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Design and Analysis for a 4-Stage Crash Energy Management System for Railway Vehicles

Authors : Ziwen Fang, Jianran Wang, Hongtao Liu, Weiguo Kong, Kefei Wang, Qi Luo, Haifeng Hong

Abstract : A 4-stage crash energy management (CEM) system for subway rail vehicles used by Massachusetts Bay Transportation Authority (MBTA) in the USA is developed in this paper. The 4 stages of this new CEM system include 1) energy absorbing coupler (draft gear and shear bolts), 2) primary energy absorbers (aluminum honeycomb structured box), 3) secondary energy absorbers (crush tube), and 4) collision post and corner post. A sliding anti-climber and a fixed anti-climber are designed at the front of the vehicle cooperating with the 4-stage CEM to maximize the energy to be absorbed and minimize the damage to passengers and crews. In order to investigate the effectiveness of this CEM system, both finite element (FE) methods and crashworthiness test have been employed. The whole vehicle consists of 3 married pairs, i.e., six cars. In the FE approach, full-scale railway car models are developed and different collision cases such as a single moving car impacting a rigid wall, two moving cars into a rigid wall, two moving cars into two stationary cars, six moving cars into six stationary cars and so on are investigated. The FE analysis results show that the railway vehicle incorporating this CEM system has a superior crashworthiness performance. In the crashworthiness test, a simplified vehicle front end including the sliding anti-climber, the fixed anti-climber, the primary energy absorbers, the secondary energy absorber, the collision post and the corner post is built and impacted to a rigid wall. The same test model is also analyzed in the FE and the results such as crushing force, stress, and strain of critical components, acceleration and velocity curves are compared and studied. FE results show very good comparison to the test results.

Keywords : railway vehicle collision, crash energy management design, finite element method, crashworthiness test
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