EXPERT OPINION
on the doctoral thesis titled
Anti-slip Control of the Traction Motor of the Rail Vehicle

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The dissertation deals with a development of anti-slip control methods for improving the traction performance of rail vehicles. This topic has become important recently due to increasing power of newly produced rail vehicles on one hand and increasing requirements on track friendliness on the other hand. The importance of the topic is very well summarized in the first chapter of the thesis "Introduction".

The objectives of the thesis are given in chapter 1.1 and are following:

1. Summarizing a large number of published studies on the wheel slip, adhesion and slip control methods.

2. Reproducing a numerical model of the tram wheel roller rig in Matlab environment that can be used for simulation of different wheel slip control strategies.

3. Proposing algorithms to control the wheel slip mechanism and establishing optimum utilization of adhesion.

4. Validation of reproduced numerical model

5. Verifying the functionality of proposed wheel slip control algorithms by either the validated numerical model or experimentally obtained results from the tram wheel roller rig.

6. Evaluation of the proposed wheel slip control algorithms with different speeds and control parameters.

All these objectives have been fulfilled that is transparently documented in the submitted thesis. However, the fulfillment of the point 3 – proposal of the algorithms – is fulfilled with reservations. This is more described below.

A large number of high quality scientific publications has been gathered and studied during the work. There are 82 references given in the thesis. The current state of the knowledge regarding the wheel slip control methods is described in the chapter 2 of the thesis. There are seven different methods described that have been already developed previously. Most of the methods are based on the knowledge of the real wheel slip. As correctly stated in chap. 2.3, an identification of the wheel slip is one of the most problematic issues of the control methods. Unfortunately, this topic is described in the chapter with the current methods very briefly and it is not a part of the development of the new methods at all.

From the seven described current methods, three were chosen for a further analysis (Slip threshold value, acceleration based, PID). The first one was improved by the author to the multiple threshold method. To these four methods another one – called "Sliding mode wheel slip control" – was also considered. This last method is also not newly invented by the author. But unfortunately this method is not mentioned in the chapter describing the current already known methods.

In total, there are five methods proposed for the further analysis.

The proposed methods were analyzed using the numerical calculations and experiments with a tram-wheel test stand that was developed by VÚKV and later renewed by the Faculty of Transport Engineering of University of Pardubice. For this purpose the advanced numerical model was created incl. detailed models of electric motors and of a wheel-roller contact. As the first, the calculations using the numerical model with implemented wheel slip control algorithms with different parameters were done. The calculations were then validated using the experimental results obtained from the test stand. The results of numerical calculations of each method are given and commented in chap. 5.2. This is followed by the results from performed experiments in chap. 5.3.

As it was already stated above – four methods of five proposed are based on the knowledge of the wheel slip. This was directly measured on the test stand and thus this problem was not a part of the work. But the identification of the wheel slip is probably the main issue of the methods implemented in the real rail vehicles. Therefore it is a considerable disadvantage of the work that it did not focus more on the application of the methods in the real vehicles taking into account also necessity of identification of the wheel slip. The topic of the thesis – based on its title – is an anti-slip control of the rail vehicle. Unfortunately, the research work finishes with an anti-slip control of the test stand. It also has to be mentioned that only one control method is unique and proposed by the author – the method based on the multiple threshold. It is very questionable if this method can be considered to be new since it is an improvement of the current one. And looking at the calculation results (in the Annex of the thesis) it is also questionable if it brings any significant improvement.

From this point of view, the main scientific contribution of the work is the creation of the numerical model of the test bench and its validation using the experimental results. There is a large number of calculations with different wheel slip control methods and with different parameters that were done and the results are documented in the thesis. Comparison of the calculated results with the results from performed experiments is very valuable and it has to be appreciated that the calculated results are very close to the experimental ones.

The main result of the work is a comprehensive comparison of several wheel slip control methods taking also into account their different parameters. This is followed by the recommendations of the usage of the methods for EMUs or locos. The comparison is especially valuable due to the usage of the experimental data obtained from the measurements on the test rig. This can be considered as a novelty brought to the studied problem.

There are four publications that were published by the author of the thesis related to the work. Three of them are contributions from international conferences. This is considered to be of a sufficient extend and quality.

Questions:

- What improvements does the multiple threshold method bring compared to the single threshold method? When comparing the graphs in Annexes with similar parameters of both methods, it seems that the differences between the methods are negligible.

- What modifications of already published sliding mode controller were done by the author?

- Which method for identification of wheel slip would be suitable for locomotives?

Conclusion:

The dissertation thesis meets the requirements for creative scientific work for awarding the title Ph.D.

Praha, 16th August, 2019
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