Introduction: Magnetic Barkhausen Noise (MBN) is emitted as magnetic domain walls abruptly move in ferromagnetic materials. It is sensitive to stress and so is useful for studying residual stress in steels. Classically, the directional properties of MBN have been studied by manually rotating a dipole electromagnet (Figure 1 left). Rather than manually rotating the electromagnet, a tetrapole electromagnet (Figure 1 right) can be used and the magnetic field rotated by vector superposition. Unfortunately, the two approaches are not equivalent as expected (see Figure 2) [1,2]. COMSOL is used to understand the differences in these two approaches.

Results: Figures 3 and 4 show the magnetic field just inside the steel substrate obtained from a dipole probe and a tetrapole operating at 0°. In the centre of the probe, the fields are very similar. The tetrapole shows some flux leakage through the extra set of poles resulting in slightly less field intensity in the center.

Computational Methods: The AC/DC module was used for the simulations. The laminated Supermendur electromagnets used a diagonal conductivity matrix and an Ampere’s law node to rotate the local co-ordinate system to align the conductivity with the laminate, preventing induced current flow between layers. The steel substrate used a diagonal permeability matrix to reflect the magnetic easy axis in the rolling direction. An Ampere’s law node was used to rotate the local co-ordinate system in the steel so that the easy axis could be rotated relative to the tetrapole. The tetrapole phase angle was varied using a parametric sweep of a 50Hz time harmonic calculation.

Conclusions: While superposition works, the field gradients produced by a tetrapole probe are oriented very differently from those produced by a dipole probe potentially causing different MBN response.

References:
1. S. A. White. A Barkhausen noise testing system for CANDU R feeder pipes, Queen’s University, 2009.
2. P. McNairnay. Magnetic Barkhausen noise measurements using tetrapole probe designs. Queen’s University, 2014