Basic Oxygen Furnace

Basic Oxygen Furnace (BOF) is a steel making furnace, in which molten pig iron and steel scrap convert into steel due to oxidizing action of oxygen blown into the melt under a basic slag.

What is the BOF?

- Primary steelmaking
- Known as Linz–Donawitz–Verfahren steelmaking

History

- In 1856, Henry Bessemer patented a steelmaking process involving oxygen blowing for decarburizing molten iron.

- For nearly a hundred years commercial quantities of oxygen were not available at all or were too expensive, and the invention remained unused.

History

- The process was developed in 1948 by Robert Durrer in Switzerland.

- Commercialized in 1952–1953 by Austrian VOEST and ÖAMG is an international steel-based technology and capital goods group based in Linz.
**Basic Functions of BOF**

- To decarburize and remove phosphorus from the hot metal.
- To optimize the steel temperature for casting with no further heat treatments.

**What about energy?**

Required energy: 1.5 million Btu per ton of steel

**Supplied Energy**

- 1. Hot Metal
- 2. Oxidation reactions
- 3. Slag Reactions

**How does BOF work?**

1. Charging hot metal
2. Blow
3. Tapping and additions
4. Slagging
1-Charging Hot Metal

Hot metal is melted pig iron in a furnace.

"heating" begins when the BOF vessel is tilted about 45 degrees towards the charging aisle and scrap charge (about 25 to 30% of the heat weight) is dumped from a charging box into the mouth of the cylindrical BOF.

Scrap Charging
The hot metal is immediately poured directly onto the scrap from a transfer ladle. Fumes and kish (graphite flakes from the carbon saturated hot metal) are emitted from the vessel's mouth and collected by the pollution control system.

Charging takes a couple of minutes.

Then the vessel is rotated back to the vertical position and lime/dolomite fluxes are dropped onto the charge from overhead bins while the lance is lowered to a few feet above the bottom of the vessel.

The lance is water-cooled with a multi-hole copper tip. Through this lance, oxygen of greater than 99.5% purity is blown into the mix. If the oxygen is lower in purity, nitrogen levels at tap become unacceptable.
**Chemical Reactions:**

- $\text{C} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}$
- $\text{CO} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2$

$\text{CO}_2/(\text{CO} + \text{CO}_2)$: Post Combustion ratio

- $\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$
- $2\text{P} + \frac{5}{2} \text{O}_2 \rightarrow \text{P}_2\text{O}_5$
- $\text{Mn} + \frac{1}{2} \text{O}_2 \rightarrow \text{MnO}$
- $\text{Fe} + \frac{1}{2} \text{O}_2 \rightarrow \text{FeO}$
- $2\text{Fe} + 3/2 \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$

Oxygen combines exothermically with C, Si, Mn, P.

**Lining Protection Techniques:**

- Avoid the most aggressive slag
- Protective slag coating
- Local repairs
3–Tapping and Additions

After blowing, purified steel is poured into ladles

Typical composition of the blown steel

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>S</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3–0.9%</td>
<td>0.05–0.1%</td>
<td>0.001–0.003%</td>
<td>0.01–0.03%</td>
<td>0.005–0.03%</td>
</tr>
</tbody>
</table>

Additions

- It is needed to further purifications according to customer requirements
- Further purifications are done by alloy additives

Some Common additives:

<table>
<thead>
<tr>
<th></th>
<th>Mn</th>
<th>C</th>
<th>Si</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferromanganese</td>
<td>8%</td>
<td>6%</td>
<td>-</td>
<td>Balance</td>
</tr>
<tr>
<td>Silicomanganese</td>
<td>66%</td>
<td>2%</td>
<td>16%</td>
<td>Balance</td>
</tr>
<tr>
<td>Ferrosilicon</td>
<td>-</td>
<td>-</td>
<td>75%</td>
<td>Balance</td>
</tr>
</tbody>
</table>

4–Slagging
Slagging

- After tapping, slag remains in the BOF vessel

- The slag is poured into slag pots

What is the current situation in Turkey today?
Second Trial:

**Materials**

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
<th>Note</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>5.00</td>
<td></td>
<td>5.00</td>
</tr>
<tr>
<td>Copper</td>
<td>2.00</td>
<td></td>
<td>2.00</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.00</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Silver</td>
<td>0.50</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Gold</td>
<td>0.25</td>
<td></td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Summary of Results**

- **Composition**
  - C: 0.55%
  - Si: 0.5%
  - Mn: 1.0%
  - P: 0.05%
  - S: 0.02%
  - Cr: 2.5%
  - Ni: 3.0%
  - Cu: 5.0%
  - Zn: 1.0%
  - Al: 0.2%
  - Others: 0.5%

- **Cost per metric ton**: $10,000

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**Additional Information**
Hot Metal Temperature = 1300 Celsius,
Bottom Stirring Gas Flow Rate= 0.1 (Nitrogen)
References

- [http://www.heatreatconsortium.com/metalsadvis/or/iron_and_steel/process_descriptions/raw_metals_preparation/steelmaking/basic_oxygen_furnace/basic_oxygen_furnace_energy_consumption.htm](http://www.heatreatconsortium.com/metalsadvis/or/iron_and_steel/process_descriptions/raw_metals_preparation/steelmaking/basic_oxygen_furnace/basic_oxygen_furnace_energy_consumption.htm)
- [https://steeluniversity.lms.crossknowledge.com/data/content/Final/1264/3A8ACA74-B2D5-28CC-80F6-0FBEF829E683/index.html#gotoExercise=1122](https://steeluniversity.lms.crossknowledge.com/data/content/Final/1264/3A8ACA74-B2D5-28CC-80F6-0FBEF829E683/index.html#gotoExercise=1122)