Vessel current monitor for the KSTAR

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1. Introduction

Considerable progress has been made in research and development activities for the KSTAR magnetic diagnostics (MDs) [1-4]. Most of the magnetic sensors was designed to be fabricated with MgO-insulated semi-rigid coaxial cable because the sensors must be compatible with the KSTAR vacuum (less than 10^{-8} Torr) and its baking temperature (up to 250 °C). Vessel current monitor (VCM), one of the KSTAR MDs, is required for the measurement of eddy current induced at the vacuum vessel during plasma discharge (especially, plasma break down or disruption) in the KSTAR machine. Thus, VCMs were fabricated and installed on the external wall of the KSTAR vacuum vessel. The technical issues on the fabrication and installation of the VCM are described.

2. Fabrication and installation of VCM

VCM measures both plasma and vessel currents during plasma discharge in KSTAR machine because it encloses the vacuum vessel in a poloidal plane as shown in Fig. 1. An eddy current induced at the vacuum vessel is obtained by taking the difference between the current measured by the VCM and the plasma current measured by Rogowski coil (RC) inside the vacuum vessel. Thus, the paired VCM and RC should be close toroidally so that non-axisymmetric halo currents flowing to the vessel from internal structures do not affect the measurement unduly.

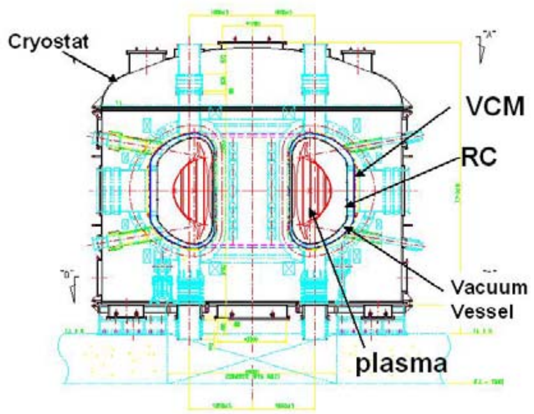

Figure 1. VCM and RC in the KSTAR machine (poloidal cross-section).

Three VCMs are required to measure the vessel current at the external wall of the KSTAR machine, and two of which will be paired with two of the RCs as shown in Fig.2.

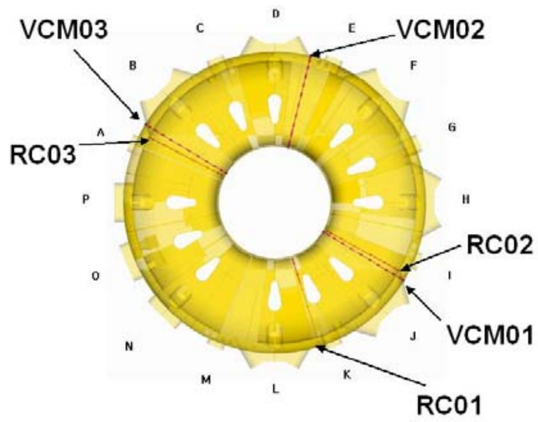

Figure 2. VCMs and RCs in the KSTAR machine (toroidal view).

2.1 Fabrication of VCM

The VCM was fabricated by winding MgO cable (1/16″ OD) on a 8.949 m MgO cable (3/16″ OD, length of 8.949 m) that works as a return loop (see Fig. 3). The VCM is flexible, so it can be easily shaped in the procedure of the installation. The additional covers are put on two ends of the VCM for the protection of the connection bonding between two MgO cables and the reduction of the effect of an electromagnetic wave field picked up at the connection as shown in Fig. 3.

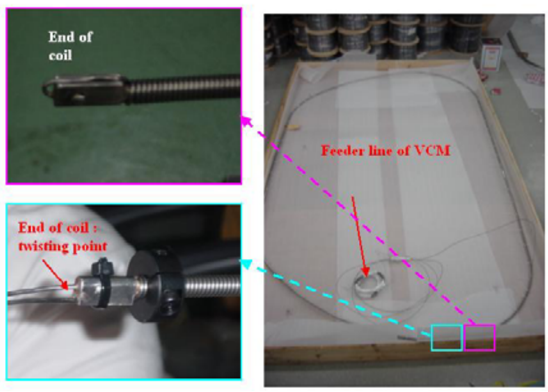

Figure 3. Fabricated VCM.

The specifications of the fabricated VCMs are given in Table 1. The resistance was measured with a DVM. The current measurement was carried out in order to calibrate the fabricated VCM. In the experimental set-up as shown in Fig. 4, the magnetic flux is measured with the VCM by flowing a pulsed electric current of 200A through the area enclosed with the VCM.

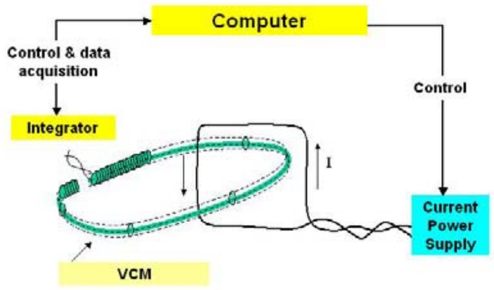

Figure 4. Experimental set-up for the calibration of the VCM.

Thus, the conversion factor, k was calibrated from the Eq.1 by using the measured magnetic flux, ϕ. The values of k obtained for each VCM are given in Table 1.

$$\frac{d\phi}{dt} = V = \mu_0 \frac{N}{l} S \frac{dI}{dt} = k \frac{dI}{dt} \qquad (1)$$

Where N, l, and S are the number of turns, the poloidal length, and the cross-sectional area of the VCM, respectively.

Table 1. Specification of the fabricated VCMs.

Sensors	Resistance [Ω]	Number of turns	Conversion factor, k [$\times 10^{-8}$ Vs/A]
VCM01	125.8	5584	4.042
VCM02	119.1	5585	3.937
VCM03	92.1	5586	3.807

2.2 Installation of VCM

VCMs were installed at different toroidal location on the external wall of the KSTAR machine (see Fig. 5). Each clip for the installation of the VCM has four fiducial points for the measurement of position after the installation. In order to prevent the VCM from the electric contact with the thermal shield panel, additional insulating buttons (made of G11) were mounted around the clips. The 3 D position of the VCM on the external wall was measured by using a laser tracker system in order to confirm the reliability of the installation. The measured toroidal angles of each VCM are given in Table 2, together with the designed value from the engineering drawing. The discrepancy between two values is less than 0.01°. Thus, the similar procedure will be carried out in the installation of MDs that will be mounted on the inner wall of the vacuum vessel.

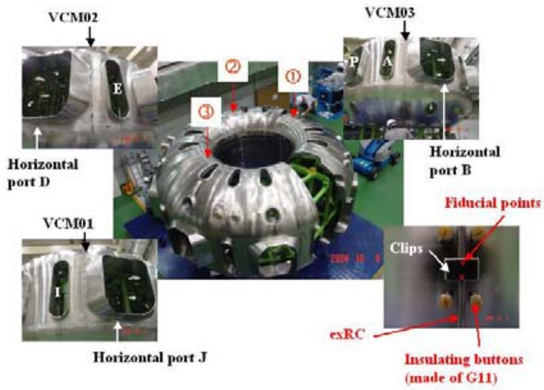

Figure 5. Three VCMs mounted on the external wall of the KSTAR machine.

Table 2. Location of VCMs (angle relative to the port L).

Sensors	Designed value [degree]	Measured value [degree]
VCM01	58.5	58.501±0.002
VCM02	166.2	166.204±0.004
VCM03	238.7	238.694±0.003

3. Summary

The VCM was fabricated and its calibration was done in the electric current measurement as a preliminary work. It was confirmed that three fabricated VCMs were successfully installed at the external wall of the KSTAR vacuum vessel, according to the results from 3D position measurement. It is required that the high electric current measurement (more than 100kA) is needed to get a more reliable data from VCM during plasma discharge in the KSTAR machine, which will be carried out in the KSTAR machine as a future work. In addition, the signal path from sensor to vacuum feedthrough will be determined after the installation of the cryostat.

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REFERENCES

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