§42. Precise ECH Power Deposition Estimation during Long Pulse Discharge

Kubo, S., Shimozuma, T., Yoshimura, Y., Igami, H., Inagaki, S., Kumazawa, R., Seki, T., Saito, K., Kasahara, H., Nakamura, Y., Mutoh, T.

In almost all the long pulse ICRH sustained plasma CW ECRH has been injected simultaneously and steadily at the power level of 100 kW. The power level at the MOU output of gyrotron corresponds to 140 to 150 kW for this condition, although the full specification of the gyrotron is 200 kW. During several optimizations of the ICRF plasma heating senario and plasma sustainment, ECRH power has been contributed to sustain the electron temperature. In order to clarify the role of ECRH, and moreover to find a optimum combined heating scenario, ECRH power deposition study has been performed. One of the advantages to maintain plasma for a long time is the improvement of the precision of various diagnostics. The precise estimation of the heating power deposition is the key for the local transport study in the plasma. In principle, the power deposition profile can be deduced as the high frequency limit of the plasma response to the modulated heating power, but the plasma response decreases as the modulation frequency becomes high. It is also well known that the dynamic response of the plasma can make the interpretation complex. The decrease of the modulation amplitude can mitigate this nonlinear situation, but again smaller response of the plasma degrade the precision of the deduced deposition profile. The possible solution is to gain the signal to noise ratio utilizing the long pulse steady target.

Here, the CW ECRH injection power is 40% square modulated for almost constant plasma parameters sustained mainly by ICRF. Figure 1 shows the modulated power monitor signal for full pulse and partly expanded in the inside box . The clear 40 kW, 35 Hz square wave modulation is applied at the 100 kW pulse. The averaged electron density and temperature are kept at 4×10^{18} m^{-3} and 1.4 keV, respectively for 30 s. The electron temperature response is measured by ECE radiometer. The modulation frequency was set at 35 Hz, but each rise and fall time were less than 1 ms. The signals are accumulated with the sampling time of 300 μs. It is hard to observe the modulation from raw signal. Each signal from the radiometer are rearranged around each turn on and off time and is used to deduced the change of the slope just before and after the turn on and off time, just like a 'box-car' averager[1]. To avoid the plasma diffusion effect, the time of analysis is limited within 3 ms before and after the modulation turn on and off. The analysis results is shown in Fig. 2. The deduced local modulated part of the power at turn on and off are plotted with up and down tip triangles. The result of the ray tracing code using the experimental plasma parameters and injection condition is also plotted with thick line. Experimentally deduced and calculated deposition profile well coincides each other at the outer half region, but the experimental profile show the broader profile than the calculation. These results show that the time interval of 3 ms for data analysis at each turn on and off timing is still critical to separate the diffusion effects, in particular, in the inner half of the radial region. Total absorbed modulated part of the power integrated over the whole plasma volume well coincides between experimental and calculated results, since the diffusion effect compensates the discrepancy of the deposition profile in the inner region. These results show the possibility of deducing the precise power deposition profile with weak slow modulation but fast rise and fall square shape using 'box-car' average technique for long pulse discharge.

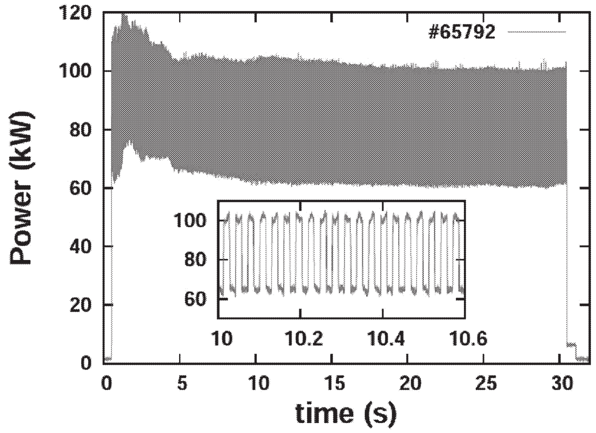

Fig. 1. Modulated ECRH power injection during 30 s ICRH sustained plasma to deduce precise power deposition profile.

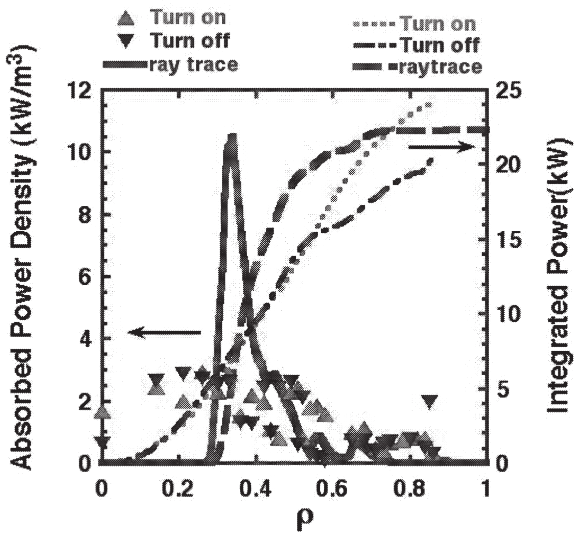

Fig. 2. Deduced power deposition profile integrated over 20 s and its comparison with the raytracing results.

references

[1]KUBO, S. *et al.*, *J. Plasma Fusion Res. SERIES*, Vol. 5 (2002) 584-587.