Modelling of wear defects under an external object for the ECT of SG tube

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Abstract

The vibration of the tubes in steam generators (SG) causes fretting-wear, especially in the tubes bended parts near anti-vibration bars (AVB). Similar degradations, with more unpredictable shapes, can also be caused by foreign objects, like a welding rod located in the secondary area of the SG for example. This joint study between CEA LIST and IRSN aims at efficiently simulating eddy current testing (ECT) signals due to fretting-wears. For this purpose new advanced geometric tools feed the 3D models developed by the CEA LIST allowing to quantify the influence of the various geometric parameters of the configuration. In particular, we want to verify the ability of usual simplified geometric representations to approximate these signatures (typically with a rectangular notch in a straight tube to represent the wear under AVB). This numerical study is accompanied by numerous experimental acquisitions on machined tubes, with and without external object.

1. Main results

1.1 Advanced modelling tools

Advanced geometric modelling tools, such as a vibratory motion associated to the external object so as to model a realistic wear defect by deforming the mesh of the tube, have been developed in the same spirit (and thus compatible) as those previously introduced for the study of the modelling of U-bend steam generator (SG) tubes [1]. First numerical comparisons could then be conducted. In particular, we found a cumulative influence of about 15 to 20% of the signature of the anti-vibration bar (AVB) and the shape of the wear defect on the amplitude of the signal, which is relatively small with respect to the influence of the depth of the defect but remains non-negligible.

1.2 First quantitative comparisons

We compared the simulated signal to acquisitions data for an AVB made of Inconel and placed at different distances from the tube that was inspected with two bobbin coils, known as the SAX probe, operated in differential mode at a frequency of 280 kHz. The experimental device, the simulated control configuration as well as the signals obtained, here the imaginary part of the impedance variation, are illustrated Figure 1.

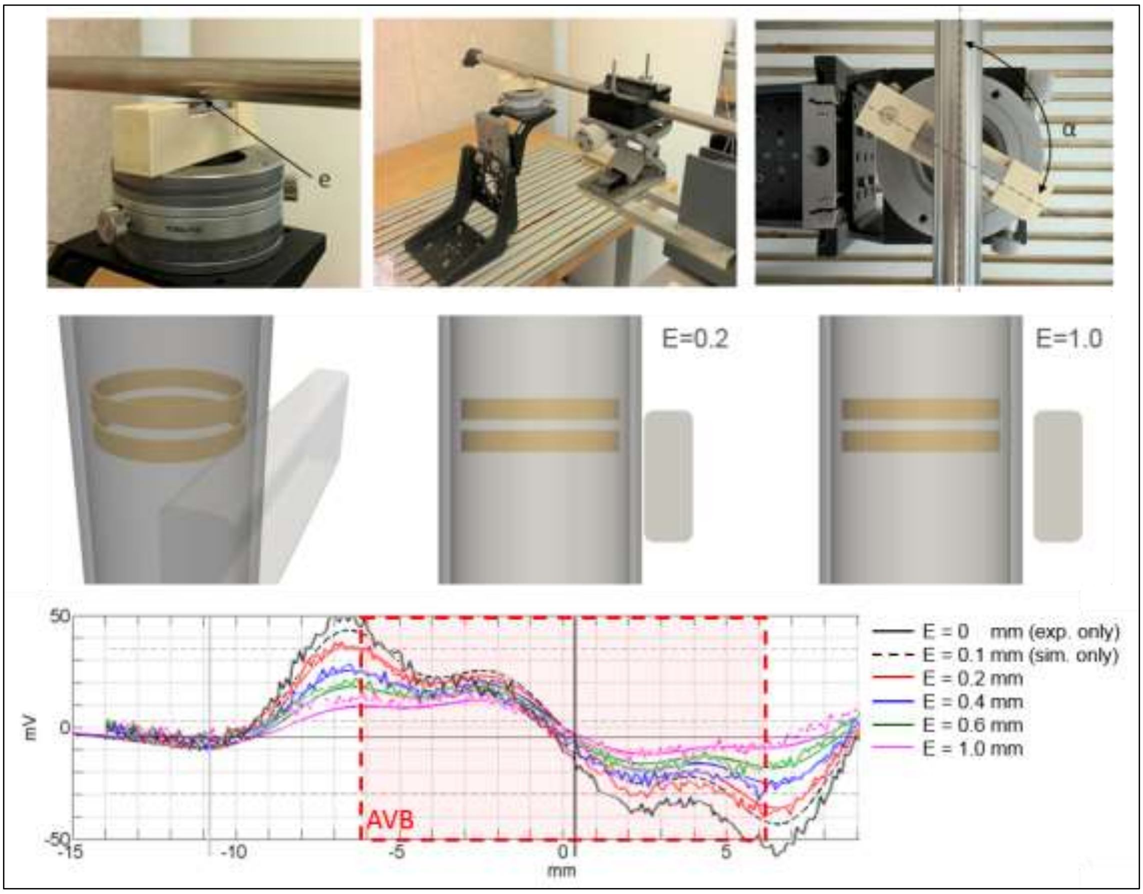

Figure 1. Quantitative comparison between simulated and experimental data with respect to the distance (E) between the AVB and the healthy tube: Experimental device (top), simulated configuration (center) and imaginary part of the impedance signal (bottom).

2. Ongoing work

These first comparisons confirmed the good behaviour of the model which faithfully reproduces the AVB signal despite being of low amplitude (in comparison with a wear defect). On the other hand, various comparisons of this (numerical) model with semi-analytical models that are available on idealized configurations (undistorted tube in the presence of holes, notches...) have confirmed the good reproduction of the simulated signals. The next validation campaign based on comparison with experimental data will concern the signal of wear defects in the absence and then in the presence of the AVB.

References

1. E. Demaldent, C. Reboud, F. Nozais, T. Sollier and G. Cattiaux, "Advances in Modelling the ECT of U-Bend steam generator tubes based on the boundary element method", 22nd International Workshop on Electromagnetic Non-Destructive Evaluation (ENDE), 2017