24P-3F-14

磁性材料の非線形性を考慮したトカマク型核融合炉における
軸対称面電流近似を用いた磁気計測の補正

Axisymmetric Surface Current Approximation of Magnetization Currents of Non-linear Magnetic Materials for the Correction of their Effects on Magnetic Diagnostics in Tokamak DEMO Reactors

小林孝行[1]、筒井広明[2]、飯尾俊二[3]
KOBAYASHI Takayuki[1], TSUTSUI Hiroaki[2], TSUJI-IIO Shunji[3]

1) 職業大、2)東工大、3)日大
1) Polytechnic Univ., 2) Tokyo Tech, 3) Nihon Univ.

1. Introduction

The employment of magnetic materials is avoided in tokamak devices, not to affect magnetometry for position and cross-sectional shape measurement of the main plasma which is essential for plasma control and MHD analysis. On the other hand, it is planned that support structures made of low activation ferritic steel, F82H, which is magnetic will be installed in the vacuum vessel of DEMO reactors, from the perspective of heat load and neutron bombardment [1]. Concerning this problem, effectiveness of correction was confirmed in the experiment on JFT-2M and JT-60U where magnetic tiles were employed for the reduction of toroidal magnetic field ripple [2][3]. However, the studies didn't consider a condition which the sensing devices installed outer side of magnetic tiles and the magnetic tiles was not magnetically saturated.

2. Model Analysis on Magnetometry

In this study, 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. Calculations for simulating the estimation was performed by a FEM (finite element method) software, COMSOL Multiphysics®, using simplified models. Physical properties of magnetic materials, which includes magnetic nonlinearity, were modeled from those of F82H. Using the sample magnetic flux values calculated with a FEM code, the current centroid and equivalent magnetic flux surfaces was reconstructed with modified filament-current approximation.

This modification is based on the following assumptions: In fusion DEMO reactors, these magnetic objects are installed discretely but very closely. Consequently, magnetization current which flows through each object can be considered as combined one large toroidal loop.

This magnetization current can be modeled as surface currents. These surface currents were modeled as a simple function which depends on the position of its toroidal cross section in order to reduce the degrees of freedom. Also due to the current flows through each object, it is necessary that the summation of currents of combined toroidal loops is zero. Based on these conditions, the filament and surface currents are computed by least-squares fit.

3. Results and discussion

As a result of this approximation, the ratio of reconstructed plasma position error to the minor radius of the reactor was under 3% by above mentioned method with one kind of surface current function. Overfitting occurs when the function has too many or too few degrees of freedom. Therefore, appropriate surface current function has to be selected for each device shape.

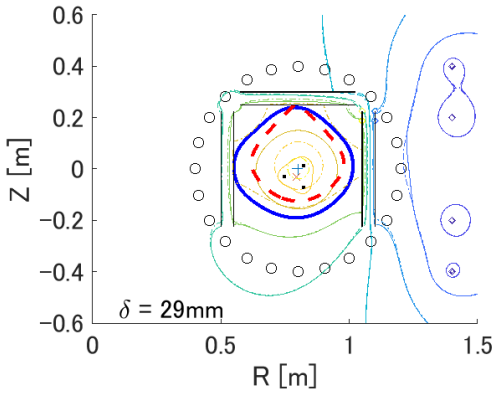

Fig. 1 Example of reconstructed plasma position and last closed magnetic surface

References

[1] K. Tobita, *et al.*: Fusion Eng. Des. **81** (2006) 1151.
[2] K. Tsuduki, *et al.*: Nucl. Fusion **46** (2006) 966.
[3] K.Shinohara, *et al.*: Nucl. Fusion **47** (2007) 997.