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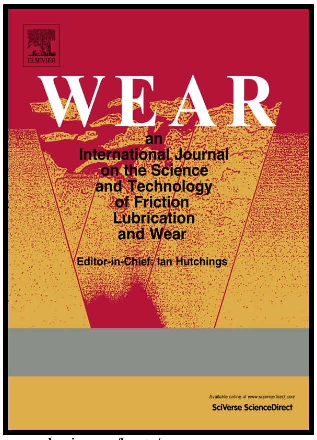

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Microstructure and mechanical properties of the running band in a pearlitic rail steel: Comparison between biaxially deformed steel and field samples

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Abstract

The large deformations occurring in the surface layer of rail heads strongly influence the material behavior. Cracks typically develop from this critical region. However, conventional material testing of this layer is not possible due to the large gradients. A method for obtaining a similar material through predeformation is therefore investigated. Subsequent analyses of the obtained material can improve our understanding of the material behavior close to the running band. Hardness, shear lines and cementite lamella orientation distributions are compared in order to determine whether the obtained material is similar to that of the field samples extracted from rails that have been in service for several years. The predeformation method produces a consistent material, which is representative of the material in the rail field samples that have accumulated large shear strains.

Keywords: Axial-Torsion, pearlitic steel, rail, microstructure, large plastic deformation

1. Introduction

Carbon steels with a pearlitic microstructure are commonly used for railway rails because they provide a good trade-off between cost, wear and strength. During their service life, the surface layers of rails and wheels are subjected to very high rolling contact loads. These lead to accumulation of large shear strains close to the running surface (see e.g. Alwahdi et al., 2013; Cvetkovski and Ahlström, 2013). Such deformation strongly alters the material behavior through strain hardening and texture development (cf. Hohenwarter et al., 2011; Kapp et al., 2016; Wetscher et al., 2007). Larijani et al. (2013) showed that the material anisotropy arising from the texture development influences how the cracks propagate in the rail. Crack development in rail heads is often denoted Rolling Contact Fatigue (RCF) and is one of the main sources for maintenance costs for the railway industry (Haidemenopoulos et al., 2006; Olofsson and Nilsson, 2002). The cracks usually initiate in the highly deformed surface layer (Johnson, 1989), which is the area of the rail that this paper mainly considers.

To enhance the understanding of the material behavior in this deformed layer, several laboratory experiments have been suggested to replicate the material state found in the surface layer of the rail heads. To enable detailed testing of the material behavior, specimens with a fairly uniform microstructure within the test volume are required. Common approaches to obtain the deformed microstructure in the laboratory are Equal Channel Angular Pressing (ECAP) and High Pressure Torsion (HPT) (e.g. Hohenwarter et al., 2011; Ivanisenko et al., 2002; Kammerhofer et al., 2013; Wetscher et al., 2007). These methods subject the material to a large compressive hydrostatic stress, while applying large shear strains. This is very similar to the loading that the surface region close to the running band of rails are subjected to. Comparing the

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