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Modeling of Rail Head Checks by X-ray Computed Tomography Scan Technology

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Abstract: To understand the internal characteristics of the Head Checks (HCs), X-ray computed tomography (CT) were applied to rail HCs inspection and modeling. Typical HCs at the rail shoulder and gauge corner in the high rail of a sharp curve of a heavy-haul railway were observed and sampled. Then, a suitable size and shape of the specimen, including several complete HCs, was designed to scan the internal HCs clearly and rapidly. Based on the CT scanning, the 3D internal information of the HC was extracted and digitized. It was found that the HCs at the rail shoulder and gauge corner propagated inside the rail in a nearly flat plane along a smooth and linear route without many large irregular fluctuations. The propagation rate along the HCs' tip towards to the lateral and longitudinal of the rail was different. The HCs can be modeled by a series of methods like plane rotation projection, abnormal point elimination, shape fitting and spatial positioning, which kept the HCs close to reality. Here, we show that the spline curve, the ellipse and the cubic polynomial curve were suitable for the HC tip shape. The entire HC contour and its ratio of length/width was effected by HC propagation and rail wear. Comparing the length and space angles of the HCs by CT scanning and modeling, the modeled HCs showed high precision compared to the real ones.

Keywords: Crack, Rolling contact fatigue, Head Checks, Computed Tomography, Modeling

1. Introduction

Head Checks (HCs), one of the rolling contact fatigue (RCF) cracks, have been common rail defects in Chinese heavy-haul railway, especially after rails with high hardness and good wear-resistance were applied, such as the alloy and heat-treated rails. Typical HCs usually occur in curve rails, which appear at the shoulder and gauge corner at the early stage after new rail installation, then at the rail crown with the accumulation of traffic[1, 2]. This kind of RCF crack was observed to propagate in the rail with a shallow angle with respect to the rail surface by a laboratory two-disc test[3, 4] and field sampling [1, 5, 6].

To understand the internal morphology, the front shape and the propagation mechanism of HCs, one common method is destructive examination (e.g. by grinding back incrementally through the rail and mapping points to define the crack at each stage) and fractographic observation (e.g. cutting the rail along the longitudinal and

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