§34. Higher Harmonic ICRF Heating Experiments

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Higher harmonic ICRF heating experiments in the LHD were conducted at the low magnetic field operation. Especially the second harmonic heating experiment was successfully performed for the first time in the LHD.

The second harmonic heating experiment was conducted at a high concentration ratio of the hydrogen. Figure 1 shows a discharge of the second harmonic ICRF heating superposed to NBI heated plasma. In this shot the magnetic field strength on the magnetic axis was B_0=1.363 T, and RF frequencies of f=38.47 and 40.47 MHz were employed. From t=1.0 to 1.6 sec ICRF heating power was applied and an increase in the plasma stored energy was observed. Figure 2 shows the count number detected by a natural diamond detector (NDD) [1]. The particles with the energy beyond 150 keV were observed. The heating efficiency, which was defined as the absorbed power divided by the injected ICRF power reached to 40 %. However the heating efficiency of the second harmonic ICRF heating was lower than that of the fundamental ICRF heating as shown in Fig. 3. The plasma could not be sustained with ICRF heating only. It was also found that the heating efficiency increased with the plasma beta value as shown in Fig. 4. The reason is that the power absorption increased due to the finite Larmor radius effect, which is a characteristic of higher harmonic heating. Experiments were conducted by changing the magnetic field strength to search the optimum location of ion cyclotron resonance layer. However dependence of the magnetic field strength to the heating efficiency was not clear. Therefore further experiments are required.

The third harmonic ICRF heating experiment was also conducted at B_0=0.909 T. However, an obvious effect of the heating in the stored energy was not seen and high-energy particles were not observed by the NDD during ICRF power injection. This may be attributed to the mechanism of higher harmonic heating; large ratio of Larmor radius to the wavelength of the perpendicular direction is required for higher harmonic heating, therefore high temperature is needed. However, temperature could not increase because of the poor energy confinement due to the low magnetic field strength.

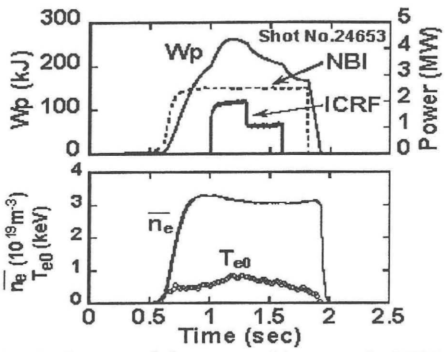

Fig.1 Discharge of the second harmonic ICRF heating.

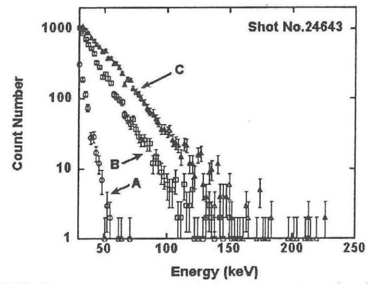

Fig. 2 High-energy particle counts during the second harmonic ICRF heating.

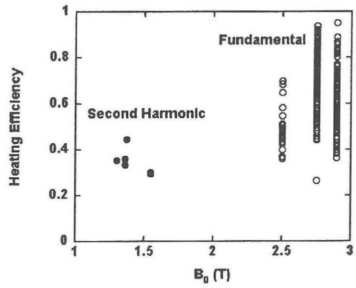

Fig. 3 Comparison of heating efficiency between second and fundamental ICRF heating.

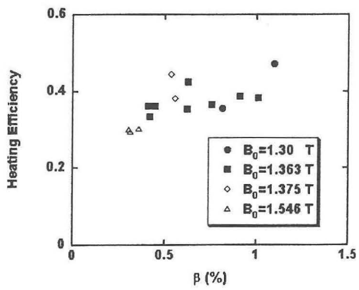

Fig. 4 β dependence of heating efficiency in the second harmonic ICRF heating.

Reference

[1] Isobe, M. et al.: Review of Scientific Instruments **72** (2001) 611.