Bench and Pilot Scale Analyses to Optimize Pelletizing Performance

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Pelletizing Process Evaluation

- Bench and Pilot Evaluation Processes
  - Concentrate Preparation
  - Agglomeration
  - Green Ball Assessment
  - Pellet Firing
  - Pellet Physical Quality Assessment
  - Chemical Analyses
  - Metallurgical Quality Assessment

Pelletizing Process Evaluation

- Bench Scale
  - Leaf Filter Testing
  - Airplane Tire Agglomeration
    - Green Ball Quality
  - Mini-Pot Furnace
    - Fired Pellet Quality
- Pilot Scale
  - Pilot Scale Disk Filters
  - 3 Foot Dia. Balling Disk
    - Green Ball Quality
  - Mixing
    - Muller, Standard
    - Littleford, High Intensity
  - Pot Grate Furnace
    - Extension of the Mini-Pot Furnace Tests
    - Straight Grate and Grate-Kiln Furnace Simulation

Laboratory Scale Process Simulation

- Bench Scale Filtering and Agglomeration Studies
  - Additives
    - Filter Aids – Surfactants, etc.
    - Balling Additives – Fluxes, Binders, etc.
  - Ore Variability
    - Grind, Ferrous Iron, Particle Size Distribution, etc.
  - Moisture content

Laboratory Scale Process Simulation

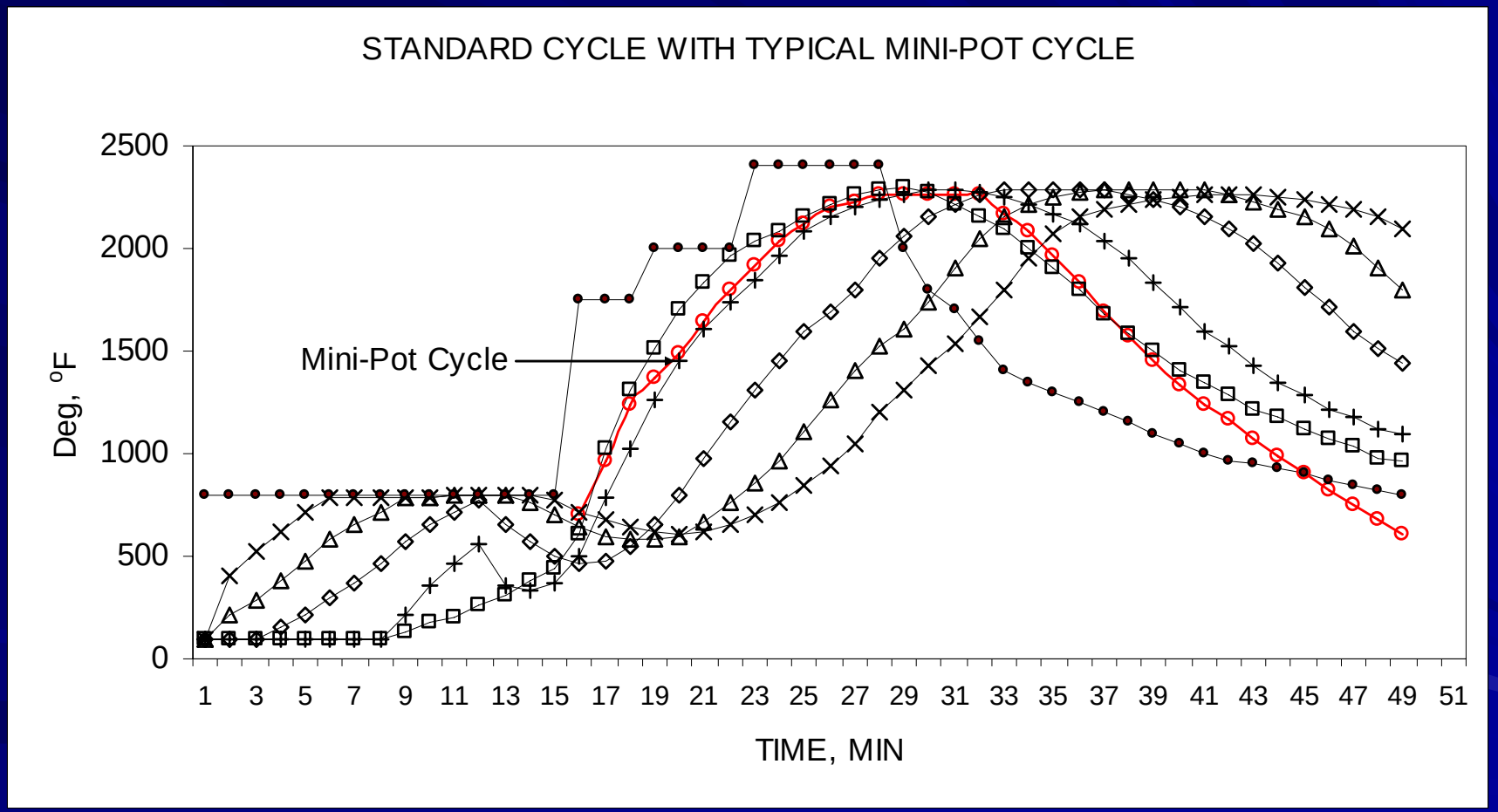
Laboratory Scale Process Simulation

- Green Ball Quality Assessment and Characterization
  - Moisture
  - 18” Wet Drop Number
  - Green and Dry Compression Strength
  - Deformation Characterization, (Stress-Strain)
  - Porosity

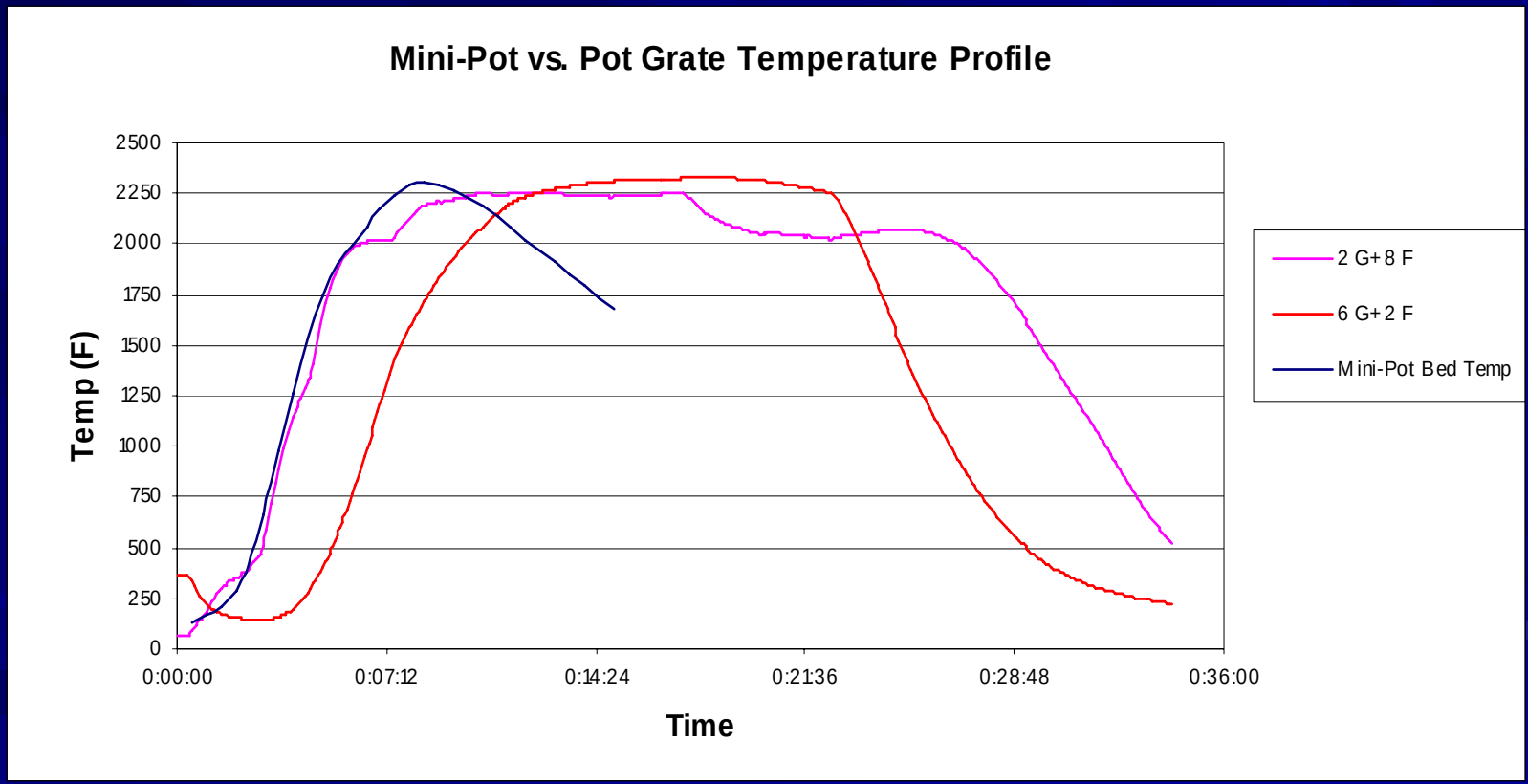
Laboratory Scale Process Simulation

- Mini-Pot Grate Furnace Induration Studies
  - Mini-pot firing cycles are representative of the drying, pre-heat and firing zones of the induration furnace
  - Firing cycles are developed to be representative of the top 1/3 of the bed
    - Relative relationship to changes in green ball feed or furnace cycles

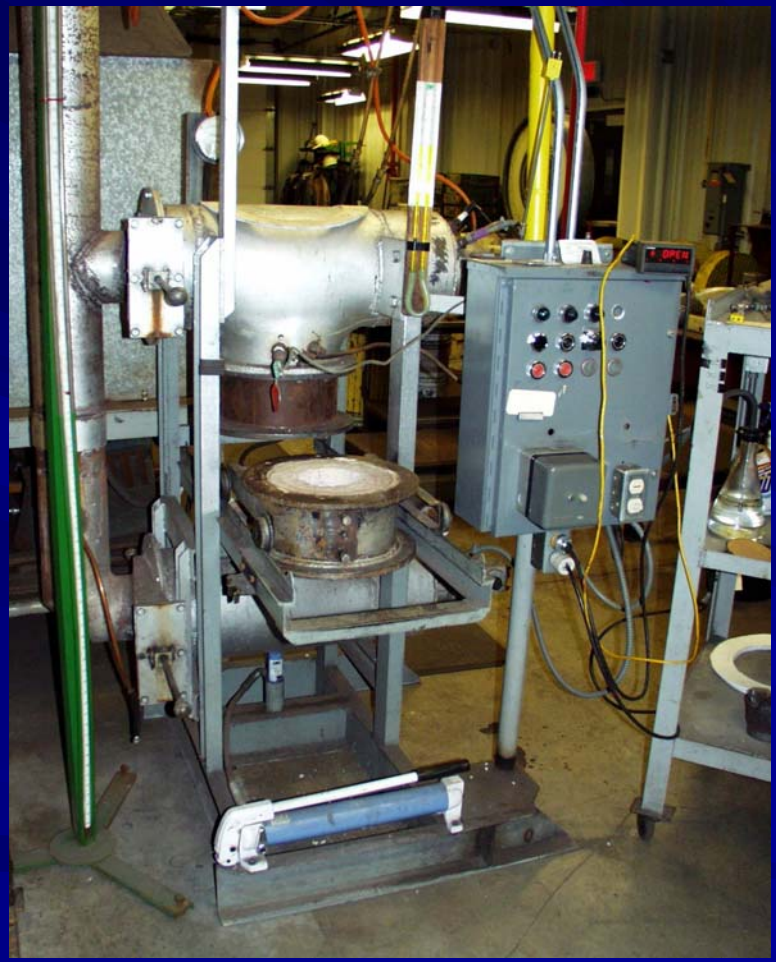
Laboratory Scale Process Simulation



Laboratory Scale Process Simulation



Laboratory Scale Process Simulation



Pilot Scale Process Simulation

- Pilot Scale Agglomeration Studies
  - Disk Filtering
  - Three Foot Diameter Balling Disk
  - Mixing
    - Littleford, High Intensity Mixing
    - Muller, Standard Mixing
  - Green Ball Quality Assessment and Characterization

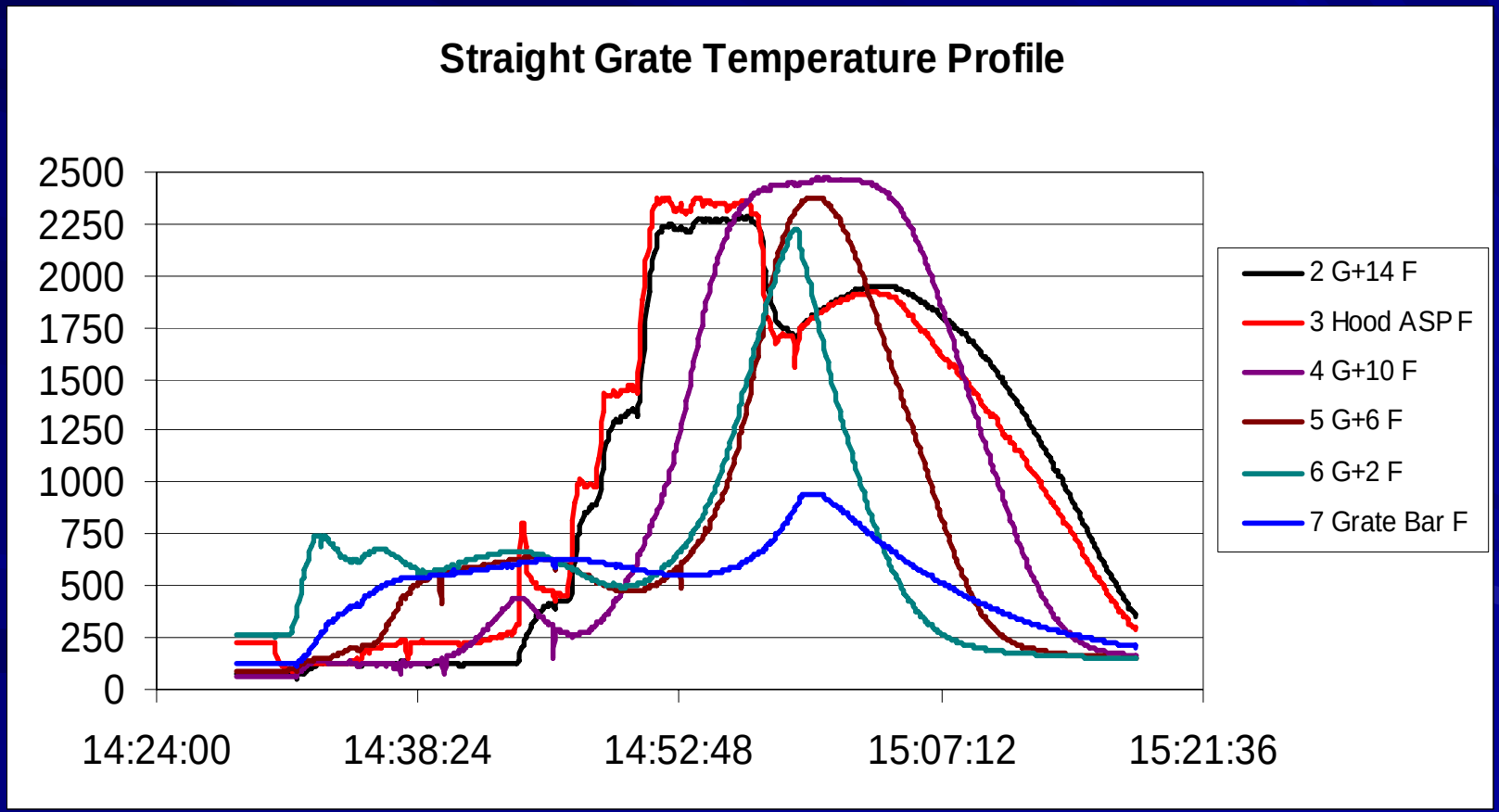
Pilot Scale Process Simulation

Pilot Scale Process Simulation

- Pot Grate Furnace
  - Straight Grate and Grate-Kiln Furnace Simulation
  - Firing cycles are developed to simulate the time, airflow and temperature profiles in a pelletizing furnace
  - Fired pellet quality produced with standard plant cycles are designed to represent plant data
    - Changes in pellet quality are evident with alterations to the green ball feed, furnace cycles or residence time
  - Extension of the Mini-Pot Furnace Tests

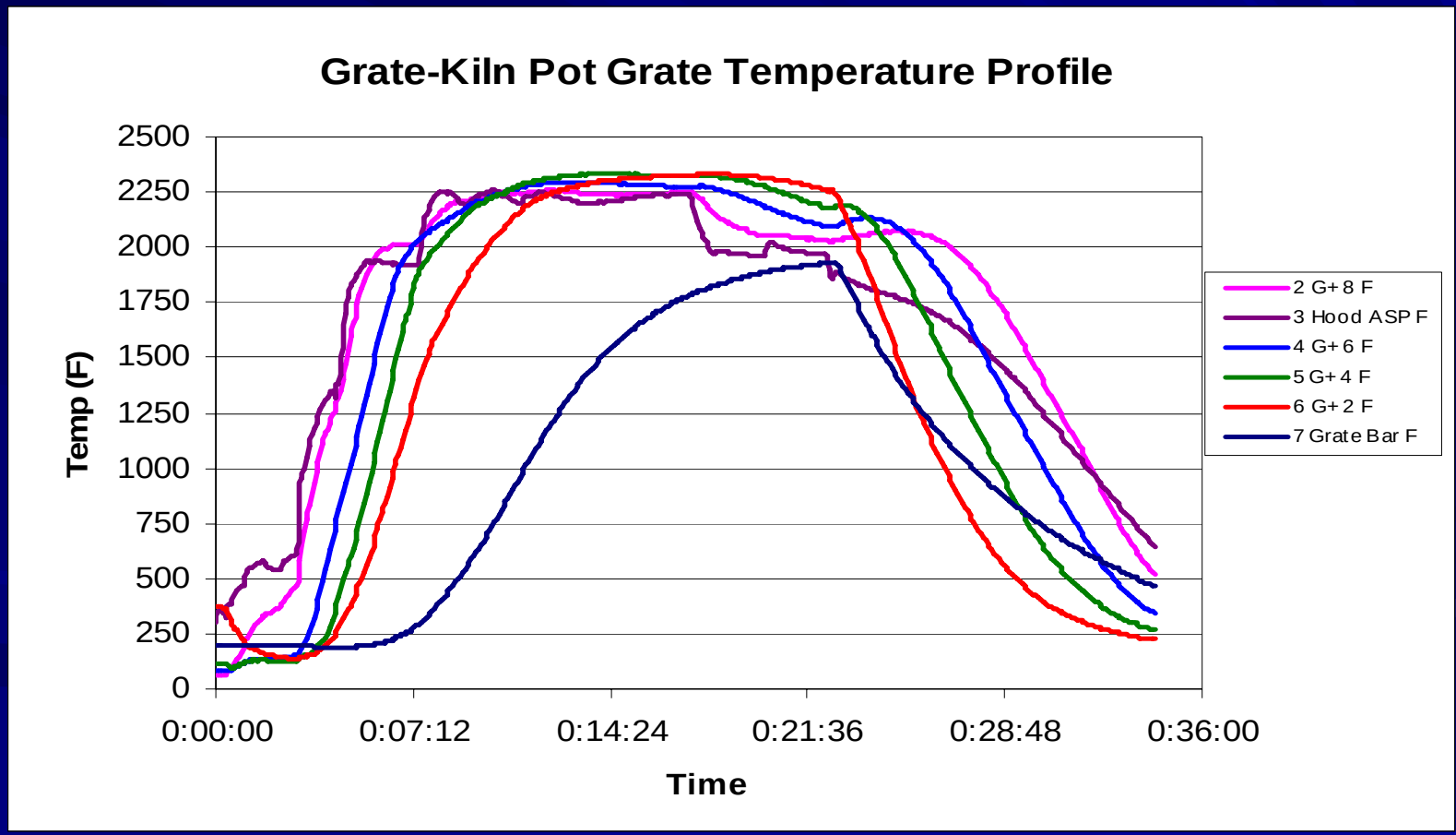
Pilot Scale Process Simulation

Typical Pot Grate Temperature Profile



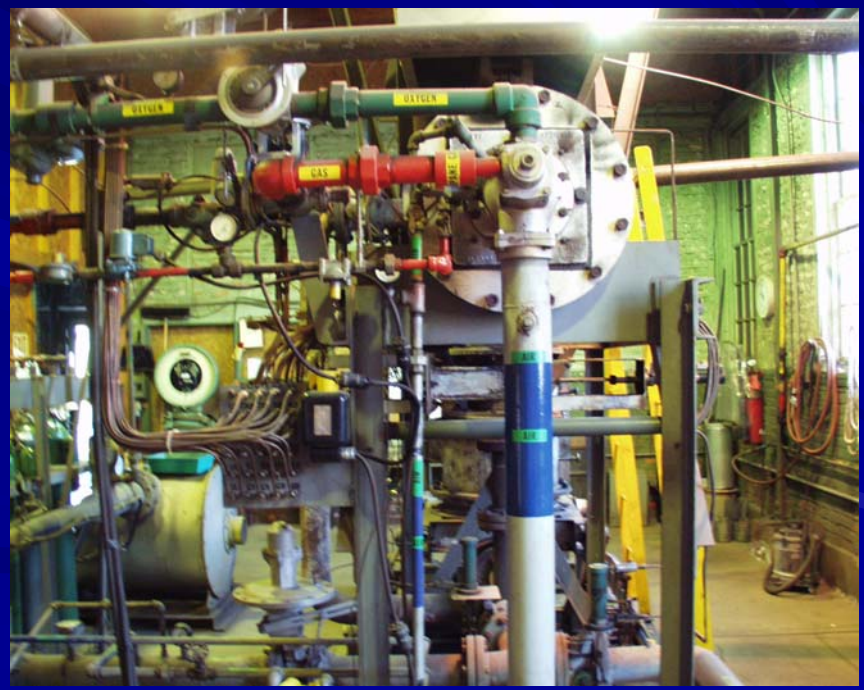
Pilot Scale Process Simulation

Typical Pot Grate Temperature Profile



Pilot Scale Process Simulation

Pot Grate Furnace



Fired Pellet Quality Assessment

- Physical Quality
  - ASTM % +1/4” After Tumble
  - Fired Pellet Compression, %-200 lbs., %-300 lbs.
- Metallurgical Quality
  - ISO 4695, Reducibility, (R40)
  - ISO 7215, Relative Reducibility, (Gaukashin)
  - ISO 4696-1, Low Temperature Disintegration, (LTD)
  - ISO 4698, Fired Pellet Swelling
  - Porosity

Fired Pellet Quality Assessment

Chemistry Evaluation

- Inductively coupled Plasma Spectroscopy (ICP)
- Iron Assay by Titration

Process Simulation Applications

- Low Level Limestone Addition to Enhance Fired Pellet Quality and Blast furnace Performance
- Change Pellet Chemistry to meet Blast Furnace Specifications
  - Changing Mn, MgO, SiO_2 content
  - Increased C/S ratio, by changing flux stone addition
- Furnace Modifications
  - Pre-heat burners
  - Drying, pre-heat or firing zone changes to compensate for chemistry changes or ore changes

Conclusions

- Process changes on induration furnaces requires considerable down-time with a great amount of risk. Effectively evaluating these changes in a laboratory setting is required to reduce costs and minimize the risk. Filtering, balling and furnace testing have proven themselves capable of simulating operating conditions and fired pellet quality on both the bench and pilot scale. When used in conjunction with proper laboratory evaluation techniques, they can effectively be used to investigate process changes.