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Probabilistic fatigue assessment for high-speed railway axles due to foreign object damage

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Abstract: Various surface defects of high-speed railway lightweight hollow axles made of alloy steel were identified carefully for assessing its operation safety and reliability. Three types of foreign object damages (FOD) from compressed-gas gun device were defined as the corner, edge and plane defects in terms of defect geometry, respectively. The fatigue probabilistic *S-N* (*P-S-N*) curves and fatigue limits were acquired for smoothed and FOD-affected specimens. In view of the variations of size and roughness between the full-scale axles and specimens, the fatigue properties with three defect types were then modified for full-scale axles. The probabilistic Kitagawa–Takahashi diagram widely used for assessing the FOD in aero-engine was well transferred to the damaged railway axles. The fatigue limits of an FOD-affected axle with 95% confidence level and 95% reliability level were evaluated to replace that of smoothed specimens, which was suggested to assess the reliability of a damaged axle at the presence of FOD generated at a prospective higher operation speed.

Keywords: High-speed railway hollow axles; Foreign object damage; Probabilistic fatigue strength; Kitagawa–Takahashi diagram; Fracture mechanics.

1. Introduction

Since the invention of the aircraft, various surface defects usually known as the foreign object damages (FOD) can frequently be observed on the blades and wings. As a notable stress increaser, such FOD is well believed to be responsible for the high cycle fatigue (HCF) failure of critical components [1-3], which induces a devastating effect on the operation safety and durability. Unfortunately, the traditional nominal stress approach cannot tackle such strong geometrical discontinuity problems due to the evolution of FOD under reversed fatigue loads. Therefore, the advanced damage tolerant concept within

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