

## Lecture 19: Emerging Steelmaking Technologies

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Key words: EOF, CONARC

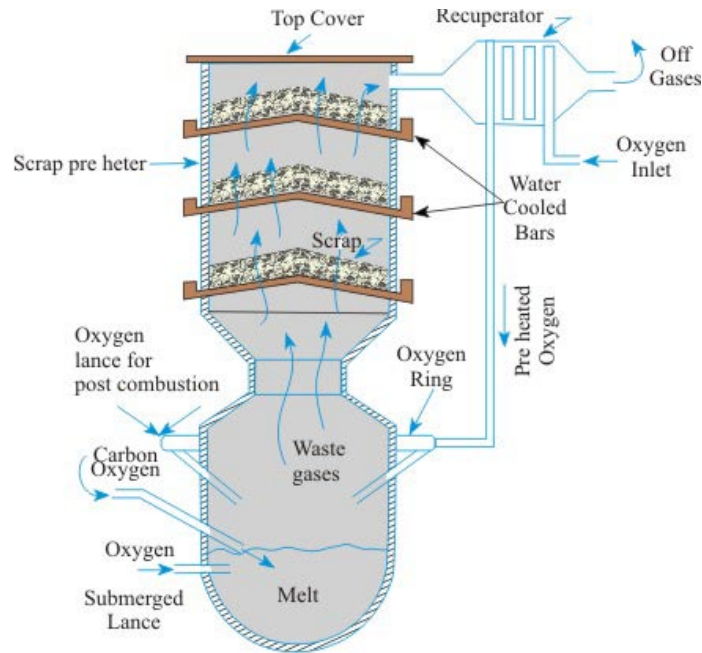
### **Basis:**

- To develop ecological balance technology. Such a technology would require processing the raw materials such that liquid products are discharged at the environmental temperature and waste products are discharged in their harmless states. This requires integrating the concept of recovery, reuse and recirculation within the process environment.
- To develop a process which is flexible to use varying proportion of metallic materials depending on their availability. Converter steelmaking is based on hot metal.
- To develop technologies which are not electric energy dependent. Electric steelmaking is dependent of availability of cheap electric power, though developments are made to use chemical energy.

In the above concept, two technologies are worthwhile to mention: Energy optimizing furnace (EOF) and CONARC (Converter + Arc furnace)

### **Energy optimizing furnace (EOF)**

Figure 19.1 is a schematic sketch of an energy optimizing furnace (EOF). EOF is a combination of three independent, interconnected reactors, namely furnace to produce steel, preheater to heat the scrap and a recuperator to recover waste heat and to reuse by heating oxygen.



**Figure19.1: Arrangement of furnace, scrap preheating chamber and a recuperator in an Energy optimizing Furnace**

Design of each reactor and their integration with each other is important such that furnace off gas exits the system at a low temperature to the extent possible and at the same time scrap is heated to the desired temperature and steel of required quality is tapped.

#### *Furnace*

The furnace is refractory lined and has a provision for injection of carbon and oxygen. Oxygen can be injected both at high speed to promote decarburization and at low speed to promote post combustion.

#### *Preheater*

A preheater is installed at the top of furnace to preheat the scrap by the waste gases flowing upward from the furnace. For scrap preheating residence time (R T) of the waste gas in the preheater

$$R T = \frac{\text{Diameter of the preheater}}{\text{flow velocity of exit gas}} = 0.785 \frac{D^3}{Q} \quad (1)$$

should be maximum. D is diameter of preheater and Q is volume flow rate of furnace gases. Both D and Q are important. For a given Q, diameter of preheater must be such that furnace gases can cool within 700 °C to 800 °C from 1300 – 1350 °C. The exit temperature of gas from the preheater is the inlet temperature of gas to the recuperator. Scrap size is also important to heat scrap to the desired temperature. Smaller size scrap can be preheated efficiently.

#### *Recuperator*

Recuperator is a counter current heat exchanger in which hot gases at 700 °C – 800 °C from the scrap preheater enters and exit gases leave at 350 °C and oxygen enters at 25 °C and preheated oxygen enters the furnace. The efficiency of the heat exchanger depends on the flow velocity of hot gas and oxygen. For a given cross section of the flow passage of the recuperator, the length of the recuperator must be optimized so that heat transfer from the furnace gases is maximum to preheat the incoming oxygen. The efficiency of the recuperator can be defined as

$$\epsilon = \frac{\text{sensible heat in oxygen at the preheat temperature}}{\text{Sensible heat in furnace gases}}$$

### *Furnace operation*

A liquid heel is left in the furnace from the previous heat in proportion which depends on scrap proportion. Higher the scrap proportion, higher is the amount of heel.

The operation in this case starts with injection of carbon in the hot metal heel until 3% carbon is achieved. This is followed by charging of the preheated scrap and refining commences immediately thereafter. Oxygen injection for refining and post combustion begins simultaneously. Slag is allowed to form so that it can flow over the sill down the pit.

The refractory consumption is kept within the limits by using water cooled panels and scrap supporting bass. To increase furnace life and effective preheating, maximum and minimum size of scrap are controlled.

### *Important Features*

- Oxygen is blown by a lance submerged in the melt for refining and simultaneously oxygen is also injected for post combustion.
- Utilization of sensible heat of furnace off-gases by preheating scrap and O<sub>2</sub>
- Flexibility to use hot metal and scrap in any proportion
- Wet de-dusting system
- Liquid steel with low levels of phosphorus and sulphur
- Low noise level
- An average of 42 heat/ day is possible.

With the above features EOF presents a low cost alternative for steelmaking combined with flexibility in terms of metallic charge mix.

### *Steel quality aspects*

1. Due to continuous slag flushing, turndown P can be obtained up to 0.008% and sulphur up to 0.025%.
2. High % hot metal produces a product with very low tramp elements, Advantages for die forging steels, special clean steels and steels for seamless pipe etc.
3. High CO partial pressure during the blow leads to very low N and H content in steel at turndown.

### *Basic Characteristics*

Standard capacities of EOF are available in capacities 30/40 t, 60/ 80 t and 100/ 120 t.

Hearth surface is 6.6 to 22 square meters

Shell diameter is around 5.3 to 7.5m

Total height from working platform to top level =17 to 25 m

No. of scrap-preheater staged 1to 2

Tilting tapping angle  $8^{\circ}$

### *Main equipments description*

1. Bottom car (2unit) is used for quick bottom exchange for a new campaign. One bottom car supports the EOF for operation and the other supports a second bottom for relining. Tilting is allowed at high speed hydraulic cylinders to allow slag free tapping.
2. Gas cleaning plant is wet system.
3. EOF has facilities for charging and weighing of bulk material and ferro-alloys.

### *Advantages*

1. Flexibility to in terms of metallic charge
2. No need of electric energy
3. High productivity
4. Low tramp elements
5. Low inclusions due to slag free toppings

### *Energy saving is due to*

- A. Post combustion (95%)
- B. Scrap preheating (850°C)
- C. High operational of flexibility.

### *Consumption of raw materials/ ton of liquid steel*

Hot metal and scrap+ pig iron are charged in 70% :30% proportion

Lime 45 kg/t (depending on P content of HM)

O<sub>2</sub> is consumed at 50-70 N cu.m./t

Fuel consumption is 5-10 M cal/t

Tapping- 1700°C without ladle furnace and 1650°C with ladle furnace.

## CONARC

In seventies there were discussions amongst scientists and technologies about the future of pure top blown and pure bottom blown steelmaking. These discussions resulted into a combined top and bottom blown steelmaking technology which has almost replaced pure top blown and pure bottom blown steel making.

In recent years discussions are in progress about EAF and oxygen steelmaking with respect to use of energy and raw material.

The objective is to develop a technology utilizing benefits of both EAF and top blown steelmaking. CONARC is the resultant of such discussions.

What is CONARC?

The CONARC steelmaking process has been developed by Mannesman Demag. It combines electrode arc melting with the oxygen steelmaking process. The process consists of two shells with one 3 phase electrode arm and one top blowing lance for hot metal treatment.

This allows a high flexibility with respect to use of raw materials as well as energy source. Worldwide there are around 12 units in operation.

- In India Ispat industries in Dolvi, Maharashtra has been integrated with Ispat's converter and arc furnace. This combination has given flexibility of alternative choices of energy resources to use for steelmaking-be it coal, electricity or gas. In addition, choice of alternative metallic charge material is also available i.e. be it iron ore, pellets, sponge iron, scrap or hot metal

This plant will be equipped with compact strip production technology to produce high grade finished steel like hot rolled coils.

Bhushan steel and strips limited have also installed CONARC.

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