Doctoral Thesis Evaluation Form

1. **Name of PhD candidate / e-mail:**
   Ing. Radovan Galas / Radovan.Galas@vut.cz

2. **Name of PhD programme:**
   Design and Process Engineering

3. **Title of PhD thesis:**
   Friction Modification within Wheel-Rail Contact

4. **Title and name of principal supervisor/e-mail:**
   Prof. Martin Hartl / Martin.Hartl@vut.cz

5. **Title and name of co-supervisor/e-mail:**
   Dr. Milan Omasta / omasta@fme.vutbr.cz

6. **Title and name of reviewer/place of employment/e-mail:**
   Meierhofer, Alexander, Dipl.-Ing. Dr.techn./ Kompetenzzentrum - Das Virtuelle Fahrzeug Forschungsgesellschaft mbH (ViF) / Alexander.Meierhofer@v2c2.at

7. **Overview of the scope of PhD thesis**

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<th>Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable</th>
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<td>Top-of-Rail (TOR) products are contaminants that are applied to the wheel-rail contact in order to control the creep force of the wheel-rail interface. This is beneficial with regards to, e.g. damage, wear, and noise. The main aim of this thesis was to investigate the influence of the applied quantities and the chemical composition of different TOR products on their performance. Therefore, two different types of laboratory test were used: a commercial tribometer and self-constructed Twin-Disc test rig. A second aim of the thesis was the question if an overdose of these contaminants can still guarantee a safe braking distance. Therefore, as well as for the validation of the laboratory tests, field experiments were conducted on a light rail system. The findings showed that both, the composition and the applied quantity strongly affect the performance. In case of water-based TOR products, evaporation also showed a significant influence. Generally, it was possible to reduce wear and surface damage significantly but it seems difficult to achieve a significant reduction of noise without impacting the braking and traction capabilities.</td>
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8. **Significance of the topic and clarity of problem statement:**

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<th>Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable</th>
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<td>Top-of-Rail (TOR) products have been used in the past few years to control the friction in-between wheel and rail. They are said to reduce wear, noise and damage while not significantly reducing the traction and braking behaviour. Such bold claims by the manufacturers demand a high level of validation, especially as this touches safety aspects. The here presented thesis uses several previously published investigations as a foundation to investigate the influence of applied quantity and composition on the performance on friction, noise, wear, and damage with three different experiments. This makes the thesis very significant as it tries to tackle every important part of the</td>
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problem but loses itself a little bit in the broad range of investigations and its own ambition instead of really delving deep into one specific part.

9. Knowledge of existing literature:

Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable

The literature review was very extensive and contained a broad overview especially regarding the composition of friction modifiers and performance in previous tests. Nearly every presented paper was extensively summarized and I am sure that the state-of-the-art summary will be a good starting point for many people that want to learn more about friction management. But due to its ambition, the literature research seems unfocused and at times meandering, presenting results for sanded conditions or leaves when this was never addressed or investigated in the work. Also, a careful look shows that the literature contains only tribometer and Twin-Disc tests. While this is valid as this thesis mostly uses the same tests, scalability is always an issue and literature regarding field experiments or at least full-scale tests needs to be mentioned. Only one full-scale test was presented, but reading the source showed that it was also a twin-disc test. Another topic that was not given a lot of care was the theoretical part. E.g. the negative friction characteristic was never once explained, effects caused by contact geometry or temperature were completely missing, and the newest model discussed was from 1963, which is not state of the art anymore.

10. Choice of methods and technical soundness:

Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable

Three different methods were used in the thesis: a tribometer, a twin-disc test rig, and field experiments. The choice of these methods was sensible, the reasons were explained satisfyingly. A lot of care went into the measurements themselves, a lot of questions were answered and a lot of different techniques were applied, which was really impressive. However, the influence of the contact geometry on the maximum Hertzian pressure as well as on the resulting force was never mentioned. Also, it was never discussed if there was a residue of friction modifier on the discs when the wear was measured on the balance. In general, the reliability of the tests, the possible errors of the measurements and the repeatability were never mentioned. While understandable due to cost constraints, it is still something that might have elevated the thesis further.

11. Quality, originality and significance of the results:

Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable

As mentioned before, there is no information about the reliability, repeatability and errors of the test rigs. As such, the quality of the results is hard to judge. But given the presented information, great care was taken to get as much information from the tests as possible and nearly everything was considered. The results seemed very original and unique; especially the investigation of the different friction modifiers needs to be highlighted in this context. The scope of the work was quite extensive and maybe a little too ambitious: all twin-disc tests were performed with the same SRR/creepage instead of repeating them with different ones. But in general, the results are very significant, especially as a valuable stepping stone for further work on this topic by the same or other authors.

12. Quality of attached papers:

2/4
Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable.

The quality of the attached papers is generally very high but for a few missteps: In some of the papers, the information on the contact geometry is missing. A twin-disc test rig was built but never really explained in detail: how was the creepage/SRR controlled? Was it at stable values? What if you changed the SRR? Such investigations might lead to different conclusions regarding the SRR at which the maximum traction occurs (called saturation point in the thesis) and the change in the shape of the curve. Also, at one point it was mentioned that an SRR value of 5% equals a slip of 2.5%. If have no idea what this means as there was never a slip value introduced or defined. Also, the negative friction characteristic, obviously a focus of a lot of the work and in the presented papers, was never really explained or discussed in any introduction of the papers. But as said before, these seem like minor oversights and I believe they could be easily corrected, so I cannot judge them harshly.

13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8–12):

Evaluate using the following scale: excellent / very good / good / satisfactory / acceptable / unacceptable.

As mentioned before, the work presented in this thesis is quite extensive and ambitious and, thus, lacks focus at times. The structure of the thesis additionally draws attention to this. While it is optically beautiful, the content seems cluttered and, thus, is sometimes hard to read. These minor setbacks aside, the investigations are competently done and the results are of very high quality. It was especially interesting to see how different components influence the traction. I really hope that somebody will pick up where this work ended and start to look further into these things as I see a lot of future potential.

14. Other comments:

None

15. Conclusion:

PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research. Choose from following: YES/NO

16. Date and signature:

26.01.2018, [signature]
Please note
A. Evaluate categories 8 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for a PhD Thesis in the top 3% of the research in your field of expertise.
B. In each category 8 to 13 explain reasons for evaluation using between 100–200 words.
C. Overview of the scope of PhD thesis (Category 7) is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.
D. E-mail the completed form to: Klara.Javorcekova@vut.cz