Available online at www.sciencedirect.com

ScienceDirect

Procedia Structural Integrity 4 (2017) 56–63

Structural Integrity Procedia

www.elsevier.com/locate/procedia

ESIS TC24 Workshop "Integrity of Railway Structures", 24-25 October 2016, Leoben, Austria

Analysis of the railway freight car axle fracture

Zoran Odanovic

IMS Institute, Bulevar vojvode Misica 43, 11000 Belgrade, Serbia

Abstract

Railway axles are vital parts of passenger or freight railway car. Their failure may result in potentially disastrous consequences with possible human victims. Accordingly, railway axles are designed to be highly reliable, while the maintenance system requires periodically regular non-destructive inspection. However, due to complex exploitation conditions, complex stress state and multiple stress concentration, railway axles could experience fatigue failures. This study presents an attempt to clarify the causes of an axle fracture of the railway freight car for coal transport. Detailed analyses were conducted on the axle mechanical properties. Novel methodology for calculation of the plane strain fracture toughness K_{Ic} based on the measured values of the yield strength and impact energy from data of samples with U grove, is estimated. Failure analysis of fractured axle was performed. Macro and microstructure of the axle material is included in analysis. Performed analysis has shown that the axle failure was caused by inadequate maintenance and insufficient properties of the axle material in the railway axle critical cross-sections.

Peer-review under responsibility of the Scientific Committee of ESIS TC24.

Keywords: railway axle, failure analysis, destructive testing, pitting

1. Introduction

Railway axles are the most loaded parts of the railway vehicles. Complex and variable stress state, multiple stress concentration, inadequate maintenance and exploitation conditions, material-related errors and inadequate mechanical properties are the most common causes of failure – fracture of the railway axles, as shown in the literature Zerbst et al. (2013), Torabi et al. (2012), Meral et al. (2010). Corrosion process could form crack initials, which may reduce the fatigue strength of axles, as discussed in the literature Beretta et al. (2015) and Odanovic et al. (2015).

* Corresponding author. Tel.: +381-63-306-120; fax: +381-11-3692-772.
E-mail address: zoran.odanovic@institutims.rs

2452-3216
Peer-review under responsibility of the Scientific Committee of ESIS TC24
10.1016/j.prostr.2017.07.009

In this study the fractured axle of a railway freight car used for transportation of coal from the coal mine to the thermal power plant was analyzed. The railway axle was in the exploitation for the past 35 years. In order to clarify the cause of this failure, detailed analysis of the mechanical properties, macro and microstructure of the axle material was performed. This study is an attempt with the aim to improve control and maintenance of the axels in exploitation and to avoid future accidents.

2. Experimental procedures

Within the scope of this research in order to identify the cause of the axle fracture, following analyses and activities have been performed:

- Visual examination.
- Analysis of the chemical composition by Optical Emission Spectroscopy (OES) technique.
- Mechanical properties. Testing was conducted in the longitudinal and transverse directions of the axle. Tensile and impact energy testing were performed according the standard EN 13261 and the hardness testing was conducted using the Brinell method. Samples for the testing were cut from the axle part next to the fracture location. Based on the results of the tensile and impact energy testing, a parameter of fracture mechanic - plane strain fracture toughness K_{Ic} was estimated.
- Metallographic investigations. Macrostructural examination was performed by macroscopic method using sulphur print (Baumann method). Microstructural investigations were conducted using Light Optical Microscopy (LOM) and Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray analysis (EDX).

3. Results and discussion

3.1. Visual examination

The damaged freight car for coal transportation from the mine to the thermal power plant has two axles. The failure has taken place on an industrial gauge used for coal transport, as shown in Fig. 1. Under exploitation conditions nominal axle load amounts to 200 kN, while railway car speed of motion is up to 70 km/h. The stopping and braking of railway car is done by brake shoes. Accordingly, under exploitation conditions, the axle is subjected to bending stress only. The axle fracture occurred in the cross-section of the rear axle between the roller bearing and the wheel on the transition radius. The fracture was not identified on the other end of the axle. The location of the axle fracture is shown in Fig. 2. Details of the solid railway axle with designated fracture cross-section and the testing zone is given in Fig. 3.

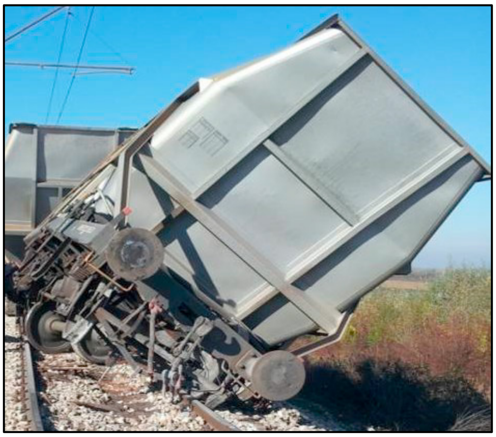

Fig. 1. Damaged railway freight car

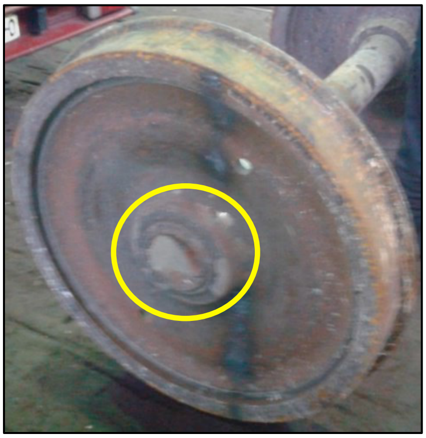

Fig. 2. The railway wheel and axle with signed fractured surface