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FINITE ELEMENT SIMULATION OF A TRANSIENT COUPLED ACOUSTO-MAGNETO-MECHANICAL SYSTEM WITH APPLICATION TO MRI SCANNER DESIGN

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Magnetic Resonance Imaging (MRI) is an important tool in the medical industry and it is used for identifying a range of medical ailments, such as tumours, damaged cartilage and internal bleeding. An MRI scanner consists of four main components: A set of main magnetic coils produce a strong uniform stationary magnetic field across the radial section of the scanner; The secondary magnetic coils are used to avoid large stray fields arising outside the scanner; The cryostat consists of a set of metallic vessels used to maintain the supercooled magnet temperatures and shield from radiation and a set of resistive coils inside the imaging volume, known as gradient coils, produce pulsed gradient magnetic fields to generate an image of the patient.

The presence of eddy currents in the cryostat is caused by changing magnetic fields, such as those generated by the pulsed gradient fields. These eddy currents can cause perturbations in the magnetic field and also give rise to Lorentz forces and exert electro-mechanical stresses in the conducting components, which cause them to vibrate and deform. These deformations cause the magnetic field to further perturb thus generating more eddy currents. The vibrations also cause perturbations of the surrounding air, which in turn produces an acoustic pressure field. These phenomena can have undesired effects causing imaging artefacts (ghosting), decreased component life and uncomfortable conditions for the patient, due to the noise from mechanical vibrations.

We have developed an efficient *hp*–finite element solution methodology for the coupled acousto-magneto-mechanical system that arises in axisymmetric MRI scanner design [1]. Our presentation will include details of our linearised solution methodology as well as comparisons with a full transient non-linear solution using a Newton-Raphson procedure, based on a rigorous linearisation of the coupled equation system, for a series of challenging benchmark examples [2].

REFERENCES

[1] S. Bagwell, P.D. Ledger, A.J. Gil, M. Mallett, M. Kruip, A linearised *hp*-finite element framework for acousto-magneto-mechanical coupling in axisymmetric MRI scanners. *Int. J. Numer. Meth. Engng.*, **112**, pp1323-1352, 2017.

[2] S. Bagwell, P.D. Ledger, A.J. Gil, M. Mallett, Submitted 2018.