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Condition Monitoring of Rail Vehicle Bogies

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Abstract: This paper details a range of work carried out by the authors within the general theme of advanced condition monitoring possibilities for rail vehicle bogies. Maintenance of rail vehicle bogies represents one of the largest areas of whole vehicle running costs and their efficient operation is of safety critical importance to the entire rail system. Currently the majority of maintenance is carried out on a scheduled basis which can be time consuming, costly and potentially not effective at fault detection. This paper reviews concepts that could allow real time detection of the condition of the bogie so as to reduce vehicle out of service time and improve safe operation. Concepts reviewed are: the use of condition monitoring for detection of suspension component condition; detection of low adhesion conditions; and assessment of the wheel-rail interface condition.

Keywords: Accelerometers, Fault Diagnosis/Detection, Kalman Filters, Nonlinear Systems, Piecewise Linear Analysis, Recursive Least Squares, Railways, Vehicle Dynamics

1. INTRODUCTION

This paper details a range of work carried out by the authors for a project within the Rail Research UK collaboration, the general theme of which was condition monitoring around the rail vehicle bogie system.

Maintenance of the rail vehicle bogie represents one of the largest areas of whole vehicle running costs, and its efficient operation is of critical importance to the safety of the entire rail system, Iwnicki (2006). The bogie system must provide the guidance for the rail vehicle, its running stability, isolate the passengers or cargo from disturbances at the rail and possibly provide the tractive effort for the vehicle, Wickens (2003).

Currently, most bogie system maintenance is performed on a scheduled basis, when critical components are checked for functionality. Key amongst these are suspension components like the secondary dampers; adhesion characteristics of the wheel-rail contact; and the geometric shape of the wheel-rail contact. All of these components can change their parameters rapidly in operation and as such can present safety issues if they alter outside of an inspection period and are not detected.

The key concept presented here is the use of condition monitoring to give a real time estimate of the parameters of these components. Ideas for monitoring have been employed in simulation in conjunction with data gathered from a real system. These techniques include; the use of particle filters for estimation of damper coefficients, Li et al. (2006), Kalman filters estimation of real time adhesion characteristics of the wheel-rail interface, Charles et al. (2008c) and various Kalman filter and system identification techniques for the estimation of the wheel-rail contact geometry, Charles et al. (2008b) and Charles et al. (2008a). More specifics of contemporary work on the latter are covered briefly in Ward et al. (2010b) and more thoroughly in Ward et al. (2010a).

These techniques present the potential to progress from scheduled calendar based maintenance to unscheduled condition based maintenance, cutting operational costs. Demand for these estimation techniques is generated by systems such as the operational Bombardier ORBITA, Bombardier (2010), where maintenance requirements are generated automatically through on train sensors, then dispatched to the relevant maintenance depot; and the European Train Control System, UIC (2010), in which a rail vehicle will be expected to brake at any position in the network where adhesion conditions may not be known, consequently making real time estimation of this important parameter a necessity.

2. THE RAILWAY BOGIE

The railway bogie is a complex, multi-degree of freedom system that is tasked with multiple roles in an extremely harsh environment, Figure 1 shows an example bogie. They consist of a bogie frame and two wheelsets of two coned wheels solidly fixed to a central shaft. The wheelsets run in a bearing house referred to as the axlebox, loads from which are transmitted to and from the bogie frame via the primary suspension. The vehicle body is then

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