§15. ICRF Heating Experiment by the ICRF Antenna without Faraday Shield in LHD

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Faraday Shield (FS) has been installed at the current strap of the ICRF antenna from the early phase of the ICRF heating experiment. It was thought to be necessary to shield out an electric field, which causes impurity influx. On the other hand, it is a great advantage for the designing and manufacturing the antenna if FS is possible to be removed.

In LHD, FS of upper current strap of PA (Poloidal Array) antenna was removed in 2013. The experiments evaluating the antenna and the heating performance were carried out. In comparison of loading resistance, the loading resistance without FS was increased twice or more, which means the higher power can be injected from the FS-less antenna when the same power is supplied from the RF amplifier. The voltage of the transmission line connected to the FS-less antenna can be reduced due to the higher loading resistance. Behavior of the plasma parameters was directly compared in the same plasma discharge. They were almost same in the antennas with and without FS. Harmful effect such as severe impurity influx and radiation collapse was not observed during the injection from without FS antenna in high power short pulse and long pulse operation.

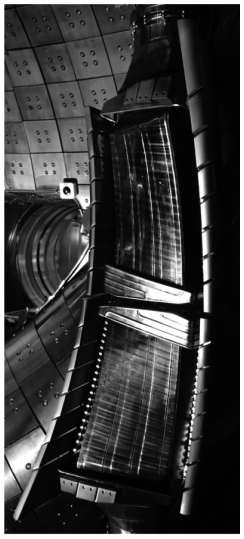

Fig. 1. Photo of PA antenna. FS of upper and lower straps was removed.

Responding to these results, FS of lower current strap of PA antenna was also removed and there was no FS on the upper and the lower straps of the PA antenna in 2014 experiment as shown in Fig. 1. The loading resistance was compared with other types of antennas as a function of the antenna-plasma gap as shown in Fig. 2. The HAS antenna was improved to increase the loading resistance by installation of the impedance transformer at the transmission line. The FAIT antenna has an impedance transformer between the antenna head and the vacuum feedthrough. Then, high loading resistance was obtained in FAIT antenna. The loading resistance of the FS-less antenna is comparable to the other antennas as shown in Fig. 2 and the FS-less antenna can inject high power to the plasma same as other antennas. Figure 3 shows the injected power of the each antenna and the plasma stored energy. The injected power is power-modulated in order to evaluate the heating efficiency. The plasma stored energy is also modulated by the injected power. The modulated amplitude of the stored energy in the case of the FS-less antenna is smaller than that of the other antenna cases. It means that the heating efficiency of the FS-less antenna is less than that of the other antennas. The heating efficiency is influenced by the antenna-plasma gap and the phase of the antenna and so on. Detail analysis is required taking those effect into consideration. Global harmful effect on the plasma parameters was not observed during the injection from the FS-less antenna.

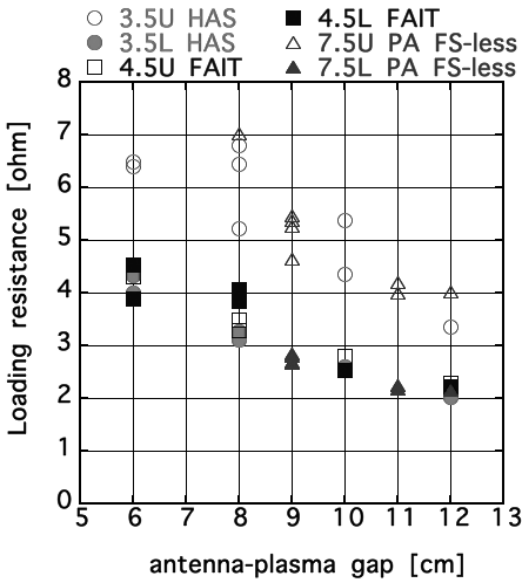

Fig. 2. Comparison of loading resistance with different antennas as a function of antenna-plasma gap.

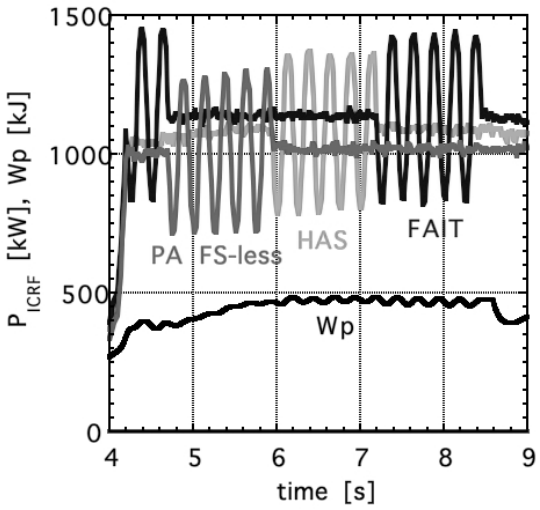

Fig. 3. Time behavior of injected power of each antenna and plasma stored energy.