ALTERNATIVES FOR HOT METAL PRODUCTION: CUPOLA, INDUCTION AND ARC FURNACE

metallon
Asistencia técnica y capacitación

Jorge Madias

COLFUN, Buenos Aires, Argentina, October 28 – 30, 2010

metallon

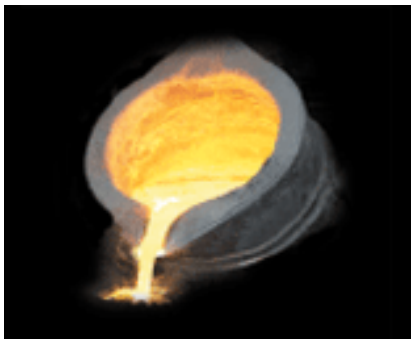
- Technical services for foundries and steel companies
  - Open and in company short courses
  - Technical assistance
  - Met lab
  - Library services
  - www.metallon.com.ar
  - jorge.madias@metallon.com.ar
  - San Nicolas, Buenos Aires, Argentina

metallon

- Next foundry-related open courses
  - 2nd International Course on Electric Arc Furnaces, Rosario, Argentina, March 29-30, 2011
  - Course on Applied Metallography, Rosario, Argentina, June 28-29, 2011
  - Course on Metallurgy of Ductile Iron, Rosario, Argentina, November 22-23, 2011

Alternatives for hot metal production

- Content:
  - Introduction
  - Cupola
  - Induction Furnace
  - Arc Furnace
  - Influencing factors
  - Trends
  - Conclusions

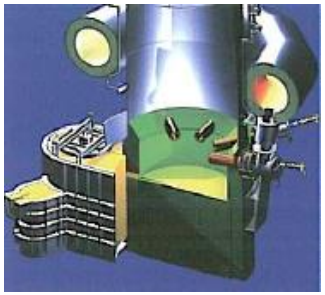


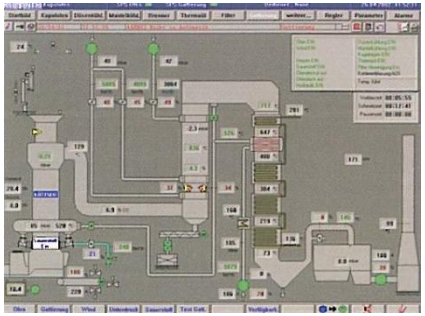
Introduction

- To obtain liquid ferrous metal departing from cold charge, several technological alternatives are available
- For a greenfield new foundry or brownfield capacity increase, these alternatives must be evaluated
- The advantages and drawbacks are discussed of
  - Cupola
  - Induction furnace
  - Arc furnace

Cupola

- Modern cupola features:
  - Fume take off below charge
  - Hot blast
  - Off gas treatment
  - Liningless larger furnaces
  - High automation level





Cupola


Standard layout showing:
Bucket charging
Below charge gas take off
Dry slag granulation
Vertical combustion chamber
Hot blast recuperator
Heat recovery bundles
Baghouse
Exhaust fan and stack

Cupola

- Fortresses
  - Thermal efficiency, in larger units
  - Acceptation of wide range of metallics
  - Less sensitivity to scrap oxidation
  - Design variants for specific aims (plasma, cokeless, oxycup)
  - Hot blast: low melting cost for larger tonnages

Cupola

- Weaknesses
  - Big off-gas generation
  - To have good environmental performance, heavy investment is necessary
  - For ductile iron production, downstream equipment is convenient
  - Temperature and chemistry control is more complex

Induction furnace

- Fortresses
  - Coke or electrodes not required
  - Possibility of producing an ample range of materials
  - Easy and fast control of liquid metal temperature
  - Easy temperature adjustment
  - Fast change of melting rate
  - Good environmental performance, with low investment

Induction furnace

- Weaknesses
  - Limitations in metallics to be charged (turnings and borings, dirty scrap, scrpap size)
  - Limitations for metallurgical tasks requiring slag-metal interaction

Induction furnace

- High power
- Automation

- Becoming usual:
  - Fume extraction
  - Push out system
  - Backslagging
  - Robot for sampling and other furnace operations




Arc furnace

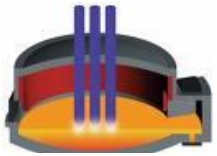
- Fortresses
  - Capacity to melt everything, including turnings and borings
  - Ability to reach high temperatures (advantage for cast steel production)
  - With basic lining, possibility to decrease sulphur or phosphorus via slag-metal interaction
  - Simple and reliable equipment

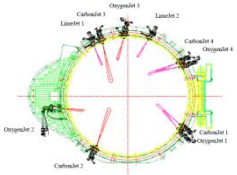
Arc furnace

- Weaknesses
  - Noise
  - Off gas generation (when oxygen injection is used)
  - Need to control emissions

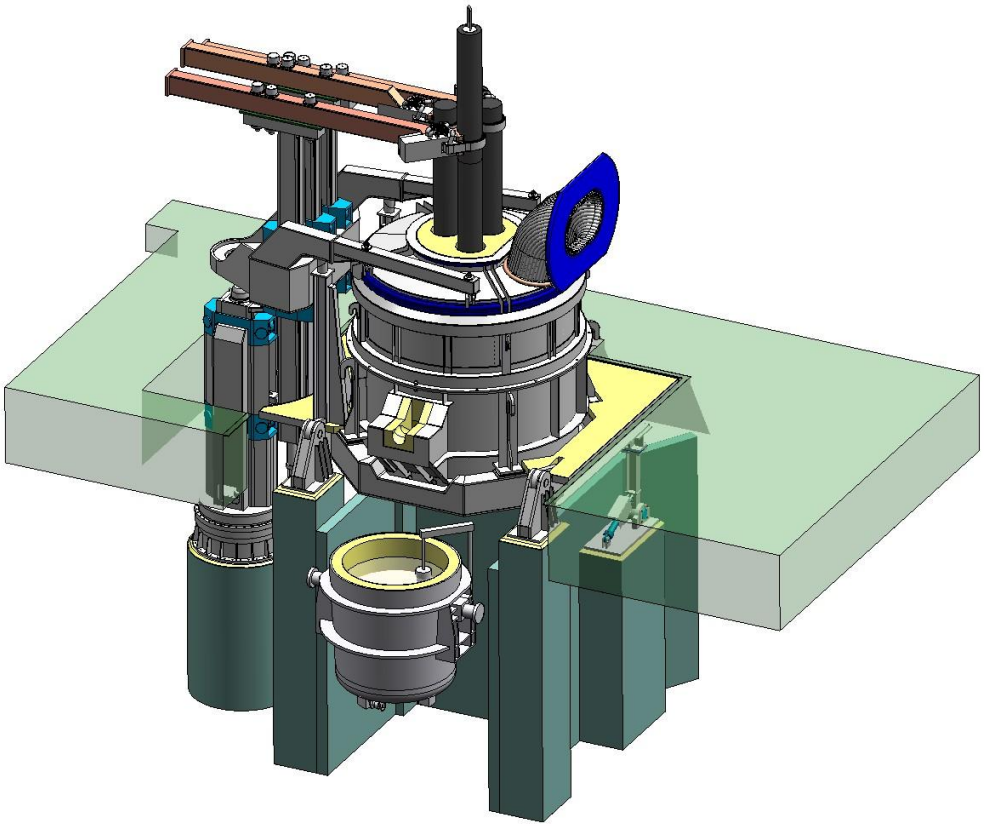
Arc furnace

- Features of modern arc furnaces
  - High power
  - Water cooled panels
  - Slag foaming
  - Excentric bottom tapping
  - Oxygen, coal, gas and lime through injectors
  - Electroconductive arms
  - Digital system for electrode regulation



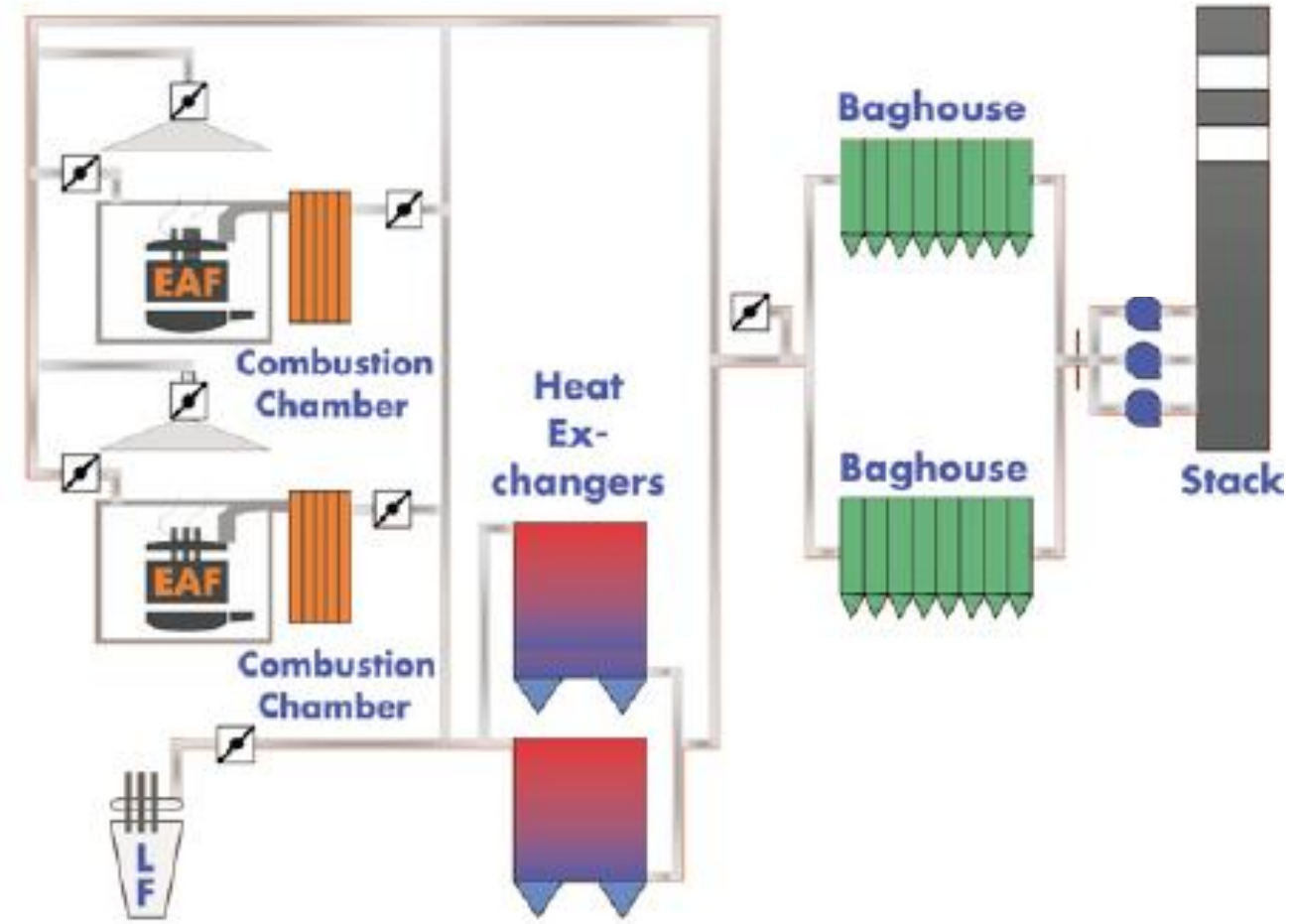


Arc furnace



Arc furnace

- Off gas treatment



Influencing factors

- Availability and cost of raw materials and consumables
- Grades to be produced
- Investment cost
- Operating cost
- Environmental restrictions

Raw materials and consumables

- Types of scrap available and cost
- Need of recycling turnings and borings
- Availability and cost of electric power, coke and electrodes





Influencing factors

- Grades to be produced

	Gray iron (%)	Ductile iron (%)	Cast steel (%)	Aluminum (%)
USA	36	32	9	16
Germany	49	28	4	14
Japan	40	32	4	21
China	60	20	10	7
India	70	9	11	8
Brazil	86		7	7
Argentina	49	34	6	11

Operating cost

Item	Cupola (USD/t)	Induction (USD/t)
Metallics	135.4	151.7
Additives	9.3	13.0
Melting	23.4	29.6
Labour	4.0	4.5
Refractories	1.8	3.1
Waste disposal	1.5	0.5
Maintenance	6.4	4.4
Building and others	10.0	10.0
Total	191.8	216.8

Greenfield; 40 t/h; 16 h /day; 4000 h/year. Hot-blast cupola; medium frequency coreless induction furnace. US costs. Kuttner study, 2001

Operating cost

Item	Savings when replacing arc furnace melting by induction melting (USD/t)
Melting energy	2.7
Energy demand	-3.3
Electrodes	33.4
Metallic charge	-20,2
Labour (production)	5,4
Refractories	1,0
Maintenance (materials and labour)	18,0
Polution control	4,8
Waste disposal	0,9
Total	42,8

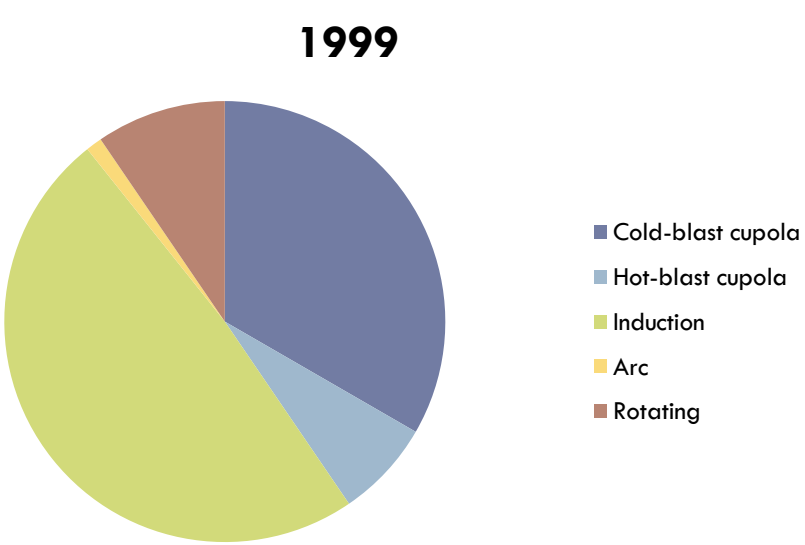
John Deere, year 2000, when analyzing a modernization with Capacity increase. Cupola in intermediate position

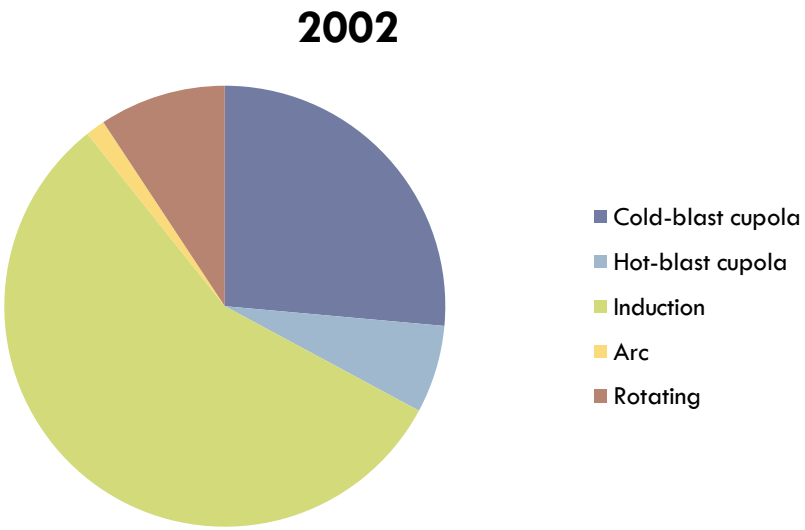
Operating cost

- France
  - 1997 cold-blast cupola the cheapest (236 €/t); induction furnace the most expensive (265 €/t)
  - 2003 Induction furnace the cheapest (252 €/t), followed closely by hot-blast cupola (253 €/t)
  - 2005 hot-blast cupola the cheapest (295 €/t)

Trends

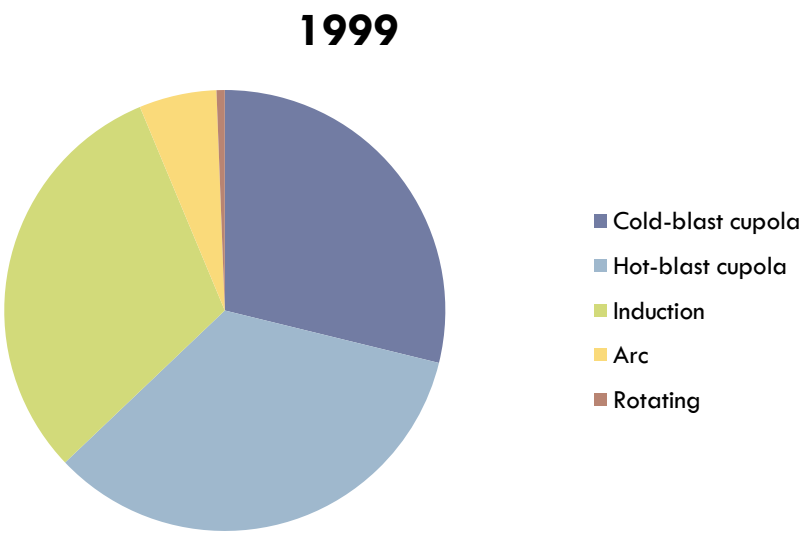
- France – quantity of furnaces for ductile iron, cast ion and malleable iron (1999 162 units; 2002 140 units)

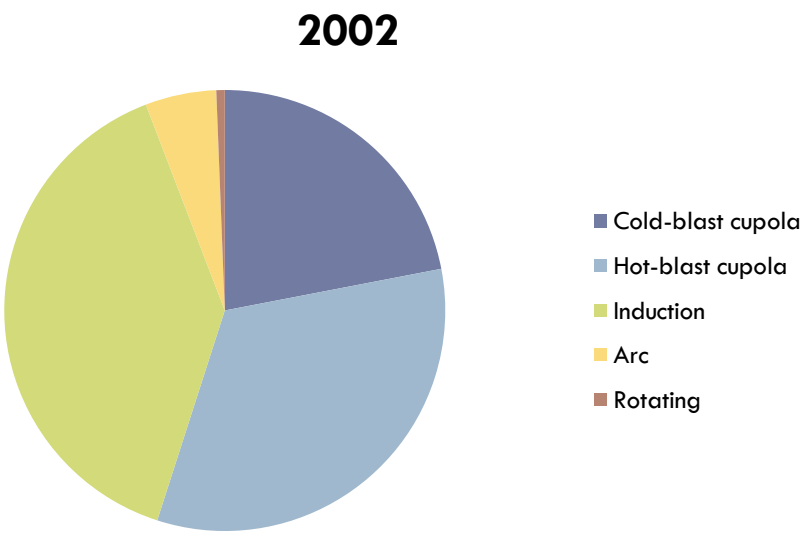




Trends

- France – tonnage ductile, gray and malleable iron (1999, 1,530,000 t; 2002 1,400,000 t)





Trends

- Argentina (Ricardo Velazquez, Foundry industry in Argentina, COLFUN 2010)
  - 1980 80% cupola, 20% induction
  - 2010 20% cupola, 80% induction
- Brazil (Roberto de Deus, private communication)
  - 2010 30% cupola, 70% induction

Conclusions

- Worlwide trend to replace melting capacity of cold-blast cupolas by induction furnaces
- For big production, using hot-blast cupola as primary melting unit is still competitive
- To make the right decision, it is always convenient to evaluate the furnace alternatives, comparing CAPEX, OPEX and other factors