3D transient analysis and movement simulation for the modelling of magnetic levitation

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Abstract: This paper presents a three-dimensional transient numerical modelling of an electromagnetic levitation problem that takes movement into account. The governing eddy current equations are given in terms of magnetic vector and electric scalar potentials, and are solved with the help of 3D finite-element method tools implemented under Matlab environment. The coupled eddy current-mechanical model is carried out through the computation of electromagnetic force by volume integration of the Lorentz force, and solving the motion equation to get the displacement. To obtain an accurate solution of the magnetic field, the reverse Cuthill-McKee ordering is used to ensure fast convergence of the Incomplete Cholesky Bi-Conjugate Gradient (ICBiCG) solver. The body movement at each step displacement is simulated using the proposed Fast Partial Remeshing Technique (FPRT) in which only the moving part is remeshed without any changes on the mesh topology and on the number of degree of freedom.

Keywords: transient eddy current; magnetic force; finite-element method; 3D movement simulation.

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1 Introduction

The modelling of eddy current-mechanical coupled problems involves four subtasks: the solution of transient electromagnetic field equations with an appropriate time-stepping scheme, reliable electromagnetic force computation, the mechanical model and its solution to estimate the displacement, and the establishment of an economical method to take into account the relative movement.

To analyse the 3D electromagnetic devices, some formulations can be used depending on the problem. If the disadvantages of the potential formulations are the