Wheel wear prediction by means of multibody simulations with non-Hertzian contact models

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EXTENDED ABSTRACT

1 Introduction

The prediction of wear involves predicting the lost or displaced volume of mate-rial from the contacting surfaces, which is a highly complex problem since it de-pends on several factors, namely, the geometry of the surfaces, sliding velocity, contact pressure, friction conditions, material characteristics, humidity, tempera-ture, and presence of debris [1]. These features influence the shape of the contact patch and the size of the adhesion and slippage regions, which ultimately affect the wear of profiles.

The relevance of this phenomenon led to the development of several computational methodologies to predict wear in wheel-rail contact using multibody simulation of railway vehicles. Although several authors have studied the wear evolution of wheel and rail profiles, the most popular wear models are the Archard, BRR, and USFD [2]. Regarding contact, most of the studies assume a simplified Hertzian contact combined with the FASTSIM algorithm to evaluate the tangential tractions. Thus, few works consider non-Hertzian contact models to predict wear progression during dynamic simulations [3]. Since the vehicle must travel thousands of kilometers to achieve a substantial wear volume, assessing wear evolution requires simulations with long tracks and, therefore, computational efficiency is essential.

The focus of this study is on the description of the numerical methods applied for the wear assessment, namely, to compute the wear, define the wear distribution or smooth the profiles, making this work replicable. The developed wear tool is demonstrated in an in-house multibody software, MUBODyn.

2 Methodology

The wear prediction tool developed in this work controls the multibody simulations performed in MUBODyn and post-processes their results according to the following consecutive steps: i) “Wear Function”; ii) “Apply Wear Distribution”; iii) “Accumulate Wear Quantity”; iv) “Smooth Wear Distribution”; v) “Remove Material From Profile”; vi) “Smooth and Update Profile”. These steps are explored in this work providing the impact of the considered assumptions and the relevant parameters, filling a gap in the state of the art.

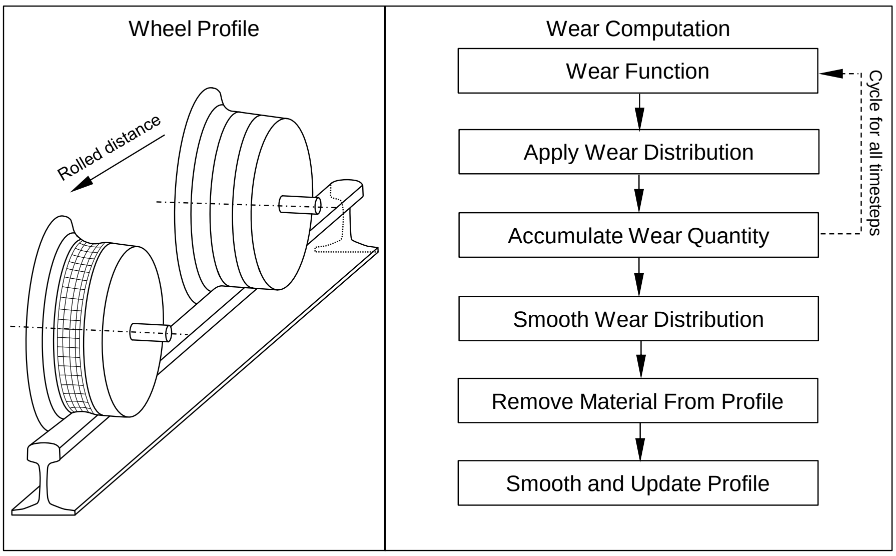

Figure 1: Wear prediction procedure.

3 Simulation cases

The wear prediction tool described is assessed through its application in a case scenario. The passenger vehicle proposed in the Manchester Benchmark is utilized in this study. The wheels have a nominal diameter of 920 mm, with the worn S1002 profile after 300,000 km. For this application case, the vehicle negotiates a right curve with a prescribed speed of 100 km/h. Track irregularities are included to obtain more realistic contact simulations, and the track flexibility is considered through a co-running model, which consist of having a model of rails, sleepers and foundation under each wheelset. The rails have the UIC60 profile with an inclination of 1/40, and the track gauge is 1435 mm. The resulting wear of the leading left (W1L) and leading right (W1R) wheels when considering the Hertzian (H) contact and non-Hertzian (nH) contact is shown in Figure 2.

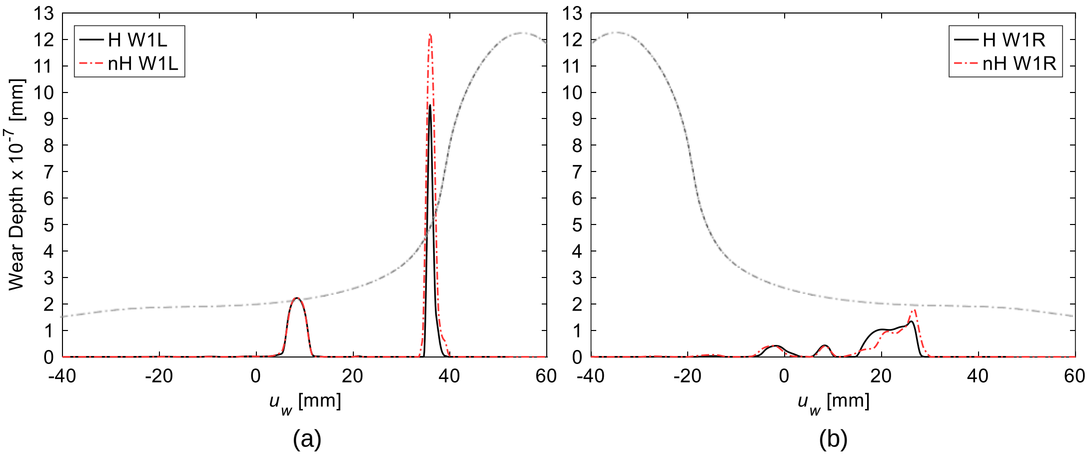

Figure 2: Wear depth comparison for (a) left and (b) right leading wheels, for both. Hertzian and non-Hertzian models. Dash dot line represents the wheel profile.

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