

§4. Study of Determination Mechanism of Plasma Current Decay Time during the Discharge Termination Phase in Toroidal Magnetically Confined Plasmas

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Purpose

The sudden decay of the toroidal current would give damages on the toroidal plasma devices confined by magnetic field. The final goal of this study is to obtain the common physical pictures of the determination mechanism of the current decay time through the comparative analyses of the current decay behaviors during the discharge termination for the various magnetic confinement plasma devices with the various MHD equilibrium characteristics. Here we specially focus attention on the interactions between the plasma confinement and the MHD equilibriums. To promote the research activities on the MHD physics of the toroidal plasmas in the Japanese universities' research groups is an additional purpose because, in recent Japanese MHD research communities, researchers of the large institutes like NIFS and JAEA mainly study the MHD issues, but a few universities' research groups do.

Methods and Results

This year is the collaborative research-starting year, and the research is progressed by the following two task groups. One group is called as the "current decay analyses" group, which study the current decay analyses of the tokomaks, for which the identification methods of the MHD equilibriums in the plasma termination have been established. Another group is called the "MHD equilibriums identification method developing" group, which develops the method in the plasma termination because it has not been developed in the helical and the RFP device. The goals of the former group are to propose a reference to compare the current decay behavior among the various magnetic configurations, apply the reference to the experiments, and summarize the analyzed results. And the latter group's goal is to develop the identification method of the MHD equilibrium for the various magnetic configurations, to apply it and to make the validation of the efficiency.

The results of this year's activities of the above two groups are as the follows;

(I) "Current decay analyses" group

On the experiment study, the main experiment device, HYBTOK-II (Nagoya univ.), did not work this fiscal year because the building, where it is set, was under the reconstruction. Then we had some meetings to list up the available hardware like diagnostic systems, current control systems and so on, and to make the research and the experiment plan of it in the future.

On the tuning-up of the simulation tools; the tuning-up of the prediction code of the current decay behavior during the discharge termination is done by the collaborators in Nagoya univ., Kyoto univ., NIFS and JAEA,

i.e. the DINA code (time evolution analyzing code of MHD equilibriums) is improved so as to take the time evolution of the electron temperature profile and the external coil current like the so-called center solenoid coils into account. We apply the tuned-up code to the current decay analysis in the JT-60 disruption discharges, which has the detail measurement data of plasma parameters during the disruption phase, and obtain the following results.

(1) The current decay time during the initial phase of the current quench of the JT-60U massive gas-puff induced disruptions are determined by the characteristics time of the peaking of the current profile, which is strongly related with the relationships between the current profile and the electron temperature profile at the beginning of the current quench (just after the thermal collapse).

(2) In the minor collapses of the high beta-poloidal JT-60U discharges, the time evolution of the external coil induces the one turn voltage as to suppress the current decay. However, the voltage is not large enough to recover the plasma current, and the time evolution of the peakedness of the current profile still affects the stronger effect on the recovery of the current.

(II) "MHD equilibriums identification method developing" group

The identification methods of the MHD equilibriums in the helical and the RFP plasmas have not been established. In the helical plasmas, the CCS method which is an established method of tokomaks' MHD equilibrium identification is extended to the helical plasmas. The method is applied to the finite beta LHD plasmas calculated by HINT code, and the method is found principally applicable to reconstruct the last closed flux surface by using the artificially huge numbers of the "measured" magnetic field and the flux data, Now the minimization of the necessary "measured" data and the effect of the measured noise signals on the accuracy are being investigated. For RFP plasmas, the CCS is extended to evaluate the eddy current in the shell in addition to the plasma current, which would be helpful to evaluate the eddy current in the vacuum vessels and/or the supporting structures in tokomaks/helical systems, the effect of which would not be ignored during the discharge termination. We are making the experiment plan to check the validation of the accuracy of the eddy current estimation method in the RELAX (Kyoto inst. tech.).

(III) In order to share the status and the results of the developments in the above groups, and to confirm the goals of the collaboration, we held the meetings twice at September and December in this year. There we also discussed the MHD research subjects by using small toroidal devices and its meaning in the development research of the fusion reactor. The discussion would be helpful to promote the research activities on the MHD physics of the toroidal plasmas in the Japanese universities' research groups.