§10. Experimental and Theoretical Studies of Startup Methods for Spherical Tokamak Plasmas

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The spherical tokamak (ST) is expected to attain both of high-beta and long confinement time. Its key issue is how effectively we can startup high-beta ST without using the center solenoid coil whose space is limited in the center of ST. The University of Tokyo have three key ST devices for ST startup but a few plasma diagnostics. On the other hand, NIFS has a variety of plasma diagnostics, especially high special resolution measurements of plasma temperature and density useful for the ST startup measurements but not ST device. Because of these reasons, we have been collaborating with the ST group in NIFS using ST committees in JSFS and IEEJ. In this program, we made for the first time the all-Japan type joint study of ST startup by collaborating not only with NFS but also with all ST groups in Japan: Kyoto Univ., Hyogo State Univ., Kyusyu Univ. and Kyusyu-Tokai University.

A final goal of our project is to optimize the ST startup methods both from theoretical and experimental points of view. In 2004, the joint group made the high beta ST startup in TS-3 and 4, by combining PF coil induction and complete merging/ reconnection of two STs and also solenoid coil-less ST startup in TST-2, using RF and PF coil induction. We also made the corresponding Magnetohydrodynamic (MHD) simulation to verify these experimental results. Consequently, our proposal of large scale merging experiment was accepted by NSTX, Princeton Univ. as a new extension of merging startup experiment. We will start the first merging / reconnection experiment of NSTX in this summer season.

Figure 1 show the 2-D MHD simulation result of the ST merging startup and Fig. 2 shows the corresponding experimental result in TS-3. They indicate that two STs can be produced by the induction of two or four PF coils and they are merged successfully in the axial direction. The high power heating of reconnection is observed to suppress the strong paramagnetic toroidal field of initial low-beta STs.

A series of ST startup activities in four universities and two institutes were summarized in the joint meeting / experiment at Univ. Tokyo in Feb.. We compared the four major ST startup methods: PF coil induction, RF, CHI, EF rampup and merging startup and finally refined their several key subjects especially from the view point of ST reactor requirements. These subjects will be tested in UTST, a new ST startup project in Univ. Tokyo and those ST groups will join it using a new remote experiment system by Super SINET in next fiscal year.

References

[1] Y. Ono et al., Fusion Energy 2004, IC/P6-44, (2005).

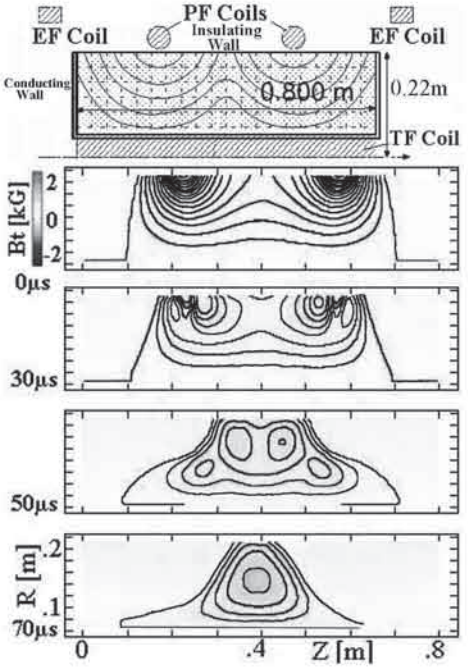

Fig. 1 Poloidal flux contours with internal B_t amplitude (color) during the merging startup (2-D MHD Simulation).

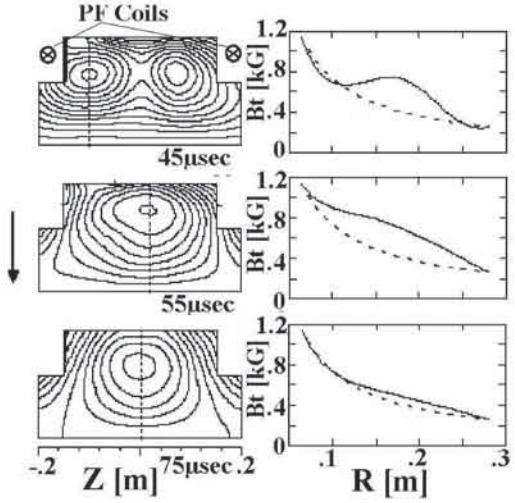

Fig. 2 Poloidal flux contours and radial B_t profiles during the merg-ing startup. The dotted lines represent vacuum B_t (TS-3 Experiment).