8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

Magnetic-Structural Coupled Analysis by Hierarchical Domain Decomposition Method

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Key Words: *Hierarchical Domain Decomposition Method, Non-Linear Magnetostatic Problems, Structural Problems, Coupled Analysis, Nodal Force Method.*

ABSTRACT

There are many machines or devices such as a computer, a cell phone, a transformer, and a Magnetic Resonance Imaging (MRI), in which electromagnetic phenomena are significant. In order to analyze these engineering or physical phenomena, computer simulation is a reliable and yet economical approach. Therefore, various general-purpose computational mechanics systems for electromagnetic analyses have been developed. Similar systems for structural, heat conductive and flow analyses have been developed, too. However, because most actual phenomena are mutual related compound phenomena with more than two kinds of mechanical and electromagnetic phenomena, the coupled analysis that contains the mutual related compound phenomena is required for obtaining characteristics of the actual phenomena in detail. In this paper, we consider to develop a general-purpose coupled analysis system which integrates two kinds of solvers for magnetic and structural analysis.

Moreover, a computational object is made to a large scale and complicated for numerical analysis recently. In addition, subdivision of the mesh is performed for the improvement of accuracy. Therefore, large-scale computations are increasingly important. To reply this requirement, we will use solvers that adopt Hierarchical Domain Decomposition Method (HDDM)[1][2] together with the data handling type "Parallel processor mode (P-mode)" [3][4] and have achievements to solve problems with over 10 million Degrees of Freedom (DOF). As a solver for magnetic analysis, ADVENTURE_Magnetic module is used. And as a solver for structural analysis, ADVENTURE_Solid module is used. These modules are finite element method analysis solvers designed in the ADVENTURE Project [5] to perform the magnetic analysis [6] and the structural analysis [2]. ADVENTURE_Magnetic module has successfully solved the 3D non-linear magnetostatic problem with 50 million DOFs in about eight and a half hours on a PC cluster that consists of 32 PCs.

ADVENTURE_Solid module has an achievement to solve the static elastic problem with 100 million DOFs in about 500 seconds on the Earth Simulator [7].

First, the magnetic flux density is obtained by the magnetic analysis. And the electromagnetic force is computed by the nodal force method [8] using the magnetic flux density. Next, the displacement is obtained by the structural analysis using the electromagnetic force as the condition of the load. Finally, the displacement is fed back to the magnetic analysis. In this paper, the bi-directional coupled analysis that repeats the above-mentioned procedure is considered and the simplified permanent-magnet type of MRI [9] is used as the computational model.

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