Mitteilung

Fachgruppe: Aerodynamik bodengebundener Fahrzeuge

Unsteady force measurements on wind tunnel train models using multi-dimensional transfer functions to take into account natural oscillations

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Future high-speed trains must be faster and more lightweight to satisfy increasing demands on personal and freight transportation, as well as on the environmental impact of rail transportation. With higher speeds, the aerodynamics of a train become highly important. Both drag and side wind stability are focused on in research. So far, optimization has been done for stationary cases in quiet wind tunnel flow. However, the real surroundings of a train track like bridges, trees, etc. together with natural wind gusts provide a very unsteady incoming flow to the train.

For automobiles it has been found that an unsteady flow sinusoidally alternating around zero with a certain maximum inflow flow angle can lead to an increase in side force compared to a steady side flow at the same constant maximum inflow angle[1]. The present research investigates if this is also applicable for long bodies like trains, what causes this phenomenon and what potentially can be done to reduce it. The side and drag forces are measured with a four-sensor platform. In order to separate the aerodynamic forces from the inherent oscillations of the model and its supporting structure, the latter oscillations are identified by an impact hammer experiment beforehand. The model and its support are equipped with acceleration sensors and the frequency responses of the impact hammer strikes are recorded.

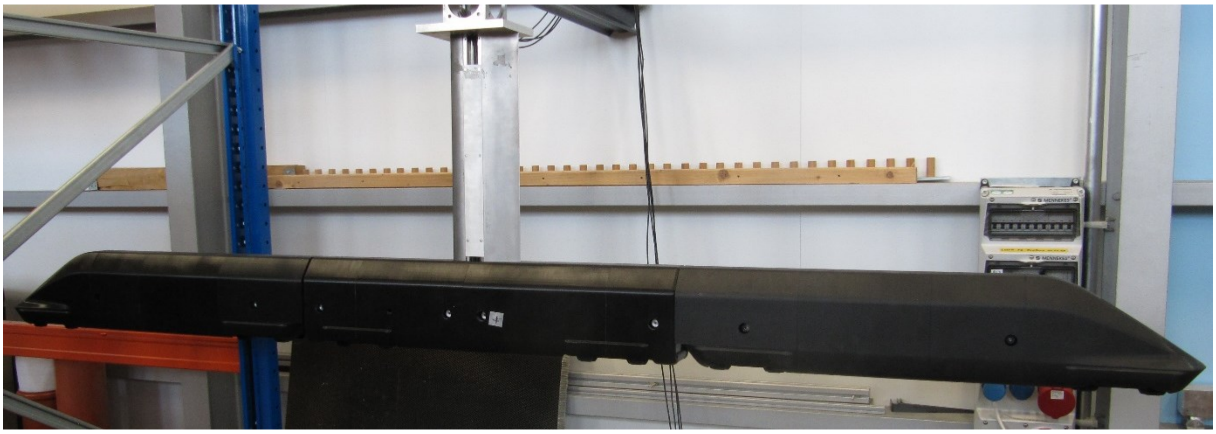

Figure 1 - train model attached to a preliminary preparation test setup outside of wind tunnel

The experiments are conducted in the crosswind simulation facility in Göttingen (SWG). As shown in figure 1, the model is connected to a vertical sting by the force sensor platform. The photo shows the model train with its aerodynamic fairing, however, the beforehand impact hammer measurements are performed on the relevant inner support structure only. For the actual wind tunnel measurements, the impact hammer experiments will be repeated including the fairing. The sensors are applied in such a way that only the acceleration in y-direction is measured, that is the side wind relevant direction. Under wind on conditions, the same acceleration sensor setup is used and – together with the results of the beforehand impact hammer test – can be used to distinguish between wind loads and inherent oscillation loads within the force sensor output.

An FFT is applied to the time signal of the acceleration sensors and impact hammer. The relationship between input (impact hammer, aerodynamic forces) and output signal (acceleration sensors, force sensors) is assumed to be linear.

Figure 2 exemplarily shows the amplitude of the frequency response in the y-direction of a sensor at the far end of the model. The data is an average of five impact hammer strikes at the same end of the model. Resonant frequencies can be identified at about 3 Hz, 5 Hz, 8 Hz and 33 Hz. The multi-dimensional transfer function combines the frequency domain results of all acceleration sensors.

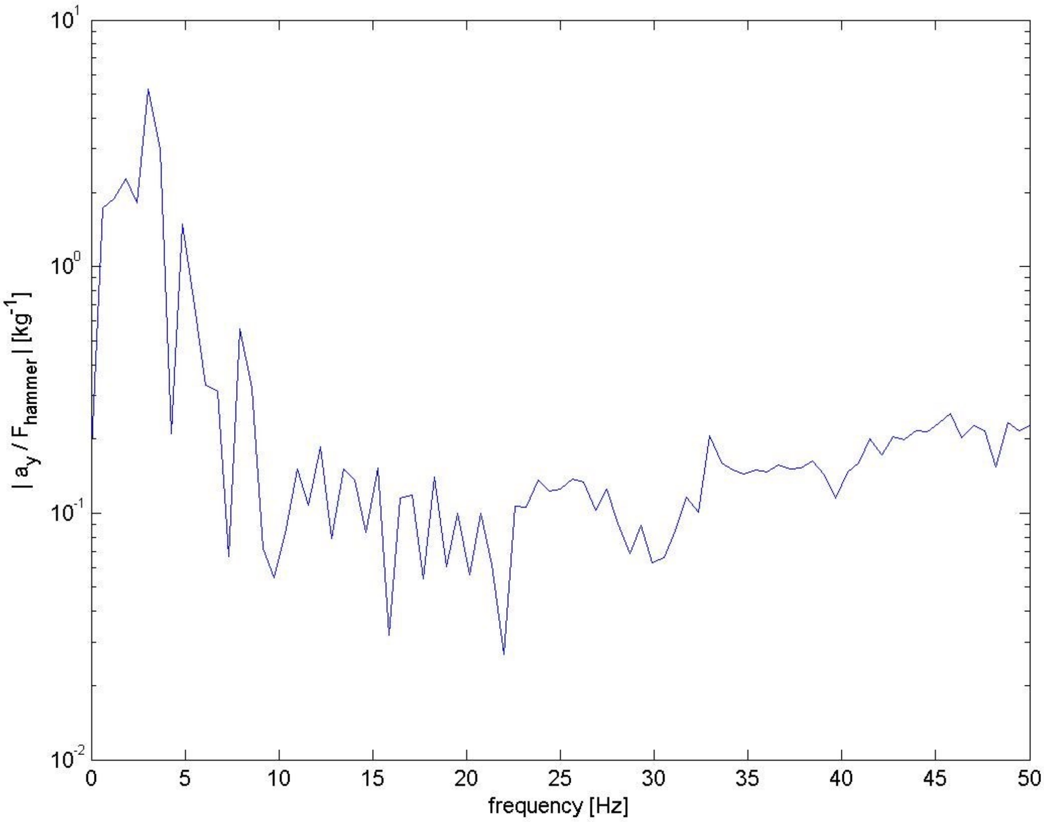

Figure 2 - amplitude of frequency response (acceleration sensor over impact hammer signal)

The influence of the number of acceleration sensors and the number of positions of impact hammer strikes, as well as the number of repetitions of impact hammer strikes on the quality of the transfer function will be investigated.

[1] Schröck, D. - Eine Methode zur Bestimmung der aerodynamischen Eigenschaften eines Fahrzeugs unter böigem Seitenwind, Dissertation, Universität Stuttgart, 2011