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トカマク型装置におけるブランケット位置に配置した磁性材の磁気計測への影響を補正するモデル解析

Model Analysis on Magnetometry for Tokamak Devices with Effect Correction of Magnetic Materials Located on Blanket Space

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In tokamaks, position and cross-sectional shape measurement of the main plasma based on magnetic diagnostics is essential for plasma control and equilibrium analysis. On the other hand, the measurement will be difficult in fusion DEMO reactors [1]. It is because there are structures made of magnetic materials in the vacuum vessels. These structures are installed in order to support the blankets and in-vessel components with low-activation and the measurement instruments must be placed behind blankets to reduce neutron and γ-ray irradiation. Due to this reason, the magnetic measurement is affected by structures with magnetic materials and thus plasma control becomes very hard. In this research, a simple way of magnetic materials effect correction is proposed to improve the estimation of the location of plasma current centroid by filament-current approximation.

In this study, calculation was performed by the FEM (finite element method) using a simplified model as follows: toroidal magnetic field B_t generated with toroidal magnetic field coils, poloidal magnetic field B_p with plasma current consisted of a filament, and structures made of magnetic materials located on blanket spaces. Physical properties of magnetic materials were modeled from those of F82H which is considered as structure materials for DEMO reactors by a design team at QST. This finite element analysis was conducted with steady-state analysis. It is because that the steady-state analysis is necessary condition for the time dependent study. Then reconstruct the current centroid and equivalent magnetic flux surfaces by filament-current approximation using the sample magnetic flux values calculated with a FEM code.

In this model, or in fusion DEMO reactors, these magnetic components are installed discretely but very closely. Consequently magnetizing current which flows through each object can be considered as combined one large toroidal loop. Then this magnetizing current can be modeled as filaments of filament-current approximation. Also due to the current flows through each component, it is necessary that the summation of currents of combined toroidal loops is zero. Then the filament currents are computed by least-squares fit based on these conditions.

As a result of filament-current approximation, Fig.1 shows the reconstructed plasma position as point of "x" and magnetic surfaces as contour line. The point shown with "+" is the plasma set position and green rectangles are the position of magnetic materials. The ratio of reconstructed plasma position error to the minor radius of the reactor was improved by above method. Even though this improved error cannot meet the requirement for plasma control, this result indicates the potential of this simple correction.

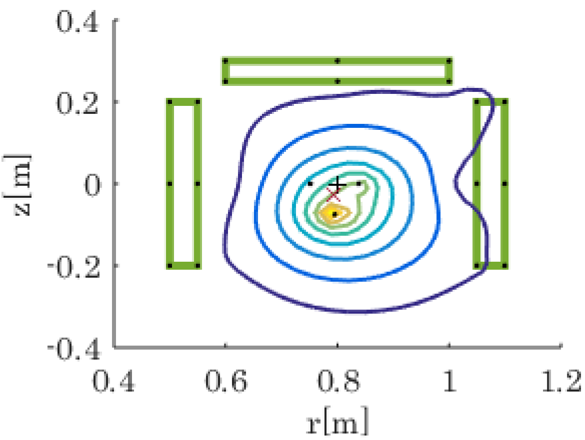

Fig.1 Reconstructed plasma position

Reference

[1] Program Committee of Technical Study on the Diagnostics for Control of the Fusion DEMO reactors: NIFS-MEMO-68 (2014).