CFD Modeling for High Rate Pulverized Coal Injection (PCI) to Blast Furnaces

Comprehensive Simulation Details Process Conditions to Improve Performance Efficiency

Blast furnaces (BF) produce approximately 53 million tons of steel, or roughly half the amount of products shipped by the U.S. steel industry each year. Coke derived from coal is the primary fuel used in blast furnace operation, but increased use of coke results in higher cost and environmental penalties vs. less expensive coals.

As an alternative, high rate pulverized coal injection (PCI) into the blast furnace can reduce hot metal cost, energy consumption, and emissions by minimizing the use of coke.

Drawbacks associated with the increased coal usage in the blast furnace include lower flame temperature, burden permeability, and chemical reactivity.

In order to better understand the complex physical and chemical phenomena in the PCI process, researchers are developing a state of the art, comprehensive computational fluid dynamic (CFD) model that can provide detailed process information to improve the BF process in real furnace operating conditions.

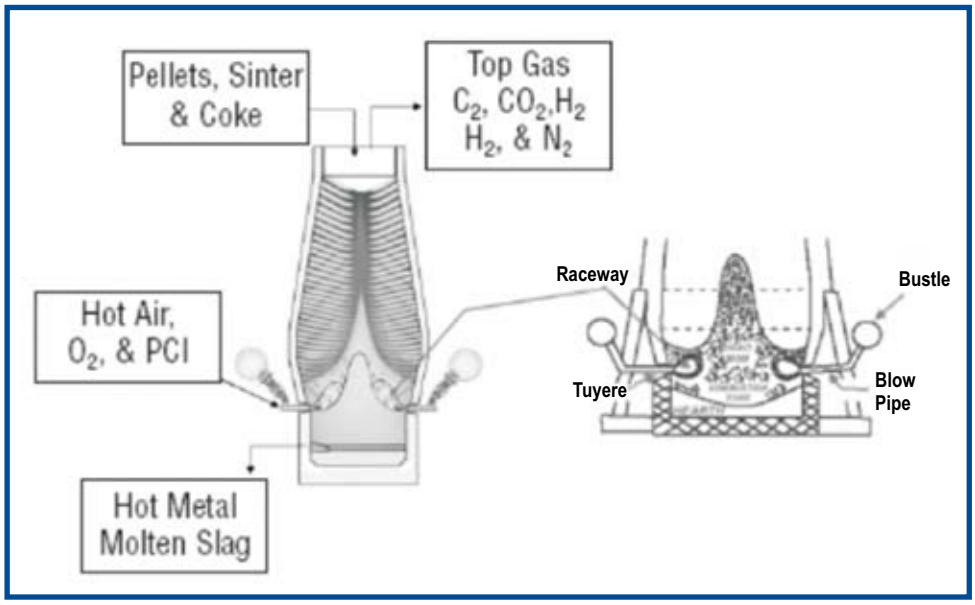
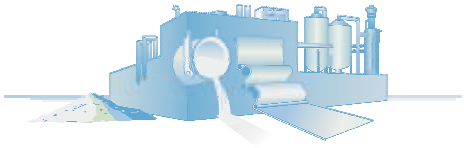


Diagram of a Blast Furnace



Benefits for Our Industry and Our Nation

- Reduces blast furnace reliance on coke
- Enhances productivity and fuel efficiency
- Decreases environmental impact
- Increases cost savings by substituting less expensive coal for coke
- Advances the state-of-the-art in CFD modeling techniques

Applications in Our Nation's Industry

Three-dimensional CFD models are powerful tools for modeling detailed process and property data and performing parametric studies for performance optimization.

Project Description

Goal: To develop a state-of-the-art CFD model to better understand the high rate PCI process. The CFD model will include major features of the PCI process in real BF operation conditions.

Using the Eulerian approach to treat multiphase (gas-coal-coke) flows, this project will model both coal and coke combustion. The CFD model will provide detailed information on gas velocity, temperature and species distributions, particle number density and unburned char distributions, raceway formation, and combustion efficiency. Upon validation with experimental data, parametric and optimization studies will investigate the effects of key operating conditions on the performance of the PCI process. The project's objective is to increase coal injection from 300 to 500 pounds per ton of hot metal. A CFD model-based strategy will maximize energy savings by finding optimum PCI rate conditions and coal combustion efficiency.

Progress and Milestones

Work on this project has included:

CFD Model Development:

- Simulation of gas-solid flow in raceway (Complete)
- Simulation of coal and coke combustion (Complete)
- Modeling of subspecies (Complete)
- Integration of all models (Complete)
- Simulate of PCI in the blast furnace (Complete)
- Model validation (Complete)

Future work will include:

- Parametric studies and optimization
- Technology transfer

Project Partners

Purdue University - Calumet
(Lead Research Organization)

Dofasco, Inc.

Mittal Steel, USA

Stelco, Inc.

Union Gas Limited

U.S. Steel

American Iron and Steel Institute
(Project Manager)

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
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Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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Ending in FY2007