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Abstract

Rail squats originate from a number of sources, such as corrugations, indentations and welds. A five-year continual field monitoring study was performed on squats induced by corrugations. This study indicated that a small black depression formed at the corrugation under wheel-rail dynamic forces, and then, a primary crack typically initiated on the gauge side edge of the depression. Subsequently, the crack began to propagate in the rail surface in a U shape toward the gauge side in both the traffic direction and the opposite-traffic direction and into the rail toward the field side at an angle of approximately 20°. Rail inclination could influence the crack initiation location and propagation path. The geometry of the black squat depression was initially elliptical, and then, its edge followed the U-shaped cracking path as it grew. The squats turned into a kidney-like shape, typically with a U-shaped crack. Tensile stress likely led to the squat crack initiation and propagation. This cracking phenomenon and mechanism are analogous to the ring/cone crack formation of brittle materials under sphere-sliding contact. As the squats grew further, a ridge formed in the middle part of the depression, and an I-shaped crack appeared at this ridge due to the impact of the wheels. This process eventually led to two-lung-shaped mature squats, typically with a Y-shaped crack. The findings of this paper provide insight into the formation of rail squats.

Keywords: Rail squats, Corrugation, Rolling contact fatigue (RCF), Crack initiation, Crack propagation, Continual field monitoring

1. Introduction

Rail squats are one of the main types of rolling contact fatigue (RCF) defects [1]. Squats were reported as black spots dating back to the early 1960s [2]. They are typically observed in the crown of the railhead in straight tracks. A typical mature squat is characterized by a localized, dark depression in a two-lung-like shape, with cracks in the rail surface and under the surface [3, 4] (Fig. 1). Further development of cracks leads to rail breakage and thus threatens the safety of rail traffic. In Europe, squats are currently the most considerable RCF threat to rails, and they increase the cost of rail maintenance dramatically. A good understanding of the root causes and formation mechanism of squats contributes to the prevention of such defects from their undesired consequences and to the reduction of the cost of maintenance.