Engineering Failure Analysis 79 (2017) 565–574

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Failure analysis of a sleeper anchor model used in railroads

Geraldo Lúcio de Faria*, Leonardo Barbosa Godefroid, Luiz Cláudio Cândido, Diego Antônio de Souza Santos

[a] *Departmentof Material and Metallurgical Engineering, Universidade Federal de Ouro Preto, Ouro Preto, Minas Gerais, Brazil*

ARTICLE INFO

Keywords:
Railroads
Sleeper anchor
Failure analysis

ABSTRACT

The sleeper anchors are important elements in railroads. They are introduced into the ballast, and, as the name suggest, they have an anchor function, increasing the railway stiffness. Many rail companies have used a double fixing sleeper anchor model for many years. However, with the increasing of the transported load last decades, this model has failed in service, allowing the undesired ballast movement and creating a dangerous situation, with imminent risk of accidents. In this context, this work presents a complete failure analysis of this sleeper anchor model. Chemical, macro and microstructural analysis were done, and mechanical tests were performed. An alternative European model was also characterized, aiming to compare their metallurgical characteristics. The obtained results showed that the recurrent failures are associated to an overload applied to the studied device. This overload promotes an undesirable plastic strain and the anchor is removed from the ballast. It was possible to conclude that the mechanical properties of this double fixation anchor do not meet the specifications for the actual load demand in railways. The European model presented best characteristics for this application.

1. Introduction

The sleeper anchor is a component of the railroad which is introduced into the ballast and has the purpose of an anchor, helping the fixing of the rails and increasing its stiffness, mainly in tight turn's tracks.

Several Brazilian rail companies have used for many years a sleeper anchor with a double fixing system. This sleeper anchor model was built without scientific studies. The design of this type of sleeper anchor was not based on technical specifications required by standards. However, with the increasing of the transported load and traffic speed, this component model has failed in service, allowing the undesired displacement of the ballast and creating an imminent derail condition. Fig. 1 presents a sleeper anchor in perfect condition. Fig. 2 presents the component installed at the railroad, fastened at two wood sleepers. Fig. 3 shows a failed component, where is possible to observe a significant plastic strain in its fastener sheet.

Failures of metallic components in railroads are strongly undesirable, because they may implies in human life, economic and environmental losses. The main causes of the failures in metallic structures are usually related to negligence in the component project, manufacturing, installation or operation. According to several authors, there are four general modes of failures in the railroad components: overload, fatigue, abrasion or corrosion. According to them, these components usually fail by a combination of two or more modes [1–6].

In this context, this work presents a thorough failure analysis study of a Brazilian sleeper anchor model. For comparative purposes, this work also presents a chemical, structural and mechanical characterization of a European sleeper anchor (Fig. 4) that

* Corresponding author.
E-mail address: geraldofaria@demet.em.ufop.br (G.L. de Faria).

http://dx.doi.org/10.1016/j.engfailanal.2017.05.034
Received 3 May 2016; Received in revised form 7 May 2017; Accepted 8 May 2017
Available online 12 May 2017

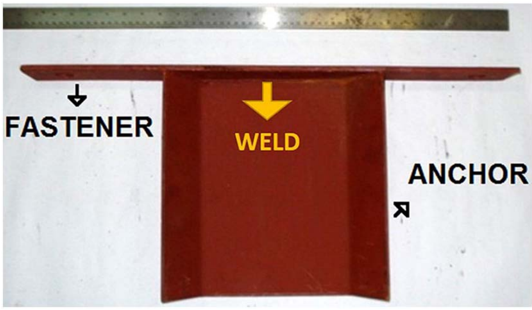

Fig. 1. Double fixing sleeper anchor.

has a great performance in heavy railroads. This European model works just with one fixing point at the wood sleeper, however, four of them are installed in each one. It is important to notice that in both studied models fastener sheets are welded to anchor sheets.

2. Materials and methods

Standard procedures for failure analysis were applied in this work aiming to investigate the behavior of a double fixing sleeper anchor failed in service. Two new sleepers anchors, used in European railroads, were also received for characterization tests. The executed failure analysis involved the following principal stages: investigation about material's fabrication and use history, sampling procedures including the preservation (cleaning) of the fractured surface, macro and microfractographic analysis, chemical analysis, metallographic analysis and mechanical tests (tensile, hardness and impact tests) for both samples.

Initially, a visual examination of the failed component was performed. Then, representative samples of the anchor and fastener areas were collected for chemical analysis and microstructural characterization. Chemical analysis was performed by optical emission spectrometry and the microstructural characterization was done according to the procedures recommended by ASTM E3-01 (2001) [7].

Specimens for mechanical tests were machined from the fasteners and anchors. Brinell hardness tests were performed according to ASTM E10-08 (2008) [8] in a universal machine (constant load of 30 kgf/mm^2). Aiming to characterize the welded joints (anchor-fastener joints), Vickers microhardness tests were executed according to ASTM E384-10 (2010) [9], in a digital microhardness machine (load of 10 gf and time of 10 s).

Tensile tests were performed according to ASTM E8/E8M-09 (2009) [10]. The used specimens were machined with gage length = 32 mm, width = 6 mm, maintained original sheet thicknesses (Table 1). Charpy impact tests were carried out on subsized specimens (5 mm thickness) according to ASTM E23-07 (2007) [11].

Finally, in order to evaluate the fracture surface of tested specimens, fractographic analyses were performed with the aid of a scanning electron microscope (SEM). All experimental procedures were performed in both sleeper anchor models.

Fig. 2. Double fixing sleeper anchor introduced at the ballast and fastened at two wood sleepers.