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## **DISSERTATION REVIEW OF THE DOCTORAL THESIS**

Doctoral thesis:	<b>Anti-slip Control of Traction Motor of Rail Vehicles</b>
Student name:	Ing. Abdulkadir ZIREK
Supervisor:	Doc. Ing. Michael Lata, Ph.D.
Specialist supervisor:	Prof. Ing. Jaroslav Novák, CSc.
Branch of study:	3706V005 Transport Means and Infrastructure
Programme of study:	P3710 Technique and Technology in Transport and Communications
Schooling place:	University of Pardubice Jan Perner Transport Faculty Department of Transport Means and Infrastructure

### **1. UP-to dateness of the topic**

The analysis of the phenomenon of anti-slip control of traction motor of rail vehicles is the issue not brand new, but up-to day very important and from the point of view of practice, very interesting too.

The recent development in power capacity of the modern vehicles enables them to reach a high torques in a short time, but the traction ability of the vehicles is limited by physical laws mainly, and often more or less by environmental and human influences too. This thesis deals with the use of anti-slip control methods for rail vehicles. To verify the validity of the anti-slip control schemes, a numerical model of a tram wheel roller rig has been created by means of MATLAB editor. To determine the coefficient of adhesion and adhesion force between the wheel and roller, the Freibauer and Polach adhesion force model was employed. Five wheel slip control strategies are in this work suggested. This work includes an experimental part in which extensive experiments are carried out on laboratory test equipment where the anti-slip algorithms are implemented and tested. I greatly appreciate, that the performances of all included wheel slip control methods were evaluated through the mathematical model and experimental investigation as well.

### **2. Selected methods of writing**

Selected method of writing is standardly used for the graduation work completing. The work consists of six chapters with introduction as the first chapter, references, publications of

student and appendices. The work is completed by list of figures, tables, symbols and abbreviations. The thesis has 137 numbered pages. The structure of the thesis is common, where in the beginning of the work is analysed the situation in the area of dissertation. There is the adhesion and slip mechanism explained here. Furthermore, the slip detection methods and slip control methods based on the literature review are introduced. The aim (purpose of the thesis) of the dissertation is quite wide specified in the first chapter. Theoretical background of the adhesion issue is in the chapter 2. The overview of applied methods and the methodology is described in chapter 3. Developed wheel slip control methods are described in the chapter No. 4. Results and discussion are evaluated in the chapter 5. The conclusion (chapter 6) contents a summarisation of the contributions. It contains completed objectives of doctoral thesis, scientific contributions of doctoral thesis and recommendations for future research. All the work structure is meaningful and proportions of the text formations is acceptable. The Ph.D. student uses correct terms specified for the processed field of study. The work is written on very good graphical level.

### **3. Objectives and their meeting**

Objectives of the work are written in the chapter No. 1 Introduction, subchapter 1.1 Purpose of the thesis. This study aims to development and implementation of the anti-slip control methods for rail vehicles and verification of the validity of the anti-slip control schemes according to various conditions. In fact I think that this is true objectives only. This is specified directly in abstract. In other text is widely in detail described all the procedure or the chain of steps, that could lead to the requested aim. More precisely, there is in advance specified every detailed activity, that are needed to meet the specified work.

On the base of the thesis study I can express, that these objectives were fulfilled.

### **4. The dissertation thesis adding**

There was developed a numerical model of the tram wheel roller rig in MATLAB environment that can be used for performance evaluation of the wheel slip control strategies. Proposed algorithms enables to control the wheel slip mechanism and to establish optimum utilisation of adhesion. Strategies are design to be used on electric multiple units and electric locomotives. The validity of the developed numerical model is proven by comparing of simulation results with experimental results. The functionality of the proposed wheel slip control algorithms is verified by the validated numerical model (under the assumption of several surface conditions). The functionality of the controllers is proven with the experimental setup under several test conditions. The validated numerical model is used for the further performance evaluation of the wheel slip control algorithms with different speeds and control parameters.

The systematic investigation in this field and (by means of computer simulation computation repeatable) results and experimental investigation, we can take into account as a new findings.

### **5. Significance for profession or scientific development**

The work may be adequately significant for other in field directed investigation. The numerical model of a tram wheel roller rig that includes nonlinear effects caused by time delay and disturbances to match the values of the experimental test setup is developed so that other researchers

can easily simulate the dynamic responses of wheel slip and electric motor control strategies. Five different strategies were suggested for the use on electric multiple units and locomotives. Employing WSCMT method (Wheel Slip Control based on Multiple slip Thresholds) on wheel slip control is a unique procedure and proposed by the author. It aims to provide an improvement to the utilisation of the adhesion. The dynamic responses of the implemented anti-slip control strategies are evaluated under different surface conditions on both experimental tram wheel roller rig and its numeric model. The performance of the control strategies with different speeds, threshold values, deceleration and increment rates were evaluated on the validated numerical model.

## **6. The extend and quality of the published works related to the dissertation**

In dependence on the processing of this work, during the doctoral study were processed and published 4 publications. Three of them were published on the conferences (1 in Turkey 2 in Czech Republic). Advantage of these articles is that probably all of them were presented in front of experts in field. One article was published in the Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit (Science Citation Index Expanded and Current Contents – Engineering, Computing and Technology). This is an excellent result. So this one express, that the good quality of the published works has been achieved.

## **7. Questions**

1. Which nonlinearities were implemented into the computer simulation model and how the results of computations correspond with the results of experimental measurements?
2. Why did you chose the Freibauer – Polach adhesion mechanism model?
3. What do you mean, are by you gained investigation results applicable in practice in short time, an if yes, where?

The Doctoral thesis and Doctoral thesis precis fulfilled all requirements there are connected with this type of document.

## **FINAL ASSESSMENT**

I can state, that reviewed dissertation thesis of Ing. Abdulkadir ZIREK meets the requirements for creative scientific work for awarding the title

**„Philosophiae doctor“  
(Ph.D.)**