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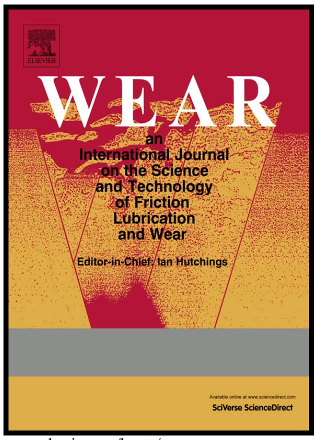

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Numerical Assessment of Materials Used in Railway Crossings by Predicting Damage Initiation – Validation and Application

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Abstract

The Dang Van damage criterion is utilized to predict (subsurface) damage initiation in railway track crossing components. A simplified, explicit finite element model is used to calculate the cyclic impact of a wheel on a crossing nose (frog point). The model is applied to an elastic and to three elastic-plastic materials (manganese steel, chromium-bainitic steel and tool steel). These three materials deform differently, and that difference affects the loading on the crossing after a period of time in use. Plastic deformation is calculated and validated with measurements. The damage parameter (P_{dv}) is then calculated to compare the damage initiation tendency of the three materials with their plastically deformed shapes. The positive effect of changing the geometry of higher strength steel crossings is also discussed.

1. Introduction

Crossings (frog points) are a key part of the track system: they allow gauge corner intersections of two different track routes. Depending on their design and type, high forces can occur during the transition of the wheel from one rail to the other. Especially fixed crossings, which have a design-related gap, are of particular interest, see Fig. 1. This design forces the wheel to move downwards and upwards (1-3 at the top in Fig.1), which leads to high contact forces and an impact of the wheel onto the crossing nose. Furthermore, the contact radii of the wheel and the rail change during the transition (2-3 at the bottom in Fig. 1), which cause slip and can also increase the contact stresses due to the small head radii of the crossing nose. Axle loads and speeds, but also the crossing geometry and wheel profiles, i.e. hollow wheels [1], influence this process and can be the reason for severe wear and damage [2].
Common tools to predict this dynamic process are the multi-body simulation (MBS) and the Finite Element (FE) method. The former enables the user to analyze complex structures very fast by dividing them into a system of rigid and flexible bodies and calculating their displacements. The FE method, however, allows to calculate stress and strain fields in the bodies with complex material laws to account for e.g. plastic deformations. To investigate mechanisms of damage locally, those results are needed.
Kassa et al. [3] developed a MBS model to calculate the dynamic response of a turnout. With additional tools, they calculated contact pressure and stresses. To predict wear and damage, they overcame the main disadvantage of MBS models and accounted for plastic deformation and evaluated stresses and strains in the body. Simplified FE models are added to the analysis chain and data is transferred between these methods.
Yan et al. [4] and Wiest et al. [5] used the explicit FE method to calculate the loading on a crossing. This method can calculate the entire dynamic process and evaluate stresses, strains and plastic deformation at a material point within the body. . For a high resolution, however, a high number of small elements is needed, which increases the