20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Multi-scale characterisation of subsurface microstructural evolution in a pearlitic rail steel induced by rolling contact tests

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Paper ID: 215
Symposium S12: Experimental mechanics and microstructural characterization of materials
Extended Abstract

Abstract

The ‘squat’-type defect is among the most concerning railways rail defects that originates during service. Squats are characterised by a depression in the rail's running band that affects train dynamics and exacerbates rail degradation. This defect is associated with the propagation of subsurface cracks, potentially initiated by tribological surface transformations. The latter, commonly referred to as White Etching Layers (WELs), appear as a white contrast phase relative to the base material under the optical microscope. The mechanisms underlying WEL formation have been widely studied due to their impact on rail maintenance. It is generally accepted that both thermal and mechanical driving forces contribute to the transformation of the original pearlitic microstructure into a brittle nanostructure composed of residual austenite, depleted cementite, secondary carbides, martensite, and ferrite. However, the respective contributions of contact parameters – namely contact pressure, temperature, and shear stresses – on the rail microstructural evolution is not fully established. To investigate the influence of tribological parameters on the evolution of the microstructure, rolling-sliding tests are performed under controlled conditions using a tribometer reproducing wheel-rail contact at a 1/10-scale. Afterward, the presence of WELs is assessed by optical microscopy. The microstructural gradient is then characterized down to the atomic scale combining transmission Kikuchi diffraction, ACOM-TEM, and atom probe tomography. This approach provides new insight into the formation mechanism of WELs in pearlitic rail steels under rolling-sliding contact.

Keywords:

White Etching Layers (WELs) Pearlitic steel Tribological surface transformation ACOM-TEM Atom Probe Tomography (APT) Wheel-rail contact