Ultrasonic inspection of seal wires for nuclear security applications

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Seal wire plays a crucial role in nuclear security applications, serving as a vital means to ensure equipment and material is not tampered with. However, its integrity primarily relies on visual inspection, which can be challenging in scenarios where full access to the wire is restricted or when visual examination is impractical. To address this, this study explores the efficacy of an ultrasonic nondestructive testing (NDT) technique for inspecting the integrity of seal wires, offering a rapid and nondestructive alternative to visual inspection.

The experiments use seal wires composed of approximately 1 mm diameter multi-strand stainless steel rope with a nylon coating. The test setup involves two shear transducers operating in a through-transmission mode, with dry contact to the seal wire. A working frequency of approximately 100 kHz is chosen based on initial investigations, ensuring optimal performance. Rigorous testing is conducted to validate the consistency and reliability of the setup. Analysis of the time-domain signal's reflection echoes enables the calculation of the shear wave's attenuation per unit length and shear wave velocity within the seal wire. This information allows for determining the maximum transmitting length of the ultrasonic wave along the wire. Multiple seal wires with artificial splices of varying lengths and positions are prepared, alongside intact wires of identical lengths for reference purposes.

Experimental findings demonstrate the clear detection of splices through both time-domain signals and frequency spectra analysis. Furthermore, the locations of the splices can be determined by comparing the time-domain signals of the test wire to those of intact wires. Additionally, the study will include an investigation into the influence of temperature variations on the measurements, considering the practical application of the technique in ambient environmental conditions.

In summary, this research showcases the potential of ultrasonic NDT as a reliable and efficient method for inspecting the integrity of seal wires, particularly in scenarios where visual inspection is unfeasible or impractical. The experimental approach and analysis contribute valuable insights into enhancing nuclear security protocols.

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