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;

Blast Furnace Equipment
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

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

HOT BLAST

• Approximately, 1000 Nm³/tonne of hot metal of hot blast is blown to tuyeres.
• But firstly pre-heated 1150-1250 °C
**PROCESS**

- 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 solid reduction.

**CHEMICAL REACTIONS**

- 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.

- The indirect reduction reactions with CO are:
  - Hematite:
    \[ 3\text{Fe}_2\text{O}_3 + \text{CO} = 2\text{Fe}_3\text{O}_4 + \text{CO}_2 \]
  - Magnetite:
    \[ \text{Fe}_3\text{O}_4 + \text{CO} = 3\text{FeO} + \text{CO}_2 \]
  - Wustite:
    \[ 2\text{FeO} + \text{CO} = 2\text{FeO}_0.5 + \text{CO}_2 \]

- 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.

**ZONES OF THE BLAST FURNACE**

- 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 solid reduction.
• The materials discharged from blast furnace, 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>
<thead>
<tr>
<th>Element</th>
<th>Typical (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (Fe)</td>
<td>94.5</td>
</tr>
<tr>
<td>Carbon (C)</td>
<td>4.5</td>
</tr>
<tr>
<td>Silicon (Si)</td>
<td>0.40</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>0.30</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>0.03</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

SLAG

• Slag is formed from the gangue materials of burden and the ashes of the coke and the other reductants.
**Operation**

- Instrumentation and Process Control
- Charging Operation Description
- Casting
- Blowing-In
- Blowing-Out
- Irregularities

**Control Architecture Layout**

- **Level 3**
  - Management Functions

- **Level 2**
  - Controlling and optimising Models

- **Level 1**
  - PLC and DSC control systems

- **Level 0**
  - Field Devices: Measures and controls process
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: 2400 m³
- Blast furnace utilization coefficient: 3.15. It is very good
- Coke rate is: 488.9 kg/M³
- Coal rate is: 50.29 kg/M³. Please try to increase it.
- Fuel rate is: 487.14 kg/M³. It is very good
- The blast temperature is: 1150 °C.
- Fe content in coke is: 59.79%. It is very good
- Energy utilization coefficient is: 89.9%. It is very good
- Carbon energy utilization coefficient is: 79.32%. It is very good
- Total cost is: 93.11 $/M³
**Hot Blast Properties**

- Temperature (°C): 1200
- Temperature drop (°C): 45.5
- Pressure (kPa): 12.0
- Humidity (g/m³): 12.5

**Results**

<table>
<thead>
<tr>
<th>Ingots</th>
<th>Slag</th>
<th>Slag Density</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0</td>
<td>1.30</td>
<td>1.03</td>
<td>41.6</td>
</tr>
<tr>
<td>S1</td>
<td>1.16</td>
<td>1.06</td>
<td>50.2</td>
</tr>
<tr>
<td>S2</td>
<td>1.08</td>
<td>1.08</td>
<td>50.9</td>
</tr>
<tr>
<td>S3</td>
<td>1.00</td>
<td>1.00</td>
<td>50.9</td>
</tr>
<tr>
<td>S4</td>
<td>0.95</td>
<td>0.95</td>
<td>50.9</td>
</tr>
</tbody>
</table>

**Heat and Mass Balance Results**

**Results**

<table>
<thead>
<tr>
<th>Mass In</th>
<th>Mass Out</th>
<th>Heat In</th>
<th>Heat Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>200 kg</td>
<td>200 kg</td>
<td>100 kg</td>
</tr>
<tr>
<td>Slag</td>
<td>100 kg</td>
<td>100 kg</td>
<td>50 kg</td>
</tr>
<tr>
<td>Total</td>
<td>300 kg</td>
<td>300 kg</td>
<td>150 kg</td>
</tr>
</tbody>
</table>

**Changing Results**

- Blast furnace volume: 2000 m³
- Blast furnace utilization coefficient: 2.15, it is very good!
- Coke rate: 425 kg/t; it is very good.
- Coal rate: 181.15 kg/t; it is very good.
- The blast temperature is 1105 °C.
- Fuel content in coke: 9.79%, it is very good.
- Energy utilization coefficient: 85.65%.
- Carbon energy utilization coefficient: 30.3%, it is very good.
- Total cost: 62.6 € / t of blast.
Thank you for Attention