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High-Speed Rail Inspection Technology via Passive Ultrasonic Monitoring

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ABSTRACT

Recent advancements in high-speed rail inspection technology, developed at the Experimental Mechanics, NDE & SHM Laboratory at the University of California San Diego, are presented. This technology relies on the 'passive' extraction of the Green's function for rail segments to identify discontinuities, such as internal defects, by monitoring changes in wave arrivals. The use of micro-machined air-coupled transducers as receivers has enabled the application of this technology at high speeds in a fully non-contact configuration, facilitating continuous condition assessment of rails. In the previous generation of this system, the wheel's natural excitation was leveraged as the excitation source, while in the present version, a controlled acoustic source was also added to strengthen the excitation, leading to a high signal-to-noise ratio. Additionally, the performance of lightweight non-contact electrostatic ultrasonic transducers is assessed as a potential means to miniaturize the developed prototype. A Real-Time LabVIEW module is created for acquiring, analyzing, and visualizing results, allowing users to monitor both the data and some of results in real-time. A series of field tests were conducted at the Transportation Technology Center Inc. (TTCI) (now MxV Rail) in Pueblo, CO, to assess the technique's performance in detecting discontinuities in the High Tonnage Loop (HTL) at varying train speeds. As part of the post-processing stage, the system's performance was assessed in terms of Receiver Operating Characteristic (ROC) curves by computing the true detection rate and the rate of false alarms flagged by the system. It is observed that higher speeds result in better flaw detection performance, a finding consistent with previous field tests conducted without the controlled acoustic source.

Keywords: NDE, Railroad, Ultrasonic Testing.