Improving Cupola Efficiency

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History of ICRI

• In the 1930’s a group of iron foundries funded research at Battelle Memorial Institute to look at improving cupola operations.

• Some of the researchers from Battelle were spun off to form the Gray Iron Research Institute.
• In the 1970’s the name was changed to Iron Casting Research Institute to reflect that we were involved with all type of iron castings.
General Comments

- Operate the cupola continuously
- Operate the cupola at constant blast
- Blast rate should be in the range of 2.4 – 2.6 times the cupola cross-section in inches
- Size tuyeres to achieve a tuyere velocity of 12-15,000 ft/min cold blast
General Comments

• Any changes made to improve the efficiency of the cupola will increase the melt rate.

• If you can’t get rid of the additional melted iron you are not going to maximize the cupola operation.
General Comments

• You need to work with scheduling to evenly load the molding lines to have a constant metal demand.

• The cupola should be sized so that the cupola is pushed to achieve the required metal demand.
Effect of Lining on Heat Loss

Heat Loss to Shell Water Cooling

- Unlined Cupola
- Unlined Cupola in Meltzone
- Lined Cupola

Diameter of Cupola Shell, inches

% of Total Heat Lost
Sizing of coke

Reference: Some Variables in Acid Cupola Melting; 1954 AFS Transactions
Effluent Gas Composition

CO/CO₂ Balance in Effluent Gas

% CO in Gas

%CO₂ in Gas

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Energy Loss to CO Formation

Heat Loss to CO, BTU/1000scf

Energy Loss to CO, BTU/1000scf

% CO in Gas

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Coke used to Generate CO

Total Carbon Used, #C/1000scf

0 5 10 15 20 25 30 35 40
% CO in Effluent Gas

0 2 4 6 8 10 12 14
#C consumed/1000scf
Effect of Hot Blast

Available Energy From Heated Blast Air, BTU/1000scf

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Divided Blast

Reference: Further results of investigation of improved cupola performance by proportioning the blast between two rows of tuyeres; 1972 BCIRA Report 1057

**Fig. 3** Reduction of charge coke quantity and increase in melting rate by operating cupola with 2 rows of tuyeres with proportioned blast supply. (Blast rate 1600 ft³/min).
Use of Oxygen

Reference: Developments in Cupola Melting; 1979 BCIRA Conference paper

Fig. 8 Effect of 4% oxygen enrichment of blast in conventional and divided-blast operation
Effect of Humidity in Blast Air


Fig. 14-23. Coke to be added to the base charge to compensate for moisture in the blast.
Savings from Dehumidification

17,500 scfm blast rate; melting 50 TPH; operating 50% of available hours/month; $500 per ton for coke

Total Savings

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Natural Gas & Liquid Fuels

- In the late 60’s and early 70’s tests were run using natural gas and fuel oil burners in the tuyeres of cupolas.
- Some of this work was actually done here in Muskegon at CWC. This work was done by Battelle Memorial Institute and Columbia Gas.
- The burners were fired with air.
Effect of Burners on Melt Rate

Reference: Oxy-Fuel Tuyere Burners; 1966 AFS Transactions

Oxy-NG Burners

Oxy-Oil Burners

MELTING RATE – VERSUS – WIND RATE
OXY-GAS BURNERS – HIGH FLOWS

MELTING RATE – VERSUS – WIND RATE
OXY-OIL BURNERS – HIGH FLOWS

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Natural Gas Burners

• In the mid 90’s and later the use of natural gas burners fired with oxygen was developed in Europe and many papers were published. These papers all indicated reduced coke usage.

• I was involved with the installation of oxy-NG burners at Wheland Foundry in the late 90’s.
Natural Gas Burners

• These burners were quite small in energy input. Approximately 5 million BTU/Hr total through 3 burners.

• We experienced an increase in melt rate of 5-10%, a reduced coke consumption of approximately 5%, and a increase in silicon recovery.
Natural Gas Burners

- The European reports of oxy-NG burner use in the last decade have reported much more substantial improvements in cupola efficiency.

- The burner outputs are substantially greater than those at Wheland Foundry.