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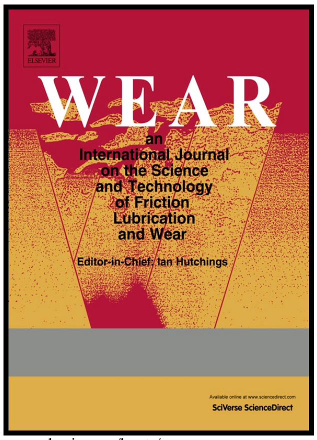

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Effects of Wheel-Rail Contact Modelling on Wheel Wear Simulation

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Abstract

Three non-elliptic contact models, namely Kik-Piotrowski method, STRIPES and ANALYN, are first compared to the Hertz theory and the CONTACT code in terms of the normal contact solution. Further, for the contact models except for CONTACT, the tangential contact solutions are calculated by a modified simplified theory of Kalker (FASTSIM) based on the normal ones to compare with that of CONTACT. Afterwards, a wheel wear prediction model, consisting of a multi-body dynamic model of the railway vehicle, a wheel-rail contact model and a wear function developed by the University of Sheffield, is developed. The influences of the five contact models mentioned above on the wheel wear prediction are investigated from viewpoints of calculation efficiency and accuracy. The results indicate that using Hertz theory and FASTSIM to solve the normal and tangential contact problem, respectively, in the wheel wear simulation is a good choice in order to consider a compromise between the calculation efficiency and accuracy.
Keywords: wheel-rail contact, non-elliptic contact, wheel wear, railway vehicle

1. Introduction

The railway, as an eco-friendly and energy-efficient mode of transportation, has attracted more and more attentions in recent years. To meet the higher requirements of the modern railway, especially of the high speed and heavy haul trains, wear of the wheel-rail contact pair has to be understood better in theory and well controlled in practice. It has been well recognized by train operators that a reliable prediction of wheel wear can help optimize the maintenance plan of wheelsets and the design of vehicles, for example the wheel/rail profiles and the suspension.

The complexity or uncertainty of wheel wear prediction may come from the simulation of the vehicle-track dynamics, modelling of the wheel-rail rolling contact, determination of the wear rate and other technical details such as the smoothing and updating of the profile after each cycle. The contact solutions required in wear prediction include the size and shape of the wheel-rail contact patch, normal and tangential contact stresses, and the stick-slip distribution in the contact patch. Sufficient accuracy is required because errors can be constantly accumulated in the simulation. The contact model used has to be efficient in computational costs because the wheel-rail rolling contact needs to be solved every time step.

Rolling contact models based on the boundary element method, like Kalker's CONTACT [1], or on the finite element (FE) method are not suitable to the wheel-rail wear prediction due to their high computational costs. Analytical solution of rolling contact is a more feasible choice, at least from point of view of the current computational power. Today, several analytical solutions for non-elliptic contact based on the virtual penetration method have been proposed by Linder [2], Kik and Piotrowski [3-4], Ayasse and Chollet [5], Alonso and Giménez [6-7]. Sichani et al. [8] developed an analytical method using the concept of approximate surface deformation. In these models, tangential problem for the non-elliptic contact is usually solved with the modified FASTSIM of Kalker [9].

Sichani et al. [10] investigated the precision and accuracy of non-elliptic contact models, including the Linder method [2], the Kik-Piotrowski method [3-4] and the Ayasse-Chollet method (STRIPES) [5]. These models were implemented and compared in terms of contact patch, as well as contact pressure and traction distributions, and were evaluated using CONTACT software. Recently, Sichani et al. [11] investigated the difference between the new method developed by themselves, named ANALYN [8], the approximate model of Kik-Piotrowski and the results of CONTACT. The research indicated that ANALYN is more accurate in terms of contact patch and stress distribution as well as creep force estimation. Enblom and Berg [12] investigated the effect of the elastic deformation on the sliding velocity and further on the wheel wear. The rigid and elastic methods embedded in the FASTSIM and CONTACT codes were compared. It was found that a reasonable agreement in wheel wear volume existed for the pure slip case with large spin, but a significant difference occurred for the partial slip case. The influence of non-elliptic contact modelling (STRIPES) on the wheel wear rate and profile shape also was investigated by Enblom and Berg [13].

This paper focuses on the calculation accuracy and efficiency of the existing non-elliptic contact models, including Kik-Piotrowski method [3-4], STRIPES [5] and ANALYN [8], and on the effect of wheel-rail contact modelling on the wheel wear prediction. These non-elliptic models and Hertz theory are used to determine the shape and size of contact patch and contact pressure distributions. Based on the normal solutions, Kalker's simplified theory (program FASTSIM) and its modified