Training Report

Vocational Training In

STEEL MELTING SHOP-II

Rourkela Steel Plant (RSP)

(from 10th May 2010 to 9th July 2010)

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ACKNOWLEDGMENT

I feel very proud to say that due to keen knowledge of the working members of Rourkela Steel Plant, it was very easy for me to earn a lot of knowledge regarding STEEL MELTING SHOP-II.

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NIT Rourkela

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1.

ROURKELA STEEL PLANT: AN OVERVIEW

1.1 Introduction

Rourkela Steel Plant (RSP) is the first of the three integrated steel plants set up by Government of India in 1959. The first Steel Industry set up under Hindustan Steel limited on 19th January 1954 which paved way for laying up of infrastructure for rapid industrialization of the country. The plant was set up in collaboration with leading steel makers of Federal Republic of Germany.

In the initial phase, 1.0 MT units were commissioned between December’ 1958 and early part of 1962. Hot Metal production in RSP started with lighting up of first Blast Furnace ‘Parvati’ on 3rd February’ 1959 by his Excellency President of India, Dr Rajendra Prasad.

To meet the additional demand of flat products in the country, the capacity of the plant was expanded from 1.0 MT to 1.8 MT between the year 1965 and 1969. Besides, expansion of the capacity of the existing units, new units like Electric Sheet Mill (for Dynamo and Transformer Grade Steel) and Galvanising lines (for corrugated and plain galvanized sheets) were added.

Subsequently, a number of units were added to enhance the product quality, production, productivity and to fulfill market needs. These units included Blast Furnaces, Spiral Welded Pipe Plant, Silicon Steel Mill, Captive Power Plant-II, Mechanical Shop, Structural & Fabrication Shop, Heavy Loco Repair Shop, Slag Granulation Plant and Coke Ovens Battery No. 5.

In the year 1988, a new era was started with modernisation in RSP. This was necessary in order to overcome technological obsolescence and to continue to remain competitive in the market place. The modernization of the Plant was completed in two phases from 1994 to 1999. With this, the production capacity of the Steel Plant increased to 2 million tons of Hot Metal and 1.9 Million tons of Crude Steel. Phase-I was completed in the year 1994 which emphasised on improving the quality of raw materials consisting of a new Oxygen Plant, upgradation schemes for Blast Furnaces, Dolomite Brick Plant, Cast House Slag Granulation Plant at Blast Furnace # 4, Raw Material Handling System, Coal Handling Plant in Coke Ovens and Power Generation and Distribution System. Phase-II consisted of a new Sinter Plant, Basic Oxygen Furnace and Slab Casting shop in Steel Melting Shop-II, except for Hot Strip Mill. Except Hot Strip Mill, which was completed in the year 1999, all other units were completed in the year 1997.

Rourkela Steel Plant has carved a name for itself as a unique producer of special purpose steels in the flat steel segment. Plates, Hot Rolled Coils, Cold Rolled Sheets and Coils, ERW Pipes, Spiral Weld Pipes and Silicon Steel Sheets and Coils are the products in RSP’s repertoire. RSP has many firsts to its credit. **It was the first plant in India to incorporate LD technology of steel making**. It is also the first steel plant in SAIL and the only one presently, where 100% of the slabs rolled are produced through the cost effective and quality centred **continuous casting route.**

RSP is the only plant in SAIL to produce silicon steels for the power sector, high quality pipes for the oil and gas sector and tin plates for the packaging industry. Another uniqueness of RSP is that it does not produce semis. The use of its Plates in ship building & high pressure vessels, Silicon Steel in the electrical machine manufacturing industries, corrugated galvanized sheets for roofing including industrial roofing, pipes in the oil & gas sectors, tin plates in packaging industry and Special Plates in the defence of the nation is well known.

1.2 Special features of Rourkela Steel Plant

a) It is the first Plant in Asia to adopt LD process of steel making.

b) It is the only Plant producing large diameter ERW/SW Pipes conforming to most rigid standards of API.

c) It is the first steel Plant in India to adopt external desulphurisation of hot metal by calcium carbide injection process.

d) It is the only Plant in SAIL producing Cold Rolled Non Oriented (CRNO) Steel sheets for use in the electrical industries with installed capacity of 73,000 Ton/year.

e) Rourkela is the first in vacuum degassing metallurgy. This system has been adopted primarily for production of silicon steel for the cold rolled non-oriented sheets. The system consists of vacuum arc refining and vacuum oxygen refining units and a degassing facility.

f) It is the first integrated Steel Plant of SAIL which adopted the cost effective and quality centred continuous casting route to process 100% of steel produced.

g) All the major production departments and some service departments certified to ISO 9001:2008 QMS.

h) Silicon Steel Mill, Environmental Engineering Department and Sinter Plant–II, HSM, PM, SPP, ERWPP, SWPP & Township certified to ISO 14001:2004 EMS.

1.3 Raw Materials

The fully mechanized captive mines under Raw Material Division (RMD), a unit of SAIL meet the bulk requirements of Iron ore, Limestone, Dolomite, Manganese, Quartzite and coal as raw materials of RSP.

a) Iron Ore: Captive Mines at Barsua, Kalta, Meghathatuburu, Kiriburu

b) Limestone: BF Grade - Purnapani and Kuteshwar
SMS Grade - Jaisalmer and Katni

c) Dolomite: BF Grade - Biramitrapur and Sonakhan
SMS Grade - Bilha, Baraduar and Katni

d) Manganese: Purchased from Barajamda and Koira

e) Ferro Manganese and Silico Manganese: Maharashtra Electrosmelt Limited (MEL)

f) Quartzite: Purchased from Local areas

g) Coal: Prime Coking Coal (PCC) and Medium Coking Coal (MCC) from Indian Sources

Imported Coking Coal (ICC) – Hard and Soft from Australia, Canada, USA and China

1.4 Major Units of RSP

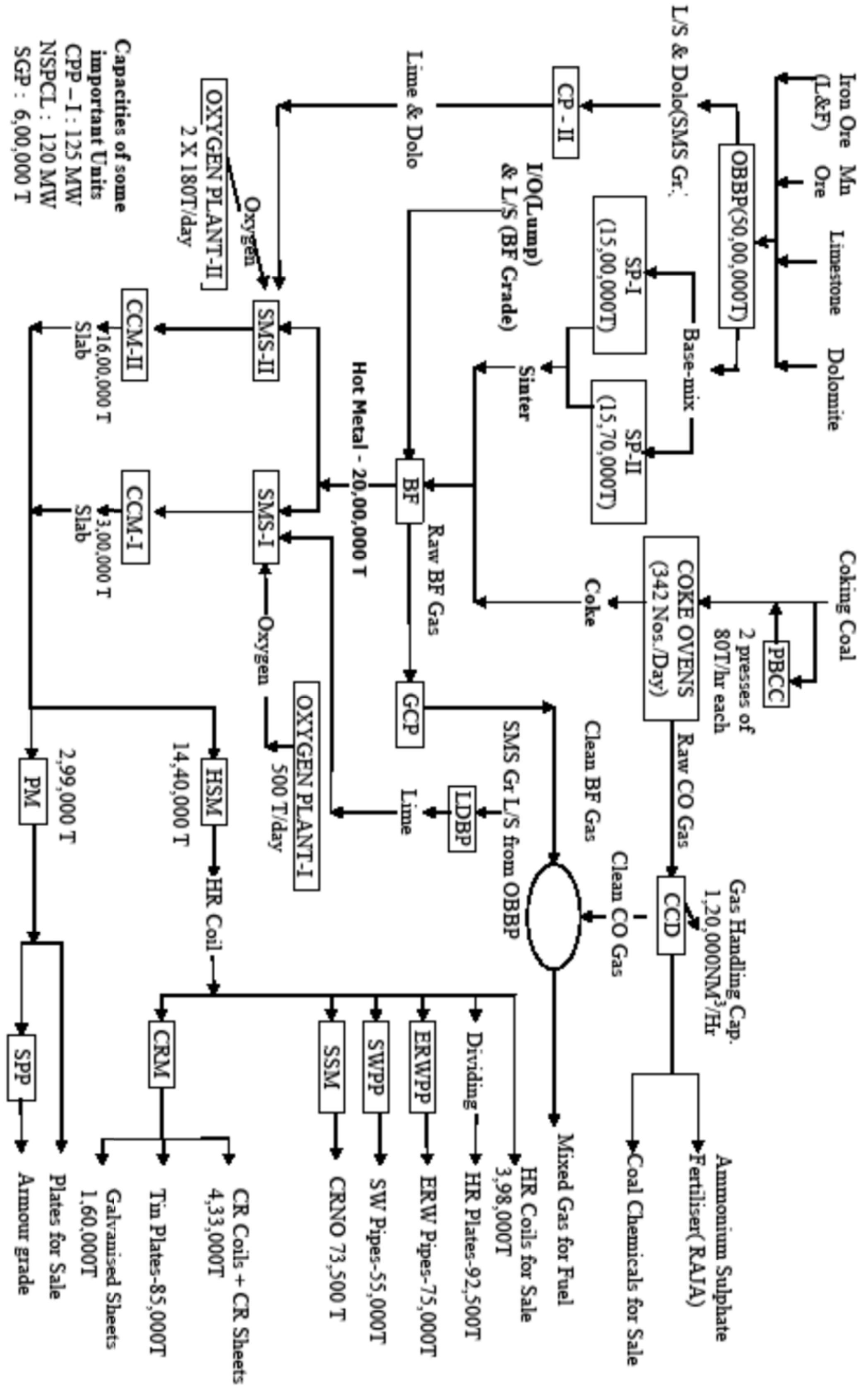
Coke Oven	3 Batteries of 70 ovens each and 2 Batteries of 80 ovens each
Blast Furnaces	3 BFs of 1139 M^3 useful volume and 1 BF of 1658 M^3 useful volume
Steel Melting Shop I	2 mixers of 1100 Ton each, 2 LDs of 60/66 Tons/blow and 1 single strand slab caster of 0.305 MT of slabs per year
Steel Melting Shop II	2 mixers of 1300 Ton each, 2 LDs of 150 Tons each and 2 single strand slab casters of 1.355 MT of slabs per year
Sinter Plant I	2 Sinter machines of 1.5 MT per year
Sinter Plant II	1 Sinter machine of 1.57 MT per year
Hot Strip Mill	• 2 Pusher furnaces of 100 Ton per hour each • 2 Walking beam furnaces of 225 Ton/hr each • 3 Stand Roughing Mill and 4 hi 6 stand Finishing Mill with a capacity of 1.67 MT HR coils per year.
Plate Mill	• 1 walking beam furnace of 100 Ton/hr • 3.1 meter wide and 4 hi Reversing Mill of 3,40,000 Tons of plates per year.
Pipe Plants	• ERW Pipe Plant of 75,000 Tons per year with high frequency welding (400 KHz) • SW Pipe Plant of 50,000 Tons per year with double sub-merged arc welding.
Cold Rolling Mill	• 2 Pickling lines • 1 Cold Reversing Mill • 1 Five Stand Tandem Mill • Hood Annealing, Continuous Annealing • 2 Skin Pass Mills • Sheet Shearing Line • Continuous Galvanising Line of 1,60,000 Tons

	per year • Continuous Electrolytic Tinning Line of 1,50,000 Tons per year
Silicon Steel Mill	• 4 Hi Reversing Mill of 73,000 Tons per year of CRNO
Captive Power Plant-I	• 5 units to produce 125 MW of power

1.5 Major Products of RSP

Products	Key Segments
Plate	Structural , Construction fabrication, Boiler Industry, Ship building , Automobiles, Railways, Pipe Making, etc.
HR Coils	Tube/Pipe Making, cold reducing, Cold Forming , LPG, Cycle Industry, Railways, Automobiles, Industrial Flooring etc.
CR Sheet/Coil	Furniture, House Hold Appliances, Fabrications, Cold Forming, Railways, Cycle Industries, Agricultural Equipment, Packaging, coating etc.
Galvanized Plain/ Corrugated Sheets	Furniture, House Hold Appliances, Cooler Body, AC Duct, Roofing, Storage Bins, Fabrications, Constructions etc.
CRNO	Electric Motors, Relays, Transformers, Rotating Electrical Machines, Laminations etc.
Tin Plates	Oil can, Non-oil cans etc.
ERW plates	Oil/Water slurry transportations, Ash Handling , Constructions etc.

1.6 Material Flow Diagram



2.

STEEL MAKING PROCESS

2.1 Introduction

Steel making is a refining or an oxidation process with the exception of reducing conditions being specifically required to eliminate sulphur. It involves selective oxidation of impurities like C, Si, Mn, P etc. from pig iron in preference to Fe. The chemistry of steel making process can be simply described as:

$$[Fe] + [O] = (FeO)$$

$$[C] + [O] = \{CO\}$$

$$[Si] + [O] = (SiO)$$

$$[Mn] + [O] = (MnO)$$

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

$$[S] + (CaO) = (CaS) + [O]$$

Except the sulphur reaction all the rest are oxidation processes and are favoured under the oxidizing conditions of steel making. Generally the S reaction is dealt separately by means of ***external desulphurization***.

2.2 Secondary Steel Making

For most applications, the surface quality, internal quality, microcleanliness and mechanical properties of steel produced by conventional route are entirely satisfactory.

However quality requirements of special steels in terms of cleanliness, grain size control, narrow hardenability range etc. have become quite stringent in recent times. These requirements and compulsions led to the development of a series of new individual requirements. There are two processes adopted in SSM. These are:

Vacuum Arc Refining (VAR)

Vacuum Oxygen Refining (VOR)

Secondary steel making can be defined as the process of making steel suitable for special applications b final refining and compositional adjustments. In RSP these two processes are adopted which is mainly based on the vacuum. The basic principle behind this vacuum treatment is that "the amount of dissolved gases in steel increases with increase in the partial pressure of gases. The other advantages are the temperature requirement for the vacuum treatment decreases according to Sievert's law.

% Gas dissolved = K×√ (partial pressure of gas at ambient atmosphere)

Benefits of secondary steel refining process:

- Improvement in the productivity of primary steel making furnaces such as BOF, EAF etc.
- Better deoxidation practice.
- Decarburizing to attain very low levels of carbon.
- Degassing to attain very low level of hydrogen and nitrogen.
- Desulphurization to attain very low level of sulphur.
- Inclusion shape control.
- Better alloying practice:
    - Improved alloy recovery.
    - Achieve chemistry in very close range.
- Dephosphorisation.
- Homogeneity with respect to :
    - Temperature.
    - Chemical analysis.

VAR/VOR process sequence:

1. LD converter steel (1650°C)
2. Teeming ladle (66T &1600°C)
3. Transfer by EOT crane
4. Lowering into VOR/VAR tank.
5. Connection of tank and ladle argon hoses.
6. Argon purging for a minute
7. Initial temperature measurement.
8. Placement of tank cover over the tank
9. Start argon purging at required/specified rate
10. Start steam ejector and attain required vacuum level

11. Start arching/ oxygen blowing
12. Continue degassing
13. Addition of
    - Al
    - Fluxes (LIME, ETC.)
    - Ferro alloys
14. Increase argon flow for thorough mixing
15. Discontinue evacuation
16. Measure temperature
17. Take sample for analysis

Degassing process

Following chemical reactions occur during degassing and processing:

$[FeO] + [C] = [Fe] + \{CO\}$, $2\{CO\}+\{O_2\} = 2\{CO_2\}$

$[MnO] + [Fe] = [FeO] + [Mn]$

$3\,[CaO.P_2O_5] + 5\,Fe = 2[P] + 5\,[FeO] + 3[CaO]$

$[S] + [CaO] + 2/3\,[Al] = CaS + 1/3\,[Al_2O_3]$

$3\,[FeO] + 2\,[Al] = Al_2O_3 + 3\,[Fe]$

$2\,[FeO] + [Si] = SiO_2 + 2\,[Fe]$

SLAG:

CaO	Al_2O_3	SiO_2
(50-55%)	(30-40%)	(5-10%)

Continuous Casting Machine: The Process

Continuous casting is the process whereby molten metal is solidified into a "semi-finished" billet, bloom, slabs or beam blank. Prior to the introduction of continuous casting in the 1950s, steel was poured into stationary moulds to form "ingots". Since then, "continuous casting" has evolved to achieve improved yield, quality, productivity and cost efficiency. Nowadays, continuous casting is the predominant way by which steel is produced in the world. Continuous casting is used to solidify most of the 750 million tons of steel, 20 million tons of aluminium, and many tons of other alloys produced in the world every year.

In the continuous casting process, molten metal is poured from the ladle into the tundish and then through a submerged entry nozzle into a copper mould cavity. The mould is water-cooled so that enough heat is extracted to solidify a shell of sufficient thickness. The shell is withdrawn from the bottom of the mould at a "casting speed" that matches the inflow of metal, so that the process ideally operates at steady state. Below the mould, water is sprayed to further extract heat from the strand surface, and the strand eventually becomes fully solid when it reaches the ''metallurgical length''.

3.
STEEL MELTING SHOP –II

3.1 Introduction

Steel Melting Shop (SMS) - II consists of a Basic Oxygen Furnace (BOF) Shop Complex and a Continuous Slab Casting Shop (CCM-II) Complex. This Steel Melting Shop was added as a part of RSP's modernisation package in late nineties. Hot metal, Oxygen and Fluxes, the main input materials for steel making are provided by Blast Furnaces (BFs), Tonnage Oxygen Plants (TOP-I & II), Calcining Plant (CP-II) and Lime Dolomite Brick Plant (LDBP) respectively.

3.2 BOF Shop Complex

BOF Shop Complex can be essentially divided into 3 sections:

a) Mixer & Desulphurisation (DS) Unit

b) Converters

c) Slag Yard and Scrap Yard

3.2.1 Mixer and DS Unit

Two **Hot Metal Mixers** are being used for storing Hot Metal (HM) that is received from all the four Blast Furnaces and to essentially homogenise the HM w.r.t. temperature and composition and to provide uninterrupted supply of HM as and when required for the converters. These are inactive mixers which effect no change in the chemical composition of hot metal. Burners are used for required heating with mixed gas (Coke oven gas+ Blast Furnace gas+ BOF gas) as the fuel. The amount of hot metal generally does not exceed 1000 T and a minimum buffer stock of 300 T is always maintained. The details of the mixers are:

Capacity: 1300 T

Operating angle: 30°

Full emptying angle: 45°

Average hot metal temperature in mixer: 1250 to 1350° C.

Two Desulphurisation (DS) Units are provided for removing excess sulphur from the HM to the acceptable norms before the HM is charged into the converter. This is being carried out by injecting CaC_2 / MgAl based compound as DS agent through top lance.

Details are as follows:

Heat weight: 150 to 165 Tonnes

Working volume: 165 m^3

Metal depth: 1165 mm

Two nos. of slag raking machines are provided to remove the slag from the HM ladles before it is charged in the converter.

Working member boom with a scrapper

Boom travel: 5000 mm

Turning angle: 20° (right or left)

Boom inclination angle: 10° upward or downward

3.2.2 Converter Shop

The shop is located at 9.5 m from ground level. Two numbers of

converters (150 T capacities each) of top oxygen blown type were installed in this shop. These converters receive HM and scrap with the help of cranes and other input materials like Ferro Alloys, Flux by mechanised (hopper with weighing facility) as well as manual process. The converters are concentric vessels manufactured from steel plates and lined with basic refractories to sustain desired temperature and corrosion during the refining process. Each converter is connected with GCP (Gas Cleaning Plant) designed to meet all the process requirements. A common gas recovery system and gas holder is designed as totally enclosed pressurized hot water system. A treatment plant for contaminated water of GCP is also provided. There are four number

of 250 T cranes for handling hot metal. Six nozzle lance with 15 degrees nozzle angle is used in each converter. The shell height to diameter ratio is 1.1. The charge consists of 150-160 T of hot metal and 15-20 T of scrap and Ferro alloys, constituting around 180 T of total charge. Preheated ladles are used for tapping of steel. Fe-Si and Si-Mn in the chip form and Al in the form of bars of 20 kg are added to tapping ladles. Al is added to remove the bubbling effect which lowers the steel temperature. The work lining is made up of magnesium-carbon and the permanent lining is made of magnesia bricks. Slag and steel lollypop samples are taken during every heat and the sample analysis is complete in 4 minutes. Oxygen supplied by Tonnage Oxygen Plants is blown into it from the top through a water-cooled lance.

Hot metal composition:

C	3.4-4.5%
Mn	0.20-0.30%
P	0.15-0.20%
S	0.03-0.06%
Si	0.5-1.2%

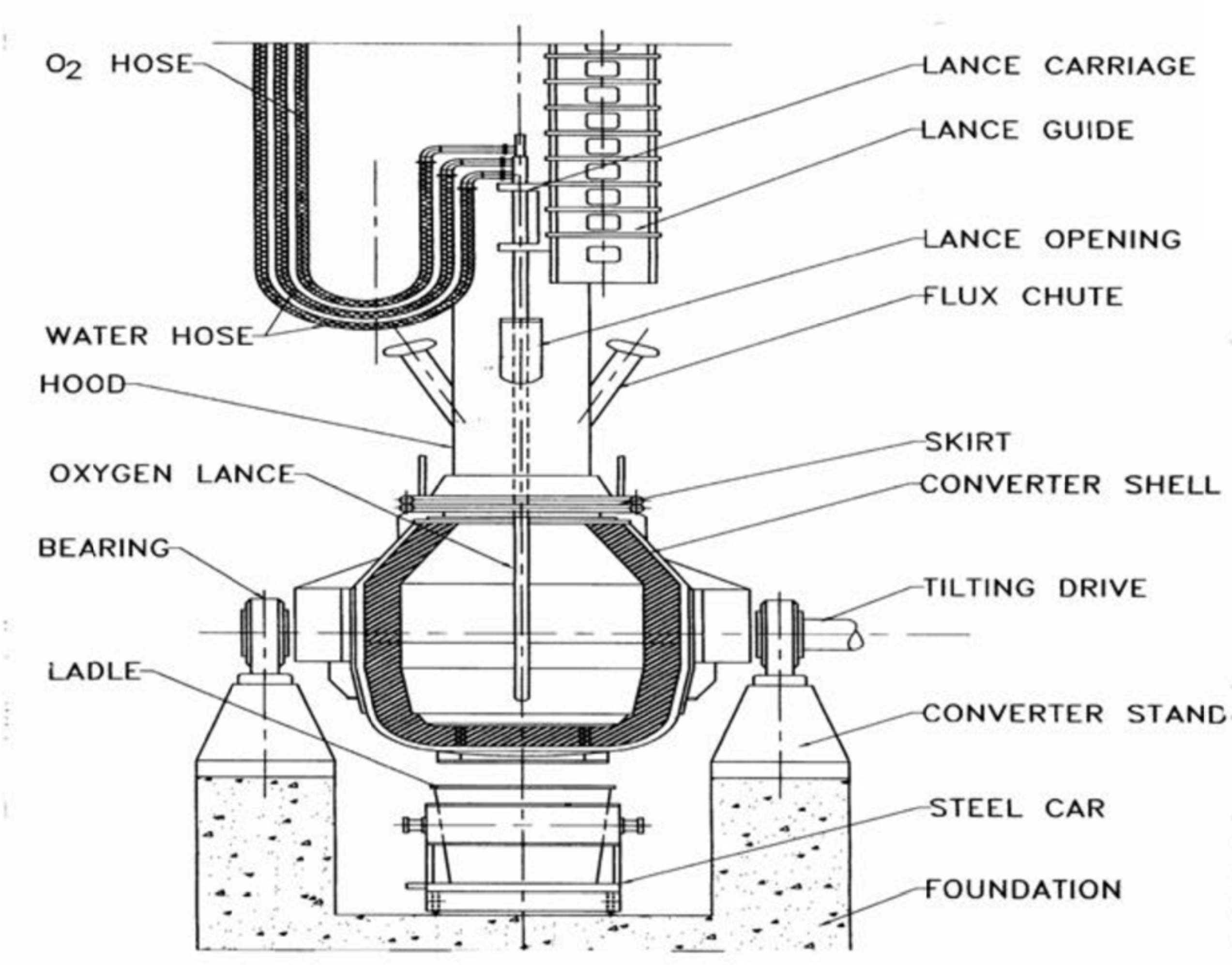
Liquid steel composition:

C	0.04-0.20%
Mn	0.14-1.24%
P	0.02-0.03%
S	0.02-0.03%
Si	0.05-0.25%
Al	0.04-0.07%

Various parameters of the shop are:

Nominal heat size of liquid steel	150 T
Maximum heat size of liquid steel	165 T
Tap to tap time (average)	45 min
Nominal volume of converter with lining	165 m^3
Maximum lining life achieved till date	4087 hits
Normal flow rate at converter mouth	96,000Nm^3/hr
Maximum gas flow rate at cooling stack inlet	25,000 Nm^3/hr
The height of the cylindrical shell	9.5 m
Angle of deslagging	90-95°
Angle of tapping	70-100°
Angle of dumping	120-135°

150 Ton LD Converter



3.2.3 Slag Yard & Scrap Yard

The slag produced by the above process is handled by Slag Yard using a remote controlled overhead crane for safety purpose.

The scrap yard stores and provides the combination of light, medium & heavy scrap as per the requirement of the shop. The crane used has magnets to do the loading and unloading.

3.3 CCM-II Shop Complex

CCM-II Shop Complex houses

a) Ladle Preparation Bay
b) Tundish Preparation Bay
c) Ladle Heating Furnace (LHF)
d) Argon Rinsing System (ARS)
e) Casters
f) Slab Yard

3.3.1 Ladle Preparation Bay

Ladle bay is utilized for preparation of ladles for tapping and making new ladles. This bay consists of 5 burners used for preheating the ladles. There is one online burner for each converter, which is used to preheat the ladle before tapping after placing it on a self-propelled steel transfer car. There is an inter bay car for transferring dumped ladle from LHF bay to ladle bay. There are two parts at the bottom of the ladle- one for slide gate operation and other for providing porous plug for argon purging in LHF.

3.3.2 Tundish Preparation Bay

Tundish bay is utilized for preparation of the tundish for caster operation and deskulling of the same. The new tundish are prepared after the refractory hands over the sprayed tundish. One Sub Entry Nozzle (SEN) is fitted at the bottom of the tundish which allows the flow of steel into the mould. A stopper is fitted at the top with the help of harness, which controls the flow of steel. The transfer of tundish to & fro from the caster bay is done through an inter bay tundish transfer car.

The parameters of these bays are:

Number of ladles	17
Total volume	30.5 m3
Capacity of ladle	165 T (Max)
Heat size	150 T (Nominal)
Capacity of the tundish	30 T (Approx.)
Ladle life achieved	125 heats (Max.)
Highest tundish sequence achieved	6.2 heats

3.3.3 Ladle Heating Furnace (LHF)

Steel at a temperature of around 1650 C is tapped from the converter into the steel ladle by on a self-propelled steel car and taken into a Ladle Heating Furnace (LHF) by means of one of the two 250 T overhead cranes. LHF is a AC furnace where the steel is initially purged by means of argon purging from the bottom of the ladle. As per requirement, the composition of steel is modified through the alloying system and Al wire feeding system. Arcing facility is provided to increase the temperature of steel, if required so as to make it suitable for casting.

One LHF is used for homogenising and final adjustment of temperature and chemical analysis of steel tapped from Converter before being sent to Casters for casting. LHF consist of:

Ladle Car

Electrode heating mechanism

Water cooled roof with dust collector system

Alloying system

Wire feeding machine

3.3.4 Argon Rinsing Station (ARS)

Argon Rinsing Station (ARS) is also situated in the same bay as LHF. It has all the facilities of LHF but without the arcing. This is utilized during LHF shut down or any other exigency condition.

One ARS is used for homogenising and final adjustment of temperature and chemical analysis of steel tapped from converters before being sent to casters for casting. ARS consists of:

Alloying system

Wire feeding machine

The parameters are:

Capacity=150/165 T

Power of LHF=33kV

Number of electrodes=3

Electrode diameter=850 mm

Heating rate (With 24 MVA)=4 C/min

3.3.5 Casters

There are 2 single strand S-type (Curved mould type) slab casters and two turrets for handling the ladles and providing steel on continuous basis. They can rotate 360° and can lift two 240 T ladles and rotate. The slab caster has a water cooled copper mould, which gives the required dimensions of the slabs produced. The strand produced is further cooled by water sprayed through specially designed nozzles and simultaneously pulled out by drive rolls and straightened. The continuous long strand is at suitable lengths to form slabs and is cut by using transverse torch cutting machine, which moves along with the strand and cuts slabs using oxygen and acetylene.

Annual capacity: 13,55,000 tonnes

Average heat size: 150 -165 tons

No. of strand / machine: 1

Casting size: 220mm thickness

Width: 900 - 1550 mm

Length: 6000 - 8000 mm

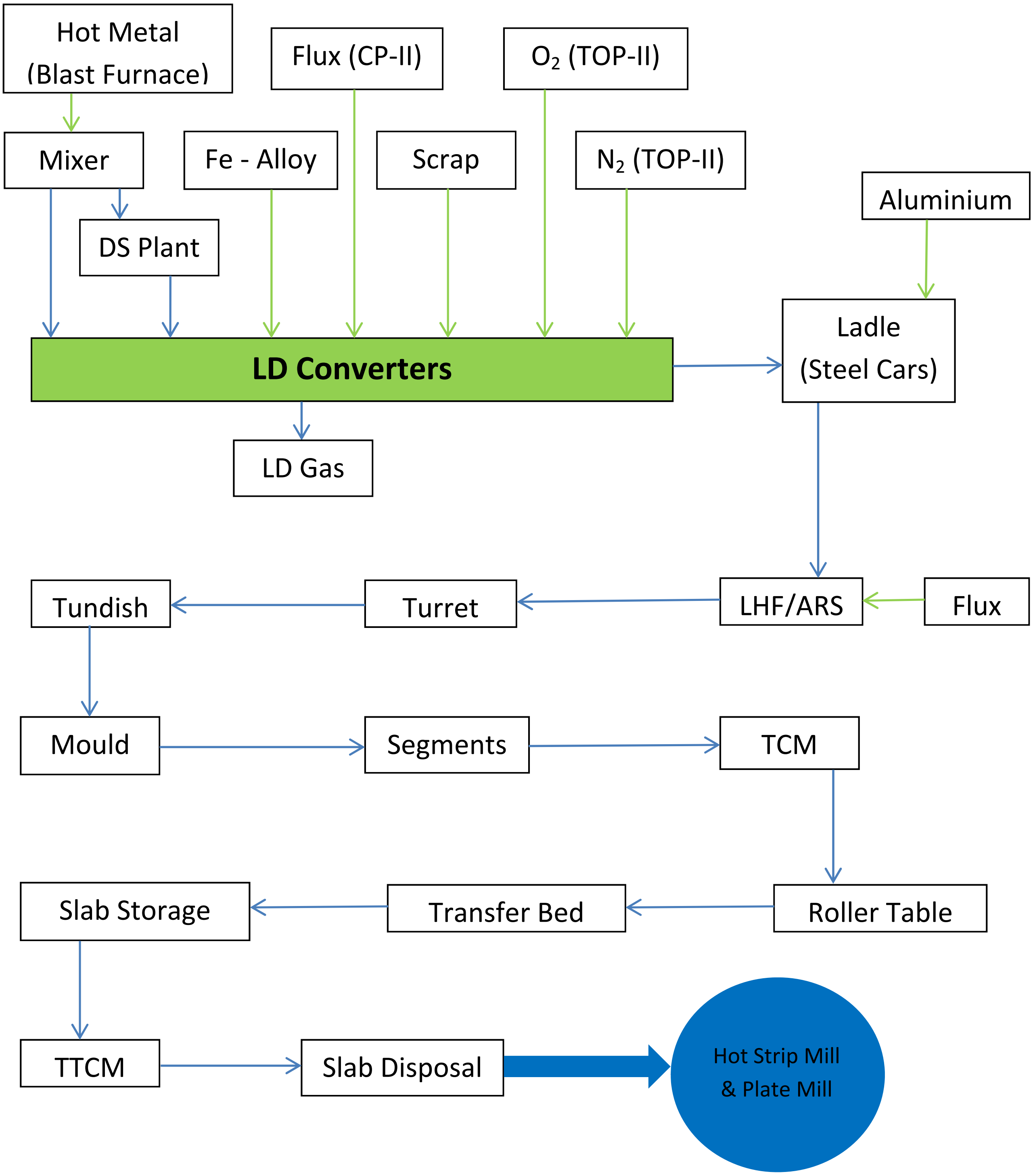
3.3.6 Slab Yards

All the slabs produced are stored in two slab yards. Slabs sent to Plate Mill are further cut to required length before being despatched. Hot slabs are also being loaded in specially made flats to Hot Strip Mill. Two slab marking machines have been installed for marking slabs thereby reducing lead time.

3.4 Other Facilities Available

There is a Pump House to cater to the exclusive needs of the SMS-II Shop. There is also a Compressor House for supplying the required compressed air that is required in the Shop.

3.5 SMS-II Material Flow Chart



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