Iterative time reversal based flaw identification

Abstract:
In the field of ultrasonic non-destructive testing, ultrasonic impulses are used to detect flaws in components without causing damage. Based on performing experiments alone, it is possible to infer the state of the component—but this usually provides only limited details about the interior damage such as its position, dimension or orientation. Furthermore, the amount of sensors that can be used to record the signals is restricted to only a few because of the shape and the dimensions of a typical specimen and considerations such as costs, additional mass and structural integrity. Further information about the flaw is hidden in the recorded experimental signals.

The idea of the proposed method is to use the experimental data together with a wave speed model of a healthy component and to try to adapt the model to generate these experimental measurements. Formally, the problem is posed as a nonlinear optimization, and the wave speed model is adapted in such a way that the discrepancy between the experimental measurements and the model output is minimized. Moreover, to overcome the problem of only a few available sensor measurements, a combination of multiple simulations corresponding to generally performed multiple experiments in SHM practice is used to improve the accuracy.

Following this approach, the position, dimension and orientation of a flaw can be detected for an emulated damaged aluminum plate. For cases when there are only few sensors available, it is shown how a combination of similar experiments can be used to improve the inversion results.