Engineering Failure Analysis 94 (2018) 78–86

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Numerical investigation on stress intensity factor in railway wheel-set under the influence of residual stresses induced by press fitting process

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ARTICLE INFO

Keywords:
Press fitting
Fatigue
Crack growth
Stress intensity factors
Boundary element method

ABSTRACT

Train and railway system is one the most common transportation methods in the world. The vast application of railway transportation make it very important to research in this field and improve the knowledge about such system. According to advancements in railway technology, a new type of train wheels named as rim-wheels are presented in recent years that their fracture is studied in this research. The aim of the present paper is to investigate stress intensity factors in railway wheels for some major parts. The study also includes a survey on the effect of crack length on crack propagation as one of its main effective factors. Stress intensity values are calculated after stress analysis for different wheel positions by boundary element method. Fatigue crack growth path is calculated and its propagation is also estimated and effect of different parameters is studied on fatigue crack growth and path.

1. Introduction

Train and railway system is the most common transportation methods in the world that its vast usage make it very important to improve research in this field in order to increase the knowledge about such transportation system. Murakami et al. [1] studied on different mechanisms that lead to fatigue crack growth in the presence of contact stresses. They concluded that the fatigue crack not only growth in load direction, but also propagates in opposite direction to loading. But it has lower growth rate in compare to the same direction with loading. Chung et al. [2] investigated on pitting phenomena due to contact stresses and also considered effect of parameters such as initial crack length and angle, contact pressure, friction and hydraulic pressure. They calculated stress intensity factors in modes I and II by means of a two dimensional finite element model and discussed about transition of cracks to pitting defects using strain energy theory. Finally, their numerical and theoretical results showed a good agreement to experiments.

Kabo [3] studied on fatigue defect deformations in wheel and rail due to rolling contact by considering over load and clustering defect effects. They applied finite element model to analyze stress, strain and fatigue deformation in the vicinity of defects. They revealed that overload is harmful and causes large deformation near the defect.

Meshii et al. [4] identified the crack tip stress intensity factor errors by finite element analysis method and usage of singular elements. Crack tip stress intensity factors (SIFs) are calculated theoretically and the results compared to SIF analysis by means of displacement correlation method (DCM). They compared such results for various examples including different loading conditions and observed that DCM lead to insignificant error and is reliable for crack tip stress intensity factor calculations. Kabo and Ekberg [5] achieved the stress distribution around a defect in wheel's hub under overload effect using elastic-plastic finite element analysis. The material defined as elastic-plastic with nonlinear hardening and results showed a complete change in stress distribution around the

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https://doi.org/10.1016/j.engfailanal.2018.07.029
Received 8 June 2017; Received in revised form 17 March 2018; Accepted 23 July 2018
Available online 24 July 2018
1350-6307/

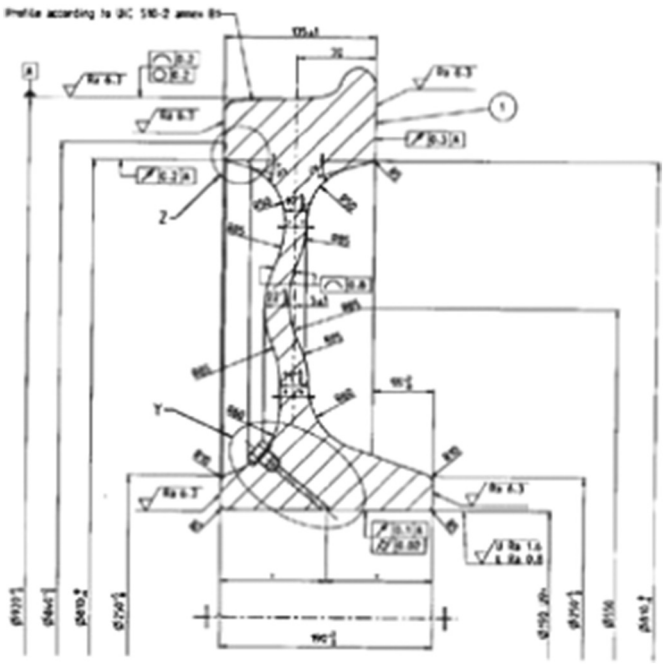

Fig. 1. Rim-wheel cross section.

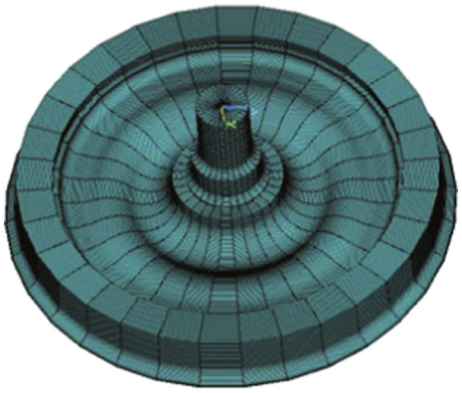

Fig. 2. Finite element model of wheel.

Table 1
Young's modulus of wheel steel.

Temperature (°C)	E (GPa)
25	215
230	199
355	191
450	170
565	101
705	50
900	43

defect.

Pavlou et al. [6] carried out a research on reducing fatigue crack growth by applying overload to crack and showed that branching in fatigue crack occurs because of overload effect and consequently leads to a reduction in fatigue crack growth rate. Skyttebol et al. [7] performed a study on the effect of welding-induced residual stresses on fatigue crack growth. They studied the effect of passing the wheel on rail on crack growth by considering residual stress effects by means of SACC finite element software.

Residual stress has important role in mechanical component [8] or removing its surface materials. Application of numerical