ON THE RIGHT TRACK

Railways systems are examined, simulated and tested at TU Graz from top to bottom. This includes rolling stock as well as track systems and superstructure, but also the underlying mobility concepts and their economic viability.

Birgit Baustädter

Working together to get mobility on track for the future – sustainable, safe, reliable and economically viable. This goal was set two and a half years ago by the railway-focused institutes at TU Graz together with the business partners ÖBB (Austrian Railways), Siemens, voestalpine Railway Systems and Virtual Vehicle in the Research Cluster Railway Systems. Since then, researchers at the Institute of Railway Infrastructure Design, the Institute of Railway Engineering and Transport Economy and the Institute of Structural Durability and Railway Technology have been working on a digital twin that virtually maps the railway system. This should simplify planning, checking, conceptualisation and operation or maintainance significantly.

Apart from this, researchers at TU Graz are scientifically interested in almost all parts of a railway system and in looking at the bigger picture.

TOTAL COSTS OF OWNERSHIP

The central topic in railway-related research is currently the total cost of ownership (TCO) concept, which is increasingly becoming the object of focus. This means that it is no longer just the acquisition costs of the individual components – such as a new

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Interview with Stefan Marschnig.*

*Interview in German

TOGETHER

locomotive – that are considered and economically assessed, but the total costs over decades of operation. In addition to maintenance on the vehicle, this also includes, for example, the damage that the vehicle causes to the infrastructure. “The railway has always been thought of as a whole system,” explains Stefan Marschnig from the Institute of Railway Engineering and Transport Economy. “And no wonder. In some cases, we have axle loads of over 20 tonnes which are transferred to a surface the size of a fingernail. The wheel and the track therefore has to fit together perfectly before anything can move at all.” Over time, however, the original focus on the system as a whole was replaced by a focus on competition. In order to avoid distortions on the market, there was an economic separation of track and vehicle – which meant that both sides only optimised for themselves. If there was a change to a vehicle, this could cause damage to the track and vice versa. “We are currently experiencing a return to the big picture,” says Marschnig, which also pleases him from a scientific point of view. This is because greater harmonisation between the vehicle and rail means less damage and therefore less maintenance and repair work – a topic that Marschnig deals with in his research, among other things. Today, these maintenance tasks are mainly carried out during operation – i.e. when one track is closed but the other one is not. This requires extensive planning work in advance, as the maintenance machines are large-scale machinery that have to be driven to the site and then carry out the work. The more traffic is shifted to rail – and this is more desirable than ever – the shorter the time windows in which maintenance can be scheduled. “We may have to completely rethink the system and, for example, close sections for construction work, as is usual for roadworks. Or optimise maintenance intervals and plan precisely in advance whether maintenance or even replacement measures make more sense.” This in turn requires an accurate data basis in order to be able to determine as accurately as possible how the infrastructure reacts to the different loads.

With this focus on the overall system, the emphasis is increasingly shifting back to the people being transported on the train. “In the past, you often had the feeling that the railway was not very welcoming or cosy. Today, you feel much more like a guest and are well looked after. The service concept is now much more firmly anchored,” says Marschnig. And he should know. After all, the train has been his favourite means of transport since his youth. “I like the speed of rail travel. On the train you experience the journey through the country you are travelling through, but you still reach your destination in a reasonable amount of time.” He himself has travelled all over India by train and taken the Trans-Siberian railway to China.

FROM MODEL RAILWAY TO RESEARCH

Ferdinand Pospischil has focused his research a little further down – on the track superstructure. This involves sleepers, support point elements, ballast or, depending on the system, a slab track. “Our focus is on the flow of forces in the track superstructure. What happens to the track when trains weighing several tonnes pass over it,” explains the researcher and head of the Institute of Railway Infrastructure Design. Strain gauges, accelerometers, various laser measurement methods and inductive motion sensors are used to generate as complete an overall picture of the reaction as possible. The aim is to improve and stabilise the route and at the same time provide passengers with the most pleasant journey possible. “We want to get more and more traffic onto the railway. This means that either considerably more tracks will have to be built, or the existing tracks will have to be used even more closely meshed and thus subjected to a much heavier load.” This poses several challenges. On the one hand, very different trains are used on one track. There are light and slow CityJets as well as long and fast international trains. Additionally, goods trains, which are built in a completely different way, travel on the same tracks as passenger trains. “For example, even more emphasis is placed on maximising profits and comfort is clearly not taken into account. If I’ve loaded wood, for example, then the logs don’t really care if they are shaken during the journey,” says Pospischil. In addition, passenger transport is provided by a manageable number of provider companies. >

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In contrast, the goods-train sets often come from a wide variety of rental pools and have different maintenance conditions, which in turn puts additional strain on the rail systems. At the same time, not all tracks and infrastructure elements are the same. The railway system is being constantly expanded and converted – the new sections or conversions are always state-of-the-art.

What particularly fascinates the researcher about working with railways is how interdisciplinary it is: “I never work on a small, self-contained part, but always as part of a team. For example, my institute is part of the Faculty of Civil Engineering, but many of my employees have their roots in mechanical engineering. At the same time, we work closely with acoustic engineers, who have a background in physics. Or with electrical engineers.” A variety that he was fascinated by from an early age – along with the model railway in his parents’ house. “Model railways have fallen into disrepute these days, but I think they’re part of a good basic education. It’s not just about making a toy go round in circles. You have to design track plans, build landscapes yourself, design circuits, solder, screw and make connections yourself, construct points and maintain small motors.”

STRUCTURAL DURABILITY

The Institute of Structural Durability and Railway Technology, headed by Martin Leitner, scientifically analyses everything that moves on rails. The institute analyses how materials, connections and components of rolling stock must be designed to safely withstand the stresses of over 30 years of operation. At the same time, the researchers are investigating how any damage can be reliably detected and at what point components need to be replaced to ensure safety. Another focus is on how less material can be used for the construction of rolling stock while maintaining the same level of safety. “The railway is not the first sector you think of when it comes to lightweight construction. But there is also great potential here. One the one hand, less energy is needed if less mass is moved, on the other hand, the underneath infrastructure is less damaged based on specific light-weight design,” explains Martin Leitner.

Among other things representative specimens, material samples and connections, for example welded structures, are analysed that are subjected to different loads. These tests provide the researchers with important data that will influence the further design of a new vehicle, as laboratory manager Peter Brunnhofer explains: “There is an extensive set of standards and regulations for the development of rolling stock so that these vehicles can be put on the rails at all. This is why all optimisations must be carried out in advance. We don’t have any prototypes here. The vehicles are only put on the rails for the final approval tests, and these are not due until they are ready for series production. And then there is very little room for change.” The major challenge with such tests is to define test scenarios that are representative of real operation, so that reliable conclusions can be drawn about the entire system.

In addition to small samples, larger components and even an entire bogie can be tested. The trick is to design the tests in such a way that they simulate the long operating times as realistically

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TU Graz-Podcast

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as possible. “In some cases, more then 20 hydraulic cylinders are used in our tests, which apply cyclical loads to our samples,” explains Martin Leitner. In addition to these laboratory tests, numerical simulations on the computer are also an important research tool.

A new test rig has just been added at the institute. It is a completely new type of brake-test rig, designed and built together with the company KS Engineers. What is special about the new concept is that it does not require any mechanical flywheels weighing several tonnes, which normally simulate the inertia of a train. “Instead, we use a comparatively powerful electric motor that can react very flexibly and change the load,” says Peter Brunnhofer.

On top of this, a new research topic is to be opened up with the test rig: measuring brake emissions. “It’s already a big issue in the automotive sector with the advent of EVs, and the brake particles will also be relevant in rolling stock in the future,” surmises Leitner. And the institute wants to be well equipped for this. “This is a very exciting new topic for which there is currently no solution, but a lot of ideas,” concludes Leitner. ■

You will find a detailed presentation of the brake test rig on page 12.

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