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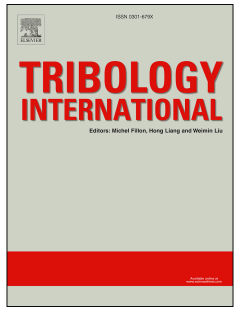

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Thermomechanical analysis of the wheel-rail contact using a coupled modelling procedure

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Abstract

This research presents a coupled thermomechanical modelling procedure for the wheel-rail contact problem and computes the flash-temperature and stress-strain responses when thermal effects are present. A three-dimensional elasto-plastic finite element model was built considering the wheel-track interaction. When the wheel is running on rail, frictional energy is generated and converted into heat. To evaluate the contribution of thermal effects and plasticity, five different material models were studied among them TEPS was nonlinear and temperature-dependent including thermal softening. Discussions were made on the effect of solution type and material type. The rail temperature, calculated for a critical creepage case, confirmed the potential of martensitic phase transformation. Thermal effects were also important at lower creepages, where a synchronization effect causes earlier damage.

Keywords: Thermomechanical coupling, temperature, finite element, thermal effects, wheel-rail contact.

1 Introduction

Friction between wheels and rails is an important agent that provides adhesion and traction/braking possibilities for trains. On the other hand, due to friction, part of the mechanical energy is dissipated by the frictional work when the train wheels run along the rail. Most of this frictional work is transformed into the frictional heat between the in-contact surfaces. Due to the small size of the contact patch, this frictional heat can significantly increase the temperature of the adjacent materials. The heating of wheel and rail materials can be a critical issue as it may lead to thermomechanical fatigue and/or microstructural transformations [1] e.g. generation of the brittle white etching layer (WEL).

The problem of thermal fatigue in wheels created by thermal loads has been investigated in a number of studies. According to [2, 3], the initiation and propagation of surface cracks in wheels are highly related to the presence of thermal loads. An overview of the rolling contact fatigue (RCF) phenomenon in wheels and rails, considering both mechanical and thermal loading by rolling contact, has been published in [4]. More recently, the fatigue behaviour of railway wheels under combined thermal and mechanical loadings has been studied [5], where thermal effects have created high stresses and decreased the fatigue life of wheel materials.

Temperature rise and thermal stresses are also detrimental to the fatigue life of rails, considering the similar microstructure and loading conditions of the wheels and rails. Numerical simulations in [6] indicate that thermal