Telematics and maintenance of rail vehicles

The research at Chair of Rail Vehicles in this area focuses on the development of telematics and sensor systems for optimization of rail freight transport and condition-based maintenance for freight wagons. The ongoing research project in this is the Shift2Rail project INNOWAG (Innovative Monitoring and Predictive Maintenance Solutions on Lightweight Wagons). The concept underpinning the INNOWAG project aims to address the actual needs of rail freight for increasing its competitiveness and attractiveness.

The INNOWAG project addresses challenges in the competitiveness of rail freight transport with regards to transport capacity, logistic capability, RAMS and LCC. For these purposes, an innovative wagon concept is proposed, integrating condition monitoring, predictive maintenance and lightweight design solutions. The concept behind cargo condition monitoring is to develop a system based on an autonomous self-powered wireless sensor network for cargo tracing and monitoring the condition of key parameters for critical types of cargo. The monitoring system mainly consists of a communication hub and distributed sensor nodes that communicate with each other via Bluetooth. The measured condition parameters such as temperature, humidity and internal pressure for tank wagons are collected in the communication hub and sent via GPRS to a cloud. To implement a predictive maintenance regime for freight wagons, both monitoring data and historical maintenance data are analysed. The algorithms for fault detection, such as wheel tread damages, axle cracks, axle bearing failures and spring-related failures, are developed for real-time onboard wagon condition monitoring. The detection results are integrated to a records of maintenance actions, for optimization of maintenance planning.
Rail vehicle acoustics

The Chair of Rail Vehicles researches innovative approaches to noise reduction for track, rail vehicles and track laying machinery. Railway acoustics is researched as an integral part of the entire railway system among the various highly linked fields of research at the Chair of Rail Vehicles. Extensive airborne and structure-borne sound measurements in combination with simulations are used to identify the potential for noise reduction as well as to implement and optimize noise reduction measures. Because the different research fields at the department are closely linked, railway acoustics is considered as part of the whole railway system.

Measurement engineering

The Chair of Rail Vehicles is equipped with a broad range of measuring instruments to characterize the acoustics of rail vehicles, typical sound and vibration sources and to measure relevant track and vehicle parameters. Some examples are:
- Measurement of pass-by noise of rail vehicles
- Measurement of wheel/rail roughness and profiles
- Measurement of track decay rate
- Sound intensity measurements
- Structure-borne sound measurements on rail and vehicle
- Experimental modal analysis

The measurements are based on current standards. They are offered as service and are used for industrial and public research projects.

Longitudinal dynamics

The longitudinal dynamics of passenger and freight trains can be examined with regard to influences of modified brake controls, other friction materials and new coupling devices. Depending on the problem, different calculation methods and different models, varying in complexity, are used. The use of multi-body systems also allows studies of indirect effects, such as the wear in the wheel-rail contact.

By combining measurements and simulations, computer models are checked for plausibility. With these models, various parameter variations are possible and the effects of modifications to components can be calculated in advance.

The consideration of longitudinal dynamic processes plays a significant role in freight trains transport. Longitudinal forces can occur due to the large train length and big masses which affect the safety. The level of these forces depends on various factors. Other can analyze the forces and develop strategies to reduce them with multi-body simulation programs.

Wear

MKS-programs can make predictions about wear between wheel and rail based on the vehicle movement on track by means of multi-body simulation programs. This offers a wide range of applications: identification of causes of attrition, development of optimization on vehicles in order to reduce the causes of wear and a comparison between different vehicle concepts.

Energy efficiency

The following topics are dealt with in this subject area:
- Calculation of energy/fuel consumption and CO₂-emission for passenger and freight trains on real relations.
- Design and assessment of energy saving potentials

For example:
- Use of hybrid drive concepts
- Reduction of resistance
- Optimization of the driving style
- Optimized use of the electrodynamic brake

Technical features:
- Low noise bogie, lower than current standards
- 22,5 t maximum wheel load/maximum speed 120 km/h
- Significant mass reduction (<4,5 t) due to inner bearings
- Hydraulic axle-box for radial steering and low curving resistance
- Condition monitoring to detect bearing failures, wheel flats and spring damage

Mechanical components:
- Energy-efficient
- Low-wear
- Maintenance-optimized
- Acoustic-optimized
- Cost-efficient

Simulation

Through linkage of simulations and measurements, numerous excitation mechanisms of railway noise can be researched. Such virtual techniques provide the basis to understand the acoustic behaviour of a system and facilitate the identification of efficient solutions for noise and vibration related problems.