§13. ICRF Antenna Conditionings in LHD

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In the 3rd cycle (1999) ICRF heating experiment, good performance plasmas were obtained after the sufficient conditioning discharges. In the initial operation phase after the vacuum break, the radiation loss power was large and the plasma was not sustained during the short heating pulse for less than one second.

Figure 1 shows the time history of the ICRF sustained plasma during the two months of the initial phase. Horizontal axis is a count number of ICRF sustained discharges of five experimental days of ICRF. During these experimental days, there were other several additional ICRF heating trials to the NBI plasma. The best performance data in Fig.1 was obtained at the 15th day of the antenna operations. Plasma stored energy obtained by ICRF was gradually increased from the start day in 1999. After the 35 of the count number, titanium gettering of LHD vacuum chamber was carried out. The titanium gettering was used before the count number of 35 and 57 in the figure.

The effects of titanium gettering were significant in Fig.2. Figure 2 shows a change of the radiation loss ratio to the input ICRF power normalized by a square of the electron density. They are plotted on the same horizontal axis with Fig.1. The radiation loss power was gradually decreased as discharge counts and it was largely decreased after the phase of the titanium gettering was started.

In the 3rd cycle experiment, several improvements of the experimental conditions were performed. One of the important changes was an installation of the carbon divertor plates at the divertor leg traces on the vacuum chamber. It worked well to suppress the metal impurity influx. In the 2nd cycle experiment, impurity lines of iron, carbon, and oxygen were observed and especially iron line had a similar time dependence with radiation loss power. In the 3rd cycle, metal impurity lines were largely decreased in both NBI and ICRF plasmas. Titanium gettering was thought to be effective to suppress the oxygen impurity. Consequently the total radiation loss power was largely decreased.

There were other factors to suppress the impurity influx. Increase of the magnetic field from 1.5 T to 2.75 T and inward shift of the magnetic axis from 3.75 m to 3.6 m and increase of ICRF frequency were might be effective to improve the impurity problem.

Successive decrease of the radiation loss made it possible to obtain the high-density plasma. The confinement time of LHD shows a scaling law having a square root dependence on the plasma density, therefore the higher density operations led to the higher stored energy plasmas. These dependences are shown in Fig.3 which data are same with that of Fig.1 and Fig.2.

A long pulse operation was an important technique for the rapid conditioning of the antennas. It needs more than several second, hopefully more than 5 second. The LHD antennas were water cooled and have steady state operation capability. That was a another key factor of these low radiation loss operations.

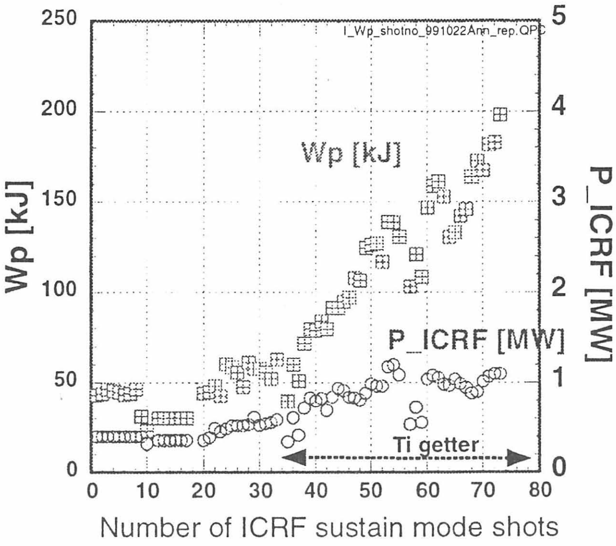

Fig.1 Time history of plasma stored energy and input ICRF power of ICRF sustained plasma. These are data of five experimental days at initial 3rd cycle phase.

(B=2.75T, Rax=3.6m, 38.47MHz, Helium (H minority)

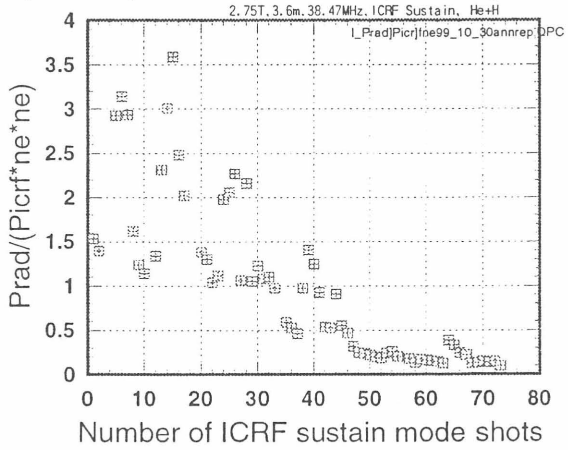

Fig.2 Time history of the ratio of radiation loss power to input ICRF power normalized by a squar of the plasma density.

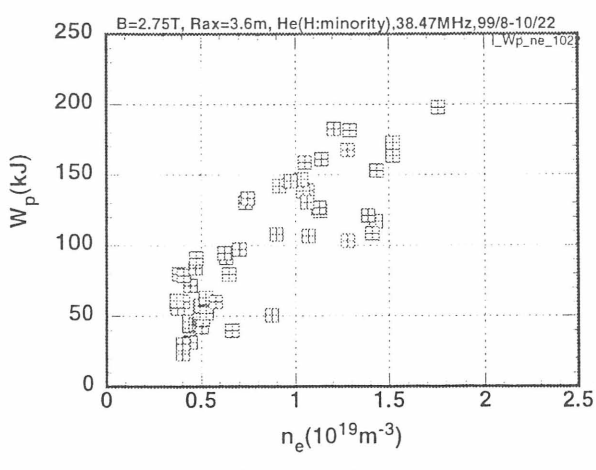

Fig.3 Plasma stored energy dependence on electron density are shown. Data base is the same with Fig.1 and 2.