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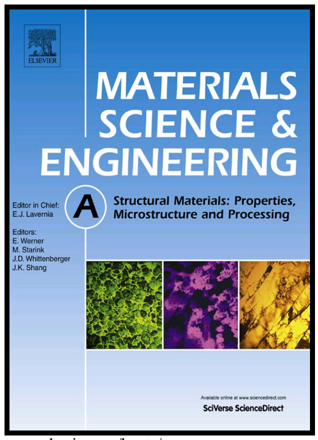

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New insights into the mechanism of cooling rate on the impact toughness of coarse grained heat affected zone from the aspect of variant selection

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Abstract

In this article, the authors tried to establish a direct correlation between crystallographic variants and impact toughness, and provided some novel insights into the mechanism of cooling rate on the impact toughness of coarse grained heat affected zone (CGHAZ) of offshore engineering steel by means of electron back-scattering diffraction (EBSD) analysis. The results showed that variant selection becomes stronger with an decrease in the cooling rate, resulting in the decline of high angle grain boundaries (HAGBs) and thus lower the impact toughness. Moreover, the variation in impact toughness is mainly correlated to the crystallographic block size. The larger the block size, the lower the impact toughness. By visualizing the crystallographic features, it has been clarified that the transition from Bain zone grouping to close-packed plane grouping with the increase of cooling rate, while the corresponding microstructure changes from granular binite to lath bainite. Furthermore, it has been found that ~25% (number fraction) reconstructed prior austenite grains in simulated CGHAZ present a twin-related structure (austenitic twin), which can enhance the variant selection and displays a negative effect on the formation of HAGBs.

Keywords: cooling rate; lath bainite; granular bainite; variant selection; boundary length; impact toughness

1. Introduction

High-strength steels for offshore engineering applications are required to obtain higher energy and cost efficiency. Meanwhile, the notably low temperature impact toughness and suitable weldability are connected to the design of alloy composition and rolling process. Currently, these high performance steels are produced either by thermo-mechanical controlled process (TMCP) or by traditional quenching and tempering (Q&T) process [1,2]. However, irrespective of the production method, weldability is an important aspect of concern because the excellent balance of high strength and toughness in base plate will be upset by the welding thermal cycles characterized by rapid heating and variable cooling rate with high peak temperature. The formation of heat affected zone (HAZ) adjacent to fusion line is often as the most critical region with regard to potential failures, especially