5th International Workshop on Laser-Ultrasound for Metals
May 5-6, 2022
Gif-sur-Yvette, France

Modeling method for the simulation of austenitic weld ultrasonic inspection - realistic prediction of echoes and structural noise in weld inspection

P.E. Lhuillier[1], A. Schumm[1], Y. Gelebart[1], J. Dalphin[2], G. Guillemot[3], C-A Gandin[3], C. Xue[3]
[1]EDF R&D – EDF Lab Les Renardières – Materials and Mechanic of Components department, Moret-sur-Loing, France.
[2]EDF R&D – EDF Lab Saclay - France
[3]MINES ParisTech, PSL Research University, CEMEF, 06904 Sophia Antipolis, France

In-service Non-Destructive examination of welds encountered in the primary circuit of nuclear power plants is a major issue for the safety of the installation. When inspected with ultrasound, the welds exhibit highly anisotropic and complex microstructures which induce beam perturbations and structural noise. The numerical modeling is then a preferred tool for the prediction of the performance of ultrasonic nondestructive examination of the weld and for the analysis of complex data obtained from weld inspection.

The simulation approach developed by EDF R&D is based on the modeling of the microstructure of a weld in association with a finite element solving of the ultrasonic propagation. Firstly, a virtual synthetic model of anisotropic and textured structure with homogeneous columnar grain orientation has been used to quantify the ultrasonic attenuation as a function of the grain to ultrasonic beam angle. The quantification of the attenuation is compared with experimental data and reveals a very good agreement.

Secondly, a similar method has been applied to compute the ultrasonic propagation into a synthetic realistic (2D) weld microstructure. The grain size, grain orientation map and crystallographic texture are obtained from Electron BackScatter Diffraction (EBSD) measurements. Voronoi tessellation is used to create an artificial weld microstructure. This approach enables to reproduce the main phenomena which degrade the inspection of welds - attenuation, beam perturbation and structural noise – and allows to obtain an accurate description of ultrasonic echoes.

Finally, in the frame of the NEMESIS project, in collaboration with CEMEF, the approach has been extended with the use of a weld microstructure obtained from a Cellular Automaton – Finite Element (CAFE) simulation predicting the solidification structure. A virtual microstructure corresponding to a Gas Tungsten Arc Welding multi-pass process has been injected as the propagation media of the 3D Finite Element solver of the ultrasonic propagation: A3D. Qualitative results are presented, and the perspectives opened by this proof of concept will be discussed.