Electric Arc Furnace—the Technology of the South East Asian Steelmakers

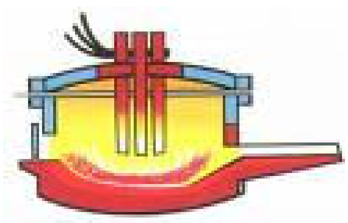
SEAISI

Rationale of Adoption

The Electric Arc Furnace (EAF) is a popular choice of steelmaking technology in South East Asia for some obvious reasons. It can be built in a small scale operation and may rely solely on scrap as the feeding material. Furthermore, low capital cost of an EAF enables many new plants to be quickly built in the region. Another advantage of EAF is that the technology can produce almost all grade of carbon steel. This scrap-based steel plant is also commonly referred as minimill.

Scrap can be substituted or more commonly blended with sponge iron (direct reduced iron—DRI), hot briquetted iron (HBI), or pig iron. In short, it is less costly to install and flexible to operate. An EAF steelmaking plant can be stop operating and restart quickly. There're is no surprise that all steelmakers in the region adopted the technology until today.

Only three companies in the region can be considered as integrated steel plant as they had merged direct reduction iron facilities with their steelmaking plant. Krakatau Steel of Indonesia became the first integrated plant in the region when it commissioned HYL I Direct Reduction plants in 1979 and later an HYL III plant (1.5 million tons capacity) was fully operational in 1993. Similar path was taken by Perwaja Steel (now a part of Kinsteel) and Megasteel of Malaysia. Perwaja operates two HYL III reactors with annual capacity of 1.4 million tons and Megasteel utilises a larger Midrex plant with a capacity of 1.7 million tons per annum.



Technology is indeed the base of a steel company's competitive advantage. It sets the choice of raw materials, product range, and also quality. Furthermore, technology also shapes the company structure. EAF technology offers a flexible and lean operation to small steelmaking companies in the region. Nevertheless, management must pay attention to some key operation areas to achieve excellent performance.

In the end, the steelmakers in the region aims to mainly produce the commercial quality steel with a cost advantage. The low investment cost EAF technology chosen by virtually all steelmakers in the region provides important support to their competitive advantage. However, steel business cycle may not always generate the expected profitability. There are times when scrap and electricity are relatively expensive hence the costs of EAF-based steel may not always be competitive.

Structure

The key parts of the EAF are the shell, the hearth, the roof, and the electrode. In addition, there is an electrode regulator which will determine the efficiency by affecting electricity consumption, graphite, and refractories. Modern EAF employs advanced computerised system for process monitoring and process control.

The shell and hearth are shielded by refractory lining to be able to contain the molten steel.

The most important key cost factor in EAF operation is obviously metal charge (scrap/DRI/HBI/pig iron), and followed by electricity, electrodes, ferroalloys, refractories, oxygen, fluxes, and labour. Therefore, high price of scrap and electricity would cost the industry enormously. For that reason, Krakatau Steel of Indonesia owned a direct reduction plant and also a 400 megawatts powerplant to be self sufficient in electricity.

Hydraulic systems are the primary mover for EAF equipments, such as roof, electrodes, furnace tilting, slag door, lances, and other auxiliaries.

In addition, the furnace and its equipments must rely on efficient water cooling systems. The cooling system will ensure maximum protection against overheating condition.

Molten steel will be poured into a ladle for casting or further refining.

Auxiliary systems may include oxygen lance system, carbon injection system, and oxy-fuel burner system.

The furnace's electrodes are made of graphite. This crystalline graphite is strong and has a very low electricity resistance. These electrodes can be raised or lowered by a hydraulic positioning system to optimize current and power input during melting process.

Process

The process uses scrap or scrap substitute as its primary raw material. The operation is much more simple than a blast furnace. Investment in iron-making facilities is only optional as an EAF can rely fully on steel scrap. The raw material quality would affect the quality of the steel to be made. Therefore, to make a high grade steel, a good quality scrap is necessary. Eventually direct reduced iron (DRI), hot briquetted iron (HBI), or pig iron will make better steel.

The scrap is charged into the furnace with the roof removed off it. The subsequent step is melting process when the electrodes are lowered down and the arc melts the metal charge. The EAF can be categorized into two types based on the types of electric current, alternating current (AC) EAF and direct current (DC) EAF. In an AC-EAF, the electric current passes from one electrode through an arc to metal charge, and then goes up to another electrode. In the DC-EAF, typically a single electrode is in the roof and the other electrode is in the bottom of the furnace. An AC-EAF typically has three electrode. Oxygen is also injected into the scrap to provide chemical energy and speed up the melting process.
An important additional charge is slag former, such as calcium oxide or magnesium oxide. Slag is a floating layer of metal oxides which also protect the molten steel from heat loss. Furthermore, slag formation is important to protect the molten steel from re-oxidation and improve electrical efficiency.

Once the metal charge is totally melted, the composition is checked according to the aimed steel specification. The molten steel is discharged into a ladle. Ladle is another equipment where several essential steps in steelmaking take place. Some alloying elements can be added to the liquid steel and also deoxidizers such as aluminum and silicon. It is called ladle furnace if the ladle is equipped with electrodes to maintain temperature of molten steel.

To produce higher grade steel, many plants have secondary metallurgy facilities, such as ladle furnace and vacuum degassing so impurities can be separated from liquid steel, and also further refining and heating to desired casting temperature.

Finally liquid steel can be transported to the continuous casting machine to be casted as billets or slabs.

Further Development

Continuous charging

A system were metallic charge can be continuously charged into the EAF using conveyor.

Oxygen and carbon injection

Modern EAF utilizes more chemical energy from high capacity oxygen and carbon injections. The injections would reduce the electricity consumption by providing heat resulted from exothermic reactions.

Vacuum degassing

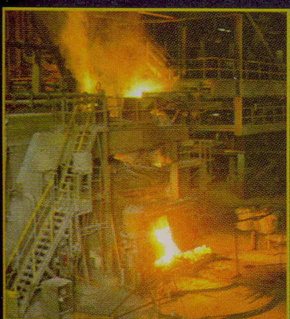
A ladle full of molten steel can be placed inside a vacuum degassing chamber to remove gasses such as hydrogen and also non-metallic inclusions.

Shaft furnace

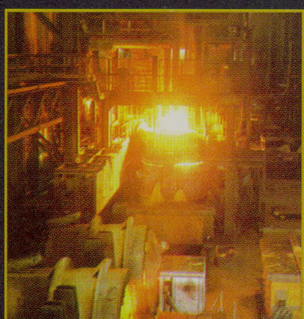
A shaft furnace utilizes heat from EAF offgas to preheat scrap feed. Preheated scrap would need less energy to be melted. Eventually tap-to-tap time will be reduced as well.

Automation

Latest generation of EAF steelmaking plants would include an advanced automatic process control systems. The computers monitor and advise the necessary actions to achieve the final condition of the steel. The automation can also include slag detection and tapping mechanism.



Electric Arc Furnace



Ladle Furnace

RH Vacuum Degassing

Continuous Casting Machine

Images: Courtesy PT Krakatau Steel