Finite Element Model Based Optimization of Pulsed Eddy Current Excitation Rise Time

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Abstract

Non-destructive Evaluation (NDE) techniques are widely used for early detection of defects in engineering components without impairing their future usefulness. Among them, Eddy Current (EC) technique is used for detection of defects in electrically conducting materials and it is known for its high speed inspection and reliability. Conventional EC technique uses sinusoidal excitation and has limited depth of penetration due to its single frequency content. Pulsed eddy current (PEC) technique, a variant of the EC technique uses high amplitude short duration pulses having a spectrum of frequencies. Hence, PEC enables wider depth of investigation compared to the conventional EC technique. The sensitivity of the PEC technique depends on the rise time of the pulse. Hence, there is a need to optimize the pulse rise time for enhanced detection of defects in materials and components. Finite element (FE) modeling is a natural choice for such optimisation studies.

For this optimisation studies, the transient analysis with COMSOL Multiphysics® - AC/DC Module has been used. The FE model PEC system consists of a probe with excitation and receiver coils placed over a thick metallic specimen. The exciter coil is fed with a current pulse whose shape like a Heaviside step function and the receiver coil senses the response due to the eddy currents produced in the metallic specimen by the pulse excitation.

Initial studies were carried out by predicting the time domain voltage response of the receiver coil placed on a stainless specimens of thickness 5 mm, 8 mm and 10 mm and 12 mm. Details Time-Frequency analysis of the model predictions using wavelet transform method revealed that the optimum rise times are unique for each thickness and it increase with increase in thickness of specimen. This has a direct relationship with skin-effect. Similar studies have also been performed for Hastelloy and Aluminium plates of different thickness towards establishing an empirical relation for optimum pulse rise time as function of specimen thickness and electrical conductivity.