Enhancing Data Analysis in Heat Exchanger Tubes through Artificial Intelligence Algorithms

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In today's global landscape, the non-destructive testing industry, particularly within the oil and gas, petrochemical, and balance-of-plant sectors, faces a daunting challenge: an aging workforce and a growing scarcity of skilled professionals specializing in shell-and-tube heat exchanger tubing inspection. This shortage is most pronounced among certified level 2 analysts capable of analyzing the data acquired. Data analysis is intricate, time-consuming, and susceptible to human error. Simultaneously, industry demands for expedited inspection campaigns continue to mount. In response, the industry is in need of innovative tools that simplify data interpretation, increase analyst efficiency, and improve consistency and confidence in results. While assisted analysis for electromagnetic tube inspection has been around for several decades, existing solutions, whether described in the literature or commercially available, have predominantly catered to Eddy Current Testing (ECT) for steam generator tube inspections. These solutions primarily rely on rule-based detection algorithms that factor in phase angle, amplitude, and relative position of the probe within the tube. However, these approaches encounter limitations when inspection conditions are less controlled, as often encountered in the field - uneven pulling speeds, incomplete tube scans, lack of encoded position data, or insufficient information about the tube bundle configuration, including unknown detailed landmark tables and re-tubed sections. These prevalent inspection challenges are very common outside the nuclear industry and compromise the efficiency and reliability of data interpretation. This paper presents the latest developments in the application of machine learning to overcome these limitations. It introduces a flexible and robust detection engine, capable of adapting to ever-evolving inspection conditions. The algorithm can perform tasks such as landmark localization, potential defect identification, and signal normalization. The paper includes typical implementation results for both ECT and remote-field testing inspection techniques.
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