A Novel Flash Ironmaking Process

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American Iron and Steel Institute

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Overview

Timeline

- Technology development predates this project.
  - 2005 – Kinetic Feasibility
  - 2008 – Proof of Concept at Lab Scale
- 2012 – began construction
- 2015 – began test program
- 2017 – exceeded 95% metallization
- 2018 – optimizing operation parameters
- Planned End date August 31, 2018
- Budget Period 3 - 75% complete

Budget

	BP1	BP2	BP3	Total	Costs to date
DOE Funded	$5.8M	$1.5M	$1.0M	$8.3M	$7.9M
Project Cost Share	$1.6M	$0.6M	$0.5M	$2.7M	$1.8M

Barriers

- Transformative technology
  - Product inlet configuration
- Location – hydrogen, work schedule, building constraints
- High heat 1400C – pilot igniter
- Product loss – off gas
- Best scale up design is not to simply enlarge Large Scale Bench Reactor.

Partners

- American Iron and Steel Institute
  - ArcelorMittal
  - TimkenSteel
  - U. S. Steel
  - Berry Metal
- University of Utah

Project Objective

- Develop a new ironmaking process with significant reduction in energy consumption and CO_2 generation
- AMO Goals - Improve energy efficiency and productivity
- MYPP – Sustainable Manufacturing
- DRI
  - Pelletization binder results in acidic gangue
  - EAF – basic slag, so need additions of lime and dolomite
  - Results in yield loss
- Flash Ironmaking
  - Pelletization not required
  - Less yield loss than DRI

Technical Innovation

Current practice

Blast Furnace

$$Fe_3O_4 + C \rightarrow Fe + CO_2/CO$$

- Produces >90% iron
- Large capital investments
- Special coal for cokemaking
- Needs pelletization/sintering
- Significant Energy Consumption and CO_2 emissions

New Approach

Flash Ironmaking Process

$$Fe_3O_4 + H_2/CO \rightarrow Fe + H_2O/CO_2$$

- Gas-Solid Suspension Reduction
  Natural Gas, Hydrogen, Coal Gas
- Iron concentrate WITHOUT
  - Cokemaking
  - Pelletization
  - Sintering
- Significant Reduction in CO_2 & Energy Consumption
- Rapid reaction rate and favorable Net Present Value (NPV)

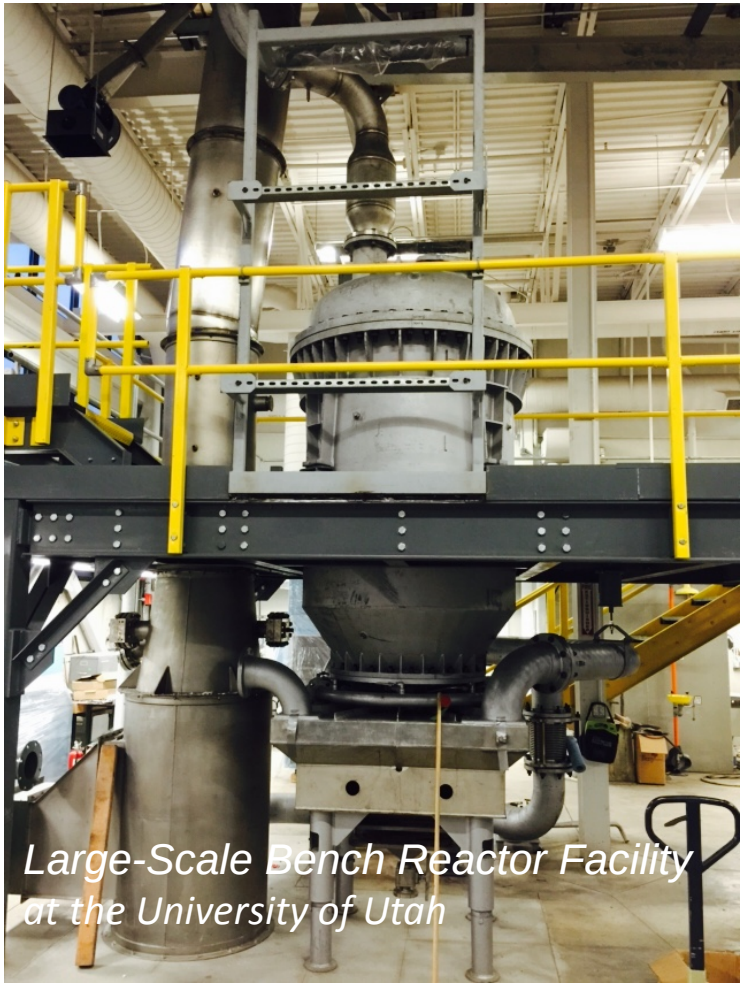
Technical Innovation

- Many possibilities for implementation.
  - Stand alone plant
- Modular design
  - Install smaller process in existing plant
- Methods of using product
- Powder in bags
- Inject through lance

- End product is the same, but a more efficient way of achieving it.

Technical Approach

- Install, commission & conduct test on a new large scale bench reactor at the University of Utah
- Multidisciplinary team:
  - American Iron and Steel Institute
    - ArcelorMittal USA
    - TimkenSteel
    - United States Steel Corporation
    - Berry Metal Company
  - University of Utah



Large-Scale Bench Reactor Facility at the University of Utah

Technical Approach

- Team Attributes
  - Technical knowledge
  - Steel industry knowledge
- Designing a product for ourselves
  - No wondering if it is what the customer wants
  - Designers and end users working together

Results and Accomplishments

- Testing milestone of 95% metallization exceeded
- Optimum operating parameters.
- Heat Mass Flow Balance
- CFD Modeling
- Pilot Plant Layout
- Operating Cost estimates

Transition

- Benefits steel users and steel-related industry
- North American steel industry is end user
- To be used to produce iron as a raw material for steelmaking resulting in:
  - Direct use of iron ore concentrate
  - Low capital cost
  - Scalable to large capacities
  - Avoidance of cokemaking
- Commercialization through licensing & royalty
- Sustainable as a more energy efficient and lower-emitting ironmaking process

Questions?