CLEANER TECHNOLOGY OPTIONS FOR SINTERING PLANT OF INTEGRATED IRON & STEEL PLANTS

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FOREWORD

Sintering plant is an important process unit of Integrated Iron & Steel industries wherein sinter is produced through agglomeration of iron ore fines, and other iron bearing wastes such as mill scale and slag. The iron ore fines, which otherwise cannot be input directly for iron making, are gainfully utilized in the form of sinter agglomerates. Sinter, due to its homogeneity, porosity and reducibility, is a much preferred input material for producing hot metal through Blast Furnace process route. In India, approximately 50% of hot metal is produced using sinter.

Sintering process has significant environmental concerns, particularly in the form of air emissions comprising particulate matter, sulphur dioxide, oxides of nitrogen, carbon monoxide, organochlorine compounds, and heavy metals. Raw material handling, crushing and screening, conveying of feedstock & product result in particulate matter emissions. Waste gaseous emissions are caused from sinter strand & cooler discharge. Use of cleaner process technologies help in minimizing these environmental problems. In view of this, Central Pollution Control Board (CPCB) undertook a study through MECON limited, Ranchi to review existing and emerging cleaner technological options for sinter plants, and suggest their adaptability in Indian steel industries.

This document, which is an outcome of the in-depth study, provides description of potential cleaner technology options, abatement techniques and best operating practices for minimizing pollution problems from sinter plants.

I appreciate the efforts made by team of MECON Limited, and my colleagues Dr. S.S. Bala, Dr. Prashant Gargava and Ms. Garima Sharma in bringing out this report under guidance of Dr. A.B. Akolkar, Member Secretary. The cooperation extended by Iron & Steel plants is gratefully acknowledged. Typing assistance provided by Ms. Richa Tuli, DEO is also acknowledged.

I hope this report will be useful to Iron & Steel industry, consultants, academic institutions, R & D organizations and regulatory authorities.

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CHAPTER -1

INTRODUCTION

India is the fourth largest producer of crude steel in the world accounting for 4.14 % of the world's total crude steel production. As per the goal decided under National Steel Policy, 2005, indigenous production of steel is targeted to achieve 100 million tons per annum by 2019-20. The estimated crude steel production in 2011-12 was 72 million tons, a growth of 5.7% compared to last year. World crude steel production for the 62 countries reporting to the World Steel Association was 122 million tonnes (Mt) in November 2012, an increase of 5.1% compared to November 2011. Presently more than 70% of hot metal in the world is produced through the sinter route. In India, approximately 50% of hot metal is produced using sinter feed in Blast Furnaces.

In sintering iron ore fines, other iron bearing wastes and coke dust are blended and combusted. The heat fuses the fines into course lumps that can be charged to a blast furnace. A typical photograph below shows the sinter in a sinter cooler **(Fig. 1.1)**.

Fig. 1.1: Sinter being cooled in a straight line cooler

Emissions from the sintering process arise primarily from material handling operations, which result in airborne dust and from the combustion reaction on the strand. Combustion gases generated in the process contain dust along with products of combustion such as sulfur dioxide, oxides of nitrogen, CO, CO_2 etc. The concentrations of these substances vary with the quality of the fuel, raw materials used and combustion conditions. Atmospheric emissions also include volatile organic compounds (VOCs) formed from volatile material in the coke breeze, oily mill scale etc. Polychlorinated dibenzo-p-dioxins and –

furans (PCDD/F), commonly known as dioxins and furans are also formed from organic materials under certain operating conditions.

Combustion gases are most often cleaned in electrostatic precipitators (ESPs) or in multi-cyclones which significantly reduce dust emissions but have minimal effect on the gaseous emissions. In some of the countries treatment of gaseous pollutants such as SO_2 and NO_X emitted from sintering processes is practiced. Fugitive emissions are also generated from material handling operations, sinter cooling, crushing and screening and are usually controlled by Dust extraction system followed by ESPs or bag filters.

Hence, a study was taken up to identify cleaner technologies for sintering plants of steel industry for better pollution control and to enhance production & energy efficiency. During course of study various existing and upcoming cleaner technologies n sintering plants were identified, assessed for economic feasibility and ease of implementation in existing and upcoming plants.

Description of cleaner technology/ techniques such as Waste Heat Recovery System of Exhaust Gas, Main Exhaust Gas Circulation, Emission Optimized sintering (EOS), Intensive Mixing & Granulation, Selective Sinter Waste Gas Recirculation System, Sinter Cooler Off-air Recirculation and Energy Recovery, Sinter Raw Mix Charging by Twin-Layer Charging System, Improvements in Feeding Equipment, Multi-slit Burner in Ignition Furnace etc. is provided in subsequent chapters.

CHAPTER – 2

ABOUT THE STUDY

Objective of the study

The study is based on the following objectives:

- Description of cleaner technologies for sintering plants of steel industry for better pollution control and to enhance production and energy efficiency.
- Assessment of technical feasibility and ease of implementation of identified cleaner technologies in existing and upcoming sintering plants.

Methodology

Step 1 : Inventorisation of all the sintering plants of steel industry operating in India and indicating their locations on the map.

Step 2 : In-depth literature survey to ascertain status of sintering plants technology and cleaner technology options available.

Field monitoring was carried out in ten sinter plants at Bhilai Steel Plant, Bokaro Steel Limited, Tata Steel Limited, Jamshedpur and NINL, Duburi during September- October, 2007. The environmental quality monitoring data was collected from all the participating sinter plants.

Table 2.1: Sinter Plants Monitored

Sl. No.	Steel plant	No. & size of sinter plants (m^2)	Sinter plants monitored
1.	Bokaro Steel Plant, Bokaro	3X312	SP-1
2.	Bhilai Steel Plant, Bhilai	4 X 50 3 X 75 + 1 X 80 1 X 320	SP-2 & SP-3
3.	Neelachal Ispat Nigam Limited (NINL), Duburi	1 X 180	SP
4.	Tata Steel, Jamshedpur	2 X 75 1X192 1X204	SP-1 & SP-3

Step 3: Analysis of finding for suggesting measures to reduce pollution, extent of safe reuse & recycling of solid / hazardous wastes in sinter feed, resource conservation and reduction in fugitive emission. Also, identification of cleaner technologies for sinter plants for better pollution control and to enhance production & energy efficiency. In addition, laboratory facilities required by the Sintering plants and monitoring programs with respect to air, water, noise, stack, fugitive emission & solid / hazardous waste were also worked out.

CHAPTER- 3

THE SINTERING PROCESS

3.1 Need of Sintering

The process of sintering was originally developed to agglomerate the ore fines. The understanding of the ideal properties of the blast furnace burden and the possibilities of achieving these in the sinter developed hand-in-hand. With time the objective of sintering enlarged to achieve the following:

- To increase the size of ore additives to a level acceptable to the blast furnace for improving permeability of burden inside the BF.
- To form a strong agglomerate with high bulk reducibility.
- To remove volatile matter like CO_2 from carbonates, H_2O from hydroxides and sulphur from sulphides type of ore fines along with their agglomeration.
- To incorporate flux in the burden.
- To utilize certain wastes containing iron, fuel and flux.
- To engineer the characteristics ferrous feed towards ideal blast furnace burden.
- Partial reduction of iron ore from Fe^{+3} stages to Fe^{+2} stages.

3.2 The Mechanism of Sintering

Sintering is a heat exchange process. In a static sinter bed there are various zones like; cold sinter, hot sinter, combustion zone, preheating zone, drying zone and cold charge. There is a downward movement of each zone with the forward movement of the pellet throughout the entire length during sintering.

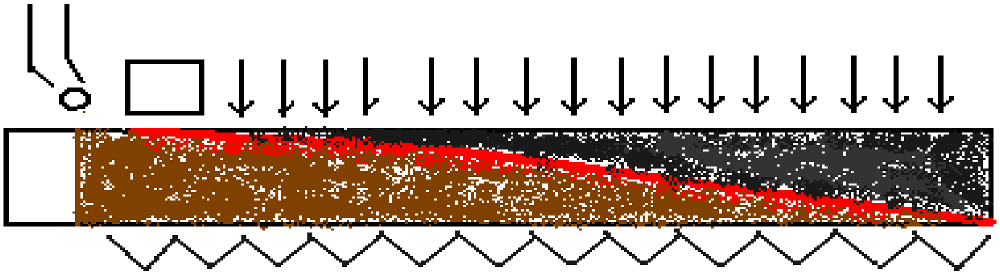


Fig. 3.1 Typical vertical section of static sinter bed

3.3 The Process of Sintering

Sintering is process of agglomeration of ore fines by fusion of ore particles due to combustion heat of solid fuel (coke, coal etc.) present in the mix. Fines generated during mining and beneficiation of iron ores cannot be charged directly into blast furnace, the sintering of such fines makes it usable and desirable blast furnace feed. It produces strong and porous lumps with high reducibility from a powdered un-compacted mass of iron ore along with iron and flux rich industrial wastes with the application of heat to the stage of incipient fusion. The coke breeze supplies the necessary process heat. Coke breeze is intimately mixed with moistened ore fines, limestone/ dolomite and industrial wastes like flue dust, return fines, LD slag, LD sludge etc. The process of sintering is performed on a traveling grate. The combustion of coke breeze, initiated in the top layer by burning of coke oven gas/ BF gas/ natural gas or oil through burners, produces a temperature of 1200-1300°C and is maintained continuously by sucking air through the bed with the help of exhaust blower connected from underneath. The suction of air makes the combustion zone, developed initially at the top, travel through the bed raising its temperature layer by layer to sintering temperature. The cold air sucked through the bed cools the already sintered layer, gets itself heated and preheats the layer below combustion zone. Process completes when combustion zone reaches to the lowest layer of the bed. Sinter cake is tipped from the grate in hot condition, broken and cooled by supplying air from the bottom of moving cooler bed in which air picks up the heat. Cooled sinter is further crushed and screened to get the desired product size of sinter for the blast furnace. The undersize material from screening is recycled back to the process. Sinter plants recycle iron ore fines from the raw material storage and handling area, waste iron oxides, and pollution control systems. Iron ore may also be processed in on-site sinter plants.

The flexibility of the sintering process permits conversion of a variety of materials, including iron ore fines, captured dusts, ore concentrates, and other iron-bearing materials of small particle size (e.g., mill scale) into a clinker-like agglomerate.

Waste gases are usually treated for dust removal in a cyclone, electrostatic precipitator, wet scrubber or fabric filter. Important aspects of sintering which merit special mention are:

a) The possibility of varying the addition of limestone to raw mix thereby influencing the basicity of product. This enables to incorporate the flux necessary for fluxing the coke ash and gangue associated with lump ore charged (if any) in furnace.
b) Limestone decomposition, a highly endothermic reaction, is transferred from the blast furnace to the sintering unit. Consequently there is a reduction in the thermal load on blast furnace decreasing fuel consumption. In addition, the evolution of CO_2 from limestone occurring outside the furnace eliminates its effect on Boudouard reaction.

A schematic diagram of the sintering process is shown in **Fig. 3.2**.

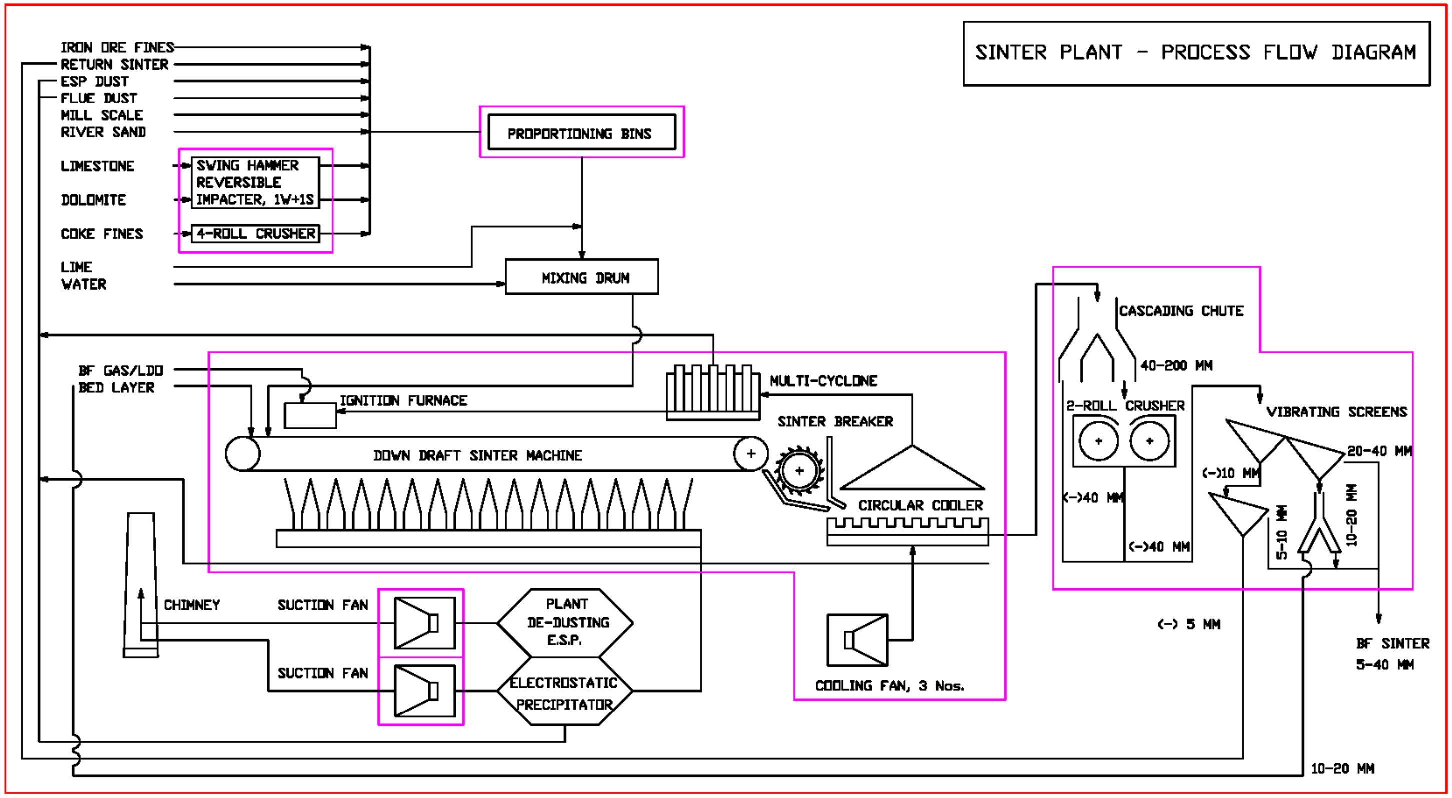


Fig. 3.2: A schematic diagram of the sintering process

3.4 Reaction mechanism

Combustion of coke breeze within the charge takes place resulting in the following chemical reaction:

$C + O_2 = CO_2 + 94220$ Cal./mole

$2C + O_2 = 2CO + 53140$ Cal. /mole

The heat liberated from the above reaction raises the temperature of the charge and creates a condition necessary for following reaction to occur:

$CO + 3Fe_2O_3 = 2Fe_3O_4 + CO_2 + 8870$ Cal. /mole

$CO + Fe_3O_4 = 3FeO + CO_2 - 4990$ Cal. /mole

Fe O so formed combines with SiO_2 and fluxes resulting in the formation of fluxed sinter.

3.5 Major facilities in a Sinter Plant:

In an integrated steel plant the major facilities at a sinter plant unit are as follows:

a) Raw material handling system
b) Flux preparation system
c) Raw feed proportioning building
d) Primary/ Secondary Mixing Drum/ Mixing cum Nodulising Drum
e) Sintering machine
f) Hot sinter breaker & Hot sinter screen
g) Instrumentation & Control Room
h) Sinter cooler
i) Sinter screening
j) Waste gas exhaust system
k) Waste gas cleaning system
l) De-dusting system
m) Electrics
n) Water system
o) Compressed air system
p) Fuel gas facility for furnace
q) Fire fighting
r) Air-conditioning & ventilation
s) Emergency DG set
t) Repair shop and store
u) Laboratory

3.6 The Raw Materials

The major raw materials required for production of sinter are as follows

1) Iron ore fines:

Production of sized iron ore lump in the mechanized mines results in generation of appreciable amount of ore fines. These fines as such cannot be charged / utilize in the blast furnace and agglomeration processes have been developed to utilize such arising of ore fines as well as to reduce the negative impact on the environment through various processes such as sintering and pelletizing. The quality of iron ore for sinter making has two requirements; one is chemical and the second is physical requirement. As chemical requirement higher iron content, lower alumina, lower alumina: silica ratio and lower phosphorus is requisite.

The alumina due to its refractory nature demands higher heat for going into sintering melt. As blast furnace is not capable of reducing any phosphorus and the total of this input reports to hot metal only, phosphorus becomes the important impurity, which should be as low as possible.

For physical requirement the super fines content (fines less than 100 mesh; 0.15 mm) should be as low as possible, preferably less than 10 percent. The super fines bring in stickiness to the ore fines hence causes flow ability problem.

In addition to the principal raw materials, a number of in-plant wastes containing various quantities of iron, flux and fuel values are also included in the mix for sintering, basically to reuse the wastes. A typical photograph below shows iron ore in a storage bin in a raw material proportioning section (**Fig. 3.3**).

Fig. 3.3: An iron ore bin

2) Flux Materials

Fluxes are added to a smelting process to bring down the softening point of gangue materials and decreases the viscosity of the slag so formed. Fluxes also decrease the activity of some of its components to make them stable or unstable in the slag phase. In general the silica (SiO_2) and alumina (Al_2O_3) are the predominant gangues present in the iron ore and prime constituents of coke ash. Therefore, CaO and MgO are required as flux. The lime stone and the dolomite are the known source of fluxes.

Limestone is composed mainly of calcium carbonate ($CaCO_3$). The dolomite is a double carbonate of calcium and magnesium ($CaCO_3.MgCO_3$). These fluxes are necessary for the removal of impurities in the iron ore or ash associated with coke during its smelting in the blast furnace. These can be added directly to the blast furnace. Due to demand of thermal energy for its decomposition these are being added during sintering stage itself. A photograph below shows flux in a storage bin in a raw material proportioning section **(Fig. 3.4)**.

Fig. 3.4: A flux bin

3) Fuel

The coke breeze, coke oven gas and some alternate solid fuel like anthracite and petroleum coke are used as sources of heat. The size fraction of coke below 10 mm generated at the coke ovens are known as coke breeze. Its generation is to the extent of 6-8% of the coal charged for coke making. It is crushed to less than 3.15 mm size. The finer size coke breeze (-0.25 mm) is not good for sinter making. This causes a mis-match of flame front and heat front. Similarly bigger size (+3.15 mm) also is not desirable due to the same reasons. In the former case it burns faster and the burning front moves ahead of sintering front and in the latter case it lags. In both the cases utilization of the heat is not proper. Due to its superior performance the -3.15 mm to 0.25 mm size range has been termed as golden size range of the coke breeze by the sinter makers. The coke oven gas or mixed gas is used for igniting the bed surface to start the sintering reaction. A photograph below shows coke breeze in a storage bin in a raw material proportioning section **Fig. 3.5**.

Fig. 3.5: A coke bin

4) Wastes generated during plant operation

Wastes generated during steel plant operation like Flue dust, LD Slag, Mill scale, Iron bearing dust / sludge, etc. are also utilized in sinter making. A typical percentage of raw materials being used in sinter making are shown in **Fig. 3.6**

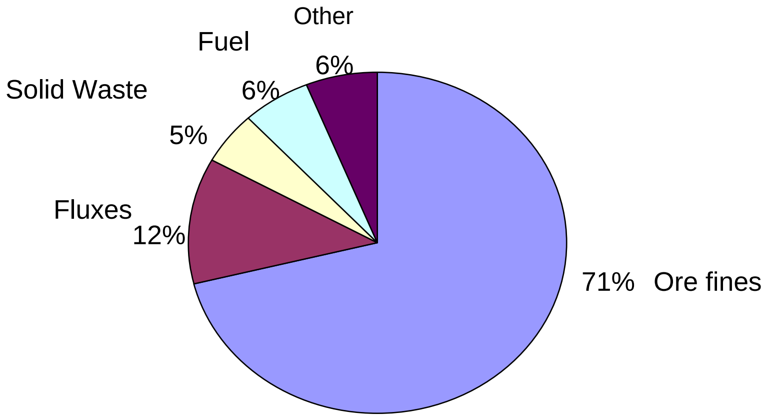


Fig. 3.6 Percentage Breakup of Raw materials used for sintering

3.7 Preferred Raw Material Characteristics

Typical raw material characteristics are given below:

i) Iron ore fines

Fe : 63 % (min.)
$SiO_2 + Al_2O_3$: 3.5 % (max.)
S : 0.02 % (max.)
P : 0.1% (max.)

ii) Coke breeze

Fixed C : 65 % (min.)
Ash : 18 % (max.)
VM : 0.5 %
S : 0.06% (Max.)

iii) Limestone

CaO : 53 % (min.)
SiO_2 : 3.6 % (max.)
MgO : 1.3 %
Al_2O_3 : 0.6 %
Na_2O : 0.08 %
K_2O : 0.3 %

iv) Dolomite

MgO : 30-40 %
SiO_2 : 30-55 %
Al_2O_3 : 0.1-3 %
Na_2O : 0.02 %
K_2O : 0.03 %
Cr_2O_3 : 0.6-1 %

3.8 The Base Blending

Sinter plant utilizes materials with different chemical and physical characteristics which are required to be homogenized before feeding to sinter machine to get consistent sinter chemistry. Iron ore fines, mill scales, LD slag, blast furnace flue dust, BF sinter return, lime stone, dolomite, coke breeze etc are blended to prepare base mix for sinter plant feed – a process called base blending. By Base blending the natural variation of raw materials chemistry and granulometry from a single mine as well as from a number of sources can be minimized and consistent sinter chemistry can be achieved.

Base blending results in reduction in the number of storage bunkers in proportioning building as only minor additions of flux and fuel are made in proportioning stage to correct basicity and sintering process.

Efficiency of blending depends on number of layers made during stacking of the mix. The number of layers may vary from 200 to 600.

Constituent required to blended are as follows.

- Iron ore fines
- Limestone
- Dolomite
- Coke Breeze
- Revert Material of Steel plant like mill scale, sludge, Blast Furnace return fines, L D slag, etc.

3.9 Mixing and proportioning

Control of raw material preparation in a sinter plant can be exercised at three stages:

(i) Proportioning stage
(ii) Mixing and Balling stage
(iii) Strand feeding stage

In the proportioning section all the raw materials are stored in separate bins. These bins are equipped with variable speed weigh belt feeder discharge system. The function of the proportioning section is to mix the various raw mix properly so as to get the required chemical composition in sinter. Sinter charge mix proportioning is always done in sequence, taking care that all the raw mix discharge is in such a way that no layer of any mix is missing throughout the transit. In general the sequence followed is as given below:

1. Iron ore mix
2. Sinter return
3. Flux mix
4. Coke breeze

Photograph below shows different raw material storage bins in a raw material proportioning section **(Fig. 3.7)**.

Fig. 3.7: A raw material proportioning section

In some of the plants the entire above activity is done in a separate Raw Material Bedding and Blending (RMBB)/ Base Blending plant and are dispatched to sinter plant.

When sinter received by the blast furnace does not meet its exact requirements of ingredients, a trimming is required in the raw mix and some of the ingredients are added to the raw mix before the mixing and rolling stage. This includes mixing of required amounts of lime fines, coke breeze and flux trimmings. About 80% of required flux and coke breeze are added in the base mix at RMBB. The remaining coke and fluxes are added along with return fines at the mixing and rolling stage in finer doses at sinter plant to have better control over sinter chemistry and process.

3.10 The Mixing & Granulation

Iron ore sintering is a very fast process. The constituents of reaction process do not go to liquid state. Hence, any in-homogeneity in layering the material at the bed is transferred to the product. This necessitates the complete homogenization of the material before its layering on the sinter machine. It is accomplished by barrel shaped drum mixer. Water at a precisely controlled rate is added continuously so that the desired moisture of green mix can be maintained. In some old plants mixing drum and granulation drums were separate. The plants which have come up in recent years have one single mixing –cum granulation drum. The sole purpose of the mixing and granulation is to add required quantity of moisture and size enlargement of fine particles of the sinter mix by inter-particle adhesion via water-bridge. Photograph below shows a mixing and nodulising drum **(Fig. 3.8)**.

Fig. 3.8: A mixing and nodulising drum

3.11 The Ignition

The combustion of coke breeze is incorporated in the mix. It is very important aspect of sintering. If proper ignition of the top layer is not achieved, both the output and quality of the sinter will suffer adversely. Proper ignition depends on the nature, amount and distribution of solid fuel in the mix and the temperature and pressure in the ignition furnace. Mainly, two types of ignition hoods are in use. They are:

1. Combustion chamber type
2. Nozzle type or torch type.

Since sinter making takes place layer by layer it is obvious that every layer is heated to sintering temperature level. This is only possible if solid fuel is incorporated in the charge and that burns layer by layer. Sintering is commenced by igniting the solid fuel in the top layer. The combustion of the solid fuel raises the temperature of the top layer to the required level. The air blast drawn thereafter through the bed not only cools the top layer but preheats the solid fuel in the next layer and the combustion zone shifts downwards. For effective sintering once the top layer is ignited adequately matching conditions should exist. The permeability of the bed, as decided by the particle size of the bed, amount of solid fuel, moisture, carbonates incorporated in the charge and the suction applied will have to be interrelated to obtain the matching conditions. Normally, Mixed Gas is used as fuel for the ignition hood. A typical analysis of the Coke Oven Gas, Blast furnace gas and Mixed Gas is given in **Table: 3.1**

Table: 3.1 Analysis of Coke Oven Gas, Blast Furnace Gas & Mixed Gas

Item	Coke Oven Gas	Blast Furnace Gas	Mixed Gas
CO_2, %	4.6	14.0	12.1
C_mH_n,%	3.6	Nil	0.7
O_2, %	0.8	0.4	0.5
CO, %	11.0	26.0	23.0
H_2, %	48.6	4.0	12.9
CH_4, %	20.5	Nil	4.1
N_2, %	10.9	55.6	46.7
Net calorific value, kcal/Nm_3	4,100	850	1,500
Specific Gravity (Air = 1)	0.48	1.03	0.92

Photograph below shows ignition of sinter mix in a sinter strand **(Fig. 3.9)**.

Fig. 3.9: Ignition of sinter mix in a sinter strand

Typical Sinter Characteristics is shown in **Table: 3.2**

Table: 3.2 Typical Sinter Characteristics

Fe %	FeO %	SiO_2 %	Al_2O_3 %	CaO %	MgO %	CaO/SiO_2
58.5	8.0	3.1	2.6	7.7	1.9	2.5

3.12 The Cooling of Sinter

Initial cooling of sinter, in the top layer, takes place on sinter strand during its travel to discharge position. The sinter cake still remains extremely hot in the bottom zone. It is necessary to cool it before it can be safely transported on conveyor belts. To achieve high output from the sinter strand the end of sintering process should coincide with the discharge of sinter from the strand. If sintering is completed before this time then the strand area is underutilized. If sintering is not fully complete on the strand then it will raise thermal load on cooler fans and also cooling will not be proper and burning of downstream conveyor belts are likely. A photograph below shows hot sinter at cooler feed end **(Fig.3.10).**

Fig. 3.10: Hot sinter at cooler feed end

Although, the sinter can be cooled by natural radiation and convection but, it will be at a very slow rate. In order to make this process as faster as production process the broken sinter cake is screened and oversized sinter is cooled by forced draught on either a rotary or on a straight line cooler. The undersize which constitutes the return fines is used to increase the temperature of the raw mix which in turn improves permeability. Photographs below show straight line and rotary coolers for sinter **(Fig.3.11 & 3.12)**.

Fig. 3.11: A Straight line cooler

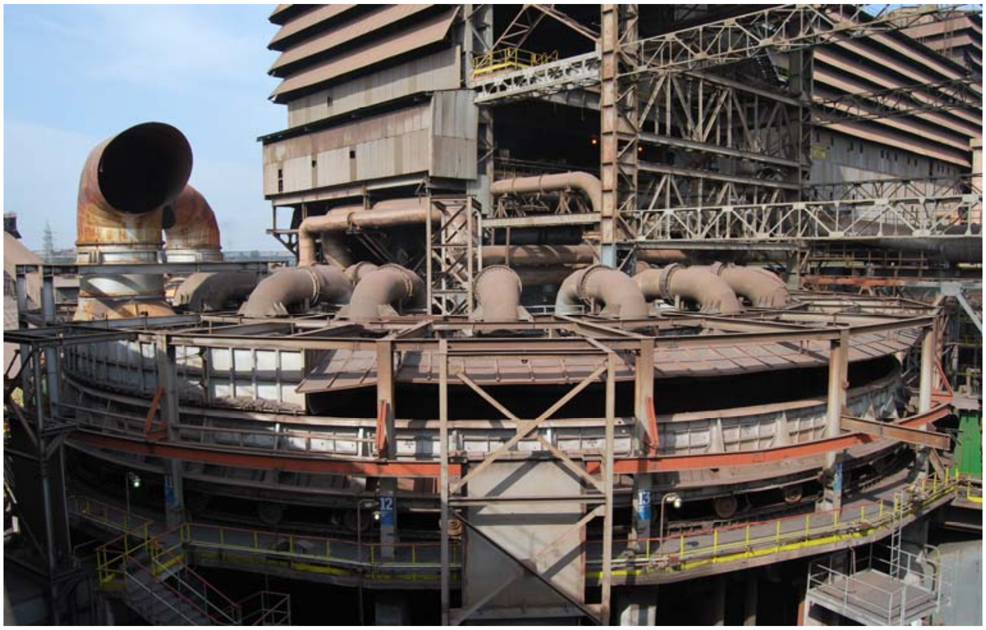


Fig. 3.12: A Rotary Cooler

3.13 The Screening

Hot sinter cake from the sinter strand is fed to hot sinter breaker and then to sinter cooler. Cold sinter is crushed in cold crusher and then screened in two or three stages in the screening plant. The over sized sinter in the size range of 12 – 22 mm is used as hearth in the sinter strand and sinter in the size range of +5 mm to 12 mm is only suitable for blast furnace. The undersize sinter of size less than 5 mm is sent back to the sintering process and is termed as return fines. In most cases the screening is carried out after the cooler. But in some cases hot screening is also practiced to remove undersized sinter and is sent to sinter strand as return fines. After cooling of the sinter further screening is carried out to separate the oversized sinter. Photographs below show screening machine **(Fig.3.13)**.

Fig. 3.13: Sinter Screening Machine

3.14 The Circulating Load

After discharge of sinter cake from the sinter machine appropriate crushing and screening is carried out to produce sinter lumps suitable for blast furnace. In this process under sizes are generated which are known as return fines. As these return fines are always present in the system in nearly same percentage, i.e., it remains in the system and circulates are known as circulating load.

3.15 Process Waste Gas and Plant De-dusting

Sources of emissions in sinter plant are:

- Process waste gas
- Plant de-dusting
- Fugitive emissions from various processes such as raw material proportioning, Mixing & Nodulising, sinter strand, sinter cooler and screening.

Process Waste Gas Dedusting

The process waste gas from the sinter machine is led into the electrostatic precipitator based gas-cleaning equipment through process gas main.

Electrically operated multiple-cone valves are provided below the process waste gas main. The material collected in the gas main is fed onto belt conveyors via these cone valves. This material is then recycled.

Chain conveyors are installed below the process gas ESP hopper to pick up the discharged fine dust. The collecting chain conveyors are equipped with double-cone valves at the discharge side for proper sealing against the atmosphere. The dust discharged from these double cone valves is transferred to the ESP dust bin for dust treatment and treated dust is recycled.

In case of electrostatic filter dust enrichment in alkalis and heavy metals, a reduction in the concentration is possible by way of temporarily opening the circuit. That means the dust separated at the last fields of the ESP will be removed through extraction via chain conveyor, double cone valve and a telescopic chute, put into special containers and taken by trucks to waste dumps. Process de-dusting ESP handles process gas up to a maximum temperature of 200^{O}C. Photograph below show process gas de-dusting ESP and stack **(Fig.3.14)**.

Fig. 3.14: Process gas de-dusting ESP with stack

<u>Plant Dedusting</u>

The dust-laden air from sinter machine, cold sinter crusher, sinter screen and various material transfer points in the plant is extracted by a duct system connected to a fan and undergoes cleaning in an electrostatic precipitator. The dust collected in the plant de-dusting ESP is transported by troughed chain conveyors and extracted by a pendulum valve into the common ESP dust bin. The temperature range of de-dusting gas is 60~90 ^{O}C.

Dust Treatment and Recycling

The dust extracted from the common ESP dust bin is wetted and granulated in a small bowl type nodulizer and finally added to the sinter mix in front of the mixer.

Stack

The stack for the process waste gas and the plant de-dusting has a suitably desired height and process waste gas stack is completely brick lined as a significant SO_2 concentration in the waste gas is expected. The sulphur mainly originates from the solid fuel and the recycle materials.

CHAPTER- 4

STATUS OF INDIAN SINTERING PLANTS

4.1 Historic Developments

The idea of sintering for non-ferrous metal industry, was developed in 1890s as Hutington Heberlein pot sintering process. It was a batch process. The continuous sintering process was developed between 1903 and 1906 by Dwight and Lloyd in Mexico, again for the sintering of non-ferrous (copper ore) metal. The first commercial plant came in 1908. Soon, in 1911 this was adopted for iron ore sintering aiming improvements in size grading of blast furnace burden without losing the fines and thus accommodating the fine concentrate produced from low grade ore. Sintering process came to India in 1957-58 during the Two Million Ton (TMT) program of Tata Iron & Steel Company Ltd. (Tata Steel) when a 1.2 mtpa Ore Crushing and Sinter Plant (OC&SP) i.e. SP#1 was set up.

However the blast furnaces had not accepted initial product, the acid sinter. Due to the improvements in every area during over five decades it process has improved. The first moment of acceptance came with switching over to basic sinter in late sixties and further to super basic in early seventies. The real break-through came in late eighties with the incorporation of blue dust, a relatively low alumina rich iron ore fines, in the sinter mix.

Majority of steel plants in India which were set up till eighties or nineties are having more than one sinter plant of different sizes which had been commissioned at different times. Sinter plants commissioned in the beginning were relatively of smaller size and sinter plants further added were normally of higher sizes than the previous ones. Most of the steel plants which have come up in the recent past are going for single and large capacity sinter plants.

As per the goal decided under National Steel Policy, 2005, indigenous production of steel is targeted to achieve 100 million tons per annum by 2019-20. The estimated crude steel production in 2013 was 81.2 million tons, a growth of 5.1% compared to last year. Out of this, around 50% crude steel comes through sinter.

4.2 Locations & Production Capacity of Sinter Plants in India

Sinter plants in India are mainly located within the premises of the steel plants and are captive to the steel plant and feed sinter to their blast furnace(s). A list of existing sinter plants and upcoming sinter plants in India along with their size and, de-dusting facilities and capacity are given in **Table: 4.1** & **Table: 4.2** respectively. Locations of sinter plants in India are shown in **Fig.: 4.1**.

Table: 4.1 Details of Existing Sinter Plants in India

Name of Steel Plant	**Sinter Plant**	**No. & Size (m^2)**	**Dedusting Facilities**		**Capacity (Mtpa)**
			Process Gas	**Plant Dedusting**	
Bhilai Steel Plant	SP – I	4 X 50	Multi cyclone	Multi cyclone	2.04
	SP – II	3 X 75 + 1 X 80	Multi cyclone	Multi cyclone	3.14
	SP –III	1 X 320	ESP	ESP	3.2
Rourkela Steel Plant	SP – I	2 X 125	ESP	ESP	1.80
	SP – II	1 X 192	ESP	ESP	1.57
Bokaro Steel Limited	SP – I	3 X 252/312	ESP	ESP	6.90
Durgapur Steel Plant	SP – I	2 X 143	ESP	ESP	1.35
	SP – II	1 X 180/198	ESP	ESP	1.71
RINL, VIZAG	SP – I	2 X 312	ESP	ESP	5.26
Tata Steel, Jamshedpur, Jharkhand	SP – I	2 X 75	ESP	ESP	1.50
	SP – II	1X192	ESP	ESP	1.52
	SP –III	1X204	ESP	ESP	2.3
	SP –IV	1X204	ESP	ESP	2.3
JSW,Tornagallu,	SP – I	1X204	ESP	ESP	2.3
	SP – II	1X204	ESP	ESP	2.3
JSPL, Raigarh,	SP – I	1X204	ESP	ESP	2.3
SISCOL	SP – I	1 X 18	ESP	ESP	0.15
	SP – II	1 X 90	ESP	ESP	0.85
NINL	SP – I	1X180	ESP	ESP	1.71
Bhushan Limited	SP – I	1X105	ESP	ESP	1.1
Jaiswal Neco	SP – I	2X36	ESP	ESP	0.91
IIL, Dolvi,	SP – I	1X198	ESP	ESP	1.8
Essar Steel Limited, Hazira,	SP – I	1X120	ESP	ESP	1.2
SUJANA	SP-I	1X50	ESP	ESP	0.5
MISL	SP-I	2X36	ESP	ESP	0.74
Jindal Saw Limited, Bhuj, Gujrat	SP-I	1X25	ESP	ESP	0.3
Jaibalajee Industries Limited	SP-I	1X60	ESP	ESP	0.6

Table: 4.2 List of Upcoming Sinter Plants in India

Name of Steel Plant	Sinter Plant	No. & Size (m^2)	Dedusting Facilities		Capacity (Mtpa)
			Process Gas	Plant Dedusting	
RINL, Vizag	SP – II	1X408	ESP	ESP	3.88
Tata steel, Kalinganagar	SP-I	1X496	ESP	ESP	5.6
JSW,Tornagallu	SP – III	1X496	ESP	ESP	5.75
Bhushan Steel & Strips Limited	SP-I	1 X 177	ESP	ESP	1.8
	SP-II	2X204	ESP	ESP	2.3
Brahmani Industries, Kadap, AP	SP-I	1X189	ESP	ESP	1.9
Electrosteel Integrated Limited, Bokaro	SP-I	2X105	ESP	ESP	2.3
Monnet Ispat Limited	SP-I	1X90	ESP	ESP	0.93
RLUL	SP-I	1X90	ESP	ESP	0.93

Fig. 4.1: Locations of Major Sinter Plants in India

4.3 Categorization of Sinter Plants

Sinter plants are installed to cater the feed requirements of the blast furnaces. Therefore, capacity of a sinter plant is based on the production capacity of the steel plant. There is no sinter plant that produces sinter for the purpose of selling. Only a very few sinter plants sell their sinter, which is surplus for them after meeting their own requirements. The size of the sinter plants operating in India varies from a minimum of 18 m^2 at SISCOL, Dolvi to a maximum of 496 m^2 at JSW, Tornagallu and Tata Steel Kalinganagar. The basic technology of sintering has not changed with the time and it remained same all over the world. The changes observed with time are in terms of size of sinter machine and more efficient pollution control practices. In the old sinter plants size of sinter strand was not as large as practiced in the new sinter plants. The length, width and depth, all the dimensions of the sinter strand were comparatively smaller as compared to the new machines. The old sinter plants were having more number of sinter strands of relatively smaller sizes. However, the present practice is to install single strand of comparatively larger size instead of a number of strands of smaller sizes.

The sinter plants can be categorized on the basis of their age and the sinter plants in India can be divided in two categories:

Category – I : Sinter plants installed before or up to the year 2000.
Category – II : Sinter plants installed after the year 2000.

In India majority of the sinter plants falling under category - I i.e., those sinter plants commissioned before the year 2000, which do not have waste gas recycling systems and sinter cooler off-air recirculation systems (EOS) and some of them even do not have ESPs for waste gas cleaning instead have multi cyclones for waste gas cleaning. Fugitive emissions in these plants are comparatively more due to old design of sinter strands and less efficient de-dusting systems. However, some of the sinter plants falling under category - II have partial recovery of heat from cooler and utilization of the same as hot air for combustion in ignition furnace. These plants have high efficiency ESPs for cleaning of process waste gases and centralized de-dusting systems. Fugitive emissions are also relatively low in category II sinter plants as compared to old plants.

4.4 Productivity

Specific productivity on yearly average basis for major sinter plants is shown in **Table: 4.3**

Table: 4.3 Specific Productivity of Sinter Plants

	Name of the sinter plant	Sp. productivity, t/m^2/hr
1.	Bhilai Steel Plant (BSP), Bhilai	(Year 2005-06)
	SP1	0.817
	SP2	1.118
	SP3	1.318
2.	Bokaro Steel Limited (BSL), Bokaro	(Year 2005-06)
	M/C-1	1.183
	M/C-2	1.183
	M/C-3	1.179
3.	Durgapur Steel Plant (DSP), Durgapur	(Year 2005-06)
	M/C-1	0.59
	M/C-2	0.60
4.	Rourkela Steel Plant (RSP), Rourkela	(Year 2004-05)
	SP1	0.72
	SP2	1.19
5.	Tata Steel, Jamshedpur	(Year 2006-07)
	SP1	1.294
	SP2	1.226
	SP3	1.177
6.	Nilachal Ispat Nigam Limited (NINL), Duburi	(Year 2006-07) 1.022
7.	Jindal Steel & Power Limited (JSPL), Raigarh	(Year 2006-07) 0.70

4.5 Power Consumption

Specific power consumption for different sinter plants is shown in **Table: 4.4.**

Table 4.4: Specific Power Consumption for Sinter Plants

S. No.	Name of the sinter plant	Sp. Power Consumption, Kwh
1.	Bhilai Steel Plant (BSP), Bhilai	(Year 2005-06)
	SP1	38.9
	SP2	44.0
	SP3	43.4
2.	Bokaro Steel Plant Limited (BSL), Bokaro	(Year 2005-06)
	M/C-1	45.6
	M/C-2	45.6
	M/C-3	45.6
3.	Tata Steel, Jamshedpur	(Year 2006-07)
	SP1	28
	SP2	36.8
	SP3	33
4.	Nilachal Ispat Nigam Limited (NINL), Duburi	(Year 2006-07) 67.1
5.	Jindal Steel & Power Limited (JSPL), Raigarh	(Year 2006-07) 35

4.6 Land Requirement

Sinter plants are not separate entity; these are one of the units of the integrated steel plant. In most cases additional sinter plants has been added to the existing steel plant based on the requirements. Area of a sinter plant varies widely depending upon the availability of land within the existing steel plant, design of the plant, considerations for future expansion plans, sharing of the facilities related to raw material handling etc.

4.7 Raw Material Consumption

The specific raw material consumption on yearly average basis for different sinter plants is given in **Table: 4.5**

Table 4.5: Specific raw material consumption for sinter plants

Name of the Sinter Plant	**Unit**	**Specific raw material consumption, Kg/ ton of sinter**															
		Iron Ore	**Lime Stone**	**Lime Dust**	**Lime Fine**	**Dolomite**	**Coke Breeze**	**Flue Dust**	**LD Slag**	**Sinter Return**	**Mill Scale**	**Anth. Coal**	**Quart.**	**BOF Sludge**	**BOF Slag**	**Flux Fines**	**Sinter Stock**
BSP	SP1	785	296	-	-	-	84	1.5	7	195	-	-	-	-	-	-	-
	SP2	758	100	6	-	116	76	-	-	213	26	-	-	-	-	-	-
	SP3	773	107	12	-	127	64	12	0	205	12	6	-	-	-	-	-
BSL	Av. For M/c-1, 2 & 3	920	112	5	-	119	77	17	16	323	13	-	-	-	-	-	-
DSP	SP1	729	-	-	96	78	81	-	-	647	24	-	-	2	28	-	-
	SP2	729	-	-	97	78	80	-	-	647	16	-	-	2	28	-	-
RSP	SP1	805	-	-	74	148	78	-	41	123	14	-	-	-	-	-	-
	SP2	769	-	18	-	-	75	-	41	141	-	-	-	-	-	183	506
NINL	SP	858	109	-	-	96	81	-	-	-	-	-	13	-	-	-	-
Tata Steel	SP1	735	109	11	-	-	58	8.3	-	187	13	-	-	-	-	134	-
	SP2	742	96	18	-	-	61	8.4	-	202	13	-	-	-	-	121	-
	SP3	1225	200	17.5	-	-	67	11.8	-	286	7.7	-	-	-	-	255	-
JSPL	SP	831	117	20	-	100	77	-	-	-	35	-	-	-	-	-	-

4.8 Water Consumption

In the sinter plant water is used for granulation of the sinter mix before its charging to sinter strand. Water requirement varies with moisture level of the raw materials coming to sinter plant. In some of the sinter plants water is also used to transport the slurry of the dust collected by pollution control equipments such as multi-cyclones/ ESPs. Dust collected by pollution control equipment is transported to settling pit and water is recycled. Consumption of water in the process of transportation of dust through slurry is to the extent of evaporation losses only. Specific water consumption for some sinter plants is shown in **Table: 4.6.**

Table: 4.6 Specific Water Consumption for Sinter Plants

S. No.	Name of the Sinter Plant	Sp. Water Consumption, m^3/t
1.	Bhilai Steel Plant (BSP), Bhilai SP1 SP2 SP3	(2005-06) 0.12 0.16 0.02
2.	Tata Steel, Jamshedpur SP1 SP2 SP3	(2006-07) 0.034 0.012 0.012
3.	Nilachal Ispat Nigam Limited (NINL), Duburi	0.04 (2006-07)
4.	Jindal Steel & Power Limited (JSPL), Raigarh	0.04 (2006-07)

CHAPTER – 5

ENVIRONMENT MANAGEMENT PRACTICES

The air emissions from sinter plant dominate overall emissions from an integrated steel plant. The air emissions comprise of various pollutants such as dust, SO_2, NO_x, CO, organochlorine compounds, heavy metals etc. Stack emissions from waste gas from sinter strand & sinter cooling and fugitive emissions from handling, crushing, screening, preparation and conveying of sinter feedstock & product etc. are sources of air emissions. All the existing and upcoming sinter plants in India have provided Electrostatic Precipitators (ESP) for process gas cleaning and dedusting, except SP-1 and SP-2 of Bhilai Steel Plant, C.G. were multi cyclones are provided.

Sinter plants are sink for solid wastes generated in a steel plants. All the dusts generated in the sinter plant are recycled back and thus no solid waste or hazardous waste is generated. However, recycling of ESP dust from last field to the process is monitored and if the alkali content in ESP dust from last field increases to 25 mg/Nm^3 than it should not be recycled instead must be disposed in landfill.

Wastewater is generated mostly in sinter plants where multi-cyclone are used for cleaning process gas.

Indian steel plants have in-house Environmental Management Department or Environmental Cell which handles environmental aspects. Environmental monitoring for ambient air quality, work zone, Stack emissions, and waste-water / effluent and noise levels is carried out mostly by Environmental Management Department or Environmental Cell of the steel plants. Some of the steel plants which do not have all the facilities to carry out all the monitoring work they generate environmental monitoring data with the help of outside agencies.

During the course of study primary and secondary data was collected. Field monitoring was conducted at sinter plants of Bokaro steel Ltd., Tata Steel, Jamshedpur, Bhilai Steel Plant and Neelanchal Ispat Nigam Ltd., Duburi. Secondary data was collected through questionnaire survey and self monitoring data provided by some steel plants. The findings are presented in subsequent pages.

5.1 Source emissions

Stack emission monitoring was conducted for sinter plants of different sizes and age at BSL, Bokaro; BSP, Bhilai; Tata Steel, Jamshedpur and NINL, Duburi from Sept. 12 to Oct. 9, 2007.

The monitoring results are presented in **Table: 5.1, Table: 5.2, Table: 5.3 & Table: 5.4** respectively.

Table: 5.1 Results of stack emissions monitoring at BSL, Bokaro

Location	Temp. ºC	Velocity m/s	Volumetric Flow Rate Nm^3/hr.	Concentration of pollutants		
				PM mg/Nm^3	SO_2 mg/Nm^3	NOx mg/Nm^3
Sinter machine-1 Duct - A	89	34.5	446935	174	82	47
Sinter machine-1 Duct - B	88	33	524605	138	67	61

Table: 5.2 Results of stack emissions monitoring at BSP, Bhilai

Location	Temp. ºC	Velocity m/s	Volumetric Flow Rate Nm^3/hr.	Concentration of pollutants		
				PM mg/ Nm^3	SO_2 mg/ Nm^3	NOx mg/ Nm^3
Sinter Plant-2 Stack – B 3	94	9.1	921060	120	69	57
Stack – B 4	97	9.8	891450	115	66	49
Sinter Plant-3 Stack – B 5	142	32	1290288	87	114	98

Table: 5.3 Results of stack emissions monitoring at Tata Steel

Location	Temp. ºC	Velocity m/s	Volumetric Flow Rate Nm^3/hr.	Concentration of pollutants		
				PM mg/ Nm^3	SO_2 mg/ Nm^3	NOx mg/ Nm^3
Sinter Plant-1	56	12.6	516040	85	164	174
Sinter Plant-3	116	28	1362646	98	238	234

Table: 5.4 Results of stack emissions monitoring at NINL

Location	Temp. ºC	Velocity m/s	Volumetric Flow Rate Nm^3/hr.	Concentration of pollutants		
				PM mg/ Nm^3	SO_2 mg/ Nm^3	NOx mg/ Nm^3
Sinter Plant	98	9.3	516040	82	86	164

As seen above during field monitoring the average PM value was found ranging between 82 mg/Nm^3 and 174 mg/Nm^3. The average SO_2 value varied from 82 mg/Nm^3 to 238 mg/Nm^3 and average NOx values had variation from 47 mg/Nm^3 to 234mg/Nm^3

In addition, most of the steel plants carry out self monitoring of source emissions at definite interval. The secondary data specific to sintering plants collected during the course of study is as presented in **Fig. 5.1**

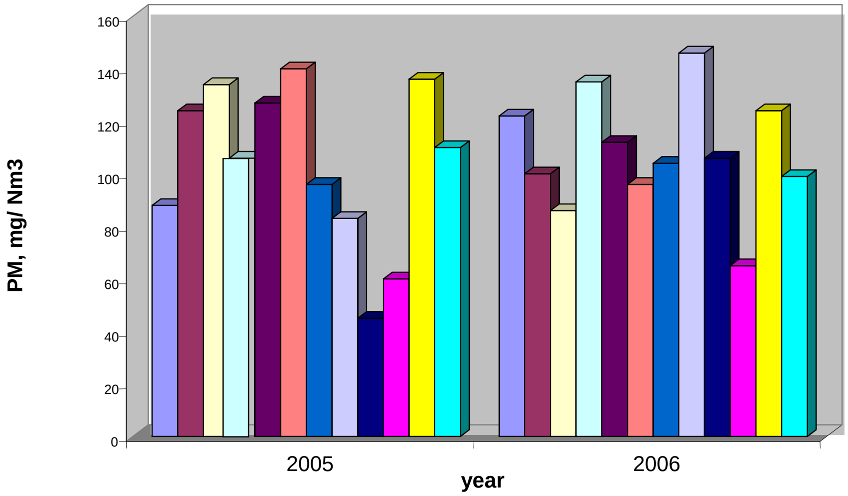


Fig. 5.1: Dust emissions from process stack of SP-1 at BSP, Bhilai

Existing levels of dust from the process stacks of sinter plants of Bhilai Steel Plant was found to be ranging from a minimum of 20 mg/Nm^3 to a maximum of 160 mg/Nm^3. Annual variations in the dust emissions are shown above in the plot. Annual variations in PM emissions in sinter plant-2 & sinter plant-3 are shown in **Fig. 5.2** & **Fig.5.3**. Minimum and maximum emission concentrations of SO_2 & NO_X from the sinter plant process stack are shown in **Fig. 5.4** & **Fig. 5.5** respectively.

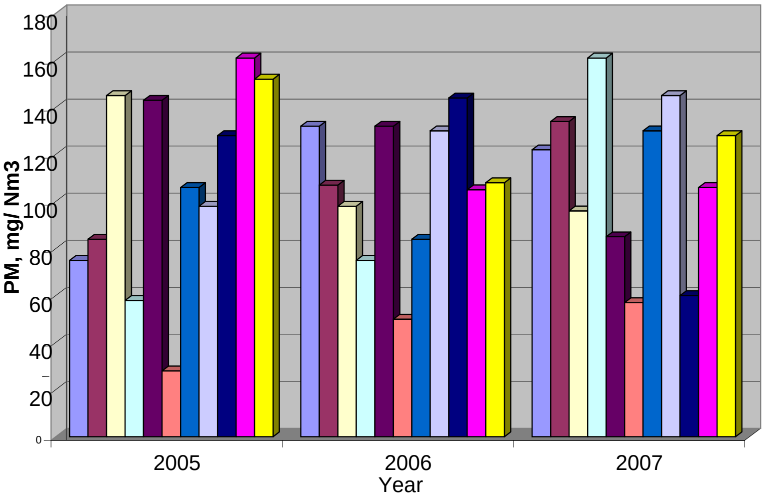


Fig.5.2 Dust emissions from process stack of SP2 at BSP, Bhilai

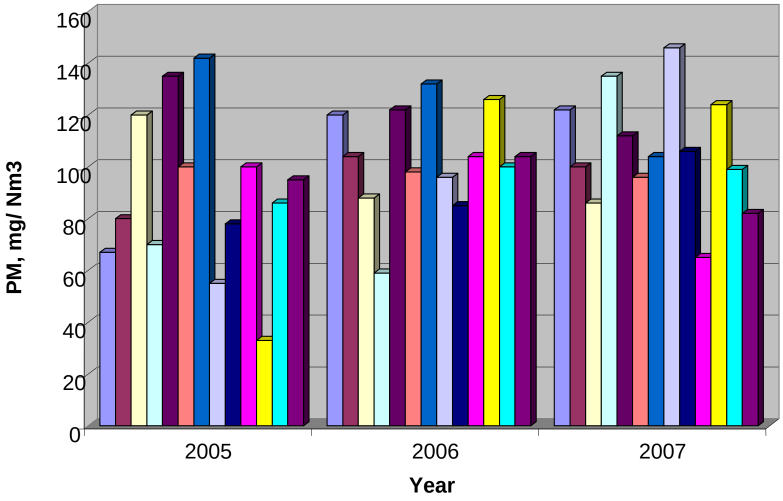


Fig. 5.3 Dust emissions from process stack of SP3 at BSP, Bhilai

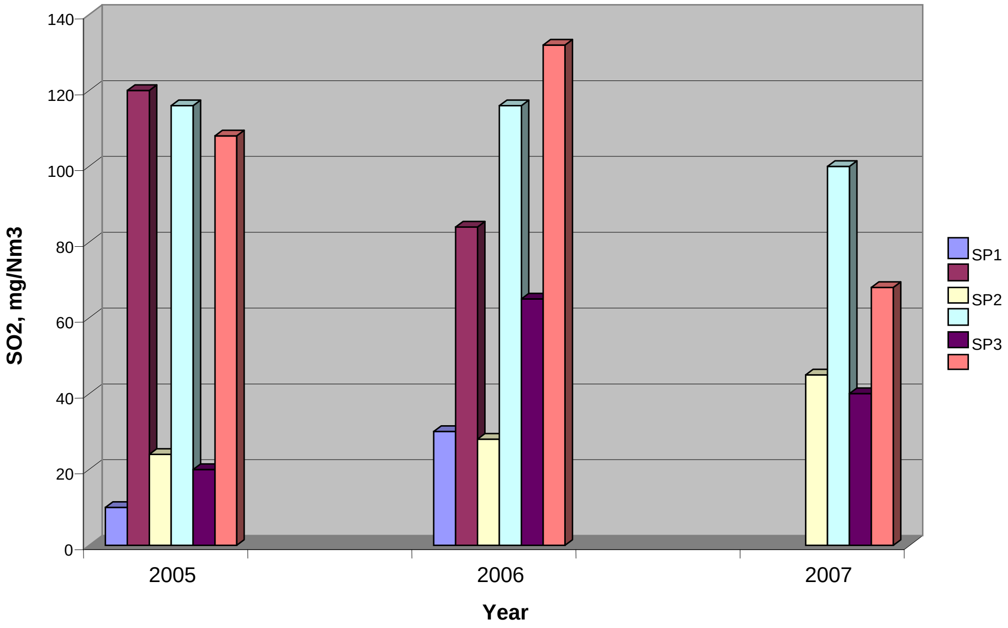


Fig. 5.4: Min. & Max. SO_2 emissions from process stacks at BSP, Bhilai

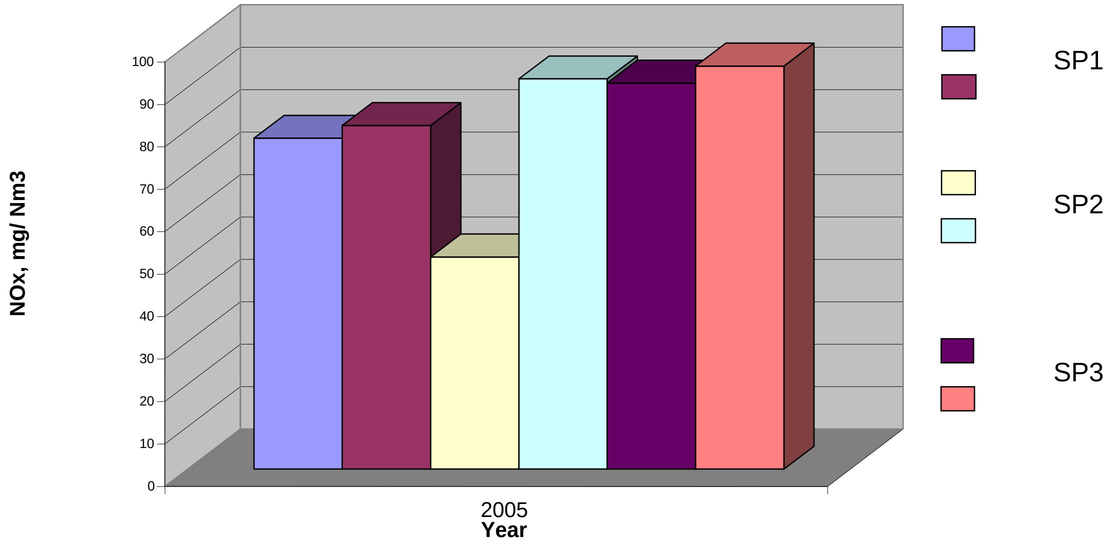


Fig. 5.5: Min. & Max. NOx emissions from process stacks at BSP, Bhilai

Annual averages of emissions from process stack of sinter plants at Tata Steel and Jindal Steel & Power Ltd. (JSPL) are shown in **Fig. 5.6** & **Fig. 5.7** respectively.

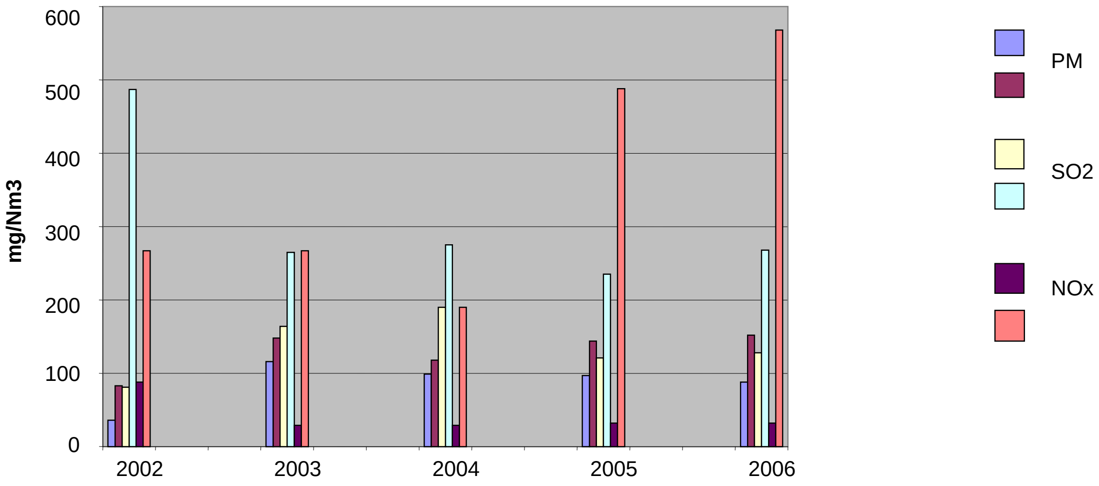


Fig. 5.6: Annual Averages of process stack gas emissions at Tata Steel

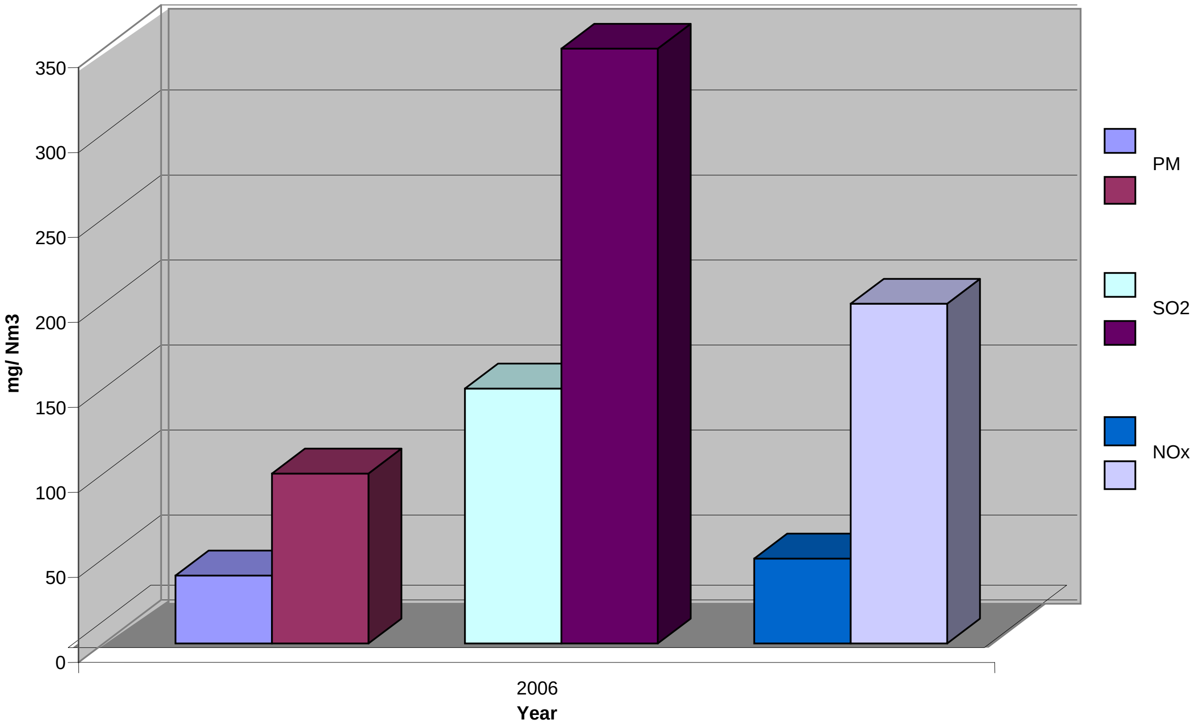


Fig. 5.7: Process stack gas emissions at JSPL

Results of primary and secondary data collected from various sinter plants show that the values for emissions of Particulate Matter, SO_2 and NOx had a wide variation. This can be attributed to efficiency of pollution control system, age of machine etc.

For cleaning of process exhaust air some of the old sinter plants have multi-cyclones/ scrubbers. However, a number of old plants and all of the new sinter plants installed after year 2000 are equipped with Electro Static Precipitators (ESPs).

5.3 Fugitive emissions

Fugitive emissions in a sinter plant are distributed spatially over a wide area and not confined to a specific discharge point. Fugitive emissions have greater ground-level impacts as they are discharged and dispersed closer to the ground. The most common pollutant is dust or particulate matter, others are SO_2 and NO_x. Most of the sinter plants have centralized de-dus system. All the material transfer points are equipped with suction hoods and ducting connected to a central ESP.

Fugitive emissions travel from the point of generation to the entire floor area. Since, the floor area in most of the shops extends from 2 to 5m from the operating facility therefore; the fugitive emissions are contained within this area of a particular shop/ building. Thus, it is not feasible to monitor fugitive emissions at different distances from the point of generation. Considering this fugitive emission monitoring was conducted at a suitable location, distance (2- 5m) and direction from the point of generation depending upon the feasibility and available space in a particular shop in the sinter plant.

Sinter plants at BSL, Bokaro; BSP, Bhilai; Tata Steel, Jamshedpur and NINL, Duburi were selected for fugitive emission monitoring at raw feed proportioning building, PMD/ SMD/ MND feed area, sinter machine discharge end, hot sinter breaker area, sinter cooler zone and sinter crusher & screening area which are major locations of dust generation.

The results of fugitive emissions monitoring are given in **Table: 5.5**.

Table: 5.5 Results of fugitive emission monitoring

Location	Concentration of fugitive emissions, μg/m^3								
	Tata Steel, Jamshedpur					NINL, Duburi			
		RSPM	SPM	SO_2	NO_x	RSPM	SPM	SO_2	NO_x
M/c Discharge End/ Hot Sinter Breaker	SP1	14268	33162	164	135	2860	4782	18	68
	SP3	1265	3028	30	534				
Sinter Cooler Area	SP1	10134	24731	50	34	3125	10908	6	35
	SP3	758	2011	67	77				
Sinter Screening	SP1	11282	30609	37	51	1299	9981	6	22
	SP3	7055	18607	<4	70				
Primary Mixing Drum/ MND	SP1	-	-	-	-	2143	6472	18	28
	SP3	6182	12740	42	53				
Raw Feed Proportioning / Base Mix Area	SP1	1390	3966	46	20	916	3315	12	23
	SP3	-	-	-	-				
Hot Screen Area	SP1	-	142554*	1657	557	-	-	-	-

* Not considered for averaging.

Table: 5.6 Results of fugitive emission monitoring

Location	Concentration of fugitive emissions, μg/m^3								
	BSP, Bhilai					BSL, Bokaro			
		RSPM	SPM	SO_2	NOx	RSPM	SPM	SO_2	NOx
M/c Discharge End/ Hot Sinter Breaker	SP2	2551	6846	24	98	2478	8538	18	41
	SP3	1533	3257	38	58				

Sinter Cooler Area	SP2	2911	6945	29	24	2940	9230	11	18
	SP3	928	2880	17	68				
Sinter Screening	SP2	5062	36028	-	-	2969	9623	7	36
	SP3	2012	5622	20	36				
Primary Mixing Drum/ MND	SP2	1696	5461	18	17	885	2920	15	12
	SP3	476	2326	22	43				
Raw Feed Proportioning / Base Mix Area	SP2	1236	3770	15	10	2524	7231	8	29
	SP3	625	2766	-	-				

As seen above, average RSPM values were between range of 758 ug/m^3 to 14268 ug/m^3. Average SPM value was between 2011 ug/m^3 to 36028 ug/m^3. Average SO_2 vary from <4 ug/m^3 to 1657 ug/m^3. Average NOx values had variation from 10 ug/m^3 to 557 ug/m^3. The variation can be attributed to efficiency of de dusting system, dust suppression system, efficiency of air pollution control system, age of the plant, source of origin, distance of measurement etc.

Graphical representation of results of fugitive emission monitoring is shown below.

Fig. 5.8: Summarized fugitive emission monitoring results of SPM

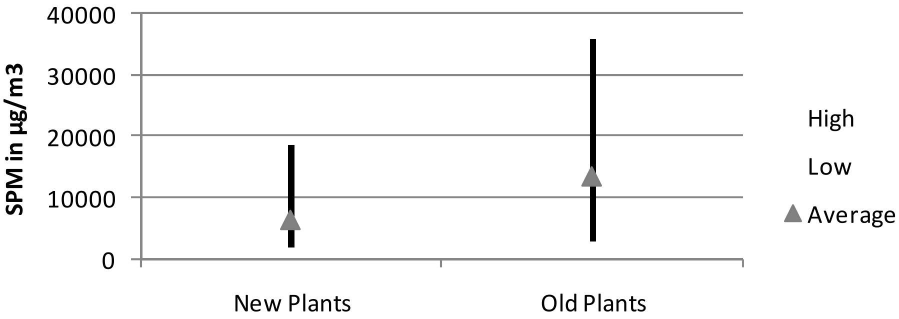
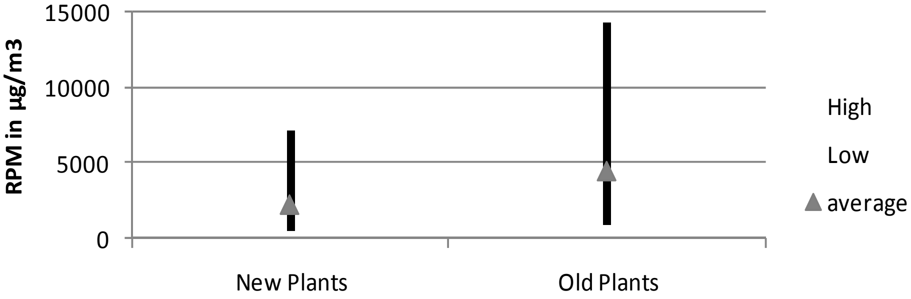


Fig. 5.9: Summarized fugitive emission monitoring results of RSPM



All new sinter plants have centralized de-dusting system, however old sinter plants do not have centralized de-dusting system and existing de-dusting systems are not very effective. Also, due to wear &

tear and openings made for the purpose of repair and other operational problems the fugitive emissions in many areas of the sinter plant were found sufficiently high. It is apparent from the results that fugitive emissions are more in old plants as compared to new plants.

5.4 Noise Pollution

In a sinter plant major areas of noise pollution are process waste gas exhauster fan, sinter cooler fan and sinter crusher. Noise monitoring was conducted in sinter plants at BSL, Bokaro, BSP, Bhilai, Tata Steel, Jamshedpur and NINL, Duburi at the following locations:

1. Proportioning building Hopper Top
2. Proportioning building Ground Floor
3. MND/ PMD Area Near Drum
4. Sinter M/c Floor
5. Near hot sinter breaker
6. Near Cooler Fan
7. Sinter Crusher
8. Near Screen Vibrator
9. Exhauster Fan

The Leq values were in the range of 90 dB to 102 dB, the peak noise was 116.7 dB near the exhauster fan.

The detailed noise monitoring results are as presented below:

Fig. 5.10: Noise levels at BSP, SP-2

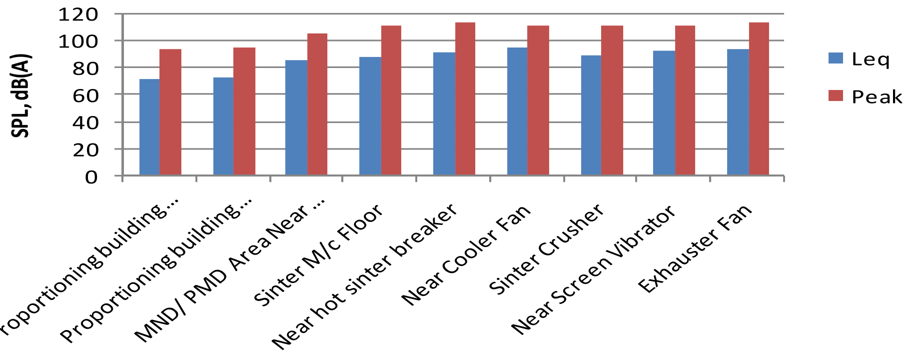


Fig. 5.11: Noise levels at BSP, SP-3

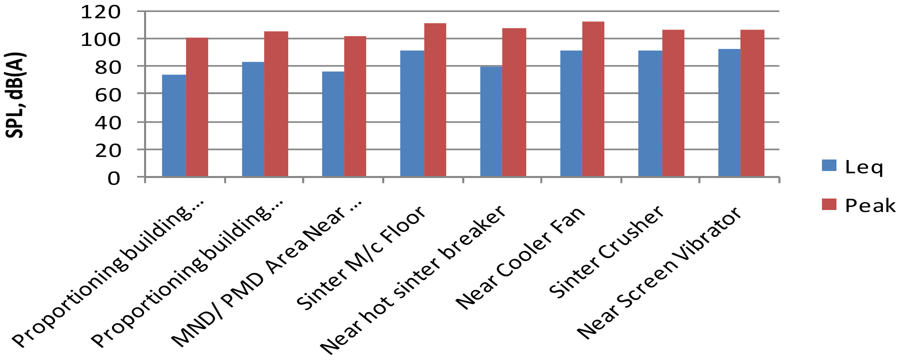


Fig. 5.12: Noise levels at Tata Steel, SP-1

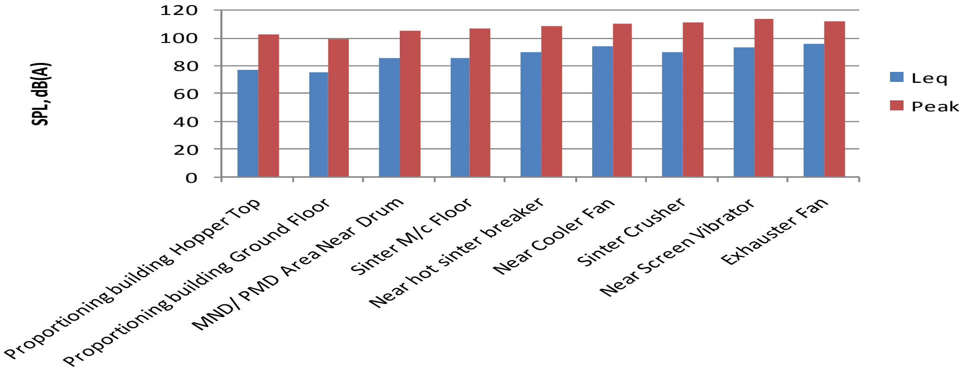
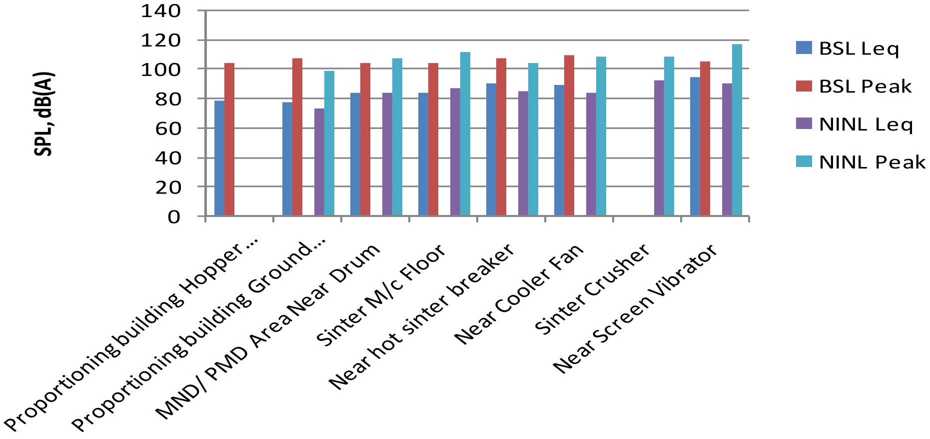


Fig. 5.13: Noise levels at BSL and NINL



5.5 Solid Waste & Hazardous Waste generation

Sinter plants acts as sinks for solid wastes generated in a steel plants. Wastes such as flue dust, LD slag mill scale, iron bearing dust / sludge etc. comprise of around 5% of total material used for sinter making. All the dust generated in sinter plant is recycled and no solid waste or hazardous waste is generated in a sinter plant. Following wastes generated in the steel plant are recycled in the sinter plant:

1. Flue Dust from blast furnace
2. Mill scale from slabbing mill, HRM & CCS
3. LD Slag from SMS
4. Lime dust from RMP
5. Sinter returns

In a few sinter plants where dust of the process exhaust air is collected from the multi-cyclones in the form of wet slurry, it is transported to settling tanks and after removing water it is stored within the plant premises. At present this dust is not reused in the sinter plant. However, possibilities should be explored by the steel plants to make use of this dust. Process of dust collection from multi-cyclones by making wet slurry and its storage is shown in **Fig. 5.14**, **Fig. 5.15** & **Fig. 5.16** respectively.

Fig. 5.14: Dust collection from multi-cyclones

Fig. 5.15: Settled dust being removed from the settling tanks

Fig. 5.16: Settled dust being removed from the settling tanks

5.6 Dioxins & Furans (PCDD/F)

"Dioxin" means polychlorinated dibenzo-p-dioxins (PCDDs) and "Furan" means polychlorinated dibenzofurans (PCDFs). PCDDs include 75 individual compounds and PCDFs include 135 individual compounds. Only 7 of the 75 congeners of PCDDs and 10 of the 135 possible congeners of PCDFs are thought to have dioxin-like toxicity. These have chlorine substitutions at 2, 3, 7 and 8 positions. Dioxins have been characterized by EPA as likely to be human carcinogens and are anticipated to increase the risk of cancer at background levels of exposure. Dioxins are widely distributed throughout the environment in low concentrations, are persistent and bio-accumulated. Most people have detectable levels of dioxins in their tissues.

Dioxins/ furans are produced in the process of sintering. These are formed in the critical temperature region of 250ºC to 450ºC below the combustion zone in the bed and then carried downward with the gas, condensed close to the bottom of the sinter bed. Transported to the discharge end with the solid mixture, these are again released in to the gas phase when the flame front approaches the bottom. Sampling and analysis of Dioxins and Furans is very complex and cost intensive. The method of sample collection and analysis of these pollutants demands high level of expertise, accuracy and instrumentation. CPCB along with MECON conducted monitoring for dioxins and furans depending on size and age of sinter plant, at Bhilai Steel Plant, Bhilai and Tata Steel Limited, Jamshedpur. The results are given in **Table: 5.7**

Table: 5.7 Results of dioxins and furans

Name of sinter plant	**Results, ng-TEQ/ m^3**		
	Sample - 1	Sample - 2	Average
BSP, Bhilai – sinter plant - 2	0.677	0.450	0.564
BSP, Bhilai – sinter plant - 3	1.122	1.151	1.117
Tata steel – sinter plant - 1	0.027	0.022	0.025
Tata steel – sinter plant - 2	0.725	0.821	0.773

As seen above, of dioxin & furan values observed at Bhilai Steel Plant were comparatively higher than Tata Steel Ltd. The value was found highest at SP-3 of Bhilai Steel Plant (1.117 ng-TEQ/ m^3), its strand area is 320 m^2 and ESP is provided for process gas cleaning and plant dedusting. The value was lowest at SP-1 of Tata Steel Ltd. (0.025 ng-TEQ/ m^3), its strand area is 75 m^2 and ESP is provided for air pollution control. At present there is no standard for dioxin & furan in India, however worldwide there are emission concentration limits for new and existing plants (see **Table 6.7**).

Treatment of these pollutants is very cost intensive therefore, primary measures to minimize the generation and formation of PCDDs and PCDFs needs to be practiced in sinter plants.

CHAPTER 6

ENVIRONMENTAL STANDARDS

8.1 Indian Standards

Environmental standards for discharge of emissions and effluent from sinter plant of an Integrated Iron & Steel Plant have been notified under The Environmental (Protection) Act, 1986 vide GSR 277(E) dated March 31, 2012, as given in **Table 6.1** below:

Table 6.1: Indian Sinter Plant Standards

Emission Standard	
Particulate Matter (mg/Nm^3)	150
Effluent Standard	
	Limiting concentration in mg/l, except for pH
pH	6.0-8.5
Suspended Solids	100
Oil & grease	10

The work zone standards of India, as per Indian Factory's Act, 2nd schedule are as tabulated in **Table 6.2** below:

Table: 6.2 Work Zone standards of India: Ref.: Indian Factory's Act, 2nd schedule

Substance	**Permissible Concentration, Time-Weighted Average (TWA), 8 hours**
(i) Silica	
a) Crystalline Quartz	
(1) In terms of dust count, mppcm	$\frac{10600}{\% \text{ Quartz} + 10}$
(2) In terms of respirable dust, mg/m^3	$\frac{10}{\% \text{ Respirable quartz} + 2}$
(3) In terms of total dust, mg/m^3	$\frac{30}{\% \text{ quartz} + 3}$
(ii) Cristabalite	Half the limits given against quartz

Substance	**Permissible Concentration, Time-Weighted Average (TWA), 8 hours**
(iii) Tridymite	Half the limits given against quartz
(iv) Silica fused	Same limit as for quartz
(v) Tripoli	Same limit as for Quartz, Respirable dust
b) Amorphous, mppcm	750

6.2 World Wide Standards

US EPA Sinter Plant Standards

National Emission Standards for Hazardous Air Pollutants for Integrated Iron and Steel Manufacturing Facilities specified by US EPA in Federal Register / Vol. 71, No. 134 / Thursday, July 13, 2006 / Rules and Regulations are as specified in **Table: 6.3.**

Table: 6.3 US EPA standards for sinter plants

Each discharge end at an existing sinter plant	:	a. You must not cause to be discharged to the atmosphere any gases that exit from one or more control devices that contain, on a flow weighted basis, particulate matter in excess of 0.02 gr/dscf
		b. You must not cause to be discharged to the atmosphere any secondary emissions that exit any opening in the building or structure housing the discharge end that exhibit opacity greater than 20 percent (6-minute average).
Each sinter cooler at an existing sinter plant	:	You must not cause to be discharged to the atmosphere any emissions that exhibit opacity greater than 10 percent (6-minute average).
Each sinter cooler at a new sinter plant	:	You must not cause to be discharged to the atmosphere any gases that contain particulate matter in excess of 0.01 gr/dscf

(0.05 grains/dscf = 120 mg/Nm^3)

Speciation profiles and UK emissions for sinter plants

Recent speciation profile has been sourced from the European IPPC bureau, Best Available Technology Reference Note (BREF) for Iron and Steel production. The 2002 NAEI data and speciation profile is compared with the proposed speciation profile and revised emission and is shown in **Table: 6.4.**

Table: 6.4 Speciation profile and revised emission in UK

NAEI speciation profile		NAEI 2002 UK Emissions, ktonne	Proposed speciation profile		Revised 2002 Emissions, ktonnes	% Change
PM10	100%	2.140	PM10	100%	2.140	0
PM2.5	75%	1.605	PM2.5	84%	1.798	+12
PM1.0	50%	1.070	PM1.0	66%	1.412	+32
PM0.1	34%	0.728	PM0.1	9%	0.193	-74

6.3 Worldwide Work Zone Emission Standards

In many countries work zone emission standards are categorized in to Permissible Concentration - Time Weighted Average (PC-TWA), Permissible Concentration – Short Term Exposure Limit (PC-STEL) and Maximum Allowable Concentration (MAC) where,

(PC-TWA): Refers the average exposure value within the working day of 8 hours while taking time as the weight.

(PC-STEL): Refers to the permissible concentration of 15 minutes time weighted average of each exposure during one working day.

(MAC) : Refers to the limited concentration of hazardous chemicals in work place, which should not be exceeded at any time during one working day.

Work zone emission standards for dust specified in China, Germany and India are given below in **Table: 6.5**, **Table: 6.6 & Table : 6.2 respectively**.

Table: 6.5: Chinese Occupational Work Zone Standards Collected From WISDRI (GBZ2-2002)

	TWA	STEL
Dolomite Dust		
Total Dust, mg/ m^3	8	10
Respirable Dust, mg/ m^3	4	8
Coal Dust (free SiO_2 < 10%)		
Total Dust, mg/ m^3	4	6
Respirable Dust, mg/ m^3	2.5	3.5
Limestone Dust		
Total Dust, mg/ m^3	8	10
Respirable Dust, mg/ m^3	4	8

Table: 6.6 Work Zone standards of Germany: Ref.: BGBl. Nr. 243/2007

Total Dust, mg/ m^3	10	20
Respirable Dust, mg/ m^3	5	10

Worldwide Emission limits for Dioxins & Furans

Emission limits that have been established for Dioxins & Furans in an iron sintering plant in other countries are given in **Table: 6.7.**

Canada-Wide Standards (CWS)

In 1998 the Canadian Council of Ministers of the Environment (CCME) established dioxins and furans as a primary substance for Canada-Wide Standards (CWS) development. The objective of the CWS process was to make significant strides in reducing anthropogenic releases of dioxins and furans. Particulate Matter concentrations in iron sinter emissions were considered to have relationship with Dioxins and furans. Thus, CWS recommended the limits for iron sintering as given in **Table: 6.8**.

Table: 6.8 Canada-Wide Standards (CWS)

Facility	Dioxins/furans emission limits (pg ITEQ/ Rm^3	Scheduled date	Anticipated particulate emissions (mg/ Rm^3)
Existing	1350	2002	<50
	500	2005	<50
	200	2010	<20
New or expanding	200	CWS effective date	<20

Table: 6.7 Emission Concentration Limits for Dioxins & Furans in Other Countries

Country	**Emission Limit (PCDD/PCDF)**	**Comments**
Austria	0.4 ng I-TEQ/m3	Applicable to new plants built after 2001
Canada	0.2 ng I-TEQ/Rm^3	For new plants
	<1.35 ng I-TEQ/Rm^3	For existing plants, to be achieved by 2002
	<0.5 ng I-TEQ/Rm^3	For existing plants, to be achieved by 2005
	<0.2 ng I-TEQ/Rm^3	For existing plants, to be achieved by 2010
Germany	0.1 ng I-TEQ/m^3	Target
	0.4 ng I-TEQ/m^3	Upper limit
Japan	0.1 ng WHO-TEQ/m^3	For new plants
	1 ng WHO-TEQ/m^3	For existing plants
Netherlands	0.1 ng I-TEQ/m^3	Desirable
United Kingdom	0.1 – 0.5 ng I-TEQ/m^3	Benchmark emission values

CHAPTER- 7

CLEANER TECHNOLOGY OPTIONS FOR SINTERING PLANTS

Cleaner technology means process and practices that avoids or minimize materials, products or energy and the creation of pollutants and wastes, and reduce overall risk to human health or the environment.

In recent years, a number of important developments have been made in the field of iron ore sintering technology, which have substantially contributed to increased productivity, improved and uniform product quality, reduced energy consumption, lower operational costs and particularly decisive environmental advantages.

During this study various cleaner technology options for sinter plant of an Integrated Iron & Steel Plants were identified. Some of the identified technologies are already implemented in few existing sinter plant and some are proposed to be implemented in upcoming plants. Later in this chapter, emerging cleaner technologies have been discussed which are under development or yet to be introduced for large scale commercial implementation.

Identified cleaner technology options for Indian sinter plant are discussed in detail in subsequent pages.

7.1 Cleaner Technology Options

7.1.1 Waste Heat Recovery System of Exhaust Gas

The sintering process takes up approximately 10 % of the energy consumption for an integrated iron and steel works. In the sintering process itself, however, exhaust heat discharged to the atmosphere makes up approximately 52 % of the output heat.

Heat recovery at the sinter plant is a means for improving the efficiency of sinter making. In a sintering process about 24.3% of the heat energy goes to the atmosphere with the waste gases and about 30.6% heat is contained in sinter cooler exhaust air. There is opportunity to tap this sensible heat and utilize to preheat the combustion air for the burners and to generate high pressure steam, which can run through turbines for electricity generation. Various systems exist for new sinter plants and as well as existing plants can be retrofitted. A Typical Energy Balance Diagram and a scheme of waste heat recovery based power plant is shown of Sinter Plant is shown in **Fig : 7.1**

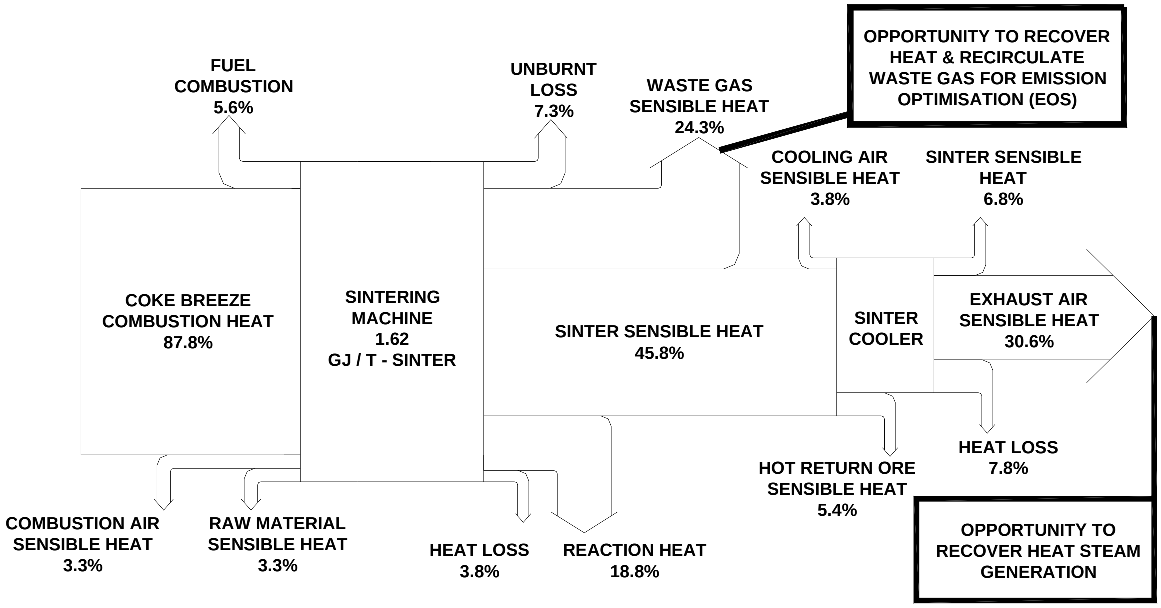


Fig. 7.1: A Typical Energy Balance Diagram of Sinter Plant

Techniques to recover exhaust heat of medium and low temperature such as cooler exhaust gas and main exhaust gas have been developed since 1976 at Kokura Steel Works, Sumitomo Metal Industries, Ltd., and practical applications of the cooler exhaust heat recovery system, the main exhaust heat recovery system and main exhaust gas circulation system have been realized. The typical flow sheet of the sinter plant with waste heat recovery system of exhaust gas is shown in **Fig.7.2.**

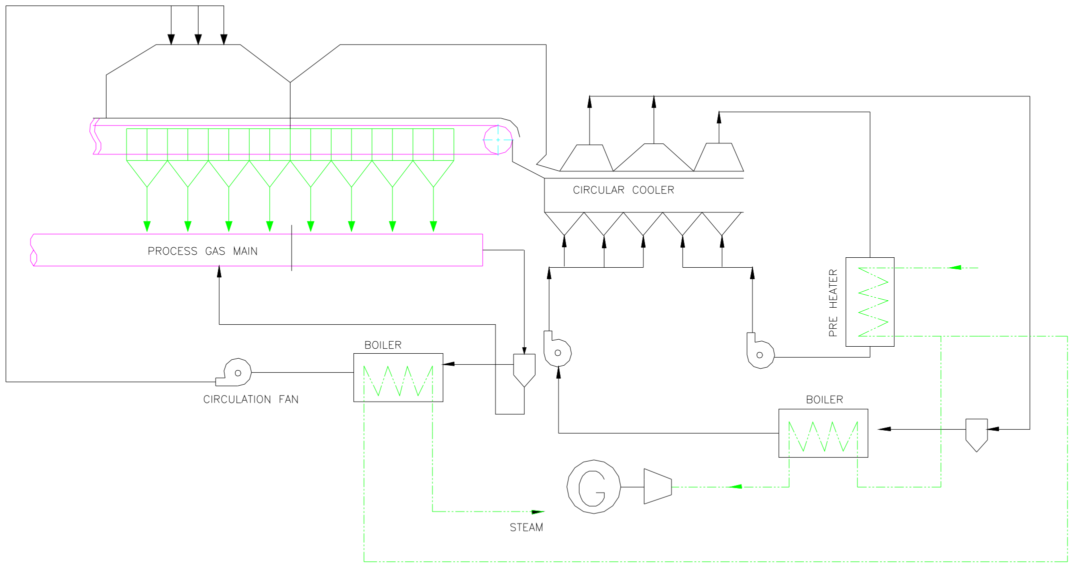


Fig. 7.2: Flow diagram of the cooler exhaust heat recovery system

A flow diagram of the cooler exhaust heat recovery system, the main exhaust heat recovery system and main exhaust gas circulation system is shown in **Fig.7.2.** These systems were constructed in 1982 and generate superheated steam with a temperature of 270 ^{0}C and a pressure of 9 kg/cm^2 G. This superheated steam is used for the generator. The recovered steam from these systems reaches approximately 110 kg/t, recovering 25% output heat at the sintering plant.

7.1.2 Main Exhaust Gas Circulation

The purposes of development of a main exhaust gas circulation technique are the reutilization of main exhaust heat after recovery and the reduction in initial and running costs of the main exhaust gas dust collector and the de-sulphurizing equipment by means of a reduction in main exhaust gas volume discharged to the atmosphere.

The main exhaust gas generated from wind boxes at the latter half of the machine is utilized for the heat exchanger of main exhaust gas. Exhaust gas with a temperature of 220°C and an oxygen concentration of 19.5 to 20.5 % after heat exchange is drafted into the sintering machine in order to increase the temperature of the sinter and the exhaust as used for main exhaust heat recovery.

7.1.3 Emission Optimized sintering (EOS)

Iron ore sintering creates substantial off-gas volumes, and treating these in order to meet increasingly stringent environmental standards is expensive. Emission Optimized Sintering process (EOS) developed by Outo Tech, GmBH, Germany uses recycling technology to reduce off-gas volumes by 40 to 50 %, resulting in smaller secondary gas treatment systems. This means:

- Lower capital investment
- Reduced operating costs

Conventional sintering uses ambient air to transport heat within the sinter bed, requiring a high air flow rate. However, EOS takes advantage of the fact that only a part of the oxygen in the air is consumed for coke combustion. Therefore, a part stream of the off-gas is recycled via the hood, enriched with ambient air to an oxygen content of 13-14 % and used as intake process air. This reduces off-gas volumes by about 40-50% without affecting the sintering process. The typical flow sheet of the sinter plant with EOS system is shown in **Fig. 7.3**.

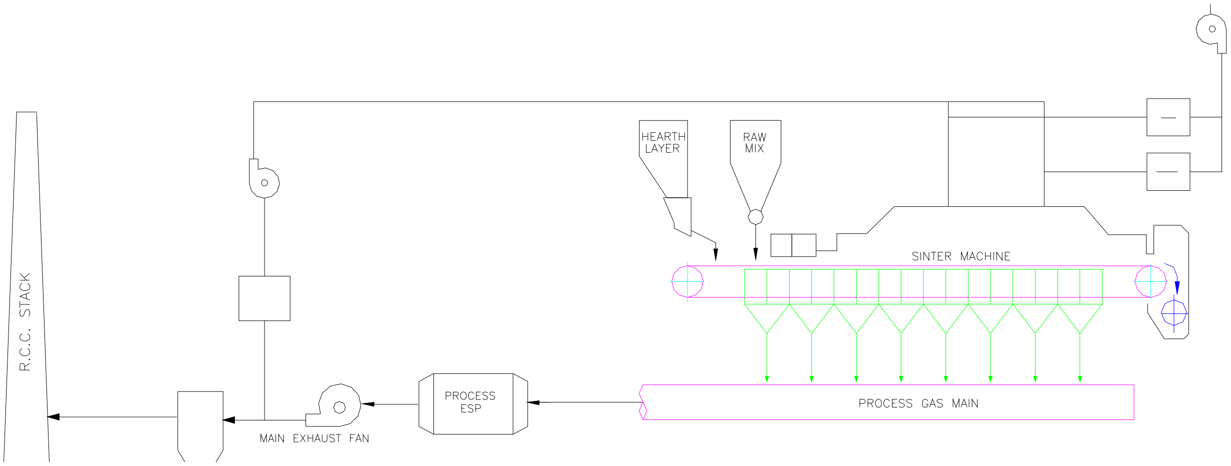


Fig. 7.3: Typical flow sheet of the sinter plant with EOS system

CO and pollutants like SO_x, NO_x dust and dioxins/furans are passed through the sinter layer together with the recirculated gas. While CO is post-combusted, substantially saving on solid fuel, the pollutants are partially retained in the sinter layer and/or thermally decomposed.

In integrated steel plants about 75% of the CO_2 emissions are generated in the blast furnace and about 12% in the sintering process. When following the international CO_2 policy, the Kyoto protocol, and as there is only a minimum technical margin for CO_2 reduction measures in the blast furnace, EOS brings significant benefits for all steel plant operators.

7.1.4 Intensive Mixing & Granulation System

Developed by	:	VAI Siemens
Year of development	:	1998
Process description	:	This process is for intensive mixing of raw materials & formation of micro-balls. A high-speed agitating mixer and a drum mixer are added to the conventional system for producing granulated ore. This will largely minimize requirement for base blending yard and drastically reduce the space requirements & consequently the cost related to the base blending yard for sinter plant.

Advantages :

- No pre blending requirement
- Completely homogeneous sinter raw mix.
- High productivity of sinter plant even with ultra-fine grain size of materials
- Low solid fuel consumption.

Status : Implemented at Dragon Steel, Taiwan; VA Stahl, Donawitz, Austria

This results in increase in productivity, less water consumption, higher granulation rate, increased permeability, better flame front speed and decrease in return fines. A block diagram of the Intensive Mixing & Granulation System is shown in **Fig. 7.4**.

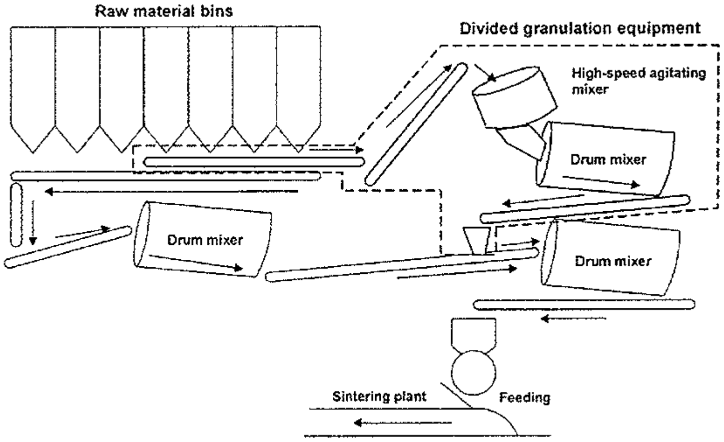


Fig. 7.4: Block diagram of Intensive Mixing & Granulation System

7.1.5 Selective Sinter Waste Gas Recirculation System

Sinter waste gas typically contains approximately 12-13% residual oxygen and sufficiently high temperature, which is suitable for recirculation to the sintering process after the addition of a small amount of supplementary air. In the existing waste gas recirculation systems a portion of the waste gas from all wind boxes is extracted for recirculation to the sinter strand. However, in the EPOSINT (environmental process optimized sintering), process, the off-gas from selected wind boxes is used for recirculation to the sinter strand. In Selective Sinter Waste Gas Recirculation System, waste gas from the 1st and 3rd zones of the sinter machine is mixed with cooler off-air and/or ambient air and subsequently re-circulated above the 2nd zone of the sinter machine with the help of a recirculation hood. A schematic diagram of the selective waste gas re-circulation system is shown in **Fig. 7.5**.

Advantages:

- Increased sinter production at stable sinter quality.
- Decreased energy consumption.
- Reduction in sinter off-gas volume.
- Suitable for installation in existing sinter plants in order to reduce the waste-gas volume emitted from the stack.

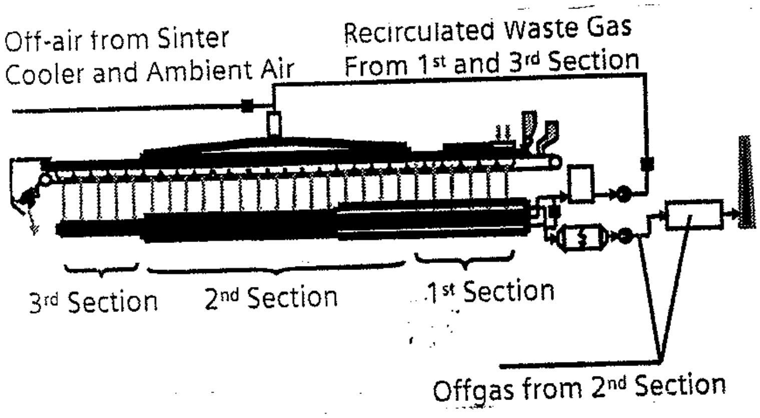


Fig. 7.5: Selective waste gas re-circulation system

7.1.6 Sinter Cooler Off-air Recirculation and Energy Recovery

The hot cooler off-air is re-circulated to the sinter machine either in a single stream or in two passes, where it is mixed in the selective sinter waste gas recirculation system for pre-drying of the sinter raw mix charged as lower layer to the sinter machine and also as hot ignition air in the ignition system to reduce ignition gas consumption.

Advantages:

- Decreased energy consumption.

A schematic diagram of the facility is shown in **Fig. 7.6 & Fig. 7.7** respectively.

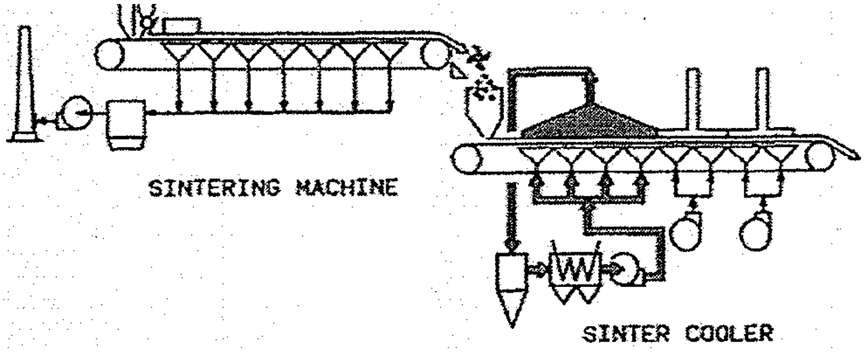


Fig. 7.6: Schematic diagram of Sinter Cooler Off-air Recirculation system in single pass

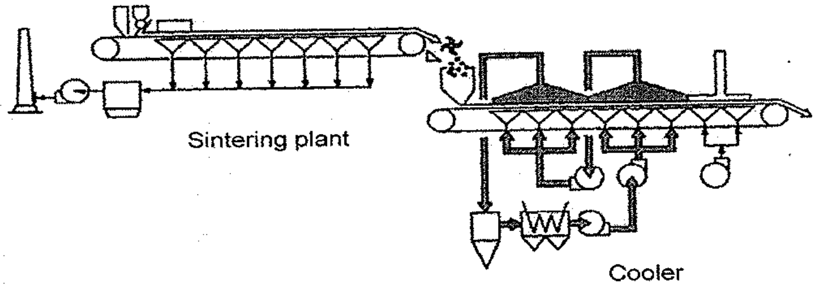


Fig. 7.7: Schematic diagram of Sinter Cooler Off-air Recirculation system in two pass

A process flow of a typical waste heat recovery before and after installation of heat recovery facility is shown in **Fig. 7.8**

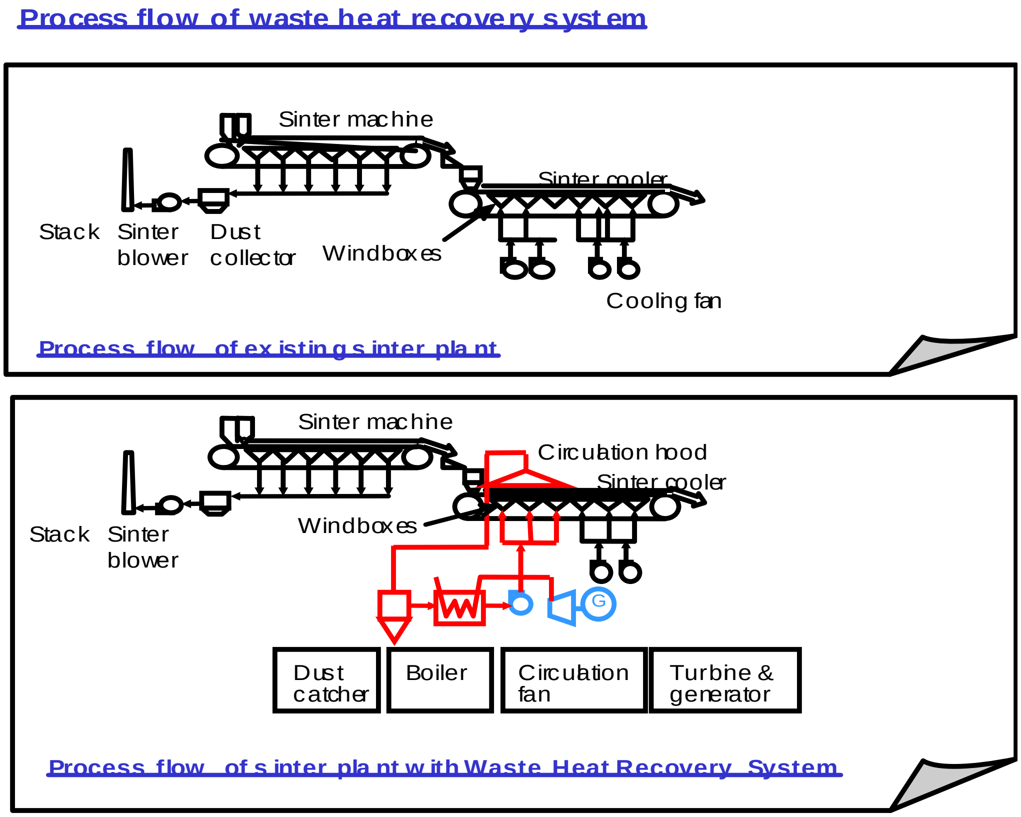


Fig. 7.8: A typical installation before and after heat recovery system

7.1.7 Sinter Raw Mix Charging by Twin-Layer Charging System

Modern sinter machines have high bed heights of up to 800 mm therefore, the raw mix charging system is of utmost importance. To achieve the required uniform segregation of the material based on grain size and to maintain a high degree of permeability, the twin-layer charging system is applied. In this system the coarser sinter raw mix is first charged on top of the hearth layer as the “lower layer”, followed by the charging of the finer sinter raw mix granules as the “upper layer”. The coke portion is automatically increased in the upper layer by segregation. A schematic diagram of the twin-layer charging system is given in **Fig. 7.9**.

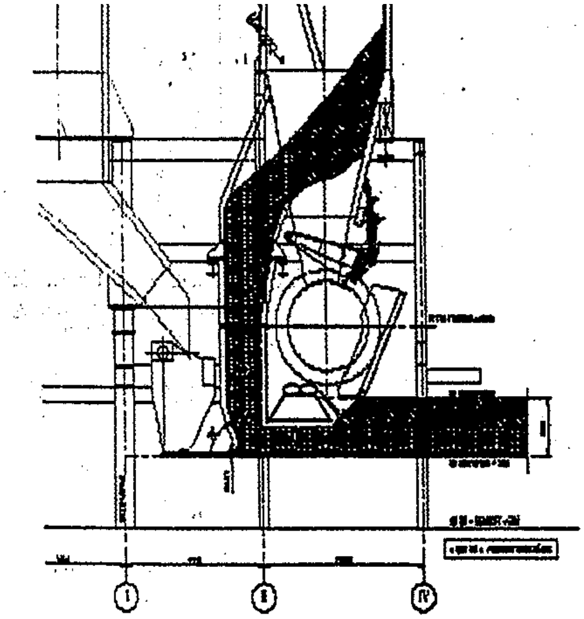


Fig. 7.9 : Twin-layer charging system

Advantages:

- High plant productivities even when the sinter machine is operated with a bed height of up to 800 mm.
- Low solid fuel consumption
- High quality, uniform and stable sinter quality.

7.1.8 Improvements in Feeding Equipment:

Installation of an additional screen on the conventional sloping chute, promotes more desirable distribution of granulated ore on the palette. The screen with a sloping chute places coarser granulated ore in the lower part of the palette and finer ore on the upper part, which achieves high permeability. A block diagram of the facility is shown in **Fig. 7.10**.

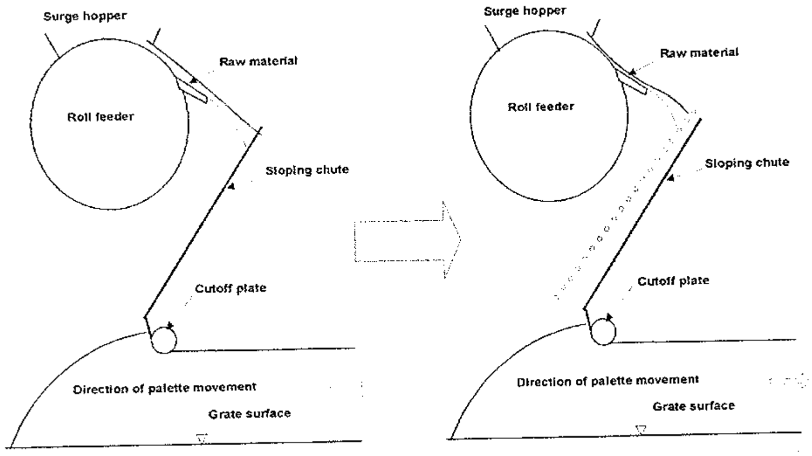
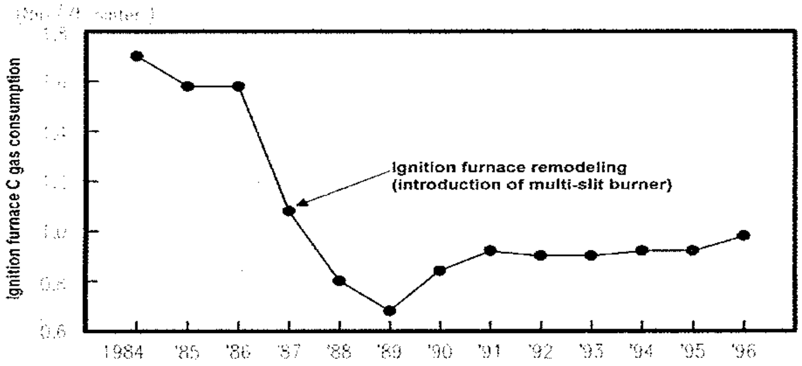


Fig. 7.10: A block diagram showing improvements in feeding equipment

7.1.9 Multi-slit Burner in Ignition Furnace:

Multi-slit burners produce wide, large and stable flame, which eliminates "no flame" areas and supplies minimum heat input for ignition, therefore saving energy. Reduction in total heat input of the order of 30% approximately has been achieved at commercial scale (**Fig. 7.11**). A block diagram of the system is shown in **Fig. 7.12.**

- ***Before/after comparison for introduction of multi-slit burner***



Transition of ignition furnace C gas basic units
(No. 5 Sintering Plant, Wakayama Steel Works, Sumitomo Metal Industries)

Fig. 7.11: Reduction in gas consumption after introduction of multi-slit burner

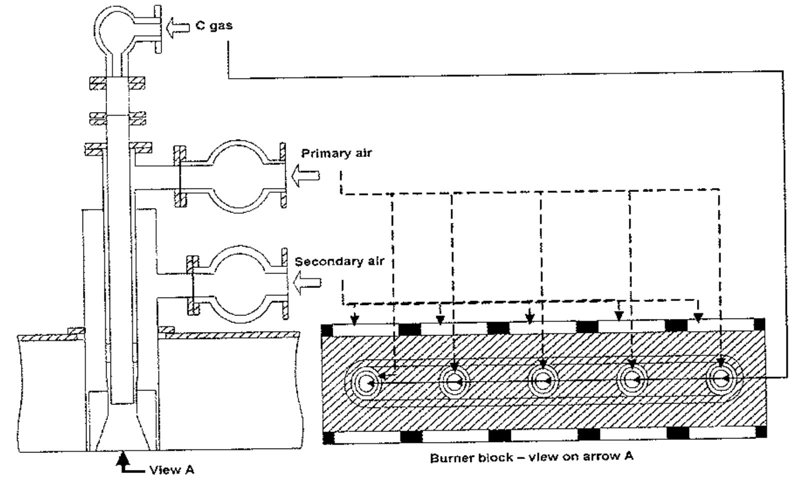


Fig. 7.12: A block diagram of multi-slit burner

7.2 End of the pipe treatment

The waste gas arising from sinter plants is treated in ESP, multi cyclone or scrubber. However, all the sinter plants installed after year 2000 and some old plants are equipped with Electro Static Precipitators (ESPs) for cleaning process emissions.

The coarse dust is removed in the dry dust catchers and is recycled back to the sinter process. Fine dust arises from the sinter process after water evaporation is complete. The fine dust is separated by ESPs or bag filters with high de-dusting efficiency. In an ESP particulate laden gases pass through perforated plate and diffusers. High voltage electrodes impart a negative charge to the dust particles. The negatively charged particles are then attracted to a grounded surface, which is positively charged, thereby producing clean waste gas. ESPs have dust removal efficiencies up to 99.9%. Three types of dust collectors are in practice in a sinter plant, ie., Cyclone, bag Filter and Electrostatic Precipitator (ESP). Their comparative utilities are shown in **Table : 7.1**

Table : 7.1 Three types of dust collectors are in practice in a sinter plant

	Dust collecting capacity	Maintenance	Cost of operation	Cost of equipment
Cyclone	Small	Easy	Medium	Low
Bag filter	Large	Difficult	High	Medium
ESP	Medium	Medium	Low	High

Flat plate type ESPs are most commonly used ESPs. A schematic diagram and the principle of Flat plate type ESPs is shown in **Fig. 7.13 & Fig. 7.14** respectively.

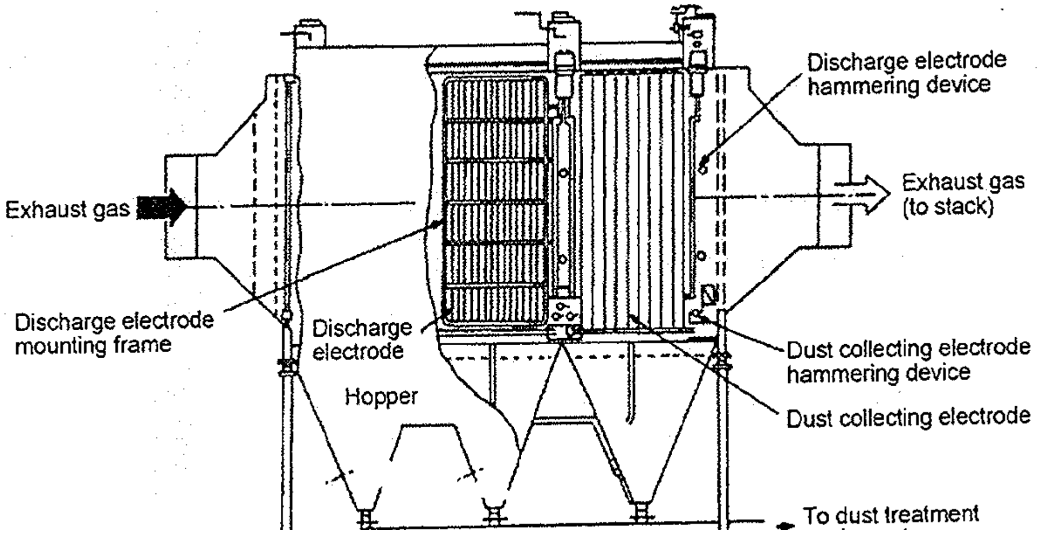


Fig. 7.13: A schematic diagram of Flat plate type ESP

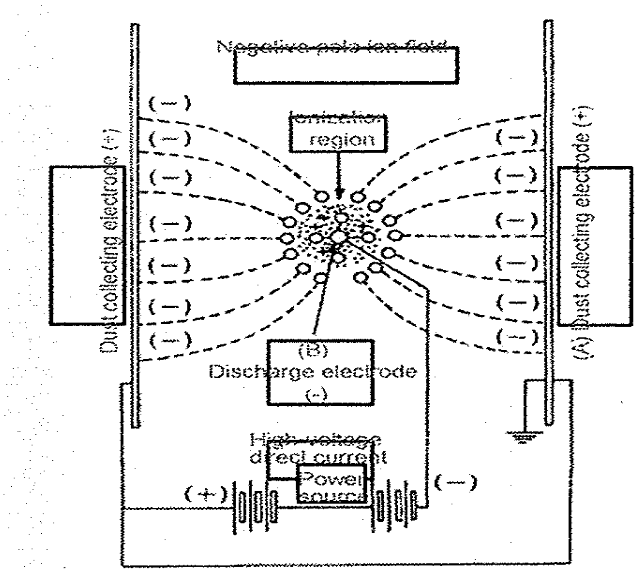


Fig. 7.14: A schematic diagram of the principle of Flat plate type ESP

In addition to conventional flat plate type ESPs, Cylindrical type ESPs and Mobile electrode type ESPs are also in practice. Typical diagram of these ESPs are shown in **Fig. 7.15 & Fig. 7.16**

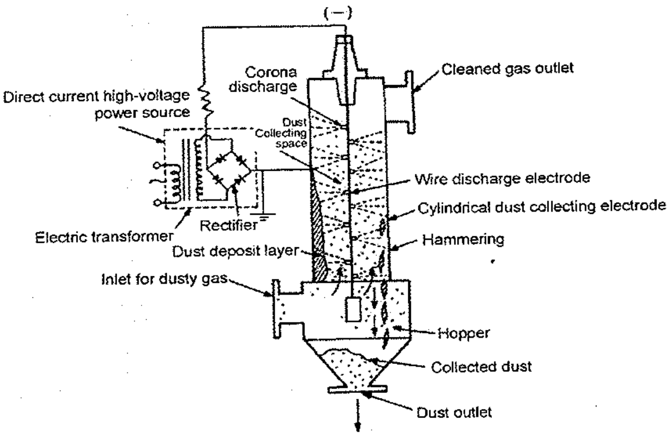


Fig. 7.15 Cylindrical type ESP

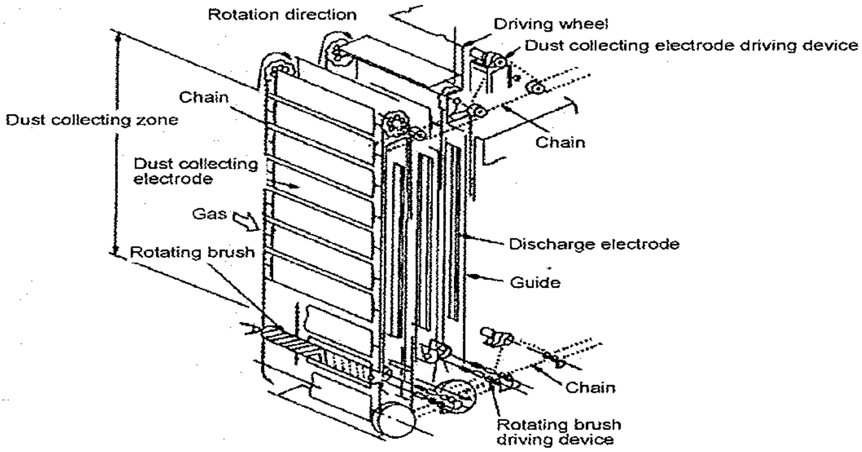


Fig. 7.16: Mobile electrode type ESP

7.3 Existing Cleaner Technologies in Indian Sinter Plants

During this study various cleaner technology options for Indian sinter plant of an Integrated Iron & Steel Plants were identified. Some of the identified technologies are already implemented in few existing sinter plant and some are proposed to be implemented in upcoming plants. Most of the upcoming sinter plants are adapting to cleaner technologies in sinter plants for improving energy efficiency & for power generation.

Some of the existing cleaner technologies are,

- Partial recovery of heat from cooler and utilization of the same as hot air for combustion in ignition furnace. (Tata Steel–SP3, BSP-SP3, NINL, JSPL)

- Variable voltage variable speed fan drives for main exhaust fan. (Tata Steel –SP3, BSP-SP3, NINL, JSPL)
- Floating foundation with vibration isolators for exhaust and cooler fans. (Tata Steel –SP3)
- Heating of water by coiling pipe at the end part of the wind box, which is at relatively higher temperature. (Tata Steel –SP3)
- Heating of water from initial one third of the cooler top, where temperature of cooler off gas is relatively high and use the same in MND. (Tata Steel –SP3)
- ESP dust granulation for recycling. (Tata Steel)

The identified cleaner technologies can be implemented in the plants to improve their environmental performance and reduce resource consumption. A comparative chart of cleaner technology options for Indian sintering plants vis-à-vis ease of implementation, limitations, environmental benefits and reference Indian steel plant is presented in **Table : 7.2** for better comparison of available options.

Table : 7.2 Comparative Chart on Cleaner Technologies for Sinter Plants

S.no	Cleaner technology	Benefits	Ease of implementation	Limitation/Cross media effect	Reference Indian Steel plant (existing/upcoming)
1.	Emission optimized sintering	50% Waste gas vol. reduced, CO post combusted, pollutants (dust, SO_x, NO_x, dioxin/furan) retained in sinter layer or thermally decomposed, reduced energy consumption	Low	In existing sinter bed it is difficult to implement due to leakages and automation interfacing limitations. interfacing	None
2.	Sinter cooler off air recirculation	Energy recovery	Moderate	Space limitations for duct network and fan installation	ISP, BSP, RSP, JSPL, Tata, Bhushan
3.	Sensible heat recovery system	Power generation (20.6MW by RINL)	Low	Space constraints for boiler fixing and high sinter cooler bed height is required.	RINL retrofitting system
4.	Intensive mixing & granulation system	Less fuel & water consumption, decrease in return fines, increased productivity	Moderate	--	ISP, BSP, RSP, JSPL, Tata, Bhushan
5.	Selective waste gas recirculation	20-30% Waste gas vol. reduced, reduced energy consumption, increased productivity	Low	Leakage problems	JSPL
6.	Raw mix charging by twin layer system	Low fueal consumption, increased productivity	Moderate	--	ISP, BSP, RSP, JSPL, Tata, Bhushan
7.	Multi-slit burner	Reduction in NOx emissions, 30% reduced heat input	Moderate	--	ISP, BSP, RSP, JSPL, Tata, Bhushan
8.	VVVF at main exhauster fan	Reduced power consumption	Low	--	ISP, BSP, RSP, JSPL, Tata, Bhushan, NINL
9.	Dioxin & furan control tech.*	Removal of Dioxin & Furan	Low	Technology under development	--
10.	MEROS*	Removal of dust, acid gases, harmful metallic and organic component from waste gas	Low	Technology under development	--

* Emerging cleaner technologies- Discussed in subsequent pages

7.4 Cost Factor

The cost of implementation of a cleaner technology is worked out on case to case basis, depending upon the size & age of the sinter plant and type of cleaner technology proposed to be adopted.

As per estimation, the cost of waste heat recovery systems with power generation is approximately 20% of the project cost. In India, such system is coming up in Vishakhapatam Steel Plant. The cost of emission optimized sintering is approximately 10% of project cost for a new plant.

Maximized Emission Reduction of Sintering (MEROS) is among future technologies and cost of implementation of such technologies is approximately 25% of the project cost.

In addition, a typical cost break-up for environmental protection measures for a new sinter plant of size 204 m^2 is given below in **Table 7.3**:

Table 7.3: Cost of environmental protection measures for sinter plant

S. No.		**Recurring Cost per annum (Rs.)**	**Capital Cost (Rs.)**
A.	**Sinter Plant**		**275 crores**
B.	**Environment Protection Measures**		
1	Air Pollution Control	35.08 lakhs	10.56 crores
2	Water Pollution Control	-	NA
3	Noise Pollution Control	-	-
4	Environment Monitoring and Management	-	Rs. 6.88 lakhs for sinter plant. Rs. 4.65 crores for centralized Env. Lab. & Management.
5	Occupational Health	-	NA
6	Green Belt	8.10 lakhs	-
7	Others (Testing & Monitoring)	15.31 lakhs for centralized Env. Lab.	-
Total		**Rs. 58.49 lakhs**	**15.28 crores**

7.5 EMERGING SYSTEMS

7.5.1 Exhaust gas treatment through De-nitrification, De-sulfurisation and Activated Coke Packed Bed Absorption

Sintering exhaust gas contains SO_X, NO_X, dust and dioxins. These contaminants are processed, absorbed, decomposed and collected as non-toxic by-products. Treatment methods to achieve these include:

- De-nitrification
- De-sulfurisation
- Activated Coke Packed Bed Absorption

Nitrogen oxides in the exhaust gas are decomposed to nitrogen, water and oxygen by de-nitrification of the sintering exhaust gases by ammonia. A schematic diagram of the facility is shown in **Fig. 7.17**

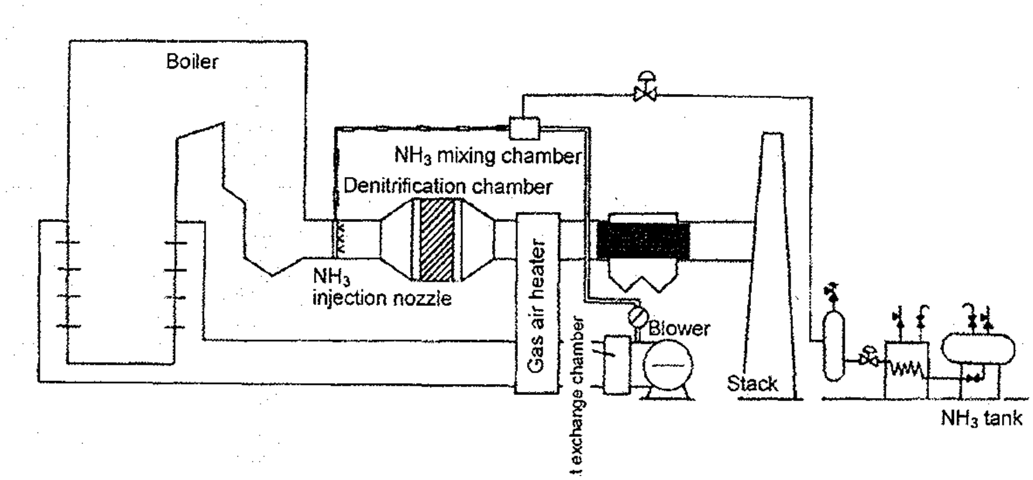


Fig. 7.17: Schematic diagram of De-nitrification facility

7.5.2 De-sulfurisation of highly concentrated SOx gases

Sintering exhaust SOx Rich Gases (SRG) are treated by utilizing either of the following methods:

1. Lime gypsum method
2. Magnesium hydroxide method
3. Soda method

A comparison of the treatment methods for sintering plant exhaust gases is shown in **Table: 7.4**

Table: 7.4 A comparison of the treatment methods for sintering plant exhaust gases

Method	**Scale of equipment**	**Product**	**Cost of operation**	**Characteristics**
Soda method	Small	Na_2SO_4	High	Suitable for small scale equipment since the cost of operation is high
Magnesium hydroxide method	Medium	Mg SO_4	Medium	-
Lime gypsum method	Large	$CaSO_4$ (Gypsum)	Low	Suitable for large scale equipment. By-product can be utilized.

By these processes SO_X is absorbed and recovered as useful by-product.

7.5.3 Activated Coke Packed Bed Absorption

Activated Coke Packed Bed Absorption Method is followed to eliminate Dust, SOx, NOx and Dioxins from sinter plant exhaust gases. Dioxins are collected and absorbed in activated coke and decomposed at 400 ºC in absence of oxygen. Dust is also collected in activated coke. Activated Coke Absorption removes dioxins to <0.1 ng-TEQ/$Nm^{3.}$ A process flow diagram of the facility is shown in **Fig. 7.18.**

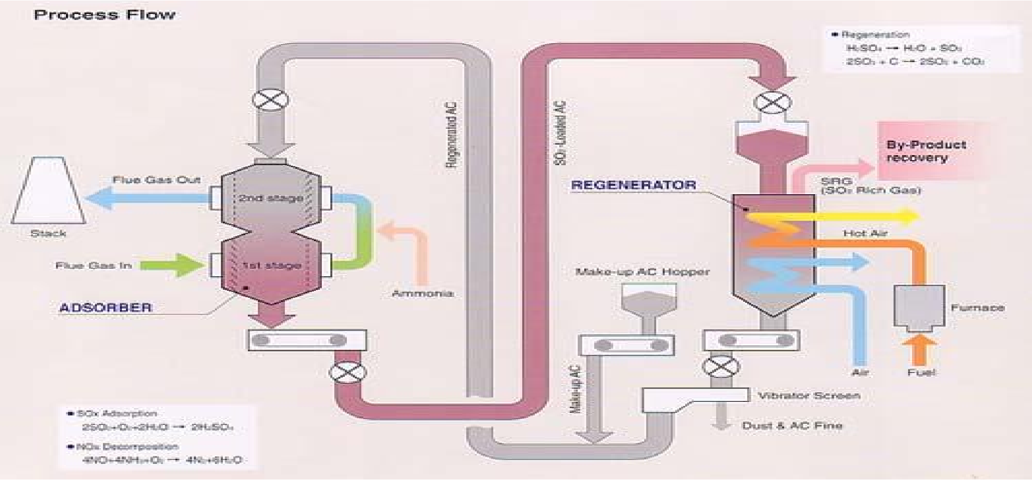


Fig. 7.18: Activated Coke Packed Bed Absorption

Effect of the Activated Coke Absorption Method is shown in **Table: 7.5**

Table: 7.5 Effect of the Activated Coke Absorption Method

Pollutant	Results
Dioxins (ng-TEQ/Nm^3)	<0.1
Dust (mg/Nm^3)	<10
SO_X (% absorbing ratio)	< 65
NO_X (% decomposing ratio)	-

Comparison of Treatment Methods for dioxin, dust, SOx and NOx in sintering plant exhaust gas is shown in **Table: 7.6**

Table: 7.6 Comparison of Treatment Methods for Sintering Plant Exhaust Gases

	Activated Coke Absorption Method	Dielectric exhaust gas purifying equipment	Mobile electrode ESPs
Dioxins in particulate form	Collects and decomposes	Collects	Collects
Dioxins in gaseous form	Absorbs and decomposes	Collects (Uncertain)	Difficult
Dust	Collects	Collects	Collects
SO_X	Absorbs	Absorbs (Requires De-SO_X equipment)	NON
NO_X	Decomposes (Requires NH_3)	NON	NON

7.5.4 Exhaust Gas Treatment through Selective Catalytic Reduction

SO_X and dioxins contained in the sinter flue gas are removed in this process by adding sodium bi-carbonate and Lignite. For SO_X removal the reactions are:

$2\ NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O \quad (T > 140\ ºC)$

$Na_2CO_3 + 2SO_2 + 1/2\ O_2 \rightarrow Na_2SO_4 + 2\ CO_2$

NO_X is removed by selective catalytic reduction reaction at around 200-450 ºC:

$4NO + 4NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$

A process flow diagram of the facility is shown in **Fig. 7.19.**

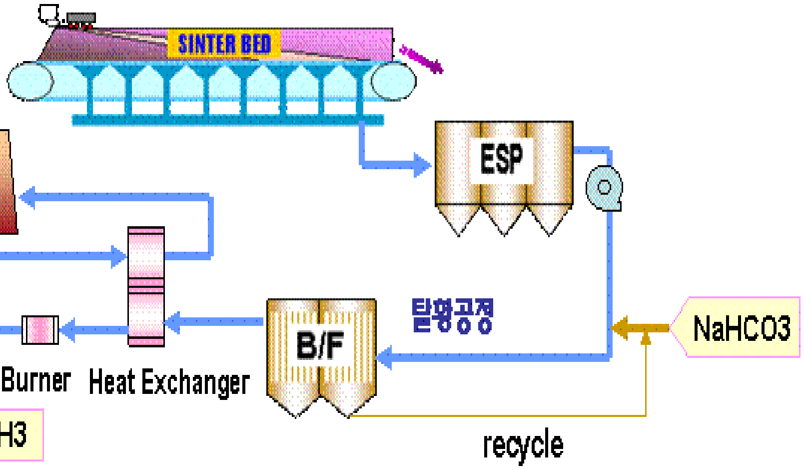


Fig. 7.19: Exhaust Gas Treatment through Selective Catalytic Reduction

7.5.5 Exhaust Gas Treatment through Low – Temperature Plasma

Active radicals of low-temperature plasma remove SO_X and $NO_{X.}$ Dioxins are also decreased with the addition of lignite to the process. Reliability and stability of the process is proved for over five years of operation. This is low cost with high pollutants removal efficiency process. Space requirement is less than other processes. Reduction in $SO_{X,}$ (>70%), NO_X (>95%) and Dioxins (< 0.2 ng-TEQ/Nm^3) has been achieved at commercial scale. A block diagram of the facility is shown in **Fig. 7.20**

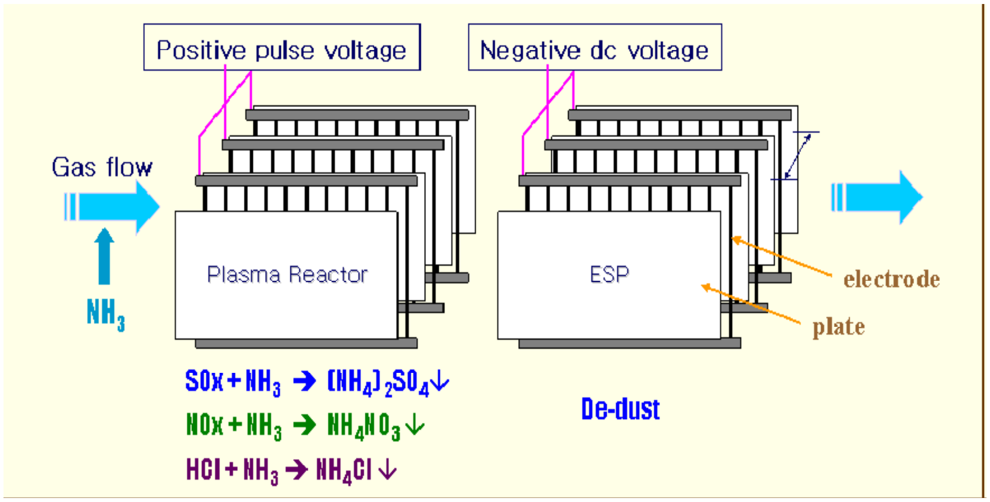


Fig. 7.20: Exhaust Gas Treatment through Low – Temperature Plasma

7.5.6 Use of Biomass

Biomass utilization practices are being developed to replace coke breeze in the sintering process. Charcoal has been found to be as effective fuel as high rank coals for the smelting of iron ores and wood char has been shown to be a suitable replacement for coke breeze in the sintering process, resulting in process improvements and reduction of acid gas levels in process emissions.

7.5.7 MEROS

The treatment of the sinter off-gas arising during the sintering process is a major challenge for which no fully satisfactory solution has existed up until now. Siemens VAI has developed a process called Maximized Emission Reduction Of Sintering (MEROS), in which dust, acid gases and harmful metallic and organic components present in sinter off-gases are removed in a few treatment steps. Installation of world's first MEROS facility was developed by voestalpine Stahl, Linz, Austria. This system is capable of treating more than 1,000,000 m^3 of waste gas per hour.

The Siemens sinter off-gas purification system consists of 3 main components :

1. The pre-dedusting system, which is installed before the sinter waste gas main blower(s).
2. The main dedusting; desulphurization, dioxin and heavy metals removal system.
3. The De NOx System

For pre-dedusting, electrostatic precipitators or special cyclones with a de-dusting efficiency of >95% are applied. Practically 100% of the dust extracted in the pre-dedusting system can be recycled to the sinter production.

For the main dedusting, desulphurization, dioxin and heavy metals removal system, a special and extremely efficient bag filter system with special coating is applied. For the DeNOx system, a special catalyst system is used. To minimize the investment and operational costs, the sinter off-gas purification system is combined with Siemens VAI's Selective Waste Gas Recirculation System. With the application of the system following results and advantages can be achieved:

Dust : <10 mg/Nm^3
SO_X : <50 mg/Nm^3
NO_X : <70 mg/Nm^3
Dioxins : <0.1 ng TEQ/Nm^3

A process flow diagram of MEROS process is shown in **Fig. 7.21**.

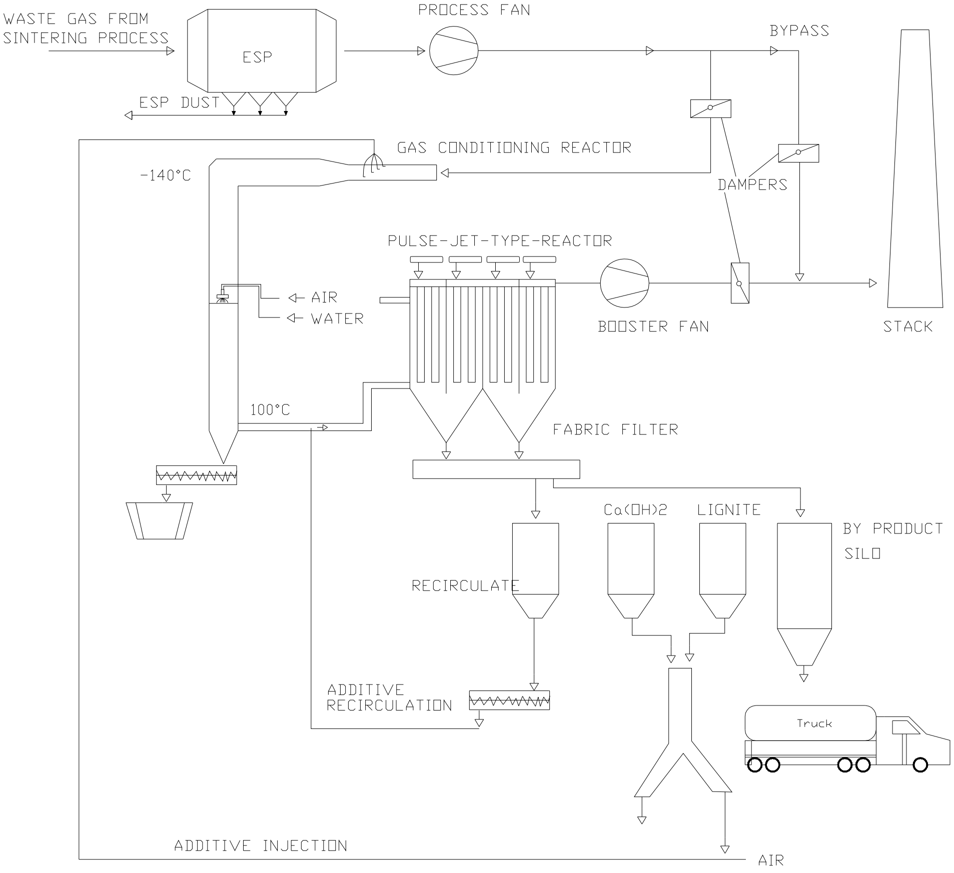


Fig. 7.21: Flow diagram of MEROS process

CHAPTER- 8

SUGGESTED PRACTICES FOR POLLUTION PREVENTION

8.1 Proposed Measures for Pollution Prevention in Sintering Plants

As outcome of this study following practices are identified for preventing and minimizing emissions from sinter plants.

Table: 8.1 Suggested Measures for Pollution Prevention in Sintering Plants

Measure	Description	Considerations
Stable and consistent operation of the sinter plant	The strand should be operated to maintain stable consistent operating conditions (e.g., steady-state conditions, minimization of process upsets. This approach will have co-benefits such as increased productivity, increased sinter quality and improved energy efficiency.	Conditions to optimize operation of the strand include : - minimization of stoppages - consistent strand speed - bed composition - bed height - additives (e.g., burnt lime) - minimization of oil content - minimization of air in-leakage
Continuous parameter monitoring	A continuous parameter monitoring system (CPMS) should be employed to ensure optimum operation of the sinter strand and off-gas conditioning systems. Operators should prepare a site specific monitoring plan for the CPMS and keep records that document conformance with the plan.	Correlations between parameter values and stack emissions (stable operation) should be established. Parameters are then continuously monitored in comparison to optimum values. System can be alarmed and corrective action taken when significant deviations occur.
Sinter Cooler Off-air Recirculation and Energy Recovery	The hot cooler off-air is re-circulated to the sinter machine as hot ignition air in the ignition system to reduce ignition gas consumption.	Decreased energy consumption.
Recirculation of Waste Gases	Waste gases should be recycled back to the sinter strand to minimize pollutant emissions and reduce the amount of off-gas requiring end-of-pipe treatment.	Recirculation of the Waste gases can entail recycling of part of the off-gas from the entire sinter strand, or sectional recirculation of off-gas.

Measure	Description	Considerations
Feed material selection : **Minimization of feed materials contaminated with POPs or leading to POPs formation.**	A review of feed materials and identification of alternate inputs and/ or procedures to minimize unwanted inputs should be conducted.	Examples include : - Removal of the contaminant from the feed material (e.g., de-oiling of mill scales) - Substituting material (e.g., replacement of coke breeze with anthracite) - Avoid use of the material containing alkali chlorides such as dust collected in the last field of ESP - Feeding unwanted substances in permissible concentrations (e.g., oil content in feed should be limited to less than 0.02%)
Feed material preparation	Fine material (e.g., collected dusts) should be agglomerated before being placed on the sinter strand. Feed materials should be intimately mixed before placement on the sinter strand. These measures will help reduce entrainment of pollutants in the waste gas, and minimize fugitive emissions.	--
Feed material transfer points	As an alternative Dual Fluid (Compressed Air + water) dust suppression system may be considered. This minimizes fugitive dust emissions.	--
Main exhauster Fan	Variable voltage variable speed fan drives for main exhaust fan.	For better process control and energy optimization
ESPs	Pulsed Energisation of ESPs for high resistivity sinter dust.	For better dust collection and energy optimization

8.2 Good Operating Practices

In addition to above, following design, operation & equipment aspects should be adopted for improving environmental performance of sintering plants:

Design Aspects

- Reduction of ignition furnace fuel
- Reinforce granulation
- Charge density control
- Reduction of furnace volume
- Speed Control of Exhauster
- Furnace pressure control
- Introduction of multi-slit/ high efficiency burner in ignition furnace
- Rationalization of blower efficiency

Operational & Equipment aspects

- Improvement of air flow (increase permeability, reduce suction pressure)
- Improve productivity (Increase in bed-height)
- Use of binder (addition of burnt lime) in Raw Mix
- Optimization of water addition
- Even baking segregation feeding equipment
- Control of coke breeze size
- Increase of surface density of bed
- Prevention of excess Air
- Crushing Reduction Index
- Prevention of air leakage
- Exhaust heat recovery of cooler exhaust heat
- Main exhaust heat recovery
- Main exhaust gas circulation
- Reinforcement of sealing between palettes
- Reduction of coke
- Reduction of electric power
- Increase of heat recovery
- Reduction in hydrocarbon level in the raw materials (e.g. in mill scale)

Following measures will also improve the productivity and reduce the pollution load from the plant.

1) Reduction in alkali chloride content of sinter process ESP hopper dust

Excess alkali chlorides dust (KCl & NaCl) contain volatile alkali metals which may evaporate in the 1st filed of ESP and condense / solidifies in the last filed of ESP collecting electrodes . By this process effective area of collecting electrode area reduces and emission level rises. To limit alkali chloride content in coming dust, recycling of ESP dust from last field to the process is regularly monitored. If the alkali chloride content in ESP dust from last field increases to 25 mg /Nm^3 then dust should not be recycled in the process. In the last section of an ESP, dust with the finest particles and the highest alkali chloride content must be treated or disposed in landfill.

2) Installation of high efficiency ESPs

Installation of high efficiency ESPs (98% or more) at new and existing plants may reduce PM emission levels at sinter plants to about 50 – 150 mg/m^3 depending on actual Specific Dust Resistivity (SDR) and/or sinter basicity, waste gas moisture content , waste gas temperature , treatment time and treatment velocity in ESP.

3) Fan System Loading Cycle Assessment and Efficiency Enhancement for Industrial Fan Systems

The Fan System Loading Cycle Assessment quantifies energy consumption and energy savings opportunities in industrial fan systems, helping users understand how well their fan systems are operating and determine the economic benefit of system modifications.

4) Use of Variable Voltage Variable Frequency (VVVF) Drive Controls

With variations in load and operational requirement air flow through sinter bed also varies. In existing technology exhauster inlet guide vanes are controlled for flow throttling. In new generation plants Variable speed drives are being introduced for dynamic control of flow by speed regulation through Variable Voltage Variable Frequency (VVVF) Drive Control which significantly reduces power consumption.

5) Improvements in Feeding Equipment

Installation of an additional screen on the conventional sloping chute promotes a more desirable distribution of granulated ore on the palette. The screen with a sloping chute places coarser granulated ore in the lower part of the palette and finer ore on the upper part, which achieves high permeability.

6) Segregation of Raw Materials on Pellets

Segregation and granulation reinforcement of raw materials on sintering pellets improve permeability and decrease return rate to sintering pellets, thus increasing productivity and saving energy.

7) Multi-slit Burner in Ignition Furnace

Multi-slit burners produce a wide, large stable flame, which eliminates “no flame” areas and supplies minimum heat input for ignition by approximately 30%, therefore saving energy.

8) Equipment to Reinforce Granulation

Addition of a high-speed mixer and a drum mixer to the conventional systems for producing granulated ore increases productivity, water content, granulation rate, permeability, Flame front speed and decreases fines return rate.

9) Increase in bed height

A conventional sinter plant waste gas cleaning system achieves over 95% efficiency and reduces the dust load in the waste gas of a typical plant from 3,000 mg/Nm^3 to about 150 mg/Nm^3. However, with increased bed height of 650 ~750 mm, dust load can be decreased up to 1000 mg/Nm^3. Increased bed height and homogeneous raw mix act as a filter medium. With similar ESP based waste gas cleaning system of cleaning efficiency 95% average stack emission can be brought down to 50 mg/ N m^3.

8.3 Suggested environmental monitoring requirements

It is suggested that all the sinter plants including existing and new should have continuous monitoring equipment for Particulate Matter (PM), SO_2, and NO_X on main exhaust gas stack(s) and PM monitor on de-dusting stacks. In addition to this Environmental Control Department of the plant should have the facilities to monitor the above parameters with conventional/ manual monitoring equipments, at least once in a month. This will also help to cross check the performance of continuous monitoring equipment or in case of any doubts arise about the performance of the continuous monitoring equipment.

Sampling and analysis of PCDDs and PCDFs is highly complex and cost intensive. All the sinter plants may not have expertise and instruments to conduct sampling and analysis for these pollutants, Hence monitoring for PCDDs and PCDFs once in a year conducted through capable laboratories/ institutions recognized by CPCB should be sufficient.

Fugitive emission monitoring for Suspended Particulate Matter (SPM) and RSPM utilizing High Volume Air Samplers and Respirable Dust Samplers should be conducted at the following locations in a sinter plant:

1. Raw feed proportioning building
2. PMD/ SMD/ MND feed area
3. Sinter machine discharge end
4. Hot sinter breaker area
5. Sinter cooler zone
6. Sinter crusher & screening area.

Noise monitoring should be carried out using an integrated sound level meter in the following areas of the sinter plant:

1. Proportioning building near belt conveyor
2. MND/ PMD Area Near Drum
3. Sinter M/c Floor Near hot sinter breaker
4. Cooler Fan
5. Sinter Crusher
6. Main Exhauster Fan

In addition to continuous monitoring systems for stack emissions the other monitoring and laboratory equipments proposed for sinter plant environmental monitoring are:

1) High Volume Air Samplers
2) Respirable Dust Samplers
3) Stack samplers
4) Micro/ Semi-micro balance
5) Spectrophotometer
6) Oven

7) Sound Level Meter
8) Water distillation unit
9) Glassware and other laboratory ware

ABBREVATIONS

BSL	Bokaro Steel Limited
BSP	Bhilai Steel Plant
BF	Blast Furnace
BOF	Basic Oxygen Furnace
CCS	Carbon Capture & Storage
ESP	Electrostatic Precipitator
EOS	Emission Optimized Sintering
EPA	Environment Protection Agency
HRM	Hot Rolling Mill
I-TEQ	Toxicity Equivalent
JSW	JSW Steel
JSPL	Jindal Steel & Power Limited
LD	Linz & Donawitz
MEROS	Maximized Emission Reduction Of Sintering
MND	Mixing & Nodulizing Drum
M/c	Machine
NINL	Neelanchal Ispat Nigam Limited
PCDD/F	Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans
RINL	Rashtriya Ispat Nigam Limited
RMP	Refractory Material Plant
SMS	Steel Melting Shop
STEL	Short Term Exposure Limit
SP	Sinter Plant
SISCOL	Southern Iron & Steel Company Limited

TWA	Time-Weighted Average
VVVF	Variable Voltage Variable Frequency
VOC	Volatile Organic Compounds