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RELAXにおけるMHDフィードバック制御システムの改良とRFPプラズマへの効果
Improvement of Active MHD Control System and Its Effect on Plasma Performance in RELAX

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1. Introduction and Background

In reversed-field pinches (RFPs), current driven non-resonant kink modes can grow as resistive wall modes (RWMs), leading to degradation of plasma performance or discharge termination mainly due to enhanced plasma-wall interaction associated with deformation of the edge magnetic structures. In the RFP, much effort has resulted in successful stabilization of the RWM by means of saddle coil arrays. The number of saddle coils is determined by the mode spectrum of the unstable RWMs; the number of saddle coils is relatively large because of the low-q (safety factor) nature of the RFP configuration.

2. Active MHD Control System in RELAX

In RELAX [1] (R/a = 0.51 m/0.25 m, $I_p \sim$ 100kA, $T_e(0) \sim$ 100eV, $n_e \sim 10^{19}$m^{-3}, $\tau \sim$ 3ms), 64 (4 in poroidal, 16 in toroidal) saddle coils are attached on the outer surface of the vacuum vessel for active feedback control of MHD instabilities. The radial sensor coils with similar saddle shape are located at the same locations as the saddle coils. In the first step experiment for stabilization of RWM, all coils were connected in series to provide the m/n = 1/2 externally non-resonant helical field. The sensor coils were connected in the same manner, and two IGBT-controlled power supplies were used to provide actuator current. The on-off feedback control worked well to suppress the growth of this mode, resulting in longer discharge duration exceeding 3 ms, which was ~ 20 % shorter without feedback [2].

3. Improvement of MHD Control System and Effect on Plasma results

On the other hand, we observed small discrepancy between the m/n = 1/2 fourier amplitude and sensor amplitude, the former provided by 16 sine- and cosine-radial coils set outside the vessel, while the latter by sensor saddle coil arrays. We have attributed this discrepancy to the toroidal non-uniformity of the feedback control field arising from the flanges with lower poloidal resistance at the two insulated poloidal gaps. To compensate for this non-axisymmetric effect, we applied separate control of the magnetic boundary conditions at the two gap sectors. At each gap sector, the inner and outer side saddle coils were controlled independently such that the radial flux penetrating the sensor coil remains zero, while the top and bottom saddle coils are connected in series to control the m = 1 vertical structure. Therefore, 6 additional power supplied were used three power supplies are used at each of the two sectors for separate control of the magnetic boundary conditions at the two toroidal sectors which include the poloidal insulated gas and flanges. The remaining saddle coils were connected in series to provide the m/n = 1/2 helical field as before. We observe further improvement in discharge duration far exceeding 3 ms [3].

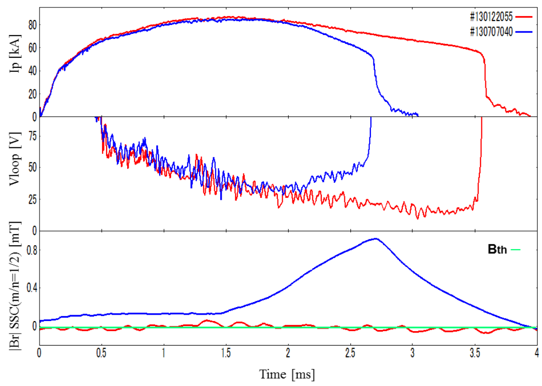

Fig: Time evolutions of I_p, V_{loop}, B_r sensor signal, without (blue) and with (red) active control.

References

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