Engineering Failure Analysis 90 (2018) 47–63

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Failure assessment of a weld-cracked mining excavator boom

Heriberto Maury*, Danny Illera, Víctor Pugliese, José Wilches, Humberto Gómez

Department of Mechanical Engineering, Universidad del Norte, km 5 vía a Puerto Colombia, Barranquilla, Colombia

ARTICLE INFO

Keywords:
Cracks
Defects
Failure analysis
Fatigue failure
Weld(s)

ABSTRACT

The boom section of a hydraulic excavator (23 m^3 capacity) suffered a catastrophic failure after nearby 40,000 h of operation at a coal mine comprising more than three-quarters of the cross-sectional area of the boom. Failure analysis is carried out to diagnose the cause(s) and mitigate potential similar failures in coal mine excavator fleet. The analysis methodology involves collection of background data, on-site visual examination, non-destructive testing, macroscopic and microscopic fractography, chemical analysis, metallographic analysis, hardness measurements as well as finite element structural analysis. A crack developed and grew up stealthily at a field weld joint between a man-hole plate and the boom plate. The collected evidence suggests a series of triggering factors leading to the unexpected failure: unmatched plate materials regarding mechanical properties, low-quality weld beads and the introduction of geometric discontinuities that effectively work as stress raisers.

1. Introduction

Surface mining machinery components are especially vulnerable to accelerated degradation as a consequence of severe and continuous loading cycles coupled with harsh environmental conditions like high/low temperature, rain or dust [1]. Consequently, it is common to find fatigue cracks on hydraulic excavator load-bearing components like the main-frame, boom, arm or bucket. Cracks are identified during scheduled inspections and repaired by weld-filling procedures or by more invasive approaches like cutting-and-replacing sections [2–4]. A repair-weld requires especial attention as it is performed on a metal with accumulated damage, encompasses severe time-constrains associated with the downtime of the equipment, and in most of the cases imposes restrictions concerning the availability of welding workshop equipment. Furthermore, an as-welded bead possesses a fatigue resistance considerably inferior of the base material (around 15%–50%) and the inclusion of weld defects (cracks, pores, blow-ups, and lack-of-fusion, among others) further adds a more detrimental effect on machine reliability. A brief overview of catastrophic failures of heavy-duty equipment involves defective welds at some point [5–11]. However, a defective weld could be caused by (but not limited to) the geometrical design of the joint itself, the selection of the parameters of the welding process, issues regarding the compatibility between joined materials, the skills of the welder, or due to unexpected service requirements [12,13]. Failure analysis is therefore imperative and mandatory to identify the specific cause of a particular failure for future prevention.

The boom section of a coal mine hydraulic excavator suffered a catastrophic failure during normal operation as a consequence of a crack developed at a field weld joint between a man-hole plate and the boom plate (refer to Fig. 1). The aim of the study relies on diagnosing the cause(s) and mitigating potential similar failures in excavator fleet.

* Corresponding author.
E-mail address: hmaury@uninorte.edu.co (H. Maury).

https://doi.org/10.1016/j.engfailanal.2018.03.022
Received 13 July 2017; Received in revised form 17 October 2017; Accepted 14 March 2018
Available online 15 March 2018
1350-6307/

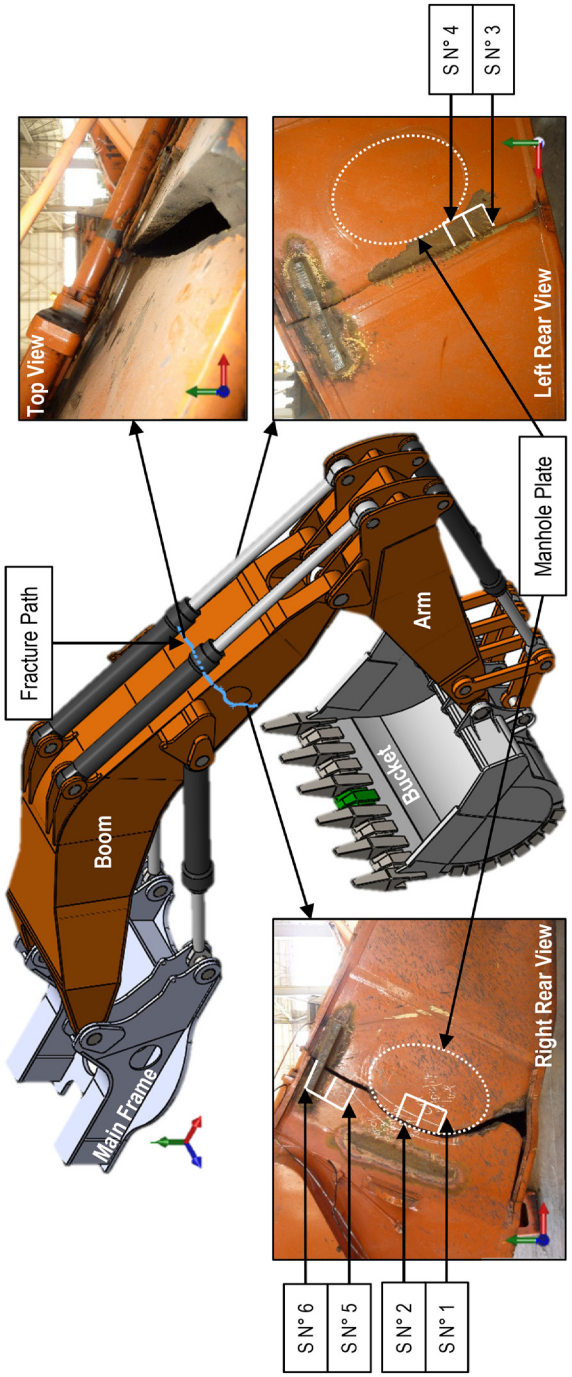

Fig. 1. On-site boom fracture visual inspection and sample selection locations.