Carnegie Mellon
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"A Study of the High-Temperature Oxidation Behavior of Recycled Low Carbon Steels Containing Copper and Nickel"

Friday, January 25, 2008
11:30 A.M. Seminar in Baker Hall A51
Refreshments precede seminar at 10:30 A.M. in 2325 Wean Hall

Copper is a problematic residual element in electric arc furnace steel production because it leads to a cracking defect known as "surface hot shortness." Cracking arises from a liquid, copper-rich phase that penetrates into and embrittles austenite grain boundaries. The liquid forms because copper is nobler than iron and enriches at the oxide/metal interface during iron oxidation. This study investigates how the distribution and evolution of the copper-rich liquid is affected by steel chemistry. Experimental work involves oxidizing a variety of low carbon steels with various copper, nickel, and silicon contents in air. Oxidizing heat treatments were conducted in a setup where the weight change could be measured during oxidation.

A fixed-grid finite difference model was also developed to predict the evolution of the enriched region from given oxidation kinetics. The effect of various parameters - initial copper content, nickel content, and gas atmosphere were investigated. Model predictions agree with measured data for an iron - 0.3 wt% copper alloy oxidized in air at 1150°C. Initial copper content and oxidation kinetics significantly influenced on the copper-rich layer evolution whereas the effect of nickel additions was small.

The oxidation rates of copper- and nickel-containing steels decreased with time and were consistently lower than the rate of a residual-free low carbon steel. An internal oxide layer comprised of oxides rich in iron and silicon was observed only in the copper- and nickel-containing steels. Steels containing copper, nickel, and silicon had more copper- and nickel-rich material found as particles entrapped in the oxide.

Bryan received his Bachelor's degree in Engineering Physics from the University of Pittsburgh in 2005 and his Master's in Materials Science and Engineering from Carnegie Mellon University in 2006. He is currently a Ph.D. candidate under the guidance of Prof. Seetharaman.