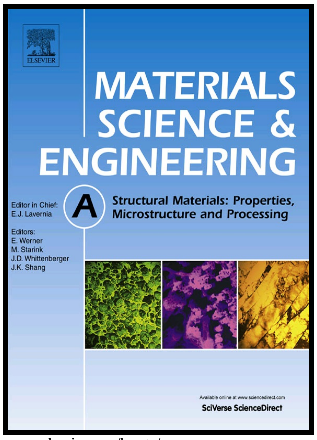

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Effect of microstructures to tensile and impact properties of stir zone on 9%Cr reduced activation ferritic/martensitic steel friction stir welds

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Abstract

The present study reports the microstructural evolution and mechanical properties of the stir zone (SZ) in friction stir welding (FSW) reduced activation ferritic/martensitic (RAFM) steel. The effects of the grain size, retained austenite (RA), and precipitates on the SZ tensile properties and impact toughness are discussed. The SZ of the weld exhibits a good balance of strength and ductility at 600 °C temperatures and a slightly decrease of impact toughness comparing with the base metal (BM). The RA plays a critical role in effecting the ductility and impact toughness of SZ. The influence of RA to the ductility of SZ becomes more effective as the carbon concentration of RA is increased to 1% or above where the thermal and mechanical stabilities are improved. The highly dispersed and refined MX carbonitrides and M_3C carbides during FSW are good for the ductility and impact toughness of SZ as well. It indicates the SZ of FSW RAFM steel weld has the potential to have good mechanical properties.

Keywords: Reduced activation ferritic/martensitic steel; Friction stir welding; Stir zone; Microstructures; Tensile properties; Impact toughness

1. Introduction

Friction stir welding (FSW) process was invented by the welding institute (TWI) in 1991. The process principle of FSW includes frictional heating and severe plastic flow with a low welding peak temperature. During FSW, the function of stirring tool probe is producing the severe plastic deformation (SPD) for the materials in stir zone (SZ) under high temperatures and high strain rates. Therefore, FSW could not deteriorate seriously the microstructure and mechanical properties of the raw material [1-3]. Such process could result in the occurrence of dynamic recrystallization, and further grain refinement and dislocation multiplication. Thus, FSW process has been used for modifying the microstructure for several alloys in some specific engineering fields to improve the mechanical properties of the materials [4-6].

Recently, martensitic heat-resistant steels with high chromium content (9-12wt%) were developed to achieve high creep properties at elevated temperatures and regarded as candidate structure materials in fossil fuel and power industry applications [7-11]. However, owing to the effect of welding thermal cycle, conventional fusion welding processes always lead to recrystallization, precipitate coarsening and dissolution in joint regions which can rapidly lose strength in high temperature and stress service conditions [12-13]. Reduced activation ferritic/martensitic (RAFM) steel with tempered martensite microstructure exhibits excellent high