Towards the design of an in-sillico computational tool for the simulation of floorborne vibrations on magnetic resonance imaging scanners

Yashwanth Sooriyakanthan[1] Antonio Gil[2] Paul Ledger[3] Mike Mallet[4]

The in-silico simulation of the effects of vibration on Magnetic Resonance Imaging (MRI) scanners is currently not possible within an industrially viable timeline (source: Siemens Healthineers). Specifically, existing three-dimensional transient solvers for coupled magneto- mechanics are not compatible due to their extremely high computational cost, thus requiring a new computational approach. Within an MRI scanner, the effects of gradient Alternating Current (AC) coils can be safely superimposed over those of superconducting Direct Current (DC) coils due to their very different orders of magnitude, permitting to leverage an efficient linearised frequency-based approach which can be effectively used during the MRI design phase.

Previous work by our group [1, 2, 3] focused on the development of a computational framework where a Lagrangian formulation was used to describe the magneto-mechanical problem of interest. After derivation of the weak form and linearisation, hierarchical H1 and H(curl) conforming finite element basis functions were used to discretise the displacement and vector potential fields of the magneto-mechanical problem of interest, respectively. Thus far, the effect of potential floor-borne vibrations has been disregarded, that is, the movement of the conducting shields was restricted to zero. In this poster, we will further expand our previous framework by exploring the effect that floor-borne vibrations can have on some of the fields of interest, specifically, the generation of eddy currents, ohmic power and kinetic energy. This will be achieved by relaxing the above homogeneous Dirichlet constraint on conductors and permitting the consideration of more complex vibration modes. The focus of future work, in collaboration with Siemens Healthineers, will be the accurate simulation of any field perturbation (linking it to MRI imaging) as a result of possible floor-borne vibrations in both MRI conducting shields and coils.

References:

[1] M. Seoane, P. D. Ledger, A. J. Gil, and M. Mallett. An accurate and efficient three-dimensional high-order finite element methodology for the simulation of magneto-mechanical coupling in MRI scanners.International Journal for Numerical Methods in Engineering, 119:1185–1215, 2019. DOI: 10.1002/nme.6088

[2] M. Seoane, P. D. Ledger, A. J. Gil, S. Zlotnik, and M. Mallett. A combined reduced order-full order methodology for the solution of 3D magneto-mechanical problems with application to magnetic resonance imaging scanners. International Journal for Numerical Methods in Engineering, 121:3529–3559, 8 2020. DOI: 10.1002/nme.6369

[1] Zienkiewicz Centre for Computational Engineering, College of Engineering, Swansea University, UK
970070@swansea.ac.uk

[2] Zienkiewicz Centre for Computational Engineering, College of Engineering, Swansea University, UK
a.j.gil@swansea.ac.uk

[3] School of Computing and Mathematics, Keele University, UK
p.d.ledger@keele.ac.uk

[4] Siemens Healthineers, MR Magnet Technology, UK
michael.mallett@siemens-healthineers.com

[3] G. Barroso , A.J. Gil, P.D. Ledger, M. Mallett and A. Huerta. A regularised-adaptive Proper Generalised Decomposition implementation for coupled magneto-mechanical problems with application to MRI scanners”, Computer Methods in Applied Mechanics and Engineering, 358:112640, 2020. DOI: 10.1016/j.cma.2019.112640