First approach of a mixed domain decomposition method for magneto-static simulation of rotating machines

Aurélia Ruda[1], François Louf[1], Pierre-Alain Boucard[1], and Xavier Mininger[2]

[1] Université Paris-Saclay, ENS Paris-Saclay, CNRS, LMT, France.
E-mail : {aurelia.ruda, francois.louf, pierre-alain.boucard}@ens-paris-saclay.fr
[2] Université Paris-Saclay, CentraleSupélec, CNRS, Laboratoire de Génie Électrique et Électronique de Paris, France.
Sorbonne Université, CNRS, Laboratoire de Génie Électrique et Électronique de Paris, France.
E-mail : xavier.mininger@geeps.centralesupelec.fr

The development of domain decomposition method allows to strongly reduce the cost of numerical simulations. Unlike primal and dual approaches, the proposed mixed domain decomposition strategy treats the dual fields of the problem at the interfaces identically. This method, which has mainly been used in solid mechanics, is particularly well suited to take into account the rotor/stator motion at low cost.

The method relies on a non-overlapping decomposition of a domain Ω into subdomains Ω_E and interfaces $\Gamma_{EE'}$. The fields exchanged through the interfaces are $\underline{W}_E$, the restriction on the boundary of the potential vector field $\underline{A}_E$, and $\underline{T}_E$ the tangential component of the magneto-static field $\underline{H}_E$. In the case of a linear resolution, the solution S can be calculated from the boundary fields. This mixed domain decomposition technique is based on the Latin method which principle is to separate local and possibly non-linear equations on the interfaces (manifold $\mathcal{L}$) from linear equations within the subdomains (manifold $\mathcal{A}$), see Figure 1. (P. Ladevèze. *Nonlinear computational structural mechanics: new approaches and non-incremental methods of calculation* Springer, 1999). Then, the solution is obtained by a two-step iterative algorithm :

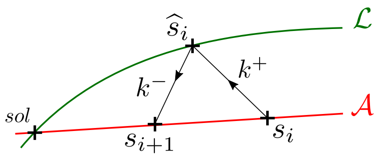

Figure 1: Scheme associated with the LATIN method

Local step ($\mathcal{L}$)

Constructing $\widehat{S}_i$ from S_i, and defined by the search direction k^+.

$$\begin{cases} \widehat{\underline{T}}_E + \widehat{\underline{T}}_{E'} = \underline{0} \\ \widehat{\underline{W}}_E = \widehat{\underline{W}}_{E'} \\ \widehat{\underline{T}} - \underline{T} - \underline{\underline{k}}^+(\widehat{\underline{W}} - \underline{W}) = \underline{0} \end{cases}$$

Linear step ($\mathcal{A}$)

Constructing S_{i+1} from $\widehat{S}_i$, and defined by the search direction k^-.

$$\begin{cases} \underline{\underline{K}}\,\underline{A}_E = \underline{\underline{t}}_E^T\,\widetilde{\underline{T}}_E \\ \underline{W}_E = \underline{\underline{t}}_E\,\underline{A}_E \\ \widetilde{\underline{T}}_E = \widehat{\underline{T}}_E + \underline{\underline{k}}^-(\widehat{\underline{W}}_E - \underline{W}_E) \end{cases}$$

An illustration of the developed method is proposed on a 2D rotating machine considering a linear material behavior law. To address the specificity of the rotation, a specific interface behavior is introduced based on the motion band method. In order to deal with magnetic saturation, a formalism introducing material non-linearity will be proposed.