s at 2 MW. The pulse length has reached 17 s at 1.6 MW and 366 kV to date.

(3) Electron cyclotron heating system

The heater current and anode voltage of a gyrotron were actively controlled during or just before the operation to keep the resonance condition, and cooling of the transmission components were improved. Using a waveguide-type dummy load with an absorption capacity of 1 MW, continuous operation for 16 s at 0.4 MW has been achieved for one unit.

(4) Lower hybrid heating system

To prevent the stainless steel antenna mouth from severe damage due to RF breakdown and heat load from plasma, the heat resistive carbon-grill-antenna was attached to the existing antenna base. In the aging process, RF breakdown is still obstacle to increasing the LHRF power, but no abnormal temperature increase has been observed.

AMTEX in JFT-2M started in 1996, and finished in March, 2004. The feasibility of ferritic steel to tokamaks has already been shown with respect to compatibility with plasma equilibrium control, confinement characteristics such as H-mode, etc. In the last campaign, the influence to high β plasmas such as β-limit etc., which are crucial to advanced tokamaks, was investigated. The result is under analysis, and will be presented together with the previous ones.