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## **Review of Doctoral Thesis**

**Author:** Altan Onat, M.Sc  
**Title:** Estimation of States and Parameters from Dynamic Response of Wheelset  
**Reviewer:** Ing. Jan Kalivoda, Ph.D.

### **1. General description**

The thesis consists of six chapters, two appendixes, bibliography and list of author's publications. The thesis is written on 155 pages all together.

The first chapter is a comprehensive and up-to-date literature review comprising areas of wheel-rail contact points search, solution of wheel rail contact geometry problem, calculation of normal and tangential wheel-rail contact forces, modelling of railway vehicles dynamics, roller rig testing and application of estimation techniques for wheelsets and railway vehicles. In chapter two, the dissertation objectives are explicitly defined. The third chapter contains overview of applied methods and models whereas in chapter four simulation results are shown and discussed, followed by summary of dissertation contributions in chapter five and conclusions in chapter six.

The structure of thesis conforms to principles and requests to the structure of scientific thesis. The formal processing of the thesis is excellent, pictures and diagrams are well arranged and clearly legible.

**The thesis fulfils the formal requests on a high level.**

### **2. The topicality of the thesis**

Condition monitoring systems that detect faults or estimate running conditions in real time are vital to enable cost efficient operation and maintenance of modern railway vehicles. Such systems can be used to improve maintenance procedures, to monitor current vehicle running conditions and adapt suspension characteristics, to optimize traction or braking algorithms etc. Kalman filter is well-understood technique that has been applied to a wide variety of parameter estimation applications. Nevertheless, due to a number of issues, such as track irregularities and wheel and rail wear, which are not directly measureable or strong nonlinearities in a wheel-rail contact, the application of Kalman filter to wheelset and railway vehicle condition monitoring and utilization of such technique on standard vehicles in normal operation is still an opened task.

**The topic of thesis is actual and relevant in the context of up-to-date research in a parameter estimation of railway vehicle systems.**

### **3. Aims and methods of the thesis**

The main objective of the thesis is to test model based filtering methods for the parameter estimation of the wheelset and railway vehicles. Instead of using commercial MBS software, own mathematical models were generated. Creating such models required additional demanding tasks which were determined as the sub-objectives of the thesis. The author should apply already published and well known methods to solve wheel-rail contact geometry and contact point search, to calculate wheel-rail contact normal and tangential forces and to build dynamic models of a railway wheelset, railway vehicle and tram wheel test stand.

**Aims and methods are clearly described; methods of research work are up-to-date and appropriate to the aims.**

### **4. Results of the thesis and their benefit**

The author has studied and in the thesis quoted considerable number of bibliography sources. Comprehensively written literature review in chapter one and the overview of selected methods in chapter three are the evidences of deep theoretical knowledge and very good orientation in the problem discussed in the thesis. Selected methods and developed models are fully consistent with the objectives of the dissertation. However, the description of the process of the application of selected methods and building dynamic models is missing. It is not entirely clear what tools or software was used to compile the simulation models, if the author created the simulation models from scratch by application of selected methods or some pre prepared software tools and libraries, which already exist at author's institution, were used.

Results of parameter estimation in four different types of application are shown.

- Friction conditions - estimation of maximum friction coefficient from the dynamic response of a wheelset.
- Parameters of primary suspension – estimation of change of primary suspension lateral stiffness.
- Parameters of secondary suspension – estimation of change of secondary suspension vertical stiffness.
- Wheel test stand – estimation of rolling radius of a tram wheel.

The main objective of the dissertation is to test the application of model based filtering methods for the parameter estimation of the wheelset and railway vehicles. The idea of using Kalman filtering for condition monitoring and parameter estimation not new and such method has been applied in many different branches. Its application to the railway vehicle and wheelset parameter estimation brings many challenges. The dissertation shows very promising results of the application of unscented Kalman filter. Although the presented results are obtained on simplified models and single wheel test stand only, based on the presented methodology the systems applicable on real railway vehicles could be developed. Such systems are very desirable because offer significant safety improvements and maintenances costs reduction. The theoretical background, and the active research work performed in the thesis are an important step in the development of such systems. Author has sufficiently presented his work related to the dissertation. The list of author's publications contains 6 papers published in international scientific journals or presented at international conferences and one paper under preparation.

**The dissertation fulfils its objectives, brings new findings and is applicable for future research and development of condition monitoring systems for railway vehicles.**

## 5. Questions

1. What software tools were used to build and solve author's dynamic models? Were all the components of presented dynamic models built by an author or were his models based on existing models or libraries? Why the MBS software Universal Mechanism was selected to validate author's models?
2. Presented parameter estimation requires full state input. Because some of the state variables are not measurable directly, indirect measurement or estimation of state variables is required. Was investigated the uncertainty of state variables measurement to the performance of presented parameter estimation?

## 6. Conclusion

In my opinion, **Altan Onat** proved his ability to do creative scientific work and his dissertation „**Estimation of States and Parameters from Dynamic Response of Wheelset**“ meets the requirements for awarding the title Ph.D.

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