CHAPTER 7

Steel Making

Present steel production methods fall into two categories:

(i) The blast furnace (BF) and basic oxygen furnace (BOF/LD) route of steel making followed in Integrated Steel Plants (ISP). These plants are large in capacity ranging from 1 to 5 million tonnes per year and covering a fairly large area of 4 to 8 sq.km.

(ii) Scrap/DRI or sponge iron and electric arc furnace (EAF) and induction furnace (IF) route of steel making as adopted in Mini Steel Plants (MSP). These are small in capacity ranging from 0.5 to 1 million tonne and in some cases up to 2 million tonnes per year, covering an area up to 2 sq. km.

7.1 TOP-BLOWN BASIC OXYGEN (CONVERTER) PROCESSES

The growth of the top-blown basic oxygen converter steel making process, originally known as the LD process, has revolutionised steel making technology in the world. LD stands for Linz and Donawitz, towns in Austria where the process was developed. The process is also known as BOF (Basic Oxygen Furnace). The BOF process was introduced in India in the Rourkela Steel Plant in late 50s. Later, almost all the major integrated steel plants in India adopted this steel making technology.

The process steps involved in BOF steel making are illustrated in Fig-65

A basic oxygen converter is a pear-like vessel with a concentrically positioned oxygen lance. The steel shell is suitably lined with basic refractories. Hot metal, scrap, fluxes and ferroalloys are charged into the converter through the throat. Oxygen (99.9% pure) is blown through a water-cooled lance fitted with a copper nozzle. The position of the lance

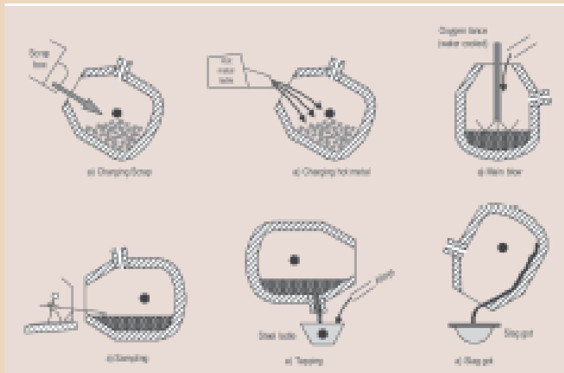


Fig-65: Process Steps Involved in BOF Steel Making

with respect to the bath and the flow-rate of oxygen are automatically controlled. The impingement of the oxygen jets at supersonic speed on the molten iron bath, results in metal droplets being ejected from the bath by impact, thereby increasing the metal surface area and the rate of oxidation of the impurities like silicon, phosphorus, manganese and carbon which are all exothermic reactions. Right at the beginning of each heat, scrap is charged into the converter along with hot metal to act as coolant for the heat generated by the oxidation reactions. The process is very quick and the steel of required carbon content could be made in less than 60 minutes. The capacity of modern BOF may range from 100 tonnes to 400 tonnes.

The charge for an oxygen converter melt is composed of hot metal, steel scrap, lime, fluorspar, etc. The proportion of blast furnace hot metal may range from 70–100%. The silicon content in the hot metal should be low, otherwise more lime will be necessary to neutralise the silicon and slag volume will become large. In some plants, blast furnace hot metal is first de-siliconised by oxygen lancing and then the low silicon hot metal is charged into the converter. Major part of the lime is added before starting the blow. Fluorspar is used to accelerate the dissolution of lime and ensure the required fluidity of the slag. Steel scrap is used to chill the bath. The pieces of steel scrap to be charged into the vessel should be suitably sized to ensure quick melting and also to avoid deflecting the oxygen jet. The proportion of steel scrap in the charge may be up to 30%. Optionally, iron ore and mill scale is also used in limited quantities to chill overheated bath. However, the gangue content of the iron ore should be low.

The blown metal needs to be deoxidised. Ferromanganese, ferrosilicon and aluminum are added in the order indicated into the ladle during tapping the steel.

7.2 ELECTRIC ARC FURNACE (EAF)

The direct arc electric furnaces are generally found in use for steel making. In this, there are three electrodes, almost always of graphite, overlying a bowl or cup-shaped hearth, which acts as the container or store for the molten metal & slag. Electric current is passed through these electrodes & arcs are struck between the electrodes & the charge, which must be conducting. Heating takes place by radiation & convection from the arcs & to a lesser degree, by the passage of electric current.

General Construction: The electric arc furnace is a three phase type with three carbon or graphite electrodes. The furnace consists essentially of a robust external steel shell circular in cross section, with a dished bottom and a removable roof ring which supports a slightly domed refractory roof. The roof has three holes, symmetrically placed about the centerline and which are at the apices of an equilateral triangle, through which the electrodes enter the furnace. At one side of the steel casting, there is a spout for pouring. Diametrically opposite to this spout there is an operating door for charging, to make additions, slagging and other operations. On large furnaces there is usually another door arranged at 90 degree from the tapping spout. Practically all steel making furnaces are tilting type, to pour their contents into a ladle. A typical electric arc furnace is presented in Fig-66.

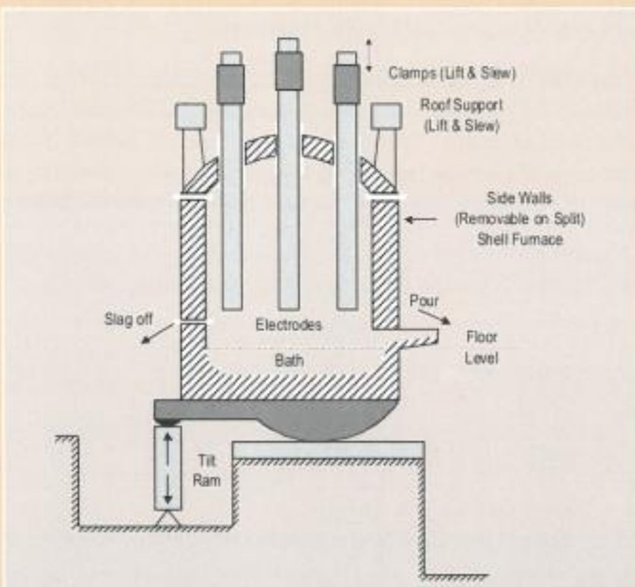


Fig-66: A Basic Electric Arc Furnace

Above the roof of furnace there are electrode arms which support electrodes and also carry the conductors leading the current to the electrodes. The electrode arms are connected to busbar which are connected to transformer.

Electrodes are raised and lowered by means of motors, or hydraulic rams, to control the amount of power delivered in the furnace. For a given transformer voltage, lengthening the arc increases the resistance, so, reducing the current flowing and the corresponding power input. Conversely, shortening the arc will increase the current and power input. Normally in all modern arc furnaces, the control of the power input is affected by means of automatic regulation.

The casing of the furnace is lined with refractory material, acid of basic, depending on the chemistry of the steelmaking process which is to be carried out.

The main advantage of EAFs lies in their ability to accept scrap, DRI, and molten hot metal in various proportions since whatever external energy is required, can always be provided by controlling the electrical power supplied. Furnace efficiency can be improved by the combined injection of carbon and oxygen through water-cooled supersonic lances at high rates. The aim is to complete cycle time for steel production in about 40 minutes thereby achieving around 40 heats per day (similar to BOF). The furnaces in the range of 30 to 200 tonnes are common.

EAFs can be of normal power of UHP (ultra high power) with one or two electrodes, single or twin-shell, as well as with and without a top shaft furnace (used for preheating the scrap before charging). However, a feature of all electric furnaces is that a considerable amount of noise is emitted; typical noise levels are between 125 and 139 dB(A). Moreover, their operation (particularly initial arcing) causes flickering in the grid.

Electrical Requirements: One of the most important consumable in electric steelmaking is the power. The power consumed in overcoming resistance is given by:

$$P = I^2R$$

The heat produced (H) in any circuit is given by:

$H = I^2RT$	Where,
1000	T = time during which the current flows Since one kilowatt hour (kWh) is equal to 860 k cal
	H=0.860 I2RT k cal.
	About 350 kWh of power is required to melt one tonne of steel.

Today, the production of plain carbon steels follows two major routes – the integrated BF (blast furnace) – BOF (basic oxygen furnace, which is the new name for the LD process) and the scrap/DRI (direct-reduced iron or sponge iron) – EAF /induction furnace (IF) route.

7.3 ELECTRIC INDUCTION FURNACES (IF)

Instead of electricity being used for arcing, it can also be used for melting a solid charge through induction as is done in induction furnaces. The electric induction furnace normally plays an important role in steel plants producing high-quality steels, particularly stainless steel from stainless steel scrap.

Like the rest of the world, the use of induction melting furnaces in India began when such furnaces were installed to produce stainless steel. But in 1981-82, some innovative entrepreneurs having small-sized induction furnaces to make stainless steel, tried to find out a success, more and smaller induction furnaces in India (500 kg to 1 tonne in size) began to be used to produce pencil ingots with power consumption of about 700 kWh/t. By 1985-86, the technology of making mild steel by the induction furnace route became widely prevalent and up to 3 tonnes per charge induction furnaces were installed.

The chemistry of the melt in induction furnaces is adjusted by adding mill scale to oxidise carbon in the bath after high-quality steel scrap is melted. The use of sponge iron (particularly fines between 1 and 3 mm in size) in such furnaces has also made it possible to make pencil ingots with no tramp elements. As much as 40% sponge iron is often used to make high-quality steels.

7.4 INDIAN SCENARIO

7.4.1. Present Status

The Indian Steel Industry comprises integrated steel plants in the primary sector using BF-BOF route of iron & steel production. In the primary sector, there are 13 integrated steel plants in the public and private sectors.

The secondary sector constitutes Electric Arc Furnace (EAF)/Induction Furnace (IF), pig iron/sponge iron units, etc. for producing either semi finished or finished steel. The structure of the Indian Steel Industry in 2008-09 is given in Table-14.

Indian Steel Industry was classified into Main Producers (SAIL plants, Tata Steel and Vizag Steel of RINL) and Secondary Producers, namely, Essar Steel, JSW Steel and Ispat Industries as well as large number of Mini Steel Plants that were based on Electric Furnaces & Energy Optimising Furnaces (EOF). Besides the steel producing units, there are a large number of Sponge Iron Plants and Mini Blast Furnace units which are spread across the country. The steel production in India during the period from 2005-06 to 2009-10 and capacity of Hot Metal and crude/liquid steel by Principal producer are presented in Fig-67 and Table-15 respectively.

Sector	Type of Units	No. of Units	Annual Capacity (million Tonnes)	Production (In million tonnes)	
				2007-08	2008-09
Primary	Integrated Plants (crude/liquid steel)	13	35.55	31.66	32.24
Secondary	Electric Arc Furnace (EAF)	38	17.99	10.80	14.15
	Induction Furnace (IF)	1074	22.18	16.93	18.05
	Pig Iron	>19	+4.83	5.31	6.21
	Sponge Iron	324	30.09	20.38	21.09

Source: Annual Report of Ministry of Steel, 2009-10.

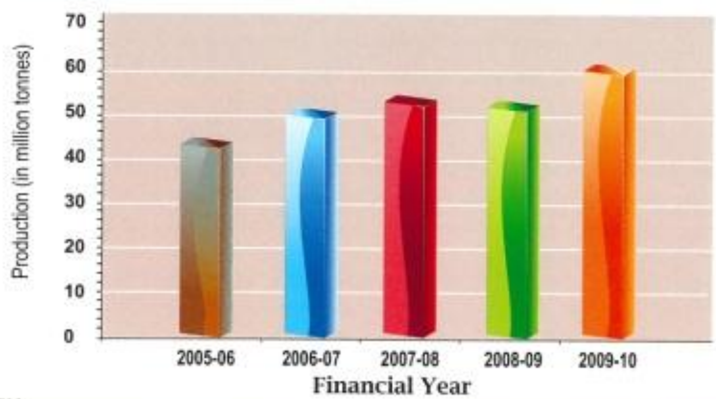
Table-14: Structure of the Indian Steel Industry

Units	Annual Installed Capacity (In '000 tonnes)	
	Hot Metal	Crude/Liquid Steel
PUBLIC SECTOR		
Bokaro Steel Plant (Jharkhand)	4585	4360
Bhilai Steel Plant (Chhattisgarh)	4700	3925
Rourkela Steel Plant (Orissa)	2120	1900
Durgapur Steel Plant (West Bengal)	2088	1802
IISCO Steel Plant, Burnpur (West Bengal)	550	500
Visvesvaraya Iron Steel Plant (Karnataka)	205	118
Salem Steel Plant (Tamil Nadu)	-	320*
Alloy Steel Plant, Durgapur (West Bengal)	-	264
Visakhapatnam Steel Plant (Andhra Pradesh)	3400	3000
IDCOL Kalinga Iron Works Ltd (Govt. of Orissa Undertaking)	170	-
PRIVATE SECTOR		
JSW Steel Ltd (Karnataka)	NA	6800
Tata Steel Ltd (Jharkhand)	NA	5000
Ispat Industries Ltd (Maharashtra)	NA	3000
Essar Steel Ltd (Gujarat)	NA	4600
Jindal Steel & Power Ltd (Chhattisgarh)	NA	2400
Lloyds Steel Industries Ltd (Maharashtra)	-	850**

* Saleable Steel; ** Finished Steel

Source: Annual Report of Ministry of Steel, 2008-09, 2009-10 and individual plants.

Table-15: Capacity of Hot Metal and Crude/Liquid Steel (Principal Producers)



Source: IBM

Fig-67: Steel Production During the Period 2005-06 to 2009-10

7.4.2. Proposed Action Plan for Augmenting Steel Production

National Steel Policy (2005) assumes that 60% of the new steel capacity would come up through blast furnace and BOF route, 33% through sponge iron & EAF/IF route and 7% through other routes.

A number of major new Integrated Steel Plants in public and private sectors are anticipated in the country besides a few are considering augmentation of capacity of their existing plants. Prominent of these projects are from South Korean company POSCO and World's largest steel maker, Arcelor-Mittal, who had entered into agreement with Orissa and Jharkhand Governments respectively for setting up a 12 MTPA plant each in the year 2005. These endeavours are still facing problems due to regulatory and other hurdles.

Considering the rising demand-supply gap, the Ministry of Steel (MoS) is actively considering setting up of ultra mega steel projects (UMSP) on fast-track basis. This ultra mega steel projects (UMSP) will be of 8-10 million tonnes capacity each and would come up in the iron ore rich states of Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh and Karnataka. The Steel Ministry also envisages a production capacity of about 120 million tonnes per annum by the financial year 2012 to meet demand-supply deficit in the Sector.

Rashtriya Ispat Nigam Limited (RINL) formerly Visakhapatnam Steel Plant also has plans to augment its steel production from the existing 3 million tonnes to 8.3 million tonnes in this decade. RINL is also looking at setting up a 3 MTPA steel plant jointly with Kudremukh Iron Ore Company Limited (KIOCL) in Bellary-Hospet region. KIOCL has some fine dumps of iron ore which it has not used and RINL is planning to utilise it. KIOCL also owns a pellet plant at Mangalore, which the Vizag Steels is keen on running. RINL is not looking at any mining activity in the Kudremukh area and would seek mining rights at a place to be granted by the state in the event of the project taking off. They have signed an agreement and formed a joint operation wing. KIOCL has got its own pellet plant in Mangalore and RINL want to set up a ductile iron spun pipe plant there. RINL plans to expand the production capacity to 20 million tonnes per annum steel by 2020 and have in place the required infrastructure and availability of iron ore from different sources, including supply from National Mineral Development Corporation (NMDC).

Steel Authority of India Ltd (SAIL), the country's largest producer of steel, plans to invest Rs 2,875 crore towards the first phase of modernisation of its integrated steel plant in Durgapur, West Bengal. This would boost the production capacity of finished steel to 1.36 million tonnes from the present 0.75 million tonnes.

SAIL also intends to enter into a joint venture agreement with Japan's Kobe Steel to set up a new mill at Durgapur using the Japanese ITMk3 technology, a more cost-efficient and environment-friendly technology in producing iron nuggets.

Development of the Chiria mines (Jharkhand), which recently got approval from the Union environment ministry, would also be vital in supporting the expansion drive that SAIL has planned to undertake for DSP. After depletion of SAIL's existing mines in the eastern region, the Chiria mines will be the sole source of iron ore for SAIL's four integrated steel plants at Bokaro, Burnpur, Durgapur and Rourkela.

Sponge iron or Direct-reduced Iron (DRI), is mostly used for steel making through conventional melting and treatment process in Electric Arc Furnace (EAF) or Induction Furnace (IF). It is used widely as substitute to steel scrap. Due to shortage of steel scrap in the country coupled with the extremely volatile international pricing of steel scrap, more and more DRI is now used for steel making in India.

The sponge iron in the country is produced through two routes, one is gas-based using iron ore pellets and other is coal-based using high-grade iron ore lumps. The coal-based DRI production dominates in Indian scenario and accounts for around 90% of the World's total coal-based production. There are approximately 350 of these furnaces operating within India and another 160 units are at different levels of implementation.

The GOI is in the process of framing a new Steel Policy to address the issues hurting the Sector's growth and devise measures that would provide the necessary impetus and that that will propel projects so that the desired national objectives could be met. The need for the new policy was felt in the light of the changing demand-supply scenario and concern over rising imports, besides delays in mega ventures for capacity addition to bridge the supply deficit.