Early detection of High Temperature Hydrogen Attack using ultrasonic arrays

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High Temperature Hydrogen Attack (HTHA) results from hydrogen reacting with carbides in steel at elevated temperatures and pressures. This structural modification introduces voids along grain boundaries that may combine to form microfissures and cracks. In order to prevent equipment from failure, Non-Destructive Evaluation (NDE) using ultrasounds is generally used to screen potential HTHA deterioration. A combination of different ultrasonic technics such as Time of Flight Diffraction, Phased Array Ultrasonic Testing, Advance Ultrasonic Backscattering Technique and more, is generally required for the technician to give his diagnostic. Usually, these NDE methods have common limitations linked with Signal to Noise Ratio and Resolution. Indeed, early detection of HTHA is related to the capability of theses methods to differentiate noise contributions from multiple point source reflectors with the material structural noise. This paper proposes a new HTHA detection method using the scattering matrix. This technic based on an ultrasonic array acquisition is interested in the scattered field from a defined zone. This post treatment method has demonstrated excellent results in super imaging and defect characterisation in highly scattering materials. In this work, an HTHA propagation model in a granular material was developed using Pogo Finite Elements software. Different grain size microstructure and material deterioration severity were simulated in an anisotropic steel block. This grains + voids modelling approach gives an insight into the HTHA detection problem by focusing on the scattered field modification. This new inspection method is not limited by image reconstruction limitation and has demonstrated excellent results in early detection of HTHA deterioration.