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REVIEW

of the doctoral dissertation of M.Sc. Eng. Yohannis Dabesa Jelila:

Method of Assessing the Condition of Wheels of Wheelsets of Railcar During Railroad Drive

1. Basis of the Review

The review has been prepared at the request of the Scientific Council of the Discipline of Civil Engineering, Geodesy, and Transport of the Silesian University of Technology, based on the resolution of the Council of the Discipline of Civil Engineering, Geodesy, and Transport of the Silesian University of Technology dated May 23, 2024.

2. Structure of the Document

Yohanis Dabesa Jelila's dissertation titled "Method of Assessing the Condition of Wheels of Wheelsets of Railcar During Railroad Drive" consists of 120 pages and 6 substantive chapters, abstracts in English and Polish and a summary of the doctoral candidate's publications. Below is a description of the content of each chapter.

Chapter 1: Introduction

In this chapter, the author presents the research background, motivations, research problem, objectives of the study, and the overall structure of the dissertation. This chapter serves as an introduction to the topic of wheel condition assessment using vibration analysis.

Chapter 2: Methods for Assessing Wheel Condition - Literature Review

This chapter discusses various techniques for monitoring wheel conditions, including vibration-based monitoring. The author reviews methods for vibration analysis in the time domain, frequency domain, and time-frequency domain (e.g., wavelet transform, Fourier transform). Different approaches are compared, evaluating their advantages and disadvantages in the context of wheel condition assessment.

Chapter 3: Wheel Condition Assessment Based on MODWPT

In this chapter, the author describes the application of the Maximal Overlap Discrete Wavelet Packet Transform (MODWPT) method for vibration analysis. The steps of signal processing and the use of MEMS sensors for vibration measurement are presented. The main goal is to detect anomalies in the signals that may indicate wheel damage.

Chapter 4: Validation of the Method Using Field Test Data

This chapter discusses the results of field tests conducted using vibration sensors. The author presents the analysis of signals obtained during tram operation and the validation of the MODWPT method for wheel condition assessment.

Chapter 5: Sensor Node for Wheel Condition Monitoring

This chapter focuses on the description of the MEMS-based sensor node used for wheel condition monitoring in practical applications. Schematics and energy consumption are discussed.

Chapter 6: Conclusions

The author summarizes the research, conclusions, and presents recommendations for further studies in this field.

Additional Content:

Appendix A contains MATLAB scripts that were used for vibration data analysis and wheel condition assessment.

This document constitutes a comprehensive study of methods for assessing the condition of railcar wheels using advanced vibration signal analysis methods, with particular emphasis on the use of MEMS technology and MODWPT.Uwagi ogólne

3. Substantive Evaluation of the Dissertation's Research Results

Doctoral candidate Yohanis Dabesa Jelila undertook a detailed analysis of the condition of rail vehicle wheels during their operation, using an innovative method based on MEMS technology and the MODWPT transform. His research project encompassed both experimental and computational stages, which significantly enhance the scientific and practical value of the work. The doctoral candidate conducted field measurements at a tram depot, where vibrations generated by rail vehicles under various conditions were recorded. He then processed and analyzed the data using custom scripts developed in MATLAB.

High precision and a methodical approach are evident in the developed measurement methodology and in the analysis of vibration signals. An important aspect of the dissertation is the validation of the proposed method in real-world conditions, which required careful planning of experiments and adjustment of measurement equipment. During the field tests, a significant number of vibration samples were recorded under various technical conditions of the wheels, allowing for statistically significant results and confirming the effectiveness of the MODWPT method in detecting wheel damage.

In the chapter related to the analysis of field test results, the candidate presented detailed calculations related to the assessment of vibration energy for different frequency bands and demonstrated the relationship between these bands and the technical condition of the wheels. The large number of analyses carried out confirms the candidate's skills in using advanced tools for signal processing and data analysis. The author of the dissertation effectively demonstrated that his method can be used to assess the condition of rail vehicle wheels, highlighting the practical applicability of the work.

Moreover, the doctoral candidate proposed several improvements that could be introduced in future studies, including the possibility of optimizing the method's parameters depending on track conditions and vehicle speed. This makes the dissertation a solid foundation for further development of technologies for monitoring the technical condition of rail vehicles.

In conclusion, both the chapter concerning the field research and the conclusions drawn from the analyses should be evaluated very positively. The dissertation makes a significant contribution to the development of diagnostic methods used in rail transport, and the presented results are original and valuable elements of this work.

4. Original contributions of PhD dissertation of Johanis Dabes Jelila

In Yohanis Dabesa Jelila's doctoral dissertation, the following chapters can be considered as original contributions:

Chapter 3: Wheel Condition Assessment Based on MODWPT – In this chapter, the author presents his developed method for assessing wheel condition using the MODWPT transform and MEMS sensors. This is an innovative approach to vibration analysis that enables effective detection of wheel damage during operation. The application of this method for assessing the technical condition of wheels can be considered an original contribution to the field of technical diagnostics of rail vehicles.

Chapter 4: Validation of the Method Using Field Test Data – This chapter includes detailed results from field tests conducted under real operating conditions. The validation of the proposed MODWPT method based on real data from a tram depot represents an innovative element of the work, confirming the practical application of the developed method.

Chapter 5: Sensor Node for Wheel Condition Monitoring – This chapter focuses on the sensor node based on MEMS technology, developed by the author for monitoring wheel condition in real operating conditions. The described system is an original solution for remote monitoring of the technical condition of rail vehicles.

These chapters bring new elements to the field of technical diagnostics, and the methods and tools used are innovative with potentially wide applications in engineering practice.

5. Critical remarks regarding the work:

5.1. Computational Complexity: The use of MODWPT, while effective, introduces high computational complexity, particularly during real-time processing. This could limit its scalability and practical implementation in real-world applications.

5.2. Signal Processing Challenges: The time-frequency analysis methods, including MODWPT, face limitations in accurately processing transient signals, which are key in detecting faults. These methods may struggle with noisy data or non-stationary signals, leading to reduced sensitivity in fault detection.

5.3. Validation Limitations: The validation of the proposed method was conducted in a controlled environment, such as tram depots. Expanding the validation to other types of rolling stock and real-world conditions, such as high-speed trains or varying track conditions, could strengthen the generalizability of the results.

5.4. Limited Sensor Placement: The MEMS sensors were only installed in limited locations under the track, which could reduce the robustness of the measurements. Additional sensor placements on the vehicle itself or across different points on the track would improve data accuracy and fault localization.

5.5. Lack of Cost Analysis: Although the dissertation discusses the benefits of MEMS-based sensors, there is no detailed analysis of the cost implications of implementing such a system on a large scale, including the installation and maintenance of sensors.

5.6. Energy Consumption in IoT Solutions: The proposed IoT-based monitoring system relies heavily on wireless communication, which may face challenges in terms of power consumption and maintaining reliable transmission, especially in noisy environments like depots.

5.7. Narrow Focus on Tram Systems: The research primarily focuses on trams, which limits its applicability to other types of rail vehicles. The system should be adapted to other contexts, such as long-distance trains or freight transport, to explore its full potential.

5.8. Transient Fault Detection: The dissertation mentions difficulties in detecting transient faults due to the nature of the signal processing methods used. This challenge, coupled with high levels of field noise, can impact the reliability of fault detection during actual operation.

The dissertation submitted for evaluation by M.Sc. Eng. Yohannis Dabesa is the result of carefully conducted research, aimed at assessing the technical condition of rail vehicle wheels using advanced methods of vibration signal analysis. The doctoral candidate presented an insightful theoretical study, supported by well-planned field tests and data analysis. The developed method, based on MEMS technology and the MODWPT transform, represents an innovative approach to technical diagnostics.

A particular achievement of the doctoral candidate is the execution of field tests, which were meticulously designed and conducted under real operational conditions. These tests provide strong validation for the proposed method and significantly enhance the practical applicability of the research.

The dissertation is an example of a well-thought-out and comprehensive research project that covers all key aspects of the problem—from a literature review, through experimental field tests, to detailed calculations. Although the critical remarks point to certain areas for further research, they do not detract from the high overall assessment of the work.

Considering the quality of the dissertation and its contribution to the development of modern diagnostic technologies, it should be recognized that it meets the formal and substantive requirements. The dissertation fulfills the requirements of the Law on Higher Education and Science (consolidated text, Journal of Laws of 2023, item 742, as amended) in the field of engineering and technical sciences, in the discipline of civil engineering, geodesy, and transport. I recommend the acceptance of the dissertation and the author's admission to public defense.

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