RESEARCH NEWS

Expert interview with Manfred Bäcker and Christoph Burkhart

"Paving the Way for Virtual Tire Development"

Before a car rolls off the production line, manufacturers run virtual tests on it. Simulating tires is particularly challenging since they are subject to extreme stress when driving over potholes and bumps. This is where CDTire comes into play. The tire modeling software developed by Fraunhofer researchers enables realistic tire models and supports the automotive industry in a wide range of analysis scenarios. Manfred Bäcker and Christoph Burkhart from the Fraunhofer Institute for Industrial Mathematics ITWM explain how the new software also helps reduce costs and shift time-consuming test drives from the real-world test track to the vehicle simulator.

Why is simulating tires such a challenge?

Manfred Bäcker: Because tires exhibit complex, non-linear behavior. Driving generates heat, which changes the tire properties. This makes it difficult to simulate their behavior accurately and quickly at the same time. We therefore need sophisticated models that take into account both the thermal effects and the non-linear dynamics of the tire on the road, which requires a lot of computing power.

How do you manage to strike a balance between computational time and accuracy?

Christoph Burkhart: CDTire is actually a family of tire models covering carcass, sidewall and tread models to strike the optimal balance between accuracy and computational efficiency for diverse applications. The aim is to create a realistic simulation that requires little computational time. This also includes real-time models.

How is CDTire driving virtual tire development?

Manfred Bäcker: In the automotive industry, tire models are integrated into vehicle simulations to virtually test and optimize driving behavior. These simulations take into account complex factors such as heat development, tire deformation and material properties, all of which affect driving behavior. Vehicle manufacturers use tire models early in the development process to obtain information on comfort, structural durability and driving dynamics for a specific development stage. About 15 years ago, tire models offered only limited functionality while tire manufacturers were already using sophisti-

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cated tire models. However, these could not be included in the overall vehicle simulation due to their high computational time requirements. CDTire bridged the gap between tire and car manufacturers. Our tool serves as an exchange format between the two industries. The tire industry uses it in early development, while the automotive industry uses it in the overall vehicle context. CDTire can quickly implement adaptations for OE (original equipment) tires, which are specifically developed for the original equipment of a vehicle.

So CDTire has become a frequently used tire model?

Manfred Bäcker: Yes. Almost all well-known vehicle and tire manufacturers are our customers. Since CDTire enables virtual test drives in vehicle simulators, companies can avoid time-consuming real-world test drives and the production of expensive prototype tires during development. Depending on the application, our tire models, which calculate in real time, can be integrated into the simulator. This development has allowed us to move away from real-world test drives and towards vehicle simulations. Our aim is for professional test drivers to evaluate tires primarily on the vehicle simulator using virtual tire and vehicle prototypes. The real-world test track would then only be required for the final prototype approval.

CDTire allows you to map the entire tire development process. How does that work?

Christoph Burkhart: CDTire provides development engineers with a tire model for almost all analysis scenarios. Our focus on carcass dynamics and interaction with 3D road surfaces delivers good prediction accuracy, even well outside the range covered by the measurements obtained for model data input. During tire simulation, the software calculates the wheel hub forces and torques on each wheel and the contact forces on the road.

What special enhancements or functionalities does the current software version offer?

Manfred Bäcker: CDTire3D is a multi-physics tool that can, for example, simulate the temperature development and, by integrating a dynamic internal-air model, also the tire’s internal air. More recently, we added a feature that also calculates tire wear. The internal air vibrations are transmitted to the vehicle interior via the vehicle chassis, causing the steering wheel and dashboard to vibrate, which reduces occupant comfort. But above all, these vibrations are audible. In electric vehicles in particular, they are perceived as annoying. In addition, our new flexible rim model allows us to assess tire and rim together as a complete wheel, significantly expanding the model's scope and possibilities.

To what extent do your simulations also play a role for the range of electric vehicles?

Christoph Burkhart: CDTire now allows us to precisely simulate rolling resistance and predict it under different driving conditions. A tire's rolling resistance is the result of energy losses. It is part of the EU tire label, which rates tires in efficiency classes from A to E. Lower rolling resistance improves the vehicle's fuel consumption and therefore also its energy efficiency. In practice, however, things are different. Tires perform below the efficiency class threshold in everyday life since people drive short distances with cold tires. This is a particularly important aspect for electric vehicles because it affects their range. This is why we adapted CDTire to include internal friction losses. The software combines internal friction with the temperature model to create a realistic simulation of the rolling resistance.

Are you planning to transfer your technology to industry?

Manfred Bäcker: Yes. We will launch our Virtual Tire Technologies (VTT) spin-off in Kaiserslautern in 2026. However, we will continue to collaborate with Fraunhofer ITWM and remain in close touch.

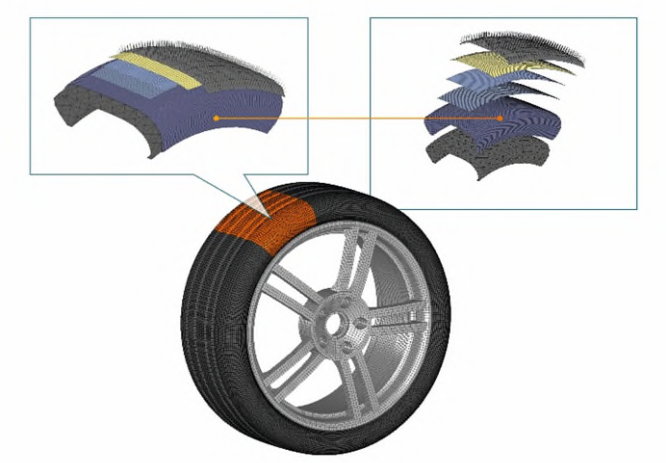

Fig. 1 Basic model structure of the CDTire/3D tire model featuring reinforcing plies. The model is connected to a flexible rim model

Fig. 2 Manfred Bäcker, research scientist at Fraunhofer ITWM, Mathematics for Vehicle Engineering department

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Fig. 3 Christoph Burkhart, research scientist at Fraunhofer ITWM, Mathematics for Vehicle Engineering department

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