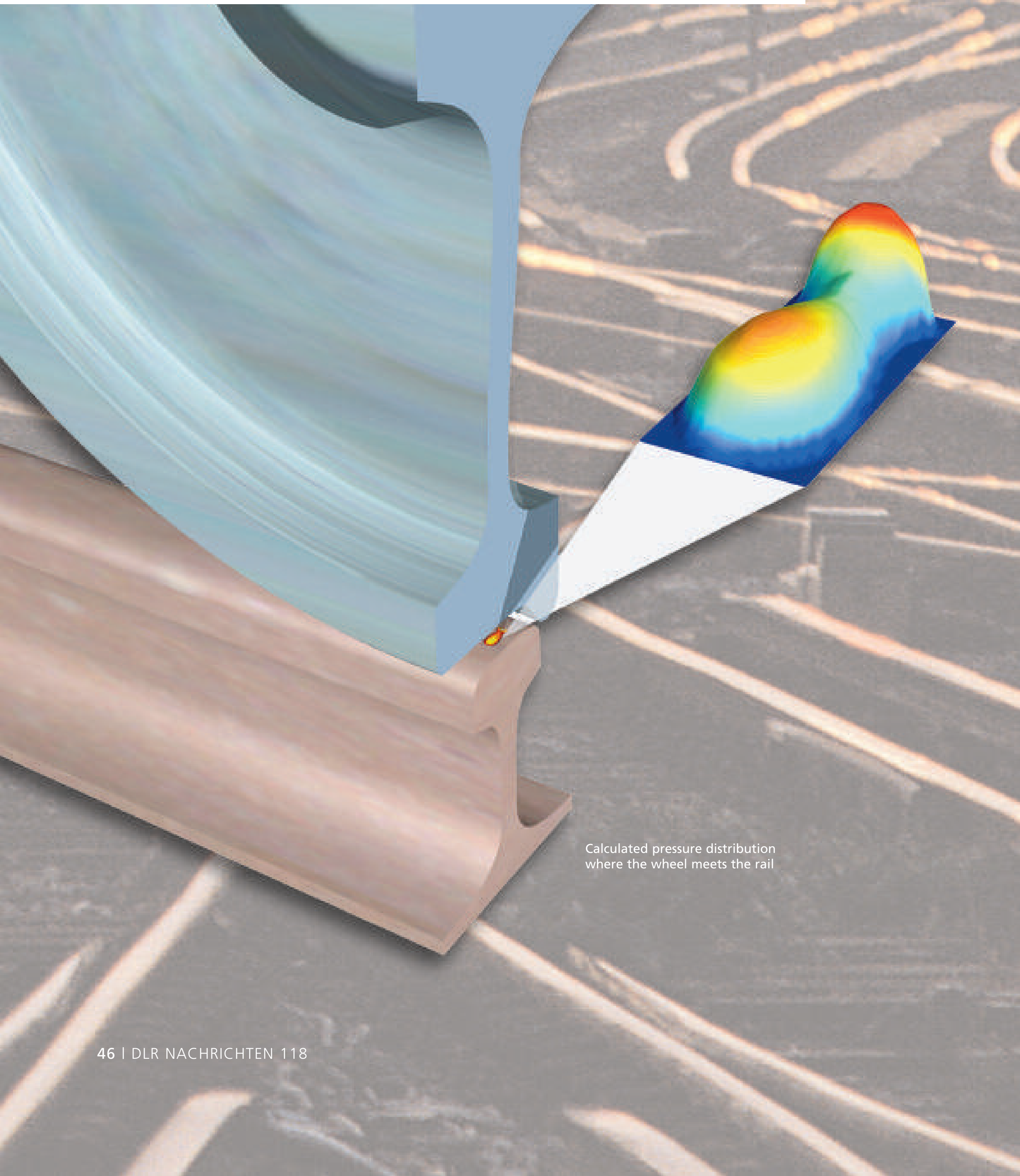
SMALL SURFACE, BIG EFFECT

Better Performance for Wheels and Rails

By Dr.-Ing. Andreas Heckmann



Calculated pressure distribution where the wheel meets the rail

HERE, A LOAD OF 8,000 KILOGRAMS PRESSES ON AN AREA THE SIZE OF A THUMBNAIL

It's hard to believe it but the forces that keep a rail vehicle on track are transmitted between the wheel and track over a contact surface of approximately one square centimeter in size. Figuratively speaking, the surface area of a thumbnail per wheel is enough to resist the aerodynamic drag or crosswinds and simultaneously support up to ten tons of vehicle weight! A traction force of only 100 Newton per wheel is enough to overcome friction and move a rail vehicle.

Form, position and force distribution of the contact surface are of course not at all constant in operation but are influenced by the complex interaction of a multitude of factors and components. This context is comprehensively described as the wheel-rail system. It comprises cargo loads and superstructures, the undercarriage, the drive train and brakes of the rail vehicle, track system and line, aerodynamic drag and side forces and many other factors. Analyzing such complex systems with regard to derailing safety, stability in the high-speed area and exposure to the influence of crosswinds is no longer imaginable without computer simulation. For this purpose, a special calculation technique, the multi-body simulation, was adapted and advanced at the Institute of Robotics and Mechatronics at DLR in Oberpfaffenhofen. Since the early 1990s, this technique has been implemented in a simulation tool which is used by the majority of rail vehicle manufacturers today.

However, as is often the case in technology, a standstill means taking a step backwards. The requirements demanded of modern rail vehicles are growing. Goals, such as CO_2 reduction, energy efficiency, high speeds, improved relation of cargo load to total weight, improved comfort, and reductions in noise and wear, are all increasing in importance.

The paramount task of guaranteeing passenger, crew and resident health and safety only becomes more difficult in the light of these new requirements. Higher speeds mean higher loads on the drive train, undercarriage and brakes. Lightweight structures tend to be affected by vibrations which increase due to higher dynamic loads in the entire wheel-rail system. The result is more wear of the wheels and rails, which again increases vibrations. This reveals that a complex system can only be analyzed and optimized in its entirety.

The key to driving safety, however, lies precisely in the forces that directly keep the rail vehicle on track. These are the forces of the wheel-rail contact. This is also where wear and tear is created. The diameter of a rail vehicle's wheel diminishes by between 1 and 10 millimeters per 500,000 kilometers of distance covered. The costs entailed by maintaining the vehicles and track infrastructure form the biggest part of the expenditure for any rail operator. Additionally, the wheel-rail contact is the cause of rolling noise which defines the noise emissions of rail vehicles. DLR thus develops methods that enable a more precise depiction of wheel-rail forces in computer-aided driving dynamics simulation for the next generation of trains. The central approach is the description of the elastic properties of the wheel set and the track, which lead to the fact that these individual bodies in themselves already are vibration-capable partial systems.

The realistic computer simulation of wheel-rail forces creates a technology which is close to practice and which will pave the way for the optimized construction of the overall system and its monitoring in operation. This will ultimately lead to safer, more wear-resistant and quieter rail vehicles.

We can thus ensure that the wheel-track technology, which was already used in 16th century mining for transporting goods more safely and more efficiently, remains on the right track with regard to the demands of the 21st century.

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