§16. Research of the Optimum Condition for ICRF Heated Plasma

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In the 17th experiment cycle (2013), another coaxial transmission line for the steady-state operation was connected to 4.5 U & L antennas.

The experiment was carried out to examine the ICRF heating characteristics about the minority ratio using a hydrogen pellet injection. Figure 1 shows the time evolutions of the plasma parameters in #123902. The initial plasma of n_e~2x$10^{19}m^{-3}$ was produced with the electron cyclotron heating (ECH) of P_{ECH}=0.8MW. The ICRF heating was started 1 second before the turn-off of ECH, i.e., at 4 sec as seen in the first figure of Fig.1. In this plasma discharge the ICRF heating power was P_{ICH}~3.5MW with all the six antennas; existing antennas, i.e., 3.5 U&L and 7.5 U&L and newly installed 4.5 U&L. Among them the Faraday screen of the 7.5 U antenna was dismantled. The ICRF heating and the ECH power were both injected for 4~5 sec. and the plasma stored energy attained to 400kJ with n_e~2x$10^{19}m^{-3}$. The electron density was gradually decreased during both ICH and ECH heating and to n_e~1.5x$10^{19}m^{-3}$ just before the turn-off of ECH. But the electron density recovered the farmer n_e~2x$10^{19}m^{-3}$ after the turn-off of ECH. Three hydrogen pellets were injected to the ICRF sustained plasma for the 2 second, i.e., 4 to 6 sec as seen in the third figure of Fig.1. At the last hydrogen pellet, i.e., at 6 sec. the increase of 110kJ in the plasma stored energy was clearly found. As the electron density was rather decreased than increased, it was thought that the increase in the plasma stored energy could be attributed to the improvement of the ICRF heating efficiency and/or of the confinement efficiency C_{eff}, which will be described later. The ratio of H/(H+He) was increased from10 to 12% at the timing of the hydrogen pellet injection.

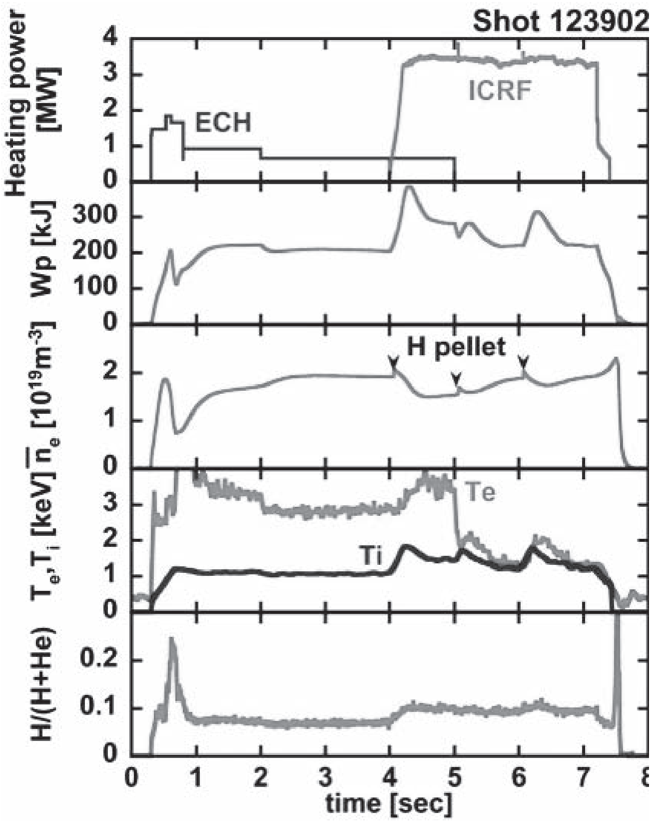

Fig.1 Time evolution of ICRF heated plasma with hydrogen pellet injection: Injected RF power (at the first figure), plasma stored energy (at the second figure), electron density (at the third figure), electron and ion temperature (at the fourth figure) and minority ratio (at the fifth figure).

Figure 2 shows the dependences of ICRF heating efficiency η and the confinement efficiency C_{eff} on H/(H+He), which was derived from the ISS04 confinement scaling $\tau_E \propto C_{eff} n_e^{0.51} (\eta P_{ICH})^{-0.61}$. These data were obtained in the 15th experiment cycle (2011) [1]. Then the plasma stored energy W_P can be expressed with $W_p \propto C_{eff}\eta^{0.39}$. On the other hand the increase in $\Delta W_P/W_P$ corresponding to the change of the ratio of H/(H+He) from10 to 12% can be assessed to be $\Delta W_P/W_P$~0.1, which is very different from the observed $\Delta W_P/W_P$~0.55.

The ratio of H/(H+He) is the one of their neutral density at the plasma periphery, measured using visible light intensity. In the previous experiment, this neutral density ratio has been compared with the ion density ratio at the plasma axis using a charge exchange recombination (CXR) method in the plasma sustained with the neutral beam injection (NBI). It was reported that both measured value agreed [2]. However it is thought that the ion density ratio near the plasma axis may be different from the neutral density at the periphery plasma specially in the hydrogen pellet injection. It is remained as a future research problem.

1) Kumazawa R., et al., Annual report 2011, p.100
2) Ida K., private communication.

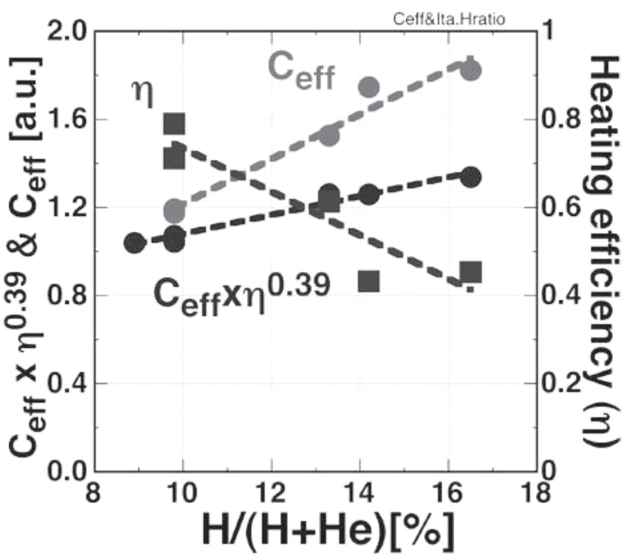

Fig.2 Dependence of $C_{eff}\eta^{0/39}$, η and C_{eff} on H/(H+He) at B=2.75T.