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Influence of Boron Content on the Fracture Toughness and Fatigue Crack Propagation Kinetics of Bainitic Steels.

Karol Felipe Rodríguez-Galeano[1*], Rodolfo Rodríguez-Baracaldo[1], Alvaro Mestra-Rodríguez[2], Jose Maria Cabrera-Marrero[2], Jhon Jairo Olaya-Florez[1]

1. Departamento de Ingeniería Mecánica, Facultad de Ingeniería, Universidad Nacional de Colombia, Carrera 45 # 26-85, 111321, Bogotá, Colombia.
2. Departamento de Ciencia de los Materiales e Ingeniería Metalúrgica, Universitat Politécnica de Catalunya, Av. Diagonal 647, 08034, Barcelona, Spain.

Abstract

The relatively good combination of high strength and ductility makes bainitic steels a candidate to replace many other steels in industrial applications. However, in service, ductility and strength are not up to standard requirements. In many industrial components, toughness and fatigue performance are also very relevant. In the present study, bainitic steels with varying content of boron were fabricated, with the aim of analyzing the fracture toughness and changes in the fatigue life. The results show that a relatively small change in the boron content can cause a notable variation in the fracture toughness of bainitic steels. The maximum value obtained in fracture toughness was for the steel with the highest boron content. It was observed that the amount of interlath martensite constituents decreases in steels with the addition of boron, leading to the promotion of the presence of void coalescence and a remarkable rise in the toughness of bainitic steels. An increase on the fatigue life of the bainitic steels with an increase in the boron content was also observed, through analysis by means of Paris' law. A comprehensive micrographic study was carried out in order to examine the mechanics of fatigue crack growth in the bainitic steels, revealing small longitudinal cracks in bainitic steels that lack boron. These cracks tend to disappear in bainitic steels that contain boron. To elucidate this behavior, micrographs of the surfaces generated by the crack growth process were taken, showing that several nano-cracks appeared between the bainite laths. It is finally argued that this high-energy consumption process of nano-crack nucleation and growth is the reason for the improved toughness and fatigue life observed in bainitic steels.

Key Words: bainitic steel, toughness, crack growth, fatigue life.

1. Introduction

Bainitic steels are regarded as relatively new steels, because not long ago it was impossible to produce them in the industry with the required strength and toughness. Their use became more extensive when low-carbon bainitic steels were introduced by Irvine and Pickering in the 60's [1-2]. After that, a great deal of research was carried out on bainitic steels, taking into consideration processing, chemical composition, and heat treatments in order to obtain good performance. Many of those studies have revealed that bainitic steels have better properties than other steels for specific tasks. Nowadays, steels with a bainitic microstructure are widely used in building construction, pipelines, automotive applications, and railway rails and crossings, since they have an optimum combination of mechanical properties for the production of final parts after cold-stamping or cold-forming [3-5].

* Corresponding author. MSc; Tel.: +57 321 482 2078.
E-mail address: kfrodriguezg@unal.edu.co (K.F. Rodríguez-Galeano).