On Heavy-Haul Wheel Damages using Vehicle Dynamics Simulation

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Abstract

Maintenance cost is one of the important issues in railway heavy-haul operations. In most of the cases, these costs are majorly referring to reprofiling and changing the wheels of the locomotives and the wagons. The main reason of the wheel damages is usually severe wear and/or surface initiated rolling contact fatigue (RCF). This work tries to enhance and improve the knowledge of the wheel wear and RCF prediction models using dynamic simulations. While most of the contents of this study can be generalised to other operational networks, this study is focused on the locomotives and wagons of the Swedish iron-ore company LKAB. The trains are operating on the approximately 500 km long IORE line from Luleå to Narvik in the north of Sweden and Norway respectively. Firstly, a literature survey of dynamic modelling of the wagons with various three-piece bogie types is presented. Then, with concentrating on the standard three-piece bogies, parameter studies are carried out to find out what the most important reasons of wheel damages are. Moreover, the long-term stability of wheel profiles of the IORE wagons is analysed. This is done by visualising the wear and RCF evolution on the wheel profiles over 150,000 km of simulated running distance. Most of the calculations for the wagons are repeated for the locomotives. However, traction and braking are also considered in the simulation model and their effects on wheel damages are briefly studied. To improve the accuracy of the wheel damage analysis, a newly developed algorithm called FaStrip is used to solve the tangential contact problem instead of FASTSIM. The damage prediction model developed in the thesis is used to study the effects of increasing axle load, correcting the track gauge, limiting the electro-dynamic braking and using a harder wheel material on the wheel life. Furthermore, a new method is developed to predict the running distance between two consecutive reprofilings due to severe surface initiated fatigue. The method is based on shakedown analysis and laboratory tests. Most of the research works in wear calculation are limited to two approaches known as wear number and Archard methods. The correlation between these two methods is studied. The possibility of using the relation between the two methods for the wear calculation process is investigated mainly to reduce the calculation time for wheel profile optimisation models.

Keywords
wear, RCF, rolling contact, traction, braking, heavy-haul, FASTSIM, FaStrip