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Novel efficient technologies in Europe for axle bearing condition monitoring – the MAXBE project

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Abstract

Axle bearing damage with possible catastrophic failures can cause severe disruptions or even dangerous derailments, potentially causing loss of human life and leading to significant costs for railway infrastructure managers and rolling stock operators. Consequently the axle bearing damage process has safety and economic implications on the exploitation of railways systems. Therefore it has been the object of intense attention by railway authorities as proved by the selection of this topic by the European Commission in calls for research proposals. The MAXBE Project (http://www.maxbeproject.eu/), a EU-funded project, appears in this context and its main goal is to develop and to demonstrate innovative and efficient technologies which can be used for the onboard and wayside condition monitoring of axle bearings. The MAXBE (interoperable monitoring, diagnosis and

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maintenance strategies for axle bearings) project focuses on detecting axle bearing failure modes at an early stage by combining new and existing monitoring techniques and on characterizing the axle bearing degradation process. The consortium for the MAXBE project comprises 18 partners from 8 member states, representing operators, railway administrations, axle bearing manufactures, key players in the railway community and experts in the field of monitoring, maintenance and rolling stock. The University of Porto is coordinating this research project that kicked-off in November 2012 and it is completed on October 2015.
Both on-board and wayside systems are explored in the project since there is a need for defining the requirement for the onboard equipment and the range of working temperatures of the axle bearing for the wayside systems. The developed monitoring systems consider strain gauges, high frequency accelerometers, temperature sensors and acoustic emission. To get a robust technology to support the decision making of the responsible stakeholders synchronized measurements from onboard and wayside monitoring systems are integrated into a platform. Also extensive laboratory tests were performed to correlate the in situ measurements to the status of the axle bearing life. With the MAXBE project concept it will be possible: to contribute to detect at an early stage axle bearing failures; to create conditions for the operational and technical integration of axle bearing monitoring and maintenance in different European railway networks; to contribute to the standardization of the requirements for the axle bearing monitoring, diagnosis and maintenance. Demonstration of the developed condition monitoring systems was performed in Portugal in the Northern Railway Line with freight and passenger traffic with a maximum speed of 220 km/h, in Belgium in a tram line and in the UK. Still within the project, a tool for optimal maintenance scheduling and a smart diagnostic tool were developed.
This paper presents a synthesis of the most relevant results attained in the project. The successful of the project and the developed solutions have positive impact on the reliability, availability, maintainability and safety of rolling stock and infrastructure with main focus on the axle bearing health.

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Keywords: axle bearings; condition monitoring system; diagnosis; condition-based maintenance

1. Introduction

The safety of rolling stock and the economic implications of rolling stock maintenance have been of significant concern to the railway industry. In the last few years the maintenance strategy paradigm is significantly changing and the longstanding preventive time based maintenance is being progressively replaced by condition based maintenance. Also the early diagnosis of the rolling stock condition will allow the improvement of the definition of the maintenance strategies for railway vehicles. Condition monitoring technologies offer to the railway operators means to increase reliability and safety. By an earlier detection of potential failures, the railway operators can better plan maintenance actions contributing to achieve financial savings (MAXBE, 2012).

The axle bearing damage process and the consequent failures can cause severe delays or even dangerous derailments implicating human lives prejudice and significant costs for railway managers and operators. The usual causes for axle bearing failures are: the ageing and the deterioration of grease; the oil separation from the grease structure; the particle contamination of the lubricant grease due to wear from components; the external particle contamination due to damaged seals and out of balance axle loads. When the axle bearing temperature rises, it can be indicative of possible failure, loss of internal kinematics, lack of lubrication and overloading, factors that can dramatically reduce bearing life (MAXBE, 2012).

In railways, the axle bearings condition monitoring can be made directly (on-board) or indirectly (on-track and on-laboratory). Regarding the wayside condition monitoring, hot axle box detectors are the most common track side monitoring systems and are used for the detection of faulty axle bearings in-service. However, these systems cannot detect damage in early stage, because when the alarm temperature is registered the axle bearing is already in an advanced state of degradation. Also, with this type of monitoring systems, overheated bearings may not be detected and false alarms can be triggered during operational conditions. Therefore, more accurate methods for the bearing health monitoring need to be developed considering vibration and acoustic analysis. But these techniques are complex and their application to the railway industry is limited. The on-board condition monitoring systems implies that different types of sensors, generally including temperature, vibration and/or acoustic emission sensors, are installed directly in the axle box, consequently, these systems are more likely to detect an axle bearing fault, especially at an early stage of evolution. But on-board systems may have technical limitations related with power supply,