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Final Technical Report

Development of a Cupola Furnace Process Model

Cooperative Agreement DE-FC07-93ID13240

American Foundrymen's Society

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Development of a Cupola Furnace Process Model

I. Project Objective

A strategic partnership was formed among the American Foundrymen's Society and the Federal government to develop and transfer the technology needed by the U.S. foundry industry to:

- increase energy efficiency of cupola melting
  - reduce fuel consumption
  - lower oxygen rates
  - increase melting rates
- improve recovery of carbon, silicon, and manganese through reduced oxidation losses
- improve productivity due to more uniform and predictable iron compositions

II. Background

An effective mathematical model of the cupola offers a solution to the complex and interactive chemical and heat transfer processes to melt cast iron. The transient changes in charge size, charge composition, blast rate, and coke rate are used to optimize operation to improve melting rates, minimize oxidation losses of valuable alloying elements (C, Si, and Mn), and maintain iron composition. Despite these challenges, the cupola produces iron at a lower cost, and have better environmental controls than other melting process with 70 percent of domestic liquid iron produced by this technique. The current study builds on a one-dimensional model developed during Phase I and Phase II to make it both user friendly and PC compatible to aid the application of this technology in operating foundries.

III. Results

A. AFS Cupola Model Update

Version 22 of the model was developed which incorporates convergence methods to increase the speed by a factor of four over Version 12 of Cupola Model. Version 24 was developed which improves the robustness to speed conversion and smooth discontinuous behavior in some variables.

B. User Friendly Development

Version 23 adds a front end preprocessor which provides user friendly inputing of the model variables. A Users Manual was prepared to assist new users by explaining the model needs to

operate and the implication of default settings. The distribution of this document is intended for both new users and potential new users.

A Technical Manual was also prepared. This document describes the algorithms used to calculate the various outputs based on the input variables. Both the engineering equations and the assumptions used in making the calculations are detailed. Distribution of this documented is limited to authorized users.

C. Foundry Verification

The tested model with applied convergence and the users interface was distributed to sponsor foundries as Version 26 for their in plant use and evaluation.

IV. Summary and Recommended Future Work

There is current need to exercise the software using a wide range as possible of cupola operating conditions. Current improvements are needed to:

- develop and install improved charge oxidation algorithms addressing slag-iron-coke reactions
- expand heat transfer subroutine to include both conductive and radiant heat transfer
- develop a three-dimensional model of the tuyere region to account for the alloy oxidation due to tuyere protrusion and gas velocity distribution fields.

V. Acknowledgements

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