§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 mainly consider the change of the plasma current as the cause of the rapid change of the plasma parameters, and the eddy current as the cause of the transient response in the surrounding structure (like the phenomena during the disruption of tokamaks), 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 four 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 model. (3) Education on the usage of the calculation program and the way to make an experimental methods beyond the local organization. (4) Identification of the new topics related with MHD research fields by the small experimental devices and the trial

(1) Development of the 3D MHD equilibrium calculation code taking the time evolution into account

The calculation model to evaluate the eddy current in the surrounding structures, like a vacuum vessel, a supporting structure, a cryostat and so on, are developed. The model consists of many four-sided frames with the filament current. To make a validity of the model, the program for the evaluation of the eddy current in the vacuum vessel with the toroidal symmetry are developed. Moreover, by the application of the the present MHD dynamics calculation code for the toroidally symmetric systems to analyze the JT-60U experimental results, we survey another necessary element to be model. As a model should be developed, we find the determination model of the boundary condition of the toroidal current in the 3D MHD equilibrium. The above consideration and the development of the model are done based on the collaborated review of the researchers in Kyoto univ., Tokyo Tech., NIFS and JAEA.

(2) Modelling of 3D effect and eddy current, and proposal of the experimental methods to validate the model

The experiments for the validation is done in the RFP device in Kyoto Tech. (RELAX) and will be in the tokamak device in Tokyo Tech (PHiX). 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. Based on the CCS (Cauchy's Condition Surface methods and the magnetics measurements, the primitive results of the eddy current profiles are obtained. 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 accounts. In this year, the tokamak has been constructed, and the first tokamak discharges are achieved.

(3) Education on usage of calculation program and the way to make an experimental methods beyond the local organization

The courses of the education related with this activity is as the follows; (a) Know-how to operate the small tokamaks, to make the diagnostics and the experimental analyzing procedure (b) Usage of the direct identification method of the eddy current. (c) Usage of the time evolution of the 2D MHD equilibrium calculation code. On (a), Nagoya univ.'s students learn them from the collaborators of JAEA, Ihikawa Tech. collage and Gifu Tech. collage and NIFS. On (b), a Kyoto Tech.'s student learn it from the collaborators of Hokkaido univ. and NIFS, which is related with (2). On (c), 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). A Kyoto univ.'s student lean the algorism of the DINA code from the collaborators of Gifu Tech. collage and NIFS, which is related with (1).

(4) Identification of new topics related with MHD research fields by the small experimental devices and the trial

The all collaborators discuss the meanings and the feasibility on the topics which were proposed in a workshop. As the results, a trial experiment on the effects of the RMP field artificially induced by the toroidal coil current ripple on the plasmas is started in the HYBTOK-II tokamak (Nagoya univ.).

Future subjects

Next year, we will make the experimental scenario for the validation methods on the model of the MHD dynamics calculation in the 3D MHD equilibrium, and proceed the preparation in the Tokyo Tech's tokamak. We are considering that the education program by the all collaborators in this activity 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.