

QUENCHING AND PARTITIONING OF PLATE STEELS

John Speer^{1*}, Rachael Stewart¹, Brian Thomas¹, Amy Clarke¹ and Emmanuel De Moor¹
¹*Advanced Steel Processing and Products Research Center, Colorado School of Mines, USA*
(jspeer@mines.edu)

1. INTRODUCTION

The quenching and partitioning (Q&P) concept originated about 15 years ago. Early research focused on fundamental studies to develop some mechanistic understanding of microstructure evolution, and mechanical property evaluation to demonstrate promising combinations of strength and ductility. These studies continue, along with applied research to develop high strength steel with retained austenite. Q&P has been employed to develop Advanced High Strength Steel (AHSS) sheet products for automobile body applications requiring high strength (~1 to 1.5 GPa) and formability, which are now being commercialized. A concept for Q&P processing of thicker hot-rolled steels was also developed, and applied recently for abrasive wear-resistant applications. Plate Q&P processing was first explored by Hong and co-workers in 2007, with encouraging strength/toughness combinations obtained in a 0.1 wt. pct. carbon steel. Plate steel Q&P concepts have been developed further; this paper highlights recently developed Q&P process-design models to help predict and understand temperature and microstructure gradients in thicker plates, and to help select processing parameters relevant to industrial plate production.

2. PROCEDURES

Thermal modeling in combination with analysis of the martensite microstructural evolution during processing was used to estimate temperature histories and microstructural development in heat-treated plate steels. Partitioning heat treatments were designed using principles of time-temperature equivalence in combination with results from literature. Experimental verification involved heat treatment simulation using a quenching dilatometer, along with hardness and microstructure characterization, including retained austenite measurements by x-ray diffraction.

3. RESULTS AND DISCUSSION

An example (modeled) thermal profile for a quench and partitioned plate is shown in Figure 1 for the case of an 18 mm thick steel plate, water quenched for 10 s (from 1100°C), then reheated in a furnace at 600°C. Surface, center (mid-thickness) and quarter point locations are shown. A typical martensite start (M_s) temperature is provided as a reference and is denoted by the dashed horizontal line..

Experimental simulations using modeled plate steel processing conditions for a 0.4 C (wt. pct.) steel with an elevated silicon concentration confirmed that high hardness in combination with substantial fractions of retained austenite (in excess of 20%) are achievable through industrial plate processing. Such steels should be of interest in applications requiring high strength with toughness and/or wear resistance.

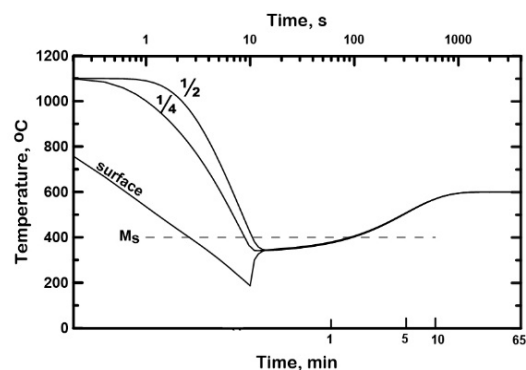


Figure 1. Temperature vs. elapsed time.

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