§2. MHD Equilibrium Dynamics Due to the Rapid Change of Plasma Parameter and the Interaction with the Confinement

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Purpose

A purpose of this activity is to establish an algorism of the analysis and the prediction of the 3D(3-dimensional) MHD equilibrium dynamics taking the rapid change of the plasma parameter into account. Here we consider the change of the plasma current and the pressure as the cause of the rapid change of the plasma parameters (like the disruption in tokamaks, and the pellet injection in the super high density operation of LHD), and the eddy current as the cause of the transient response in the surrounding structure (RFP), and will make a validation of the algorism and the improvement through the comparison between the prediction and the experiments, which would enable our common knowledge and understandings on the torus plasmas to extend. Another purpose of this activity is to encourage the experimental MHD research activities in the small laboratory of the universities through the collaboration on this research with the experimental devices belong to the laboratory.

Methods and results

The research activities are categorized in the follows from three aspects. (1) Development of the 3D MHD equilibrium calculation code taking the time evolution into account. (2) Modelling of the 3D effect and the eddy current, and proposal of the experimental methods to validate the modeling. (3) education on the usage of the calculation program and the way to make an experimental methods beyond the local organization (like the laboratories).

(1) Development of the 3D MHD equilibrium code

A MHD equilibrium calculation method used by a typical 3D MHD equilibrium calculation code (VMEC) for a typical ITER operation with the axisymmetric configuration has been proposed, where the external current source like the coil current and the eddy current are taken into account. There the almost same results are reproduced by both methods based on the VMEC free boundary version and the VMEC fix boundary version with virtual casing method. We has specified the spec of the calculation based on the results, the VMEC free version is applied to calculate the MHD equilibrium taking the external currents into account, and the VMEC fix boundary version with virtual casing method is applied for the evaluation of the eddy current in the surrounding structure like the vacuum vessel, and consistent equilibrium solution between time evolution of the plasma current and the external current by applying them interactively, and the time evolution of the plasma current is calculated by the current diffusion model with a boundary condition based on the one turn voltage consistent with the electric circuit model. The spec is specified based on the collaborated review of the researchers in Kyoto univ., Tokyo Tech., NIFS and JAEA.

(2) Modelling of the 3D effect and the eddy current, and proposal of the experimental methods for the validation.

The experiments for the validation will be done in the RFP device in Kyoto Tech. (RELAX) and the tokamak device in Tokyo Tech. In the RELAX, the direct identification method based on the magnetics and the boundary element method are verified under the assumption with the axisymmetric configuration. The experimental set up is being developed by the other activity of the NIFS collaboration program. In the activity, the results of the experiments are used to make a preliminary validation of the time evolution algorism in our developing code because our goal includes the 3D effect. As the next step, in the Tokyo Tech.'s tokamak, we have a plan that the validation of the eddy current analysis model taking 3D effect into account s. In this year, we made the experimental specification, the rough cost estimation and the experiment scenarios by the researchers in Kyoto Tech., Tokyo Tech., Kyoto univ., NIFS and Hokkaido univ.

(3) Education of the graduated students by the all researchers in this activity.

The courses of the education related with this activity is as the follows; (a) Usage of the time evolution of the 2D MHD equilibrium calculation code (b) Knowhow to operate the small tokamaks, to make the diagnostics and the experimental analyzing procedure (c) Usage of the direct identification method of the eddy current. On (a), A Kyoto univ.'s student lean the usage of the DINA code and the TSC code from the collaborators of JAEA and Tokyo Tech. to verify the present algorism through comparison between the calculation and the experiments, which is related with (1). Tokyo Tech.'s students learn the usage of the VMEC code from the collaborators of Kyoto univ. and NIFS to make a scenario of the tokamak operation with 3D effects, which is related with (2). On (b), Nagoya univ.'s students learn them from the collaborators of JAEA, Ihikawa Tech. collage and Kyoto univ. and NIFS. On (c), A Kyoto Tech.'s student learn it from the collaborators of Hokkaido univ. and NIFS., which is related with (2).

Methods and results

This year, we have not started the collaborative experimental researches. Next year, we want to start it in the RELAX(Kyoto Tech.). We continue the education of the students by the all collaborators in this activity, the program is the very effective way to educate the students in the MHD research field in the universities, and would lead to the increase of the community related with the MHD researches.