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The condition assessment of insulated rail joints with help of an already existing measuring system

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Abstract

In this paper, the potential of an already existing measurement system for the condition assessment of insulated rail joints is shown. The system properties of the so-called rail surface measurement system are described and the potential of systematic data analysis is addressed. The measured short-wave range and the high sampling rate offer the possibility of adding further facets to the existing track condition assessment. The data source is particularly suitable for evaluating short-wave effects, which were previously difficult to describe. With the help of a positioning algorithm it becomes possible to evaluate isolated rail joints regarding their quality development over time. It can be shown that insulated rail joints deteriorate in a super linear manner. In order to reduce the negative influence on the quality behaviour of the entire track, intervention thresholds for a preventive maintenance regime have to be defined. Using technical-economic assessments, these intervention thresholds can be defined in a way to ensure undisturbed railway operation with the lowest possible life cycle costs.

Keywords: Insulated Rail Joints, Condition Monitoring, Life Cycle Management, Data Analysis

1 Introduction

Insulated rail joints are an indispensable part of the infrastructure for many railway networks. They are used to isolate sections of track from each other and thus divide the track into blocks necessary for the train control system.[1] However, the installation of an insulated rail joint also results in a point of inhomogeneity, which often leads to a poor-quality condition of the joint itself as well as of components in the area of the joint. Since the abandonment of this technology is out of the question for many infrastructure operators, the focus should be on condition-based maintenance concepts. For this, however, it must be possible to objectively assess the condition of an insulated rail joint. In most cases, this assessment is currently carried out by means of visual inspection. Due to the high competence of the responsible personnel, the visual inspection still brings the most reliable results. Nevertheless, there are significant disadvantages to this method. The regular route inspections are carried out at walking pace and are therefore very slow, which results in high costs on the one hand and low frequency on the other. As the trend moves towards less available personnel, it is to be expected that track condition assessment can no longer be done by track inspections alone in the future. In addition, as the number of trains increases, entry into the danger zone must be reduced to a minimum.

The aim of this paper is to show a possibility to evaluate insulated rail joints by means of data analysis. Data from a measuring system that is already installed on the EM250, the main measuring wagon of OeBB Infrastruktur (Austrian Federal Railways), will be used.

2 Methods

The data source used for the evaluation of insulated rail joints is the original measurement output of an already implemented measurement system, the rail surface signal. This signal is obtained from the rail surface measurement system, a chord-based system in which three optical distance sensors are mounted in a row. The first and the last laser build a virtual chord. The actual measurement value describes the distance between the rail surface of the middle laser and the chord surface at the same position. The measurement system can be mounted onto vehicles with speeds up to 250 km/h and still returns a data point every 5 mm. This fact is potential and challenge in signal handling at the same time. On the one hand, a very detailed image of the rail surface can be generated without reducing track availability if mounted on a regular (inspection) vehicle. On the other hand, an advanced data positioning algorithm and powerful data analysis are required for working with this kind of data.
Although, the measurement system has been mounted onto the EM250 since 2005 and some modified parameters are already partly in use, the original output signal of the system was not investigated up to now. The main reason might be the precondition of an exact positioning process. Without this re-positioning, the potential of a small sampling rate cannot be exploited.

For the re-positioning we use an algorithm based on [2] that shifts signals of different measurement runs synchronously to each other. For this purpose, signal characteristics are used and a similarity criterion is defined. To demonstrate what synchronous means, the Figure 1 shows the input to the described algorithm and the output after the computing.

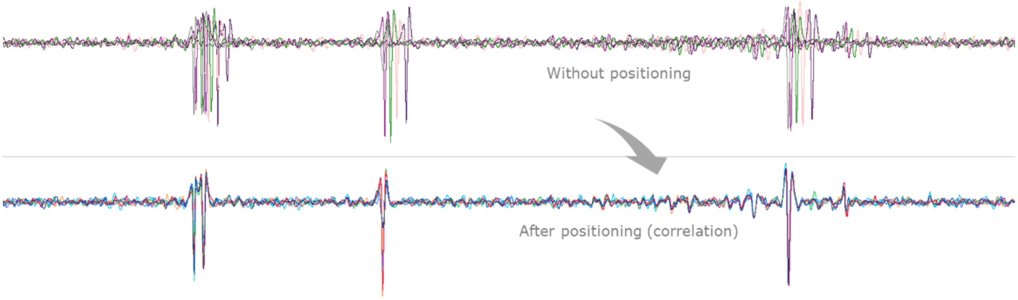

Figure 1 Input and output of the positioning algorithm

The different colours of the signals in Figure 1 reflect different runs of the measuring car, in this case 5 runs are included, which corresponds to about 1.5 years. The lines in the upper half of the figure represent the filtered signal without exact positioning. While the signal characteristics appear to match each other, the different runs are displaced from each other. The lower half of the figure shows the same signals after precise positioning. Since after this process, the characteristics of the different runs match each other, the quality behaviour of insulated rail joints over time can now be examined without making a significant error due to inaccuracies.

3 Results

In order to clearly identify insulated rail joints in the data source, the typical signal characteristics of these joints are analysed. This characteristic can be seen in the middle section of Figure 2, where a filtered version of the rail surface signal in the area of an insulated rail joint is shown.

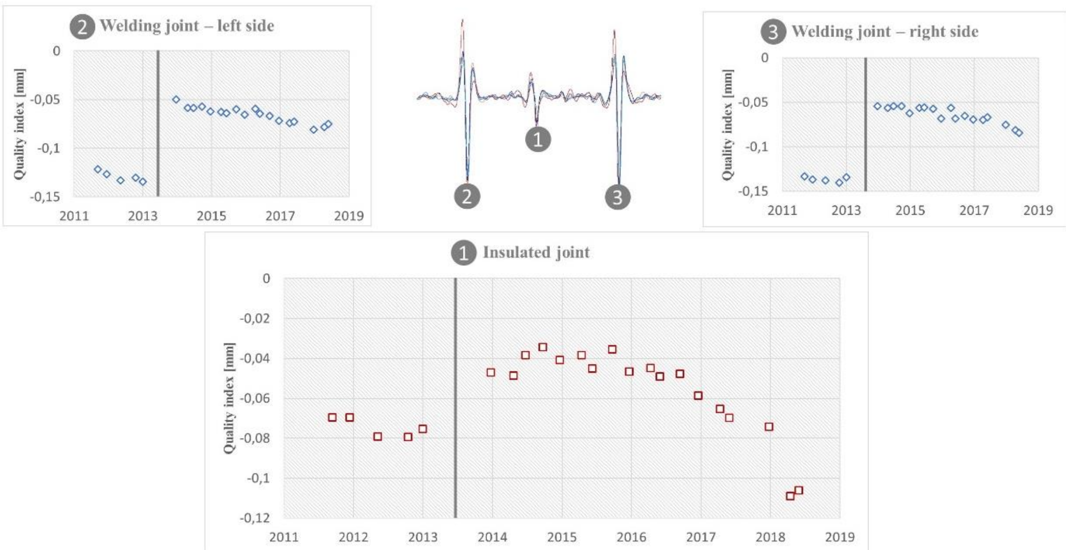

Figure 2 - Time Series analysis of an insulated rail joint

The local peak marked "1" represents the insulation spot itself, the peaks "2" and "3" indicate welding joints. Since, at least in Austria, all insulated rail joints are assembled in the factory and then welded into the track as a whole, this characteristic applies to every insulated rail joint. The extent of the peaks depends on the condition of the joint, leading to a situation where at least isolated rail joints in medium to poor condition are reflected in the data. Examining the development of the peak values over time, a downward trend of the quality index can be observed. The amplitude of the inhomogeneity thus grows continuously. Only in 2013 a significant improvement of the quality index can be recorded, here a maintenance intervention has most probably taken place. While liner growth occurs in the two welding joints, the insulating joint appears to deteriorate in a super linear pattern. This circumstance also corresponds to empirical reports. In order to reduce the negative influence of an insulated rail joint on the holistic performance of the track, intervention levels should be defined. If the intervention threshold is reached, appropriate maintenance measures must be carried out, with the aim of reducing the dynamic load caused by worn insulated rail joints. These are to be defined with the help of technical-economic considerations in such a way, that the life cycle costs, including an assessment of non-availability, can be kept as low as possible. Doing so, would in turn, also ensure a high level of safety. The definition of reasonable intervention levels is currently part of the research and will be published as soon as available.

4 Conclusions and Contributions

General evaluations of the impact of short-wave effects on track geometry quality show that, due to the additional dynamic forces, untreated disturbances of the rail surface can lead to significantly poorer track geometry than expected [3]. The extent of this impact is strongly dependent on the severity of the short-wave effect, therefore in many cases it may be useful to treat short-wave effects preventively. These relationships have also been demonstrated for insulated rail joints. [2] shows in his dissertation that isolated rail joints are essentially responsible for the poor track geometry in turnout areas. From a life cycle management perspective, it therefore makes sense to maintain insulated rail joint well in advance by means of a suitable maintenance regime. The methodology presented here shows the potential to implement such a regime in practice. The data source used for this is a measuring system that has already been installed on the OeBB measuring car for years, but whose full potential could not yet be explored, due to high positioning requirements. By means of the described positioning algorithm, it is possible to evaluate the time based deteriation of insulated rail joints. It is shown that the insulated spot appears to deteriorate in a superlinear manner, which is consistent with practical experience. Future work will focus on defining sensible intervention levels for maintenance planning, with the focus on undisturbed railway operation on the one hand and lowest possible life cycle costs on the other.

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