CHARACTERIZATION OF PLANE DEFECT IN A RAIL

Chong Myoung Lee[1], Younho Cho[2], and J. L. Rose[1]
[1] The Pennsylvania State University, Engineering Science & Mechanics Department, University Park, PA, USA; [2] Pusan National University, School of Mechanical Engineering, Pusan, South Korea.

Abstract:

This paper presents the theoretical phase velocity dispersion curves and wave structures of a rail. For the characteristics of multiple modes of a rail, the wave structure is an important factor for practical application. The result of this study could help to establish the guideline for the experimental design.

Introduction: Concern on nondestructive testing has increased over decades. Especially, the application of NDE in a nuclear power plant or to a mass transportation system such as a train is more essential since failure can cause a serious disaster. For this reason, many nondestructive testing methods have been developed as a consequence of a great effort of engineers and researchers. Ultrasonic testing using guided wave is a very promising technique because the guided wave can propagate long distance along the structure. The defects are found by detecting reflected waves. The sensitivity can be improved by proper mode and frequency selection.

Practical applications of guided waves for pipes were performed by Rose et al., Lowe et al., and Alleyne and Cawley[1-4]. The applications to the rail are also carried out by Rose, Cawley and Hayashi[5-8].

In this paper, the phase velocity dispersion curves and wave structures for a rail is presented. The experimental data of a vertical crack in the rail head using pulse-echo and through transmission techniques are also discussed.

Numerical Results of a Rail : The phase velocity dispersion curves of a steel rail are calculated using the SAFE technique[9-10]. For the calculation of phase velocity dispersion curves, 68 elements and 101 modes were used. Figure 1 shows the cross-section and meshes of a rail and the phase velocity dispersion curves are represented in figure 2.

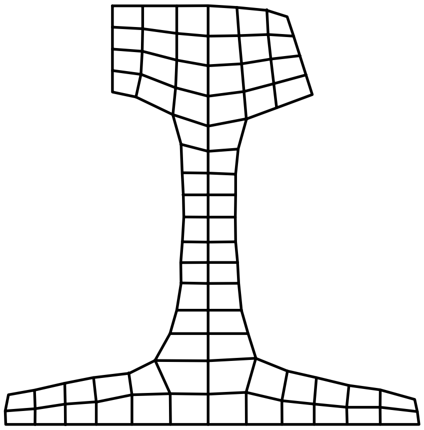


Fig. 1 Cross-section of a rail

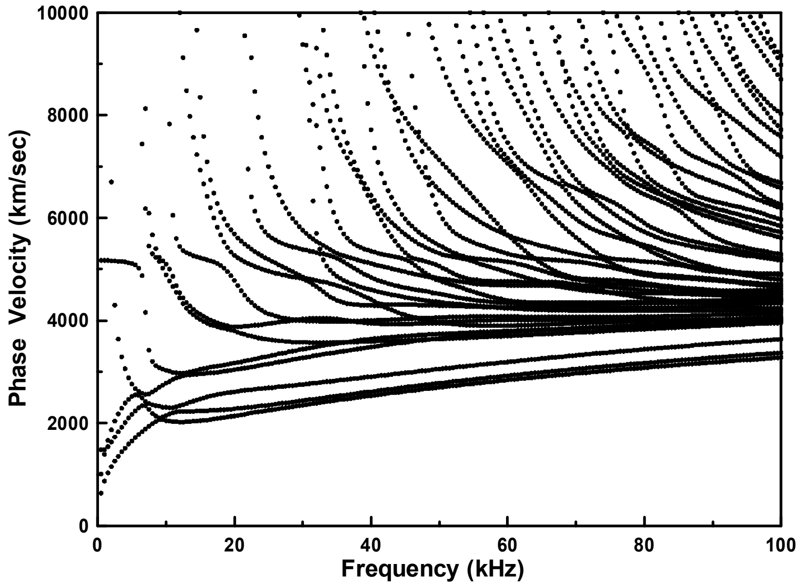
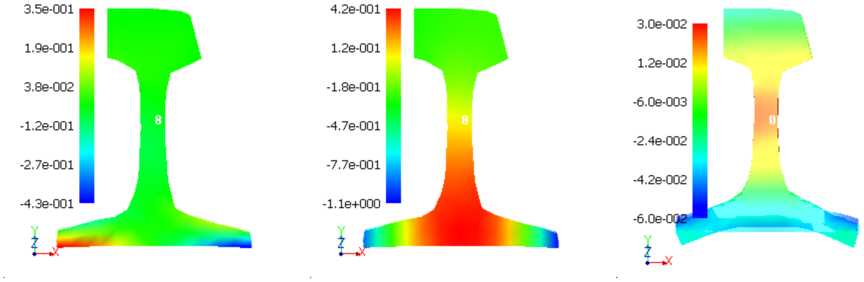


Fig. 2 A phase velocity dispersion curve of a traction free rail.

As it is shown in figure 2, the multiple modes exist in a rail. Comparing with the phase velocity dispersion curves of a plate, the phase velocity dispersion curves of a rail show more complex patterns. For this reason, the wave structure becomes important because it shows whether the energy is at some portion of a rail to be inspected or not. It will provide us with improved insights into wave propagation in a rail for determination of special excitation regions for best sensitivity. Figure 3 shows the displacements in the *x*, *y*, and *z* direction at 10 kHz and a phase velocity of 4.45mm/sec.



(a) displacement x (b) displacement y (c) displacement z

Fig. 3 Wave structure diagrams for a rail

Experimental Result of a Rail : Figures 4 and 5 show the experimental results of vertical defects with various crack depths. The guided waves are generated with 60kHz shear horizontal EMAT transducer located 14’ apart from the defect. In pulse-echo technique, the amplitudes of reflected signals are increased with the crack depth. On the contrary, the amplitudes of the transmission signals are decreased with the crack depth.

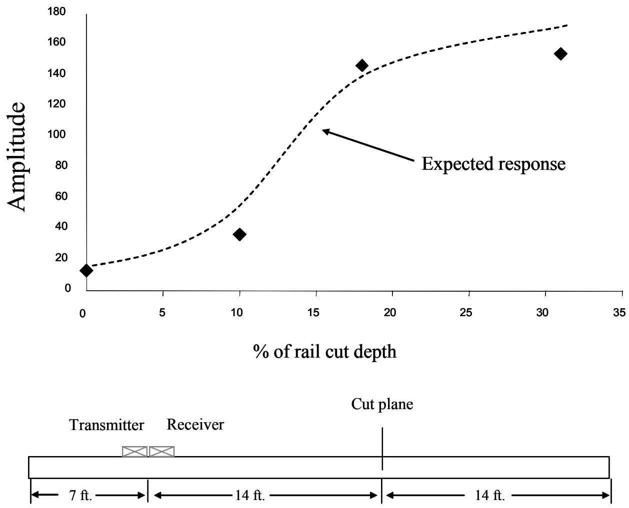


Fig. 4 Experimental result for pulse-echo evaluation of 60 kHz SH EMATs

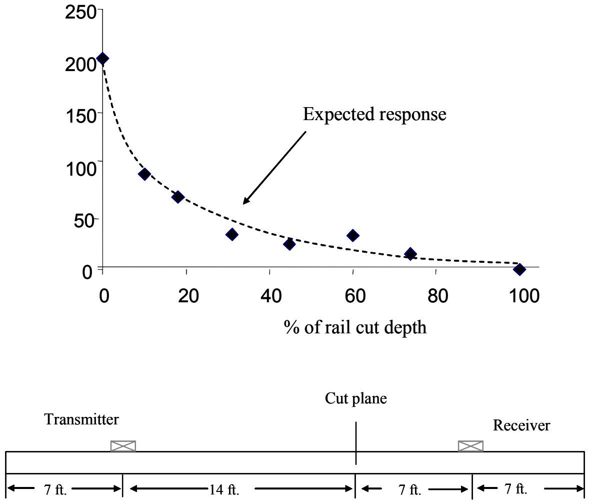


Fig. 5 Experimental result for through transmission evaluation of 60 kHz SH EMATs

Concluding Remarks: The phase velocity dispersion curves and wave structures of a rail are theoretically calculated and presented in this paper. The reflected and transmitted signals are experimentally obtained with 60kHz EMAT transducers. The wave structures could be a guideline of experimental design and data acquisition.

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