

PHYSICAL IMPLICATIONS OF CHARACTERISTIC SPEEDS AND WAVEFORMS OF RAILS ON ELASTIC FOUNDATIONS

Cory A. Kaufman

Dr. P. Frank Pai, Thesis Supervisor

ABSTRACT

When a moving load is applied on an elastic rail with an elastic insulator, wave propagation can occur and become problematic after certain characteristic speeds are reached. Research of these waveforms and characteristic speeds is specifically applicable for understanding electromagnetic railgun dynamics. There are three characteristic speeds for an elastic rail on an elastic foundation: critical, shear, and bar speeds - critical speed being the slowest and the first speed reached by the armature, followed by shear and bar speeds respectively. Studying these speeds and the deformations associated with them is essential in understanding the dynamics and damage effects of rail-armature interaction. One dimensional analysis of a quasi-stationary load moving along an infinite beam on an elastic foundation reveals different waveforms between these characteristic speeds. Furthermore, two-dimensional finite element analyses of rail cross-sectional planes reveal the geometrical mode shapes and their longitudinal wave propagation within the rail. Under different excitation frequencies the magnitudes and propagation speeds of these modes change. With an elastic foundation we show that some of these modes have cut-on speeds, which result in different critical velocities in the rail-armature system. Moreover, the relationship between the critical speeds and different size, geometrical, thermal, and insulator properties are examined. Understanding the waveforms and mode shapes of a typical rail foundation is the goal of this research. With a firm understanding of the dynamics and accurate modeling, various computational scenarios are investigated to find a feasible solution that can reduce the damaging interaction between the armature and rails.