Contribution ID: **4** Type: **35 min Oral**

Challenges on Long Pulse Operation in LHD

Monday, 14 November 2022 11:00 (35 minutes)

The Large Helical Device (LHD) started its operation in 1998. One of the main objectives of the LHD project is the comprehensive study for the steady-state operation towards fusion reactors. Since the plasma current is not essential for LHD/stellarator devices to confine plasma, it is free from intensive efforts to drive and sustain plasma current. However, any other issues necessary for achieving long pulse operation are still left to LHD/stellarators. In this conference, summary of steady-state studies for more than 20 years in LHD are presented, focusing on common issues both in LHD/stellarators and tokamaks.

In LHD, ultra-long pulse discharges more than 47 minutes were obtained. The plasma was heated and sustained by ECH and ICH whose power was about 1.2 MW, and total energy of 3.36 GJ was injected into the plasma, which is the world record between stellarators and tokamaks. Active plasma control via plasma heating and fuelling/pumping was the key to the steady-state operation. Fast interlock system and the real-time feedback control system of ICH/ECH and the gas puffing worked successfully in accordance with changes of the plasma wall interaction (PWI) effects. A stable plasma of electron and ion temperatures of about 2 keV and electron density of 1.2E19m-3 were maintained. In the operation, when the plasma density abruptly increased, RF power was quickly boosted up, then plasma temperature soon recovered. For optimization of the heating efficiency of ICH, minority ion ratio was also controlled, which resulted in the spark mitigation and consequently in the avoidance of the impurity accumulation.

The global particle balance during long duration helium plasma was analyzed, which revealed key physics of particle behavior between plasma and the vacuum vessel wall. It was observed, in LHD with graphite divertor plates and with stainless-steel vacuum vessel wall, that there exists dynamic change of the helium wall retention. By quantitative analyses of particle balance, it was found that the change could be attributed to two kinds of helium reservoir and those retention capabilities depending on temperature, i.e., graphite divertor plates and co-deposition layers on the stainless-steel vacuum vessel wall. In detailed analyses of the co-deposition layer with the TEM observation, it was found that the layer consists of mixed materials of carbon and iron. Another wall retention effect by the boron powder injection was recently observed, which contributes not only to edge particle control but also to core plasma performance.

Long duration discharges were terminated mainly by excess outgassing from highly heated plasma facing components, e.g., divertor plates and/or armors. In order to lower the surface temperature of the divertor plates, the actively cooled divertor component consisting of tungsten target plate and copper heat sink has been developed, which can withstand steady-state heat flux of about 20 MW/m2. Another engineering development about cryogenic pump which can be used in the neutron irradiated environment like ITER and/or DEMO will also be introduced at the conference.

Primary author: MORISAKI, Tomohiro (National Institute for Fusion Science)

Co-authors: Dr GILSON, Erik (Princeton Plasma Physics Laboratory); MOTOJIMA, Gen (National Institute for Fusion Science); KASAHARA, Hiroshi (National Institute for Fusion Science); LUNSFORD, Robert (Princeton Plasma Physics Laboratory); MASUZAKI, Suguru (National Institute for Fusion Science); NESPOLI, Federico (Princeton Plasma Physics Laboratory); OSAKABE, Masaki (NIFS); SHOJI, Mamoru (National Institute for Fusion Science); YOSHIMURA, Yasuo (National Institute for Fusion Science)

Presenter: MORISAKI, Tomohiro (National Institute for Fusion Science)

Session Classification: LPO session

Track Classification: Long-Pulse and Steady-State Operation and Control