§3. Development of a Real Time Control System for MHD Instabilities

Masamune, S., Takemura, Y., Yamashita, T.,
Nakamura, M., Sanpei, A., Himura, H., Ikezoe, R.,
Onchi, T., Oki, K. (Kyoto Institute of Technology),
Watanabe, K.Y., Sakakibara, S., Narushima, Y.

In LHD, the most important instability is the resistive interchange mode arising from the magnetic hill configuration near the plasma edge. In fact, edge modes with low-mode number sometimes grow in a regime where β> ~4%. The aims of this research include understanding the mechanism of growth and saturation of this mode, and designing a real-time control system for this particular mode as a part of the high-beta plasma research in LHD. We started development of a MHD control system forf high-β plasmas. As a test bench, we have used the RFP configuration, where current-driven tearing or kink instabilities are the most important. even in high-β regime.

(1) Test of feedback system

In the present ontrol system, real-time Fourier transform will be applied to the signals from sensor coils (arrays of saddle loops set sat the actuator coils) set around the torus to obtain toroidal mode spectrum of MHD instabilities. Comparing the measured spectrum with reference mode spectrum, actuator coils will be driven to compensate for the difference to provide the reference mode structure for MHD mode control. We are planning to adopt a digital feedback controller. In the virtual shell control scheme, single input single output control model can be applied, so, we have developed a real time control system for RWM stabilization, and test of the system has been performed at one of the poloidal gaps to compensate for the field errors. That is, we apply horizontal and vertical fields to realize the boundary condition Br=0 at the poloidal gap. Figure 1 shows the effect of feedback control As a result of feedback, field errors are suppressed to the amplitude lower than 1mT on the average. The discharge duration has been improved by ~10% as a result of field effort compensation. In the control circuit, IGBT H bridge. Time response of the system was as follows; current turn-on time of ~3μs, and turn-off time of 10μs were realized.

(2) Design of saddle coils and power supplies

Feedback controlled 16 power supplies similar to the above-mentioned one are under construction for the purpose of RWM stabilization in RELAX. Figure 2 shows the saddle coil arrays for the feedback control; poloidally separated by 4 and toroidally by 32. In the experiments, optimization of the cil coverage will be studied by using part of these coils. Advanced control of tearing modes will require digital feedback controller, and we are starting collaboration with the University of Washington group to apply the ADI Blackfin 537STAMP board.

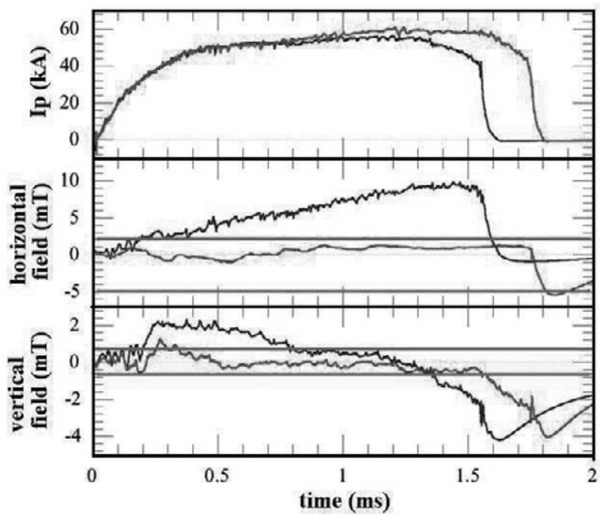

Fig.1: Reduction of field errors with feedback.

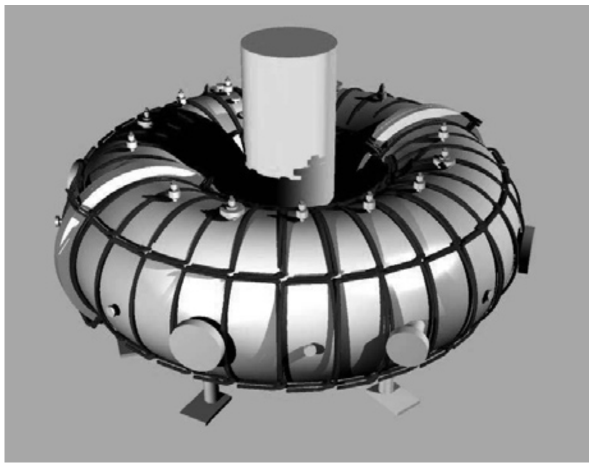

Fig.2: Saddle coil arrays for RWM control in RELAX

1) S. Masamune et al., "MHD properties of low-aspect-ratio RFP in RELAX", J. Fusion Energy, **28**, Issue2 (2009), 187.
2) A. Sanpei et al., "Characterization of equilibria in a low-aspect ratio RFP", J. Plasma Fusion Res. SERIES, Vol. 8 (2009), 1066.
3) R. Ikezoe et al., "Characterization of MHD behavior in a low-aspect-ratio RFP", J. PLasma Fusion Res. SERIES, Vol.8 (2009), 1031.
4) M. Nakamura et al., 26th JSPF Annual Meeting, 4aD17P (2009).
5) M. Nakamura et al., IEEJ Plasma Meeting, PST-09-32, PPT-09-32, ED-09-76 (2009). (awarded Excellence in Presentation Awards).