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Failure and damage tolerance aspects of railway components

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ABSTRACT

Railway structures such as rails and axles are safety relevant components since any failure includes the risk of catastrophic derailment. This paper gives a brief overview on the most important potential failure scenarios driven by fatigue crack initiation and propagation and discusses the effects of important influencing factors such as vehicle weight and speed, track quality and environmental conditions. The present paper summarizes earlier work of the authors in this field.

1. Introduction

Despite substantial advantages in design, materials and non-destructive inspection, fatigue propagation in and failure of railway components remains an important issue for safety engineering [1] which is also emphasised by a number of accidents over the last decades. At the background of an increased volume of traffic, higher traffic speeds and higher axle loads reliable damage tolerance design and effective maintenance methods have to be established. The following sections will provide a brief, not exhaustive overview on the most important failure scenarios of railway rails and axles the knowledge of which forms the necessary background for this.

2. Railway rails

An extended overview on potential failure scenarios and on damage tolerance considerations of rails is provided in [2]. Typical cracks in modern rails are the so-called head checks (in curved track sections) and squats (in straight or slightly curved sections). Head checks are groups of fine surface cracks at the running (gauge) corner of the outer rail with a typical interspacing of 0.5–10 mm. Their multiple occurrence makes them particularly dangerous as has been demonstrated, e.g. by the Hatfield accident in 2000 [3]. The first crack that failed caused a knock-on effect. When also the adjacent pre-damaged rail sections failed the track damage became so extended that it caused derailment with dramatic consequences. Four passengers where killed and more than seventy were injured. Note that investigations on fatigue crack propagation in rails have started well before this incident (see the citations in Zerbst et al. [2]), however, the latter has dramatically emphasised the importance of the topic.

Squats are also rolling contact induced defects which, however, occur randomly at isolated sites at the running surface. Both types of cracks have in common that their initiation is not associated with any metallurgical fault but is caused by

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