§2. Real-Time Plasma Current Control Experiment

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The real-time plasma current control (RCC) system using a standard personal computer (DOS/V machine) was designed and constructed as the first step of the real-time plasma control system. This computer is linked to the LHD power-supply (PS) control computer through the reflective memory (RFM). Date input and output of the coil currents are carried out using this RFM. The measured plasma current (I_p) is inputted to the digital signal processor (DSP) through an analog digital converter (A/DC). The digital input and output (DI and DO) are used for the communication of the timing signal and the statements of the RCC system with the central control system computer. The Coil currents for the plasma current control are calculated using the standard proportional-integral (PI) control algorithm in the DSP and sent to the RFM with 100msec cycle (max. 20msec). During the 4th experimental campaign, this RCC system was used for the real-time feedback control of the plasma current.

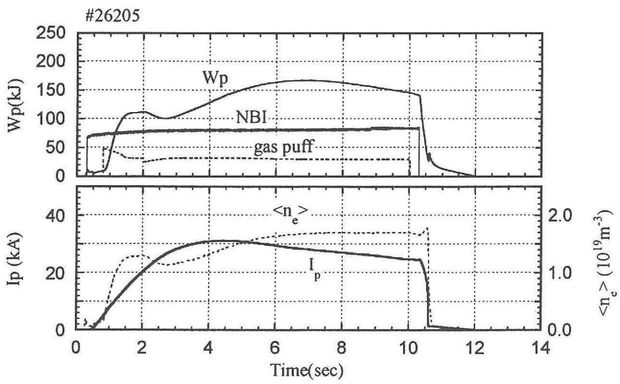

Fig. 1. Time evolution of various plasma parameters in real-time plasma current control shot.

The real-time plasma current control experiment using the RCC system was carried out at 1.5T during the 4th cycle experimental campaign. Figure 1 shows the time evolution of a plasma stored energy (W_p), neutral beam injection (NBI), gas puffing (gas puff), a line averaged electron density ($<n_e>$) and a plasma current (I_p). The plasma was produced and sustained by the NBI only. The control of the plasma current by the RCC system was started at 2 sec and terminated at the end of the plasma discharge. As shown in Fig.1, the plasma current (I_p) starts to decrease at 4 second.

Figure 2 shows the comparison of the plasma current without control (#17106) and with control (#26205). Ip (ref.) is the reference current. The RCC system compares the plasma current (I_p) and this reference, and calculates the needed coil current ($I_{IV\text{-}coil}$). The change of the coil current ($I_{IV\text{-}coil}$) was also shown in Fig. 2 bottom. The coil current increases continuously at the rate of 40A/sec. This rate is the upper limit of the present coil power supply. The plasma current of about 30kA was reduced by the RCC system. The simulation was carried out using a single filament model. Used plasma parameters are as follows; T_e=0.7keV, $<n_e>=1.7\times10^{19}m^{-3}$, R_p=3.6m, a_p=0.6m. The plasma resistance and inductance are $r_p=5.02\times10^{-6}$ Ω and $L_p=9.6\times10^{-6}$ H. The loop voltage is 0.0096V when the coil current ($I_{IV\text{-}coil}$) changes at the rate of 40A/sec. The time constant (L_p/r_p) is 1.91 sec. This simulation result shows the similar tendency to the experimental result. The plasma resistance may cause the difference between the simulation and the experiment because the simulation result is very sensitive to the plasma resistance.

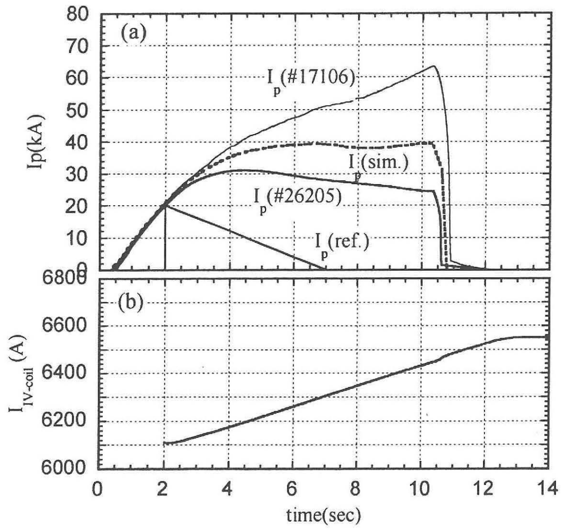

Fig. 2. Experimental result at 1.5T.
(a) shows plasma currents and (b) shows IV-coil current.
I_p(#17106) : without current control,
I_p(#26205) : with current control,
I_p(sim.) : simulation result,
I_p(ref.) : reference current for control.

We are planning the plasma current control experiments at higher magnetic field in the next experimental campaign.