Engineering Failure Analysis 18 (2011) 557–563

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Corrosion fatigue crack propagation in a heat affected zone of high-performance steel in an underwater sea environment

Dong-Hwan Kang [a], Jong-Kwan Lee [b], Tae-Won Kim [a,*]

[a] School of Mechanical Engineering, Hanyang University, 17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Republic of Korea
[b] Steel Structure Research Laboratory, Research Institute of Industrial Science & Technology, Hwaseong 445-813, Republic of Korea

ARTICLE INFO

Article history:
Available online 18 September 2010

Keywords:
Corrosion fatigue crack propagation
Heat affected zone
Fracture mechanics
Seawater
High-performance steel

ABSTRACT

Fatigue crack propagation in high-performance steel, HSB800, was investigated in air and seawater environments using three-point single-edge notched bending fatigue tests. Two types of heat affected zones (HAZ) resulting from welding processes, coarse grained and inter-critically reheated coarse grained zones, together with as-received metal were used to analyze the behavior. A 3.5% sodium chloride solution was used as the seawater, and several types of loading conditions, according to the stress ratio and loading frequency, were applied. The fatigue crack propagations were then assessed using the da/dN–ΔK curves. The results showed that the corrosion fatigue crack in seawater was more rapidly propagated than was that in the air environment. The third region of crack propagation was not observed in the da/dN–ΔK curve for the seawater environment, particularly in base metal. Generally, high stress ratio and load frequency shows a low threshold value in the stress intensity factor range. Furthermore, a different microstructural aspect of the crack propagation behavior in HAZs, as compared with that of the base metal, has been identified according to the crack propagation mechanisms.

1. Introduction

Recently, increasing demand for mega-structural applications, such as long-span bridges, skyscrapers, and huge vessels has lead to the development of high-performance steels. Development of high-performance steel requires much attention to high strength, high ductility, good weldability and weatherability due to the severe environmental requirements. In particular, securing of fracture toughness, together with weather resistance of the materials, to suppress fatigue crack propagation (FCP) related to corrosion damage in complex environments is one of the most important issues in the development of high-performance steel.

Steel architectural structures are typically composed of a large number of welding sub-structures that are constructed via high temperature processes. As a result, the structural materials may contain heat affected zones (HAZ) which usually have reduced mechanical properties due to the modified grains. Furthermore, huge structures, such as long-span bridges, are often constructed seaside because of geopolitical considerations in the design process. Thus, the materials used in such structures are required to possess a substantial amount of corrosion resistance.

In general, the fatigue and corrosion fatigue resistances of a structural material are influenced by various loading factors, such as load ratio and frequency. Regarding the load ratio, Schmidt et al. [1] and Murakami et al. [2] have reported that the fatigue crack propagation rate (FCPR) decreases with increasing stress ratio in high-strength steels. Different results,

* Corresponding author. Tel.: +82 2 2220 0421; fax: +82 2 2292 0401.
E-mail address: twkim@hanyang.ac.kr (T.-W. Kim).

1350-6307/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engfailanal.2010.08.019