# Eddy Current Probes For The Non-Destructive Detection Of Cracks In Complex Structures

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## Abstract

Eddy current based crack detection is a fast, accurate and well-established technique for detecting surface and sub-surface cracks in electrically conducting materials. Numerical modeling of eddy current detection has been explored in the literature and is challenging due to the small differential signals produced by the relevant defects. Real specimens are frequently more complex than the simplified structures explored in numerical studies. For example, it is sometimes necessary to detect the presence of sub-surface cracks in structures of non-uniform thickness, such as that shown in Figure 1.

In this paper, we present an initial feasibility study exploring the possibility of distinguishing a sub-surface crack from a rib in a metallic structure (in the case of interest, the cracks are orientated at 45 degrees to the ribs). The cracks are distinguished from the ribs by tuning the depth sensitivity of the probe as well as by designing a differential probe that is insensitive to certain orientations of the ridges. We also propose a novel simulation technique for modeling multiple configurations of a scanning probe using a single mesh, enabling 3D simulations of eddy current probes even when the differential signal is small and challenging to distinguish from mesh related effects.

Figure 2 (a) shows the geometry considered in this study. A split D probe is employed, which consists of a single drive coil surrounding a pair of deferentially wound sense coils (each wound in a "D" shape around a high permeability core). To examine the effect of ridge or cracks, we create a model in which multiple defects at different locations are represented in a single geometry. For the case of a ridge it is possible to remove the defect by assigning air as the material for the protruding part of the ridge. For the case of a crack we assign metallic material to its interior to remove it. Using this method, we explored the response of the probe in multiple configurations using the same mesh, enabling small differential signals to be analyzed even when mesh convergence to the point of resolving those signals might be impractical.

We analyzed the structure using COMOL Multiphysics® Magnetic Fields physics interface, with the differential sense coils coupled together with a matching impedance in the Electrical Circuits interface. The resulting magnetic field at the surface of the specimen is shown in Figure 2 (b) and the induced eddy currents in a uniform specimen are shown in Figure 2 (c). Figure 3 (a) and (b) shows the results obtained from placing the probe at different positions with respect to a crack and ribs within the structure. As shown in Figure 3(c), the probe is scanned in a direction to minimize the effect of the ribs, and consequently a significantly larger differential signal is generated from the crack than from the ribs. Scanning over a rib in the other direction, generates a differential signal approximately four times larger than that from the crack.

Further work will include more detailed mesh refinement studies and tolerance analyses.

## Figures used in the abstract

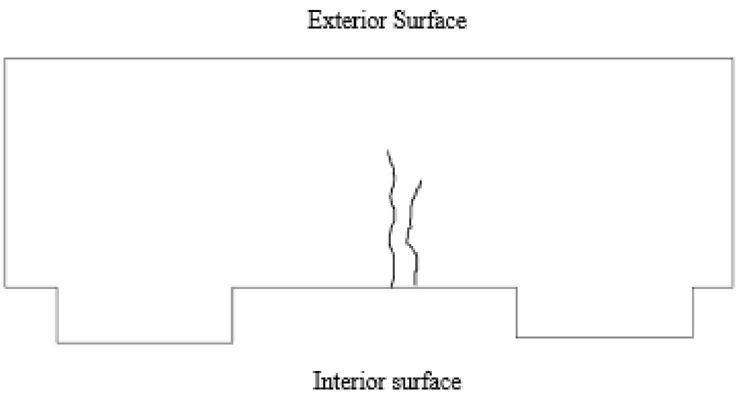


**Figure 1** : Schematic showing the system to be investigated in this study. Cracks are to be detected on an inaccessible, interior surface which is also ribbed.

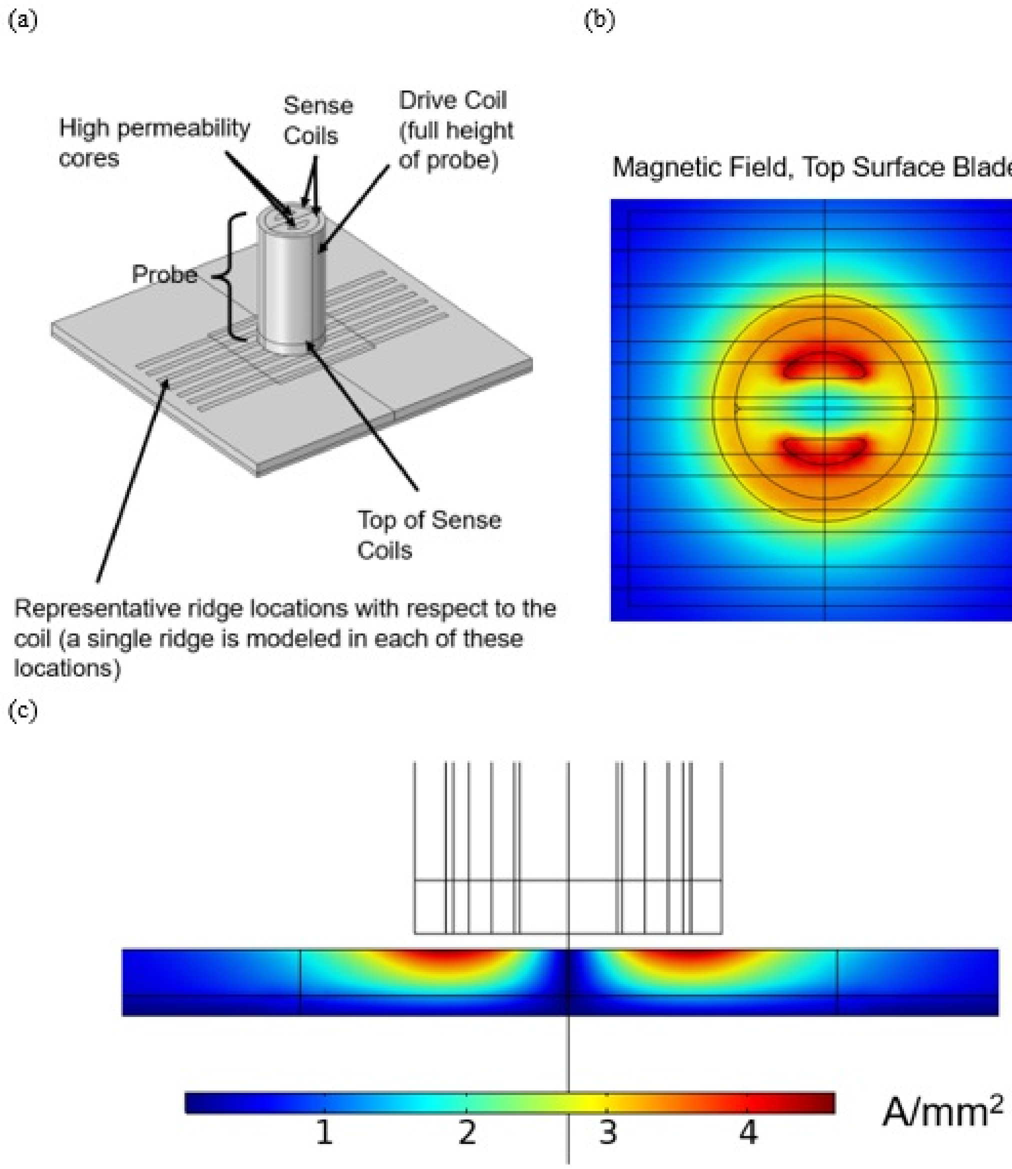


**Figure 2** : Model geometry showing split D probe (a) along with the magnetic field density at the top of the specimen (b) and the induced eddy currents (c).

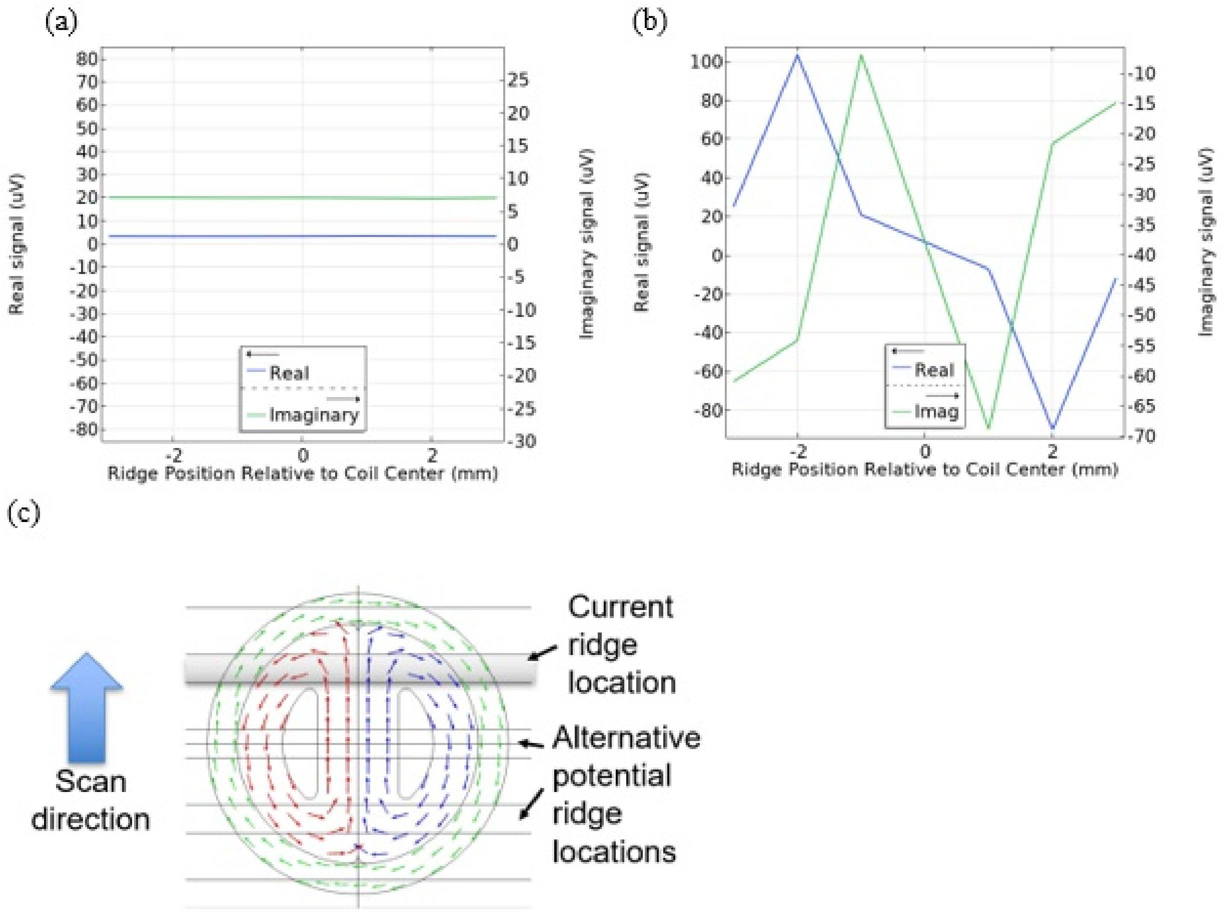


**Figure 3** : Image showing the signal resulting from a ridge (a) and from a crack (b), orientated at 45  with respect to the ridge. The ridges are symmetric with respect to the probe (c).