ELECTROMAGNETIC AND THERMAL MODELING FOR EDDY CURRENT BRAKES IN HIGH SPEED TRAINS AND INTERACTION WITH WHEEL SENSORS.

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KEYWORDS – Eddy current brake, high speed trains, wheel sensors, electromagnetic compatibility, electromagnetic and thermal modelling

ABSTRACT

Research and/or Engineering Questions/Objective: (max. 100 words)

Eddy Current Brakes (ECB) have been used in high speed trains during the last few years, particularly in Germany. They have been proven to be a reliable solution for emergency and service operation with high rates of brake forces with no material wear. The main difficulties to extend its application to other countries in Europe are based on Electromagnetic Compatibility (EMC) with wheel sensors located alongside the track and possible track buckling due to high rises in temperature. In the context of the ECUC project, computational models are provided to study worst case conditions for ECB-wheel sensor and ECB-track interaction.

Methodology: (max. 150 words)

Knorr-Bremse L4 and L5 linear ECBs are considered in the study. From an EMC point of view, their interaction with Frauscher RSR 123 and RSR 180 wheel sensors is considered. Three cases have been studied: the presence of the ECB passing by the wheel sensors; the analysis of the ECB switched on with low frequencies involved coming from the induction caused by a fast moving DC source; and the analysis of the ECB switched on with high frequencies emanating from the harmonics of the power supply. An EM model is realized within CST Microwave Studio environment. Proper characterization of materials in the scenario are extracted from measurements. The temperature model is realized in FEM, modelling the typical operation over UIC 60 rail. All kinetic energy is assumed to be converted into heat and introduced to the rail. Evacuation of heat through the lateral surface is also covered in the model.

Results: (max. 150 words)

Models of the ECB are integrated with models of wheel sensors on the same CST platform for the EMC interaction. Simulations results are compared with measurements under different conditions taken in the laboratory. Input impedance of single ECB poles, radiated magnetic fields in close proximity and ECB fingerprints on wheel sensors are compared to determine the final 3D simulation model. The final comparison shows agreement between simulated and measured results. The typical deviation is 8% for the different outcomes. It enables the study of worst case conditions. Once the model is verified, test set ups and procedures can be defined with the aid of the model. Thermal model provides temperature in the rail after the use of ECB and it can be compared to maximum temperature levels provided by technical specifications. Different scenarios are considered, varying the velocity of trains, the frequency of operation, rail initial temperature and ambient temperature.

Limitations of this study: (max. 100 words)

The study is limited to two representative ECBs by Knorr-Bremse: L4 and L5, and two wheel sensors by Frauscher: RSR 180 and RSR 123. The methodology could be easily extrapolated, particularly to new generation ECBs. Material characterization is a key challenge in the study. Saturation and magnetic hysteresis effects in the material caused by high currents cannot be directly transferable to EM modelling, so reasonable equivalents are found. Thermal calculations are limited to UIC60 profile, although the model could easily be extrapolated to other profiles. Fitting of parameters to consider evacuation of heat (through convection) is based on experimental results.
What does the paper offer that is new in the field in comparison to other works of the author: (max. 100 words)

The paper offers a more comprehensive compilation of the project results. The difficult issue of modelling a complex scenario in which train operation, accurate ECB-rail distance definition, material characterization, ECB position uncertainty etc have been addressed in a novel and promising approach. The comparison of the available simulation with measurement results are promising and allows further steps in the project to be addressed, which includes currently ongoing measurement campaigns on track, with reasonable expectations.

Conclusion: (max. 100 words)

EM and thermal simulation have been applied to model the interaction of ECB-wheel sensors and ECB-rail track for high speed trains. Result deviation is typically 8% in the different outcomes (input impedance of the poles, magnetic radiation etc). With this approach, once the model is corroborated after the measurement campaigns on track, worst case conditions for ECB performance when facing EMC and thermal issues can be predicted. Therefore proper test set ups can be simplified when targeting worst cases known as a priori.