Söffker, D.; Kirchenkamp, S.: A scheme for validation of dynamic vehicle-wheel-track-subgrade models. 17th IAVSD (International Association for Vehicle System Dynamics) Symposium 'Dynamics of Vehicles on Road and Tracks', TU Denmark, Lyngby, Denmark, August 20-24, 2001, 3 pages.

A scheme for validation of dynamic vehicle-wheel-track-subgrade models

DIRK SÖFFKER * and SVENJA KIRCHENKAMP †

SUMMARY

First results of principally investigations of the project 'Observer-Based Validation of the Rail-Wheel Contact' as a part of the german priority program 'System Dynamics and Long Term Behavior of Bogie, Rail and Subgrade', supported by the German Research Council (DFG) are presented. The project concerns model validation of dynamic models used in vehicle system dynamics, like contact models etc. Therefore validated or verified parts of the system description are combined with measurements. Using a modified disturbance observer technique it is shown that values and ratios within unknown parts of the system can be estimated and therefore compared with those of related models. The procedure can be realized with simulated or real measurements. As an example the reconstruction of the adhesion behavior within the rail-wheel contact is examined and gives the validation of the contact model. Therefore only wheelset displacements, angles and rail and wheelset parameters without using contact related parameters or models are used.

1 THE SCHEME, THE APPLICATION TO CONTACT ADHESION RECONSTRUCTION AND RESULTS

Modeling has a large tradition in mechanics and is important not only for construction or prediction of the considered system behavior. Due to actual questions related to the short and long term behavior new questions related to the quality of the models appear. Models developed describing some special effects, work well as a single model related to the development goal. Combining these models with other models describing a more complex part of the considered reality, problems appear. This is mainly caused due to interaction effects and the restricted validity of models. Model validation is understand as the process of the prediction and related comparison of output values. If the prediction is

*University of Duisburg, Dynamics and Control, D-47048 Duisburg
†University of Wuppertal, Safety Control Engineering, D-42097 Wuppertal

good the model is good. Model validation often is done using specific test-rigs to realize measurements, which typically can not be related directly to practice. In practice, several effects are known, but can not be measured directly.

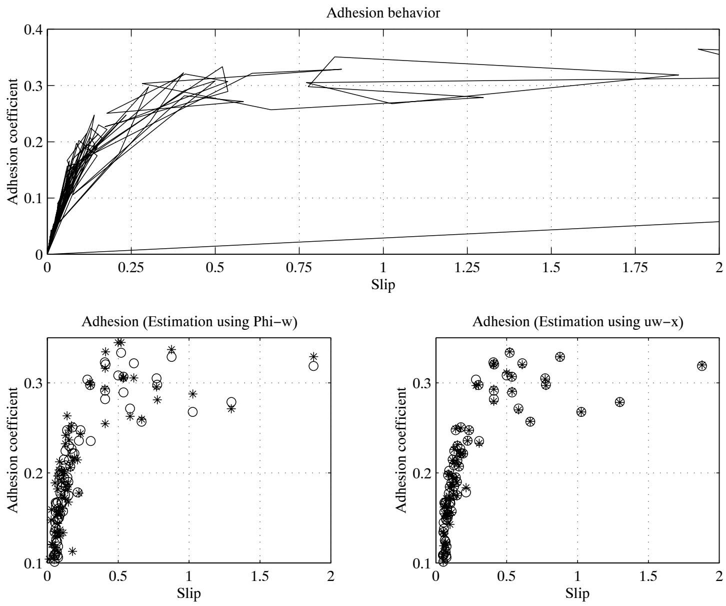

Figure 1: Reconstruction of the adhesion charakteristic
for a step-wise traction torque:
Up: Friction Time-behavior Down: Friction Ratio Estimation
o: simulated values, x: estimated values

The idea of the proposed project is to use available and simple to realize measurements and model knowledge to predict inner values of unknown parts of the considered structure. From this point of view the proposed technique appears as a virtual measurement device. As a new result it is possible to use inner degrees of freedom for model validation.

The idea of the proposed validation scheme is as follows:

- assume the considered system as modeled by the part-models 1,2,3.
- take the known models, assume them as correct, apply the proposed robust observer technique and estimate states, external effects or ratios of states and/or effects of the unknown part.

Driven by simulated or measured states, the estimation of inner effects, which typically can not be measured directly, are realized.

What does it mean concretely? For first investigations the tangential contact force of a driven wheelset is estimated as a function of time. The typical model for simulation purposes is the model of Shen-Hedrick-Elkins [2]. To understand the interaction between the elastic supported wheelset, the elastic supported rail, the elastic traction drive different models are used: the model of the wheelset (1), of the bogie (2) and of the rail (3), furthermore the mentioned contact model. Additional informations like the inertial velocity of the wheelset are assumed as available. Using the models 1, 2 and 3 an uncomplete or unknown part of the system is assumed as interacting with the known parts. Based on the known models 1, 2 and 3 an observer is build, cf. fig. 2. The interaction is considered as an unknown external effect to the known system (model 1, 2, 3). Using available measurements (assuming the observability) the unmeasurable effect (here the contact force) is estimated.

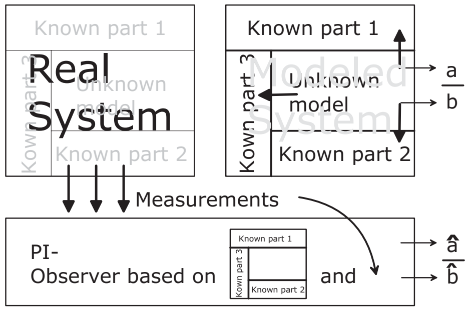

Figure 2: Principal scheme for model validation

Here the combination of contact force with the (measured) slope allows the detailed reconstruction of the adhesion characteristic, e.g. for validating the Shen-Hedrick-Elkins contact model, as shown in fig. 1. The principle strategy is given in Fig. 2. This procedure also can be applied to other unknown parts within the rail-wheel-subgrade modeling. In cooperation with other project-partners of the DFG-project the estimation of stiffness coefficients within the subgrade will be realized. Here the identification of weak spots within the subgrade should be considered. For the purpose the neccessary measurements will be realized by experiments. For the modeling of the rail-wheel-subgrade structures models developed in Ripke [1] will be used.

REFERENCES

1. Ripke, B. “Hochfrequente Gleismodellierung und Simulation der Fahrzeug-Gleis-Dynamik unter Verwendung einer nichtlinearen Kontaktmechanik” VDI-Fortschrittberichte, Reihe 12, Nr. 249, Düsseldorf, 1995
2. Shen, Z.Y.; Hedrick, J.K.; Elkins, J.A. “A comparison of alternative creep force models for rail vehicle dynamic analysis“ Proc. of 8th IASVD Symposium, MIT, Cambridge, August 15-19, 1983
3. Söffker, D. “Observer-based measurement of contact forces of the nonlinear rail-wheel contact as a base for advanced traction control” in: Wallaschek, J.; Lückel, J.; Littmann, W. (eds.)“ Mechatronics and Advanced Motion Control”, HNI-Verlagsschriftenreihe, Band 49 (1999), pp. 305-320