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Thermal Analysis of Tread Braking Using Scaled TwinDisc Testing and Experimentally Validated Numerical Models

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1 Objective

Tread braking is the traditional braking system installed on railway freight wagons, due to its advantages related to small costs, simple design and simple replacement. Traditional shoes were made of phosphorus cast iron (P10 shoes), which however were known for producing high levels of rolling noise because of the high tread surface roughness generated by thermoelastic instability (TEI) phenomena. Therefore, to reduce the noise pollution related to railway freight traffic, and to comply with the EU limits on rolling noise [1], traditional P10 cast iron shoes are being replaced with shoes made of composite materials.

Composite shoes tend to have values of thermal conductivity which are more than one order of magnitude lower than those of P10 shoes. This causes a higher amount of the total friction heat flux to flow into the wheel, hence causing higher thermal stress and possible undesired microstructural changes.

The prediction and estimation of the temperature field in the wheel and shoes is hence essential to ensure a reliable and safe operation of freight wagons. Combining the results of numerical models and experimental tests is the key to gain a deeper understanding of the thermo-mechanical phenomena at the wheel-shoe contact interface for a wide range of brake shoe materials.

To this purpose, in past activities, the Politecnico di Torino (PoliTo) railway research group designed and built a scaled twin-disc test bench for the experimental investigation of wheel-rail wear and wheel-shoe interaction [2,3]. At the same time, the research team implemented several numerical models for the calculation of the temperature field in wheels [4,5] and shoes [6,7].

The present work shows the upgrades made to the original twin-disc configuration to include a system with pyrometers for the evaluation of the temperature of wheel and shoes during braking operations. The collected values are used to tune and validate previously developed numerical models. The results of the activity can lead to a better understanding of the thermal interaction between tread braked wheels and shoes, hence leading the path towards the development and implementation of reliable on-board monitoring systems.

2 Method

To achieve the objectives of the work, the PoliTo twin-disc bench was upgraded with a specifically designed system for the installation of several commercial pyrometer sensors for the measurement of temperature in different locations of interest. These include: i) the wheel tread close to the contact with the shoes, ii) the shoes and iii) the rail roller close to the contact with the wheel roller. Sensors are fixed to plates mounted to the main bench stationary components.

Different tests under drag braking conditions are run measuring the temperature field with the selected pyrometers. The bench allows to test different shoe materials for two configurations of the tread braking system, namely with one (1Bg) or two (2Bg) brake shoes acting on the wheel tread surface. The greatest advantage of the scaled tread braking system is that it was designed following a specifically conceived thermal similitude model [3]. This ensures that the temperature field recorded in the scaled laboratory device has unitary scaling with respect to the full-scale system.

The temperature values recorded on the experimental tests are used to tune and then validate simplified numerical models for the wheel and shoe. Precisely, the tuning activity allows to optimize the main model parameters, including the heat flux partitioning factor, that determines the amount of the total friction heat flux flowing towards the wheel and shoes. The model parameters are identified with trial and error as well as with numerical optimization routines, that aim at minimizing the difference between simulated and experimentally recorded temperature values.

3 Results

The results of the activity enable an overall comparison of different types of shoe materials on the thermal behavior of the wheel. The tuning and validation of the thermal models makes it possible to perform predictions of the temperature field over a wide range of operating conditions, in terms of dissipated power and energy, for different speed values.

4 Conclusions

The newly built system with pyrometers for the measurement of temperature on the scaled twin-disc bench allows to test different types of shoes in laboratory conditions. The validated numerical models can be adopted to evaluate the temperature evolution during specific braking operations. The models could be further simplified in future activities for implementation within on-board monitoring systems.

References

[1] 2006/66/EC: European Commission, Commission Decision of 23 December 2005 Concerning the Technical Specification for Interoperability Relating to the Subsystem 'Rolling Stock Noise'of the Trans-European Conventional Rail System; European Commission: Brussels, Belgium, 2006.

[2] Magelli, M.; Pagano, R.; Zampieri, N. Design of an Innovative Twin-Disc Device for the Evaluation of Wheel and Rail Profile Wear. Designs 2024, 8, 73. doi: 10.3390/designs8040073.

[3] Magelli, M.; Pagano, R.; Zampieri, N. Adapting a scaled twin-disc device for tread braking investigations based on an ad-hoc thermal similitude model. Wear 2025, 574-575, 206105, doi: 10.1016/j.wear.2025.206105.

[4] Bosso, N.; Cantone, L.; Falcitelli, G.; Gjini, R.; Magelli, M.; Nigro, F.M.; Ossola, E.; Zampieri, N. Simulation of the thermo-mechanical behaviour of tread braked railway wheels by means of a 2D finite element model. Tribology International 2023, 178, 108074, doi: 10.1016/j.triboint.2022.108074.

[5] Magelli, M.; Zampieri, N. A new finite element axisymmetric model with non-axisymmetric thermal loads for thermal analyses of tread braked wheels. Tribology International 2025, 209, 110675, doi: 10.1016/j.triboint.2025.110675.

[6] Wu, Q.; Magelli, M.; Zampieri, N.; Bernal, E. Adding a brake shoe temperature model into freight train longitudinal braking dynamics simulations. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit 2022, 237, 631-641, doi: 10.1177/09544097221126274.

[7] Magelli, M.; Zampieri, N.; Wu, Q. Integration of brake block thermal equations within a railway vehicle multibody model: a multiphysics approach. International Journal of Rail Transportation 2025, 13, 69-84, doi: 10.1080/23248378.2023.2301618.

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