Chapter 10

Electric Furnace Steelmaking

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Over the past 20 years the use of the electric arc furnace (EAF) for the production of steel has grown considerably. There have been many reasons for this but primarily they all relate back to product cost and advances in technology. The capital cost per ton of annual installed capacity generally runs in the range of $140–200/ton for an EAF based operation. For a similar blast furnace–BOF based operation the cost is approximately $1000 per annual ton of installed capacity. As a result EAF based operations have gradually moved into production areas that were traditionally made through the integrated route. The first of these areas was long products—reinforcing bar and merchant bar. This was followed by advances into heavy structural and plate products and most recently into the flat products area with the advancement of thin slab casting. At the current time, approximately 40% of the steel in North America is made via the EAF route. As the EAF producers attempt to further displace the integrated mills, several issues come into play such as residual levels in the steel (essentially elements contained in the steel that are not removed during melting or refining) and dissolved gases in the steel (nitrogen, hydrogen, oxygen).

Both of these have a great effect on the quality of the steel and must be controlled carefully if EAF steelmakers are to successfully enter into the production of higher quality steels.

There have been many advances in EAF technology that have allowed the EAF to compete more successfully with the integrated mills. Most of these have dealt with increases in productivity leading to lower cost steel production. These are described in the detailed process sections.

10.1 Furnace Design

The design of electric arc furnaces has changed considerably in the past decade. Emphasis has been placed on making furnaces larger, increasing power input rates to the furnace and increasing the speed of furnace movements in order to minimize power-off time in furnace operations.

10.1.1 EAF Mechanical Design

Many of the advances made in EAF productivity over the last 20 years are related to increased electrical power input and alternative forms of energy input (oxygen lancing, oxy-fuel burners) into the furnace. These increased energy input rates have only been made possible through improvements in the mechanical design of the EAF. In addition, improvements to components which allow for faster furnace movement have reduced the amount of time which the furnace stands idle. Thus the objective has been to maximize the furnace power-on time, resulting in maximum productivity.

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10.1.1.1 Furnace Structural Support

In the 1960s and 1970s it was common to install electric arc furnaces at grade level. These furnaces would have pits dug out at the front for tapping and at the back for pouring slag off into slag pots. This configuration lead to many interferences and delays and is no longer recommended for large scale commercial operations. Modern furnace shops usually employ a mezzanine furnace installation. Thus the furnace sits on an upper level above the shop floor. The furnace is supported on a platform which can take on several different configurations. In the half platform configuration, the electrode column support and roof lifting gantry is hinged to the tiltable platform during operation and tapping. When charging the furnace, the complete assembly is lifted and swiveled. This design allows for the shortest electrode arm configuration. In the full platform design, the electrode column support and roof lifting assembly is completely supported on the platform. These configurations are shown in Fig. 10.1.

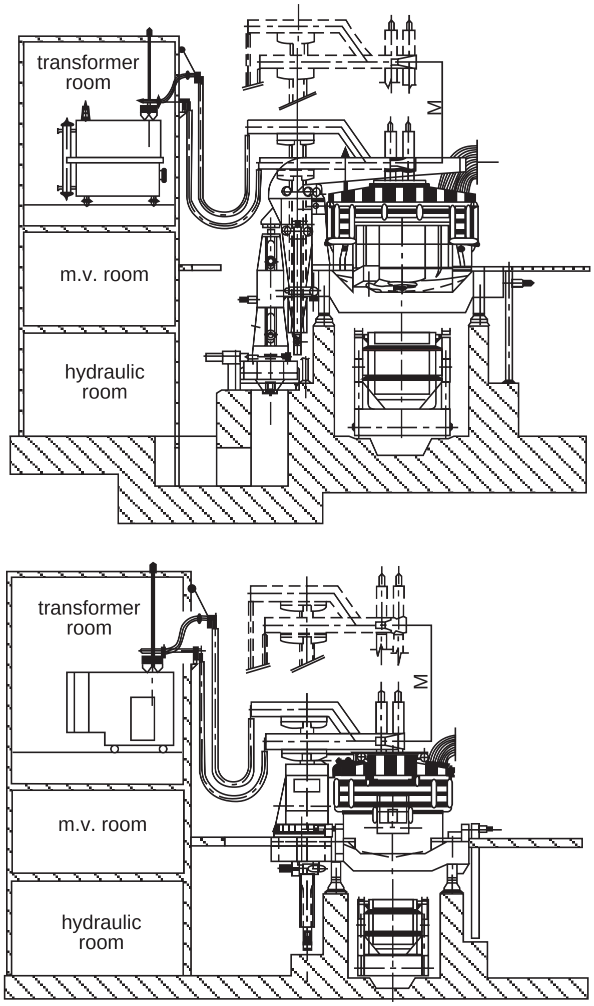

Fig. 10.1 Furnace platform configurations. *(Courtesy of Danieli.)*

10.1.1.2 General Furnace Features

The EAF is composed of several components as shown in Fig. 10.2. These components fall into the functional groups of furnace structures for containment of the scrap and molten steel, components which allow for movement of the furnace and its main structural pieces, components that support supply of electrical power to the EAF, and auxiliary process equipment which may reside on the furnace or around its periphery.

The EAF is cylindrical in shape. The furnace bottom consists of a spherically shaped bottom dish. The shell sitting on top of this is cylindrical and the furnace roof is a flattened sphere. Most modern furnaces are of the split shell variety. This means that the upper portion of the furnace shell can be quickly decoupled and removed from the bottom. This greatly minimizes down time due to changeout of the top shell. Once the top shell is removed, the furnace bottom can also be changed out fairly quickly. Some shops now follow a practice where the shell is changed out on a regular basis every few weeks during an eight hour downshift.

The furnace sidewall above the slag line usually consists of water-cooled panels. These panels are hung on a water-cooled cage which supports them. The furnace roof also consists of water-cooled panels. The center section of the roof which surrounds the electrode ports is called the roof delta and is a cast section of refractory which may be water cooled. The furnace bottom consists of a steel shell with several layers of refractory. This is discussed in more detail in Section 10.1.2. Fig. 10.3 shows a modern EBT EAF.

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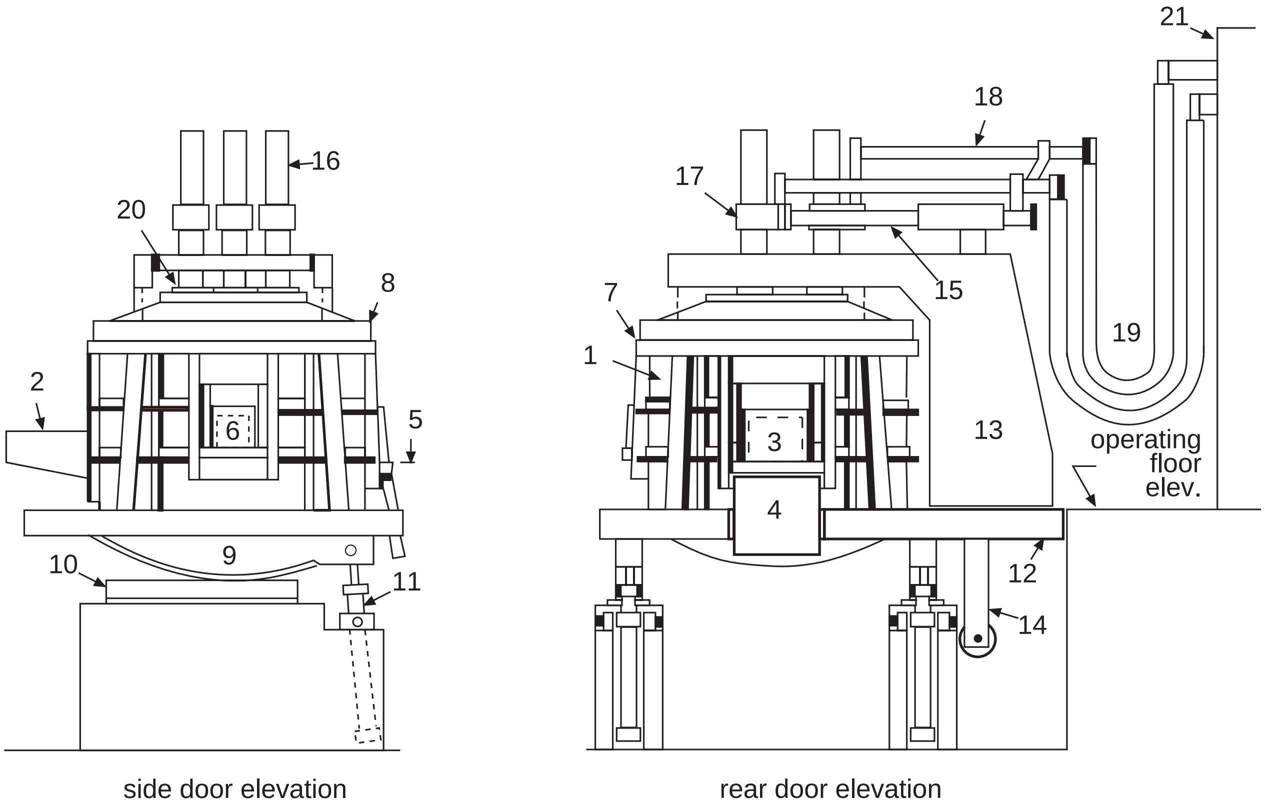

Fig. 10.2 EAF general features. *(Courtesy of Center for Materials Production.)*

1. shell
2. pouring spout
3. rear door
4. slag apron
5. sill line
6. side door
7. bezel ring
8. roof ring
9. rocker
10. rocker rail
11. tilt cylinder
12. main (tilting) platform
13. roof removal jib structure
14. electrode mast stem
15. electrode mast arm
16. electrode
17. electrode holder
18. bus tube
19. secondary power cables
20. electrode gland
21. electrical equipment vault

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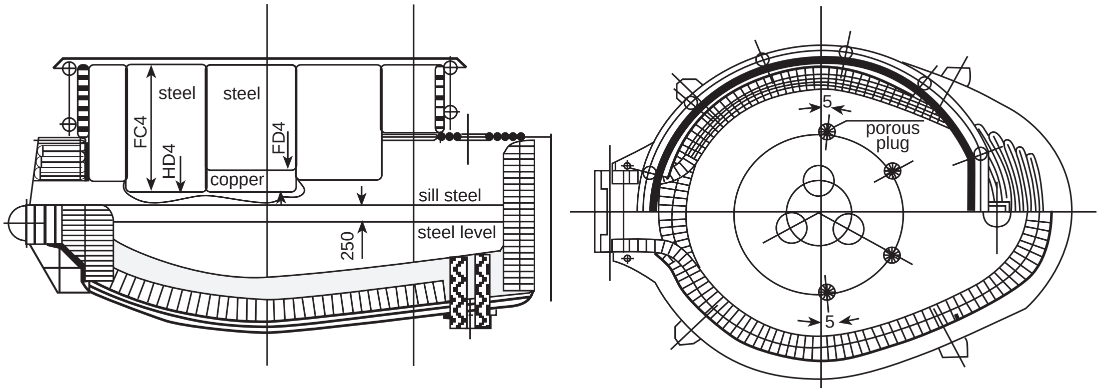

Fig. 10.3 Plan and section views of a modern EBT EAF. *(Courtesy of Danieli.)*

10.1.1.3 Water-Cooled Side Panels

One of the most important innovations in EAF design was water cooling, Fig. 10.4. Although this was used to a limited extent in older furnace designs for cooling of the roof ring and door jambs, modern EAFs are largely made up of water-cooled panels which are supported on a water-cooled cage. This allows for individual replacement of panels with a minimum of downtime. By water cooling the cage structure, it can be ensured that thermal expansion of the cage does not occur. Thus warping of the cage due to thermal stresses is avoided as are the resulting large gaps between the panels. Water-cooled panels allow very large heat inputs to the furnace without damaging the furnace structure. In the older EAF designs, these high power input rates would have resulted in increased refractory erosion rates and damage to the furnace shell.

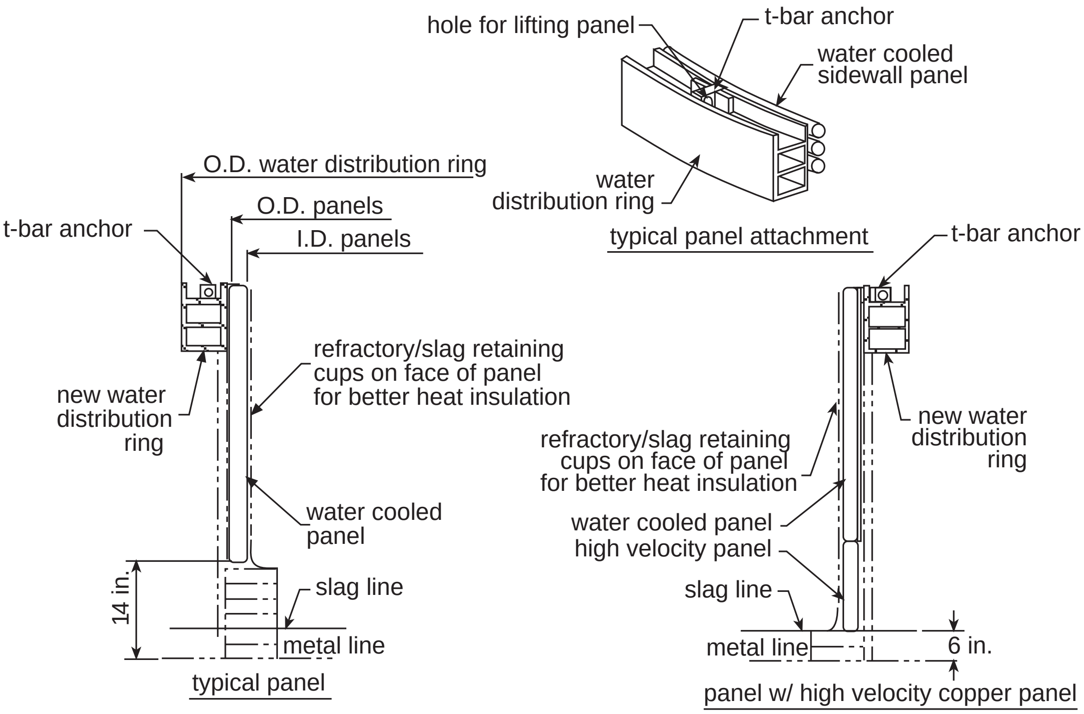

Fig. 10.4 Water-cooled panel designs. *(Courtesy of Fuchs.)*

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