EXPERIMENTAL BASES FOR THE RAIL TRACK SURFACE DAMAGE DETECTION SYSTEM

A diagnosis of rail surface is generally based on the classical method of direct assessment and track geometry measurements. Identification and qualification of inequality and damage on the surface rails is depend on the skills and experience person who conducting inspection. In times of increasing exploitation of railways, infrastructure managers decide to use systems supporting the assessment of technical condition of the railways. In order to improve efficiency of detecting and maintaining uniform assessment criteria developed systems for detecting and monitoring inequalities damage on the surface rails. This article presents the assumption being the basis of the experimental monitoring system dedicated to the Polish railway infrastructure manager. The foundation of the research will be measurement and analysis of the dynamic response of the selected railway vehicle. The functional requirements and the actual research methodology on selected section of the main railwayline have been discussed. The paper presents architecture of measurement subsystem installed on typical type passenger electric locomotive. The implementation of a method for assessing in existing monitoring system has been proposed.

Keywords: diagnostics, maintenance, railway lines

1. INTRODUCTION

The technical condition of the railways constitutes the largest impact on safety and comfort of the rail vehicles. The basis of diagnosis is surface railway is made up of the direct assessment in conjunction with the analysis of the surface geometry measurements of the railways. In Poland, the basic meaning in the diagnosis and

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assessment of damage to the surface on rails is an expert opinion provided by a track specialist. Identification and qualification of the damage is based on the knowledge and experience of the person who conducting the inspection. The increase in the number of monitoring systems resulting technical state of constructions in many areas of technology is noticeable. The development concerns both branches of railway vehicles [2], their individual systems [1] as well as railway infrastructure and public transport [4].

Poland, thanks to its central location, has one of the most important transport systems in Europe. It has approx. 19.500 km of active railway lines, as a result of which it is classified, after Germany and France, in third place among all European Union countries. An average of 5.5 thousand passenger and freight trains move on the Polish railway lines on a daily basis. The annual report [6] on the activities of the main railway infrastructure manager, the PKP Polish Railway Lines indicates that the technical condition of as much as 26% of lines in Poland is unsatisfactory. Such a low rating qualifies the tracks for immediate and comprehensive resurfacing. 27% of the rail lines received a sufficient assessment, which means that more than half of the railway lines in Poland are suitable for the process of modernization and revitalization. The current state of rail infrastructure testifies to the many years of neglect on the part of managers. Negligence result not only from the limited funding allocated for maintenance, but also with negligence resulting from the used methods of diagnosis rail surface.

![Fig. 1. Assessment of the technical condition of the railway lines in Poland [6]](image)

The systems used in diagnosis of the rail surface can be divided into stationary, which are part of the rail infrastructure and the nonstationary, which are placed on trains. Stationary systems allow you to focus on the assessment of the technical condition of the rolling stock or a selected portion of rail infrastructure. Nonstationary diagnostics systems allow selected elements of the rail vehicle and, what is more important, technical or qualitative evaluation of the surface elements of the rail infrastructure to be carried out. When making measurements of the
dynamic response of a rail vehicle in operation, a qualitative assessment is performed. Based on the common standards and legal regulations [8, 9] a classification of irregularities and failures of selected elements of surface railway lines can be made. Many countries and infrastructure managers apply individual surface evaluation system based on an analysis of the dynamic response of the rail vehicles. An example of such solutions can be the Japanese Furukawa, Dutch Pupil or Canadian Interaction Map systems [4]. An analysis of the dynamic response measurement enables the identification of rail surface damage and determines the wavelength vertical and horizontal inequalities. Defining their length and amplitude allows their impact on the comfort and safety of rail vehicles to be assessed. The registration of vibration acceleration wheel set allows the condition of rail surface to be determined. In addition, it is possible to identify local damage occurring on surface of rails, waviness and assessment of connections on the track classic or contactless. Another element resulting from the analysis is the assessment of the quality of the components turnouts and crossings.

Despite the above-mentioned possibility of assessing the state of rail surface with help of dynamic response rail vehicle and conducted preliminary field research [2], the presented method is not used in Poland for diagnostic purposes surface railway lines.

In Poland, rail surface diagnostics are based on the occasional flaw detection tests and an organoleptic evaluation. The research is conducted with the frequency depending on the class of the railway lines. Unfortunately, evaluation is performed during the run railway traffic, which especially on lines with heavy traffic, introduces additional danger. Despite the uniform assessment criteria, due to the different experience and skills of people conducting the research, discrepancies in the assessment of damage to surface elements of railway lines are present.

2. FUNCTIONAL REQUIREMENTS

This article describes the basic assumptions of experimental studies that are foundation of a system for monitoring and diagnostics surface railway lines intended for exploited rail vehicles.

The following initial assumptions were assumed at the beginning of the analysis:
- monitoring of rail surface will be carried out from the position of the rail vehicle,
- the (NVH signal) vibroacoustic signal is the basic carrier of information,
- monitoring will exceed acceptable levels, established at the end of periodic experimental studies,
- the simplicity of execution and low cost of implementation monitoring system is a fundamental feature.
the proposed architecture of the system cannot affect the operation of the equipment or other railway vehicle systems,

construction of the system will allow for any subsequent extension of its functionality.

Experimental studies will allow for monitoring and a qualitative assessment of the following phenomena:

identification of some defects and damage to rail surface (e.g. Cracks, Squat),

qualitative assessment of the rail surface,

qualitative assessment rail connections in track classic and contactless,

qualitative assessment component parts of turnouts and crossing,

determine the length and wave amplitude of vertical and horizontal inequalities.

The concept identification of the system for rail surface damage is a qualitative assessment of the vehicle – track based on the dynamic response of the vehicle. Such an assessment can be done via spectral analysis, depending on the dynamic responses occurring on wheel rail vehicle – rail segment. The qualitative evaluation not only focuses on rail surface defects but can also include geometrical irregularities of the track. In simulation studies [5] with the use of spectral and statistical analysis, it was demonstrated that two methods are complementary. Based on the above analysis, one can determine the condition of rail surface and an additional component, which is comfort.

The studied line is a fragment of the main rail lines with a maximum speed of 160 km/h, heavy load carriage mixed traffic and with selected surface damage. The designated line track has a contactless laid ballasted. When selecting the lines, an inspection was conducted with a view of identifying and locating selected defects and surface defects such as rail for example Squat and headchecking. The choice of such a reference section is not coincidental; it focuses on the commonly occurring injuries and impact of the dynamic load transferred to their changes. To measure the dynamic response will be carried out at a maximum allowed speed of rail vehicle during exploitation. Measurements will be used to select one type of new electric locomotive. The organoleptic research assessment carried out on the section of track in comparison with the actual test results and the determination of vehicle positioning, will allow the results obtained in dynamic response with selected damages to be confronted. Periodic, several month long, actual measurements show the impact load transferred from the operation to the change of the geometrical characteristics of the registered damage. The assessment of the changes will be carried out by analyzing the collected vibroacoustic signal. Local rail connections will be subject to additional qualitative assessment. The assessment of connection rails will result from the analysis of the measurements and the transferred load.
3. BOARD SUBSYSTEM

The part of board subsystem is installed on typical rail vehicles operated on the Polish Railway Lines infrastructure. Its role of it will be acquisition signals coming from sensors placed in various parts of the vehicle’s running gear system. Data collected will allow for an estimation of rail surface conditions on the basis of instantaneous values and trends occurring with collected data. Careful selection of right components incorporated in the subsystem will allow for the necessary frequency and accuracy of the research. The open architecture will allow for possible extension of system with additional sensors and its application to different types of rail vehicles. Figure 2 presents the architecture of the board subsystem.

![Architecture of the board subsystem](image)

The system architecture provides for the installation of four modules, however, the system can be supplemented with additional elements dedicated to user demand. The application of the vibration transducers module will allow for a specification of the level of vibration acceleration of selected elements running gear. The module will consist of a series of distributed sensors recording vibration acceleration from a predetermined frequency. The registration and data acquisition module will be responsible for downloading and recording the measurement data. Another element that can be used overall assessment is vehicle positioning module. By means of determining vehicle position, it is possible to compare the levels noise and vibroacoustic signals with analysis of measurements on a particular track segment. The overall assessments facilitate the evaluation of phenomena occurring on the researched rail surface [6]. The on-board computer module allows the control subsystem and current preview recorded data to be monitored.
4. CONCLUSION

The results obtained of the conducted actual research will be the basis of implementing the proposal of the measurement system to monitor and assess the quality of the railway infrastructure elements. The idea of solutions, basic functional blocks and the operation of measurement subsystem installed on rail vehicle selected reference were discussed. The created database of diagnosed damage can be used to confront real time measurements with simulation research. The application of the proposed solution in diagnostic process of railway lines in Poland will improve the safety and comfort of use. Field research will test the proposed architecture of measuring system. Periodic monitoring of the rail surfaces will contribute to a reduction in costs allocated for diagnostics and maintenance. The proposed method of measurement will improve the work of the safety inspectors conducting the diagnostics and rail traffic. At the same time, the identification and monitoring of the damage will allow for the assessment of their changes in exploitation conditions.

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Streszczenie
