Analysis of the Coupling Mechanism Between Rack Meshing and Wheel-Rail Rolling Contact in Rack Railways - Postprint

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Date: 2024-02-07T00:00:00+00:00

Abstract

For rack railways suitable for mountain rail transit, a three-dimensional transient contact finite element model of rack-wheelset-track based on explicit time integration is established. The model can analyze medium- and high-frequency coupled dynamic interactions between gear-rack meshing and wheel-rail rolling contact. Actual geometries of the wheelset and track, the "wheel paradox" phenomenon caused by the diameter difference between gear and wheel, and structural vibrations are all considered. The gear-rack meshing and wheel-rail contact are solved using a "surface-to-surface" contact algorithm with integrated Coulomb friction. By comparing conditions of zero and non-zero wheel-rail friction coefficients, the influence of the "wheel paradox" phenomenon on dynamic contact is deconstructed. Taking a preliminary designed Strub-type rack railway as an example, dynamic contact phenomena are analyzed at a speed of 10 km/h and gradients of 0‰, 240‰, and 480‰. The results show that, due to the influence of gear meshing, both rack and wheel-rail contact forces exhibit periodic fluctuations, while the total vertical contact force and total traction torque fluctuate around the gravitational load and traction torque, respectively. The "wheel paradox" reduces the rack vertical force and normal contact stress, while increasing the wheel-rail vertical force and normal contact stress; the tangential contact stress on the tooth surface and the slip zone area within the contact patch increase correspondingly. Under a gradient of 240‰, when the wheel-rail friction coefficient increases from 0 to 0.2, the maximum normal contact stress of the rack and wheel-rail changes from 248.69, 752.66 MPa to 195.17, 757.44 MPa, and the maximum tangential contact stress changes correspondingly from 24.48, 152.84 MPa to 21.31, 2.14 MPa. The wheel-rail contact patch exhibits full slip due to significant creep. Under the same speed and friction conditions, increasing the gradient leads to increased rack vertical force and traction force, decreased wheel-rail vertical force and traction force, and contact stresses vary correspondingly.

Full Text

Preamble

The provided text is severely corrupted and does not contain readable Chinese content. The body consists primarily of encoding artifacts, broken characters, and meaningless fragments that cannot be meaningfully translated. All mathematical expressions and placeholders were preserved as instructed, but no coherent academic prose could be extracted from the source material.

Note: Figure translations are in progress. See original paper for figures.