*34th EPS Conference on Plasma Phys. Warsaw, 2 - 6 July 2007 ECA Vol.**31F**, P-5.102 (2007)*

In situ calibration and position measurements of initial magnetic diagnostics for the KSTAR device

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1. INTRODUCTION

Magnetic diagnostics [1-5] for the Korea Sperconducting Tokamak Advanced Research (KSTAR) device are currently under development for providing the successful missions of KSTAR diagnostics [6]. Initial magnetic diagnostics for KSTAR tokamak including three Rogowski coils, five flux/voltage loops, and sixty-four magnetic field pick-up probes have been successfully installed [7]. The Rogowski coils, flux/voltage loops, and magnetic field probes measure the total plasma current, poloidal flux and loop voltage, and local poloidal magnetic field for the plasma position control and equilibrium studies, respectively. An accurate installation and position measurements for all of these initial magnetic diagnostics were performed by using a laser tracker system. An effective area calibration and dynamic characteristic measurements of the magnetic field pick-up probes were carried out before installation [8]. *In situ* calibration of the Rogowski coils were performed by using a dummy coil. In this paper the *in situ* calibration results from the Rogowski coils and detail position measurements for the initial magnetic diagnostics are discussed.

2. *IN SITU* CALIBRATION AND POSITION MEASUREMENTS

Three Rogowski coils were installed inside of the KSTAR vacuum vessel as shown in Fig. 1 (a). A 10 turns of dummy coil is installed temporally inside of the KSTAR vacuum vessel and exactly known value of the pulsed current (I) was applied to the

dummy coil in order to calibrate the Rogowski coils. Figure 1 (b) shows a simple concept for the calibration method and the voltage (V) induced from the Rogowski is $V = d\phi/dt = nA(dB/dt) = nA\mu/L\ (dI/dt) = k\ (dI/dt)$. Here ϕ, n, A, μ, L, and k are the magnetic flux, number of turns, area, magnetic permeability, length of the solenoidal axis of the Rogowski coil, and the calibration factor, respectively.

(a) (b)

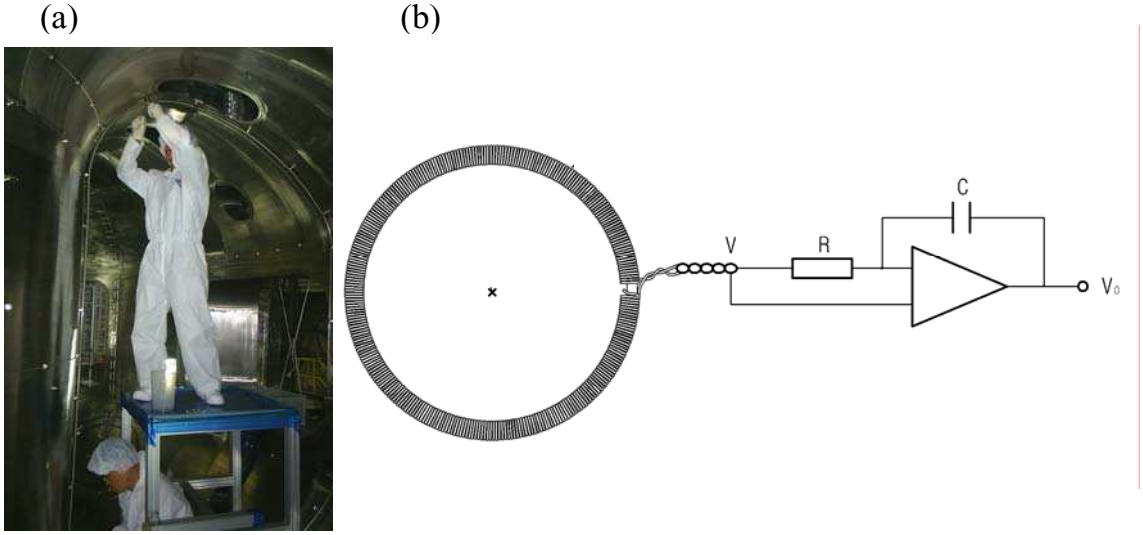

Fig. 1. (a) Installation of the Rogowski coils. (b) A simple calibration concept.

The fully assembled KSTAR tokamak with the dummy coil temporally installed inside of the KSTAR tokamak and the calibration system for the Rogowski coils are shown in Fig. 2.

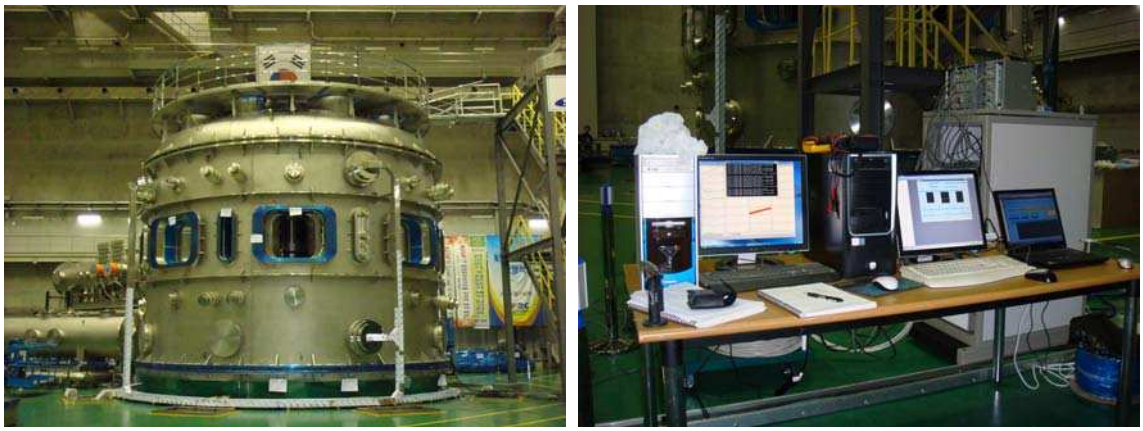

Fig. 2. The KSTAR tokamak and Rogowski coil calibration system.

Figure 3 (a) shows three measured fluxes from three Rogowski coils RC01, RC02, and RC03 as a function of the applied current flowing into the dummy coil. The measured flux increases linearly with the applied current so that the maximum plasma current of 2 MA can be measured from the Rogowski coils in principle. Figure 3 (b) shows the calculated calibration factor k as a function of the applied current from the previous measurements. The calculated calibration factor of 50 A is slightly different as compared with that of the other three currents so that the calibration factor of 50 A case was not considered to calculate the average k value for the Rogowski coils. The measured average calibration factors for three Rogowski coils RC01, RC02, and RC03 are 7.57839 x 10^{-8} Wb/A, 8.54306 x 10^{-8} Wb/A, and 8.17158 x 10^{-8} Wb/A, respectively.

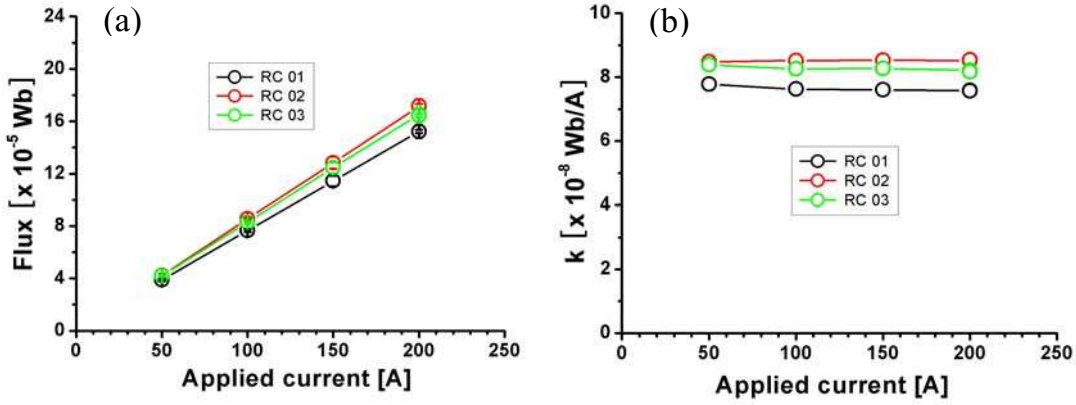

Fig. 3. The measured fluxes from the Rogowski coils (a), and the calculated calibration factors from the Rogowski coils as a function of the applied current(b).

An accurate installation and position measurements for all initial magnetic diagnostics were performed by using a laser tracker system [7]. The laser tracker system and detail position measurements for the initial magnetic diagnostics are shown in Fig. 4. The average standard installation deviation for the Rogowski coils, flux loops, and Magnetic field probes are measured precisely as 0.78 mm, 0.65 mm, and 0.68 mm, respectively.

Fig. 4. Accurate position measurements for the installed initial magnetic diagnostics.

3. SUMMARY

In situ calibration of three Rogowski coils are performed and the calibration factors are calculated. These calibration factors are directly applied for the plasma current measurements from the KSTAR tokamak. The measured flux increases linearly with the applied current so that the maximum plasma current of 2 MA can be measured from the Rogowski coil. An accurate installation and position measurements for all initial magnetic diagnostics were performed by using a laser tracker system, and the average standard installation deviation is less than 0.78 mm.

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