Master Thesis Proposal
Eddy Current Imaging of Electrically Conducting Media

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Introduction The aim in this master thesis is to investigate numerical modeling and optimization techniques enabling the eddy current imaging of electrically conducting media. Examples of application of this non-destructive testing technique include the detection of corrosion spots in gas pipelines and of cracks in sheet metal. The thesis is to be carried out in the context of a collaboration between the Delft Institute of Applied Mathematics (DIAM) and the Instrumentation Oil and Gas Division of TNO Science and Industry (TNO). DIAM will provide support in mathematical modeling and numerical methods (partial differential equations, discretization methods, non-linear, linear system solvers and optimization methods) while TNO will bring in its expertise in the application of imaging using electromagnetic sources and provide a bench mark model with measurement data.

Problem Formulation In the context described above we formulated two thesis proposals in which we distinguish between solving the so-called *direct* and *inverse* problem [4]. The direct problem consists of solving for the effect (the electromagnetic fields distribution) assuming the cause (sources) to be given. In the context of electromagnetic imaging the direct problem usually amounts to solving a (set of) partial differential equation(s) derived from the Maxwell equations supplied with boundary conditions. The inverse problem consists of finding the sources giving rise to a a-priori given or measured effect. It amounts to solving an optimization problem in which one looks for the source field that minimizes the discrepancy between the measured and data obtained through modeling.

Being ill-posed and computationally more complex, the inverse problem is typically harder to solve than the direct problem. Constructing appropriate algorithms is therefore of paramount importance. In this thesis we aim at a contributing to this final goal. We will classify solution techniques for inverse problems including regularization and non-linear optimization methods [3], select a few of the most promising ones and implement these in a demonstration software package and apply them to a model problem of electromagnetic imaging.

Roadmap To succesfully carry out the project, we distingiush the following steps:

- perform a literature study into topics such as eddy current imaging, inverse problems including regularization techniques [1, 2], partial differential equation constrained optimization problems and non-linear optimization methods; this study should lead to a motivated selection of one or a few strategies to solve the inverse problem.
- properly formulate both the direct and inverse problem in eddy current imaging;
- formulate model and quasi realistic problems. These problems will serve as a test bed for the solution algorithms choosen.
- construct an software environment allowing to call the different solution techniques chosen. The use of the Comsol Multiphysics finite element software environment is to be considered here;

- test the software on the model problems chosen;
- write the thesis report

Deliverables As delivarables in the project we foresee

- a documented perspective of existing methods to solve the eddy current imaging problems
- a properly motivated selection of one or a few solutions methods
- a prototype implementation of selected method(s)
- master thesis report

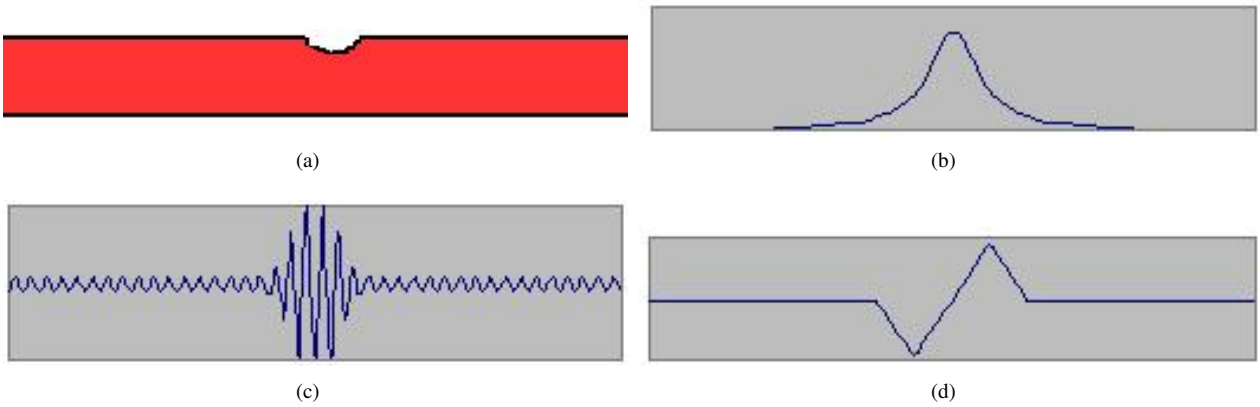

Figure 1: Eddy current imaging of a pipeline (courtesy of RST Projects Ltd).

References

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