§21. ICRF Heating Power and Plasma Loading Resistance Measurement

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ICRF heating experiment has been carried out with five antennas. RF power is supplied to antennas through an impedance matching circuit, consisting of two stab tuners as shown in figure 1. Incident power from oscillator, Pinc, and reflected power from the antenna, Pref, are measured by a directional coupler. The radiated RF power from the antenna to plasma, Pnet, is calculated from the following equation, using Pinc and Pref;

$$Pnet = Pinc - Pref - Ploss. \qquad (1)$$

Here Ploss is dissipated RF power in the impedance matching circuit and the antenna. From the definition that plasma loading resistance, Rp, and antenna resistance in vacuum, Ra, are series resistances, Pnet and Ploss are expressed with antenna current, Ia;

$$Pnet = Ia^2 Rp, \quad Ploss = Ia^2 Ra. \qquad (2)$$

The antenna current can be obtained by measuring RF voltage on the coaxial transmission lines. Figure 2 shows the RF voltage distribution of the standing wave on the coaxial transmission line between the stab tuner and the antenna. The relation between antenna current and maximum RF voltage of the standing wave, Vmax, is $Ia = Vmax / Z_0$, where Z_0 is a characteristic impedance of the coaxial transmission line, $Z_0 = 50\Omega$. The antenna resistance, Ra, can be obtained when the plasma does not exist. Under this condition, Ploss is calculated from subtracting Pref from Pinc, since Pnet = zero in eq.(1). Ra can be obtained from eq.(2).

Pnet can be calculated from Pinc, Pref and Vmax with Ra in eq.(1). Figure 3 shows a typical time evolution of Pinc, Pref and Pnet. During this ICRF heating pulse, electron density gradually increased. The impedance matching condition changed with

time, because the plasma loading resistance depends on the electron density. RF reflected power became minimum at60ms (Pref/Pinc=0.03), increased with electron density and ended up to 40kW (Pref/Pinc=0.12). Then injection efficiency defined as Pnet/Pinc is 80% throughout ICRF heating pulse.
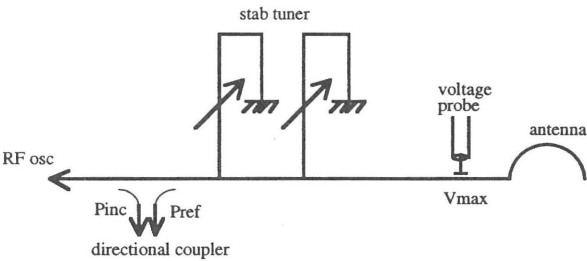

Fig. 1 Impedance matching circuit with directional coupler and RF probe.
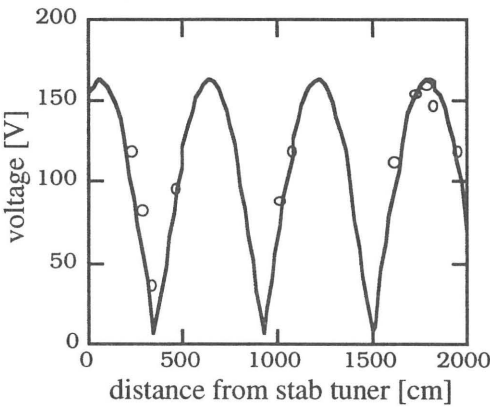

Fig.2 Standing wave distribution on the coaxial transmission line with the incident power of 5.4W. Open circles are measured RF voltages and the line is fitting curve.
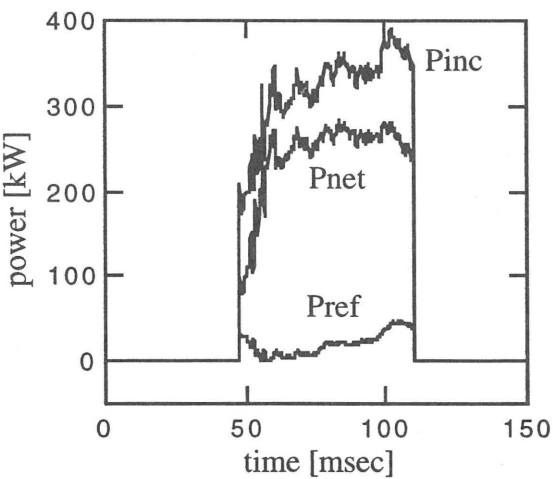

Fig. 3 Time evolution of incident power, reflected power and radiated power into plasma.