

SAFE-3D Analysis of a Piezoelectric Transducer to Excite Guided Waves in a Rail Web

Dineo A. Ramatlo^{1, 2}, Craig S. Long², Philip W. Loveday² and Daniel N. Wilke¹

¹ University of Pretoria, Department of Mechanical and Aeronautical Engineering, Pretoria, South Africa

² CSIR Material Science and Manufacturing, PO Box 395, Pretoria, 0001, South Africa

Abstract

Our existing Ultrasonic Broken Rail Detection system detects complete breaks and primarily uses a propagating mode with energy concentrated in the head of the rail. Previous experimental studies have demonstrated that a mode with energy concentrated in the head of the rail, is capable of detecting weld reflections at long distances. Exploiting a mode with energy concentrated in the web of the rail would allow us to effectively detect defects in the web of the rail and could also help to distinguish between reflections from welds and cracks. In this paper, we will demonstrate the analysis of a piezoelectric transducer attached to the rail web. The forced response at different frequencies is computed by the Semi-Analytical Finite Element (SAFE) method and compared to a full three-dimensional finite element method using ABAQUS. The SAFE method only requires the rail track cross-section to be meshed using two-dimensional elements. The ABAQUS model in turn requires a full three-dimensional discretisation of the rail track. The SAFE approach can yield poor predictions at cut-on frequencies associated with other modes in the rail. Problematic frequencies are identified and a suitable frequency range identified for transducer design. The forced response results of the two methods were found to be in good agreement with each other. We then use a previously developed SAFE-3D method to analyse a practical transducer over the selected frequency range. The results obtained from the SAFE-3D method are in good agreement with experimental measurements.