20PB-100

Eddy current analysis on reactor internal structure including magnetic materials
磁性体を考慮したトカマク炉内構造物の渦電流解析

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Eddy current distribution influencing the plasma position sensors was calcurated by Finite Element Method (FEM). It is shown that eddy current distribution is influenced by the exitence of magnetic materials in blanket. This result indicates there is some possibility that the magnetic materials preclude magnetic measurements.

1. Introduction

Prototype reactors of nuclear fusion have been studied from various viewpoints as the next reactors to ITER. Among them, magnetic measurements are a big issue although it is known as a method to determine the position and shape of tokamak plasmas. But in prototype reactors, sensors should be placed behind blanket since it is revealed that the sensor will be damaged due to high neutron flux in the blanket region. Figure 1 shows the intensity distribution of neutron flux in a prototype reactor [1]. Neutron shield by blanket protection will likely to disturb the magnetic measurements with influence of its magnetic material or the eddy currents flowing in the blanket.

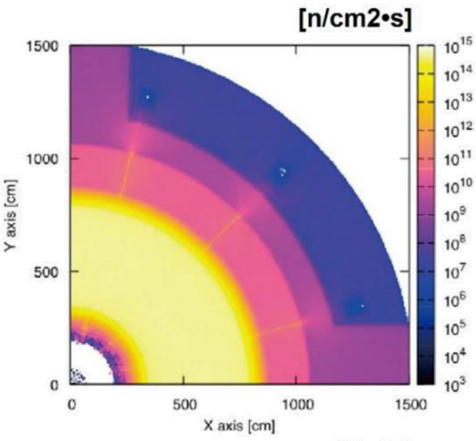

Fig. 1. Intensity of neutron flux

2. Method

To investigate the influence of the blanket, a simple model was considered. Frequency response of the magnetic field made by a simulated plasma current in axisymmetric model on a prototype reactor was calculated with a FEM code, “COMSOL Multiphysics”. Extreme examples was simulated that the blankets were only made of ferric steel and these would not be magnetically saturated, but only had a value of 1000 or 1 as a relative permeability. Input is sine wave of 1-MA peak value in the domain of simulated plasma.

3. Results

Figure 2 is the frequency response at 1 Hz and 10 MHz. Each contour shows current density. These models show that presence or absence of magnetic material causes changes in the position of the eddy currents induced in conductor shell. In the case that relative permeability is unify, induced eddy currents in conductor shell are nearly uniform. But, in another case that the relative permeability has value of 1,000, induced eddy currents in conductor shell are concentrated near the gap of blankets. Magnetic flux surfaces are plotted and magnetic flux density are mapped with color in Fig. 3.

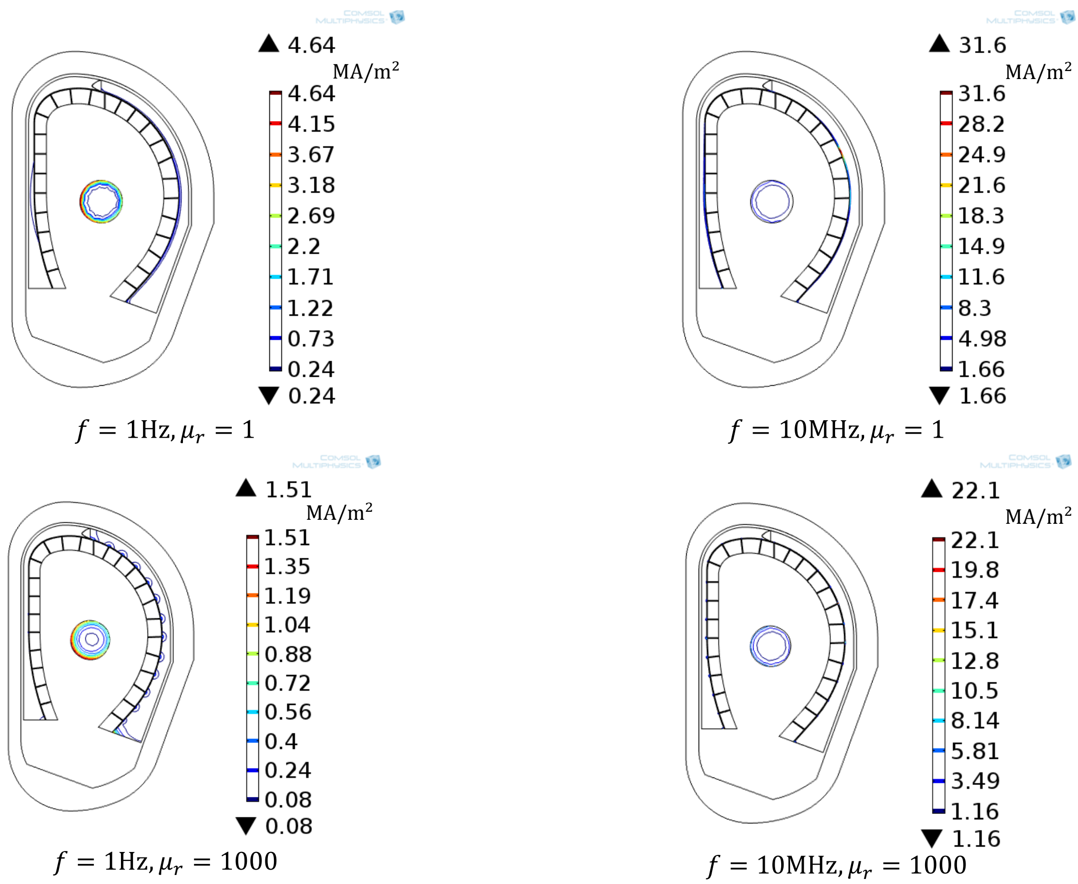

Fig. 2. Frequency response of the magnetic field

4. Conclusion

This model was simple because the ferric steel is not modeled basing on B-H curve but constant relative permeability ($B = \mu_r \mu_0 H$) is assumed. This magnetical nonsaturation causes inaccuracy of simulation. But it suggests the possible influence by magnetic material. In this work, the model was axisymmetric, not 3D. In near future, we will simulate with an advanced model.

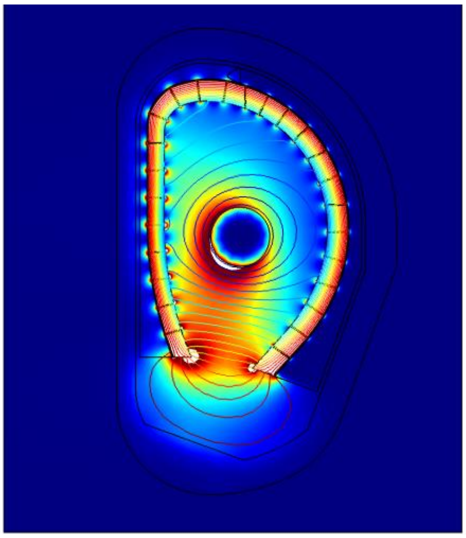

Fig. 3. Magnetic flux surfaces and color map of magnetic flux density ($f = 1$ Hz, $\mu_r = 1000$)

References

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