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Insights towards Condition Monitoring of Fixed Railway Crossings

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Abstract

Evaluation methods and field trial results in terms of geometry and loading of fixed railway crossings are proposed in this paper. Based on these experiences the fundamentals towards condition monitoring are created to allow predictive maintenance actions. For this, a fixed crossing has been instrumented with strain gauges and installed in track with mixed traffic. The strain gauge signals were recorded in irregular intervals to establish a database for the development of model based condition monitoring. A signal processing chain was developed that shall serve as base for continuous monitoring of crossing nose via strain measurements. To this end a data processing work flow is proposed that enables to monitor changes in the combined system of crossing geometry/ wear and bedding state.
To quantify the geometry development of the crossing nose (due wear and plastic deformation) a laser based non-contacting measurement of the crossing geometry has been set up. 2D profiles recorded at predefined positions of the crossing enabled a 3D reconstruction of the crossing geometry. During 30 months in service the geometry of the crossing nose and adjacent regions has been recorded in 3 to 6 months intervals. The superposition of the corresponding 2D profiles and the 3D reconstruction allowed a quantitative measurement of the geometry changes during service.

Keywords: railway, crossing, condition monitoring, strain, geometry, wear

1. Introduction

Currently many railway operators have to deal with the fact that maintenance actions on turnouts are based on a fixed schedule and in many cases the condition is recorded in cost intensive visual inspections. Recent developments in sensor technology and calculation power give new opportunities for railway operators to reduce inspection costs by surveillance systems that report the condition and demand for maintenance actions.

In a railway turnout there are two main inspection areas: First, the switch panel with moveable rails and the positioning/ locking devices and second the crossing panel where high vertical loading out of impact loads and slip sets high demands on the material. Generally, the material response to loading can be distinguished between plastic deformation, wear or rolling contact fatigue (RCF) and all these mechanisms can lead to a worse transition geometry that demands for maintenance actions.

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The work presented here is dedicated to condition monitoring of railway crossings, especially fixed crossings. Fig. 1 shows the picture of an instrumented turnout right after installation and gives a nomenclature of the rail components. The instrumentation and specifics of this turnout will be detailed later on.

Design and implementation of condition monitoring (CM) systems is a very diverse field due to the wide range of systems and the variety of application domains. Jardine et al. (2006) pointed out that first-generation CM systems accomplished their task often by observing sensor output closely related to fault states and applying limits which leads to so called limit-based CM systems. This approach is limited to systems featuring directly observable fault states and matching sensors.

In the case of railway crossings with moving components, save interlocking is generally surveilled by position sensors. The position sensors allow an on-line observation of the actual component position; however, they do not allow a prediction whether the next switch operation will be successful.

As detailed by Isermann (2005) modern CM systems utilize predictive models of the device to be monitored. Such CM systems are called model-based CM (MBCM) systems. In MBCM, a model of the system is used to interpret observed sensor changes and to predict the system status based on preceding data.

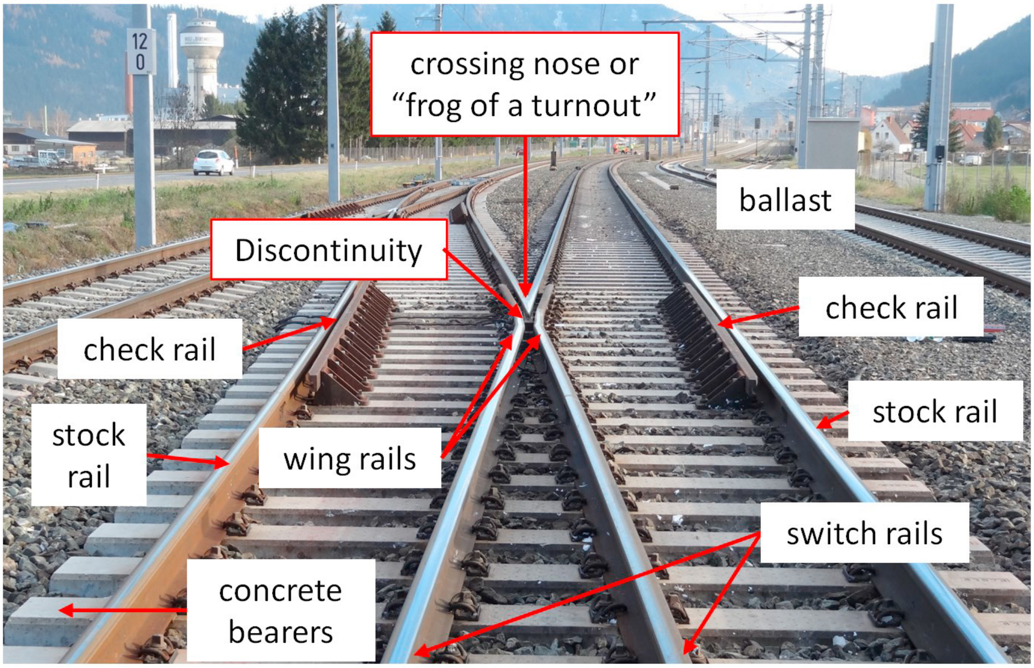

Fig. 1. (a) Picture of the instrumented turnout shortly after installation at the test site with a nomenclature of the rail components; due to the right-hand traffic the majority of trains runs on the straight route on the right track.

In the case of railway crossings the observation and model based interpretation of the force by the switch machines during performance can be used to predict the need for maintenance. Thus, the development of condition monitoring systems for moveable devices has been high priority and the sensor equipment, data manipulation and interpretation can be considered as state of the art. A corresponding technical solution is the VAE condition monitoring system ROADMASTER 2000 described by Marx et al. (2011).

However, moveable or fixed railway crossings additionally demand for visual inspection in predefined intervals, because e.g. RCF damage respectively exceeding wear limits cannot usually be detected by the same sensor equipment; see the corresponding chapter by Marx et.al. (2011). During these inspections the judgement of the need for repair is based on the staff experience. Fixed crossings have a discontinuity in the running surface of the rail that leads to exceptionally high loads at the crossing nose (see Fig. 1) and thus the crossing nose is one of the most maintenance intense parts of a turnout. Past findings on the tradeoff between RCF and wear behavior of rails (Burstow, 2006) cannot be transferred directly to fixed crossings because of the fact that material wear and plastic deformation have a significant influence on the dynamic loading and higher loads directly influence the RCF behavior. Therefore some available fixed crossing diagnostic systems, like the ESAH-M of DB Systemtechnik, focus on acceleration measurement that also correlates with transition dynamics. In this work the signal analysis is based on strain gauge measurement data that is also significantly influenced by transition dynamics that is again a result of RCF, wear and/ or plastic deformation of the geometry.