Eddy Current Array Testing for Subsurface Defects Detection

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Eddy current testing is widely used in many industries, including power generation, aviation, and oil and gas. In nuclear power plants, eddy current testing is commonly applied to inspect tubular products such as those found in steam generators, balance-of-plant (BOP) heat exchangers and main steam condensers. Recently, the eddy current array (ECA) technique was introduced to the NDE industry. This technique can drive numerous eddy current coils that are positioned next to one another in the same probe assembly. EPRI conducted research on the eddy current array (ECA) technique to detect and characterize subsurface flaws in terms of volumetric examination. Multiple ECA probes (with frequencies ranging from 1 kHz to 15 kHz) and various coil topologies were considered to assess the ECA technology in this study. A 316L stainless steel specimen was fabricated with FBHs and notches of different sizes and depths to simulate the condition of the subsurface defect. The experiment result showed that the low-frequency ECA probe was able to detect a 4 mm subsurface volumetric defect and a 3 mm subsurface notch. Eddy current array modeling and simulation study for subsurface defects were conducted to compare the experimental results. The simulation results show that good detection can be expected for subsurface defects having a ligament up to 2 mm using low-frequency ECA probes. The flaw signals were clearly seen both in measurements and in simulation results. For defects with a ligament of over 3 mm, the experimental flaw signal becomes low in amplitude and noisy. However, the simulation results, even if its amplitude is low, the flaw signal is clearly seen since the noise is not modeled but the amplitude obtained in the simulation is still well correlated to measurements. Overall, the ECA modeling and simulation could predict the signals on the subsurface defect with a good match, and it can be adapted for the development of the ECA inspection technique and sensor design for specific applications. Surface and sub-surface flaw detection capabilities were also evaluated in typical control rod drive mechanism (CRDM) and bottom-mounted instrumentation (BMI) J-groove weld as-built configurations as seen in the current fleet of operating pressurized water reactors (PWRs) plants. At test frequencies of 25 to 50 kHz, this probe was able to detect all surface and sub-surface flaws with a signal-to-noise (S/N) ratio of > 5:1. It is expected that through the results obtained from this research, the ECA technology can be applied to detect and size the subsurface flaws in the nuclear power plant with optimized frequency and coil topologies for the target applications.