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3-D Adaptive Mesh Refinement Using Nonconforming Mesh

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3-D ADAPTIVE MESH REFINEMENT USING NONCONFORMING MESH

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1. Introduction

If the conventional method of adaptive mesh refinement[1] which uses only conforming mesh is applied to the brick element having many advantages[2], it is difficult to make freely a region which is locally subdivided into fine mesh. A nonconforming mesh[3,4] enables us to overcome this difficulty.

In this paper, the 3-D adaptive mesh refinement using the nonconforming mesh is investigated, and its effectiveness is illustrated by analyzing magnetic fields in 3-D models.

2. Adaptive Mesh Refinement

For simplicity, a nonconforming mesh is explained using a 2-D example shown in Fig.1. The potential at the nonconforming node p is interpolated by the potentials at the adjacent nodes q and r[3,4].

The discontinuity of the normal component of flux density is used as an error index: Namely, the error index δB_{1n} for the edge c-d of an element ① in Fig.2(a) is defined by

$$\delta B_{1n} = | B_{1n} - B_{2n} | \times L_{1n} \quad (1)$$

where B_{1n} is the perpendicular component to the edge c-d of the flux density at the center of gravity in the element ①. L_{1n} is the length of the edge b-c which is perpendicular to the edge c-d. If δB_{1n} is relatively large, the element ① is subdivided into elements ③ and ④ as shown in Fig.2(b). If two or more nonconforming nodes exist on one edge g-h as shown in Fig.3(a), the element ⑤ is subdivided into two elements ⑥ and ⑦ as shown in Fig.3(b).

In 3-D analysis, the same idea mentioned above can be applied.

3. Application

The adaptive mesh refinement is applied to the analysis for linear and nonlinear 3-D models and the accuracy and the CPU time are compared with those of the conventional method.

An example of the IEEJ linear magnetostatic model[5] is shown in Figs.4-6. The magnetic field is calculated using the magnetic scalar potential method. The final mesh has high mesh densities near the upper edges of the core. Figure 7 shows the flux density Bs at a point S near the corner of the core. If the ordinary conforming mesh using brick elements, having similar number of elements to the nonconforming mesh, is applied, it is difficult to get such an accurate solution.

A nonlinear example (TEAM Workshop Problem 13[6]) will be reported in the full paper.

References

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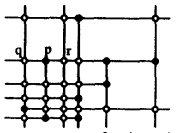
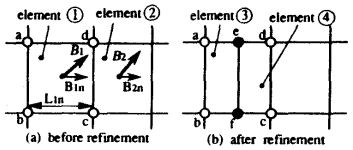
[5] T.Nakata, N.Takahashi and K.Fujiwara: Electromagnetic Fields in Electrical Engineering, 285 (1989) International Academic Publishers.
[6] T.Nakata, N.Takahashi, K. Fujiwara, T.Imai and K.Muramatsu: IEEE Trans. Magnetics, MAG-27, 5, 4073 (1991).



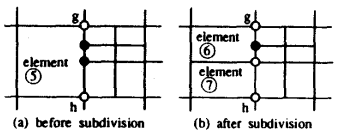
●: nonconforming node

Fig. 1 Nonconforming mesh.



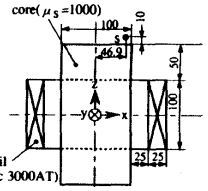
(a) before refinement (b) after refinement

Fig. 2 Method of mesh refinement.



(a) before subdivision (b) after subdivision

Fig. 3 Method of subdivision.



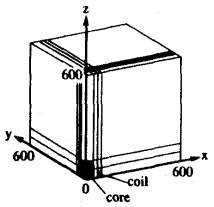


Fig. 5 Initial mesh.

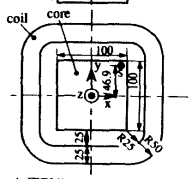
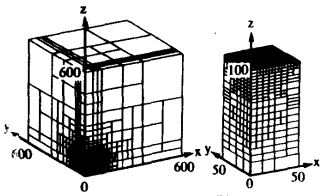


Fig. 4 IEEJ linear magnetostatic model.



(a) whole view (b) core region

Fig. 6 Final mesh.

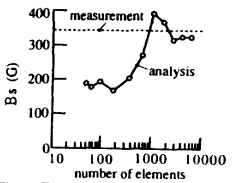


Fig. 7 The relationship between number of elements and flux density at a point S.