BLAST FURNACE

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INTRODUCTION

What is blast furnace (BF)?

- A type of metallurgical furnace used in pyrometallurgy
- Where the smelting operation and the chemical reactions take place
- A large steel structure about 30 metres high

INTRODUCTION

Purpose of blast furnace;

- To chemically reduce and physically convert iron oxide ores into liquid iron

These plants combined together to produce steel;

- Coke oven
- Sinter plant
- Pellet plant
- Blast furnace
- Basic oxygen furnace

INTRODUCTION

The course divided into the following subtopics;

- Equipment
- Process
- Input
- Output
- Operation

Blast Furnace

The blast furnace is a complex machine that is exposed to extreme high temperature and forces. The following module describes all the main and auxiliary components into this process.

Blast Furnace

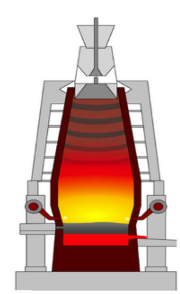
In order to analyze more in details Blast Furnace they will be divided into two groups;

Main Components

Auxiliar Equipment

Blast Furnace Equipment

- Throat
- Shaft
- Belly
- Bosh
- Hearth
- Bustle Pipe
- Tuyere
- Taphole
- Slag Taphole / Cinder notch
- Charging System



The Charging Systems

- The materials are usually held in hoppers at the top of the furnace until a charge, usually consisting of some type of metallic (ore, pellets or sinter) , coke and flux have accumulated. The precise filling order is developed by the blast furnace operators to carefully control gas flow and chemical reactions inside the furnace.

RAW MATERIAL

- Ore and coke => 1600 kg of iron bearing for one tonne hot metal
- Ores can be pellets, lumps or just sintered
- Consume 380 kg of coke reductant

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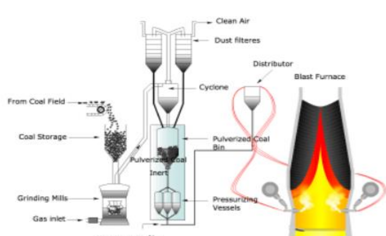
PULVERISED COAL INJECTION

- 90-120 kg/tonne hot metal of pulverized coal injection as a reductant
- From the tuyere to the lower part of the furnace



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HOT BLAST

- Approximately, 1000 Nm^3/tonne of hot metal of hot blast is blown to tuyeres.
- But firstly pre-heated 1150-1250 ^0C

PROCESS

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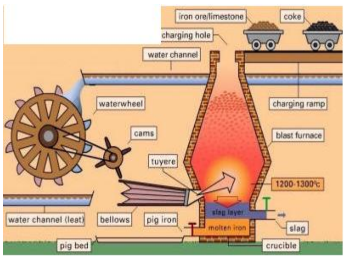

CHEMICAL REACTIONS

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- The indirect reduction reactions with CO are:

- During the descent of the burden in the furnace, the iron-bearing materials are indirectly reduced by carbon monoxide gas in the low-temperature zone of the upper furnace.

Hematite:

$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$

Magnetite:

$Fe_3O_4 + CO = 3FeO + CO_2$

Wustite:

$2FeO + CO = 2FeO_{0.5} + CO_2$

CHEMICAL REACTIONS

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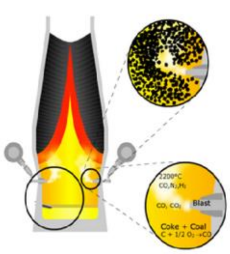

- In the lower part of the furnace, carbon dioxide, produced by the reduction of the remaining iron ore by carbon monoxide is instantaneously reduced by coke (C) into carbon monoxide which again reduces the iron oxide.

(1) $FeO + CO = Fe + CO_2$

(2) $CO_2 + C = 2CO$

Total $FeO + C = Fe + CO$

- Direct reduction uses carbon (coke) as the reductant and generates extra CO gas; direct reduction costs a lot of energy. Direct reduction is also called solution loss.

ZONES OF THE BLAST FURNACE

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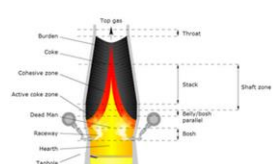
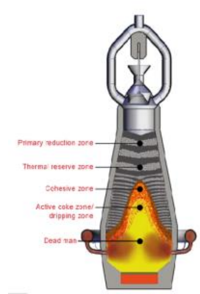
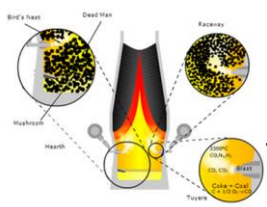




TUYERES, RACEWAY, HEARTH



Schematic view of Tuyeres

The figure illustrates where the tyueres, raceway as well as deadman lie in the blast furnace, and a closer look at these special areas.

Blast Furnance Steelmaking

- The materials discharged from blast furnance, are;
- hot metal (1803K)
- molten slag ,
- exhaust gas

discharged from the furnace top.

HOT METAL

- It is a carbon saturated iron with number of impurities.

Table: Chemical Composition of Hot Metal

Element		Typical (wt%)
Iron	Fe	94.5
Carbon	C	4.5
Silicon	Si	0.40
Manganese	Mn	0.30
Sulfur	S	0.03
Phosphorus	P	0.07

SLAG

- Slag is formed from the gangue materials of burden and the ashes of the coke and the other reductants.

hematite > magnetite > wustite > metallic iron

$$3Fe_2O_3 + CO\ (H_2) = 2Fe_3O_4 + CO_2\ (H_2O)$$

$$Fe_3O_4 + CO\ (H_2) = 3FeO + CO_2\ (H_2O)$$

$$FeO + CO\ (H_2) = Fe + CO_2\ (H_2O)$$

OPERATION

-Instrumentation and Process Control

-Charging Operation Description

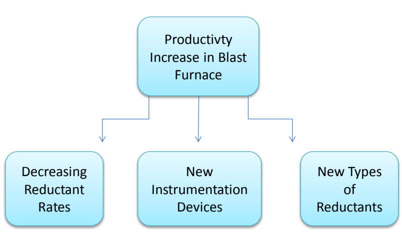
-Casting

-Blowing-In

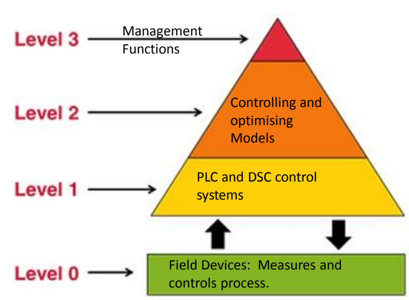
-Blowing-Out

-Irregularities

Instrumentation and Process Control



Control Architecture Layout

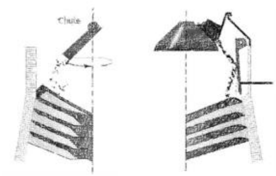


A well-instrumented , modern blast furnace has;

- Thermocouples
- Pressure taps
- Retractable below-burden probe
- Fixed above-burden probes
- Transverse radial profile meter
- Stock movement sensors

Charging Operation Description

- Burden material properties and used charging equipments have great influence on operation and performance of blast furnace.



CASTING

- An excellent casthouse operation is an important factor in a low cost, high productivity blast furnace operation.
- The prime objective is to remove the liquid iron from the blast furnace at a casting rate and through a number of casts per day that is determined by the smelting rate.

Blowing-In

- Drying
- Filling
- Lighting

Blowing-Down

- Charge free operated furnace
- Water sprays control the top gas temperature
- The steam sprays are activated after passing burden level.
- The blast rate and temperature are reduced.
- The salamander is drained.

IRREGULARITIES

- Slip
- Scaffolding
- Channeling

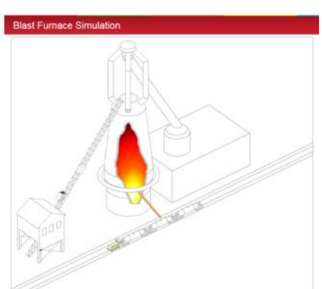
Simulation

Charging rates

- Ore
- Fuel
- Flux

Production settings

- Type of pig iron:
- Target (Composition)
- Process settings
- Temperatures (°C)
- Gas Additions (%)
- Hot Blast Properties
- Heat Loss Model



Charging Results

Blast Furnace Volume: 2600 m^3

Blast furnace utilization coefficient : 3.15. It is very good!

Coke rate is: 388.93 kg / t HM.

Coal rate is: 98.26 kg / t HM. Please try to increase it.

Fuel rate is: 487.19 kg / t HM. It is very good!

The blast temperature is: 1155 °C.

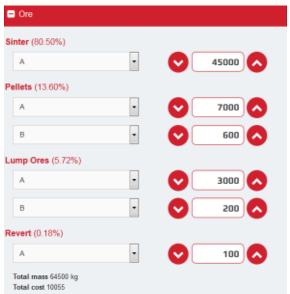
Fe content in ores is: 59.79%. It is very good!

Energy utilization coefficient is: 88.59%.

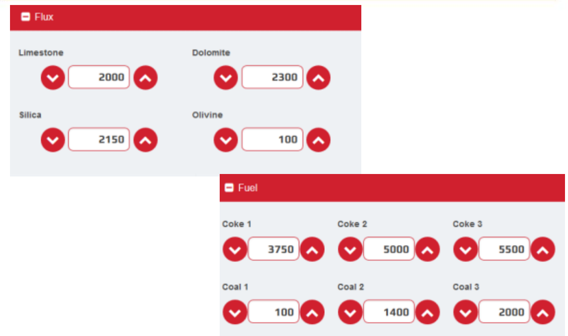
Carbon energy utilization coefficient is: 70.53%. It is very good!

Total cost453.49 $ / t HM

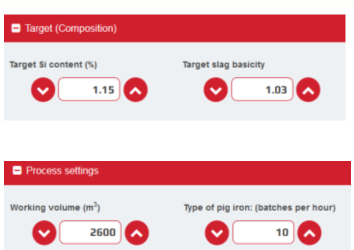
Ore



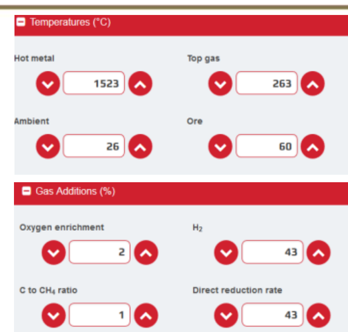
Flux and Fuel



Target and Process settings



Temperatures and Gas additions



Hot Blast Properties

Hot Blast Properties

Temperature (°C)	Temperature drop (°C)
1200	45.5

Pressure (kPa)	Humidity (g/Nm³)
120	12.5

Results

Outgoing Compositions

Hot metal	
Fe	94.97
C	3.45
Si	1.15
Mn	0.30
Ti	0.01
V	0.00
S	0.02
P	0.10
T / °C	1763

Slag	
FeO	1.01
CaO	40.65
SiO2	35.43
Al2O3	8.94
MgO	13.98
MnO	1.05
V2O5	0.00
TiO2	0.14
CaF2	0.00
P	0.00
S	0.67

Slag Basicity	
R2:	1.147
R3:	1.542
R4:	1.231

Top gas	
CO2	26.42
CO	21.46
N2	52.00
H2	-0.40
CH4	0.51

Yield	
t HM / year	2843067.21
t HM / day	8199.18
t HM / batch	34.16

Costs	
Oxygen	1.54
Blast	6.18
Humidity	0.08
Top Gas	-27.76
Hot Blast	9.99
Burden	472.82
Total Cost	462.84

Results

Heat and Mass Balance Results

Mass In		
Mixed ore	1633.88kg / t HM	43.14%
Coke	412.76kg / t HM	11.01%
Small coke	0.00kg / t HM	0.00%
Coal powder	101.13kg / t HM	2.75%
Lump coal	0.00kg / t HM	0.00%
Flux	191.73kg / t HM	5.17%
Blast	1326.30kg / t HM	36.10%
Free water	8.04kg / t HM	0.22%
Total	3673.84kg / t HM	98.39%

Mass Out		
Hot Metal	1000.00kg / t HM	27.74%
Slag	364.25kg / t HM	10.11%
Top gas	2168.10kg / t HM	60.15%
Dust	57.53kg / t HM	0.41%
Moisture	14.66kg / t HM	1.60%
Total	3604.55kg / t HM	100.00%

Heat In		
Carbon oxidation	8441160kg / t HM	78.77%
Hot blast	1779332kg / t HM	16.60%
Hydrogen oxidation	103197kg / t HM	0.96%
Slag forming	119004kg / t HM	1.11%
Materials heat	273438kg / t HM	2.55%
Total	10716131kg / t HM	100.00%

Heat Out		
Oxide decomposition	7294830kg / t HM	68.07%
Carbonate decomposition	139234kg / t HM	1.30%
Moisture decomposition	194508kg / t HM	1.82%
Free water evaporation	17492kg / t HM	0.16%
Coal decomposition	-9030kg / t HM	-0.08%
Molten iron	1159570kg / t HM	10.82%
Slag	488940kg / t HM	4.56%
Top gas	545903kg / t HM	5.09%
Loss	884685kg / t HM	8.26%
Total	10716131kg / t HM	100.00%

Results

Charging Results

Blast Furnace Volume: 2600 m³

Blast furnace utilization coefficient : 3.15. It is very good!

Coke rate is: 404.5 kg / t HM.

Coal rate is: 101.13 kg / t HM.

Fuel rate is: 505.63 kg / t HM.

The blast temperature is: 1155 °C.

Fe content in ores is: 59.79%. It is very good!

Energy utilization coefficient is: 86.65%.

Carbon energy utilization coefficient is: 68.75%. It is very good!

Total cost462.84 $ / t HM

Thank you for Attention