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CONDITION MONITORING OF RAILWAY BOGIE COMPONENTS USING NUMERICAL SIMULATIONS

Pedro Millan[(1)], João Pagaimo[(1)], João Neves Costa[(2)], Jorge Ambrósio[(1)]

[(1)]IDMEC, IST, Universidade de Lisboa, Lisboa, Portugal
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pedro.millan@tecnico.ulisboa.pt, joao.pagaimo@tecnico.ulisboa.pt, joao.n.costa@tecnico.ulisboa.pt, jorge.ambrosio@tecnico.ulisboa.pt

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Summary: In a context of pressing need to combat climate changes, railway transportation emerges as a vital part of the solution. To increase the competitiveness of the railway sector, it requires a reduction of maintenance costs and increase rolling stock availability while ensuring, or even further increasing, the current levels of safety. To that purpose, railway manufacturers and operators, along with national and European initiatives, are investing boldly in predictive maintenance and new condition monitoring techniques. This work explores the development of condition monitoring techniques, in the context of the European project LOCATE, to detect faulty components in the bogies of locomotives.

Data-driven approaches are often used to correlate the vehicle measured responses to the condition of the railway vehicle components. However, data-driven methods often disregard the physical phenomena behind the correlation between fault-response and rely on great amounts of data to correlate the causes to the effects. Particularly, it requires data corresponding to the vehicle running in faulty condition, which is most often unavailable, either because there are few data recorded when the vehicle components are damaged, or because it is uncertain when the damage appeared. Moreover, in the railway industry it is very difficult, if not impossible, to run full scale tests with vehicles with faulty components; the railway operators cannot risk damaging the rolling stock just to generate data of the vehicle running under faulty conditions, and the infrastructure owner cannot risk compromising the railway lines. Numerical dynamic simulations become the ideal solution to understand the vehicle dynamic behaviour under faulty conditions, avoiding the high risks and inherent costs to physical testing faulty vehicles. Yet, this requires that reliable and realistic numerical models are available.

This work explores two main points: 1) the development and validation of a multibody model of a freight locomotive, for realistic dynamic simulations, and; 2) the development of new condition monitoring techniques, based on the dynamic simulations of the locomotive running in nominal and faulty conditions. The types of faults addressed in this work include damage in the primary suspension elements and the loss of structural integrity of the bogie frame due to fatigue cracks. To that purpose, transmissibility-based methods, that relate the frequency response measured at various points of the bogie structure, are used to correlate the vehicle response to the type and extent of damage. Particularly, the Transmissibility-Damage-Indicator (TDI) and the Localized-TDI (LTDI) are used to detect the existence of damage, whereas the method of the Maximum Occurences (MO) is used to locate the position of the damage.

The results obtained show that the TDI method successfully detects cracks with a moderate-to-large dimension, while the MO method identifies the region where those cracks occur. Additionally, the LTDI is particularly suitable to assess the condition of damaged springs and dampers of the primary suspension. Therefore, the transmissibility-based methods are a reliable technique that may contribute to enhance the inspection of railway vehicles, and multibody simulations allow to overcome the costs and risks of physical testing.