Toughness dependence of nano-bainite on phase fraction and morphology

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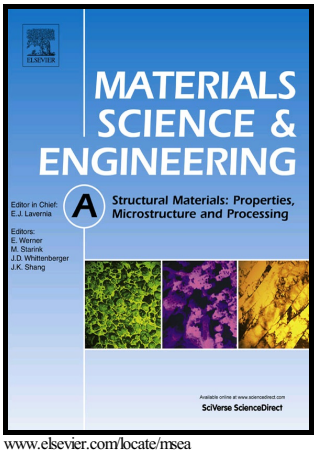

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Toughness dependence of nano-bainite on phase fraction and morphology

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Abstract

Yield strength of nano-bainitic steels is enhanced while retaining significant ductility with a refinement in the bainitic lath thickness and increasing its volume fraction. This study makes an effort to improve toughness of nano-bainite by investigating the effect of content, size and morphology of constituent phases when austempered at 250°C, 300°C and 350°C. Improved impact and fracture toughness at higher austempering temperature has been observed primarily due to higher content of ductile phase austenite in spite of its coarser morphology. Micrographs of the fracture surface show quasi-cleavage fracture for all the conditions.

Keywords: Steels, nano-bainite, strength, fracture toughness, impact toughness

1. Introduction

The class of high carbon carbide free nanostructured bainitic steels is well known as super-bainite. The microstructure contains nano-scaled bainitic laths immersed in film type retained austenite [1,2]. The strength of these alloys primarily arise from dislocation movement interruption by the numerous boundaries of nano-scaled bainite laths. Dislocation density and interface density grows with increasing carbon percentage and decreasing isothermal transformation temperature [3]. In most cases, the ductility of nanostructured metals and alloys decreases significantly with a decrease in microstructural length scale [4,5]. However, the presence of film-type retained austenite in between the bainitic subunits provides adequate ductility to nanostructured bainitic steels [3,6]. The other type of retained austenite present in the microstructure is blocky austenite which is less stable than film-type retained austenite enriched with higher carbon content. During the tensile tests of nanostructured bainitic steels, retained austenite transforms into the harder phase martensite which gives transformation strain (TRIP effect) and enhances the work hardening capacity [3,7]. Hence the morphology and volume percentage of phases present in the microstructure control the strength-ductility combination. However, the possible incorporation of nanostructured bainitic steels in engineering applications will be determined by the resistance to impact loading as well as tolerance to the presence of flaws. Thus, it is critical to investigate the role