Bucket wheel excavator: Integrity assessment of the bucket wheel boom tie-rod welded joint

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Article info
Article history:
Received 16 March 2010
Received in revised form 2 September 2010
Accepted 5 September 2010
Available online 15 September 2010

Keywords:
Bucket wheel boom tie-rod
Non-destructive testing
Welded joint
Fatigue
Structural integrity

Abstract
The bucket wheel boom tie-rods are vital structural parts of the bucket wheel excavators (BWE). Their failures inevitably cause BWE collapse and are followed, among other things, by a substantial financial loss (millions of €). Non-destructive testing revealed a flaw in the butt welded joint of the body and eye-plate of the bucket wheel tie-rod. Its size exceeds the level allowed by current technical regulations. An integrity assessment of the bucket wheel tie-rod has been carried out, i.e. the remaining fatigue life has been determined based on the stress-state characteristics in the welded joint and defined by experimental research in real working conditions. The calculation results show that despite the excessive size of the internal flaw the welded joint integrity is not compromised. During periodical inspections of the welded joint in the past two years (BWE was put into operation in December 2007) changes that could compromise the structural integrity were not observed. In this way, by using a “fail-safe” philosophy design, a considerable financial saving (ca. 1,600,000 €) was achieved while at the same time there was no threat to the worker’s safety and life, the safety of the machine and the production process in the open pit mine.

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1. Introduction

Bucket wheel excavators (BWE), Fig. 1, present the backbone of the open pit coal mining system. When in working mode, they are exposed to a significantly strong effect of dynamic loads, which are furthermore stochastic. Continuous exploitation in harsh working conditions provides fertile ground for the occurrence of fatigue cracks. Their propagation in the vital parts of the support structure, such as tie-rods (of the bucket wheel boom – BWB, counterweight arm or portal) and their supports can lead to catastrophic consequences. The results of numerical-experimental researches given in [1] identified the main reasons of the BWE SchRs 1760 collapse, Fig. 2, as highly pronounced stress concentration (design faults), Fig. 3, low fracture toughness of parent metal and flaws in the welded joint of elements of the portal tie-rod support (manufacturing faults), Fig. 4. BWE KWK-1400 also collapsed due to failure of the counterweight arm tie-rod [2], caused by design and welding faults. According to [3], less than 6 months after the first load test with iron ore, the bucket wheel stacker–reclaimer (BWSR) collapsed. The conclusion, based on the analysis results given in [3], is that the main cause of failure is a high stress concentration in the zone of the welded joint of basic elements of the BWB tie-rod (tubular tie-rod and flange) combined with cleavage crack propagation in the direction of the lower fracture toughness. A typical example of a catastrophic failure resulting

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doi:10.1016/j.engfailanal.2010.09.001