Engineering Failure Analysis 18 (2011) 36–46

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Analysis of the cracking causes in an aluminium alloy bike frame

S. Cicero [a,*], R. Lacalle [a,b], R. Cicero [a,b], D. Fernández [a], D. Méndez [a]

[a] Universidad de Cantabria, ETS Ingenieros de Caminos, Canales y Puertos, Departamento de Ciencia e Ingeniería del Terreno y de los Materiales, Av/Los Castros s/n, 39005 Santander, Cantabria, Spain
[b] INESCO Ingenieros SL, Centro de Desarrollo Tecnológico de la Universidad de Cantabria (CDTUC), Fase A, Mod. 203, Av/ Los Castros s/n, 39005 Santander, Cantabria, Spain

ARTICLE INFO

Article history:
Received 22 June 2010
Received in revised form 9 July 2010
Accepted 2 August 2010
Available online 7 August 2010

Keywords:
Bike frame
Stress Corrosion Cracking
Solution potential
Overageing

ABSTRACT

Two cracks were detected in the bike frame of an amateur cyclist, before the final failure of the component and after using it for around 35,000 km. The cracks were located in the joint between the bottom bracket, the chain stays, the seat tube and the down tube.

This paper analyses the causes of the cracking process and comprises, basically, chemical analysis for material identification, visual inspection of the frame, microstructural analysis, microhardness measurements, mechanical characterisation through Small Punch tests and SEM (plus EDX) analysis of the fracture surface.

The analysis concludes that both cracks were caused by corrosion and Stress Corrosion Cracking (SCC) processes that are justified by the differences in the solution potentials between the base material and equilibrium precipitates produced by an overageing treatment. The latter are more anodic and hence easily dissolved in a humid saline environment.

1. Introduction

After three years and around 35,000 km of service, two cracks were detected in the bike frame of an amateur cyclist. Both cracks were located in the joint of the bottom bracket with the chain stays, the seat tube and the down tube, and were detected before the in-service failure of the component. The bike was used in the north coast of Spain, and therefore, in a humid climate (average relative humidity around 80% over the year, precipitation of 1200–1300 mm/year, and 150–180 rainfall days per year) with a saline environment.

Fig. 1 shows the bike frame and the location of the cracks, while Fig. 2 shows a detail of both cracks. It can be seen how the chain stays, the seat tube and the down tube are welded to the bottom bracket, generating a complex geometry with numerous weld beads. Crack 1 is located in one of the chain stays, close to the weld bead and with most of its path on the Heat Affected Zone (HAZ), whereas Crack 2 is located in the seat tube, also close to the weld bead on the HAZ and even with part of its path along the weld itself. In Fig. 2, some indications of corrosion can be noticed in the interior of the bottom bracket and also in the vicinity of the cracks, in which the cyclist had performed a manual sanding, depriving these zones of the paint layer. Fig. 3 presents the cracked section containing Crack 1, which is the largest one. The extension of the crack and its approximate geometry can be observed here.

The analysis has consisted in the chemical analysis of the tubes composing the bike frame, the visual inspection of these tubes, microstructural analysis of the base metal and the welds, microhardness measurements and the mechanical characterisation of the material through Small Punch tests and SEM analysis (together with EDX analysis) of the fracture surface of the cracks.

* Corresponding author. Tel.: +34 94220017; fax: +34 942201818.
E-mail address: ciceros@unican.es (S. Cicero).

1350-6307/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engfailanal.2010.08.001