Title: In-situ studies of delta-ferrite/austenite phase transformation in low carbon steels

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In-situ studies of delta-ferrite/austenite phase transformation in low carbon steels

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IN-SITU STUDIES OF

DELTA-FERRITE/AUSTENITE

PHASE TRANSFORMATION

IN LOW CARBON STEELS

A thesis submitted in fulfilment of the
requirements for the degree of

Master of Engineering by Research

From

University of Wollongong

by

Salar Niknafs BEng(Hon), MEng(Prac)

Materials Engineering

2007

CERTIFICATION

I, Salar Niknafs, declare that this thesis, submitted in fulfilment of the requirements for the award of Honours Master of Engineering by Research, in the Materials Engineering Discipline, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Salar Niknafs

August 2007

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"If I have been of service, if I have glimpsed more of the nature and essence of ultimate good, if I am inspired to reach wider horizons of thought and action, if I am at peace with myself, it has been a successful day."

-- Alex Noble

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ABSTRACT

During continuous casting of steel, the delta-ferrite to austenite phase transition occurs following solidification in the meniscus region of the solidifying strand. It is of great industrial significance to gain a better understanding of the nature and mechanism of this reaction because product quality is in large measure determined by events occurring during and shortly following solidification. Moreover, the exact way in which delta-ferrite transforms to austenite may influence the subsequent transformation of austenite to ferrite, by which much of the mechanical properties of the steel is determined.

Relatively little attention has been devoted to the delta-ferrite to austenite phase transition in the past, in part because of the difficulty of making in-situ observations at the high temperature at which this phase transition occurs. The recent development of high-temperature laser-scanning confocal microscopy has provided new opportunities to observe in-situ high temperature phase transformations and this technique has been employed in the present study.

In order to limit grain boundary pinning by alloying elements and alloy compounds during growth of delta-ferrite grains and their influence on the δ-to-γ phase transition, the solid-state phase transformation was studied in low-carbon iron-carbon alloys. Experimental observations of the effect of cooling rate on the δ/γ phase transformation are discussed in terms of three different morphologies that have been observed.

At low cooling rates the newly formed austenite phase that nucleated at triple points grow by an advancing planar interface but at higher cooling rates the transformation occurs by a massive kind of transformation. The mechanisms of grain boundary movement also been investigated. Two types of grain boundary movement, continuous motion and staggered motion have been observed. Quantitative analysis of grain boundary movement show that at low cooling rates grain boundaries are stationary for a few seconds after the initiation of the phase transformation and then they progress exponentially. Computer simulations have been used in an attempt to better explain the experimental observations.

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