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Mirnov coils and diamagnetic loops for 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]. Mirnov coil (MC) and diamagnetic loop (DL) as the KSTAR MDs were designed to diagnose magnetic instability at edge region and plasma stored energy, respectively, during plasma discharge in the KSTAR machine. The design features of MC and DL in the KSTAR and the technical issues on the fabrication and the installation of their prototypes are described.

2. Mirnov Coil

Mirnov coil (MC) measures magnetic fluctuations (up to 1MHz) at edge region during plasma discharge in KSTAR machine. MC is mounted on the backplate and it is covered by four PFC tiles with a gap of 2mm for better performance of its frequency response of MC. Figure 1 shows an array of MC locating near plasma boundary and enclosing fully plasma column for the analysis of the poloidal mode number in the fluctuation. There are two poloidal arrays and a toroidal one as given in Table 1. Poloidal and toroidal mode number, m and n, are determined from measured signals of sensors in each array.

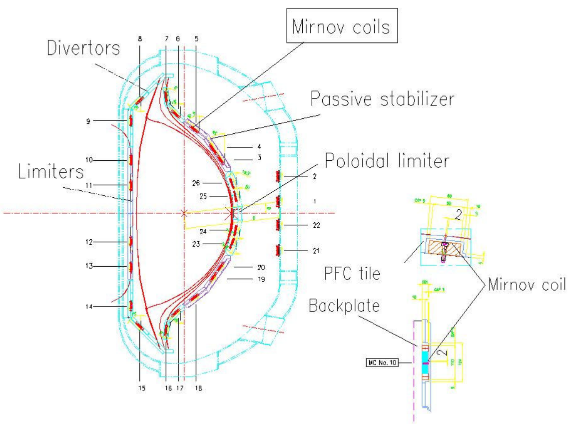

Figure 1. A typical array of MC in the KSTAR machine.

Table 1. MC arrays in the KSTAR machine.

Arrays	# of sensors	Location [degrees]	Comments
MC1P	22(1)	ϕ_{tor} = 162-163	$m \leq 9$
MC2P	26(1)	ϕ_{tor} = 254-259	$m \leq 11$
MC1T	20(2)	θ_{pol} = 56	$n \leq 10$

A prototype of MC was fabricated by winding a copper wire (2 × 3 mm^2) on the grooved ceramic bobbin (110 × 50 × 20 mm^3) with two layers. The number of turns in each layer was 7. Two ends of the wire are connected to 1/16″ OD MgO cables of 9m, and two cables were twisted. The connection was done by using a brazing method. The connection part of the cable was checked from a leak test. The leak rate of 1.2 ~ 2.4 × 10^{-9} mbar liter/s was detected by a leak detector (ASM 180 TD+ @alcatel) with a base rate of 4.2 × 10^{-10} mbar liter/s. Figure 2 shows the prototype of MC.

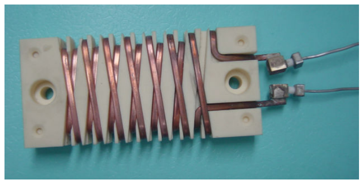

Figure 2. A prototype of MC.

3. Diamagnetic Loop

Diamagnetic loop (DL) measures plasma diamagnetic flux, and consists of two concentric loops; the main and compensation loops. Figure 3 shows poloidal loops enclosing plasma column. There are three DLs in the KSTAR machine as given in Table 2.

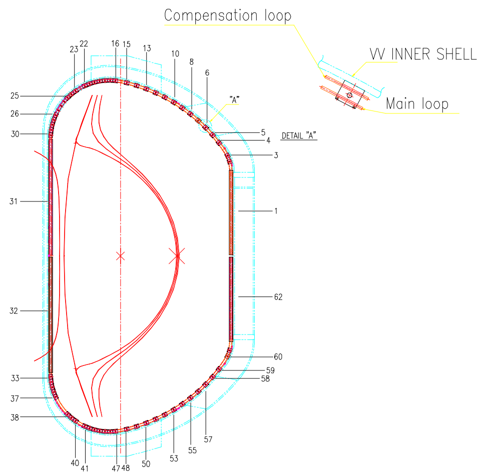

Figure 3. A typical DL in the KSTAR machine

Table 2. DLs in the KSTAR machine.

Sensors	# of loops	Location [degrees]	Comments
DL01	2	ϕ_{tor} = 107.5	
DL02	2	ϕ_{tor} = 152.5	
DL03	2	ϕ_{tor} = 343	

The inner and outer loops as a DL, made of a combined MgO cables, were installed on the wall of the prototype of vessel, which was similar to a quadrant sector of KSTAR vacuum vessel as shown in Fig. 4. The installation was done by using 104 clips along the poloidal line in the wall. The inner loop measures both toroidal magnetic fluxes due to plasma and the external magnetic field. The outer loop, as additional one, is needed for compensating such as a ripple from the external magnetic field. Thus, the plasma store energy is obtained from the diamagnetic loop signal compensated by using two concentric loops. The radial distance between two loops was fixed as 20mm by each clip because the space for mount was limited at the inboard side in the KSTAR machine.

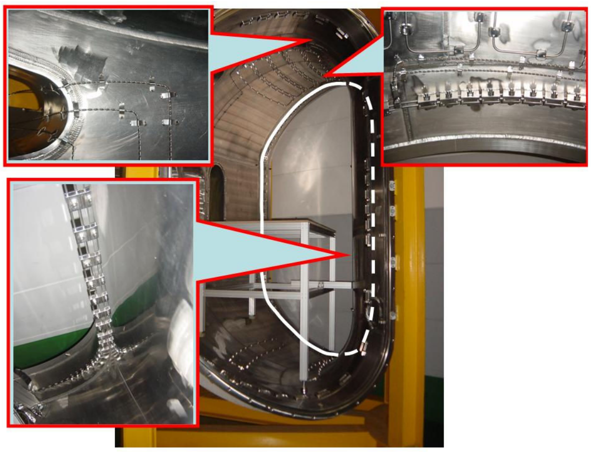

Figure 4. DL installed in the prototype of vessel.

The combined MgO cable consists of a 3/16″ OD cable as a sensing part and 1/16″ OD cables as a twisted feeder line as shown in Fig. 5.

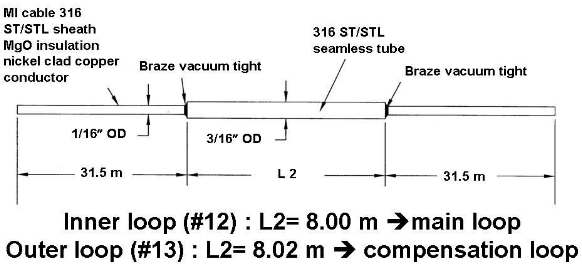

Figure 5. Combined MgO cable.

The location of clips and loops mounted on the wall was checked from 3D position measurement as shown in Fig. 6.

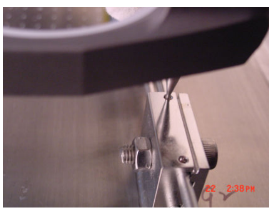

Figure 6. 3D position measurement of the DL location.

The difference between designed values and the 3D position measurements is given in Table 3. From offset values at the measured points, it is estimated that the plane enclosed by two concentric loops has a small tilt angle with respect to a normal plane in the toroidal direction.

Table 3. Offset & tilted angle of plane enclosed by DL.

Measured point	Offset (mm)	design value [Deg.]	Measured value [Deg.]	Tilt angle [Deg.]
IN	-1.77	228.0	227.91	0.1139
OUT	1.37		228.03	
TOP	-0.64		227.98	0.0043
BOTTOM	-0.87		227.97	
CENTER	-0.75		227.97	-

4. Summary

Considerable progress has been made in engineering design of MC and DL. The prototype of MC was fabricated by winding copper wire on ceramic bobbin and then connecting copper wire with MgO cable as a feeder line. The leak test on the connection part was carried out in order to confirm its vacuum tightness required for the installation within the KSTAR machine. Two concentric loops were installed on the wall of the prototype of KSTAR vessel. The installation of DL was satisfactory because there was a slight difference between design values and 3D position measurements.

The frequency response of the MC prototype will be investigated from its performance test. Two concentric loops will be installed on the inner wall of the KSTAR vacuum vessel by using the same method for the installation work in the prototype of KSTAR vessel.

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REFERENCES

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