Abstract

In this thesis, a new method for calculating the curve resistance of freight cars in marshalling yards is developed.

The need for a new method is a result of enhanced requirements of modern automated shunting procedures, like target shooting, regarding the precision of estimating the running behavior of freight cars. Outcomes of earlier investigations show that existing empirical models are not exact enough to estimate the curve resistance within the required precision. The reason is that restrictive assumptions of the models, e.g. fixed axles or quasi-static curving, are often not applicable in terms of shunting. There are different dynamic simulation tools based on multi-body formulation, which are able to calculate the running behavior of the freight cars with high precision. However, the calculation of these simulation models takes too much time for the usage in automation systems.

For this reason, a simplified model approach is developed which shows a tradeoff between precision and calculation time. Therefor, the dynamic behavior of freight cars in typical tracks of marshalling yards is analyzed. The analysis is done with the aid of a validated multi-body simulation environment. Exemplarily, two freight car models, one with Y25-bogie and the other with double chain link suspension, are created.

For the validation of the multi-body models, reference data was gathered during a measurement in the marshalling yard Maschen Süd-Nord. Two freight cars with the abovementioned running gears were equipped with sensors. Therewith, the parameters velocity, displacement angle of front bogie and yaw rate were measured continuously.

A parameter variation by using the validated multi-body model is conducted and the results assessed. The conclusion for which parameters have to be considered in a simplified model and which parameters may be neglected for a good tradeoff between precision and calculation time are made.

The implemented new curve resistance model is based on a Divide-and-Conquer-approach with decision tree. With the help of the decision tree, predefined curving stages are identified in dependence of the type of freight car and type of track. Each of the predefined curving stages has their own submodel with a simplified structure to fulfill the requirement of calculation time.

Finally, the goodness of fit for the developed model approach is being tested and validated. For this, a sample of approximately 16000 datasets of the control system installed in the marshalling yard of Maschen Süd-Nord is used. It is shown that the precision of the estimated curve resistance is 19 % higher for two-axle wagons with double chain link suspension and 12 % higher for four-axle wagons with Y25-bogies. However, the greatest improvement can be reached by a separate examination of the different running gears. Relating to the whole sample, improvements up to 50 % can be reached.