Model based design of an EMAT probe for wall thinning evaluation in pipe elbows using guided waves

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The PYRAMID project is an International Collaborative Research Project (PRCI), which brings together French and Japanese public laboratories, an International Joint Unit and the Nuclear Technology Research Laboratory at CRIEPI a nonprofit research foundation, supported by the electrical Japanese industries. PYRAMID project aims to develop new tools and techniques to detect and quantify wall thinning due to Slurry Flow induced Corrosion (SFC) in piping systems. SFC is a special case of Flow Accelerated Corrosion (FAC) in presence of a flow with a high concentration of debris of various kinds (concrete, corrosion, metallic…). The final goal is to provide a risk management system based on prediction-monitoring of wall thinning due to SFC. In terms of NDT, an ultrasonic Non Destructive Testing (UT) method based on guided waves produced by Electro-Magnetic Acoustic Transducers (EMAT) will be developed. One of the major issues to address concerns the mode conversions happening when the guided waves are scattered by an elbow and a flaw. Adapted modelling tools are thus needed to support the probe design. Numerical studies of GW scattering are often computationally expensive because of very short wavelengths compared to the size of the pipe. Furthermore, the number of scattered modes from non-axisymmetric defect (as typical corrosion area, crack…) can be too large for standard finite element method (FE). Accordingly, the simulation platform CIVA deals with models based on a Modal Formalism to simulate non-destructive inspection by GW using the Semi-Analytical Finite Element method (SAFE). Presently, EMAT sources are taken into account in an efficient hybrid SAFE/FE method for computing the scattered modes by an arbitrary complex defect that has been implemented for several years in CIVA NDT simulation platform by CEA. This paper presents experimental configurations, consisting in carbon steel pipes with straight parts but also elbows, which are used to validate the simulation code. An EMAT excitation is used to generate UT guided waves in the pieces under test. Quantitative comparisons between experiments and simulations will be shown and discussed. In particular, we will show that simple experimental configurations allow to validate the simulation tool. Some prospects will finally be discussed for the simulation of more realistic configurations and the design of a full NDT system design.