Multiple Parameter Extraction from Eddy Current Data: Comparison of Inverse Analytical and Machine Learning Algorithms

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Eddy current inspection data may be simultaneously influenced by multiple parameter variations that affect the recorded signal response and thereby, the desired inspection outcome. Under these conditions detection capability and information regarding a target flaw or measurement may be severely compromised. In this work eddy current based measurement of separation (gap) between two coaxial conducting tubes from within the inner tube is examined. The tubes are components in the fuel channels of CANDU® reactors. During operation, the horizontally oriented 6 m long pressure tube (PT) carry nuclear fuel bundles and heavy water for heat transport at temperatures of 300 °C. The gap provides an insulating barrier between the inner PT and surrounding calandria tube (CT), which is cooled by an external heavy water moderator. Initially, four annulus spacers maintain the gap. However, over time PT creep, due to high temperatures and weight of the fuel bundles, brings the tubes closer together with the risk of contact. Contact avoidance is critical, since it can lead to the formation of hydride blisters on the PT with the risk of cracking. The multi-frequency eddy current measurements from within the PT are essentially a lift-off measurement of the CT, also impacted by variable parameters of the PT. These include variations in PT wall thickness, PT resistivity, and lift-off of the probe from the PT surface. Compensation for these multiple parameter effects, to achieve a high accuracy gap measurement, is examined using inverse algorithms based on an analytical model and machine learning. The relative advantages and shortcomings of each of the methods are compared and potential solutions for a robust gap measurement algorithm are explored.