§16. Analysis of Heating Performance of the ICRF Antenna without Faraday Shield in LHD

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ICRF heating using Faraday shield (FS)-less antenna has been carried out in recent years in LHD. It was started by removing the FS of upper current strap of PA (Poloidal Array) antenna. In those experiments, no harmful effect on the plasma parameters was observed. In response to the relatively good results, we removed all the FS of the PA antenna next year as shown in Fig. 1. The structure of the antenna without FS is quite simple as shown in the photo. The design and manufacture of the antenna will be easier and the risk of causing the problem will be reduced. Then, evaluating the antenna performance without FS is interesting for considering the future antennas.

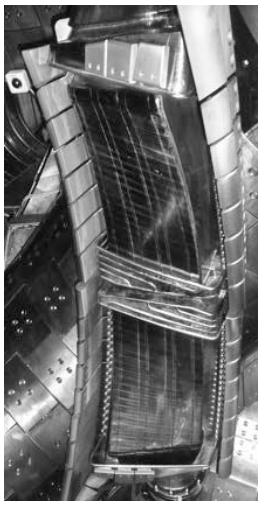

Fig. 1. Photo of PA antenna without FS. FS of upper and lower straps was removed.

In former experiments, we investigated the plasma loading resistance of the FS-less antenna. The loading resistance of the FS-less antenna was higher than that of the antenna with FS. This means that higher power is injected from the antenna without FS in the same voltage of the transmission line. Moreover, the antenna without FS is possible to be operated far from the plasma compared to the antenna with FS. However, the heating efficiency of the FS-less antenna seemed inferior. For evaluating the heating efficiency, the power modulation method [1] was employed. Figure 2 shows the heating efficiency of the FS-less antenna as a function of the antenna current phase between the upper and lower antenna straps. In these experiments, the plasma condition such as the hydrogen minority ratio might not be best for the minority heating. The antenna position was relatively far from the plasma. Then, the heating efficiency may increase much further if the heating condition is optimized. It was found that the heating efficiency has dependence on the antenna current phase. This dependence was unclear and not studied deeply in the antenna with FS. It was thought to be come out by removing FS. High heating efficiency was obtained near 0 degree and the antenna currents of upper and lower straps flowed the same direction in this case.

The highest injection power of the ICRF heating was obtained using the FS-less antenna together with other two sets of the antennas. Figure 3 shows the injection power of the FS-less antenna and the voltage of the transmission line of each strap. The FS-less antenna injected about 1.5 MW without any problem. It means that the antenna without FS can be used same as the antenna with FS in the pulse operation. The voltage of the transmission line was about 30 kV in both straps and an allowance of 5 kV remained to the limit of the voltage interlock. The antenna current phase was adjusted to balance the voltage of transmission line for injecting the high power. The total ICRF power of 4.5 MW was injected in this experiments and the ICRF heating contributed to increase the beta value.

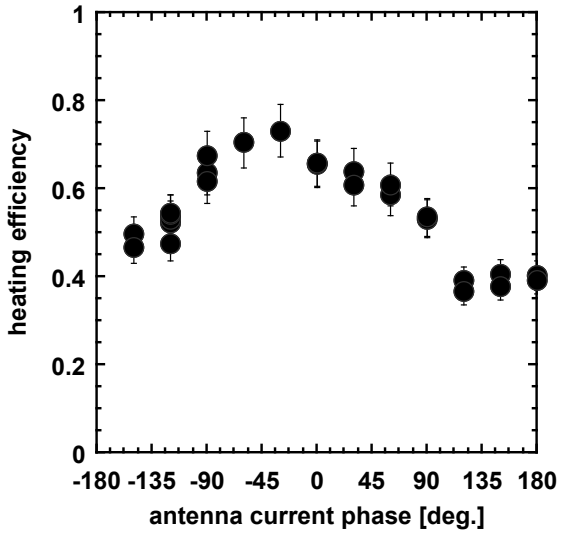

Fig. 2. Heating efficiency as a function of antenna current phase between upper and lower straps.

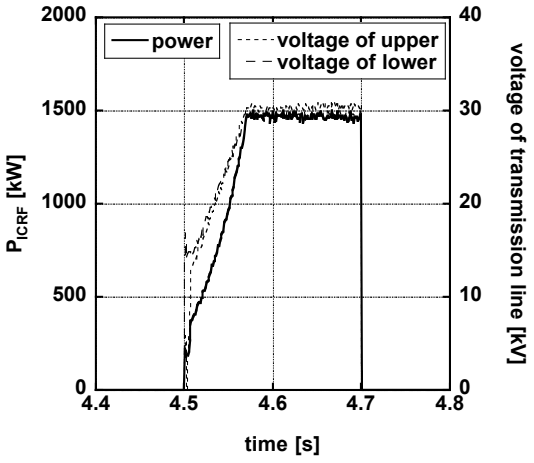

Fig. 3. Time behavior of injected power of the FS-less antenna and voltage of transmission line of each strap.

1) Torii, Y. et al.: Plasma Phys. Ctrl. Fusion **43** (2001) 1191.