Success Story
COMET

FFG

AC²T research

XTribology
Excellence Centre of Tribology
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K2-Centres
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Lifetime enhancement under tribodynamical wear conditions

From lab to prototype – Development environment established for rail industry

The demand, e.g. higher speeds and axes loads, requires a faster development of rail track materials. The current period for rail materials from conception to use in field lasts up to 10 years. AC²T set up a development environment from simulation – over model tests – to prototype verification in lab-scale with a novel test rig for investigating early-damage performance. These research work is done in close collaboration with one of the project partners, who is running full-scale tests.

Environmental objectives challenge rail materials

The European Union set the goal in a white paper published in 2011 to shift 50% of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.

An increase in rail traffic, operational speed and freight transportation will unavoidably lead to a higher train frequency and larger axle load. The achievement of these new demands will require the subsequent development of new steel grades with higher resistance to wear and rolling contact fatigue.

Unfortunately, the development and certification of novel rail grades is a long and expensive way. Rail development can require about 10 years from its initial conception until it is finally mounted in a rail track. This path becomes a bottle neck and is clearly incompatible with the environmental goal to increase rail traffic for both freight and passengers in the immediate future.

The objective of AC²T is to establish a development framework ranging from simulation – over model tests – to prototype verification on lab-scale with the aim of supporting our industrial partners to speed up the time from concept to application. Therefore, the development framework complements their long lasting experience and available component testing procedures.

From simulation – over model tests – to prototype verification

The establishment of a development framework for rails requires an integral research approach. The goal is to capture in a controlled laboratory environment the most relevant parameters and conditions affecting rail damage. The determination of the real field conditions is complex, and often many parameters cannot be measured directly. In this case, computer simulations of the rail-wheel contact are an essential tool to estimate inaccessible parameters such as the contact area and stress distribution. The knowledge of this data is required for defining realistic test parameters in model tests performed at the laboratory.

The scientists are able to simulate a large variety of contact and environmental conditions using a newly developed test rig. One advantage of the test rig (Fig. 1) is that it uses segments machined out of real rails. The segments allow to easily reach the contact stresses typically found in real

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rail-wheel-contacts – though using smaller loads. The sample geometry can also be easily achieved using rods, thus allowing the possibility to screen prospective rail materials without the need of manufacturing a real rail.

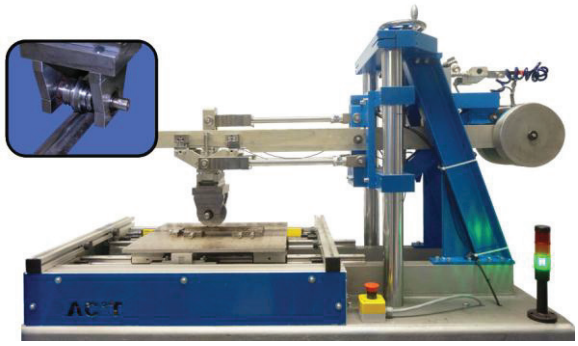

Figure 1. Rail-wheel-model tribometer (test-rig)

The environmental conditions in the test rig can be varied in order to simulate cold and hot weather conditions ranging from -20 °C up to 70 °C. The wide temperature range is important since rails can be used in alpine or desert conditions. Also operational elements such as lubrication of rails, humidity and presence of sand can be taken into account.

During the test, a wheel rolls over the rail segment repeatedly. The rolling contact can be superposed with tensile and bending stresses in order to simulate different loading conditions faced by the rails. During a testing time of typically 2-3 days, the rail segments undergo ~100,000 cycles. Within this short testing time, plastic deformation, wear resistance and rolling contact fatigue properties of the rails segments are evaluated.

Crack initiation of cyclic loaded surfaces during the operation is determined. These early stage cracks are typical indications for the growth of head checks (Fig. 2). Different novel rail materials can be analysed in a very short time with special focus on crack initiation and lifetime forecast.

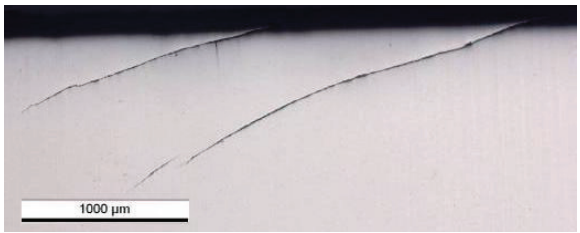

Figure 2. Cross-section of a damaged rail track "head-checks"

Impact and effects

The development environment at AC²T is a suitable tool to complete development efforts and validation procedures available at our project partners.

Our research concept complements component tests using full rails and wheels or track testing available at the industry, which undoubtedly still provide the ultimate benchmark before market certification. However, it provides a reliable tool for narrowing the selection of materials and for investigating the interaction of materials with environmental factors and lubricants.

The framework can be applied for transportation rails, but it can be deployed as well for the investigation of crane rails, which are of high industrial relevance and whose loading conditions are more severe.

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