Adaptive mesh refinement for eddy current testing finite element computations

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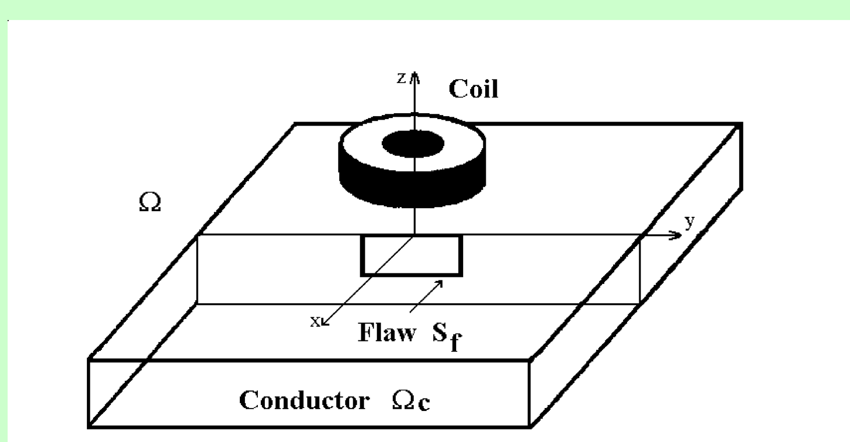
Introduction

This paper deals with an adaptive mesh refinement method applied to 3D eddy current non-destructive testing computations by finite element method. The principle of Ligurian is used as error estimator and applied in a general computation processing loop. This work takes place within the framework of the development of a non-destructive computer-aided numerical simulation environment. It has been applied to the TEAM Workshop Problem 15.

Eddy Current Testing (ECT) Problem



ECT-NDT configuration

Excessive computational time

Loop for probe displacement

computation with flaw

Computation without flaw

I = I + 1

Computational aspect

Ref ISEM

Error estimation

Ligurian approach : minimize the error in the magnetic constitutive law which describes the relationship between B and H.

In harmonic linear case the energy density error λ_m is defined as

$$\lambda_m = 2\left(\frac{\mathbf{B}_1^2}{2\mu} + \frac{\mu}{2}\mathbf{H}_1^2 - \mathbf{H}_1\mathbf{B}_1\right) + 2\left(\frac{\mathbf{B}_2^2}{2\mu} + \frac{\mu}{2}\mathbf{H}_2^2 - \mathbf{H}_2\mathbf{B}_2\right)$$

with $H = H_1 + iH_2$ and $B = B_1 + iB_2$

For each element, the local magnetic Ligurian estimator can be written as :

$$\lambda_{mi} = \int_{K_i} \lambda_m(\mathbf{B},\mathbf{H})\, dK_i$$

Mesh modification

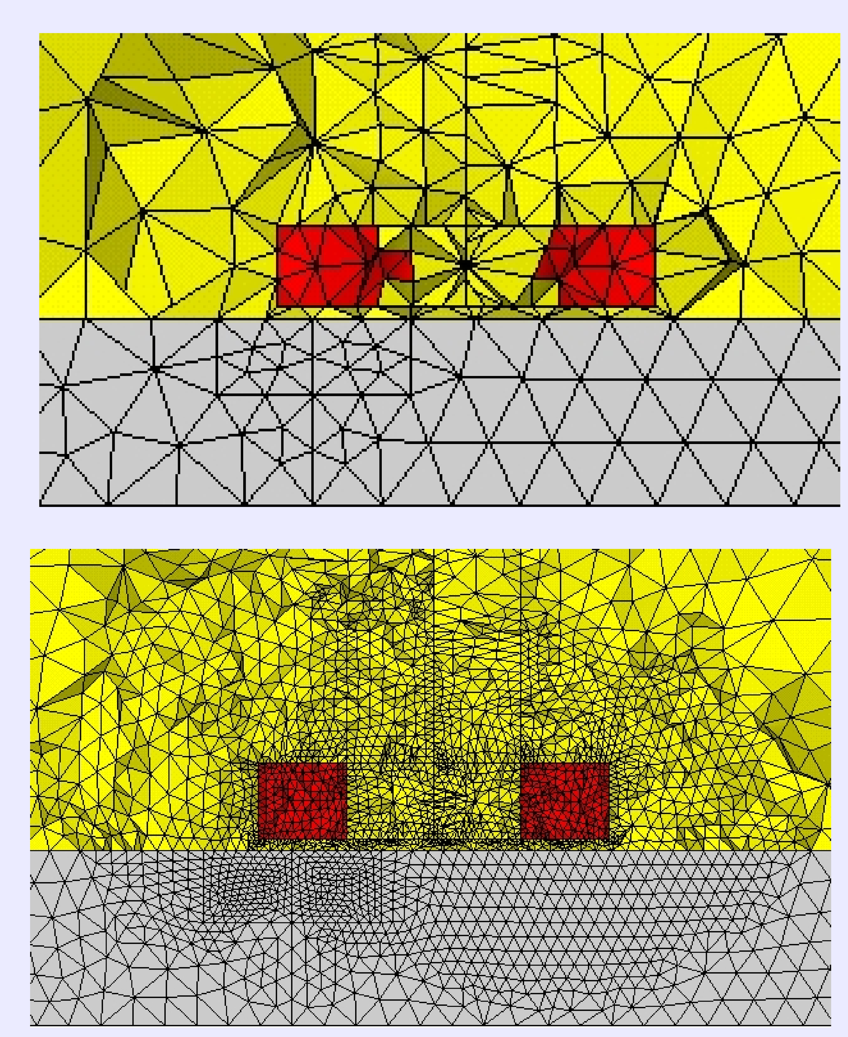
The refinement indicator Li is computed as

Li=	0 if $l_{mi} \leq l_{th}$ element i is not split
	1 if $\lambda_{mi} > \lambda_{th}$ element i is split

Two general kinds of mesh modification are possible : h-type and p-type.

The list of elements to be split is then introduced in the ANSYS mesh generator which produces the refined mesh. The “erefine” command is then used in an ANSYS batch script.

Results



Conclusion

Computational time saving is quasi-proportional to processors number and can be better with a true multi-processors architecture. The proposed method can be used of course with a single hyper-threaded processor such as Pentium III and Pentium 4 processors to exploit parallelism. This technique is well adapted to the ECT problem which is easily divisible in independent problems.