

# METAL C

## Project Fact Sheet



## INTELLIGENT CONTROL OF THE CUPOLA FURNACE

### BENEFITS

- Energy savings of 400 million Btus per year per unit
- Applying modern techniques to improve the environmental performance of existing cupola technology...revitalizing cupola operations in the U.S.
- Decreased coke requirements and elimination of associated emissions
- Reduced carbon, sulfur and manganese losses
- Fewer rejects

### APPLICATIONS

The foundry cupola has historically been the primary method for melting iron because of its low cost and simplicity. Recently, however, the need for pollution control devices and foreign competition has contributed to a decline in the domestic market. This project is designed to advance the quality of cupola operations, reduce material costs, reduce processing costs and improve product quality. It will enable the U.S. metal casting industry to once again use low-cost melting technology with environmental controls designed for the 1990s and beyond.

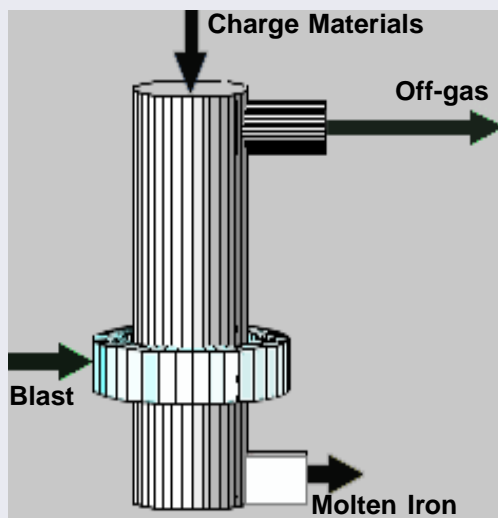
### APPLICATION OF ADVANCED INTELLIGENT CONTROL METHODS TO THE CUPOLA MELTER INVESTIGATED

The design and application of automatic control technology for the cupola furnace with reduce material and processing costs for cupola operation, reduce energy requirements and environmental impacts and improve product quality.

This project investigated the application of advanced intelligent control methods to the cupola melter, a furnace using pig iron, scrap steel, cast iron scrap, foundry return scrap, and ferroalloys to a specified tapping temperature and chemical composition.

An 18-inch experimental research cupola was designed and constructed. A neural network model of the cupola, and techniques for training the neural network were developed. All experiments have been completed and have successfully demonstrated the feasibility of using automatic control in cupola operations.

#### CUPOLA FURNACE



The Cupola Furnace: Experimental Cupola and Schematic of Cupola Process



## Project Description

**Goal:** To investigate the application of advanced intelligent control methods to the cupola melter and to improve the environmental performance of the cupola, and thus its role as a low cost melter in the U.S. metal casting industry.

## Progress and Milestones

- A fully instrumented 18-inch experimental research cupola was designed and constructed at the Albany Research Center for verification and testing of models and control algorithms. This facility uses a PC-based, stand-alone data acquisition and control system developed using LabView by the Idaho National Engineering and Environmental Laboratory (INEEL).
- A neural network model of the cupola and techniques for training the neural network were developed at INEEL. The neural network, which gives steady-state relationships between selected cupola inputs and outputs, is trained using data generated from a first-principles model of the cupola developed under the sponsorship of the American Foundrymen's Society.
- Using control algorithms developed at Idaho State University, a series of increasingly complicated proof-of-concept experiments at the Albany Research Center for process-level control have demonstrated the feasibility of using automatic control in cupola operations. In the final experiment, a three-input, three-output multi-loop controller with dead-time compensation was successfully used to simultaneously maintain iron composition, temperature and melt rate at desired setpoints by varying the percent coke, oxygen enrichment and blast rate respectively.
- A number of papers and key interim reports have been produced by the project team over the three years of the cupola project. Presentations have been made at numerous industry conferences.



### PROJECT PARTNERS

Albany Research Center  
Albany, OR

American Foundrymen's Society  
Des Plaines, IL

Dalton Foundry  
Warsaw, IN

Foxboro Company  
Eden Prairie, MN

General Motors Research Center  
Warren, MI

GM Powertrain  
Saginaw, MI

Idaho National Engineering and  
Environmental Laboratory  
Idaho Falls, ID

Modern Equipment  
Port Washington, WI

Waupaca Foundry  
Waupaca, WI

### FOR ADDITIONAL INFORMATION,

#### PLEASE CONTACT:

HARVEY WONG  
Office of Industrial Technologies  
Phone: (202) 586-9235  
Fax: (202) 586-6507  
Harvey.Wong@ee.doe.gov  
<http://www.oit.doe.gov/IOF/metalcast/>

Please send any comments,  
questions, or suggestions to  
[webmaster.oit@ee.doe.gov](mailto:webmaster.oit@ee.doe.gov).

Visit our home page at  
[www.oit.doe.gov](http://www.oit.doe.gov)

Office of Industrial Technologies  
Energy Efficiency  
and Renewable Energy  
U.S. Department of Energy  
Washington, D.C. 20585



April 1998