Physics based models for predictive maintenance of rail-infrastructure components

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Introduction

Maintenance time intervals of rail-infrastructure components are mainly based on historic data. Damage prediction is not possible for time-varying loading or environmental conditions. This problem can be solved by using physics based models.

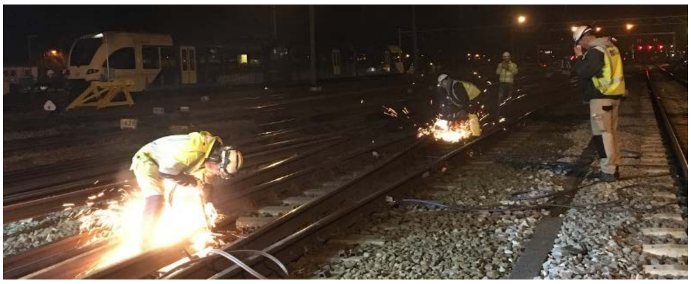

Figure 1: Maintenance activity in Zwolle.

Approach

The physics based model requires understanding of the underlying physical failure mechanisms of the critical components. Tracks and switches have been selected as the most critical components with wear and Rolling Contact Fatigue (RCF) as the most dominant failure mechanisms.

Simplified Wear Model

Firstly a physics model based on the wear mechanism has been implemented in Matlab. Three fully developed models are often used for this purpose, see Figure 2.

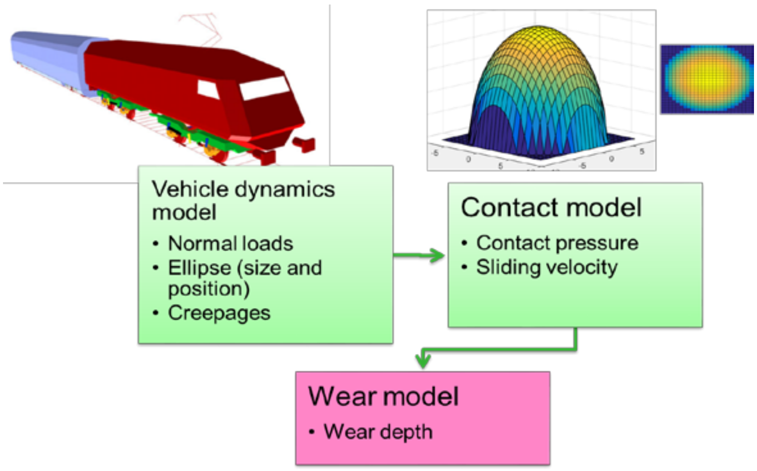

Figure 2: Relation between the different type of models.

For the current simplified model the results used for the contact model were not extracted from dynamic simulation but were assumed to be constant. The amount of wear V was calculated by using the Archard's law:

$$V = K\,\frac{s\,N}{H}$$

K = wear coefficient, s = sliding distance, N = normal load, H = material hardness

This model has been used to predict a certain amount of wear for specific loading conditions on a straight track and the results were in good agreement with real wear measurements provided by Strukton Rail. The validation with literature [1] was also a success.

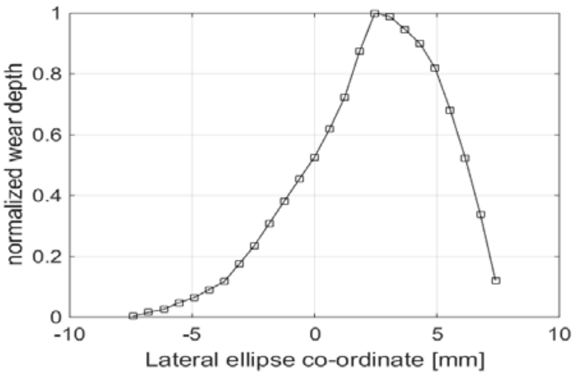

Figure 3: Normalized wear depth.

Future work

The following step is to relate the usage parameters (e.g. operating conditions) to the input parameters of the physics based wear model, see Figure 4. This will enable damage (amount of material removal) prediction for different loading, environmental and maintenance conditions.

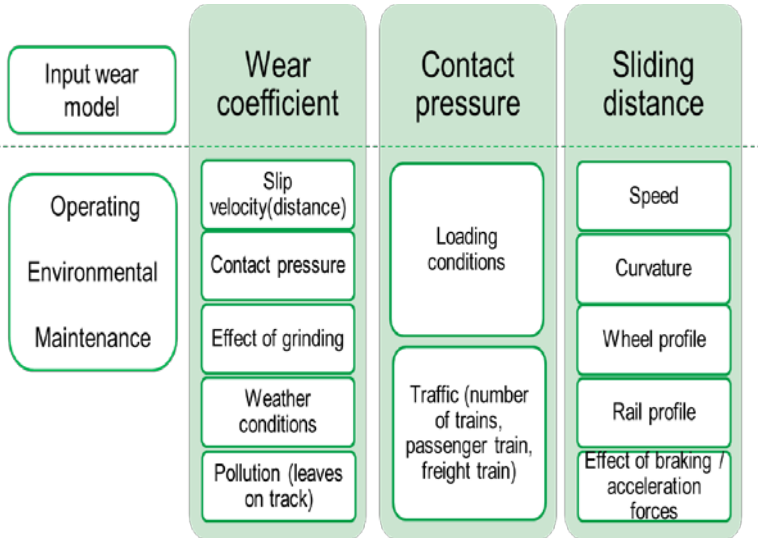

Figure 4: Coupling between usage parameters and input parameters of the wear model.

References

[1] Enblom, R., & Berg, M. (2005). Simulation of railway wheel profile development due to wear—influence of disc braking and contact environment. Wear, 258(7–8), 1055-1063.