Basic Oxygen Furnace

Process Metallurgy

MET 374E

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Istanbul, Turkey

Basic Oxygen Furnace

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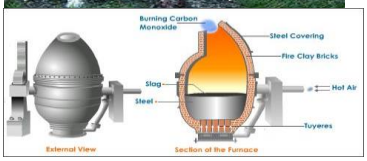
Contents

HISTORY OF BOF

- **At the ancient times:** Hammering the heated solid iron in air
- **In 1850:** The beginning of modern steel making with Bessemer
- **In 1879:** Dolamitic lining
- **In 1952:** Replacement of air by pure oxygen
- **In early 1970s:** Bottom blow oxygen by usage of tuyeres protected by hydrocarbon gas or fuel oil
- **In late 1970s:** Mixed blowing
- **In early 1980s:** Hot metal dephosphorization

HISTORY OF BOF



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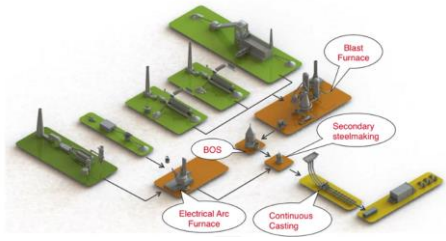
OVERVIEW



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OVERVIEW

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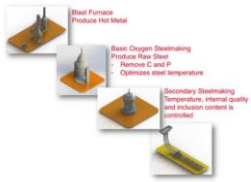
The main functions of the Basic Oxygen Furnece (BOF) are :

-to decarburize and remove phoshous from the hot metal

-to optimize the steel temperature



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OVERVIEW

-The exothermic oxidation reactions that occur during BOF generate a lot of heat energy

	Hot Metal	Steel
%C	4.7	0.05
%Mn	0.2-0.3	0.1
%Si	0.2-1.5	0.0
%P	0.06-0.12	0.01-0.02
%S	0.02	0.01-0.02
%O	0.0	0.06
Temperature (° C)	1350-1400	1620-1720

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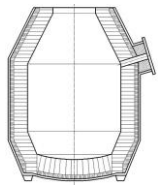
BOF OPERATION

Basic oxygen steelmaking is a primary steelmaking process for converting the molten pig iron into steel by blowing oxygen through a lance over the molten pig iron.



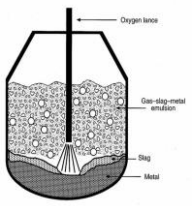
Cross-Section of a basic oxygen furnace

BOF OPERATION

- Charging hot metal(25-30% of the total charge weight)
- Pouring molten pig iron from blast furnace
- Reducing sulphur, silicon and phosphorus before charging the hot metal

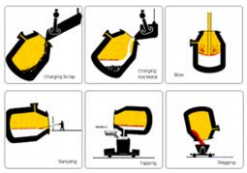
BOF OPERATION

- Starting oxygen blowing(about 20 min)
- High purity oxygen at a pressure of 100-150 psi
- During "blowing," churning of metal and fluxes in the vessel forms an emulsion, that facilitates the refining process
- Lowers the carbon content of the molten iron and helps remove unwanted chemical elements



BOF OPERATION

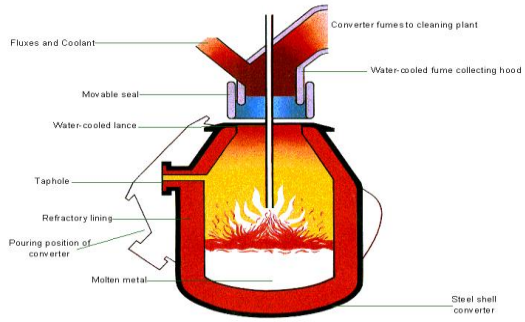
- Tapping - pouring the steel to a ladle
- De-slagging - pouring the residual slag into the slag pot. The furnace is turned upside down in the direction opposite to the tapping hole



BOF OPERATION

- The steel is poured through a tap hole into a steel ladle with basic refractory lining
- After the steel is poured off from the BOS vessel, the slag is poured into the slag pots through the BOS vessel mouth and dumped

BOF BASIC EQUIPMENTS



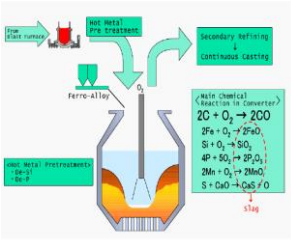
BOF BASIC EQUIPMENTS

- **Taphole:** When the desired molding temperature and the carbon percentage is reached, the furnace is bended the casting side and metal is taken to the ladle from the taphole.
- **Refractory Lining:** This wall is exposed to the molten iron flow and withstand to the high temperature on the specific Basic Oxygen Furnace operations.
- **Steel Shell Converter:** This converter is constructed entirely of welded stainless steel. This eliminates the heat loss for brick lining, thus allowing for rapid heat-up for start-up operations.
- **Molten Metal Chamber:** This chamber contains the molten metal.

BOF BASIC EQUIPMENTS

- **Water-cycling oxygen lance:** the top blown process a water cooled oxygen lance is lowered from the top of the furnace and blows oxygen at supersonic speed into the melt.
- **Fume Head:** uses for transfer the gases for decreasing inside pressure for reaction continuity
- **Taking sample equipment:** taking sample from the melted ingredient for chemical analysis

Basic oxygen furnace reactions



$C + ½O2 \rightarrow CO$

On the presence of other elements, rapid oxidation is occured on contact with the injected oxygen.

During refining, many oxidation reactions are developed.

$CO2/(CO+CO2)$ The ratio which forms in partial oxidation of CO into CO2 is called post combustion ratio (PCR).

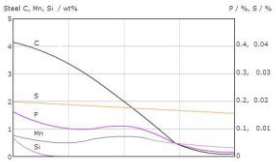
Oxides in other oxidation reactions forms a liquid slag which floats on the surface of the metal bath.

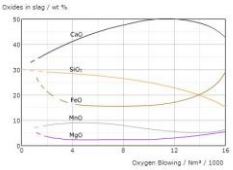
Refining reactions

Changes in melt composition during the blow

- **Oxygen is imposed into the system in order to oxidixe the impurities in scrap metal such as C, Si and Mn.**
- **These impurities in the oxide form, are combined with lime and forms slag.**

Changes in the slag composition during the blow





Dephosporization

The conditions in steelmaking processes favor dephosporization of iron, which takes place by oxidation of phosphorus and combination with basic slag.

$$2[P]+5[O]+4(CaO)= (4CaO.P_2O_5)$$

Dephosphorization in the BOF

Dephosphorization in the BOF is governed by the following equation:

$$\%Psteel= \%PE/ [1 + LP.Qslag/ (1+\Delta Peq/ \%Peq)]$$

where :
%PE = 100 × (Ptot, in / Msteel)
Qslag= Mslag / Msteel : specific slag consumption
LP = %Pslag / %Peq : equilibrium partition ratio
ΔPeq = %Psteel - %Peq : slag / metal disequilibrium

I – Actions on L_P
The CaO input should be such that 3 < v-ratio < 5 for all hot metal Si contents.

III – Actions on $\%P_{hot\ metal}$
That would be the role of hot metal pretreatment.

II – Actions on Qslag
Best measure if %Si hot metal is very low is to add lime and silica

IV – Action on kinetics (decrease of ΔP_{eq})
Adapt blowing pattern for optimized refining path
If necessary use of fluxes but beware of refractory wear, campaign life and effect on productivity

- The main aim is to reduce the carbon content to the desired value in the shortest time possible.
- Reactions

$Fe + ½ O_2 = FeO$

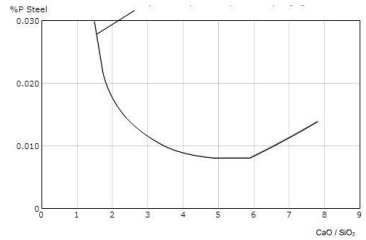
$FeO + C = Fe + CO$

$C + ½ O_2 = CO$

However, the time must be long enough to enable the slag to form,the desired tapping temperature to be achieved,the phosphorus and sulfur to be removed from the system until the desired levels are reached.

Dephosporization in the BOF

The following diagrams shows the effect of the major parameters on steel P content.



Hot metal : 0.4%Si
0.08%P
25%FeO
T Steel : 1650 °C
ΔP(eq): 0.005%

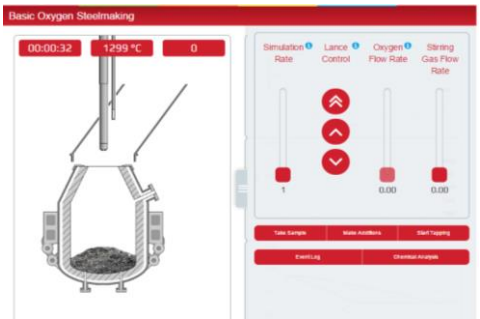
Blow Theory

Most efficient refractory materials
Dolomite -> in the past
Magnesia Bricks -> very good mechanical stability and chemical stability

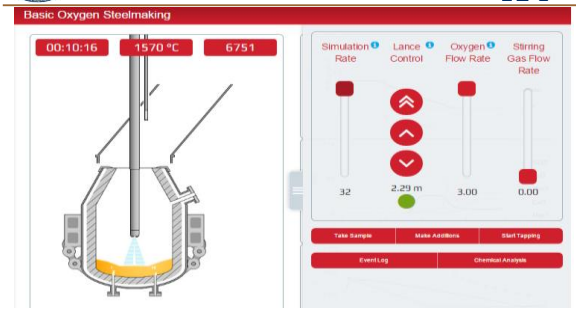
Lining Protection Techniques
➢Avoid the most aggressive slags
Too high FeO contents at high temperatures
Use dolomitic lime as an input material to saturate the slag in MgO
➢Protective slag coating
Add large quantities of MgO to the slag just before slag off and project it on the refractroy by blowing nitrogen through the oxygen lance.
➢Local Repairs
Perform timely localized repairs by gunning refractory materials in the most damaged zone.

Simulation Part

Initial data

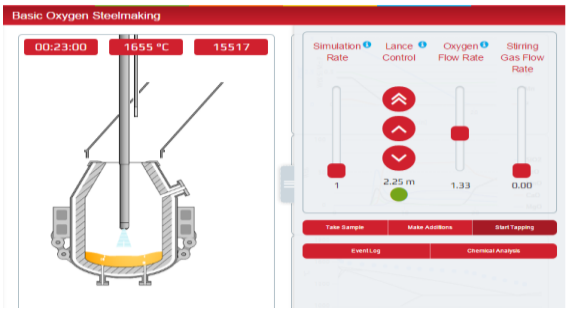


Simulation Part



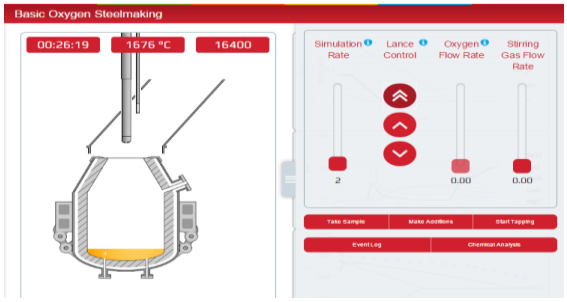
Oxygen flow rate increased !

Simulation Part



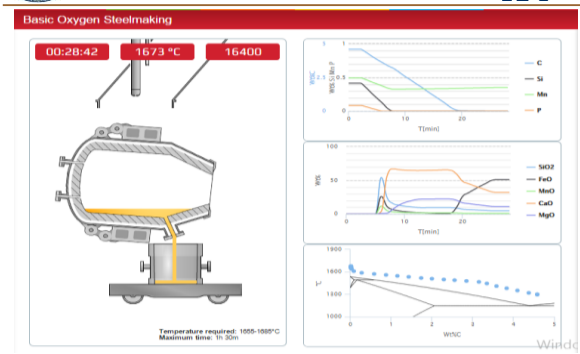
Oxygen flow rate decreased !

Simulation Part



Oxygen flowing stopped, lance retracted from furnace

Simulation Part



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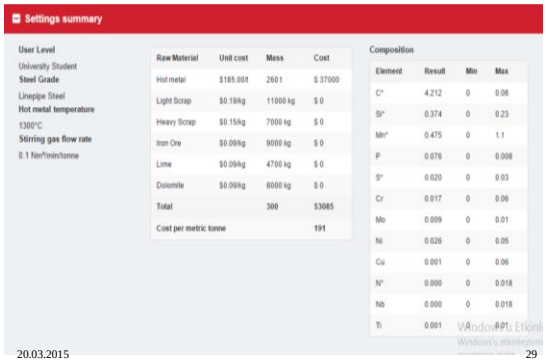

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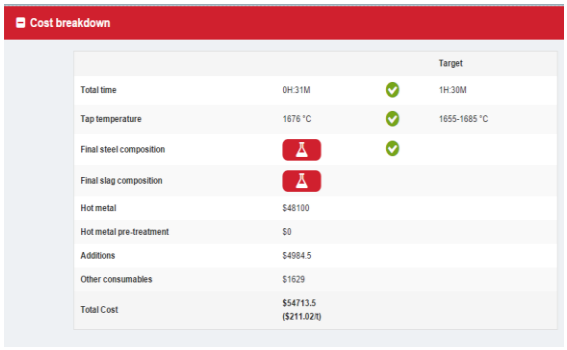

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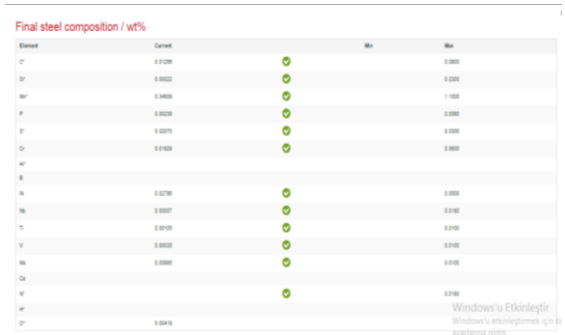

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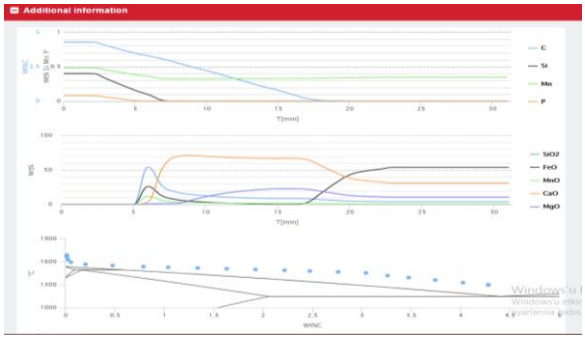
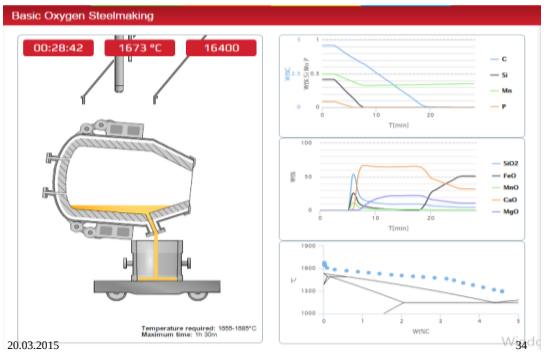


Simulation Part

	C	Si	Mn	P
Initial	4,28	0,40	0,48	0,08
Final	0,01	0,00	0,35	0,00

Simulation Part



To Sum Up Of BOF

Steelmaking is a primary steelmaking process for converting the molten pig iron into a steel by blowing oxygen through a lance over the molten pig iron.

Blust furnace Compounds

- Tophole
- Refractory Lining
- Steel Shell Converter
- Molten Metal Chamber

There is a head important process of steelmaking process

- Hot metal pretreatment (ferro alloy)
- Refining
- Casting
- Some Chemical Reaction e.g. $2Fe + O_2 = 2FeO$
- Dephosporization

Thank you for listening…