Progress of long pulse plasma discharge using ICRF heating in LHD

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Steady state operation is one of the main subjects in the Large Helical Device (LHD) project. Experiments of long pulse plasma discharge using ion cyclotron range of frequencies (ICRF) heating has been carried out since 1999.

Minority heating was adopted in helium majority and hydrogen minority plasma. Magnetic axis sweep was effective to disperse the local heat load on divertor plate. Real-time impedance matching was essential technique for injecting the ICRF power for long time. The operation range was extended gradually year by year.

The maximum pulse length achieved to date was 54 min. 28 sec. in 2005. The injected heating energy reached 1.6 GJ. The line-averaged electron density was 0.4×10^{19} m^{-3} and average heating power was 490 kW. After this achievement, long pulse discharge with higher power injection and higher plasma density was investigated. The newly designed antennas replaced two pairs of the ICRF antennas among three pairs. Control systems for the gas puffing and the ICRF power were improved and the operability was increased. ECH power for long pulse operation was increased. The maximum pulse length was 47 min. 39 sec. in the line-averaged electron density of 1.2×10^{19} m^{-3}. The total heating power was 1.2 MW and the injected heating energy reached 3.4 GJ.

The plasma was terminated by density rise. There are two types of the density rise: gradual density increase and abrupt density rise. The former density rise was thought to be caused by outgassing from the plasma facing components. This may be solved by conditioning discharge by repeated long pulse discharge. The latter density rise was thought to be caused by injection of the impurities. They are generated and exfoliated during long pulse operation. The higher temperature and higher density with higher power injection may be needed to solve the problem. This is the biggest problem for long pulse operation at the moment.