# §10. Positional Stabilization of Torus Plasma with Simple Helical Coils

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In tokamaks, elongated plasmas for good confinement suffer from so-called vertical displacement events (VDEs) during disruptions. On the other hands, it has been shown that the plasma position is robustly stable in a current-carrying stellarator, whereas that in an equivalent tokamak is unstable.[1)] In order to suppress VDEs, we proposed saddle shaped stellarator system, which is composed of four coils on the outside of a vacuum vessel.[2)] The objective of our study is to investigate the principle and to improve the configuration of the coils for vertical stability experimentally.

We designed and started constructing a small tokamak device shown in Fig.1 ($R = 0.33$ m, $a = 0.09$ m, $B_t = 0.3$ T) which has an elongated cross section to demonstrate above mentioned effect. Firstly, we optimized the numbers and size of the toroidal field coils to reduce the toroidal field ripple. To evaluate the effect of the iron core on the magnetic fields, magnetic field analysis using the finite element method (FEM) was performed. In this device, the plasma region on the midplane is set in the range where the ripple ratio is less than 2%. Then, the shape and arrangement of the vacuum vessel with a rectangular cross-section were determined under the condition of possible confinement of plasmas with $\kappa = 1.8$. Figure 2 shows a newly manufactured vacuum vessel. We also confirmed the soundness of the coils support structure by stress analysis. A strength test on a prototype coil is under way.

Secondly, we investigated the configuration of poloidal magnetic field coils. As a result of axisymmetric MHD equilibrium calculations, we found that elongated divertor configurations up to 1.8 are feasible even with a simple combination of four PF coils (Fig. 3). In addition, we confirmed that a plasma with circular cross-section can be generated which is stable both vertically and horizontally. This result was supported by evaluation of the distribution of the magnetic field decay n-index which is an indicator of positional stability. To investigate current ramp up scenarios, we are simulating discharge evolutions with the tokamak simulation code (TSC).

Thirdly we tested a small induction generator with a flywheel for the poloidal magnetic field power supply. The voltage was demonstrated to be maintained within 10% drop even under three times the rated load during required periods for tokamak experiments (~ 20 ms).

1) H. Ikezi, K. F. Schwarzenegger, Phys. Fluids 22, 2009 (1979).
2) S. Hatakeayama *et. al.*, P1.046, EPS/IPCC2012, Sweden, 2012.

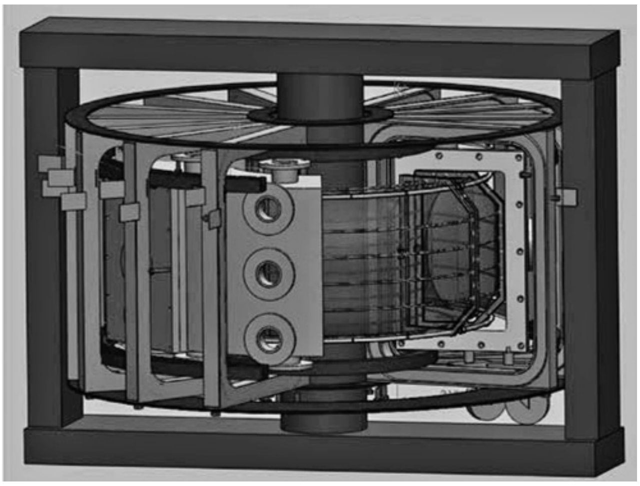

Fig. 1 Schematic illustration of the tokamak device under contruction

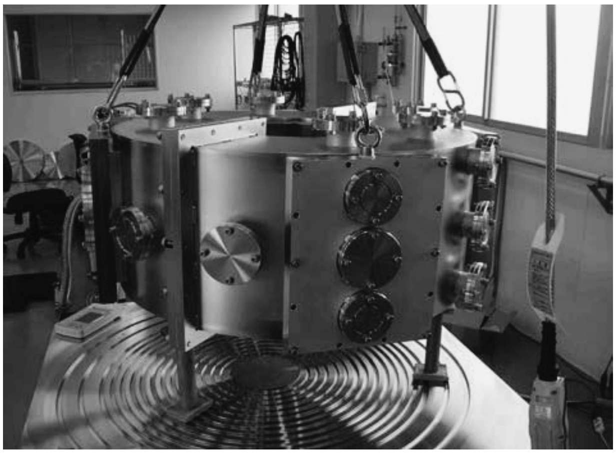

Fig. 2 Picture of the newly made vacuum vessel with rectangular cross-section,.

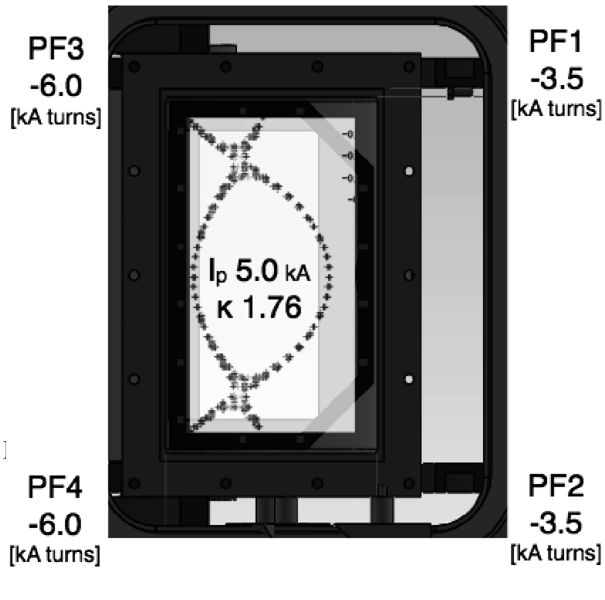


Fig. 3 An example of PF coil currents and MHD equilibrium configuration. The red parts indicate the location of PF coils.