Ultrasonics

Estimation of rail properties using semi-analytical finite element models and guided wave ultrasound measurements

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Abstract

Guided wave based monitoring systems require accurate knowledge of mode propagation characteristics such as wavenumber and group velocity dispersion curves. These characteristics may be computed numerically for a rail provided that the material and geometric properties of the rail are known. Generally, the rail properties are not known with sufficient accuracy and these properties also change due to temperature, rail wear and rail grinding. An automated procedure is proposed to estimate material and geometric properties of a rail by finding the properties which, when input into a Semi-Analytical Finite Element (SAFE) model, accurately reproduce measured dispersion characteristics. Pulse-echo measurements were performed and spectrograms show the reflections from aluminothermic welds of three modes of propagation. The SAFE method was used to solve the forward problem of predicting the dispersion characteristics for specified rail properties. Dispersion curves are computed for different combinations of Poisson's ratio and three geometric parameters. These dispersion curves are scaled to cover a range of longitudinal speeds of sound of the rail material. A technique is developed to determine which SAFE model provided the best fit to the experimental measurements. The technique does not require knowledge of the distances to the reflectors; rather these distances are estimated as part of the proposed procedure. A SAFE model with the estimated rail parameters produced dispersion curves and distances in very good agreement with the measured spectrograms. In addition, the estimated mean geometric parameters agreed with the measured profile of the rail head.