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The new locomotive wheel force testing system at the Dessau workshop of "DB Fahrzeug – Instandhaltung GmbH" as an example of wheel force load measuring equipment

Modern wheel force load testing systems drive down costs and fault rates while new force measurement techniques provide reproducible statements on the wheel force load distribution as they actually occur in the later operation of the rail vehicle.

The position of the track is crucial for the safety of the interplay of running gears and rails because it is responsible for significant wheel load distribution changes in vehicles during trips. At the same time, it is the malfunction point and source of stimulation for the rail vehicle. The track position decides on how safe, fast and comfortable people and goods can be transported.
That means that the rail vehicle is simply called upon to ensure best (i.e., the most even) wheel force distribution. The running gears are adjusted when the vehicle is manufactured and maintained and wheel force measuring equipment is used to test and correct wheel force distribution whenver necessary.
Even vehicle wheel force distribution spells out substantial economic benefits for the infrastructure owner and the operator of the rolling stock because tracks and vehicles are loaded more evenly, keeping down wear and tear.

Methods for Recording Wheel Forces
Vehicle manufactures, rail operators and industrial enterprises have a wide variety of methods for recording wheel forces ranging from the simplest system (such as mobile measuring equipment) right down to intricate combinations of measuring track and equipment. We distinguish static and dynamic systems (systems that measure during the trip). There is a controversial debate underway as to what loads have to measured at least simultaneously (axle loads, bogie loads or wagon (segment) loads) and whether a measured section should be used with or without a rail gap. Finally, the impact the environmental situation has (such as track position, temperature or vehicle drive) is very important for accuracy and reliability.
The importance of measuring equipment and accuracy requirements are often underestimated when testing and adjusting. Indeed, many people say "...± x % measuring accuracy is enough." Unfortunately, measuring systems and measuring methods developed from this point of view are correspondingly simple (because they are inexpensive).
Only when money comes into play and billing is done do people realise they need 30-50 times more accuracy. This is why it is very important to spend more time thinking about accuracy in the performance specification stage. After all, technical testing processes almost always demand high measuring accuracy and reproducibility to track down the different factors.
Figure 1 shows why it is necessary to have a high ac-

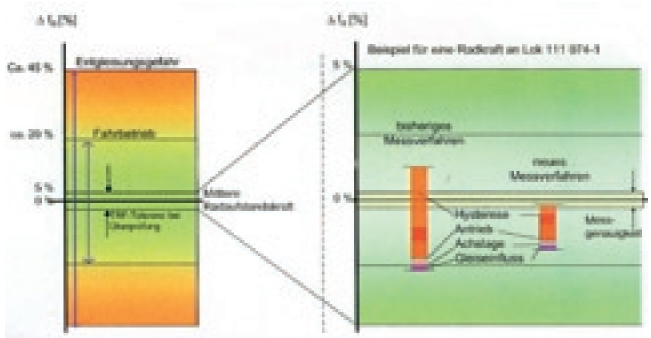

Figure 1: Wheel force distribution:from measuring accuracy to derailing hazard

curacy resp. whiy it is important to consider influencing variables with wheel force testing systems for rail vehicles. For instance, if the manufacturer and / or operator define a wheel force tolerance of $\Delta f_R = \pm 5$ %, the first thing necessary is to estimate how great the natural scattering proportion (the total reproducibility fault) will be from the measuring technique applied. There are typical reproducibility faults resulting from the hysteresis properties of springs and shock absorber elements in the vehicle, the vehicle's drive influence, the axle position in the track channel and less-than-ideal track geometry. That applies to stationary systems in workshops just as much as field-based diagnosis systems. It makes sense to set the measuring accuracy for actual force measurement so that each individual impact can be studied reliably. In any event, the accuracy of the force measurement should be at least 5 times better than the total reproducibility fault of the measuring principle.

The Physical Principle of Measuring the Wheel Force
There are not only a wide variety of methods, but also a wide range of principles (Figure 2) applied to measuring wheel forces. The strain gauge measuring principle has emerged everywhere as the most widely accepted weighing and force measurement technique for high rated loads in past decades because of its robustness and outstanding measuring properties.
Legal for trade measuring equipment can only be found with strain gauge equipment because it is the only equipment that meets the high protection class, electromagnetic compatibility and temperature characteristic requirements of equipment to be verified.

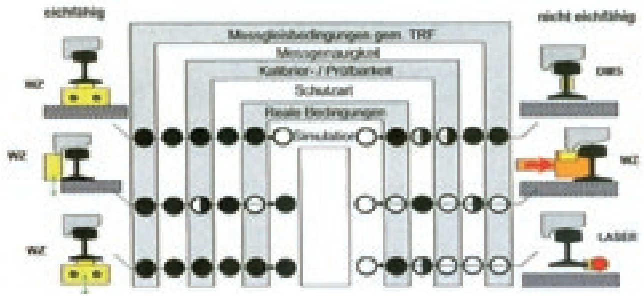

Figure 2: The design principles of commercially available wheel load measuring equipment

The systems shown in Figure 2 can be divided up into measuring systems for wheel flange and measruring systems for the running surface in terms of their design. The ideal location for recording all the forces as per the actual operating conditions is between the rail and tie. Other sensors can be used to suppress interference, for instance if you want a measuring or weighing system without a gap.

Potential measuring accuracy

The force measuring accuracies of a number of commercially available strain gauge load cells range typically between 1,000–5,000 parts (in other words, better than 0,2 to 1 ‰ accuracies). However, you can only score accuracies on this scale for actual measuring operation if you adapt your equipment to the specific requirements of rails. Strain gauge load cells have a varying reaction to minimal changes in load introduction and discharge and the additional parasitic loads and moments. But the load sensor or other bearing elements have to transmit these parasitic components specifically with track-led track vehicles. Since it requires a great deal of effort to adjust these bearing elements, meaning they are hardly ever free of play and service, special design weighbeams (Figure 3) have proven their worth for the force measurement technique under rails. They are bolted without play to allow all loads and moments to be transmitted on a substantial scale while measuring the vertical load component verifiably in each and every case with as many as 2,000 parts.

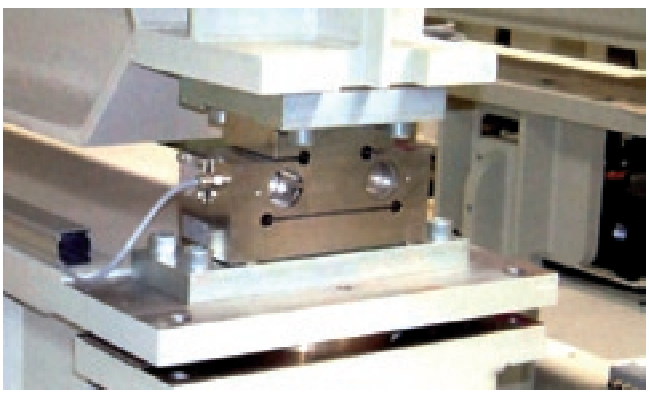

Figure 3: Weighbeams – bolted directly and without play

Wheel Load Testing System for Locomotives

The overwhelming majority of the electrical locomotives operated by DB-AG comes to the Dessau Facility (DB – Fahrzeuginstandhaltung GmbH) for service and maintenance work where they carry out overhauls, needed improvements, modernisation and repair greater damage for virtually every design series.

To put it simply, modern maintenance companies see the technical and economic requirements made of a wheel load testing system as "reduced costs + reduced fault rates". In other words, a testing system is automated and should be equipped with the appropriate accuracies. Ideally, a state-of-the-art test system should also have the potential for taking other optimising steps by applying enhanced methods and technologies.

The requirements from EBO and the TRF Module 0014 have to be complied with including logging, storing and printing out the data in conformity with the sets of rules. In this case, the operator made major requirements of the wheel load testing system because all wheel loads were supposed to be recorded simultaneously on the test specimen at a measuring accuracy better than 0.25% of the final value (i.e., the specific locomotives), i.e. without pushing the locomotive between weighings. Making specific changes in the height position per wheel measuring segment based upon the measuring track reference level had the purpose of simulating changes in adjustment. They wanted to simulate changes in adjustment in both directions (±) by lifting the measuring bridges with the test specimen to a higher measuring track level.

The lifting paths needed – linked with the measuring accuracy – called for precise design with outstanding reproducibility properties. Logically, an electromechanical design was used that working points could be moved to-

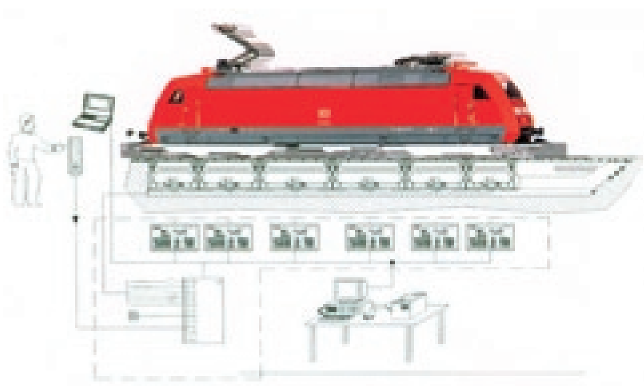

Figure 4: The wheel load testing system

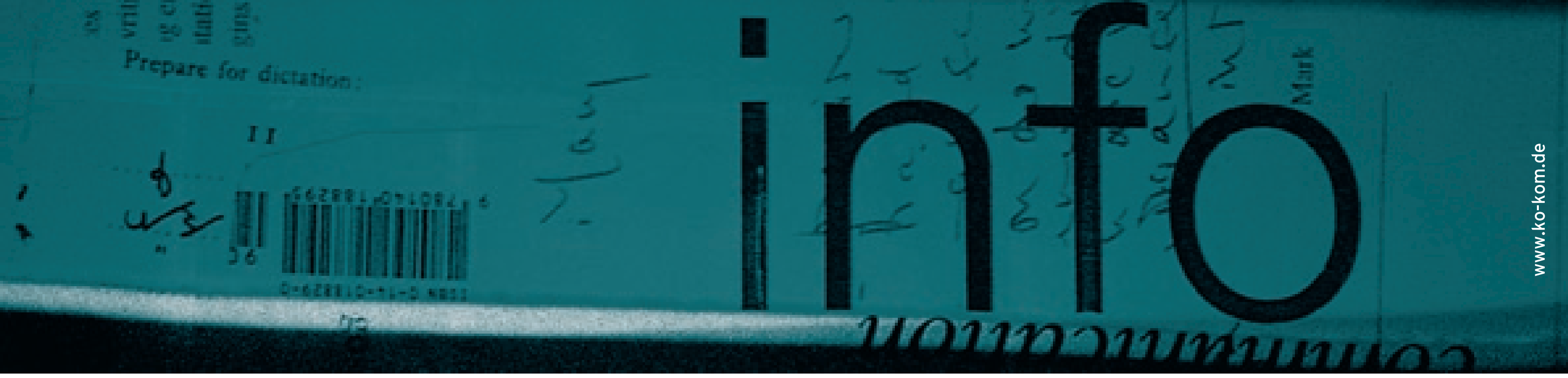

Figure 5: Accessible working pit

wards in a highly reproducible fashion controlled by load or path. The weighbeam already described made it possible to design this equipment without any play in terms of the weighing equipment. It was also a benefit that the working pit was accessible to the operator (Figure 5).

The wheel force testing system automatically records and displays all wheel forces simultaneously. Beyond this, it is not necessary to push the test specimen (i.e., the locomotive) and additional information on hysteresis properties of the load exerted can be recorded and applied by varying the lift. In turn, changes in track position (as are witnessed on a everyday basis) can be simulated and the wheel force can be optimised with an individual "height movement" for each individual wheel derived from that.

Authors:
Dipl.-Ing. Peter Palmer, planning engineer for infrastructure and capacity/investment development, DB Fahrzeuginstandhaltung GmbH at the Dessau Facility, peter.palmer@bahn.de
Dipl.-Ing. Peter Groll, manager of the Train Diagnosis Systems Business Unit at Schenck Process GmbH, Darmstadt, p.groll@schenckprocess.com

schenck process

Schenck Process GmbH
Marketing Communication
Pallaswiesenstr. 100
64293 Darmstadt, Germany
T +49 61 51-32 29 87
F +49 61 51-32 27 54
press@schenckprocess.com
www.schenckprocess.com

www.ko-kom.de