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SPONGE IRON INDUSTRY

CENTRAL POLLUTION CONTROL BOARD
MINISTRY OF ENVIRONMENT & FORESTS
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FOREWORD

The series of publication entitled 'Comprehensive Industry Document Series' (COINDS) is designed to cover the status of each specific type of industry in the country in respect of number of units, their location, capacities, type of product, usage of raw material, manufacturing processes, pollution potential, preventive measures to control pollution, and various pollution control technology available. The evolution of the National Environmental Standards, which could be achieved by an industry is facilitated by these documents.

The Comprehensive Industry Document on Sponge Iron Industry is one in the series that the Central Pollution Control Board has taken up for publication. Thus, in a sense, the main objective of this document, apart from giving an overall view of this type of industry, is to develop the National Environmental Standards and to specify Guidelines / Code of Practice for Pollution Prevention for the Industry. Due care has been taken in developing the standards by CPCB that it cannot be relaxed by any State Board and the Standards are in line with the guidance, provided in National Environment Policy – 2006, of Ministry of Environment & Forests for developing Standards. The State Boards can, however, make it more stringent depending on the location and quality of the recipient environment.

This study was taken up by the Central Pollution Control Board through, MECON Limited, Ranchi. The help and assistance extended by the State Pollution Control Boards and Sponge Iron Industries and their Association during the study is gratefully acknowledged.
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I commended the efforts made by my colleagues Er. R. C. Kataria, Senior Environmental Engineer and Er. J. S. Kamyotra, Additional Director for co-ordinating the study and finalizing the report under guidance of Dr. B. Sengupta, Member Secretary, CPCB. The contribution of Shri Mahendra Kumar Gupta, Data Entry Operator, in preparing the typed manuscript also deserves acknowledgement.

We, in CPCB, hope, that the document will be useful to the industry, regulatory agencies, the consultants and others interested in pollution control in Sponge Iron Industry.

(J. M. Mauskar)

20th March 2007

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CHAPTER - 1

1.0 PREAMBLE

From a meager production of 1.31 million tonnes of sponge iron in 1991-92 the present production level of sponge iron level jumped to 7.67 million tones in 2002-03 and 10 million tones in 2004-05 and India emerged as the largest producer of Coal based sponge iron in the world since 2001.

There are two types of technologies available for producing sponge iron: Coal based and gas based. In the former case, coal is the reductant while for the later natural gas is used to reduce the iron ore. For coal based rotary Kiln processes several technologies like SL/RN, CODIR, ACCAR, JINDAL,TDR and OSIL are in use while gas based plants have predominantly used MIDREX,HYL I and III technologies. As Natural gas is not available in many parts of the world, the growth of coal based plants have increased in those countries like India (where natural gas is available to a limited extent) where there is abundance of non coking coal and good grade Iron ore.

As on January 2004, India has 36 existing coal based production units and 3 gas based production units registered with Sponge Iron Manufacturers Association (SIMA). The existing capacity of production of Sponge iron is 6.978 million tonnes in coal based and 3.86 million tonnes in gas based units.

In addition to these there are several mini Sponge Iron plants in India who are operating but not registered with SIMA.

CPCB has initiated the study to develop National Environmental Standards for Sponge Iron Plants and to prepare Guidelines / Code of Practice for Pollution Prevention.

Scope of work

Central pollution control Board (CPCB) has assigned MECON Ltd Ranchi to carryout the study. The objectives of the study are given below in brief:

- Description of Clean Technology for Sponge Iron plants for better pollution control and to enhance production and energy efficiency
- Development of Environmental standards for sponge iron Plants
- Developments of siting guidelines of Sponge Iron plants.

CHAPTER - 2

2.0 INVENTORISATION OF SPONGE IRON PLANTS

2.05 Historical Development of Sponge Iron Making

Sponge iron provided the main source of iron for many centuries before the blast furnace was developed. In historic times, sponge iron was produced in shallow hearths, which used charcoal as reductant fuel. The product of these early smelting process was a sponge mass of coalesced granules of nearly pure iron intermixed with considerable slag. Usable articles of wrought iron were produced by hammering the sponge mass, while still hot, to expel most of the slag and compact the mass. By repeated heating and hammering, the iron was further freed of slag and forged into the desired shape.

All of the methods through which low carbon wrought iron can be produced directly from the ore are referred to as direct reduction processes. After the development of the blast furnace, which produced high carbon pig iron, direct processes were nearly abandoned. However, direct reduction process is still used because of the ease with which iron ores are reduced making the processes appear enticingly simple, and primarily because the reduction takes place at relatively low temperature compared to Blast Furnace. Process that produce iron by reduction of iron ore, below the melting point of the iron produced, are called direct reduction processes, and the products referred to as Direct Reduced Iron (DRI), commonly called sponge iron.

In modern times, sponge iron has found increasing use in the manufacture of wrought iron and as substitute of scrap during steel making. Sponge iron is chemically more active than steel or iron millings, turnings or wire strips. Sponge iron is produced as granular material or as sintered mass, depending upon the methods of treatment applied to hot material. In the granular form, it is commonly known as powdered iron and used in the manufacture of many useful articles by the techniques of powder metallurgy.

Today the major portion of DRI is melted along with Hot Metal / Pig Iron/scrap in the Electric Arc Furnace (EAF) and Induction Furnace(IF) for steel making and producing steel castings (rounds/ slabs/ billets/ blooms). The attempts to develop large-scale DRI plants have embraced practically every known type of apparatus suitable for the purpose, including pot furnaces, shaft furnaces, reverberatory furnaces, regenerative furnace, rotary hearth furnace / rotary kilns, electric furnaces, fluidized bed furnaces and plasma reactors. Many different kinds of reducing agents, such as natural gas, coal, coke, graphite, charcoal, distillation residues, fuel oil, tar, producer gas, coal gas, and hydrogen have been tried. However, no effort has been made to evaluate or compare the different processes on either on economical or technical basis because in many cases, factors associated with location, capital cost and availability of ore and fluxes, availability of trained manpower, and proximity of markets, may be overriding.

Over the past several decades, experiments were made to develop a low cost and simple to operate substitute of blast furnace. Many of these developments were targeted to use non-coking coal or natural gas as reductant.

The processes that produce molten product (similar to blast-furnace hot metal) directly from ore are generally classified as direct smelting processes. In some of the more ambitious projects, the objective is to produce liquid steel directly from ore and these processes are generally classified as direct steel making process**.** These broad categories are clearly distinguished by the characteristics of their respective products, although all of these products may be further treated to produce special grades of steel in the same refining or steel making process. The direct smelting process and direct steel making process is outside the scope of this project.

2.06 World DRI Production Scenario

All over the world, blast furnace will continue to remain the chief source of pig iron / molten metal for use in steel making because of its superior technology, higher conversion efficiency, product quality and achieving stringent environmental norms. DRI contributes only meager 3-4% of the world's total iron making with an output of about 49.5 million tons per annum (2003). Most of the DRI plants in the World use natural gas as reductant, whereas the DRI plants of India using coal as reductant constitutes almost two third of the production capacity.

The major part of DRI produced all over the world is used as a substitute for steel scrap in the Electric Arc Furnace (EAF) and Induction furnace (IF) while making steel. Countries that have plenty of steel scrap available in domestic market or countries that have taken policy decision to maximize steel scrap recycling by way of reduced custom duty do not favour DRI process.

The various DRI process technologies followed all over the world is illustrated in **Figure 2.1**. The details about the various process technologies is described in **Chapter 3**. The name and location of existing DRI plants all over the world and the technology followed is given in **Table 2.1**. The world DRI production figures (country wise) in 2003 indicated in Table **2.2**. The world DRI production figures by process technology is shown in **Table 2.3**. It can be inferred that almost 90% of the total sponge iron production in the world in 2003 are from Gas Based using Midrex or HYL-III technology. This shows worldwide increasing trend on the use of gas based process. The capacity of gas based plants are also huge; upto 1.36 million tons per annum modules are available. Compared to this size, the maximum capacity of coal based plant is 150,000 tpy/180,000 tpy depending on ash content of reductant.

2.07 Indian DRI Production Scenario

India accounts for almost 13% of the world's total DRI production. The present DRI production capacity is approximately 12 million tons per annum. There are 118 large and small sponge iron plants operating in India, among them only 3 are natural gas based processes and balance 115 are coal based process. Several small sponge iron plants are under planning/commissioning stage. These are not included in the study.

Almost 35% of DRI production in India in year 2003-04 were through gas-based process compared to 55% in year 1999-2000. This clearly shows an increasing trend on use of coal for sponge iron making. The coal based kiln capacity ranges from as small to as 50 tons/day to as high as 500 tons/day. The largest coal based plant in India is 620,000 tons per annum DRI plant of Jindal Steel & Power Limited, located at Raigarh in Chattisgarh State. This is also the world's largest coal based plant. The largest gas based DRI plant complex in India is 2.40 million tons per annum DRI / HBI plant of Essar Steel Limited, located at Hazira in Gujarat State. The name and location of DRI plants in India is given in **Table 2.4**. Technology and capacity-wise DRI plants in India is shown in **Table 2.5**. The location map of iron ore, coal and natural gas deposits in India is shown in **Figure 2.2**. The location map of DRI plants is shown in **Figure 2.3**.

No categorization has been done for small and large DRI plants. Some accept small sponge iron plants as those having production capacity up to 30000 tons/annum (100 tons/day). All others are large plants (>100 tons/day). Others accept plants having waste heat utilization facility as large plants. Waste heat utilization facility is economically feasible only in DRI plants of above 100 TPD capacity.

2.08 Location

Sponge iron, customarily called direct reduced iron (DRI) is used as prime metallic in the secondary steel making process using the electric furnace or Induction furnace route. DRI is a substitute to scrap. Sponge iron is produced by reduction of iron ore in the solid phase using either solid (non coking coal) or gas (Reformed natural gas or coal gasification) as reductant. Besides supplying the reducing agents, namely carbon monoxide and hydrogen, the energy requirement for the reduction reaction is also supplied by a part of the reductant as fuel.

Sponge iron plants based on two major commercially established processes, namely coal based rotary kilns and gas based shaft furnace reactors. The coal based rotary kilns produce DRI lumps/ pellet being more stable can be stored for longer time. The gas fired shaft furnace produces DRI that needs to be used immediately or converted to blocks of Hot Briquetted Iron (HBI), that can be packed and stored for longer time.

Sponge iron constitutes around 3-4% of world's total iron making capacity. Today, India is the largest producer of sponge iron in the world, having 118 plants with an installed production capacity of 11.85 million tons per annum (MTPA); 115 plants are coal based producing 65% of the total production. There are 3 natural gas based plants producing 35% of the total annual production. 100% sponge iron demand of India is met from internal sources. The sponge iron plants in India are located near the source of raw materials. The gas based plants are located along the west coast of Maharastra and Gujarat. The coal based plants are concentrated near iron ore and coal mines of Jharkhand, Orissa, West Bengal, Chattisgarh, Maharastra, Andhra Pardesh, Goa and Karnataka. The typical areas are Durgapur, Ranigunge, Purulia, Bankura, Midnapore, Raipur, Siltara, Raigarh, Taraimal, Bilaspur, Champa, Durg, Adityapur near Jamshedpur, Giridih, Chaibasa, Chandil, Hazaribagh, Koderma, Keonjhar, Jharsuguda, Rourkela, Brajrajnagar, Sundergarh, Sambalpur, Jajpur, Mayurbhanj, Nagpur, Bhandara, Chandrapur, Bellary, Hospet, Kurnool, Khammam and Goa.

The sponge iron production capacity (year 2003) of the top producers in world like Venezuela is 3.9 MTPA, Mexico is 5.62 MTPA, Iran is 5.62 MTPA, Australia is 1.95 MTPA, Saudi Arabia is 3.29 MTPA, USA is 0.21 MTPA and Germany is 0.59 MTPA, all of them from gas based processes. About 90% of the total world's sponge iron production of 49.5 MTPA comes from gas based process.

Table - 2.1 : Name, Location and Technology of DRI Plants of World

Plant name	**Address**	**Technology used**	**Capacity (Tons per annum)**
Country: Argentina			
Acinder Industria Argentina de Aceross SA	Ruta Provincial 21,km 247,2919 Villa construction, Provincia de Santa Fe	1 Midrex 400 Series	800000
Country: Brazil			
Gerdan SA	Simoes Filho Plant ,BR. 324; Centro Industrial de Aratu; Simoes filho, BA	HYL III	320000
Country: Canada			
Sidbec-Dosco (Ispat) Inc.	Contrecoeur Works ; 3900 Route de Acieries, Contrecoeur, JOL ICO	2 x Midrex	150000 (combined)
Country: Egypt			
Alexandria National Iron and Steel Co.	Alexandria- Matrou Rd. El- Dikhelika, Alexandria	1 x Midrex Series 600	716000
Country: Germany			
Ispat Hamburg Stahlwerke GmbH	H.O. : Dradenaustrasse 33, 21129, Hamburg	1 Midrex (4.8 m dia stack)	450000
Country: Iran			
National Iranian Steel Co. (NISCO)	Ahwaz Steel Complex, Ahwaz	1 x Purofer 3 x Midrex 1 x HYL III	2530000

Plant name	Address	Technology used	Capacity (Tons per annum)
Mobarekeh Steel Co.	Espahan, Iran	4 modules Midrex	3200000
Country: Japan			
Sumitomo Metal Industries Ltd.	Hokayama Steelworks, 1850 Minbato, Hokayama	1 x SDR Rotary Klin	168000
Kashima Steel works	3, Hikari, Kashima -- cho, Kashima – guh, Ibaraki	1 x SPM rotary klin	150000
Country: Libya			
Libyan Iron and Steel Company (LISCO)	P.O. Box: 17858, Misurata	2 x Midrex	550000
Country : Malaysia			
Amsteel Mills Sdn. Bdh. –HBI O Parafien	Ranca-2 ,Industrial estate, P.O. Box: 81555, 87015 Labuam Sabah	1 x Midrex 600 Series	660000
Pevwaja Steel Sdn. Bdh.	Kemaman Plant P.O. Box.61, Kemaman Terengganu	1 x HYL III	1200000
Country : Mexico			
HYL Sade CV	Puable Works , Carreteva, Mexico-Pueblo KM 108, San Miguel, Xoxtla, 72620 Puebla PU	1 x HYL (batch)	587000
Ispat Mexicana SA de CV –Imexsa	Fco Mujica, B, azara-Cardenas, Mich 60050	2 x HYL III	1100000
Country : New Zealand			
BHP New Zealand Steel Ltd.	New Zealand	4 x Stelco-Lurgi rotary Klins	1100000
Country : Nigeria			
Delta Steel Co. Ltd.	Warri, Nigeria	2 x Midrex 600 series	1020000
Country :Qatar			
Qatar Steel Co. Ltd.	Qatar	1 x Midrex	400000
Country :Saudi Arabia			
Saudi Iron and Steel Co.	Tareeq @30, Madinat, Al-Jubil, Al-Sinayah	1 x Midrex 600 series. 2 x Midrex 400 series	2300000

Plant name	**Address**	**Technology used**	**Capacity (Tons per annum)**
Country : South Africa			
Iscor Ltd.	Vanderbijl park Works, P.O. Box #2, Vanderbijlpark, Gautenj	4 x SL/RN Klins	720000
Dunswant Works	C/o Vanderbijl park Works, P.O. Box #2, Vanderbijlpark, Gautenj	1 x KRUPP-CODIR	120000
Saldanha Steel (Pvt.) Ltd.	Saldanha Bay, South Africa	1 x Midrex	800000
Scaw Metals- a division of Amic Industries Ltd.	Black Reef Road., Dinwiddie, Germiston	5 x DRC klins	425000
Country: Thailand			
Nakoruthi Stri Mills Public Co. Ltd.	Choubury Industrial etate (Bowin) Chouburi-20230	1 x Inmetco Rotary hearth	500000
Country: Trinidad & Tobago			
Caribbean Ispat Ltd.	P.O. Bag 476, Point Lisas, Couva	2 x Midrex 400sr.	1200000
Country: United States of America			
American Iron Reduction		1 x Midrex	1200000
Georgetown Steel Corporation		1 x Midrex 400 Sr	525000
Country: Venezuela			
Comisigua-Complejo Sidevurjicode Guyana	Matanzas	1x Midrex plant	1000000
Minorca Minevales	Puerto	1 x Midrex HBI plant	830000
Sidetur-Siderurgica del turbino SA	Fior Plant, Zona Industrial Mahanzas	1 x Fior Plant	400000
"	Vemprecar Plant ,Zona Industrial Mohanaz	1x Midrex	715000 at briquettes
Sidor –CVG Siderurgical del Orinoco CA	Venezuela	1 x HYL I 3 x HYL III 4 x Midrex	3713000
Vemprecar	Motanzas	1 Midrex with Hot Briquetting facility	600000

Table - 2.2 : World DRI Production Country wise (Million tons)

	Country	1995	2000	2003
1	FR Germany	0.41	0.46	0.59
2	Sweden	0.12	0.13	-
3	European Union (15)	0.53	0.59	0.59
4	Russia	1.68	1.92	2.91
5	Canada	1	1,13	0.50
6	Mexico	3.7	5.95	5.62
7	United States	0.42	1.56	0.21
8	NAFTA	5.12	8.63	N.A
9	Argentina	1.33	1.42	1.74
10	Brazil	0.29	0.41	0.47
11	Peru	0	0.08	0.08
12	Trinidad & tobago	1.08	1.51	2.28
13	Venezuela	5.1	6.41	6.90
14	Latin America	7.79	9.83	17.02
15	Egypt	0.85	1.53	2.87
16	Libya	0.96	1.49	1.34
17	Nigeria	0.04	0	0
18	South Africa	0.95	1.53	1.54
19	Africa	2.8	4.54	N.A
20	Iran	3.3	4.54	5.62
21	Qatar	0.62	0.62	0.78
22	Saudi Arabia	2.13	3.06	3.29
23	Middle East / North Africa	6.05	8.22	13.89
24	PR China	0	0.05	0.31
25	India	4.27	5.5	7.67
26	Indonesia	1.71	1.82	1.23
27	Malaysia	1.18	1.26	1.60
28	Myanmar	0.02	0.04	0.04
29	Asia	7.17	8.67	-
30	Australia	0	0.56	1.95
31	**World**	**31.15**	**42.96**	**49.5**

Table - 2.3 : World steel making grade DRI capacity

Sl. No.	Process	Reductant	No. of units in operation	Total installed capacity, Mt	Production in 2003, Mt/yr
		Gas Based			
1.	Midrex	Natural gas	50	29.71	31.91
2.	HYL-I	-do-	9	5.18	0.63
3.	HYL-III	-do-	18	11.15	9.09
4.	FINMET	-do-	8	4.40	2.57
5.	Iron Carbide	-do-	3	0.96	--
6.	GHAEM	-do-	1	0.60	0.15
7.	CIRCORED	-do-	1	0.50	--
8.	Iron Dynamics	-do-	1	0.50	0.02
9.	FIOR	-do-	1	0.40	--
10.	Purofer	-do-	1	0.33	--
		Sub-Total		**53.73**	**44.37**
		Coal Based			
1.	SL/RN (LURGI)	Coal	14	1.64	1.51
2.	JINDAL	-do-	10	0.88	0.88
3.	DRC	-do-	5	0.63	0.63
4.	CODIR	-do-	4	0.52	0.39
5.	SIIL	-do-	11	0.33	0.33
6.	OSIL	-do-	2	0.25	0.24
7.	TDR	-do-	2	0.24	0.24
8.	DAV	-do-	1	0.04	0.04
9.	KINGLOR-METOR	-do-	2	0.04	0.04
		Sub-Total		**4.57**	**4.30**
		Others			**0.83**
		Grand Total		**57.94**	**49.50**

Table - 2.4 : Name and Address of Sponge Iron Plants in India

Sl. No.	Name of the DRI Plant	Location and address
West Bengal		
1.	Adhunik Corporation Ltd.	Angadpur, Durgapur
2.	Jai Balaji Sponge Ltd.	Angadpur, Durgapur
3.	Howrah Gases Ltd.	G-4A Mangalpur Industrial Estate, Ranigunge
4.	Ma Chandi Durga Ispat Ltd.	Kanjilal Avenue, Durgapur
5.	Ritesh Tradefin Ltd.	Plot no. 3513, Kanjilal Avenue, Durgapur
6.	SPS Sponge Iron Ltd.	Dr. Zakir Hussein Av., G.T. Road, Durgapur.
7.	Shri Ramrupai Balaji Steel Ltd.	Vill:Banskopa, Rajbandh, Durgapur
8.	Haldia Steels Ltd.(Unit II)	Raturia Industrial Area, Angadpur,Durgapur
9.	Sova Ispat Alloys Ltd.	Mejia,Bankura
10.	Howrah Gases Ltd.	G/4A Mangalpur Industrial Estate, Baktarnagar, Ranigunge
11.	Jai Balaji Sponges Ltd. (Unit I)	Mangalpur Industrial Complex, PO.-Ranigunge
12.	Jai Balaji Sponges Ltd. (Unit II)	Mangalpur Industrial Complex, PO.-Ranigunge,
13.	Shree Gopal Govind Sponges Pvt. Ltd.	G/4 A,Mangalpur Industrial Complex, PO.-Ranigunge
14.	Shyam Sel Ltd. (Power Division)	Mangalpur Industrial Eastete, P.O.-Baktarnagar Ranigunge
15.	Dhanbad Fuels Pvt. Ltd.	Mangalpur Industrial Estate, PO.--Ranigunge
16.	Satyam Iron & Steel Pvt. Ltd.	G-7,Mangalpur Industrial Complex, Ranigunge
17.	Shyam Siel Ltd.	Palitpur Road, Dewandighi P.O- Burdwan
18.	Maheswari Ispat Pvt. Ltd.	Vill-Beldanga, P.O.-Chota, Ramchandrapur
19.	Savitri Sponge Iron Pvt. Ltd.	Chatardange,P.O.- Searsol Rajbari, Ranigunge
20.	Divya Jyoti Sponge Pvt. Ltd.	Chatardange,P.O.- Searsol Rajbari, Ranigunge
21.	M.B. Ispat Corporation Ltd.	Plot no.1861,P.S.-Barjora, Dist- Bankura
22.	Amiya Steels Pvt. Ltd.	Vill.- Tarapore,P.O. & P.S.-Mejia, Dist-Bankura
23.	Vision Ispat Pvt. Ltd.	Rakta, PO–Madhukunda, PS-Santuri, Dist.-Purulia

Sl. No.	Name of the DRI Plant	Location and address
24.	Maithon Steel and Power ltd.	Vill.- Bora, P.O.-Bonra, P.S.-Neturia, Dist.- Purulia
25.	Bisco Sponge iron Pvt. Ltd.	Mouza-Berma, PO-Ranagadih, PS-Balarampur, Dist.- Purulia
26.	Shiv Shankar Sponge Iron	Vill.- Dantia, PO.- Shyam Nagar, PS.- Balarampur, Dist.-Purulia
27.	Ma Chinnamastika Power and Steel Pvt. Ltd.	Manadish, P.O.- Bartoria, P.S.- Neturia, Dist.-Purulia
28.	Mark Steel Ltd.	Vill.-Jagannathdihi, P.O.-Murulia, P.S.-Santhuri Dist-Purulia
29.	ASL Iron & Steel Co. Pvt. Ltd.	Vill.- Dantia, PO-Shyam nagar, P.S.- Balarampur, Dist.-Purulia
30.	Rashmi Cements Ltd.	Vill. Raghunathpur, PO Jhargram, West Midnapore
31.	Rashmi Ispat Pvt. Ltd.	P.O. Jhargram ist. Midnapore (West)
32.	Rishabh Sponge Pvt. Ltd	Barjora,Bankura
33.	Bravo Sponge Iron Pvt. Ltd.)	Vill.-Rahuda, PO Rukni, PS-Para, District-Purulia
Chattisgarh		
34.	Singhal Enterprises Pvt. Ltd.	Vill: Taraimal, .PO. Gerwani, Dist: Raigarh
35.	Ispat Godavari Ltd.	Plot no. 428/2, Phase 1 Industrial area, Siltara
36.	HEG Ltd.	PO Borai Rasmada, Durg
37.	Nalwa Sponge Iron Ltd.	Vil.Taraimal, Gharghoda Rd, Raigarh
38.	Jindal Steel & Power Ltd.	Kharsia Road. Raigarh.
39.	Raipur Alloys and Steel Ltd.	Siltara Industrial growth Center, Siltara, Raipur, C.G.
40.	Prakash Industries Ltd.	Vill: Hathnewra, Th: Champa Dist: Janjgir Champa.
41.	Monnet Ispat Ltd.	Chand Khuri Marg, Mandir Hasaud, Raipur
42.	Nova iron & Steel Ltd.	Vill: Dagori, Dist: Bilaspur
43.	Shreee Radhe Industries Ltd.	Vill: Silpahari, Th: Bilha, Dist: Bilaspur
44.	Nutan Ispat Pvt. Ltd.	Vill: Jaroda, Dist: Raipur
45.	Millenium Hi-tech Industries	Vill: Parsada- Tilda, Dist: Raipur
46.	Seleno (Balaji) Steels Ltd.	Vill: Taraimal, PO: Gerwani, Dist: Raigarh

Sl. No.	Name of the DRI Plant	Location and address
47.	Shri Shyam Ispat Pvt. Ltd	Vill: Taraimal, P.O.: Gerwani, Dist: Raigarh
48.	Raigarh Electrode Ltd.	Kharsia Rd., Dist: Raigarh
49.	Niros Ispat Pvt. Ltd.	14 'A" H.I.A., Hathkhoj, Bhilai, Dist: Durg
50.	Ind Agra Synergy Limited	Raigarh
51.	Vandana Global Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
52.	Mahamaya Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
53.	Agarwal Sponge Pvt. Ltd.	Siltara Industrial Area, Phase-II, Siltara, Raipur
54.	Ghunkan Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
55.	JRG Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
56.	PD Industries Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
57.	Mahendra Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
58.	Dholia Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
59.	Baldev Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
60.	G R NR Sponge Pvt. Ltd.	Siltara Industrial Area, Phase-II, Siltara, Raipur
61.	Harekrishna Sponge Pvt. Ltd	Siltara Industrial Area, Phase-II, Siltara, Raipur
Orissa		
62.	Kusum Powermet Pvt. Ltd.	Village-Kutugaon. Dist: Keonjhar
63.	Neepaz Metaliks Pvt. Ltd.	Chandrihariharpur,P.O. Karmunda, Sundergarh
64.	Orissa Sponge Iron Ltd.	Palaspanga, Keonjhar
65.	Rexon Strips Ltd	Vill. Kumakela, Via Lathikata , Dist. Sundargarh
66.	Scan Sponge Iron Ltd.	Ramabahal,Vill- Laing, Dist: Sundergarh
67.	Scaw Industries Pvt ltd.	Gundichapada Industrial Estate,Dist: Dhenkanal
68.	Shree Metaliks Ltd.	Vill: Loidapada, P.O. Guali,Dist: Keonjhar
69.	Deepak Steel and Power Ltd.	Topadihi, P.O. Guali, District: Keonjhar
70.	Grewal Associates	Vill-Matkambeda, Barbil, Dist. – Keonjhar
71.	M/s N.K. Bhojani (P) Ltd.	Rugudihi, Main Road, Barbil, Dist- Keonjhar
72.	Deepak Minerals Pvt. Ltd.	At/PO-Topadihi, PO-Guali, Dist. – Keonjhar

Sl. No.	Name of the DRI Plant	Location and address
73.	Orion Ispat Ltd.	At / Po. Boneikala, Dist. Keonjhar
74.	M/s Rungta Mines	Karakola, Barbil, At/Po - Barbil, Dist. – Keonjhar
75.	M/s M.S.P. Sponge Iron	Haladiguna, At– Vill:-Haladiguna, P.O. – Gobardhan, Dist. - Keonjhar
76.	Prabhu Sponge Iron (P) Ltd.	Jhagarpur, Rajgangpur, Dist Sundergarh
77.	Suraj Products Ltd.	Baspali, Kesarmal, Rajgangpur, Dist-Sundergarh
78.	OCL India Ltd.	Lamloi, Rajgangpur, Dist. – Sundargarh
79.	Mangalam Ispat Pvt. Ltd.	D-5, Civil Township, Rourkela, Dist. – Sundargarh
80.	Shristi Ispat Ltd. (Unit-III)	Main Road, Rajgangpur Dist-Sundergarh
81.	Aditya Sponge & Power Ltd.	PO- Telkoi, Dist-Keonjhar
82.	Shri Mahavir Ferro-Alloys Pvt. Ltd.	C-12, Seth Deokaran Das Commercial Complex, Kacheri Road, Rourkela, Dist. Sundargarh
83.	Scan Steels Ltd.	Ramabahal, Rajgangpur, Dist: Sundergarh
84.	Utkal Metaliks Ltd.	V-7, Ground Floor, Civil Township, Rourkela
85.	Shiv Shakti Sponge Iron Ltd.	Pandersil, Via – Joshipur, Dist. – Mayurbhanj
86.	Surya Sponge Iron Ltd.	PO-Budhakendu, Dist. – Jajpur
87.	Pawanjaya Sponge Iron Ltd.	At – Bijabahal, P.O– Kunjharia, Dist. – Sundargarh
88.	Maa Tarini Industries (P) Ltd.	At – Balanda, PO – Kalunga, Dist. Sundargarh
89.	T.R. Chemicals (P) Ltd.	Barapalli, Rajgangpur, Dist. – Sundargarh
90.	Suryaa Sponge Iron Ltd.	Budha Kendua, PO-Kalkala Dist :Jajpur ,Orissa
91.	Shiv Sakti Sponge Ltd	Pandersil,Mayurbhanj
92.	Tata Sponge Iron Ltd.	Vill-BeliapadaPO- Joda, Dist: Keonjhar
Jharkhand		
93.	Ashirwad Steel & Industries Ltd.	Plot no A1, A3 ,A5,A7 ;Phase 5 Adityapur Industrial Estate, Jamshedpur
94.	Bihar Sponge Iron Limited	Umesh Nagar, Chandil, Dist-Sarikela Kharsawan
95.	Jharkhand Sponge Pvt. Ltd.	Chota Lakkha, Chandil, Dist-Sarikela Kharsawan
96.	Sai Sponge India Limited	Naogaon Jhink Pani, Dist-West Singhbhum
97.	KYS Sponge Iron Pvt. Ltd	NS 85, 6th Phase, Adityapur Industrial Area, PO-Gamaria, Dist-Sarikela Kharsawan

Sl. No.	Name of the DRI Plant	Location and address
98.	Chandil Industries Limited	Kurli, Chandil, Dist-Sarikela Kharsawan
99.	BISCO Sponge Iron Pvt. Ltd.	NS 5 & 56, 6th Phase, Adityapur Industrial Area PO-Ghamaria, Dist-Sarikela Kharsawan
100.	Maa Chinmastika Sponge Iron Pvt. Ltd	Binjhar, Marar, PO_ Ramgarh, Dist-Hazaribagh
101.	Laxmi Ispat Udyog Pvt. Ltd.	Bandi Dighdgu, Chandwara, Dist-Koderma
102.	Jai Durga Iron Pvt. Ltd.	Talai Basti, Dist-Koderma
103.	Balmukund Sponge Iron Pvt. Ltd.	Chatro, Tundi road, Dist-Giridih
104.	Vishwanath Ferroalloys and Sponge Iron Pvt. Ltd.	Biswasdih, Dist-Giridih
105.	Atibir Hitech Pvt. Ltd.	Tundi Road, Dist-Giridih
106.	Shivam Iron & Steel Pvt. Ltd	Tundi Road, Dist-Giridih
107.	Palash Sponge Iron Pvt. Ltd.	Rambagh, Dist- Hazaribagh
Other States		
108.	Ind Agro Synergy Limited	Village Malgaon ,Saoner, Nagpur, Maharashtra
109.	Sunflag Iron and Steel Co. Ltd.	P.O Bhandara Road, Maharashtra.
110.	Ispat Industries Ltd.	Geetapuram, Dolvi, Ta-Pen, District Raigad Maharastra
111.	Lloyds Metals & Engineers Ltd.	Plot No. A -1 & 2 M.I.D.C, Ghugus Dist: Chadrapur Maharastra
112.	Vikram Ispat	Vill. Salav, Revdanda, Sub P.O. Taluka Murud, Dist: Raigad, Maharashtra
113.	Sponge Iron India Ltd.	SIIL Campus Dist: Khammam Andhra Pradesh
114.	Sunder Steels Ltd	229,230 Gaganpahad,Rangareddy dist.
115.	Bellary Steel and Alloys Ltd.	P.B # 19, S-10/11 Anantpur Road, Bellary Karnataka
116.	Ambey Metallic Ltd.	Plot no. 69-75, 143-160, Pissurlem Industrial Estate, Pissurlem ,Goa: 403506
117.	Essar Steel Ltd.	27 Km, Surat-Hazira Road, Hazira, Gujarat
118.	Vallabh Steel Limited	Sahnewal,Ludhiana,Punjab

Table - 2.5 : Technology & Capacity-wise Sponge Iron Plants in India

Sl. No.	Name of Plants	Location / Address	Process Knowhow	Capacity (tons/annum)
Plants Registered with Sponge Iron Manufacturers Association (SIMA) **Total 41 registered units (36 operating 5 proposed)**				
1	Adhunik Corporation Ltd.	Hahnimann Sarani, Angadpur, Durgapur	Popuri	72000
2	Ambey Metallic Ltd.	Plot no. 69-75 , 143-160, Pissurlem Industrial Estate, Pissurlem, Goa	Popuri	30000
3	Ashirwad Steel and Industries Ltd.	Plot no A1, A3 ,A5,A7 ;Phase 5 Adityapur Industrial Estate, Jamshedpur	Lurgi	24000
4	Bellary Steel and Alloys Ltd.	S-10/11 Anantpur Road, Bellary 583 101,Karnataka	SIIL	60000
5	Deepak Steel and Power Ltd.	Topadihi, P.O. Guali District: Keonjhar, Orissa	Popurri	84000
6	Essar Steel Ltd.	27 Km,Surat-Hazira Road Hazira 394270	Midrex	2,400,000
7	HEG Ltd.	Industrial Growth Centre Borai PO. Rasmada-491001, Durg, Chattisgarh	SIIL (Sponge Iron India Ltd.)	60000
8	Howrah Gases Ltd.	G-4A Mangalpur Industrial Estate, Ranigunge , West Bengal	Lurgi	60000
9	Ind Agro Synergy Ltd.	Village Malgaon, Saoner, Nagpur, Maharashtra,	Customized	100,000
10	Ispat Godavari Ltd.	Plot no. 428/2, Industrial area, Siltara Ph-I 493111, Raipur Chattisgarh	Customised	100,000
11	Ispat Industries Ltd.	Geetapuram ,Dolvi Teluka – Pen,District Raigad 402107, Maharastra.	Midrex	1,600,000
12	Jindal Steel & Power Ltd.	P.B. # 16,Kharsia Rd. Raigarh-496001, Chattisgarh	Jindal	1,370,0000
13	Kusum Powermet Pvt. Ltd.	Village-Kutugaon. Dist: Keonjhar, Orissa	Popuri	30000
14	Lloyds Metals & Engineers Ltd.	Plot no. A-1 &2 M.I.D.C.,Ghugus-442505 Dist: Chadrapur, Maharastra	OSIL (ACCAR)	150,000
15	Monet Ispat Ltd.	Chand Khuri Marg, Mandir Hasaud, Raipur 492101,Chattisgarh	Jindal	300,000
16	Nalwa Sponge Iron Ltd.	Vil.Taraimal, Gharghoda Rd., Raigarh – 496001, Chattisgarh	Jindal	200,000
17	Neepaz Metaliks Pvt. Ltd.	Chandrihariharpur, P.O. Karmunda, Sundergarh, Orissa	Popuri	60000
18	Orissa Sponge Iron Ltd.	Palaspanga, Keonjhar-758031, Orissa	OSIL (ACCAR)	100,000
19	Raipur Alloys and Steel Ltd.	Siltara Industrial Growth Center, Siltara Ph-I Raipur, Chattisgarh	SIIL (Sponge Iron India Ltd.)	60000
20	Rashmi Cements Ltd.	Vill. Raghunathpur, PO. Jhargram,West Midnapore,West Bengal	Popurri	60000

Sl. No.	Name of Plants	Location / Address	Process Knowhow	Capacity (tons/annum)
21	Rashmi Ispat Pvt. Ltd.	P.O.Jhargram Dist. Midnapore (West),West Bengal	Popurri	60000
22	Rexon Strips Ltd	Vill. Kumakela, Via Lathikata, Dist. Sundargarh Orissa	Jindal	60000
23	Rungta Mines Ltd.	Karokola,Barbil,Orissa	Popurri	60000
24	Scan Sponge Iron Ltd.	Ramabahal,Vill - Laing, Dist: Sundergarh, Orissa	Popurri	24000
25	Scaw Industries Pvt ltd.	Gundichapada Industrial Estate, Dist: Dhenkanal, Orissa	Customised	100,000
26	Shyam Sel Ltd.	G-6 ,Mangalpur Industrial Estate, Ranigunge, W.B.	Customised	100,000
27	Singhal Enterprises Pvt. Ltd.	Vill: Taraimal,P.O. Gerwani, Dist: Raigarh Chattisgarh	Popurri	138,000
28	Sponge Iron India Ltd.	SIIL campus P.O Dist: Khammam 507156, A.P.	SIIL (Sponge iron India Ltd)	60000
29	Shree Metaliks Ltd.	Vill: Loidapada, P.O. Guali, Dist: Keonjhar, Orissa	Popurri	144,000
30	Sunflag Iron and Steel Co. Ltd.	P.O. Bhandara Rd.-441905, Maharashtra.	KRUPP-CODIR	150,000
31	Suryaa Sponge Iron Ltd.	Budha Kendua,P.O. Kalkala 754082, Dist :Jajpur , Orissa	Popurri	60000
32	Tata Sponge Iron Ltd.	P.O. Joda , Dist: Keonjhar, Orissa	TISCO Direct Reduction (TDR)	400,000
33	Vallabh Steel Ltd	RO - Sahnewal, Ludhiana Punjab	TDR	120,000
34	Vandana Global Pvt. Ltd.	Siltara - Ph-II, Raipur Chattisgarh	Lurgi	60000
35	Vikram Ispat	Vill. Salav, Revdanda, Sub PO. Taluka Murud, Dist: Raigad, Maharashtra	HYL III	900,000
36	Jai Balaji Sponge Ltd.	Redg.Office:5,Bentinck Street,Kolkata-7000001	Customised	105, 000
Total (organized sector, SIMA registered; 2001-02) 9,055,000				
Small Sponge Iron Plants in Unorganised Sector				
	Chattisgarh - 20	Information obtained from State Pollution Control Boards.	Basis of calculation – each 100 TPD plant	650,000
	Orissa – 20			650,000
	West Bengal - 27			900,000
	Jharkhand -13			430,000
	Andhra Pradesh, Goa, Karnataka, Maharastra) -5 New; name not available)			170,000
B. Total (unorganized sector)				**2,800,000**
C. Net Total				**11,855,000**

Reductant (External)
Natural Gas, Gassified Coal or Oil

↓

DRI / HBI/HDRI
Gas Based Process

↓

Technology

Shaft Furnace (Moving Bed)
1. Midrex
2. HYL-III
3. NSC
4. Iron carbide
5. Ghaem
6. Circored
7. Iron dynamics

Shaft Furnace (Static Bed)
1. HYL-I

Fluidized Bed
1. FIOR
2. Finmet

Reductant (Internal)
Non-Coking Coal

↓

DRI
Coal Based Process

↓

Technology

Kiln Process
1. Krupp Rein
2. Krupp CODIR
3. SL/RN (Outocompu)
4. ACCAR
5. DRC
6. Customised (Jindal/ SIIL/TDR/ OSIL/ Popurri/Indigenous)

Rotary Hearth Furnace
1. Inmetco
2. Fastmet

Retort/Tunnel Process
1. Hoganas
2. Kinglor Metor

Technology Break-up
1. Midrex - 64.6%
2. HYL-III -18.4%
3. HYL -1.3%
4. Coal based -10.20%
5. Others (Gas) - 5.6%
Total (World) - 100%

Fig. 2.1 : Various DRI Process Technology Followed in World (Year 2003)

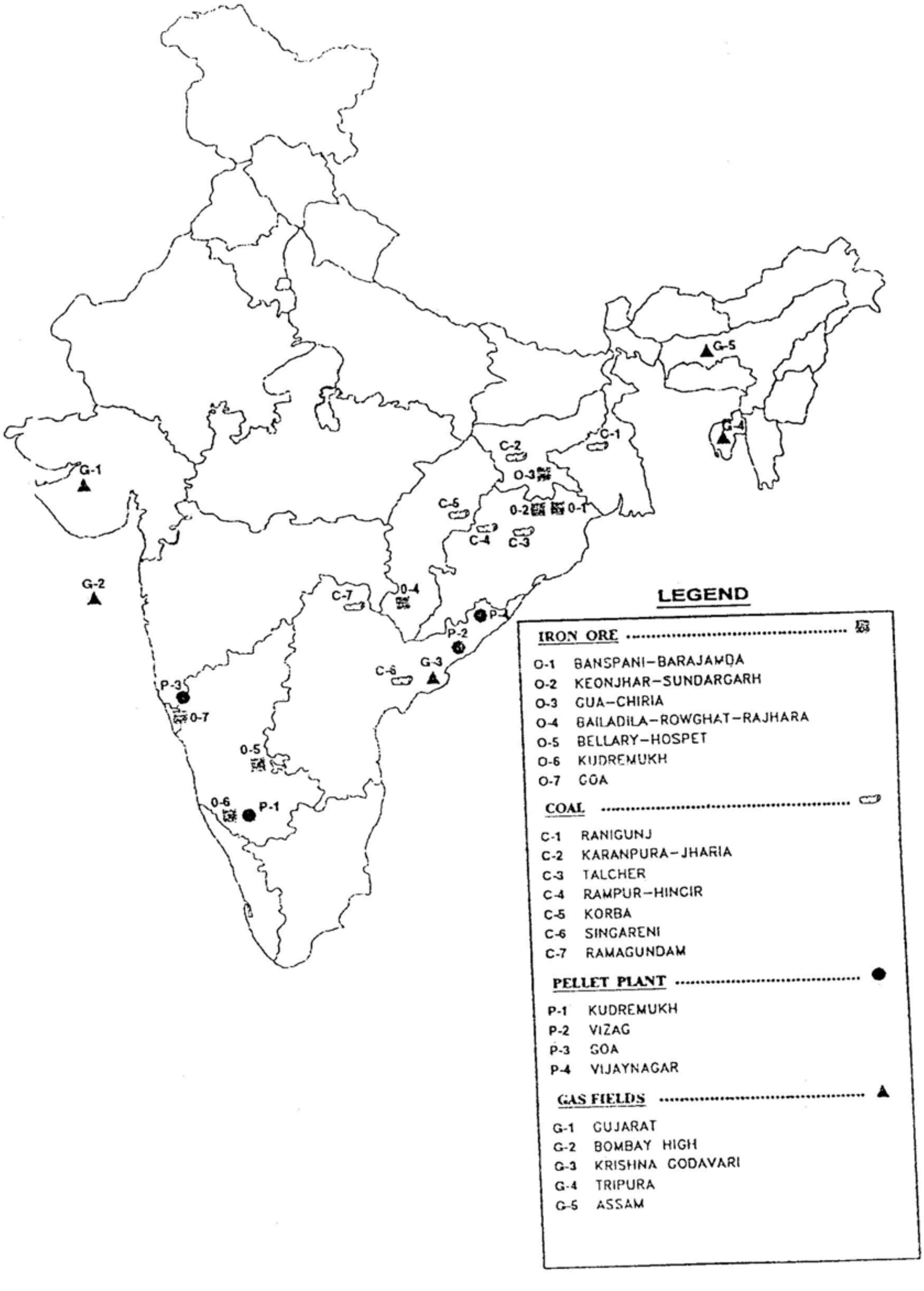

Fig. 2.2 : Source of Iron Ore, Coal and Natural Gas in India

Fig. 2.3 : Location of Sponge Iron Industries in India

CHAPTER - 3

3.0 PROCESS TECHNOLOGY FOLLOWED FOR SPONGE IRON

This chapter describes the various process technologies adopted at present all over the world for production of Direct Reduced Iron (DRI).

In order to understand the process technology in a comprehensive manner it is necessary to understand the various terms used in DRI production as well as desired DRI quality for use in steel making.

3.27 Type of Process Technology

Sponge iron, also known as "Direct Reduced Iron" (DRI) and its variant Hot Briquetted Iron (HBI) have emerged as prime feed stock which can replace steel scrap in EAF/IF as well as in other steel-making processes. It is the resulting product (with a metallization degree greater than 82%) of solid state reduction of iron ores or agglomerates (generally of high grade), the principal constituents of which are metallic iron, residual iron oxides, carbon and impurities such as phosphorus, sulphur and gangue (principally silica and alumina). The final product can be in the form of fines, lumps, briquettes or pellets. Sponge iron when briquetted in hot condition at elevated temperature is called hot briquetted iron (HBI).

Direct reduction processes available can be broadly grouped under two categories based on the type of reductant used. These are:

- Solid based processes
- Gas based processes

3.28 Solid Based Processes

From amongst various solid based processes, only a few have attained commercial significance. Most of the processes such as SL/RN, KRUPP-CODIR, DRC, TDR, SIIL, JINDAL, OSIL, Popuri utilise rotary kiln for reduction whereas Kinglor Metor process utilises an externally heated vertical retort.

3.29 Process Technology

Generally in any sponge iron process, reduction is conducted in a refractory lined rotary kiln. The kiln of suitable size, generally inclined at 2.5 % slope rest on two-four support stations, depending on the kiln size. The transport rate of materials through the kiln can be controlled by varying its slope and speed of rotation. There are inlet and outlet cones at opposite ends of the kiln that are cooled by individual fans. The kiln shell is provided with small sampling ports, as well as large ports for rapid removal of the contents in case of emergency or for lining repairs. The longitudinal positioning of the kiln on its riding rings is controlled hydraulically.

The coal and iron ore are metered into the high end of the inclined kiln. A portion of the coal is also injected pneumatically from the discharge end of the kiln. The burden first passes through a pre-heating zone where coal de-volatilization takes place and iron ore is heated to pre-heating temperature for reduction.

Temperature and process control in the kiln are carried out by installing suitable no. of air injection tubes made of heat-resistant steel spaced evenly along the kiln length and countercurrent to the flow of iron ore. Tips of the air tubes are equipped with special internal swirlers to improve uniformity of combustion.

A central burner located at the kiln discharge end is used with LDO for heating the cold kiln. After initial heating, the fuel supply is turned off and the burner is used to inject air for coal combustion.

The kiln temperatures are measured with fixed thermocouples and Quick Response Thermocouples (QRT). Fixed thermocouples are located along the length of the kiln so that temperatures at various sections of the kiln can be monitored. Fixed thermocouples, at times may give erratic readings in case they get coated with ash, ore or accretion. In such cases QRT are used for monitoring the kiln temperatures.

The product (DRI) is discharged from the kiln at about 1000°C. An enclosed chute at the kiln discharge end equipped with a lump separator and an access door for removing lumps transfers the hot DRI to a rotary cooler. The cooler is a horizontal revolving cylinder of appropriate size. The DRI is cooled indirectly by water spray on the cooler upper surface. The cooling water is collected in troughs below the cooler and pumped to the cooling tower for recycling alongwith make-up water.

Solids discharged to the cooler through an enclosed chute are cooled to about 100°C. without air contact. A grizzly in the chute removes accretions that are large to plug up or damage the cooler discharge mechanisms. The product is screened to remove the plus 30mm DRI. The undersize – a mix of DRI, dolo char and coal ash are screened into +/- 3mm fractions. Each fraction passes through a magnetic separator. The non-magnetic portion of the plus 3mm fraction is mostly char and can be recycled to the kiln if desired. The non-magnetic portion of – 3mm fraction mostly spent lime, ash and fine char is discarded. The magnetic portion of each fraction is DRI. The plus 3mm fraction can be used directly for steel making and the finer fraction can be briquetted / collected in bags.

The kiln waste gases at about 850-900°C pass through a dust settling chamber where heavier dust particles settle down due to sudden decrease in velocity of gases. The flue gases then pass through an after burning chamber where un-burnt combustibles are burnt by blowing excess air. The temperature of the after burner chamber, at times, is controlled by water sprays. The burnt gases then pass through a down duct into a evaporation cooler where the temperature is brought down and through a pollution control equipment namely ESP / Bag filter/ scrubber where balance dust particles are separated. Then the gas is let off into the atmosphere through stack via ID fan.

In certain coal based large plant in India is equipped with waste heat recovery system, the flue gases after the after burning chamber pass through an elbow duct to waste heat boiler where sensible heat of the gases is extracted. The gas is then let off into the atmosphere after passing through pollution control equipment like ESP, ID fan and stack.
In solid based processes, the non-coking coal and iron ore which are at intimate contact start reacting at the prevailing temperature.

Reaction mechanism

There are two major temperature zones in the kiln. The first pre-heat zone is where the charge is heated to 900 – 1000°C. The second metallization zone is held fairly constant at 1000-1050°C.

The charge into the kiln consists of a mixture of iron oxide lump, fluxes such as limestone and/or dolomite (amount depending of sulfur content of the coal) and medium volatile non-coking coal. In the pre-heating zone, the moisture is driven off first, and then the hydrocarbons and hydrogen evolve by thermal decomposition of the coal.

As the combustible gases rise from the bed of solid material, a portion of the gases is burnt in the free board above the bed by controlled quantities of air introduced through the air tubes. As the kiln rotates, the primary mode of heat transfer is by radiation to the tumbling charge and subsequently by internal solids mixing and renewal of the exposed bed surface.

In the pre-heat zone, the reduction of iron oxide proceeds only to ferrous oxide (FeO) (Equation I).

$$Fe_2O_3 + CO = 2\,FeO + CO_2 \quad \text{............................} \quad \text{(I)}$$

Final reduction to metallic iron occurs in the metallization zone by reaction of CO with FeO to form CO_2 and metallic iron (Equation II).

$$FeO + CO = Fe + CO_2 \quad \text{...........................} \quad \text{(II)}$$

Most of the CO_2 reacts with the excess solid fuel in the kiln and is converted to CO according to the Boudouard reaction (Equation III).

$CO_2 + C = 2\,CO$ .... (III)

Coals with higher reactivity are preferred as they provide rapid conversion of CO_2 to CO, thereby maintaining reducing conditions in the kiln metallization zone. The highly endothermic reaction of coal with CO_2 prevents the bed from over heating and attaining high temperature that could lead to melting or sticking of the charge.

High coal reactivity decreases the reduction zone bed temperature but increases the relative capacity. Desired bed and gas temperature in the freeboard can be achieved with high reactivity fuels even with very high throughput rates.

Air admitted to the ports below the bed in the pre-heat zone will burn some of the gases that otherwise leave the kiln unburnt to improve fuel consumption

3.30 Available Module Size

Coal based plants are available in module sizes in the range of 50 tpd (15000 tpa), 100 tpd (30,000 tpa), 300/350 tpd (100,000/120,000 tpa) and 500 tpd (150,000 tpa).

3.31 Preferred Raw Material Characteristics

The principal burden material used for production of steel making grade DRI in the sponge making process is iron oxide lump ore, non-coking coal and lime stone/dolomite. The iron ore should be preferably high in Fe content (>65% Fe) and non-decrepitating type. Coals with a high reactivity and high fusion temperature are preferred. The coal should also be non-coking. A low ash fusion temperature is undesirable as it promotes formation of accretions in the kiln. The coal ash composition is also important as a siliceous ash might react with ferrous oxide to form low melting ferrous silicate and interfere with the reduction to metallic iron.

<u>TYPICAL RAW MATERIAL CHARACTERISTICS</u>

i) Iron ore lump

Fe	:	65 % (min.)
SiO2 + Al2O3	:	3.5 % (max.)
S	:	0.02 %(max.)
P	:	0.035%(max.)
Size	:	5-20 mm

ii) **Coal (dry basis)**

Fixed C	: 42.5 % (min.)
Ash	: 27.5 % (max.)
VM	: 30 %
S	: 1.0 % (max.)
Moisture	: 7 % (Max.)
Reactivity	: 1.75 cc of CO/gmC/sec
Caking index	: 3 max.
Size	: 0 - 20 mm

iii) **Limestone**

SiO_2	: 8 % (max.)
CaO	: 46 % (min.)
MgO	: 8-10 %

iv) **Dolomite**

SiO_2	: 5 % (max.)
CaO	: 28 % (min.)
MgO	: 20 %

3.32 Typical Product Charachteristics

The typical sponge iron (coal based) characteristics are as follows:

Fe (total)	: 92 % (min.)
Fe (Met.)	: 83 % (min.)
Metallization	: 90 % (min.)
Carbon	: 0.25 % (max.)
S	: 0.025 % (max.)
P	: 0.06 % (max.)
Re-oxidation characteristics	: Non-pyrophoric

3.33 Major Facilities of Coal Based DR Plant

a) Reactor
b) Cooler
c) Off gas handling
d) Reactor feed system
e) Product processing
f) Briquetting (Optional)
g) Instrumentation & control

h) Electrics
i) Dust collection and disposal system
j) Water system
k) Compressed air system
l) Fuel oil facility
m) Fire fighting
n) Air-conditioning & ventilation
o) Emergency DG set
p) Raw material, product storage and handling
q) Repair shop and store
r) Laboratory

3.34 Technology Options for Coal Based Plants

3.08.03 Krupp Renn process

An annual production of 450000 metric ton (500000 net ton) of DRI has been achieved by using the Krupp Renn process. The Krupp –Renn process was developed in the 1930's to treat high silica ore with a basicity ratio as low as 0.2 to 0.3, with the addition of limestone. In this process a mixture of minus 64 mm (2.5 inch) ore and fine grained carboneous reducing agent (coke breeze or bituminous coal fines) is fed continuously in rotary kiln.

The maximum temperature of kiln is kept at 1230 to 1260^{o}C (2250 to 2300°F), which is sufficient to convert the gangue in the ore to a very viscous high silica sludge and also to effect coalescence the sponge iron obtained from the reduction of the iron ore. The reduced iron welds into nodule called "luppen" which become embedded in the pasty sludge. This product is discharged from the kiln. After cooling it is crushed and luppen are magnetically separated from the sludge. Recovery of iron in the luppen varies between 94% to 97.5%.

High Titania ore can also be used in this process and iron can be separated from titanium since the latter is not reduced. Almost any solid carboneous fuel can be use as a reducing agent. Since a large part of the sulphur contained in the reducing agent goes in the luppen, the sulfur content of the metal becomes high and difficult for economically conversion of the luppen into steel by the conventional steel making practices. In some places, the process is used to concentrate low grade iron ores containing up to 30% silica, and the luppen been fed in to blast furnaces.

The process flow diagram of Krupp Renn process is shown in **Figure 3.1**.

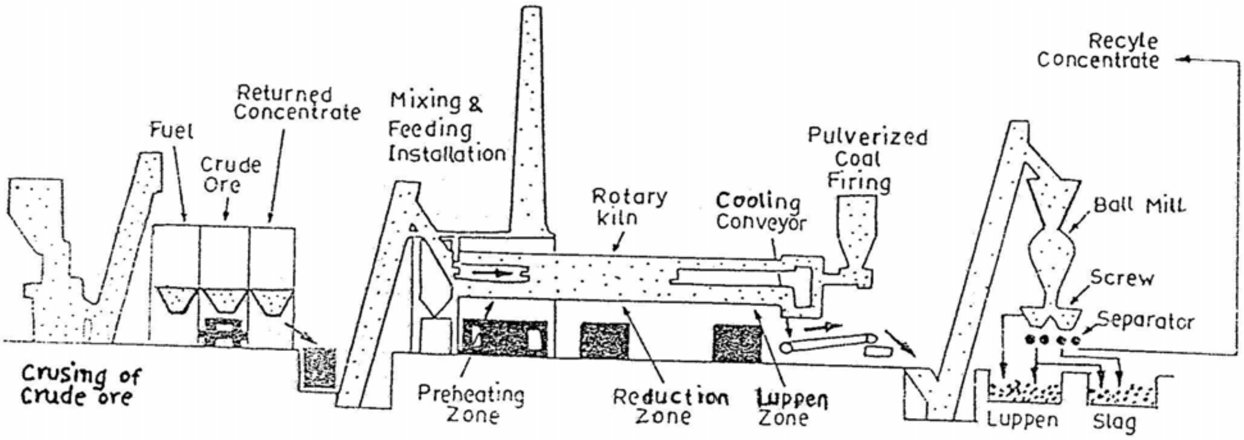

Fig. 3.1 : Krupp-RENN Process Flow Diagram

3.08.04 Krupp – CODIR process

The Krupp – CODIR process of Krupp Industries, West Germany, seems similar to original Krupp – Renn process. The process operates at a lower temperature then the Krupp – Renn thus producing a standard DRI product. Furthermore, limestone or dolomite in the furnace charge absorb a substantial part of the sulfur introduced with fuel.
A Krupp CODIR plant designed for a facility of 150000 metric ton (165000 net tons) started operation 1973 at the Dunswart Iron and Steel Works Ltd. at Benoni, Rpublic of South Africa. The reduction kiln in this plant is about 4.0 meter (13 feet) inside diameter and 74 meters (243 feet) long. The energy consumption is about 15.9 million kilojoules per metric ton (13.7 million BTU per net ton) of DRI when low volatile anthracite is used for the reduction coal. As mentioned previously, the gross energy requirement increases when high volatile matter coals is used.

In this process lump ore or oxide pellets, solid reductant, dolomite or limestone as flux is needed. The feed size of the solids is closely controlled to expedite separation. Typically, the preheating zone extends from 25% to 40% along the CODIR process kiln.

Primary heat is supplied to the kiln by the combustion of pulverized coal injected at the solids discharge end of the kiln. Secondary heat is supplied by in injecting air into the kiln gas space through tubes spaced along the entire length of the kiln. The secondary air is introduced axially (along the kilns centre line). In this way, a uniform charge temperature profile between 950 and 1050^{o}C (1740 and 1925°F) is achieved in the reaction zone of the kiln.

The DRI, char, coal ash and spent flux are discharged via an enclosed chute from the rotary kiln burner hood into a shield rotary cooler. Cooling is accomplished by spraying a controlled amount of water directly into the hot solids and by spraying additional water on the outside of the cooler shell. The cooled solids are discharge over a 5 mm screen The minus 5 mm fraction is processed through further screening at 3 mm and magnetic separation to separate the final DRI from recycled char, spent flux and coal ash. Minus 3 mm DRI is separated as cold briquettes and 5-3 mm DRI is combined with plus 5 mm fraction. Char is separated by gravity for return to the kiln feed, and ash and spent flux are separated for disposal.

The process flow diagram of Krupp CODIR process is shown in **Figure 3.2**

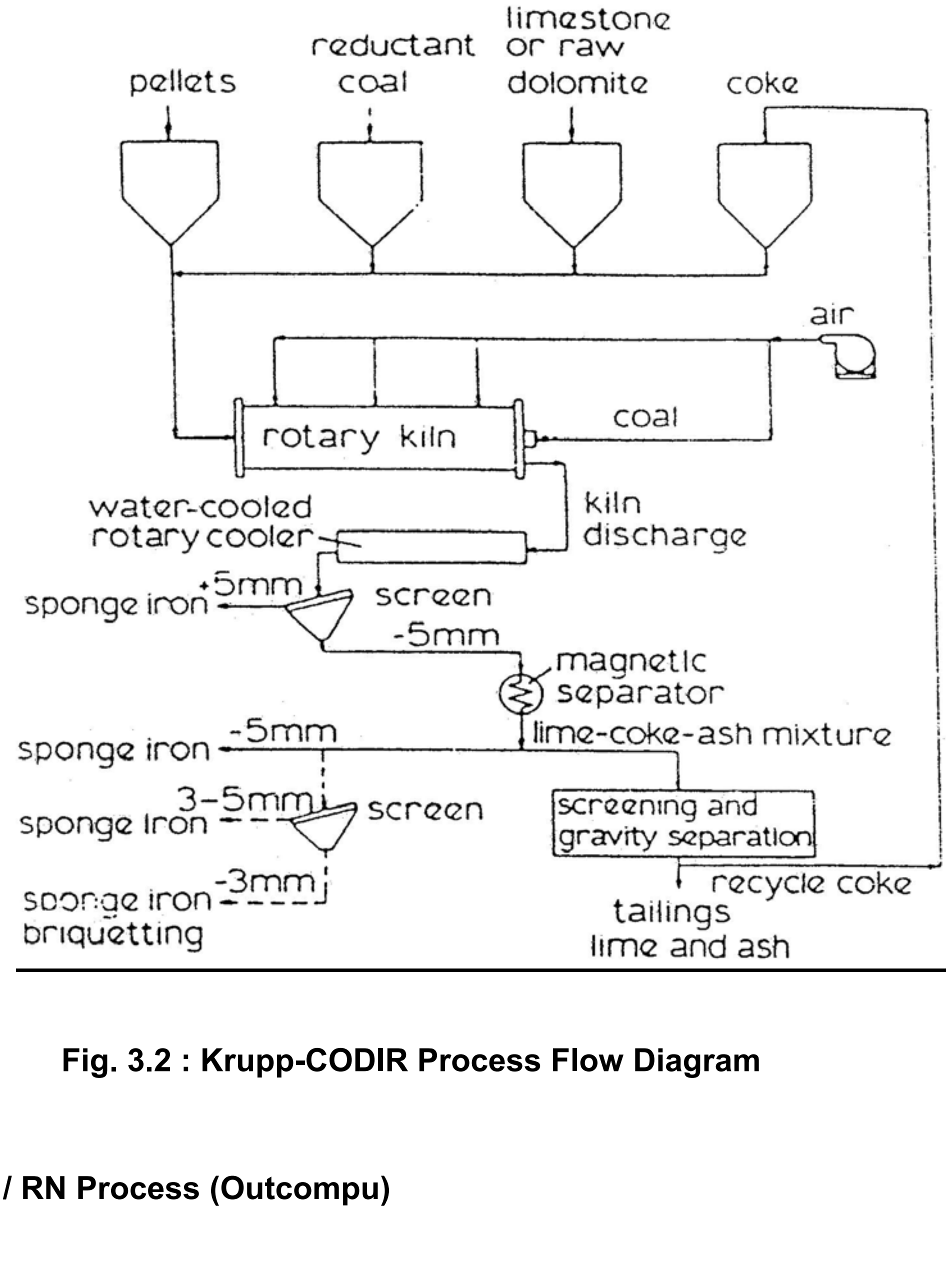

Fig. 3.2 : Krupp-CODIR Process Flow Diagram

3.35 SL / RN Process (Outcompu)

A forerunner to the SL / RN process, RN process (for Republic Steel Company and Nations Lead Corporation) was developed originally in Norway, primarily to recover TiO2 from titanium bearing ore for the production of paint pigments. However, further development showed that other iron bearing ores could also be treated successfully to produce iron. Subsequently, a pilot plant is built in the United State, and in 1964 Lurgi Chemie acquired the RN patents and developed the technology further with the Steel Company of Canada Ltd. (Stelco) to the SL/RN process.

The SL/RN process flow typically rotary kiln operation described earlier. The largest commercial SL/RN plant, design to produce 360000 metric ton (400,000 net ton) of DRI per year was installed by Stelco at Griffith Mine in Ontario, Canada and began operating in 1975. The reduction kiln in this plant is 6 meters (19.7 feet) inside diameter and 125 meters (410 feet) long. The energy consumption at this plant is about 22 million kilojoules per metric ton (19 million BTU per ton) of product when the process is operated with high volatile sub-bituminous coal. This relatively high consumption occurs because most of the volatile matter in the reductant coal leaves the kiln and is not recovered.

Other commercial installations based on the SL / RN process include one installed in 1970 by New Zealand Steel Ltd. in Glenbrook, Auckland, New Zealand for recovery of iron from native iron sands and another plant installed at the Fukuyama Works of Nippon Steel in Japan in 1974. The New Zealand Steel Limited plant was subsequently modified to included a multiple hearth furnace for reheating the iron sand feed and charging the reduction coal. The Fukuyama plant was designed to process waste oxides generates at the Fukuyama Works. Other plants have been constructed the more recent plant are operating or under construction in Peru, and South Africa.

The SL / RN process consists of lump ore or pellets, coal, recycle char, and flux need to scavenge sulphur from the coal. In the kiln preheat zone, the charge is heated to about 980°C (1800°F) by counter flowing hot freeboard gases. For high kiln efficiency the reheated zone is made as short as possible usually 40 to 50% of kiln length. Reduction begins when the charge reaches temperature in excess of 900°C (1650°F) when the carbon gassification reaction starts generating carbon monoxide. To maintain a uniform reduction zone temperature by burning combustibles released form the bed, air is blown by shell, mounted fans, feed air into the freeboard gas stream, through burner tube space uniformly along the length of the kiln. Air is introduced axially in to the kiln and additional combustion air is blown into the kiln through a central airport of the discharge end.

The solids are discharged forms the rotary kiln via transfer chute into a sealed rotary cooler. Water sprays on the cooler shell reduces the temperature of solids to about 95°C (200°F) in a non-oxidizing atmosphere. External lifter aide heat transfer in the cooler discharge material that are continuously separated into DRI, DRI fines, non magnetic by a system of screen and magnetic separation. Char is separated from the waste by gravity separation.

The SL /RN process kilns are now equipped with nozzles for under-bed injection of about 25% of the process air in the preheating zone of kiln. The air is available for combustion of the volatile matterr in the coal with in the bed in the preheating zone. As a result, the length of preheating zone of the kiln is reduced because of improved heat transfer and fuel utilization. More of the kiln length can therefore be used as a reduction zone.

The process flow of SL/RN process is shown in **Figure 3.3**

3.36 ACCAR Process

The Allis Chalamers Controlled Atmosphere Reactor (ACCAR) produces highly metabolized DRI in a rotary kiln. Liquid, solid and gaseous fuels singly or in combination are used directly in the kiln with an external reformer or gasifying plan. The ACCAR kiln is equipped with an intricate port system and with valves arranged radically around the circumference of the kiln and spaced uniformly along its length, for liquid or gases fuel injection. Versatility in the use of fuel is claimed as an advantage for this process as it permits use of the most economical fuels available.

The original ACCAR development work started in the late 1960 and was based on hydrocarbon gases and liquids. Work was started in a 0.6 meter (2 feet) diameter by 7 meter (23 feet) long pilot plant at Milwaakee and continued in a 2.5 meter (8 feet) diameter by 45 meter (148 feet) long demonstration plant at Niagara Fall, Ontario, Canada.

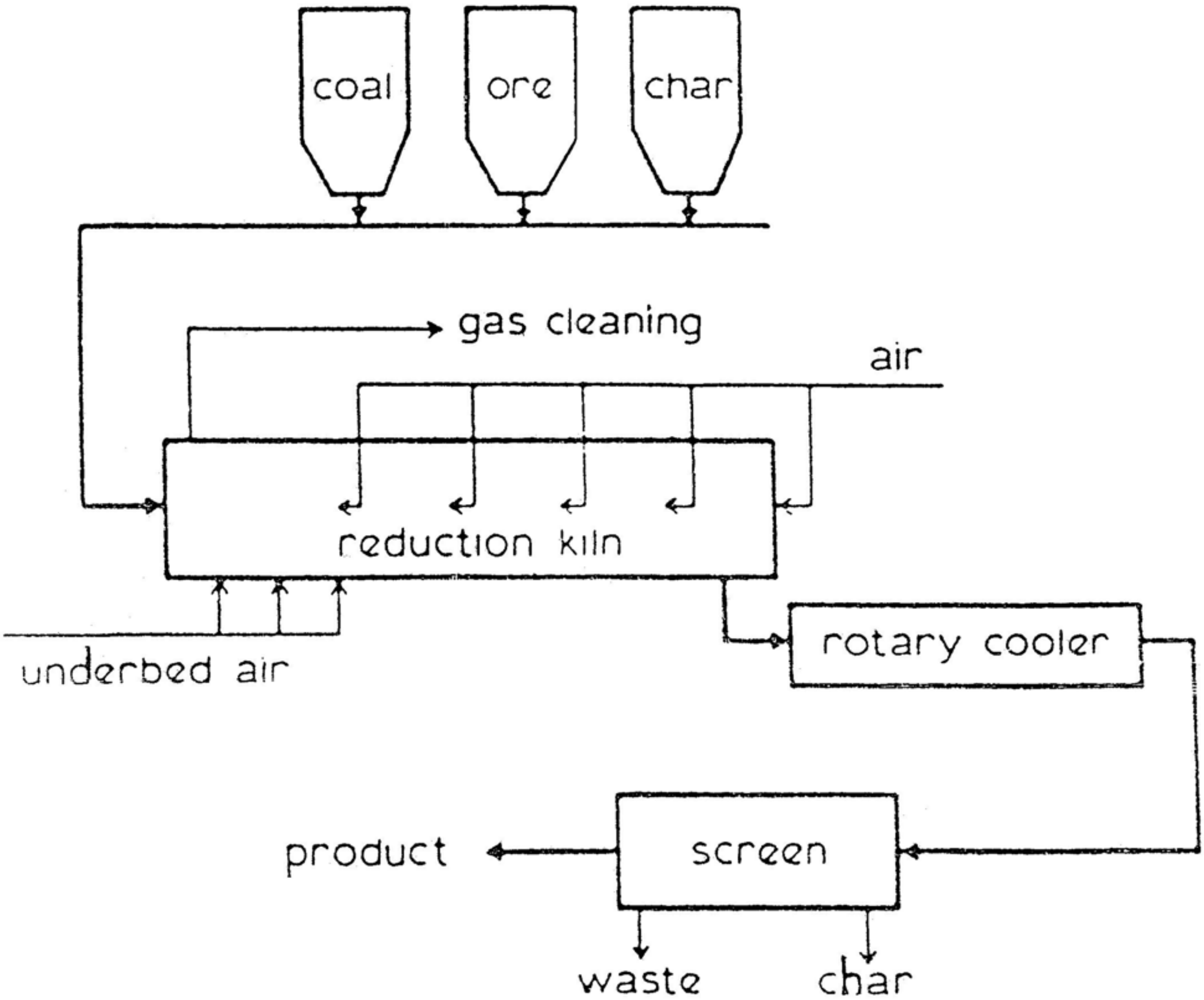

Fig. 3.3 : SL/RN Process Flow Diagram

The first commercial ACCAR plant for operation with natural gas and fuel oil was established through modification of an existing SL /NR plant in Sudbury, Ontario. The plant started operating in 1976. The reduction kiln is 5 meter (16.4 feet) inside diameter and 50 meters (164 feet) long and is claimed to be capable of producing 233,000 metric ton (257,000 net tons) of DRI per year with a total energy consumption of 15.7 million kilojoules per metric ton (13.5 million BTU per net ton) of DRI.

A second ACCAR plant of 150,000 metric ton (165.000 net ton) per year capacity start operation in 1983 in India. The plant operates with coal and oil. The oil can be injected under the bed for two third of the kiln length. The kiln design was modified to permit the addition of fine coal from the discharge end.

With 80% of the hydrocarbon fuel is released by coal, ACCAR has projected that a reduction kiln 6 meters (19.5 feet) inside diameter by 122 meter (400 feet) long will be capable of reducing 600,000 metric ton (660,00 net tons) per year of DRI. The total energy consumption is predicted to be about 18.6 million kilojoules per metric ton (16 million BTU per net ton) of DRI.

Because gases and liquid fuels are in short supply, operation of the ACCAR process with coal is popular. Coal has been used successfully to supply from 80 to 90% of the fuel for the ACCAR kiln, with the remaining fuel requirement being supplied by liquid and gaseous fuels. Coal and lump ore and or oxide pellets are fed into the fed end of the rotary kiln. The solids are heated to reduction temperature by the counter-current flow of hot gas. Volatile matter is released from the coal during heat up and carried out along the kiln exhaust gas. As the coal and iron oxide travel through the kiln, reduction is accomplished by the carbon and carbon monoxide reduction mechanism. The coal feed is controlled so that it is essentially consumed as the burden enters the final stage of the reduction. Combustibles released from the bed are burned in the kiln freeboard with air introduced through the port in the kiln shell.

The final degree of reduction is achieved by introducing liquid and or gaseous fuel through the kiln shell port near the product end of the kiln as they pass under the solid bed. In passing through bed, this fuel is corrected to form hydrogen and carbon monoxide to complete the iron oxide reduction and to provide a protective atmosphere for the highly metalized product. This method of fuel injection permits operation with the excess of coal required to maintain a reducing atmosphere in the bed in other coal based DR process. Thus char recycling is eliminated.

Solids are discharged from the rotary kiln into a rotary cooler where cooling is accomplished with external water spray. The DRI is separated from the coal ash by magnetic separator, and is then screened to achieve coarse and fine product separation.

If waste heat recovery is not practiced, the kiln gas is cleaned and the heavier solids are removed in dry dust collector, and the fine solids are removed in a wet scrubber, which also cool the gas before it released to the atmosphere.

The process flow diagram of ACCAR process is shown in **Figure 3.4**

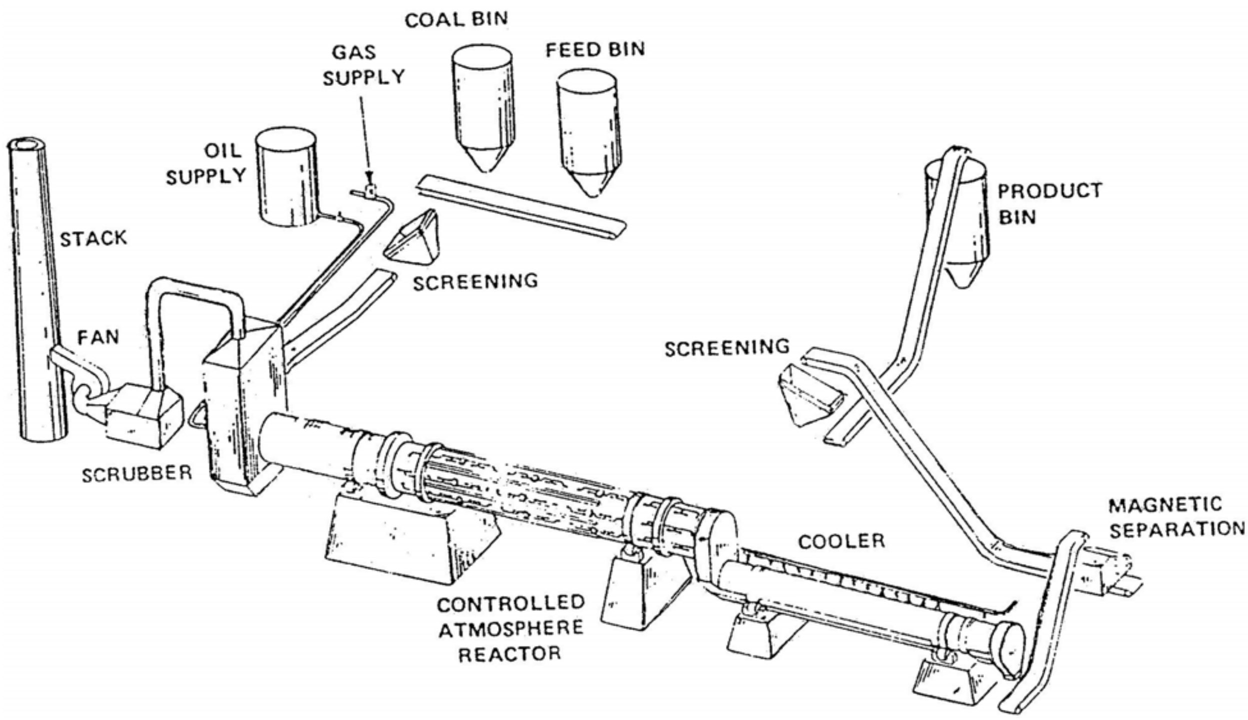

Fig. 3.4 : ACCAR Process Flow Diagram

3.37 DRC Process

The DRC process of the DAVY Reduction Corporation (DRC), a Division of Davy Mckee, stems from the Hockin process of Western Titanium Ltd. of Australia, Formerly Azion, DRC operate a pilot in Rockwood, Tennessee as a member of the Amcon group of Consolidated Gold Fields. The first commercial furnace was constructed for Scaw Metals in Germiston, South Africa.

Operations at Scaw Metals started in July of 1983. The kiln size is 4.5 metres (14.75 feet) shell diameter by 60 metres (197 feet) long. The rated annual capacity is 75000 metric tons (83000net tons). Reportedly, the plant exceeds this capacity. The coal consumption is 0.72 ton per ton of DRI based on 55 per cent fixed carbon. Davy / DRC anticipates construction of larger kilns in the future. They also stress high operability and control of their plant (including sulfur in the product) through complex consideration regarding raw material and proprietary design and operating future for the rotary kilns and ancillaries.

Ore, coal, recycled char, and flux if required, are continuously fed into the rotary kiln. Passage of the burden through a preheat zone and a reducing zone in the kiln flows typically rotary kiln operation. Some minus 9.5 mm coal (about 12.5 % of the total coal is blown by low pressure air into the discharge end of the kiln. Process heat is supplied by burning combustible in the kiln freeboard combustion air is blown in to the kiln shell mounted fans via tubes spaced along the length of the kiln. The bed and gas temperature profiles are controlled by adjustment of the air input through the tube.

In the reduction zone iron oxide is reduced by carbon from the coal, with reaction (2), (4), (6) and (9) controlling the complex gas solid reactions

$3Fe_2O_3 + H_2 = 2Fe_3O_4 + H_2O$ (1)

$\underline{3Fe_2O}_3 + CO = 2Fe_3O_4 + CO_2$ (2)

$Fe_3O_4 + H_2 = 3FeO + H_2O$ (3)

$Fe_3O_4 + CO = 3FeO + CO_2$ (4)

$FeO + H_2 = Fe + H_2O$ (5)

$FeO + CO = Fe + CO_2$ (6)

$3Fe + CO + H_2 = Fe_3C + H_2O$ (7)

$3Fe + 2CO = Fe_3C + CO_2$ (8)

$CO_2 + C = 2CO$ (9)

The maximum kiln bed temperature in the reduction zone is about 1060^oC (1940^oF) with a maximum kiln gas temperature of about 1160^oC (2120^oF). Emphasis is placed on maintaining a high ratio of carbon monoxide to carbon dioxide in the kiln bed to achieve a high degree of reduction. Control of the rate of the heat transfer to the bed and control of the bed temperature are also critical for steady operation of the kiln, the achieve stable process chemistry and favourable reaction kinetics. The hot waste gases leave the kiln of about 800^oC (1470^oF).

Solids are discharged from the kiln via a sealed transfer chute in to a sealed rotary cooler. Cooling is achieved by spraying water on the outside shell of the screening and magnetic separation circuits. Pores and fine DRI and charge that is recycled are thus separated from the fine waste.

The process flow diagram of DRC process is shown in **Figure 3.5**

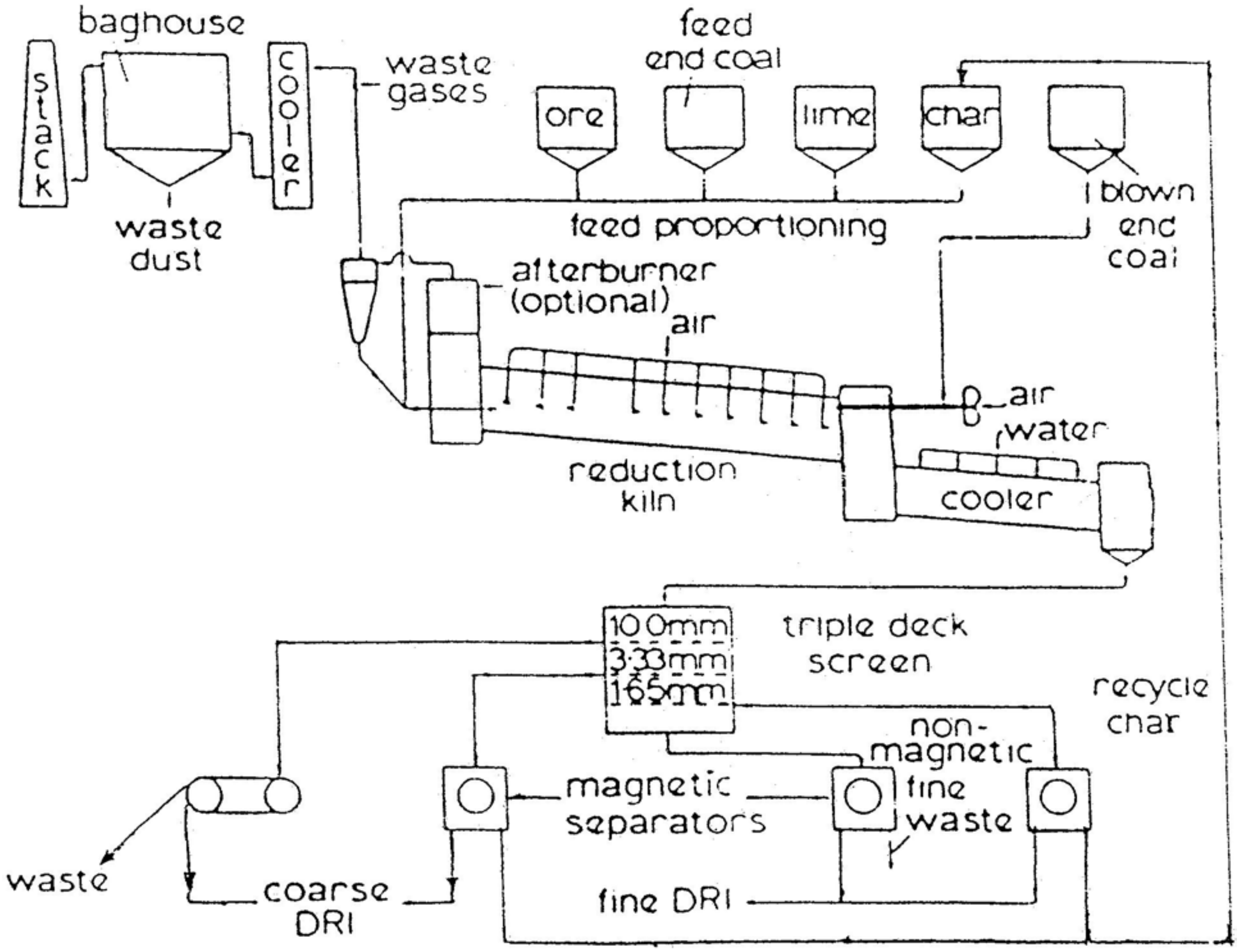

Fig. 3.5 : DRC Process Flow Diagram

3.38 Customized or Indigenous Process

In India, the standard DRI processes are modified in a minor way and thereafter referred to as customized / indigenous technology. Only trivial changes in terms of the feed ratio, length and the diameter of the kiln are made in the name of customized technology. These customized technologies are dominating the coal based sponge iron process in India. Jindal, TDR, Sponge Iron India Limited (SIIL), Orissa Sponge Iron Limited (OSIL), Popurri Engineering, etc have customized and adopted and market such technology. Except OSIL none of the customized processes are patented.

In India, the coal based DRI production process employs a rotary klin as the main reactor wherein the process of reduction of the iron oxide is carried out with coal as reductant. Refractory lining of about 150-200 mm thickness is given inside the kiln to protect the shell. The kiln has a general slope of 2.5 - 3% down towards the discharge end. There are air blowers mounted on the kiln shell having dampers to provide required air for combustion at different heating zones.

Sized iron ore and coal in required proportion are fed in to the kiln with the help of the weigh feeders at the feed end. Due to the rotational motion of the kiln and due to the slope provided, the charge moves forward to the discharge end. Thermocouples are mounted on the kiln to measure and control the temperature of the different heating zones. Fine coal is also injected through the discharge end of the kiln with the help of the coal injector machines & lobe compressor, to meet the additional carbon and volatile matter requirement of the reaction.

Kiln discharge material which is a mixture of sponge iron and char (mixture of unreduced iron, uncalcinated limestone, gangue and semi burnt coal) is taken to a rotary cooler. Water is sprayed on the cooler shell to indirectly cool the kiln discharge mix to about 120^{o}C. The cooler also has a slope of about 2.5%. The cooler discharge falls onto a hopper and taken through conveyors for screening of fines and coarse materials. After separating the -3 mm and +3 mm sizes in the product screen, the cooler discharge mix is subjected to magnetic separation where sponge iron is separated from char. Sponge iron and char of coarse and fine sizes are stored in separate silos or hoppers.

The reducing gases generated from the combustion of the coal, flow counter current to the direction followed by the solids and emerge from the feed end. The kiln is maintained at a positive pressure of about +5 mm water column. The flue gases then passes through the gravitational Dust Settling Chamber (DSC) and pass on to the After Burner Chamber (ABC) located right above the DSC. In the ABC, the CO is converted to non toxic CO_2. Therefore, in ABC the off-gas laden with combustible matter is burnt. On the top of the ABC, there is an emergency cap to maintain the kiln pressure by letting out the accumulated gases.

The DRI plants installed in early eighties and nineties uses quenching through Wet Scrubber to treat the dust bearing flue gases. In this system the huge amount of sludge is generated, which is disposed in ash ponds. The laltest trend in DRI plant is to use Electrostatic Precipitator for dust trapping. In this system, the flue gas, at about 900^{o}C - 950^{o}C, is taken to a Gas Conditioning Tower (GCT) where quenching water is added to cool the gas to about 150^{o}C. The cooled gas then travels to the Electrostatic Precipitator (ESP). Dust is trapped in the ESP and the flue gas is let out using chimney.

Off late, some large DRI plants have installed Waste Heat Recovery Boiler (WHRB) after the ABC, to utilise the waste heat content of the flue gas. The WHRB generates steam at high pressure and use it to run turbines and produce electricity. The general technology followed in all the coal based DRI plants is similar to that of SL/RN (Lurgi process). The process flow diagram is shown in **Figure 3.6**.

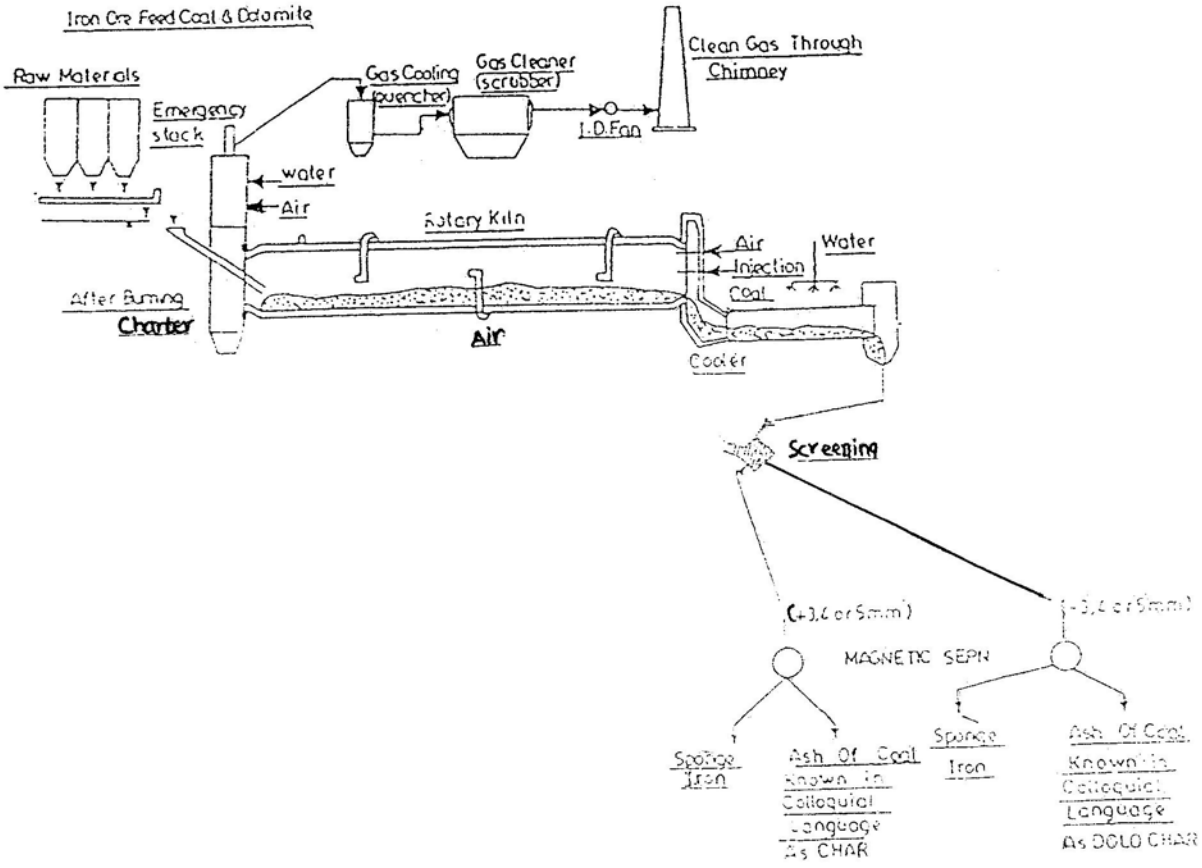

Fig. 3.6 : Flow Diagram of Coal Based Customized / Indigenous Technology

Sponge Iron India Limited: In India, the first sponge iron plant of 100 tons/day capacity was constructed in 1979 by a Company styled as Sponge Iron India Limited (SIIL) at Paloncha in Khammam District of Andhra Pradesh. SIIL is a joint venture between Govt. of India, Govt. of AP, UNDP and UNIDO. The technology supplier to this plant was Lurgi (SL/RN Technology). In this plant, the kiln is 3 m in diameter and 40 m length. The feed rate of iron ore was fixed at 6.7-7.0 tons/hour and coal feed rate at 3.5-5.0 tons/hour. The feed was retained in the kiln for 4-6 hours and the temperature of the preheating zone was 650-800^{o}C, reduction zone was 900-1000^{o}C. The production started in 1980 and the DRI output was 100 tons/day. Wet scrubber was used to clean the dust laden gases.

The SIIL plant was meant to demonstrate production of DRI from iron ore and non-coking coal available in abundance in India and to establish the suitability of Indian raw material for DRI making. The initial shortcomings in the process were overcome by SIIL engineers and the operation streamlined. Based on the results of operation of these units, other DRI plants started coming up in India. Similar plant was established in 1990s by HEG Ltd. at Durg, Bellary Steel & Alloy Limited at Anantapur Road, Bellary in Karnataka and Raipur Alloys Ltd. at Siltara in Chattisgarh.

Popurri Engineering: Mr. Popurri Ankineedu was one of the engineers associated with the SIIL project, who later left SIIL and started marketing this process knowhow under the brand name of Popurri Engineering. Today there are over 50 small DRI plants all over India, which are based on process knowhow supplied by Popurri Engineering. Some other engineers who were also associated with the earlier DRI plants also started supplying the process knowhow to the upcoming DRI plants, thereby closing the flow of standard technologies into Indian DRI market. Large Indian steel majors however did not support these small time freelancing engineering endeavours driven by the desire to establish their own brand knowhow and market them for profits. The steel majors like Jindal and TISCO have also made minor modifications to the original Lurgi technology and came up with their own brand of Jindal Technology and TDR technology.

Jindal Technology: Jindal Steel & Power Limited started their first kiln of 300 tons/day capacity in 1991 at Raigarh in Chattisgarh. Subsequently they have established five similar kilns till 2000. Today they are the worlds largest producer of coal based DRI with an installed capacity of 620,000 tons/annum. They have successfully provided the Jindal Technology to Monnet Ispat, Nalwa Sponge, Vallabh Steel, and Rexon Strips. The kilns of Jindal Technology are having diameter of 3.8 m and lenth of 70.8 m. The feed rate is 9-10 tons/hour and the size of feed is 5-20 mm for iron ore and 3-20 mm for coal. Coal injection is done from the discharge end of the kiln having lump size of 3-20 mm and fines of –3 mm. The temperature at the feed end is maintained at 750-900^oC, middle of kiln at 990-1040^oC and discharge end at 1010-1050^oC.

TDR Technology: Tata Steel established a sponge iron plant in 1983 at Beliapada, near Joda of Keonjhar District in Orissa named Tata Sponge Iron Limited. The process is similar to SIIL. Lurgi provided technical support. The process was called TISCO Direct Reduction (TDR). The first kiln was established in 1986 having DRI output of 300-350 tons/day. The kiln diameter is 4.2 m and the length is 72 m. The feed rate is 21 tons/hour and the kiln retention time is 8-9 hours. The size of the feed is 5-20 mm for iron ore and 0-15 mm for coal. At the feed end the temperature is kept about 800^oC and at the discharge end it is about 1000^oC. The second kiln of 350 tons/day was established in 1998. TSIL appointed Dastur and Lurgi GMbH for providing technical support so that certain shortcomings, inherent in the design of the first kiln, could be rectified. Emphasis was laid on the general lay-out of the plant. The working point at kiln inlet was reduced from 14.9m to 12.9 m .ESP was used for dust trapping compared to wet scrubber in the first kiln, and the plant was totally automated through the PLC system. The length of the rotary cooler was increased to 42 m against 35 m of the first kiln, at a discharge end a weigh hopper with a variable discharge system has been installed to ensure positive sealing. In order to increase productivity a counter current iron ore fines injection system of 2.5 tons/hour was installed. Castable refractory lining was done in Dust Settling Chamber. The third kiln of 500 tons/day was established in

2004. Till now, no other plants has come up in the country using TDR technology.

Orissa Sponge Iron Limited: Orissa Sponge Iron Limited (OSIL) was set up in 1983 in Palaspanga of District Keonjhar in Orissa. It was based on ACCAR process having an underbed injection of diesel from the discharge end. OSIL later used coal fines in place of diesel and patented it as OSIL technology. In 1995 OSIL supplied the technology to Llyods sponge iron plant at Ghuggus in Chandrapur district of Maharashtra. In OSIL, the diameter of kiln is 4.0 m and the length is 84 m, having refractory thickness of 230 mm rendering an effective diameter of 3.54 m. The kiln output is 300 tons/day. Non-coking coal is fed from the feed and discharge end as reductant, whereas provision for injecting solid, gaseous and liquid fuels are provided through the 300 portholes located on the kiln shell. The reactor can operate using single fuel or combination of fuels. To facilitate combustion, air is driven into the kiln through the port holes. The reductant product having temperature of 1050C is discharged into the rotary cooler where it is indirectly cooled with water spread on the cooler shell. The cooled product is discharged from the cooler having temperature of about 100C and brought for magnetic separation. The product usually has a degree of metallisation of +90%.

3.39 Rotary Hearth Process

3.13.03 Inmetco Process

The INMETCO process is currently operated by the International Mettle Reclamation Co. Inc. in Ellwood City Pennsylvania for the recovery of waste iron ore dust. The oxide pellets are fed into a rotary heath furnace, which is separated by air curtains into oxidizing, reducing, and natural discharge zones. Burners above the bed are fired with oil or natural gas (coal burners have been tested and can be used as well). The shallow bed depth results in high heat transfer rates. Residence time for the pellets in the bed is approximately 15 to 30 minutes.

As of 1980, the process operated at 80000 metric tons (88000 net tons) of feed per year in the recovery of metal from waste dusts. An operating rate up to 250000 metric tons (275 000 net tons) of feed per year per single unit has been proposed.

3.13.04 Salem Direct Reduction Process

To avoid accretion problem common in rotary kiln direct reduction processes, the Salem Furnace Company proposes using a rotary heath furnace as the reduction reactor. For the Salem DR process the rotary heath is surmounted by a stationary roof, which is fitted with a series of water-cooled rabble arms fixed across one radius. Lump ore, or pellets, and coal, are fed through a chute at the periphery of the heath. As the heath rotates several times, the rabble arms toward a central discharge heat-soaking pit move the burden. In this manner the material that is turned and displaced by a rabble makes one completes revolution as a quiescent bed before a reach the next rabble.

Volatile matter in the coal and combustible released from the bed are burned in the freeboard between the roof and the hearth layer to provide the heat for the charge. Combustion air preheated by the process exhaust gases, is admitted to the freeboard through port in the root and side walls. The reduced product is discharged through the currently locate soaking pit in to rotary cooler, cooled by external water spray. The DRI is separated from the coal ash and residual char by screening and magnetic separation.

The process flow diagram of Salem DR process is shown in **Figure 3.7**.

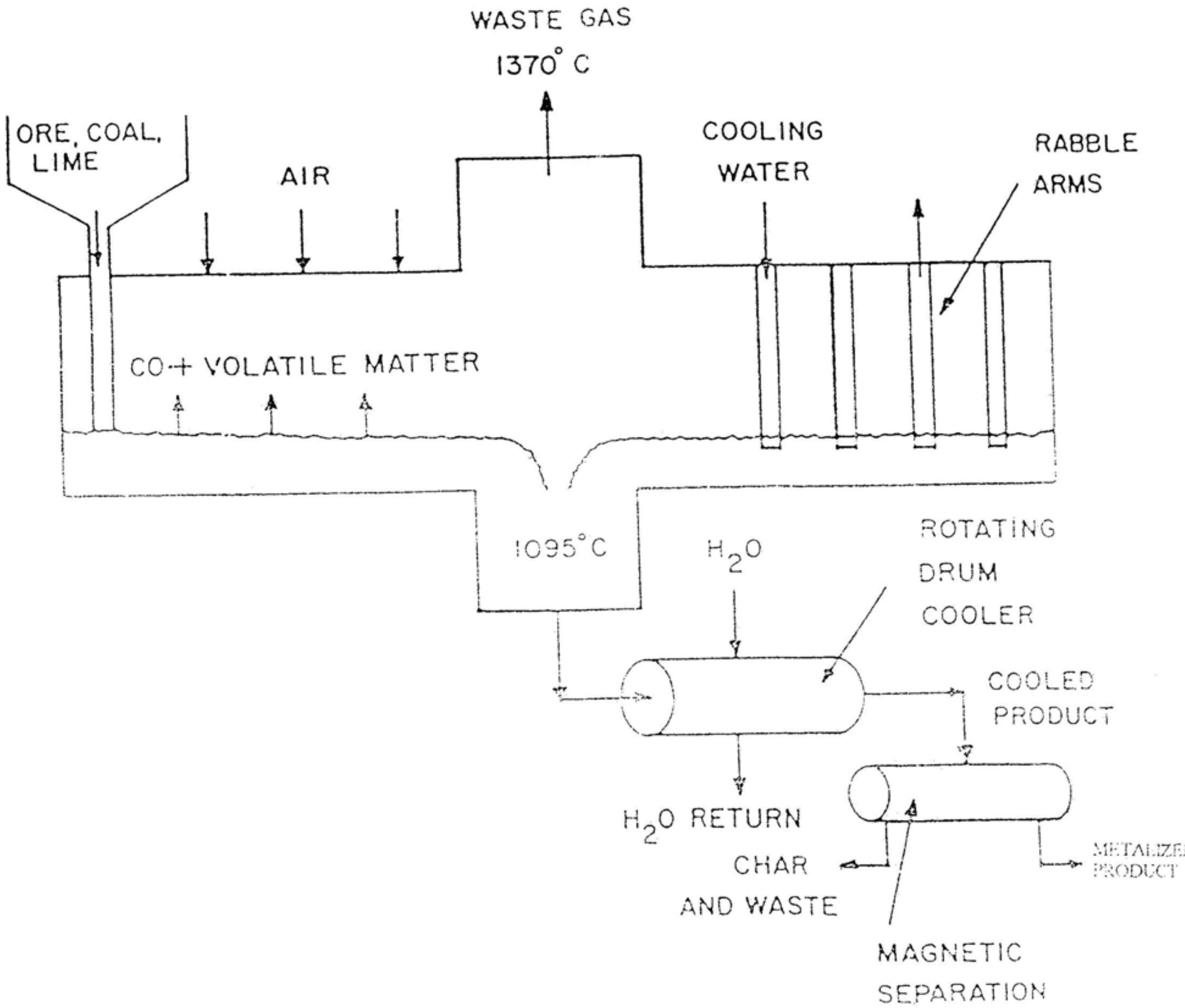

Fig. 3.7 : Salem Rotary Hearth Direct Reduction Process

3.40 Retort Process

3.14.03 Hoganas Process

The E. Sieurin Hoganas process was developed at Hoganas in Sweden in 1910 and is still in commercial use. Alternate layers of fine-grained high-grade iron ore, dry coke breeze, and limestone are charged into cylindrical ceramic containers called saggers are then heated to a maximum temperature of 1260°C (2300°F) in a furnace of the tunnel-kiln type used for burning brick. The furnace is heated by burning producer gas and the carbon monoxide evolved by the reduction of the ore. The containers are cooled in the furnace, removed, and the reduced iron is separated and cleaned. Total retention time of a container in the tunnel kiln is about 80 hours. Most of the DRI produced is sold as iron powder. The largest Hoganas plant in operation has two tunnel kilns and is capable of producing 38000 metric tons (41000 net tons) annually.

3.14.04 Kinglor Metor Process

The Konglor-Metror process is based on the concept of producing DRI continuingly by heating mixture of ore and coal in an externally fired rectangular shaft or retort. Earlier attempts to implement this concept failed because the reduction reaction are highly endothermic and the production was severely limited by the slow rate of heat flow into the charge through the retort walls which were made of firebrick. Kinglor Metor overcame this limitation by constructing the wall of the retort with highly conductive silicon carbide and by burning reduction with in a preheating zone in the upper part of the retort a schematic flowsheet of the process.

Danieli & Cie Limited installed a pilot plant comprising tow reactor at Buttrio, Italy. The reactors are essentially vertical shaft of conical shape about 11 m (33 feet) high with top diameter of 0.4 m (1.3 feet) and bottom diameter of 0.7 m (2.3 feet). The energy consumption is claimed to be about 16 million kilojoules per metric ton (13.8 million kilojoules per metric ton (0.43 million BTU per net ton). The pilot-plant operations demonstrated the process to be simple to construct, easy to operate, and flexible with respect to feed and reluctant requirements.

A commercial plant capable of producing 40000 metric tons (44000 net tons) per year has been installed by Ferriere Arvedi & Cie in Cremona, Italy. The plant consists of two identical 20000 metric tons (22000 net tons) per year modules. Each module contains six vertical retorts 13 m (43 feet) high, 12.5 m (41 feet) long, and 3 m (8.8 feet) wide. Ore and coal are fed continuously into a silicon- carbide reactor that is heated to about 1100°C (2010°F) with natural gas radiant burners. Solid fuel requirements of about 8.5 kilojoules per metric ton (7.4 million BTU per net ton) of DRI and gaseous fuel requirement of about 7.9 kilojoules per metric ton (6.8 million BTU per net ton) are claimed for the process.

The process flow diagram is shown in **Figure 3.8**.

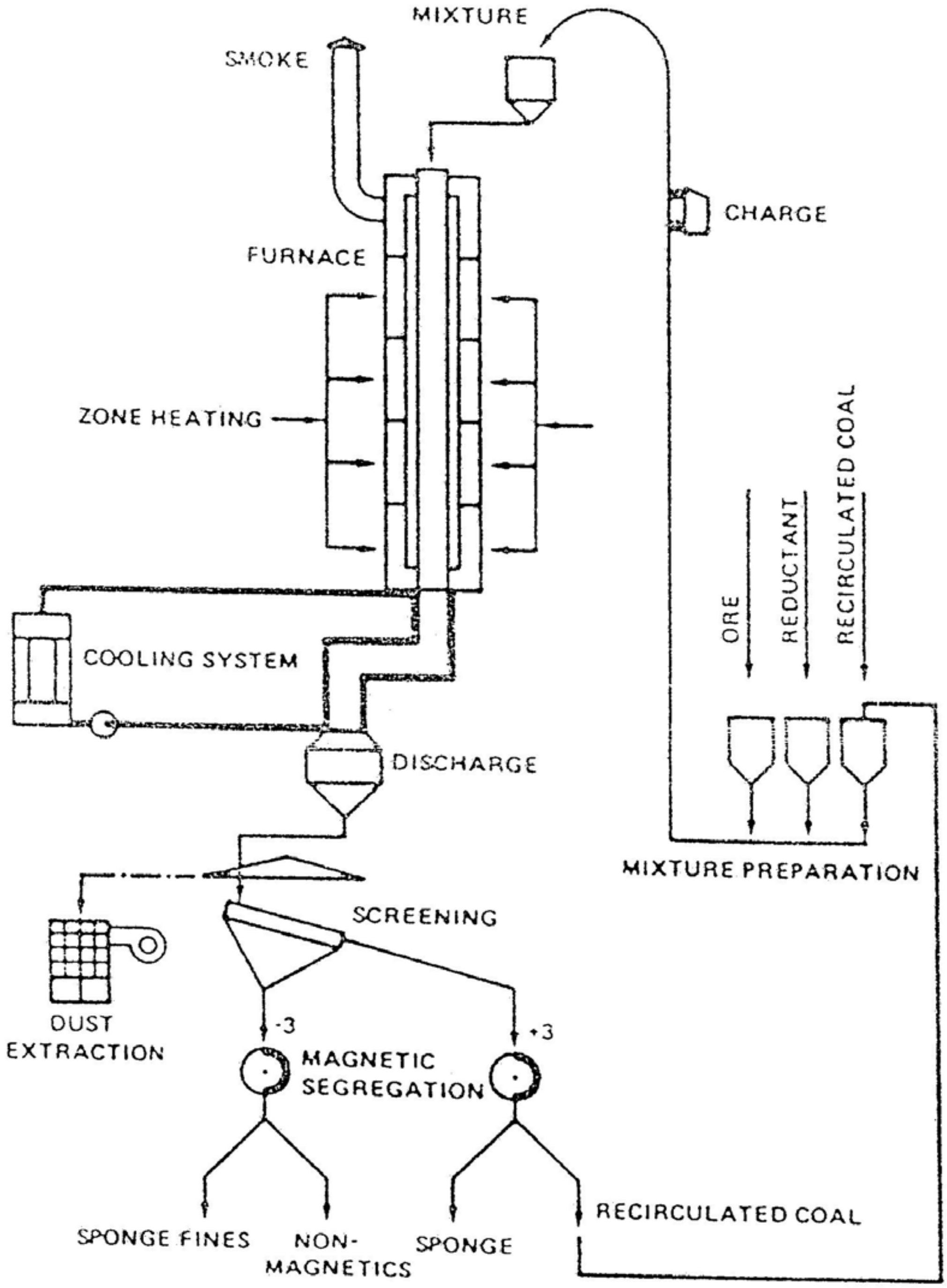

Fig. 3.8 : Kinglor – Metor Process Flow Diagram

3.41 Gas Based Processes

Today gas based DR plants subscribe to more than 90% of installed DR capacity in the world, of which MIDREX and HYL together have about 85 % of the total capacity to their credit.

In the gas based processes, the reduction of iron oxide is carried out by a mixture of CO & H2 at a temperature of about 750-950°C.

The reducing gas is produced by reformation of natural gas. The reformation is partial oxidation of hydro-carbons. To enhance the reformation process, normally a catalyst is used.

3.42 Major Facilities of Gas Based Plant

a) Direct reduction furnace
b) Hot briquetting system (OPTIONAL)
c) Process dust collection system
d) Reformer
e) Recuperator and flue gas system
f) Gas scrubber and cooler
g) Process gas compressors and blowers
h) Water system
i) Effluent treatment system
j) Natural gas system
k) Inert gas/seal gas system
l) Compressed air system
m) Steam facilities (for HYL-III plant only)
n) Electrical equipment
o) Instrumentation
p) Raw material, product storage & handling system
q) Repair shop and laboratory
r) Ventilation and dedusting system

3.43 Typical Raw Material Characteristics

SL. NO.	ITEM	PELLET	IRON ORE LUMP
1.	Fe	66.57%	66.50%
2.	SiO_2	2.25%	0.71%
3.	Al_2O_3	0.28%	1.66%
4.	P	0.017%	0.015%
5.	S	0.011%	0.005%
6.	CaO	2.10%	-
7.	MgO	0.08%	-

3.44 Typical Consumption Of Raw Materials & Services (Per T Of Dri/Hbi)

SL. NO.	RAW MATERIAL/ SERVICES	UNIT	PER "t" OF DRI/HBI
1.	Iron oxide	t	1.55-1.60
2.	Natural gas	Nm^3	300-320
3.	Power	kWh	90-120

3.45 Typical Quality of Dri/Hbi

SL. NO.	ITEM	DRI	HBI
1.	Fe total, %	90-91	90-91
2.	Degree of metallisation, %	92-94	92-94
3.	Carbon, %	1.5-2.5	1.0
4.	Gangue, %	3.5-4.0	3.5-4.0
5.	Bulk density, t/m^3	1.8	2.7
6.	Nominal volume, cm^3	-	30X60X100 or, 30X60X90

Of the direct reduction process using gaseous reductant , Midrex and HYL are predominant conditioning around 85 % of the production and installed capacity. Plants based on these technologies are available in India. At present HYL offers only HyL III modules. The description of the process is as follows:

3.46 Midrex Process

Surface combustion division of Midland developed the Midrex Process. In the mid-1960s the Midrex division became a subsidiary of Korf industries. In 1974 Midrex was acquired by Kobe Steel Limited in 1983. The first commercial midrex plant was intalled near Portland Oregon and started production in 1969. The plant included two shaft reduction furnaces of 3.4 m (11.2 feet) inside diameter and had a total capacity of 300000 metric tons per year. The average energy consumption of this plant was about 15 million kilojoules per metric ton (12.9 million BTU per ton of DRI). Many difficult engineering and operating problems were solved during the first several years of operation of this plant.

The Midrex DRI plants of 1970s comprise the 4.88 m (16 feet) inside diameter midrex series 400 and the 5.5 m (18 feet) inside diameter series 600 shaft furnace modules. The number of the series originally designated the DRI capacity in thousand of metric tons per year. By 1983, more than twenty Midrex modules were installed having a total capacity of about 9 million metric ton per year (9.9 million net ton per year).

The main components of the process are the DRI shaft furnace, the gas reformer, and the cooling gas system. Solid and gas flows are monitored and the process variables are controlled within the operating limits. The temperature and composition of each gas stream to the shaft furnace are controlled within specification limits to maintain optimum bed temperature for reduction, degree of metallization, carbonization level (Fe_3C contents), and to ensure the most efficient utilization of the reducing gas.

The DRI furnace is steel vessel with an internal refractory lining in the reducing zone. The charge solids flow continuously in to the top of the furnace through seal legs. The reduction furnace is designed for uniform mass movement of the burden by gravity feed, through the preheat, reduction, and cooling zones of the furnace. The cooled DRI is continuously discharged through seal legs at the bottom of the furnace. The use of seal legs for feeding and discharge solids eliminates the need for complex lock hoppers. Inert gas is injected into the seal legs to prevent escape of process gases. On discharge from the shaft, the DRI is screened for removal of fines. Special precautions are undertaken to minimize any danger of spontaneous ignition of the pyrophoric DRI product during extended storage or shipment. Either the patented Midrex CHEMAIRE process or a Hot Briquetted Iron Process is employed to protect the DRI.

Reducing process gas, about 95% combined hydrogen + carbon monoxide, enters the reducing furnace through a bustle pipe and ports located at the bottom of the reduction zone. The reducing gas temperature ranges between 760 & 950^{O}C. The reducing gas flows countercurrent to the descending solids. Iron oxide reduction takes place according to reaction following.

$3Fe_2O_3 + H_2 = 2Fe_3O_4 + H_2O$ (1)

$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$ (2)

$Fe_3O_4 + H_2 = 3FeO + H_2O$ (3)

$Fe_3O_4 + CO = 3FeO + CO_2$ (4)

$FeO + H_2 = Fe + H_2O$ (5)

$FeO + CO = Fe + CO_2$ (6)

The partially spent reducing top gas, containing about 70% carbon monoxide plus hydrogen, flow from an outlet pipe located near the top of the DRI furnace into the top gas scrubber where it is cooled and scrubbeed to remove the dust particle. The largest portion (about two third) of the top gas recompressed, enriched with natural gas, preheated to about 400^{O}C (750^{O}F) and piped into the reformer tubes. In the catalyst tubes, the gas mixture is purified to form carbon monoxide and hydrogen. The hot reformed gas (over 900 ^{O}C or 1650 ^{O}F), which has been restored to about 95% carbon monoxide plus hydrogen is then recycled to the DRI furnace.

The reformation reactions are as follows:

$CH_4 + CO_2 = 2CO + 2\ H_2$ (1)

$CH_4 + H_2O = CO + 3H_2$ (2)

The balance top gas (about one third) provides fuel for the burner in the reformer. Hot flue gas from the reformer is used in the heat recuperates to reheat combustion air for the reformer burners and also to preheat the process gas before reforming. The addition of heat recuperates to these gas streams has enhanced process efficiency, helping to decrease annual fuel to a full usage reported low figure of 11.4 to 11.6 million kilojoules per metric ton of DRI.

Cooling gases flow countercurrent to the burden in the cooling zone of shaft furnace.The gas then leaves at the top of the cooling zone and flow through the cooling gas scrubber. The cleaned and cooled gas is compressed, passed through a demister, and is recycled to the cooling zone.

An alternative flowsheet uses cold shaft furnace top gas for cooling prior to it introduction into the reformer. The DRI absorbs sulphur in the top gas that comes from the raw material. This helps to prevent sulphur poisoning of the catalyst.

The process flow diagarm of Midrex process is shown in **Figure 3.9**.

Typically Midrex offers the following module sizes :

i) 400 Series modules

ii) 600 Series modules

iii) 800 Series modules

iv) Midrex Mega Module

v) Midrex Super Mega Module

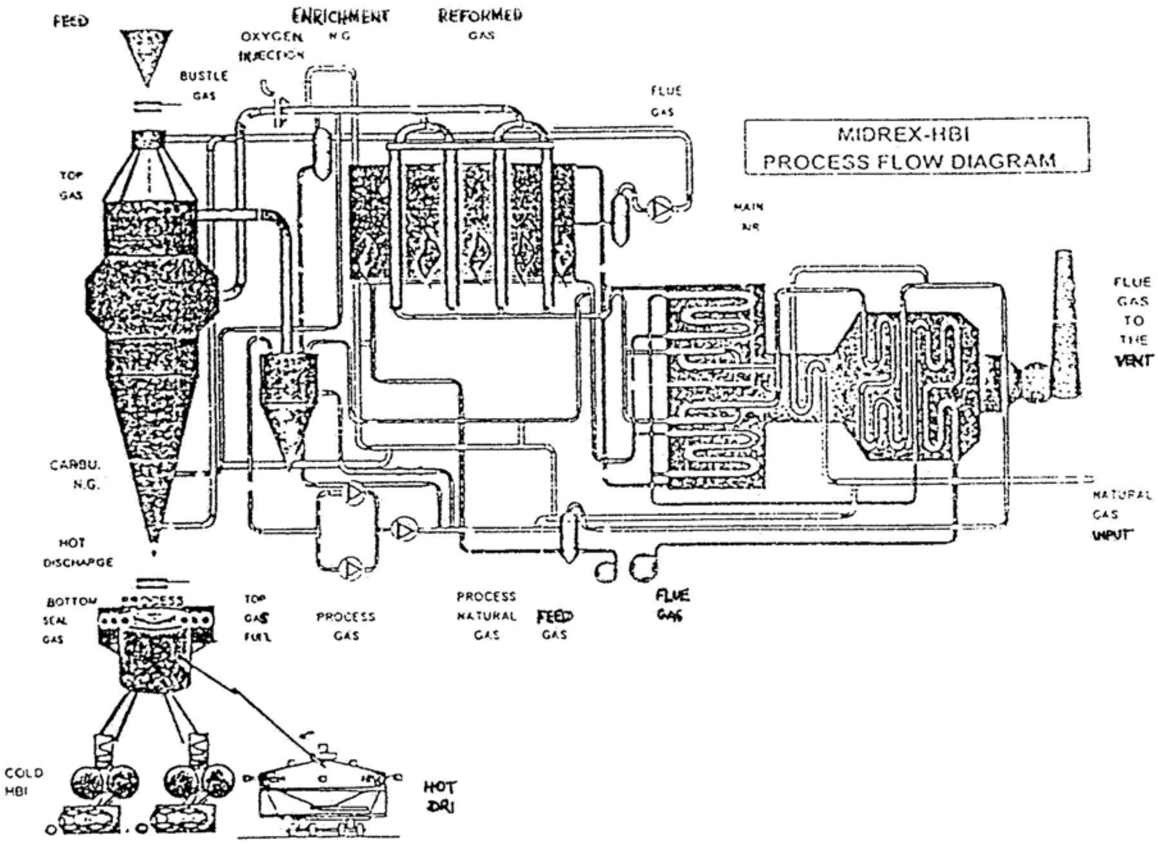

Fig. 3.9 : Midex Standard Process Flow Diagram

3.47 Process Description

HYL-III process

The HYL-III process of Hylsa of Monterrey, Mexico evolved from the original HYL process by retaining the catalytic reformer, the gas reheater, and the off gas handling system which condenses water and remove particulate in a scheme that recycles the reduce–reactor off-gas. In the HYL III process, a single shaft furnace with a moving bed is used in place of the four original fixed bed reactors.

The HYL plants operated with iron ore, iron oxide pellets or mixture of the two, natural gas consumption equivalent to about 10.7 million kilojoules per metric ton of DRI is quoted for green field construction. The power consumption of gas compression is 90 kWh per metric tons of DRI.

The main equipment of HYL-III comprises a DR shaft furnace, a gas reformer, and a gas reheated. The principles of operation of the furnace are similar to the midrex shaft furnace described previously. Continuously

descending iron- bearing material is reduced in an upper zone by the countercurrent flow of gas, which is rich in carbon monoxide and hydrogen. Reduction is accomplished by reaction of the reducing gas which is introduced through a distribution system about the circumference of the shaft at an intermediate height. The main reactions are as follows:
Reforming reactions

$CH_4 + H_2O = CO + 3H_2$

Reduction reactions

$3Fe_2O_3 + H_2 = 2Fe_3O_4 + H_2O$ (1)
$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$ (2)
$Fe_3O_4 + H_2 = 3FeO + H_2O$ (3)
$Fe_3O_4 + CO = 3FeO + CO_2$ (4)
$FeO + H_2 = Fe + H_2O$ (5)
$FeO + CO = Fe + CO_2$ (6)

A proper selection of iron oxide feed stock permit operation at 950°C. The addition of 5 per cent non-sticking ore alters the sticking tendency of iron oxide pellets and improves performance by promoting uniform descent of the burden. This increases productivity and decreases fuel consumption.

After reduction, the hot DRI continues to descend through a constant pressure zone, which separates the upper reducing zone form, the lower cooling zone. The DRI is cooled to below 50°C by an independent gas stream. The cooling gas is withdrawn at the top of the cooling zone. After cooling, cleaning and compressing. This gas is recalculated at the bottom of the shaft furnace. The composition and temperature of gas flow to the shaft furnace are carefully controlled to permit independent control of the metallization and carbon content of the DRI. It is claimed that a high reduction temperature and the formation of an iron carbide shell protect the DRI from spontaneous rexidation. Like Midrex, there is provision of hot briquetting facilities in the system.

The HYL III shaft furnace operates at about 54 kg/cm^2 (5atm) for this reason, the design incorporates special pressure lock system for charging iron oxide feed materials at the roof and for discharging cold DRI at the bottom. Possible advantages of high pressure operation are enhanced reduction kinetics, higher gas throughput, and condensation at elevated pressure which lowers the moisture content of the recirculated top gas.

Insofar as reducing gas is concerned, the HYL III process employs catalytic steam reforming of natural gas. As in the original HYL process excess steam is used, the reformed gas is cooled to condense water, which increases the carbon monoxide plus hydrogen content to a high percentage.

The sensible energy of the reformed gas is recovered during cooling by heat exchangers to the steam system. The usual heat recovery system in the flue gas stack of the reformer and gas reheater is also used. The cold reformed gas is mixed with compressed top gas from the shaft furnace This top gas had previously been processed to remove a substantial part of its moisture and particulates. The mixed reducing gas is then reheated introduced in to the shaft furnace along with natural gas, excess shaft furnace of gas (over that amount recirculated the process) is used as fuel in the reformer and gas heater.

The process flow diagram of HYL-III process is shown in **Figure 3.10**.

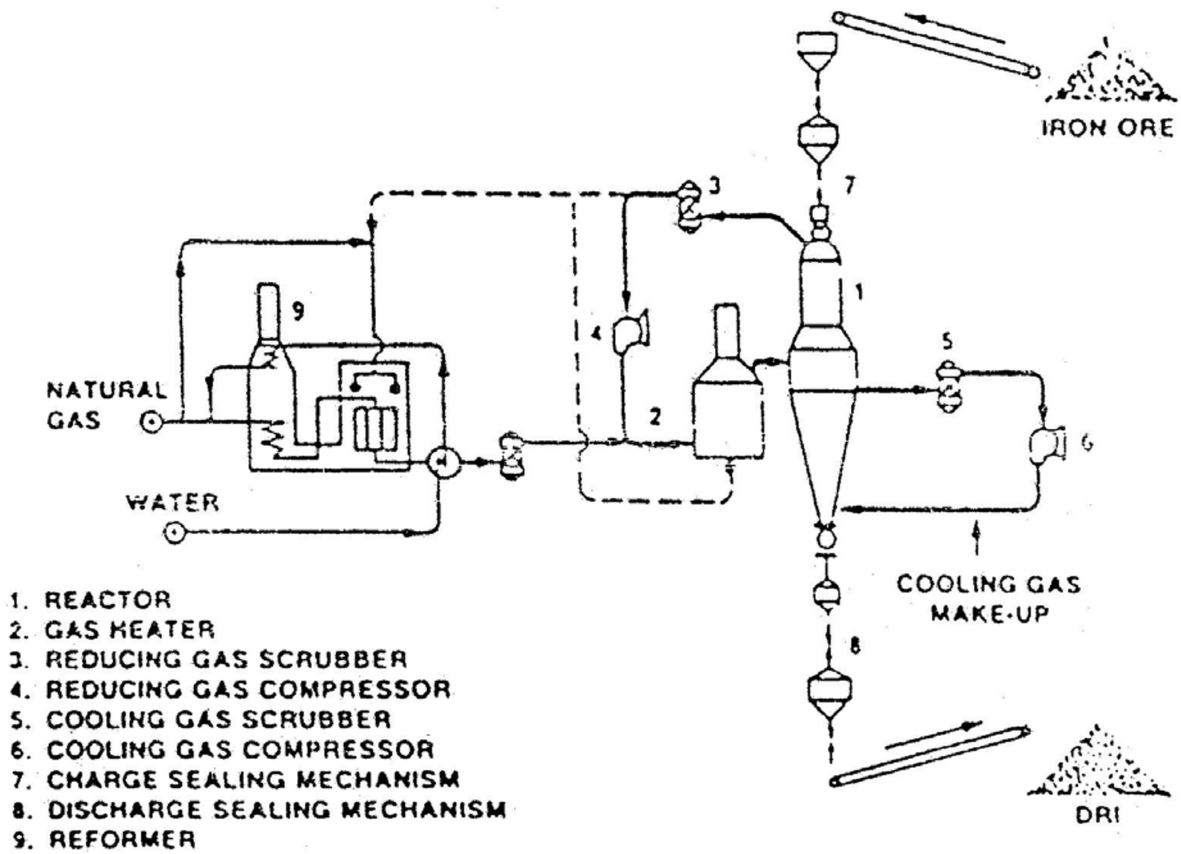

Fig. 3.10 : HYL-III DR Process Flow Diagram

3.48 Available Module Size

Typically HYL offers the following module sizes :

i) 250,000 tpa module
ii) 500,000 tpa module
iii) 750,000 tpa module
iv) 1,000,000 tpa module

The other gas-based process (few in number) are not operating in India and hence not kept under review.

3.49 NSC Process

The Nippon Steel Corporation (NSC) began fundamental research on their shaft furnace DRI process on a small scale in 1970 in conjunction with the Iron and Steel Institute of Japan. At the same time, the Hirohata Works and Texaco, Inc were jointly developing a fuel oil partial-oxidation gasifier for producing reducing gas for blast furnace injection. These efforts formed the basic for the design and construction of a shaft furnace pilot plant that started operation in 1971. Reducing gas was generated by the partial oxidation of fuel oil.

A demonstration plant with a design capacity of 150000 metric ton (165000 net ton) per year of DRI was built by NSC at their Hirohata works. The plant was operated in 1977. The shaft furnace, which exhibits lines similar to the blast furnace, has a 2.1 m (6.9 feet) inner diameter at the lower gas injection point, and is 9 m (29.5 feet) high. The shaft furnace is pressurized up to 5 bars (5 atmospheres) to gain advantage in the recycled system and blowing rate of gas a discussed previously for HYL III. The shaft furnace is equipped with lock hopper charging system, which is pressurized with seal gas to prevent leakage of reducing gas. The burden in the shaft furnace is supported at thew bottom by a table. Hot DRI is removed periodically by the controlled action of scrapers. The DRI collect in an underlying conical section below the table and subsequently flow in to a separate but connected cooling vessel. A flow of recirculated gas cool the DRI to below 100°C (212°F). Carburization is effected in the same unit. NSC proposed briquetting to protect their DRI product from reoxidation.

A Texaco partial oxidation gassifier is employed in the process. It is design for the production of 16700 Nm^3 per hour of gas from 5 metric tons (5.5 net ton) per hour of light oil. The generated gas temperature exceeds 1100°C (2000°F temperature) and contains about 87 % hydrogen and cabon monoxide in a ratio of about 10.5 to 1. Recycle shaft furnace of gas temper the generated gas temperature to between 800 and 1000°C (1475 and 1830°F) the mixed gas is then injected into the shaft furnace provision are made to remove carbon soot from the gasifier product. However certain amount of soot retards sticking and promote burden movement in the shaft furnace. The process operates with lump ores and oxide pellets, which are, reduce by reaction (1) to (6) as descend by gravity through the shaft furnace countercurrent to the upward flow of gas. Most of the lean gas from the top of the shaft is cooled in a recuperative heat exchanger, cleaned, recompressed, and stripped of CO_2. This gas is then reheated in the recuperated heater followed by a fixed heater is controlled to yield the desired temperature of the reducing gas entering the shaft furnace. The flow of process fuel to the gassifier is equivalent to 9.5 million kilojoules per metric ton (8.2 BTU million net per ton) of DRI additional fuel and power is required for heating and compressing gas and for operation of the unit for CO_2 removal.

The shaft furnace is equipped with a probe from sampling the solid and gas at various elevations. A computer assists in the precise control of operating variables of the plant. The operation confirms the result of single particle reduction studies which indicate that reduction kinetic level of after the pressure is increased by a few atmosphere with no further benefits as the pressure is raised higher.

The process flow diagram of NSC Process is shown in **Figure 3.11**.

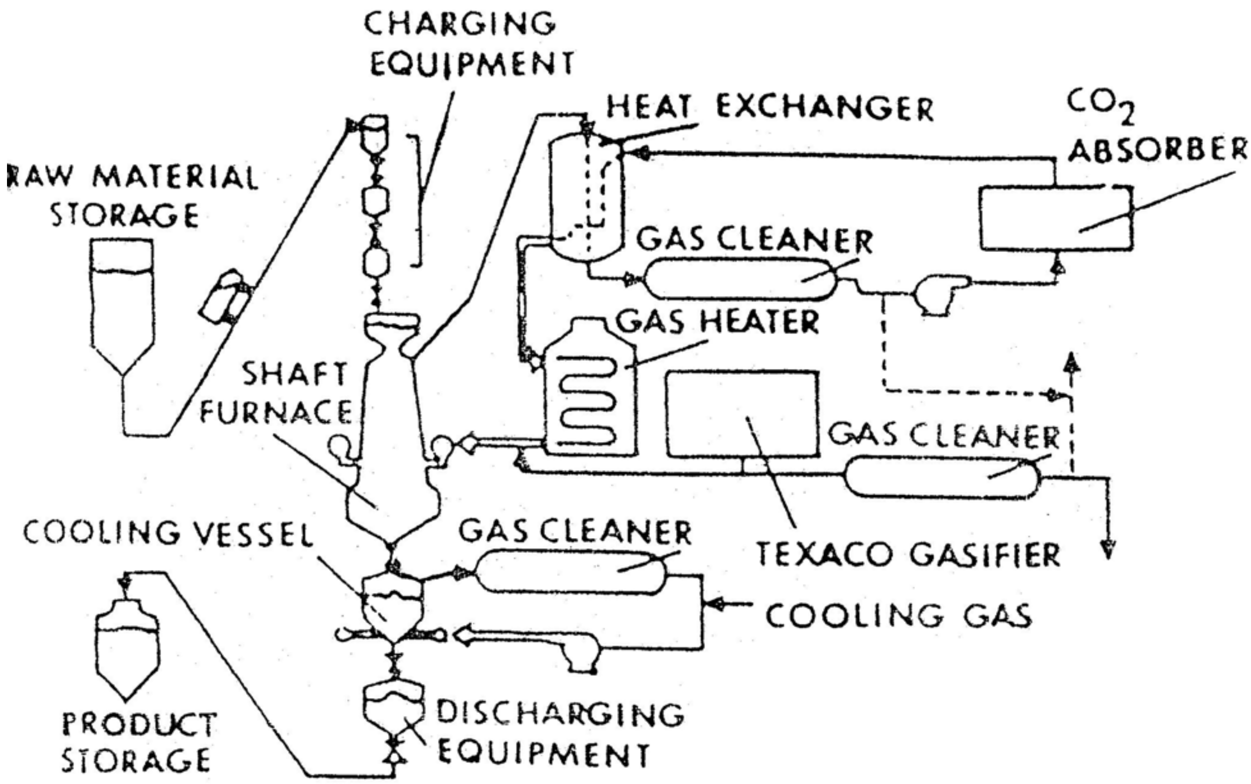

Fig. 3.11 : NSC DR Process Flow Diagram

3.50 Shaft Furnace Process (Static Bed)

3.24.02 HYL Process

The HYL process was developed by Hojalata y Lamina S.A. (HYLSA) of Monterrey, Mexico in the HYL process, lump ore and fired plates are produced in the fix bed retorts by performed natural gas.

The first commercial HYL plant was installed at Monterrey and started production late in 1957.this plant has a capacity of 200 metric tons per day (220 net tons per day) of DRI, and the reactor are about 2.5 meters (8 feet) in diameter and hold about 15 metric ton (16.5 net ton) of ore in a 1.5 meter (5 foot0 deep bed. By 1980, fifteen HYL plants with a total capacity of about 10 million metric ton (11 million net ton) per year of DRI were scheduled to be in operation in world wide. The reactor in the most recent plant are 5.4 meter (17.5 feet) in diameter and 15 meter (50 feet) high. Design capacity is about 1900 metric ton per day (2100 net ton per day) of DRI having a average reduction of about 90 %. The energy consumption in the most recent plant is 14.9 million kilojuoles per metric ton (12.8 million Btu per net ton) of 90 % reduced DRI. The more recent plants of the HYL II design (1) use high temperature alloy tube in the reducing gas reheating furnace, which permits heating the gas to the higher temperature, and (2) reduced the number of heating furnace for the original four units to two units. This eliminates thermal cycling of the earlier designs.

In the HYL II process reducing gas (rich in carbon monoxide and hydrogen) is generated, typically by nickel based catalytic reforming of natural gas which is mixed with steam before entering the reforme, Commercial HYL operations use excess steam over stoichiometric requirements, as show in reaction (14), to prevent carbon reformation and promote long catalyst life.

HYL's practice of using the cold reducing gas for both product cooling and carbonization negates any advantage of using catalytic that permit near to stoichiometric steam use.

Much of the water vapor in the reformed gas must be removed by quenching achieve hydrogen – rich reducing gas. Reformer heat is supplied by the combustion of reduction process tail gas. Process steam for the reformer is produced in a west heat boiler, using the heat in the reformer flue gas. With added boiler capacity, additional steam can be generated to feed steam turbine – driven equipment, thus lowering the electrical energy requirements.

The reducing section consists of a set of four reactors, three of which are in operation while the fourth is engaged in discharging and charging operation. The HYL process is a cyclical batch operation, and three on line reactors operates in series. The reduction of the charge is performed in two stages, an initial reduction stage and main reduction stage. Cooling and carbonization (Fe_3 C) and the final adjustment of metallization are performed in the third stage. Each stage of operation takes about three hours. An intricate system of valves permits the reactors to be connected in any desired order so that any one reactor can be connected in its correct process stage.

The flow of reducing gas is counter-current of the iron oxide change stages. The quenched fresh gas from the reformer is used first in the reactor, in the cooling stage that will be discharge as its next operation. The gas then flow through the reactor that is in the main reduction stage, and finally through the reactor that has most recently been charged for the initial reduction stage. Reduction is accomplished according to reduction (1) to (6). Because water is performed during reduction, the reducing gas is quenched when it leaves each reactor to condense the water and enhance the reduction potential of the gas. Before entering the reactors in the reduction stage, the quenched process gas is heated to about 815°C (1500°F) in an indirectly heated gas fired furnace. The gas is further heated to about 1050°C (1925°F) by the combustion of residuals unreformed hydrocarbons with the controlled injection of air at the entrance to the reactor. The process tail gases used to provide fuel for the reformer and for the gas-heating furnace. The reducing temperature in the HYL process is above 980°C. The advantages of using this high reducing temperature are improved reduction efficiency for a hydrogen-rich reduction pyrophoric tendency.

As the product in the cooling stage passes through the temperature zone of about 550°C (1020°F) carbon deposited on the reduced product as Fe_3 C (cementite), see reaction (7) and (8). The advantage cited for this cementites shell is protection against reoxidation. HYL practices carbon-level control between 1.0 and 2.5 per cent by adjusting the time that the product remains at this carburization is attained by controlling cooling- gas composition.

The process flow of HYL Process is shown in **Figure 3.12**.

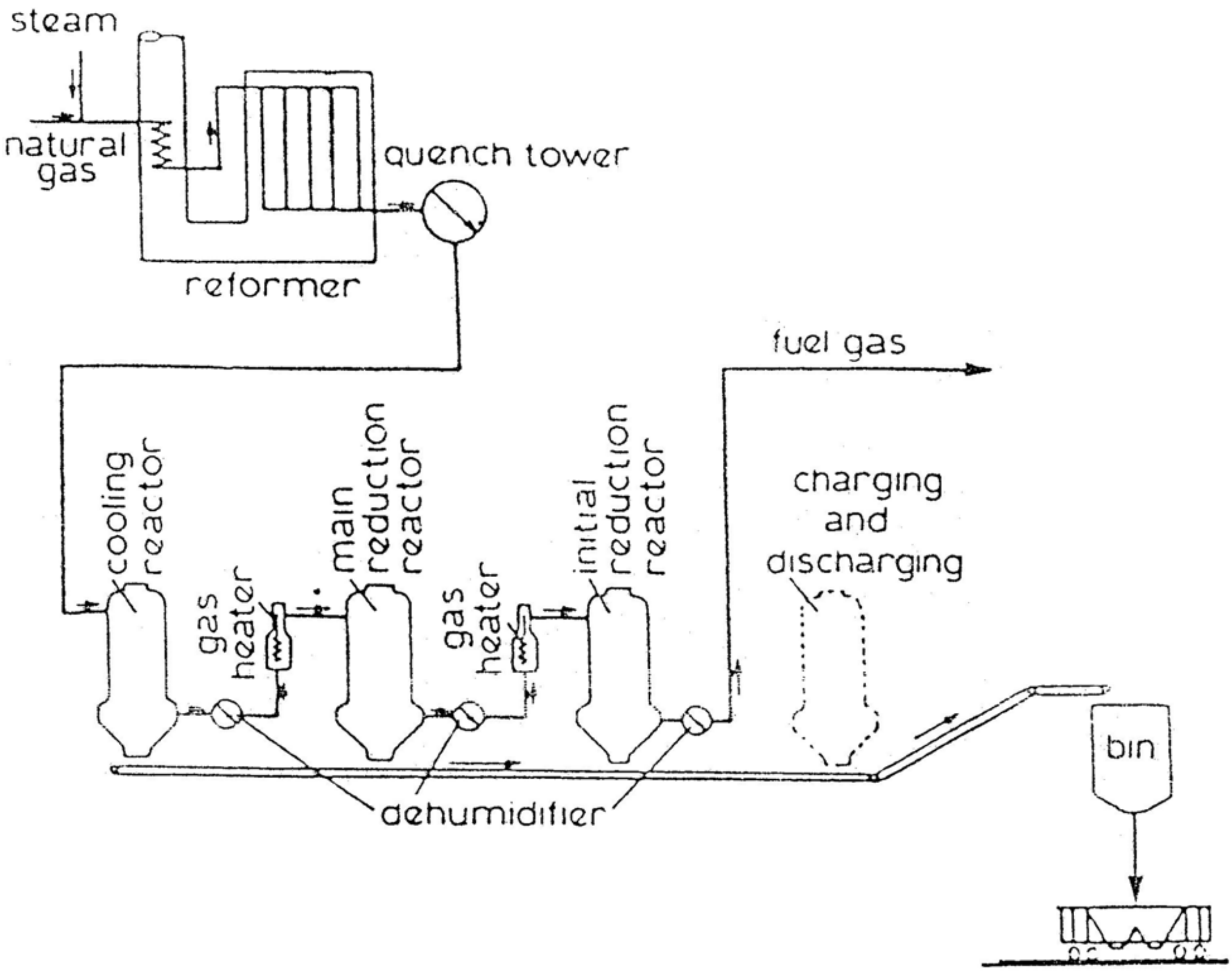

Fig. 3.12 : HYL DR Process Flow Diagram

3.51 Fluidized Bed Process

3.25.02 FIOR Process

The FIOR (Fluid Iron Ore Reduction) process is a continuous direct reduction process developed by Esso Research & Engineering Company (ERE), a subsidiary of the standard oil company of New Jersey (Renamed Exxon Corporation in 1973). Development was started in 1955 in co-corporation with Arthur D. Little Inc. and in the early stage it was called the Esso – Little process. After 1960, ERI continued development on their own and pilot plants were subsequently built at Baton Rouge, Louisiana (1961) and Dartmouth, Nova Scotia (1965). The FIOR process is now under the direction of the Davy Mc Kee Corporation.

The FIOR process reduces iron ore fines in a series of four fluid bed reactors. In additional, the process uses a reformer to produce fresh reducing gas and a brequitting section in which reduced iron ore fines are compacted. The fluid bed reactors are built in tower structure thus enabling gravity to enhance the flow of solids between stages.

Ore that has been properly sized and dried is raised to the top of the structure by either pneumatic lift or a skip hoist. Since the FIOR process operate at elevated pressure (reportedly 10 atmosphere), numerically lifted ore could be fed directly in the first reactor but ore raised by skip hoist would require the use of an intermediate surge hopper system in which the pressure can increasing ton operating pressure.

The ore is fed continuously to the preheating reactor. Where residual water is driven off and the ore is heated to about 800°C (1470°F). The combustion product is used to fluidize and heat the ore. As the ore level builds up in the preheated, it overflowing to the first of three reduction reactors.in the first, the operating temperature is about 700°C (1290°F) and about 10% reduction take place before the ore overflow successively in to the second and third reactor. The 91 to 93% metallized ore fines leaves the third stage reactor at a temperature of about 750°C (1380°F). Compressed reducing gas enters the bottom of the lowest reactor and flow countercurrent to the descending ore. Thus, richest reducing gas, a blend of about 75% recycled reactor top gas and 25% fresh for the reformer is mostly hydrogen with some carbon monoxide, carbon dioxide, and water vapor. Fresh reducing gas is produced by methane steamed reforming in a catalyst tube reformer. The reformer condition is controlled to produce a gas 90 %hydrogen. The entire reducing gas stream is heated to operating temperature in a furnace. Reacted top gas is burned as the fuel indirect-heat furnace.

Reactor top gas leaves the first stage reduction reactor and is scrubbed and cooled to remove dust and most of the water product in the reduction reaction. Some of the top gas stream is bled off for use a process fuel gas, and in this way, a gradual build – up carbon dioxide in the recycling gas steam is avoided. The recycled top gas stream is compressed and blended with fresh gas from the reformer before the combined stream enters the reducing gas furnace.

Direct reduced iron fines are discharged from the final reactor in to the briquetting feed bin from which they era fed, still hot, to the brequitting press. Compacting the hot DRI fines between the two roles of the press reforms the bellow shaped briquettes. The briquettes are discharging from the press in continuous, joined by a thin web of compact DRI fines. The sheet is broken in to individual briquettes in a trammel screen. The DRI briquettes are then cooled in rotary cooler, thin film of iron oxide forms on the surface of the briquettes in the cooler, rendering them inert.

The process flow diagram of FIOR process is shown in **Figure 3.13**.

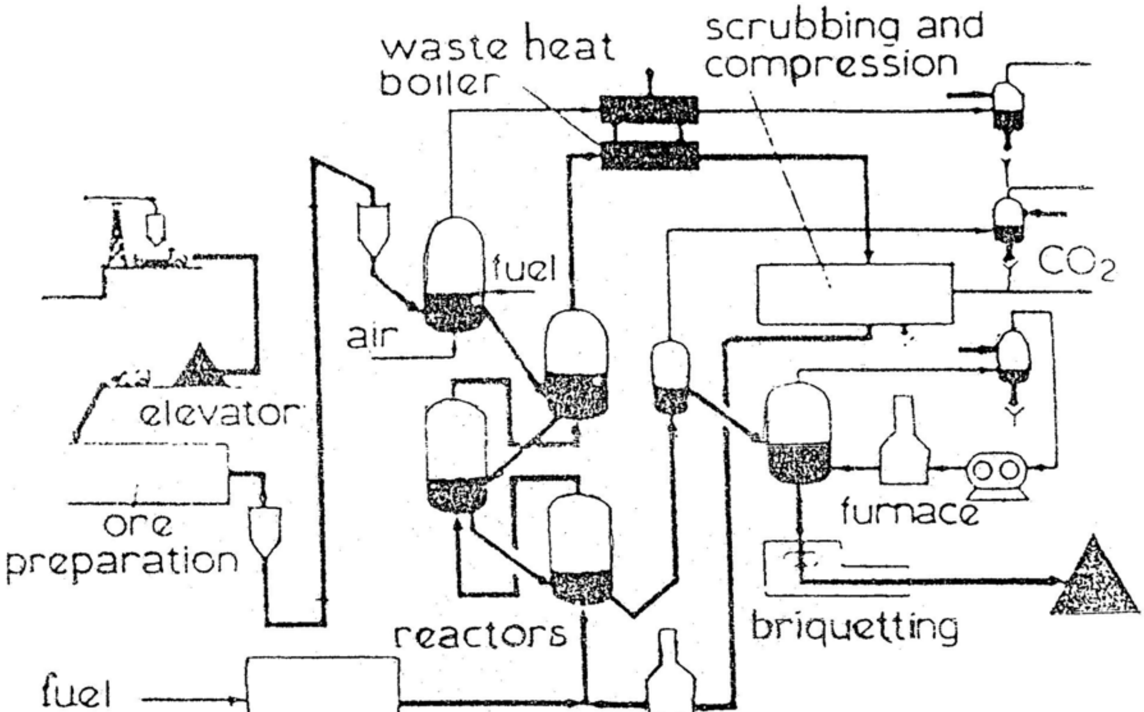

Fig. 3.13 : FIOR Process Flow Diagram

3.52 HIB Process

The HIB (High Iron Briquettes) process is a continuous Direct Reduction developed by. United States Steel Corporation. Development was started in 1952, and. In the pilot-plant stages at south works in Chicago, it was called the NU-iron process.

In the process, minus –2 mm (minus-10 mesh) iron ore is reduced by reformed natural gas in a tow-stage fluidized-bed reducer at about 700°C (1300°F) and 360 kPa (52 psi) pressure. Reducing gas for the process could all be manufactured from naphtha, fuel oil, pulverized coal or other fuel by several commercially proven methods. Dry iron ore is pre heated to about 810°C (1500°F) in fluidized bed preheaters consisting of two stages and fed in to the first reduction stage where Fe_2O_3 is reduced to FeO by partially spent fluidizing gas from the final reduction stage. Solids from the first reduction stage flow continuously in to the final reduction stage where FeO is reduce to Fe by fresh reducing gas that enters at about 750°C (1380°F). and 360 kPa (52 psi) pressure. Reducing gas for the process could also be manufactured from naphtha, fuel, oil, pulverized coal, or other fuels by several commercially proven methods. Dry ion roe is preheated to about 810°C (1500°F) in fluidized bed preheaters consisting of tow stage and fed in the first reduction stage where Fe_2O_3 is reduced to FeO by partially spent fluidizing gas form the final reduction stage. Solid from the first reduction stage flow continuously into the final reduction stage where FeO is reduced to Fe by fresh reducing gas that enters as about 750°C (1380°F) the product is briquette in continuous roll presses while still hot and is then cooled by inter gas in continuous shaft cooler. The off-gas from the first reduction stage in scrapped and reused in the plant. This tow-stage iron reduction flowsheet is well suited to producing 75% reduced high-iron briquettes as prereduced blast – furnace burden. Modification of this folowsheet, including a third reduction stage in series with the other reduction stages, would be made to produce a more highly reduced product (about90% reduced) for steel making. The flowsheet could also be modified to include recycling a portion of the spent off-gas form the first reduction stage.

A plant based on the HIB process designed to produce about 900000 metric tons (one million net tons) per year of 75 per cent reduced briquettes was constructed at Perto Ordaz, Venezuela and started operation in 1971. The plant comprises three identical trains with the two-stage reduction vessel being 6.7 m (22 feet) inside diameter and 30 m (100 feet) high. The annual production of this plant was about 300000 metric tons (330000 net per tons) per year as of 1977. The energy consumption for the process is projected to be 19.9 million kilojoules per metric ton (17.1 million BTU per ton) of 75 per cent reduced HIB and 21.4 million kilojoules per metric ton (18.4 million BTU per net ton) of 93 per cent reduced HIB.

The process flow of HIB process is shown in **Figure 3.14**.

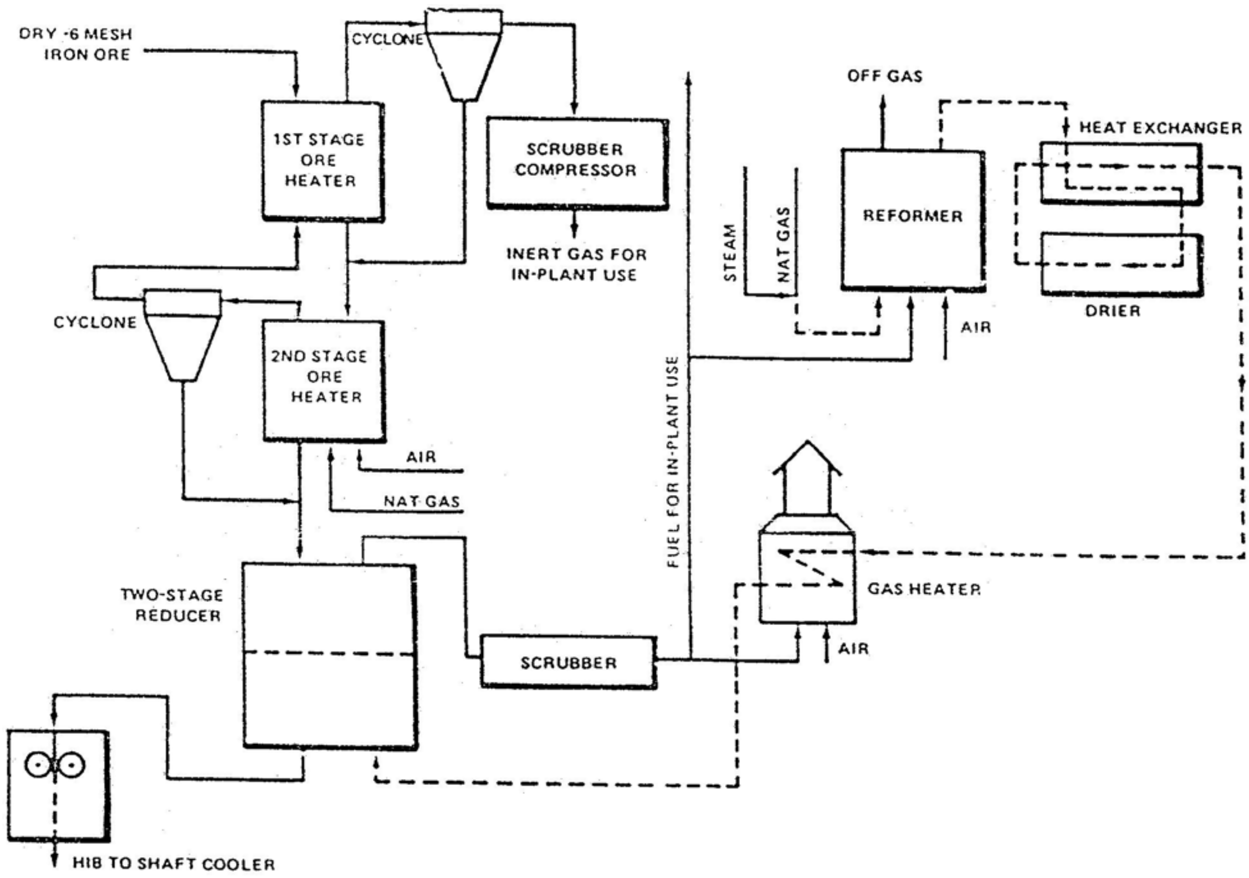

Fig. 3.14 : HIB Process Flow Diagram

CHAPTER - 4

4.00 STATUS OF INDIAN SPONGE IRON PLANTS

4.04 Questionnaire Survey

Project specific questionnaire was prepared in consultation with Central Pollution Control Board (CPCB) that includes information like name, address, capacity, technology, process details and raw materials consumption etc. Relevant environmental information related to water consumption and wastewater management, air pollution and management, solid waste generation and management, hazardous waste management, plant safety measures, project cost and cost of pollution control measures were also included in the questionnaire.

Sponge Iron Manufacturers Association (SIMA) was contacted and list of members of SIMA was obtained from their office at New Delhi. In addition Various State Pollution control boards were contacted for the list of Sponge Iron plants in their State. CPCB was also approached for list of Sponge Iron plants in India.

The questionnaires **(Annexure-I**) were sent by post/ couriered to the sponge iron plants registered with Sponge Iron Manufacturers Association (SIMA) on 24th June 2004. Again questionnaire was sent through email to all SIMA members whose email is available. The questionnaires were couriered to the sponge iron plants located in West Bengal Chattisgarh, Orissa and Jharkhand after obtaining their list from the respective State Pollution Control Boards .As a reminder, the questionnaires were again couriered to all the units on 20 th July, 2004. The last date for receipt of the questionnaire was fixed as 31-8-2004.

It was ensured that the questionnaire was delivered to the addressee by taking proper acknowledgement from the courier service provider. Very few of the sponge iron plants filled-in the questionnaire and returned it, inspite of the reminder. All the plants have received the questionnaire

During the visit of the plants, taking assistance from the visiting officials, the plants filled in the questionnaire and handed over to the visiting team. Hence, 25 questionnaires were collected during the plant visit.

4.05 Secondary Information from Visit to Sponge Iron Plants

Visit to some sponge iron plants were made to collect secondary information about the manufacturing process, technology, raw material consumption and environmental management systems. The names of plants proposed for the visit were finalized by MECON in consultation with Central Pollution Control Board (CPCB). The selected plants covered all technology and process in the large and small category. 33 large and small sized DRI plants (including 1 gas based DRI plant) were visited during August 2004 and relevant secondary information collected. In depth study was also conducted for various type, capacity of Sponge Iron plants. Samples for environmental monitoring were conducted in some plants also.

The name and address of sponge iron plants visited, date of visit, plant capacity and process technology adopted has been summarized and provided in **Table 4.1**.The name and address of sponge iron plants who has replied to the questionnaire has been summarized in the same table.

The raw material consumption pattern and specific consumption of iron ore and coal is given in **Table 4.2**. The specific consumption of dolomite is uniform in all the plants (0.05 ton/ton of DRI).

The summary of project cost, persons employed, pollution mitigation cost is provided in **Table 4.3**.

4.06 In depth Study

4.03.10 Outcome of study

Sponge iron, also referred as Direct Reduced Iron (DRI), is mostly used for steel making through conventional melting and treatment process in Electric Arc Furnace or Induction Furnace. It is used widely as substitute to steel scrap. Due to shortage of steel scrap in the country coupled with the extremely volatile international pricing of steel scrap, more and more DRI is now used for steel making in India. Raw materials like iron ore, coal and dolomite are available at competitive prices in the country, hence coal based DRI plants are being established in large numbers. Due to availability of natural gas in western coast of the country, some large DRI plants have been also established. The gas based DRI plants produces DRI and use it spontaneously for steel making or convert the DRI to Hot Briquetted Iron (HBI) for storage and sale. Today India is the largest hub of coal based DRI plants in the world. Production-wise India ranks first in the world. In the present scenario, every week new DRI plants are being established in the country. The Sponge Iron Manufacturers Association (SIMA) had 36 member units in early 2004, 41 units in mid 2004 that increased to 45 units by 31-8-2004. The existing Sponge Iron Manufacturers are joining SIMA thus the increase in numbers.

4.03.11 Categorization

The coal based DRI plants can be categorized into two classes, namely large and small. Some Plants are having one to four 50 tons/day kilns or one to two 100 tons/day kilns produce about 60000 tons/annum of DRI. These plants do not have Waste Heat Recovery Boilers (WHRB) or Fluidized Bed Combustion (FBC) Boilers to utilize the char and coal fines for producing steam / power. Due to their small size and lack of capability to utilize waste heat and char (solid waste), they are categorized as small DRI plants. Most of these plants also do not have any pollution control equipment to clean the kiln gas. After taking the gas to dust settling chambers (DSC) the same pass on to After Burning chamber(ABC) located right above DSC , simply they discharge the gas through stacks located on the top of ABC.

Plants having more than two numbers of 100 TPD kilns, producing more than 60000 tons/annum of DRI are categorized as large DRI plants.

Very few of these large DRI plants are equipped with waste heat recovery boilers and / or FBC Boilers for steam / power generation

4.03.12 Location

The DRI plants in India are mainly located close to the source of raw material. The DRI plants are located in the following districts:

a. Durg, Raipur, Bilaspur, Raigarh in Chattisgarh (Coal from South Eastern Coalfields and Iron Ore from Northern Orissa)
b. Bhandara, Chandrapur and Nagpur in Maharastra (Coal from Western Coalfields and Iron Ore from Northern Orissa)
c. Jharsuguda, Sundergarh, Rourkela, Barbil, Joda, Keonjhar in Orissa (Coal from Mahanadi Coalfields and Iron Ore from Keonjhar District)
d. Jhargram, Ranigunj, Durgapur, Bankura, Purulia in West Bengal (Coal from Eastern Coalfields and Iron Ore from Northern Orissa)
e. Jamshedpur, Chandil, Chaibasa, Giridih, Koderma, Hazaribagh in Jharkhand (Coal from Central Coal fields and Iron Ore from Northern Orissa)
f. Khammam, Kurnool in Andhrapradesh ((Coal from Southern Coalfields and Iron Ore from Karnataka)
g. Hospet, Bellary in Karnataka (Coal from Southern Coalfields and Iron Ore from Karnataka)
h. Goa (Coal from Southern Coalfields and Iron Ore from Goa)
i. Hazira [Gujarat Coast] and Raigad [Maharashtra coast] (Natural Gas from Bombay High and Tapi Estuary and Iron Ore lump from Karnataka by sea route and Iron Ore pleet from Pellet Plants near Visag in Andhra Pradesh by sea route.

The coal based DRI plants are located mostly in clusters. In Siltara Industrial Area near Raipur approximately 13 DRI plants are present. In Taraimal Reserve Forests of Raigarh approximately 6 DRI plants are present. In Barbil-Joda-Palaspanga belt and Sundergarh, Jharsuguda and Rourkela belt of Orissa (25 Nos.), Jhamshedpur-Chandil belt of Jharkhand (6 Nos), Durgapur-Ranigunj-Purulia belt of West Bengal (28 Nos) similar cluster of DRI plants are present. Except for Taraimal region of Raigarh (Chattisgarh), most of the belts are in industrial area. The cluster of DRI plants of Taraimal in Raigarh district of Chattisgarh are located inside dense and ecologically sensitive Reserve Forests, having high diversity of Wildlife.

1. **Easy availability of raw material** : The distribution of the iron ore and non-coking coal in India is restricted chiefly to the Eastern, South-Eastern and in some parts of the Deccan Plateau. This is the reason behind the boom of coal based DRI plants in the Orissa-Chattisgarh-Jharkhand-West Bengal region. The location of the iron ore mines in Banspani - Barjamda, in the Keonjhar– Sundergarh area of northern Orissa and the Gua-Chiria mines in Jharkhand have additionally helped the coal based DRI Plants to come up in this area. Coal based DRI units in the western Maharashtra-Goa-Karnatak region have come up depending on the proximity of the iron ores mines in Goa and Bellary - Hospet - Chikamglur region (Karnataka).

2. **Easy availability of Gas :** Whereas the presence of the Natural Gas fields in the Gujarat and Bombay high area have played the key role in the development of the gas based DRI plants in this area. Iron ore lump and pellet from the East coast is transported by ships and delivered to convenient ports in Gujarat and Maharashtra. This very reason prevents certain portions of the country like the North, North West and South region from becoming the hub of coal or gas based DRI plants.

3. **Proximity of Market and other Infrastructure** : The setting of a DRI plant is also dependent on the proximity of the secondary steel making market and related infrastructure like road, rail and ports. For example, the future boom of DRI plants in Gujarat can be attributed to the availability of the port facility in the Arabian sea which are used to bring the raw material in from the interiors of the country as well as for the dispatch of finished product. Another reason, which contributes significantly to the cause is the setting of many Induction Furnaces and Electric Arc Furnaces, which are essentially dependent on these DRI plants for supply of sponge iron. The North East, blessed with ample amount of natural gas, is yet to become a hot spot for DRI generation, which could be blamed to the lack of necessary infrastructure like ports, rail and road and more importantly the secondary steel making market.

4. **Potential areas** : The South Eastern coast line of India, viz. Tamil Nadu and Andhra Pradesh holds ample potential for the development of the coal based DRI plants, because of their proximity to the iron ore mines and coal fields as well as good connectivity. Few gas-based plants would come up in Krishna Godavari basin of Andhra Pradesh due to the availability of Natural Gas and iron pellets from Kudremukh, Mangalore and Bailadila. Gas based DRI plants will be equally possible in the western coast of India near the central to southern part of Karnataka or in the northern part of Kerala. The availability of iron ores in the Bellary-Hospet and in the Kudremukh and the supply of cheap natural gas from Bombay High through gas pipelines will make these plants viable.

5. **Conducive Economic and Socio-Political Environment** : The prosperity of any industry in any region of the country depends on the economic policy adopted by the local government and the socio-political environment of the region. A stable socio-economic-political environment coupled with a bold economic policy by the State Government could bring the best out of DRI industry. As for example, another reason for the boom of the DRI industry is the financial subsidy awarded to the sponge iron generated in terms of reduced excise and custom duty. The presence of such financial rewards not only encourages the producers of the DRI but also renders their product a competitive benefit. In contrast, unstable and often turbulent socio-political atmosphere makes it very difficult to choose it as a possible spot for gas based DRI plants. The DRI is a substitute to scrap used in steel making. Majority of the scrap is imported in India and it attracts high custom duty, making its price uncompetitive compared to locally produced DRI. The abundance of peace loving, selfless, unskilled local workforce also contributes to the growth of DRI plants. With reduction in availability of scrap, dependence on DRI will increase further in India.

4.03.13 Process Technology

The DRI is produced in India by two different process, namely the coal based and the gas based process. Numerous standard as well as customized technologies are available for both the processes. For coal based plants, SL/RN (Lurgi) technology has been widely used but later the promoters resorted to customized process (Rotary kiln type). The DRI plant of Sunflag is based on Krupp CODIR process and that of Orissa Sponge is based on ACCAR process. Orissa Sponge later did some modifications (firing coal fines instead of diesel in kiln) and patented the process under the brand OSIL process. The customized process are minor modification of Lurgi Technology and are supplied under the style of Jindal process, TDR process, SIIL process, Popurri process, etc. There are about 118 coal based DRI plants presently operating in India, the number is increasing with each passing week.

India is having 3 large sized gas based DRI Plants. Among the gas based plants, Essar Steel Limited and Ispat Industries Limited are using Midrex technology whereas Vikram Ispat Limited uses HYL III technology. The gas based process have shaft furnace and are huge in size. While Essar Steel has an annual production capacity of over 2.4 million tons, Ispat Industries has about 1.20 million tons and Vikram Ispat about 0.9 million tons.

4.03.14 Plant Area

During the plant visit some information on actual plant area has been collected. The land requirement plant capacity ratio ranges from 0.03 to 0.07 Ha/TPD. In case of Tata Sponge it is 0.09 Ha/TPD because of storage of GCP sludge, process dust, accretions and char inside.the plant. The information is summarized below.

	Name of the Plant	Capacity	Plant Area	Area Ha / TPD

1	Tata Sponge	1300 TPD	122.5 Ha	0.09
2	Vandana Global	700 TPD	30 Ha	0.04
3	Shree Metallics	480 TPD	33.5 Ha	0.07
4	Sunflag Steel	500 TPD	12.5 Ha	0.03
5	Raipur Alloys	700 TPD	50 Ha	0.07
6	Ispat Godavari	300 TPD	12.5 Ha	0.04

For small 1x 50 TPD plant the approximate area required is 5 ha.

4.03.15 Raw Material Consumption

The specific raw material consumption (average basis) of Iron Ore is 1.6 tons/ton DRI, Coal is 1.2 tons/ton DRI and dolomite is 0.05 ton/ton DRI.

4.03.16 Material Transportation

The raw materials are mostly transported by trucks from mines to plant site. Where rail siding facilities are available, namely in case of steel plants, the raw materials are mostly transported by rail wagons. The finished product (DRI) is transported mostly by trucks and rail, if rail siding is available. In case of gas based plants, natural gas is transported by pipelines and ore by ships. The product is transported by ships as well as trucks. In most of the plants, trucks that brings raw material into the plant are used to carry back the solid waste for dumping.

4.03.17 Power Consumption

The power consumption ranges from 130 units / ton DRI (kwhr = unit) in Tata Sponge, 55 unit/ton DRI in Jindal and 45 units / ton DRI in small plant. The high power consumption in Tata Sponge is due to Wet Dust Cleaning system and sludge handling.

4.03.18 Employment Generation

A 100 TPD plant normally employs 75-80 people, 200 TPD plant employs 120-150 people and 500 TPD plant employs about 200 people. The 1800 TPD plant of Jindal at Raigarh employs 650 people. The 2000 TPD gas plant at Hazira employs 153 people. In addition about 50-75 casual workers are also deployed daily. Given the employment pattern in sponge iron industry, it can be inferred that smaller capacity plants require more persons to operate compared to large sized plants. Also that less persons are required to operate gas based DRI plants when compared to coal based DRI plants.

Now a days owner also run their plant by contracting the whole plant to outsider. Popurri engineering runs several plant based on a fees per tonnes of Sponge Iron

Table 4.1: Name & Address, Date of Visit, Technology & Capacity

S. No.	Name of Plant & Address	Date of visit	Process Knowhow	Kiln Size(TPD)	Capacity & Category
1	Adhunik Corporation Ltd. Angadpur, Durgapur (WB)	13-8-04	Popurri	2x100+1x100*	200 TPD Large
2	Agarwal Sponge Pvt. Ltd. Siltara Industrial Centre, Raipur (CG).	10-8-04	Customized	2x50+4x100*	100 TPD Small
3	Anjani Steels Co. Ltd. Ujalpur village, Taraimal, Raigarh (CG).	6-8-04	Popurri	1x100+1x100*	100 TPD Small
4	Essar Steel Ltd. Hazira, Surat (Gujarat)	26-8-04	Midrex		6000 TPD Large
5	Haldia Steel Plant (Unit II) Angadpur Industrial Area, Durgapur (WB)	13-8-04	Customized	2x100	200 TPD Large
6	HEG Ltd. Borai, Post- Rasmara, Dist.- Durg (CG)	10-8-04	SIIL	2x100	200 TPD Large
7	Ispat Godavari Ltd. Industrial Area Siltara, Raipur (CG)	9-8-04	Customized	1x300+1x500*	300 TPD Large
8	Jindal Steel & Power Ltd. P.B. no. 16, Kharsia Road Raigarh (CG).	6-8-04	Jindal	6x300+4x545*	1800 TPD Large
9	Maa Chandi Durga Ispat Pvt. Ltd. Lenin Sarani, Durgapur (WB).	12-8-04	Popuri	2x50+3x50*	100 TPD Small
10	Mahamaya Sponge Iron Pvt. Ltd. Plot-2I-22, PhaseII, Siltara, Raipur (CG).	10-8-04	Customized	1x50	50 TPD Small
11	Nalwa Sponge Iron Ltd. Taraimal Dist Raigarh (CG)	6-8-04	Jindal	6x100	600 TPD Large
12	Orissa Sponge Iron Ltd. Vill: Palaspanga , Dist: Keonjhar (Orissa)	10-8-04	OSIL	1x300	300 TPD Large
13	Raipur Alloys and Steel Ltd. Industrial Area Siltara, Raipur (CG)	9-8-04	SIIL	2x100+1x500*	200 TPD Large
14	Ritesh Tradefin Ltd. Lenin Sarani, Durgapur (WB).	12-8-04	Popurri	2x50	100 TPD Small
15	Shree Metaliks Limited Barbil Dist: - Keonjhar, Orissa	9-8-04	Popurri	6x80	480 TPD Large
16	Sidhi Vinayak Iron Pvt. Ltd. Punjipatra, Ghargoda Rd. Raigarh (CG)	7-8-04	Popurri	1x100	100 TPD Small
17	Sova Ispat Ltd. Mejia ,Bankura (WB).	12-8-04	Popurri	1x300	300 TPD Large
18	Sunflag Iron & Steel Industry Bhandara Road, Bhandara (Maharashtra)	4-8-04	KRUPP-CODIR	1x500	500 TPD Large

S. No.	Name of Plant & Address	Date of visit	Process Knowhow	Kiln Size(TPD)	Capacity & Category
19	Tata Sponge Iron Ltd. vill- Belaipada, Keonjhar (Orissa)	9-8-04	TDR	2x400+1x500*	1300 TPD Large
20	Vandana Global (P) Ltd. Industrial Area Siltara Ph-II, Raipur (CG)	9-8-04	Customised	2x100+1x500*	200 TPD Large
21	Seleno Steel Limited Taraimal, PO-Gerwani, Raigarh, (CG)	7-8-04	Customised	1x100	100 TPD Small
22	Singhal Enterprises Limited Taraimal, PO-Gerwani, Raigarh (CG)	7-8-04	Popurri	2x100+1x100*	200 TPD Large
23	Howrah Gases Limited G-4A, Magalpur IE, Ranigunj (WB)	14-8-04	Lurgi (SL/RN)	2x100	200 TPD Large
24	Bihar Sponge Iron Limited, Umesh Nagar,Chandil	24-8-04	Lurgi (SL/RN) & Popurri	1x500 1x100	500 TPD Large 100 TPD
25	KYS sponge Iron Pvt Ltd, 6 th Phase adityapur Industrial area,Gamaria	13-9-04	Popurri	1x50+2x50*	50 TPD Small
26	Asirbad Steel and Industry Pvt Ltd, 5 th place adityapur Industrial area,Gamaria	13-9-04	Popurri	3x50	150 TPD Small
27	BISCO sponge Iron Pvt Ltd, 5 & 56 6 th Phase adityapur Industrial area,Gamaria	13-9-04	Popurri	2x50	100 TPD Small
28	Shyam Sel (Power)Limited G-4A, Magalpur Industrial Area, Ranigunj (WB)	2-9-03	Popurri	3x100	300 TPD
29	SPS Sponge Iron. Ltd. Dr Zakir Hussain Aveneue, Durgapur (WB).	1-9-04	Popurri	2x50+1x100	200 TPD
30	Jai Balaji Sponge Ltd (Unit I), Magalpur Industrial Area, Ranigunj (WB)	2-9-04	Popurri	3x50	150 TPD
31	Jai Balaji Sponge Ltd ,(Unit II) Magalpur Industrial Area, Ranigunj (WB)	2-9-04	Popurri	2x100	200 Tpd
32	Savitri Sponge Ltd, Magalpur Industrial Area, Ranigunj (WB)	3-9-04	Swami	1x50	50 TPD
33	Rasmi Ispat Pvt Ltd,Jhargram(WB)	Qtn Replied	Popurri	2x100	200 TPD
34	Sponge Iron India Ltd, Khammam(AP)	Qtn Replied	SIIL	2x100	200 TPD

Note: * denote under expansion

Table 4.2 : Raw Material Consumption Pattern in Sponge Iron Plants

S. No.	Name of Plant	Capacity	Raw Material Consumption (tons/annum)	Sp. Consumption (ton/ton DRI)
1	Adhunik Corporation Ltd. Angadpur, Durgapur (WB)	200 TPD	Coal: 67800 TPA Iron Ore: 91200 TPA	1.13 1.52
2	Agarwal Sponge Pvt. Ltd. Siltara Industrial Centre, Raipur (CG).	100 TPD	Coal: 37500 TPA Iron Ore: 50100 TPA	1.25 1.67
3	Anjani Steels Co. Ltd. Ujalpur village, Taraimal, Raigarh (CG).	100 TPD	Coal: 45720 TPA Iron Ore: 54000 TPA	1.27 1.50
4	Essar Steel Ltd. Hazira, Surat (Gujarat)	6000 TPD	Iron Ore: 3180000 TPA Gas: 632400000 Sm^3/yr	1.58 --
5	Haldia Steel Plant (Unit II) Angadpur, Durgapur (WB)	200 TPD	Coal- 76200 TPA Iron Ore. 93600 TPA	1.27 1.55
6	HEG Ltd. Borai, Post- Rasmara, Dist.- Durg (CG)	200 TPD	Coal: 75000 TPA Iron Ore: 99000 TPA	1.25 1.65
7	Ispat Godavari Ltd. Industrial Area Siltara, Raipur (CG)	300 TPD	Coal: 120000 TPA Iron Ore: 160000 TPA	1.20 1.60
8	Jindal Steel & Power Ltd. P.B. no. 16, Kharsia Road Raigarh (CG).	1800 TPD	Coal: 745200 TPA Iron Ore: 980100 TPA	1.38 1.70
9	Maa Chandi Durga Ispat Pvt. Ltd. Lenin Sarani, Durgapur (WB).	100 TPD	Coal- 37500 TPA Iron Ore: 42000 TPA	1.25 1.40
10	Mahamaya Sponge Iron Pvt. Ltd. Plot-2I-22, PhaseII, Siltara, Raipur (CG).	50 TPD	Coal: 10950 TPA Iron Ore: 24750 TPA	1.27 1.65
11	Nalwa Sponge Iron Ltd. Taraimal Dist Raigarh (CG)	600 TPD	Coal: 247500 TPA Iron Ore: 297000 TPA	1.25 1.50
12	Orissa Sponge Iron Ltd. Vill: Palaspanga , Dist: Keonjhar (Orissa)	300 TPD	Coal: 104000 TPA Iron Ore: 147000 TPA	1.15 1.62
13	Raipur Alloys and Steel Ltd. Industrial Area Siltara, Raipur (CG)	200 TPD	Coal: 72000 TPA Iron Ore: 96000 TPA	1.33 1.52
14	Ritesh Tradefin Ltd. Lenin Sarani, Durgapur (WB).	100 TPD	Coal: 36000 TPA Iron Ore: 47400 TPA	1.20 1.58
15	Shree Metaliks Limited Barbil Dist: - Keonjhar, Orissa	480 TPD	Coal: 187200 TPA Iron Ore: 223200 TPA	1.3 1.55
16	Sidhi Vinayak Iron Pvt. Ltd. Punjipatra, Ghargoda Rd. Raigarh (CG)	100 TPD	Coal: 38400 TPA Iron Ore: 49500 TPA	1.28 1.65
17	Sova Ispat Ltd. Mejia ,Bankura (WB).	300 TPD	Coal: 117000 TPA Iron Ore: 144000 TPA	1.30 1.62

S. No.	Name of Plant	Capacity	Raw Material Consumption (tons/annum)	Sp. Consumption (ton/ton DRI)
18	Sunflag Iron & Steel Industry Bhandara Road, Bhandara (Maharashtra)	500 TPD	Coal: 172500 TPA Iron Ore: 231000 TPA	1.15 1.58
19	Tata Sponge Iron Ltd. vill- Belaipada, Keonjhar (Orissa)	800 TPD	Coal: 288000 TPA Iron Ore: 355200 TPA	1.20 1.48
20	Vandana Global (P) Ltd. Industrial Area Siltara Ph-II, Raipur (CG)	200 TPD	Coal: 22000 TPA Iron Ore: 99700 TPA	1.20 1.62
21	Seleno Steel Limited Taraimal, PO-Gerwani, Raigarh, (CG)	100 TPD	Coal: 38350 TPA Iron Ore: 51300 TPA	1.23 1.70
22	Singhal Enterprises Limited Taraimal, PO-Gerwani, Raigarh (CG)	200 TPD	Coal: 78000 TPA Iron Ore: 103200 TPA	1.30 1.72
23	Howrah Gases Limited G-4A, Magalpur IE, Ranigunj (WB)	200 TPD	Coal: 75000 TPA Iron Ore: 97200 TPA	1.25 1.62
24	Bihar Sponge Iron Limited, Umesh Nagar,Chandil	500 TPD 100 TPD	NA	1.2
25	KYS sponge Iron Pvt Ltd, 6 th Phase adityapur Industrial area,Gamaria	50 TPD	NA	1.5 1.5
26	Asirbad Steel and Industry Pvt Ltd, 5 th place adityapur Industrial area,Gamaria	150 TPD	NA	1.55 1.75
27	BISCO sponge Iron Pvt Ltd, 5 & 56 6 th Phase adityapur Industrial area,Gamaria	100 TPD	NA	
28	Shyam Sel (Power)Limited G-4A, Magalpur Industrial Area, Ranigunj (WB)	300 TPD	NA	1.3 1.6
29	SPS Sponge Iron. Ltd. Dr Zakir Hussain Aveneue, Durgapur (WB).	200 TPD	NA	1.2 1.6
30	Jai Balaji Sponge Ltd (Unit I), Magalpur Industrial Area, Ranigunj (WB)	150 TPD	Coal: 111600 TPA Iron Ore: 141500 TPA	1.24 1.6
31	Jai Balaji Sponge Ltd ,(Unit II) Magalpur Industrial Area, Ranigunj (WB)	200 TPD	NA	1.24 1.6
32	Savitri Sponge Ltd, Magalpur Industrial Area, Ranigunj (WB)	50 TPD	NA	1.5 1.55
33	Rasmi Ispat Pvt Ltd,Jhargram(WB)	200 TPD	Coal: 78000 TPA Iron Ore: 96000 TPA	1.3 1.6
34	Sponge Iron India Ltd,Khammam(AP)	200 TPD	Coal: 67-84000 TPA Iron Ore: 103-120000 TPA	1.12 1.72-

Table - 4.3 : Project Cost, Persons Employed and Cost of Pollution Mitigation as reported by Plants

	Name of Plant	Capacity	Project Cost	Persons employed	Environ-mental cost (Fixed)	Environ-mental cost (Recurring)
1	Adhunik Corporation Ltd. Angadpur, Durgapur (WB)	200 TPD	10 Cr	200	40 lakhs	9 Lakhs
2	Agarwal Sponge Pvt. Ltd. Siltara, Raipur (CG).	100 TPD	7 Cr	152	1	--
3	Anjani Steels Co. Ltd. Ujalpur, Taraimal, Raigarh (CG).	100 TPD	7 Cr	127	300	12
4	Essar Steel Ltd. Hazira, Surat (Gujarat)	6000 TPD	702 Cr	153	512	10
5	Haldia Steel Plant (Unit II) Angadpur, Durgapur (WB)	200 TPD	10 Cr	72	150	8
6	HEG Ltd. Post- Rasmara, Dist.- Durg (CG)	200 TPD	6 Cr	133	300	14
7	Ispat Godavari Ltd. Industrial Area Siltara, Raipur (CG)	300 TPD	7 Cr	200	200	13
8	Jindal Steel & Power Ltd. Kharsia Road Raigarh (CG).	1800 TPD	263 Cr	650	1318	37
9	Maa Chandi Durga Ispat Pvt. Ltd. Lenin Sarani, Durgapur (WB).	100 TPD	6 Cr	72	400	12
10	Mahamaya Sponge Iron Pvt. Ltd. Plot-2I-22 Siltara, Raipur (CG).	50 TPD	4 Cr	45	30	2
11	Nalwa Sponge Iron Ltd. Taraimal Dist Raigarh (CG)	600 TPD	49 Cr	200	200	25
12	Orissa Sponge Iron Ltd. Palaspanga , Dist: Keonjhar (Orissa)	300 TPD	9 Cr	236	300	12
13	Raipur Alloys and Steel Ltd. Industrial Area Siltara, Raipur (CG)	200 TPD	6Cr	175	250	17
14	Ritesh Tradefin Ltd. Lenin Sarani, Durgapur (WB).	100 TPD	7Cr	80	36	12

	Name of Plant	Capacity	Project Cost	Persons employed	Environ-mental cost (Fixed)	Environ-mental cost (Recurring)
15	Shree Metaliks Limited Barbil Dist: - Keonjhar, Orissa	480 TPD	23 Cr	250	100	37
16	Sidhi Vinayak Iron Pvt. Ltd. Punjipatra. Raigarh (CG)	100 TPD	12 Cr	75	25	6
17	Sova Ispat Ltd. Mejia ,Bankura (WB).	300 TPD	27 Cr	225	230	12
18	Sunflag Iron & Steel Industry Bhandara, Bhandara (Maharashtra)	500 TPD	27 Cr	106	400	10
19	Tata Sponge Iron Ltd. vill- Belaipada, Keonjhar (Orissa)	1200 TPD	82 Cr	251	750	480
20	Vandana Global (P) Ltd. Siltara Ph-II, Raipur (CG)	200 TPD	10 Cr	120	300	12
21	Seleno Steel Limited Taraimal, Raigarh, (CG)	100 TPD	7 Cr	110	40	6
22	Jai Balaji Sponge Ltd. G-1, Baktarnagar, Ranigunj (WB)	350 TPD	16 Cr	200	100	12
23	Singhal Enterprises Limited Taraimal, Raigarh (CG)	200 TPD	11 Cr	175	65	12
24	Howrah Gases Limited G-4A, Magalpur IE, Ranigunj (WB)	200 TPD	10 Cr	180	65	10
25	Rasmi Ispat Pvt Ltd,Jhargram(WB)	200 TPD		73	256	21.72

CHAPTER - 5

5.00 ENVIRONMENTAL MANAGEMENT STATUS IN INDIAN SPONGE IRON PLANTS

The information collected through questionnaire, plant visit during in depth study are collated and enclosed as **Table 5.1.** These information are furnished as furnished by various Plant authorities.

5.09 Air Pollution Mitigation Measures

5.01.03 Stacks

Inside the rotary kiln, the DRI gases flow counter-current to the kiln feed. The temperature at the product discharge end in a rotary kiln is about 950-1050^oC compared to 750-900^oC towards the feed end. The counter-current flow of hot DRI gases enable it to remove the moisture content from feed. The hot DRI gases contains huge amount of fine dust comprising oxides and unburnt carbon and toxic carbon monoxide. It needs treatment before discharging into the atmosphere.

The raw material feed side of rotary DRI Kiln has a natural structure below the After Burner Chamber (ABC) that acts as Dust Settling Chamber (DSC). About 15-20% coarse dust settles in DSC by means of gravity. In ABC, the CO content of gases is converted to CO_2. This conversion process is exothermic and the temperature of gases rises to 1000-1050^oC. Some plants (very few) have Gas Conditioning Tower(GCT) followed by pollution control equipment and cleaned gas is emitted through stacks mostly of 30 m in height.

In most of the Plants where Popuri technology is involved there is no pollution control equipment provided to clean the waste gas. Some of the plants are adding pollution control facilities to clean the gas at present to comply with statutory requirements and is under erection stage.

In some of the bigger size plants, the heat content of hot gases is utilized to generate steam through Waste Heat Recovery Boilers (WHRB). The steam is used to operate small size turbines to produce electricity.

The exhaust gases coming out of WHRB, having temperature around 150-175^oC is taken to pollution control equipment for particle separation. Different industries using different type of pollution control equipment like Bag filter, scrubber and some also have Electrostatic Precipitators (ESP). The clean gas is let out through stacks. There is no basis for calculation of stack height.

The old rotary kiln DRI plants have used Gas Cleaning Plant (GCP) based on Venturi Scrubbers (wet cleaning) for the treatment of DRI gases. This system generates dust bearing sludge, that needs separate handling and disposal. However, this system can take care of particulate matter as well as gaseous pollutants. No new plants are using GCP.

Small rotary kiln DRI plants (upto 50 tpd) that did not have the capability to utilize the heat content of DRI gases use Gas Conditioning Tower (GCT) to quench and cool the hot DRI gases to 150-175°C before passing it through ESP.

The Suspended Particulate Matter (SPM) content of treated DRI gases of rotary kiln have been reported by these industries to State Pollution Control Board (SPCB) of their state as to be less than 150 mg/Nm^3 in all the plants, irrespective of the pollution control devices applied.

Rotary kiln DRI plants have emergency stack/safety cap above the ABC of feed end column. The safety cap is required to maintain the positive pressure inside the kiln and avoid chances of CO related explosion. In many of the plants it is observed that continuous black smoke was discharged from this cap. At night the flame cum black smoke is more visible. The owners resort to this practice of discharging untreated emissions from the cap and bypassing GCP /GCT + ESP which pollutes the atmosphere.

Stack monitoring for various capacities of the Sponge Iron plants are carried out by State pollution control board and given as **Table 5.2.**

The gist of the Table 5.2 is given below.

Monitored By Others:

Plant Capacity	**Values of Particulate matter (mg/nm3) with Pollution control system are installed**			
	Kiln	**Cooler discharge**	**Coal Crusher**	**Product House**
2x 50 tpd	99-534	499		292
3x 50 tpd	84-474	375	96	
1x 100 tpd	47-1067	548-960	1173	110-1845
2x 100 tpd	125-916	352-753		385
3x100 tpd	279	1566	3203	118

In addition to above MECON had conducted stack monitoring by MECON in house laboratory in 50 tpd, 100 tpd and 500 tpd plant. The results are given below:

Plant Capacity	**Kiln Monitoring (mg/Nm^3) with ESP as Pollution control system**			
	Temp °C	**PM**	**SO_2**	**NO_X**
Haldia Steel Angadpur, Combined stack of 2 x 100 tpd	172	302-727	65-90	80-112
Balajee Steel, Mangalpur Combined Stack of Kiln 5 & 6, 2x 50 tpd	142	127-162	51-64	92-137
Balajee Steel, Mangal pur Combined Stack of Kiln 1 & 7, 2x 50 tpd	148	43-47	54-77	45-60
Ramrupaya Steel ,Durgapur Combined 2x 100 tpd	172	561-683	84-92	60-63
1X500 tpd ,Jharkhand	165	24960		

Before ESP				

5.01.04 Fugitive Dust generation

The sources of fugitive dust generation in rotary kin based DRI plants are the Raw Material Handling Yard (unloading, stacking, reclaiming operations) and Product discharge system (cooler discharge conveyors, transfer points, junction house, screens, magnetic separators, storage silos, truck loading and packing operations). The dust at RMH yard is controlled using water sprinklers in bigger sized plants. Covered Product House further reduces the wind blown dust. Skirt boards and covered conveyor belts also generates less fugitive dust.

Raw Material Preparation

The production of sponge iron requires sized of raw materials i.e. iron ore and coal. The sizing of raw materials involve the crushing, screening and conveying operation. During the crushing and screening operation fines are generated along with which the micron size dust flies in the air. Coal is mostly received in higher size (100- 250 mm depending upon Mines) which need to be crushed in a crusher to get the required size of 0-20 mm, thus all most all the plants are provided with coal crusher of required capacity. Iron ore is generally available in sized condition after a number of crushing units was set up in Orissa. Thus crushing of Iron ore by and large is not required at plant side. Dolomite are available in required size, thus crushing is not required.

With out any pollution control unit it is very difficult to arrest dust in crusher area. Most of the plants are devoid of any pollution control equipment.

Cooler Discharge and Product Separation

The iron ore, coal and dolomite/lime stone, which are fed into the rotary kiln, are converted to sponge iron, char and burnt lime respectively. During the operation the fines are generated due to tumbling action. Part of fines come out of the cooler through the double pendulum valve, and dust is generated at the transfer point.
The cooler discharge (CD) material contains sponge iron and char (unburnt coal). The cooler discharge material is screened and then fed to the magnetic separators where sponge iron, being magnetic, gets separated. The magnetic sponge iron and non-magnetic char is taken to their respective bins and dust generates during these operations.

The Pollution control system installed by a few sponge Iron plants were observed in the following area :

Sl No	Place/Shop	Type of dedusting equipment
1	Raw Material Handling	Bag filter
2	Coal Crusher	Bag filter
3	Cooler discharge	Bag filter

4	Product House	Bag filter

After cleaning the dust in bag filter, the clean gas is emitted through a small height stack. In some case the stack height is less than the near by building height.

Stack monitoring for various dedusting systems of various capacities of the Sponge Iron plants are carried out by State Pollution control Board and given as **Table 5.2**

Greenbelt may be developed around plant premises and all other open spaces inside the plant covered with lawns and gardens. These systems are effective in ensuring dust free / aesthetic working environment. But most of the 50 tpd or 100 tpd plants does not have adequate space for green belt.

In gas based DRI / HBI plants, GCP is used to control air pollution. Due to use of Natural Gas and Pelletized Iron Ore, the dust generation is less. The SPM content of the outlet of wet scrubber is less than 50 mg/Nm^3. The untreated hot gases generated from gas reforming operation have SPM below 50 mg/Nm^3.

In gas based plants, the plant dedusting system is done using hydroclones, multiclones or bag filters. The system is quite effective in ensuring dust free environment in the Product House.

In addition to above, MECON had conducted Work Zone air quality monitoring by MECON in house laboratory in 50 tpd, 100 tpd and 500 tpd plant. The samples were collected for 8 hourly sample in High Volume air sampler/Respirable dust sampler at site. The testing methodology is as per CPCB. The results are given below:

Work zone air quality monitoring results

1X 500 +1X 100 TPD plant

Sl. No.	**Monitoring location**	**Result, $\mu g/m^3$**		
		SPM	**SO_2**	**NO_X**
1.	Near Mechanical sub station (Kiln area)	11110	28	68
2.	Near Wet scrubber of Kiln No.2	6698	47	43
3.	Near Cooler of Kiln No. 1 (100 Tpd)	10941	48	55
4.	Near Cooler of Kiln No.2 (500 tpd)	22566	26	36
5.	Near Iron Ore emergency Hopper	37345	17	30
6.	Crusher building	9092	17	22

3x 50 TPD

Sl. No.	Monitoring location	Result, µg/m³		
		SPM	SO_2	NO_X
1.	In between crusher and charging area	3949	18	48
2.	Near Cooler	4791	46	61

4x50 TPD

Sl. No.	Monitoring location	Result, µg/m³			
		SPM	RPM	SO_2	NO_X
1.	Ore charging junction	3300	-	48	65
2.	Near Ore Crusher	1903	-	57	61
3.	Product House in between cooler no. 1,2 & 7	1760	878	42	70
4.	Cooler discharge	3289	-	49	68

2x100 TPD

Sl. No.	Monitoring location	Result, µg/m³		
		SPM	SO_2	NO_X
1.	Cooler discharge	16825	38	71
2.	ABC building	12210	48	62
3.	Ore charging place near hopper	5220	41	83
4.	Near Coal Handling plant	5588	53	76
5.	Product house	10780	49	75

3x100 TPD

Sl. No.	Monitoring location	Result, µg/m³			
		SPM	RPM	SO_2	NO_X
1.	Product House in between cooler no. 2&3	5525	1367	81	59
2.	ABC building between cooler no. 1&2	3100 0	-	37	41
3.	Ore charging place near hopper	940	-	56	72
4.	Near Coal Handling plant	8064	-	69	81
5.	Product house in front of kiln no.2	1102	-	45	71

5.10 Water Pollution Mitigation Measures

In the closed based sponge iron plants water is used mainly in three areas namely cooler, ABC and wet scrubber (In case dry type equipment are not in operation). The water requirement in rotary kiln DRI plant is mainly for cooling the discharge feed from 950-1050°C to below 100°C. Water is continuously sprinkled over the rotary cooler shell and is allowed to fall on a settling tank located below the rotary cooler/ near the cooler. Make-up water is added in the tank to cool the hot water and compensate evaporation loss. The water from settling tank is re-circulated for sprinkling over the rotary cooler. The water requirement varies from 5-6 kl/ h/ 100 TPD DRI.

In ABC water is sprayed through the nozzles in the form of fine spray. This controls the temperature of the gasses. The quantity of water required is 2 kl/h/100 TPD DRI

Though none of the plants are discharging any waste water from plants, but to know the quality of waste water ,water sampling is carried out and tested for relevant parameters.

MECON had conducted water quality monitoring by MECON in house laboratory in 50 tpd, 100 tpd and 500 tpd plant. The samples were collected and tested at MECON laboratory. The testing results are as follows:

Location of Water Monitoring Stations

Sl. No.	Sample No.	Plant	Type
1	SW1	2x 50 TPD	DSC water
2	SW2	3x 50 TPD	Re circulation water after Cooling
3	SW3	1x 50 TPD	Re circulation water after Cooling
4	SW4	1x500+1x100+ AFBC Boiler	Effluent discharged into River Swaranrekha
5	SW5	2x100 TPD	Re circulation water after Cooling
6	SW6	4x100 TPD	Effluent discharged into Drain

Sample no.	pH Value	TSS mg/l, Max	TDS mg/l, Max	COD mg/l, Max	Iron (as Fe), mg/l, Max	Oil & Grease mg/l, Max
SW1	7.5	247	1714	126	1.78	<10
SW2	6.9	166	5490	263	2.73	<10
SW3	7.8	104	714	63	3.91	<10
SW4	7.6	88.0	406	80.0	18.6	34.0
SW5	7.8	326	756	1054	27.5	16.5
SW6	7.6	4720	584	1040	17.5	13.6

Some of the big plants is using water for fugitive dust suppression in RMH yard, haul roads and other places. The water requirement varies from 1-1.5 kl/h/100 TPD DRI.

Some of the plants is having wet scrubber as pollution control system for kiln off gas (instead of ESP). Here after ABC the gas is passed through scrubber/venturi scrubber wherein the gas is scrubbed with plain water. The water with finer particles is collected and taken to thickener. The water from thickener is recirculated to scrubber unit. Underflow of thickener is cleaned periodically for small plants and for big plants it is taken to sludge settling ponds (SIIL, Khammam). Plants coming up now are mostly with ESP system. The water requirement varies from 3-3.5 kl/h/100 TPD DRI

The domestic water consumption is for cooling, washing and sanitary purpose. About 50-100 kl/ person/ day water is used for domestic purpose. About 5-10% water is generated as sanitary wastewater. The sanitary wastewater is disposed into soak pits / septic tanks.

5.11 Solid Waste Generation and Disposal

Char, flue dust, GCP sludge and kiln accretions are the solid wastes generated from DRI plants. Char comprises unburnt carbon, oxides and gangue and is segregated from the product during magnetic separation. The materials deposited on the inner surface of kiln, comprising metallic oxides is called accretion. Flue dust is generated from air pollution control systems like DSC, ESP and Bag Filter. Sludge is generated from the GCP, if the plant is based on wet scrubber for dust treatment.

Char contains moderate calorific value (1500-1600 kcal/kg) because of the presence of fixed Carbon content. Char do not have volatile matter and cannot be independently used as fuel. It is washed to free the impurities, mixed with coal fines, pulverized and then used as fuel in Fluidized Bed Combustion Boilers (FBC). In India very few plants are using char to produce electricity. Most of the plants (upto 100 tpd) dump it in low-lying area. Some of the plants sell it to local entrepreneurs for making coal briquettes (In Durgapur area of West Bengal)

It can also be mixed with coal fines, converted to briquette and used in brick kiln.

The kiln accretions are dislodged from the shell at periodic intervals because it hampers the feed movement and heat transfer inside kiln. It also reduces the surface area of kiln. The dislodged accretions are heavy solid lumps and are being used as landfill. However this material can be used as sub-base material for road construction.

The flue dust and sludge collected from air pollution control equipment are non-hazardous, non-toxic oxides that are mainly dumped in near by areas. These can be used for brick making and land filling.

The quantity of dust/char generated is depended upon the raw materials, its source, kiln size etc.

To have an idea several solid waste samples were collected from Sponge Iron plants namely

1. Char
2. Dedusting dust from pollution control equipment of Product handling area
3. Kiln accretion waste
4. Dedusting dust from pollution control equipment of Cooler discharge area
5. Scrubber sludge (scrubber is installed as pollution control equipment of Kiln)
6. Process dust from pollution control equipment of Kiln

These samples are tested in MECON Laboratory, Ranchi.

SOLID WASTE ANALYSIS REPORT

Name of Industry : Jai Balaji Sponge Iron **(50TPD)**

Sl. No.	**Parameters**	**Results***	
		ESP Dust	**Product House Bag filter**
A.	**Composition**		
1.	Loss of ignition, % **(at 600°C including at 120°C)**	25.86	36.09
2.	Silica (as SiO_2), %	19.76	27.14
3.	Aluminum (As Al_2O_3), %	5.6	5.40
4.	Iron (as Fe_2O_3), %	34.68	19.34
5.	Calcium (as CaO), %	6.36	2.38
6.	Magnesium (as MgO), %	4.15	1.87
7.	Manganese (as MnO_2), %	1.04	2.56
8.	Other, %	2.55	5.22
	Total, %	100.0	100.0
B.	**Metals**		
1.	Chromium (as Cr), mg/Kg	<0.01	<0.01
2.	Copper (as Cu), mg/Kg	3.35	1.85
3.	Lead (as Pb), mg/Kg	10.2	<0.01
4.	Nickel (as Ni) mg/Kg	17.9	31.8
5.	Cobalt (as Co), mg/Kg	6.44	3.89

Name of Industry : KYS Sponge Iron **(50TPD)**

Sl. No.	Parameters	Results*			
		ABC Wet Dust	Cooler discharge BF dust	Kiln Waste	Char dust
A.	**Composition**				
1.	Loss of ignition, % **(at 600°C including at 120°C**)	43.67	54.35	37.92	56.43
2.	Silica (as SiO_2), %	31.77	17.85	22.05	34.56
3.	Aluminum (As Al_2O_3), %	1.89	5.29	0.53	0.85
4.	Iron (as Fe_2O_3), %	6.72	12.65	30.65	0.82
5.	Calcium (as CaO), %	6.36	1.89	1.55	1.58
6.	Magnesium (as MgO), %	4.39	1.37	1.17	1.24
7.	Manganese (as MnO_2), %	1.23	2.29	2.45	0.14
8.	Other, %	3.97	4.31	3.68	4.38
	Total, %	100.0	100.0	100.0	100.0
B.	**Metals**				
1.	Chromium (as Cr), mg/Kg	<0.01	<0.01	<0.01	<0.01
2.	Copper (as Cu), mg/Kg	3.10	1.68	3.71	1.00
3.	Lead (as Pb), mg/Kg	0.63	0.64	0.29	26.6
4.	Nickel (as Ni) mg/Kg	26.8	21.7	1.26	25.1
5.	Cobalt (as Co), mg/Kg	3.28	2.29	2.03	1.40

Name of Industry : Ashirwad Sponge Iron **(50TPD)**

Sl. No.	Parameters	Results*		
		BF dust	**Bag House**	**Char dust**
A.	**Composition**			
1.	Loss of ignition, % **(at 600°C including at 120°C)**	32.52	16.97	59.95
2.	Silica (as SiO_2), %	30.66	31.36	24.49
3.	Aluminum (As Al_2O_3), %	6.27	5.60	4.89
4.	Iron (as Fe_2O_3), %	19.2	36.08	1.28
5.	Calcium (as CaO), %	2.56	2.25	5.66
6.	Magnesium (as MgO), %	1.93	1.82	2.45
7.	Manganese (as MnO_2), %	3.97	2.77	0.18
8.	Other, %	2.89	3.15	1.10
	Total, %	100.0	100.0	100.0
B.	**Metals**			
1.	Chromium (as Cr), mg/Kg	<0.01	<0.01	<0.01
2.	Copper (as Cu), mg/Kg	3.91	4.38	0.86
3.	Lead (as Pb), mg/Kg	9.99	0.01	1.99
4.	Nickel (as Ni) mg/Kg	15.5	27.4	36.4
5.	Cobalt (as Co), mg/Kg	5.83	4.52	1.76

Name of Industry : Adhunik Sponge Iron **(100TPD)**

Sl. No.	Parameters	Results*
		BF dust
A.	**Composition**	
1.	Loss of ignition, % **(at 600°C including at 120°C)**	24.84
2.	Silica (as SiO_2), %	31.21
3.	Aluminum (As Al_2O_3), %	5.10
4.	Iron (as Fe_2O_3), %	27.5
5.	Calcium (as CaO), %	2.93
6.	Magnesium (as MgO), %	1.61
7.	Maganese (as MnO_2), %	2.17
8.	Other, %	4.64
	Total, %	100.0
B.	**Metals**	
1.	Chromium (as Cr), mg/Kg	6.2
2.	Copper (as Cu), mg/Kg	3.36
3.	Lead (as Pb), mg/Kg	9.07
4.	Nickel (as Ni) mg/Kg	50.4
5.	Cobalt (as Co), mg/Kg	5.73

Name of Industry : Ma Chandi Sponge Iron **(2x50TPD)**

Sl. No.	Parameters	Results*	
		BF dust	Sludge
A.	**Composition**		
1.	Loss of ignition, % **(at 600°C including at 120°C**)	20.55	63.77
2.	Silica (as SiO_2), %	29.64	17.90
3.	Aluminum (As Al_2O_3), %	6.68	4.17
4.	Iron (as Fe_2O_3), %	24.51	8.72
5.	Calcium (as CaO), %	7.76	1.06
6.	Magnesium (as MgO), %	5.45	0.76
7.	Maganese (as MnO_2), %	4.16	1.44
8.	Other, %	1.25	2.18
	Total, %	100.0	100.0
B.	**Metals**		
1.	Chromium (as Cr), mg/Kg	10.2	<0.01
2.	Copper (as Cu), mg/Kg	7.1	0.54
3.	Lead (as Pb), mg/Kg	8.57	0.36
4.	Nickel (as Ni) mg/Kg	28.1	6.3
5.	Cobalt (as Co), mg/Kg	6.52	1.74

Name of Industry : BISCO Sponge Iron **(50TPD)**

Sl. No.	Parameters	Results*				
		Kiln waste	**Bag house**	**Product house BF dust**	**Kiln dust**	**Char dust**
A.	**Composition**					
1.	Loss of ignition, % **(at 600°C including at 120°C**)	33.96	60.45	59.67	21.7	61.27
2.	Silica (as SiO_2), %	12.22	23.11	22.47	28.74	25.61
3.	Aluminum (As Al_2O_3), %	6.16	2.14	4.79	7.11	4.74
4.	Iron (as Fe_2O_3), %	38.21	9.61	5.14	30.45	0.51
5.	Calcium (as CaO), %	2.1	1.35	1.59	2.39	2.38
6.	Magnesium (as MgO), %	1.53	0.16	1.08	1.68	1.79
7.	Manganese (as MnO_2), %	1.55	0.8	2.12	3.18	0.29
8.	Other, %	4.27	2.38	3.14	4.75	3.51
	Total, %	100.0	100.0	100.0	100.0	100.0
B.	**Metals**					
1.	Chromium (as Cr), mg/Kg	<0.01	<0.01	<0.01	<0.01	<0.01
2.	Copper (as Cu), mg/Kg	0.97	2.17	1.72	3.99	0.75
3.	Lead (as Pb), mg/Kg	0.94	0.61	0.33	<0.01	<0.01
4.	Nickel (as Ni) mg/Kg	8.2	23.0	42.8	18.7	41.2
5.	Cobalt (as Co), mg/Kg	2.21	2.86	4.02	5.12	4.92

Name of Industry : Shyam SEL Sponge Iron **(100TPD)**

Sl. No.	Parameters	Results*	
		ESP dust	**Product house BF dust**
A.	**Composition**		
1.	Loss of ignition, % **(at 600°C including at 120°C)**	19.40	23.46
2.	Silica (as SiO_2), %	28.41	34.67
3.	Aluminum (As Al_2O_3), %	5.67	4.97
4.	Iron (as Fe_2O_3), %	34.83	27.9
5.	Calcium (as CaO), %	1.59	2.23
6.	Magnesium (as MgO), %	1.31	1.74
7.	Manganese (as MnO_2), %	3.85	3.12
8.	Other, %	4.96	1.91
	Total, %	100.0	100.0
B.	**Metals**		
1.	Chromium (as Cr), mg/Kg	<0.01	<0.01
2.	Copper (as Cu), mg/Kg	3.46	2.80
3.	Lead (as Pb), mg/Kg	7.47	<0.01
4.	Nickel (as Ni) mg/Kg	9.9	40.3
5.	Cobalt (as Co), mg/Kg	4.14	4.15

Name of Industry : Ritesh Sponge Iron **(50TPD)**

Sl. No.	Parameters	Results*	
		Kiln Accl^n Waste	**Cooler discharge dust**
A.	**Composition**		
1.	Loss of ignition, % **(at 600°C including at 120°C)**	40.63	20.95
2.	Silica (as SiO_2), %	23.52	36.18
3.	Aluminum (As Al_2O_3), %	6.00	4.91
4.	Iron (as Fe_2O_3), %	17.83	31.27
5.	Calcium (as CaO), %	3.18	0.8
6.	Magnesium (as MgO), %	2.42	0.62
7.	Manganese (as MnO_2), %	2.61	2.50
8.	Other, %	3.81	3.77
	Total, %	100.0	100.0
B.	**Metals**		
1.	Chromium (as Cr), mg/Kg	<0.01	3.9
2.	Copper (as Cu), mg/Kg	2.10	2.83
3.	Lead (as Pb), mg/Kg	<0.01	0.51
4.	Nickel (as Ni) mg/Kg	23.9	28.0
5.	Cobalt (as Co), mg/Kg	3.38	2.83

Name of Industry : Savitri Sponge Iron **(50TPD)**

Sl. No.	Parameters	Results*
		Cooler discharge BF dust
A.	**Composition**	
1.	Loss of ignition, % **(at 600°C including at 120°C**)	26.29
2.	Silica (as SiO_2), %	31.64
3.	Aluminum (As Al_2O_3), %	5.85
4.	Iron (as Fe_2O_3), %	26.43
5.	Calcium (as CaO), %	1.47
6.	Magnesium (as MgO), %	1.16
7.	Manganese (as MnO_2), %	3.70
8.	Other, %	3.46
	Total, %	100.0
B.	**Metals**	
1.	Chromium (as Cr), mg/Kg	<0.01
2.	Copper (as Cu), mg/Kg	2.58
3.	Lead (as Pb), mg/Kg	<0.01
4.	Nickel (as Ni) mg/Kg	40.1
5.	Cobalt (as Co), mg/Kg	4.29

Testing results are compared with schedule 2 of Hazrdous waste (Mangement and Handling) Rules 1989 and as amended in May 2003 and found that none of these are hazardous in nature.

5.12 Noise Generation and Control

DRI plants do not generate noise. The main source of noise generation in gas based plants are the briquetting machines, compressors etc.For Coal based plants, the moving parts of kilns, cooler and associated equipment like gear boxes, fans etc that generates upto 90 dB(A) noise. Other noise sources in DRI plants are vehicular movement, air blowers, vibrating screens / separators. Administrative control is the only method applicable; hence, the workers while going to the noisy areas are advised to wear earplugs and earmuffs.

Actual noise monitoring was carried out at different coal based Sponge iron plants by MECON Laboratory during August- September 2004.

In order to have an idea of the present background noise level of the coal based Plants, a detailed measurement of noise level was carried out at different locations. Precision integrated sound level meter (type 2221 of Bruel & Kjaer of Denmark) was used. The measurements were recorded by the operating the instrument for 10-15 minutes in each place in which Leq. (A) have been measured

Monitored By MECON :

Sl No	Place	Sound Pressure Level	
		Leq dB(A)	**Peak dB(A)**
1x 50 TPD Plant			
1	In front of Kiln	82.5-83	101.5
2	Near kiln	84.6-85.4	
		82.0-84	100.5-101.6
3	Near Kiln Cooler	89-91	109-110
4	Near Bag filter of Cooler	89-90	
5	100 m away from Kiln	75	
6	200 m away from Kiln	73.5	
7	Near bag filter	79-80	100
2x 50 TPD Plant			
1	In front of Kiln	77-82	101-104
2	Near cooler	83.0	100.8
3 x 50 TPD Plant			
1	In front of Kiln	75.1	
		76.0	
2	In the middle of kiln	80.0	108.0
		82.0-84.0	102.0
3	Cooler side	83.0	103.5
4	500 meter away from cooler	80.0	
5	Near main gate	65.0-68.0	
4x50 TPD Plant			
1.	Coal crusher	90.5	110.6
2.	ABC	93.2	115.0
3.	Cooler discharge	87.5	106.0
4.	Product house	92.0	111.4
5.	Near gate	72.4	98.6
2x100 TPD Plant			
1.	Product house	82.4	102.6
2.	Cooler discharge	85.6	110.6
3.	Middle of the kiln	92.4	111.2
4.	Near ABC	88.2	105.6
5.	Compressor room	91.4	107.2
6.	Stock house	85.7	106.5
7.	Near gate	73.6	99.5
3x100 TPD Plant			

Sl No	Place	Sound Pressure Level	
		Leq dB(A)	Peak dB(A)
1.	Near ABC	90.6	109.6
2.	In front of kiln	85.4	111.5
3.	Near ESP	80.2	118.2
4.	Near Ore crusher	94.5	111.6
5.	Cooler discharge	89.2	108.4
6.	Near gate	87.4	105.6
4x100 TPD Plant			
1.	Product house	79.2	104.0
2.	Cooler discharge	87.2	110.2
3.	In front of kiln	85.1	107.0
4.	Near ABC	97.2	118.4
5.	Between ABC & cooler discharge	89.5	106.2
6.	Coal crusher	89.0	105.0
7.	Near stack	83.5	110.2
8.	Near gate	74.5	98.5
1 x 500 TPD Plant			
1	In front of Kiln	70-82	104
2	Near Wet scrubber	75.6	106.2
3	Near main gate	65.7	91.2

5.13 Hazardous Wastes and Chemicals

Coal based DRI plants do not handle any hazardous chemical (as stipulated in Manufacture, Import and Storage of Hazardous Chemical Rules) nor generate any hazardous solid waste (as stipulated in Hazardous Wastes Management & Handling Rules).

Spent oil and lubricants generated from moving equipment / machinery are collected in drums and given to authorized re-processor for recycling. The volume of spent oil and lubricant is about 300 l / year /100 TPD DRI

5.14 Occupational Health and Safety

At present, no occupational health system is followed by most of the DRI plants.

DRI Plants falls under 1st Schedule of the Factories Act. 2nd Schedule prescribes the following limits for pollutants in the work environment (time weighted average for 8-hours continuous exposure).

- ❖ Silica (in quartz and amorphous form-fly ash having more than 50% silica content and counted as total dust) - Permissible level of silica (in amorphous form, counted as total dust) is 10 mg/m^3
- ❖ Coal dust (respirable fraction <10 μ size; containing less than 5% quartz) - Permissible level of silica (in amorphous form, counted as total dust) is 2 mg/m^3
- ❖ Iron oxide fumes - Permissible level is 5 mg/m^3
- ❖ Carbon Monoxide CO - Permissible level is 55 mg/m^3 (TWA for 8hours), 440 mg/m^3 (STEL for 5-minutes)

The occupational health envisaged in DRI plants are respiratory problems due to dust and CO poisoning due to accidental exposure to untreated DRI gases. Workers working in areas like RMH yard and Product House that generates fugitive dust should wear nose masks / dust filters. CO probes with electrochemical sensors should be installed after the ABC, at stack and at kiln discharge end. In case a person inhales CO, he should be removed to fresh air and given mediated oxygen through a mask for 30 minutes and if required cardiopulmonary resuscitation should be performed. Thereafter, supportive treatment if required should be given in the nearest hospital. In order to cater to routine mechanical injury to body parts, first aid boxes equipped with medicines should be kept handy. The employees exposed to dusty environment should be subjected to regular health check-up. The workers should be diagnosed for respiratory functions at periodic intervals and during specific complaints for lung function test, sputum test, X-ray test, etc.

5.15 Environmental Impact

With all pollution control measures the impacts due to the plant cannot be avoided. MECON planned to carryout ambient air monitoring in selected sponge iron plants. As monsoon is not over MECON and CPCB decided to carryout the same in the winter months. However various data were collected to know about the impacts of the plant in neighboring area.

Ambient Air

Results of Ambient air quality for a 2 x 100 tpd plant in Siltara (Chattisgarh):

Place of Monitoring (Uninhabited area)	SPM	SO2	Nox
Near Storage yard (Wind ward direction)	540-573	27.4-30.6	28-28.3
Above time office against wind direction	367-406	19.8-23.5	20.4-24

Results of Ambient air quality for a 2 x 100 tpd plant in Purulia (WB):

Place of Monitoring (habited area)	SPM	SO_2	NO_X
Village Ragudih	211-341	<10	11-28
Village Bhasko	225-279	10-11	20-34
Village Lalgarh	251-420	<10	13-20

Results of Ambient air quality for a cluster of plant 1x 500 tpd, 1x100 tpd and 3x 50 tpd plant in Jharkhand:

Place of Monitoring (Inhabited area)	SPM	SO_2	NO_X
Near Residential area of 500 TPD plant (1.2 km)	322	20	32
Down wind direction of all these plants	356	14	21

Note: Fig in µg/m^3

Ambient air quality monitoring results of Angadpur Area (Cluster of Sponge iron plants)

Sl. No.	Monitoring location	Result, µg/m^3			
		SPM	RPM	SO_2	NO_X
1.	Near Hari Mandir Angadpur	271-305	-	23-32	16-25
2.	Tentultalla, Raturia	457 -515	-	23-34	29-31
4.	Angatpur industrial Area	713-844	278	52-94	39-72

Ambient air quality monitoring results of Mangalpur Cluster **(7 Sponge Iron plants)**

Sl. No.	Monitoring location	Result, µg/m^3			
		SPM	RPM	SO_2	NO_X
1.	Near Gwailor Cement	1556	-	51	38
2.	Baket nagar	386	132	29	22
3.	Shyam Sel Ltd.	834	-	37	51
4.	Govind Gopal Ltd.	1246	-	17	30
5.	SKS Public School	301-378	200-225	17-42	48-60

Note: Fig in µg/m^3

5.16 Environmental Monitoring

At present, no structured environmental monitoring program is followed by most of the DRI plants. Regular monitoring in a systematic and standardized manner helps in assessment of current environment and provides information on operational performance of installed pollution control facilities.

Specially smaller plant like 50 tpd or 100 tpd plants are not carrying out any environmental monitoring at present except a few exceptions.

The DRI plants should conduct routine environmental monitoring. The following aspects are essential.

a) Monitoring of stack emissions (main kiln stack and other stacks) for Temperature, Velocity, PM, SO_2, NOx, and CO. This should be carried out once in a month.

b) Monitoring of ambient air quality at plant boundary for fugitive emissions for SPM, RSPM, SO_2 and NO_2. This should be carried out twice in a month.

c) Monitoring of raw water quality and ground water quality of surrounding area of dump yard for pH, conductivity, total solids, suspended solids and oil and grease. This should be carried out once before monsoon and one after monsoon.

d) Noise monitoring near the kiln, product house, RMH yard and plant boundary (in Leq DB(A) using Noise Meter) . This should be carried out once in a month.

e) Monitoring of solid wastes quantity and utilization potential (Char, accretions, flue dust and sludge)

Table - 5.1 : Status of Pollution Mitigation Measures in Sponge Iron Plants

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
Large Plants							
1	Tata Sponge Ltd. Belaipada, (Orissa) Customized TISCO Direct Reduction process 2 x 400 TPD Installed capacity 240,000 TPA (1 x 500 TPD Kiln III under construction) (Capacity after expansion - 400,000 TPA)	Kiln I Stack 45 m Monitored results SPM: 110 mg/Nm^3 SO_2 : 520 mg/Nm^3 NO_x : 78 mg/Nm^3 Kiln II Stack 50 m Monitored results SPM: 110 mg/Nm^3 SO_2 : 520 mg/Nm^3 NO_x : 78 mg/Nm^3 Dedusting system Kiln I: Stack. 37m , SPM:110 mg/Nm^3 Dedusting system: Kiln II Stack 45 m SPM: 10 mg/Nm^3 Fugitive emissions not monitored DRI Gas produced - 284,000 Nm^3/h (Kiln I and II), used to generate 7.5 MW power generated through WHRB	Gas Cleaning Plant in Kiln I (Wet Venturi Scrubber) WHRB and ESP in Kiln II WHRB and ESP planned in Kiln III Bag Filters in product House (Cooler Discharge, Screening, Loading Plant) Fugitive Dust Control 1. Chemical mixed water spray 2. Telescopic unloading sprout 3. Vacuum machine 4. Fogging device	125 kl/h for Rotary Discharge Cooling, Flue Gas Scrubbing, Fugitive Dust Suppression and Domestic use Source of water: Kundra Nala	Cooling water is recycled. Sludge is disposed inside the premises in 6 Nos. settling ponds Sanitary waste is disposed in septic tanks and soak pits.	Process Dust: 72.8 TPD Sludge: 37 TPD Char: 250 TPD Kiln Accretions: 25 TPD	Char Dumped inside the plant premises. I O, Dedusting Sludge sold, ESP dust Brick making

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
2	HEG Ltd. Durg (CG) 2 x 100 TPD Lurgi process by SIIL Installed Capacity - 60000 TPA (Expansion Planned)	ESP in DRI Kilns, 30 m tall stacks (2 Nos.) WHRB and FBC available for power generation (12.8 MW) Emissions monitoring not done	ESP in Kiln Bag Filters in Product House Water sprinklers for fugitive emissions	15 kl/h water is required for Cooling & Dust suppression. Ground water used. 7kl/day groundwater used for domestic purpose	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char : 65 TPD Kiln Accretions : 1.1 TPD 10 TPD process dust from ESP & Bag Filter	Dumped inside the plant premises Flyash brick plant installed.
3	Jindal Steel & Power Ltd. Raigarh (CG) Lurgi Process by Jindal 6 x 300 TPD Installed capacity - 600,000 TPA 4 x 545 TPD Kilns under construction (Installed capacity after expansion will be 1300,000 TPA	WHRB and ESP (3 Nos.) Stack: 45 m Flow: 100 Nm^3/h Temp: 380°- 425°K SPM: 100 mg/Nm^3 SO_x and NO_x not monitored. Bag Filters at Product House. Water sprinklers at Raw Material Handling Yard. Other stacks not monitored Fugitive dust at plant boundary < 500 ug/m^3	ESP in DRI Kilns Product House : 10 Bag filters 1 Cyclone (Similar provisions kept in new plant) DRI gas generated - 2880,000 Nm^3/h used to generate 33 MW power through WHRB.	104 kl/hr water is required cooling Water source-Kelo river 65 kl/d from borewell used for domestic purpose	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char: 438 TPD Klin Accretion: 66 TPD Process dust (APCD): 588 TPD	Char mixed with coal and used in AFBC (partial used balance dumped) Accretions dumped Process dust dumped inside and outside the plant premises.
4	Vandana Global Pvt. Ltd. Raipur (CG) Lurgi process customized	WHRB and ESP in DRI Kilns Stack: 72 m SPM: 150 mg/Nm^3	Kilns: ESP Product House: Bag Filters	18 kl/h of water required for Cooling 10 kl/day water for	Cooling water recycled through settling tanks	Char: 65 TPD Process dust: 25 TPD Accretions: 4 TPD	Char is partially used in AFBC Boilers after

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	2 x 100 TPD Installed capacity: 60000 TPA 1 x 500 TPD under construction. Installed capacity will be 210000 TPA	SO_2 and NO_x not measured Bag Filters in Product House Fugitive emissions not monitored	DRI gas produced - 45000 Nm^3/h WHRB and 2 Nos. AFBC installed to generate 32 MW power.	domestic use Source of water - Local Authority	Sanitary waste disposed through soak pits		mixing with coal fines. Other wastes dumped outside the plant premises
5	Orissa Sponge Iron Ltd. Palaspanga (Orissa) ACCAR Process (modified and patented by OSIL) 1 x 300 TPD Installed Capacity 100000 TPA	WHRB and ESP in Kiln, stack 45 m SPM: 150/ Nm^3 Bag Filters in Product House, 10 m stack SPM level of these stacks not available. SO_x & NO_x are not monitored Fugitive emission not monitored	WHRB and ESP in Kiln WHRB uses the off gas to produce 10 MW power. Bag Filters in Product House Water sprinkling in RMH Yard	60 kl/hr for Rotary Discharge Cooling 75 kl/day for domestic use.	Cooling water recycled. Septic tanks for sanitary wastes	Char - 100 TPD Kiln Accretions - 35 TPD Process dust - 19 TPD	Dumped
6	Nalwa Sponge Iron Ltd. Raigarh (CG) SL/RN (Lurgi Process) customized by Jindal 6 x 100 TPD Installed capacity - 200000 TPA	WHRB and ESP, Stacks 54 m tall (3 Nos.) SPM: 150 mg/Nm^3 SO_x & NO_x are not monitored Fugitive emission monitored, concentration: < 500 ug/m^3	WHRB and ESP for Kiln Bag Filters for Product House Water sprinkling for RMH Yard	35 kl/h water for Rotary Discharge cooling. 35 kl/day for domestic use. Source: Groundwater	Cooling water is recycled through settling tanks. Sanitary waste disposed in soak pits	Char - 200 TPD Kiln accretion - 35 TPD Process dust - 85 TPD.	Char is mixed with coal and used in AFBC boiler. . Other solid wastes are used for landfilling

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
7	Shree Metaliks Keonjhar (Orissa) 6 x 80 TPD Popurri process Installed Capacity - 144,000 TPA	ESP, 6 stacks 30 m SPM: 55 mg/Nm^3 SO_x & NO_x not monitored Bag Filters in Product House Fugitive emissions not monitored	GCT and ESP installed for DRI Kiln emissions Bag Filters installed in Product House WHRB will be installed in future Water sprinklers are installed for suppressing fugitive dust emissions	50 kl/h water for cooling 20 kl/day for domestic use Source: Groundwater	Cooling water recycled through settling tanks Sanitary wastes disposed into soak pits	Char- 175 TPD Kiln Accretions - 50 TPD Process dust - 80 TPD	Dumped.
8	Sova Ispat Ltd. Mejia (WB) Popurri process 1 x 300 TPD Installed Capacity 90000 TPA (under commissioning)	GCT and ESP for Kiln emissions Bag Filters for Product House Water sprinklers for RMH Yard	GCT and ESP for Kiln emissions Bag Filters in Product House	24 kl/h of water for cooling purpose 8 kl/day for domestic purpose	Cooling water recycled through settling tanks Sanitary waste disposed in soak pits	Char - 100 TPD Kiln accretions - 50 TPD Process dust - 80 TPD	Dumped outside plant premises
9	Singhal Enterprises. Raigarh (CG) Popurri process 2 x 100 TPD Installed capacity: 60000 TPA (1 x 100 TPD under construction, capacity after expansion will be 90000 TPA)	GCT and ESP in DRI Kilns Stack: 30 m	The Kiln off gas is passed through GCT and then through ESP	20 kl/h of water required for Cooling 10 kl/day water for domestic use Source of water - Groundwater	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 70 TPD Process dust: 50 TPD Accretions: 12 TPD	Dumped Outside and inside the plant premises

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
10	Sunflag Steel Limited Bhandara (Maharashtra) Krupp CODIR Technology 1 x 500 TPD Installed Caapacity: 150000 TPA	ESP in Kiln Stack -55 m SPM: 127 mg/Nm^3 SO_2 - 760 kg/d NO_x -2.86 ppm Scrubber Stack 28 m SPM: 127 mg/Nm^3 Dedusting Stack: SPM: 104 mg/Nm^3 Fugitive emission monitoring not done.	WHRB and ESP for Kiln emission. Bag House in Product Hopper Water sprinklers in RMH Yard DRI Gas - 140000 Nm^3/h, used for 9.5 MW power generation through WHRB	6.3 kl/h water is required for direct cooling of hot DRI inside Rotary Discharge Cooler. 18 kl/day water is needed for Dust Suppression and other uses Source of water Wenganga River	Cooling water is evaporated, spillage is collected and recycled. Sanitary waste disposed in septic tanks and soak pits	Process dust from APCD and Plant - 82 TPD Char: 90 TPD Klin Accretion : 4.5 TPD (Waste refractory linings - 150 TPA)	Char and coal fines is used in FBC. ESP dust is used in brick making
11	Raipur Alloys and Steel Ltd. Raipur (CG) SIIL process Large Plant 2 x 100 TPD (1 x 500 TPD under construction) Installed capacity: 60000 TPA	WHRB and ESP in DRI Kilns Stack common : 45 m SPM: 150 mg/Nm^3 SO_2 and NO_x not measured Bag Filters in Product House	The Kiln off gas is passed through GCT and then through ESP Bag filters installed in product House control fugitive emissions WHRB and 2 Nos. AFBC installed to generate 32 MW power.	8.3 kl/h of water required for Cooling 10 kl/day water for domestic use Source of water - Kharun River	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 65 TPD Process dust: 25 TPD Accretions: 4 TPD	Char is partially used in AFBC Boilers after mixing with coal fines. Other wastes dumped outside the plant premises
12	Jai Balagi Sponge Ltd. Raniganj (WB) Popurri process 7 x 50 TPD Installed capacity: 100000	Wet Venturi Scrubber and ESP in DRI Kilns Stack common : 28 m SPM: 150 mg/Nm^3 SO_2 and NO_x not measured Bag Filters in Product	The Kiln off gas is passed through Wet Scrubber and then through ESP Bag filters installed in product House control fugitive emissions	22 kl/h of water required for Cooling 12 kl/day water for domestic use Source of water - Local Authority	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 92 TPD Process dust: 20 TPD Accretions: 8 TPD	Dumped

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	TPA	House	Water sprinkling system installed in RMH yard.				
13	Rasmi Ispat Pvt Limited Jhargram (West Bengal) Popurri process 2 x 100 TPD Installed capacity: 60000 TPA	ESP in DRI Kilns Stack : 30 m SPM: 13 mg/Nm^3 SO_2 465 mg/Nm^3 NO_x not measured	The Kiln off gas is through ESP Bag filters installed in product House, Cooler discharge, Raw material section to control fugitive emissions Water sprinkling system installed in RMH yard.	20 kl/h of water required for Cooling 10 kl/day water for domestic use Source of water – Ground water	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 92 TPD Process dust: 20 TPD Accretions: 8 TPD	Dumped
14	Sponge Iron India Limited Khammam (AP) SIIL process 2 x 100 TPD Installed capacity: 60000 TPA	Wet Venturi Scrubber in DRI Kilns Stack : 40 m each SPM: 25 mg/Nm^3 SO_2 in Traces and NO_x not measured Wet scrubber in plant dedusting system	The Kiln off gas is passed through WHRB of 12 tph FBC Boiler 15 tph to generate 4 MW power from Char & kiln gas Water sprinkling system installed in RMH yard.	5.5 kl/h of water required for Cooling 350 kl/day water for domestic use Source of water – Kinnerasani River	Water from scrubber is treated in thickner. Slurry are taken to sludge pond for settlement Cooling water recycled Sanitary waste disposed through soak pits	Char: 50 TPD Process dust: 7 TPD Accretions: 1.3 TPD Char is used to produce power	Sludge from Gas cleaning plant and iron ore washing plant is used for land filling
15	Ispat Godavari Limited Raipur (CG) Lurgi process customized 1 x 300 TPD Kiln	WHRB and ESP SPM: 150 mg/Nm^3 Bag Filters in product House	ESP for Kiln emissions Bag Filters for Product House	22 kl/h for cooling and 10 kl/day for domestic use. Source: Kharun river	Cooling water recycled through settling tanks. Sanitary waste disposed using septic tanks.	Char - 100 TPD Accretions: 8 TPD Process dust - 40 TPD	Dumped outside AFBC Boiler is proposed

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	Installed capacity - 90000 TPA (1 x 500 TPD under construction, total capacity after expansion will be 240000 TPAA)	Water sprinkling in RMH Yard Fugitive emissions monitoring not done	DRI gas-55000 Nm^3/h used for 7 MW power generation through WHRB				
Gas Based Plant (Large)							
16	Essar Steel Ltd. Hazira (Gujarat) Midrex process (Gas based) 6000 TPD Installed capacity - 2000000 TPA (after expansion)	3 Process Dust Collection Systems (PDCS) stacks: 20 m Flow: 30000 Nm^3/ h. & Exit Temp.: 334^0 K SPM: 26 mg/ Nm^3 3 Recuperator Reformer stacks: 40 m tall Flow: 200000 Nm^3/ h Exit Temp: 667^0 K SPM level in Reformer SPM: 18 mg/ Nm^3	3 Nos. Wet Venturi Scrubbers for Furnace (200000 Nm^3/ hr./ module) Hydrocyclone for Product Fines collection (35000 Nm^3/ hr./ module)	245 kl/h for Cooling 100 m^3 /d . Water source: Tapi river	Clarifier of 6083 m^3 capacity has been installed	1100 TPD iron ore fines is reused after pelletization.	No other solid waste reported.
Small Plants							
17	Agarwal Sponge Pvt Ltd. Raipur, CG 2 x 50 TPD Popurri process Installed Capacity - 30,000 TPA (1 x 100 TPD under construction)	2 stacks, 32 m No monitoring done	None, ESP being installed. No control system in Product House and Raw Material Handling	Use - 8 kl/hr for Cooling Source of Water: Underground 7 kl/day domestic water required. Taken through borewell	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char : 30 TPD Kiln Accretions : 0.5 TPD	Dumped outside

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
18	Anjani Steels Co. Ltd. Raigarh (CG) 1 x 100 TPD Popurri process Installed Capacity - 30,000 TPA (1 x 100 TPD under construction)	ESP for Kiln 42 m stack 9 m stacks for Product House. No monitoring done.	GCT and ESP for Kiln emissions. Bag Filters (5 Nos.) Product House Water sprinkling for fugitive emission control in Raw Material Handling.	8 kl/h water for cooling purpose Water taken from Kelo river. Ground water (6 kl/day) for domestic use.	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char : 30 TPD Kiln Accretions : 0.5 TPD	Dumped inside the premises. Char sometimes sold
19	Mahamaya Sponge Iron Pvt. Ltd. Raipur (CG) 1 x 50 TPD Customized Installed Capacity - 15,000 TPA	30 m tall stack	Order placed	5 kl/h water for cooling. 4 kl/day water for domestic use Water supplied by Authority	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	17 TPD char 2 TPD Kiln accretions	Dumped outside
20	Seleno Steels Ltd. Raigarh (CG) 1 x 100 TPD Popurri process Installed Capacity - 30,000 TPA	30 m stack No monitoring done..	None	9 kl/h water for cooling purpose 5 kl/day water for domestic use Ground water is used.	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char : 35 TPD Kiln Accretions : 0.5 TPD Process Dust - 4 TPD	Dumped outside and inside the premises. Char sometimes sold

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
21	Adhunik Corporation Ltd. Durgapur (WB) 2 x 100 TPD Popurri process Installed Capacity - 60000 TPA	Common Stack of 30 m for both kilns. SPM : 140 mg/Nm^3 Dedusting Stack - 15 m SPM :120 mg/Nm^3 Product House Stack - 30 m SPM: 130 mg/Nm^3 SO_x & NO_x not monitored Fugitive emissions not monitored.	Wet Scrubber (Gas Cleaning Plant) for Kiln emission Bag Filters for Product House Water sprinklers in Raw Material Handling Yard	Use - 20 kl/hr for Cooling, Dust Scrubbing and Suppression Source of Water: Damodar River 7 kl/day domestic water required. Taken through borewell	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char : 60 TPD Kiln Accretions : 1 TPD Process Sludge: 4-8 TPD	Dumped outside the plant premises Some char is also sold. Sludge dumped in pond.
22	Haldia Steel (Unit II) Durgapur (WB) 2 x 100 TPD Customized process Installed Capacity - 60000 TPA	40 m tall Stack SPM: 150 mg/Nm^3 Product House: Bag Filters (6 No.) 6 Stacks each 25 m SPM: 150 mg/Nm^3 Fugitive emission not monitored	Gas Conditioning Tower and ESP for DRI Klin emissions. Plant Dedusting by 6 Nos. Bag Filters: Water Sprinklers for suppressing dust	15 kl/h water is required for Cooling & Dust suppression. 7kl/day domestic groundwater used	Cooling water Re-cycled through settling tanks. Sanitary waste disposed in soak pits	Char : 62 TPD Kiln Accretions : 0.9 TPD	Dumped outside the plant premises
23	Maa Chandi Durga Ispat Ltd. Durgapur (WB) Popurri process 2 x 100 TPD	Kiln stack : 30 m SPM: 120 mg/Nm^3 4 Nos. Bag Filters in Product House Stacks 21m (4 No.)	Gas Cleaning Plant in DRI Kiln (Wet Scrubber) , to be replaced shortly by ESP Bag Filters in Product House	16 kl/h water for cooling and dust suppression. 5.5 kl/day.water is required for drinking and green belt development	Cooling water Re-cycled through settling tanks. Sanitary waste	Char : 68 TPD Kiln Accretions : 2 TPD 5 TPD sludge from GCP 2 TPD process dust from	Dumped outside the plant premises

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	Installed capacity: 60000 TPD	Fugitive emission not monitored	Water sprinkling in RMH Yard		disposed in soak pits	Bag Filter	
24	Ritesh Tradefin Ltd. Durgapur (WB) 2 x 100 TPD Popurri process Installed Capacity - 60,000 TPA	DRI Kiln Stack - 30 m Exit Temp: 523^0 K SPM: 150 mg/Nm^3 Product House: Bag Filters (3 Nos. 25 m tall stacks SPM: 150 mg/Nm^3 Fugitive emissions not monitored	Gas Cleaning Plant for DRI Kiln (Wet Scrubber) (being replaced by ESP shortly) Bag Filters in Product House Water sprinklers at Material Handling	16 kl/h cooling water 5 kl/day for domestic use Water available from DPL	Cooling water recycled through settling tanks Sanitary wastes disposed in soak pits	30 TPD Char 4 TPD accretions 2 TPD of process dust 14 TPD of Sludge	Char partially sold, balance dumped Process dust and sludge dumped outside the plant premises
25	Sidhi Vinayak Iron Pvt. Ltd. Raigarh (CG.) Popurri process 1 x 100 TPD Installed capacity 30000 TPD	No stack, kiln emissions are let out through kiln feed end cap, after Dust settling Chamber.	None	15 kl/h.for Cooling 5 kl/day for domestic use	Cooling water recycled through settling tanks. Sanitary waste disposed in soak pits	Char- 30 TPD Kiln accretions - 15 TPD Process dust - 8 TPD	Dumped
26	Howrah Gases Ltd. Raniganj (WB) Popurri process 2 x 100 TPD	Wet Scrubber and ESP in DRI Kilns Stack: 30 m SPM: 150 mg/Nm^3 SO_2 and NO_x not measured	GCT and ESP Product House: Bag Filters Water sprinkling in Material handling	17 kl/h of water required for Cooling 6 kl/day water for domestic use Source of water - Local Authority	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 60 TPD Process dust: 18 TPD Accretions: 5 TPD	Dumped

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	Installed capacity: 60000 TPA	Fugitive emissions not measured	section				
27	Asirbad Steel & Industries Ltd. Gamaria (Jharkhand) Popurri process 3 x 50 TPD Installed capacity: 45000 TPA	No stack, kiln emissions are let out through kiln feed end cap, after Dust settling Chamber	Bag Filter for DRI Kiln (Proposed & Under Construction) Bag Filters in Product House, Cooler discharge, Coal Crusher All Conveyor are covered	15 kl/h water for cooling. 5 kl/day water for domestic use Water supplied through Bore well	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits		Dumped
28	KYS Sponge Iron Pvt Ltd. Gamaria (Jharkhand) Popurri process 1 x 50 TPD Installed capacity: 15000 TPA 1x 50 TPD proposed	No stack, kiln emissions are let out through kiln feed end cap, after Dust settling Chamber	None Bag Filters in Product House,Cooler discharge,Coal Crusher	5 kl/h water for cooling. 5 kl/day water for domestic use Water supplied through Bore well	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 18 TPD	Dumped
29	BISCO Sponge Iron Pvt Ltd. Gamaria (Jharkhand) Popurri process	No stack, kiln emissions are let out through kiln feed end cap, after Dust settling Chamber	None, DSC with water bath Bag Filters in Product House,Cooler	10 kl/h water for cooling. Water supplied through Bore well	Cooling water recycled through settling tanks Sanitary waste disposed through	Char: 31 TPD	Dumped

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	2 x 50 TPD Installed capacity: 30000 TPA		discharge,Coal Crusher		soak pits		
30	SPS Sponge Iron Ltd Durgapur (WB) Popurri process 2 x 50 TPD + 1x 100 TPD Installed capacity: 60000 TPA	Wet Scrubber for 100 TPD and ESP for 50 TPD in DRI Kilns Stack: 30 m SPM: 150 mg/Nm^3 SO_2 and NO_x not measured Fugitive emissions not measured	Wet Scrubber being replaced by ESP shortly) Bag Filters in Product House,Cooler discharge Water sprinklers at Material Handling	15 kl/h water for cooling. 10 kl/day water for domestic use Water supplied by DPL authority	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 35 TPD	Char,Dust sold
31	Shyam Sel Ltd (Power Division) Mangalpur,Ranigunge (WB) 3 x 100 TPD Installed capacity: 60000 TPA	Wet Scrubber and ESP in DRI Kilns Stack: 40 m SPM: 150 mg/Nm^3 SO_2 and NO_x not measured Fugitive emissions not measured	The Kiln off gas is passed through GCT and then through ESP Bag filters installed in product House and other area for control of fugitive emissions WHRB and. AFBC are under installation	20 kl/h water for cooling. 10 kl/day water for domestic use Water supplied from Open cast mines/ADDA authority	Cooling water recycled through settling tanks Sanitary waste disposed through soak pits	Char: 110 TPD	Char,Dust sold
32	Savitri Sponge Iron Pvt Ltd Ranigunge (WB) Swami process	Recuperator Stack: 33.5 m SPM: 50 mg/Nm^3	ESP under commissioning for DRI Kiln Bag Filters in Product	5 kl/h water for cooling. 3 kl/day water for domestic use	Cooling water recycled through settling tanks Sanitary waste disposed through	Char 18 TPD	Dumped

Sl. No.	Name of Plant Visited and Other Details	Air Environment Status	Air Pollution Control System	Water Environment Status	Water Pollution Control System	Solid Waste Generation Status	Solid Waste Management
	1 x 50 TPD Installed capacity: 15000 TPA 1x 50 TPD proposed	SO_2 and NO_x not measured Fugitive emissions not measured	House, Cooler discharge area	Water supplied from Ground Water	soak pits		

Table - 5.2 : Stack Monitoring Data

Name of Plant	Maithan Steel & Power			Shyam Sel Palitpur		Jai Balaji			Jai Balaji		
Address	Boura Purulia			Dewandighi, BDN		Mangalpur			Mangalpur		
Date of Monitoring	4/16/2004			4/16/2004		5/13/2004			5/14/2004		
Capacity	1x100 tpd			3x50 tpd		3x50tpd			4x50tpd		
Stack connected to	Product house	Kiln	Cooler discharge	Kiln 2	Kiln 3	Cooler discharge BF	Coal crusher	Kiln 1,7	Kiln 3,4,5,6	Coal crusher BF 3,4,5,6	Cooler discharge kiln 3,4
Stack height (m)	30	30	15	30	30	15	15	30	31	15.2	12.19
Cross section Area (m2)	0.385	2.5457	0.2828	1.02	1.02	0.282	0.166	1.539	1.13	0.282	0.166
Dia (m)	0.70	1.80	0.60	1.14	1.14	0.60	0.46	1.40	1.20	0.60	0.46
Flue gas temp(°C)	76	130	56	55	62	75	80	170	80	65	70
Gas velocity (m/s)	8.85	4.14	7.22	3.62	3.3	5.8	4.5	6.7	5.6	4.8	5.1
Gas volume (Nm3/h)	10473.63	28055.71	6657.93	12076.85	10779.24	5042.16	2270.20	24970.57	19231.38	4296.28	2647.91
Percentage CO2	-	7	-	2.6	2	-	-	10.6	6.8	-	-
PM (mg/Nm3)	148	330.8	56.9	84	39	375	96	474	1490	1255	48
Pollution Control equipment	BF	ESP	BF	Pre Collection chamber, venturi scrubber, condenser	Pre Collection chamber, venturi scrubber, condenser	BF	BF	ESP	V Scrubber	BF	BF

Contd…

Name of Plant	Mark steel	Ma - Chandi	Vision Sponge	SPS Sponge

Address	Jagannathdihi,Murulia, Purulia			Kandil Avenue			Madhukunda			Durgapur		
Date of Monitoring	5/25/2004			5/26/2004			6/10/2004			6/17/2004		
Capacity				2x100tpd			1x100 tpd			1x100 tpd	2x 50 tpd	
Stack connected to	Product bag filter	Cooler discharge	Rotary kiln	Kiln 2	Cooler Discharge	Product house	Product house	Cooler discharge point	Kiln	Kiln 100 tpd	Kiln 2x50 tpd	Cooler discharge 2x50
Stack height (m)	21	12	30	28	12.19	22	31.5	20	34.5	30	30	17.5
Cross section Area (m2)	0.196	0.107	0.331	1.1668	0.164	0.2917	0.33	0.246	0.785	0.785	1.538	0.1808
Dia (m)	0.50	0.37	0.65	1.22	0.46	0.61	0.65	0.56	1.00	1.00	1.40	0.48
Flue gas temp(°C)	42	40	67	84	49	45	55	58	155	190	70	65
Gas velocity (m/s)	7.03	6.18	7.7	8.96	7.93	4.84	4.34	5.7	7.87	15.45	10.22	11.83
Gas volume (Nm3/h)	4692.67	2266.45	8041.90	31416.30	4332.91	4762.92	4684.34	4544.65	15485.29	28101.91	49162.26	6788.68
Percentage CO2	-	-	62	84	-	-	-	-	9.8	9	5.4	-
PM (mg/Nm3)	745	3292	170	520	753	385	1280	425	204	28	99.67	499
Pollution Control equipment	BF	BF	BF	Quenching Tower, Ventury scrubber, cyclone separator	BF	BF	BF	BF	Heat exchange & ESP	ESP	Venturi scrubber	BF

Contd…

Name of Plant	Haldia Steel Unit No.2		Rishab sponge Durgapur-Bankora			Maa Chinnamastika Madandi,				Ram rupai	
Address	Angadpur Industrial area		Main Rd Banjora			Bartoria,Nituria				Durgapur	
Date of Monitoring	6/17/2004		6/23/2004			6/29/2004				7/7/2004	
Capacity	2x 100 tpd		1x100 tpd			1x100 tpd				2x 100 tpd	
Stack connected to	Kiln	Cooler discharge	Kiln	Cooler discharge	Product	Cooler discharge	Coal crusher unit	Product House	Kiln 1	2x100 tpd kiln	Cooler discharge 2x100 tpd
Stack height (m)	40	23	30	15.24	22.86	19	19	30	45	35	16
Cross section Area (m2)	2.26	0.282	3.79	0.166	0.166	0.1962	0.1962	0.302	2.5434	2.54	0.283
Dia (m)	1.70	0.60	2.20	0.46	0.46	0.50	0.50	0.62	1.80	1.80	0.60
Flue gas temp(°C)	132	46	160	55	50	45	44	46	168	114	34
Gas velocity (m/s)	5.52	4.72	4.4	4.7	4.2	8.6	7.24	5.58	10.05	6.89	4.36
Gas volume (Nm3/h)	33045.42	4476.30	41316.43	2551.82	2315.65	5692.32	4807.25	5667.21	62181.46	48513.29	4311.75
Percentage CO2	6.8	-	14	-	-	-	-	-	-	6.2	-
PM (mg/Nm3)	125	18	19	548	15	960	1173	1845	47	916.3	352
Pollution Control equipment	ESP, GCT	BF	FD cooler, ESP	BF	BF	BF	BF	Bf	ESP	HBC, GBC, ESP	BF

Contd…

Name of Plant	Shyam SEC Power				Ritesh Tradefins			Vikash Metal			
Address	Mangalpur				Durgapur			Paradina Purulia			
Date of Monitoring	7/12/2004				7/21/2004			7/22/2004			
Capacity	3x100 tpd				2x50tpd						
Stack connected to	Product area	Cooler discharge area	Coal crusher	Kiln	Cooler discharge	Kiln 1	Product House	Cooler discharge	Product House	Kiln 1& 2	Crusher (coal)
Stack height (m)	15	15	15	40	17	27	22.5	12	22.5	50	20
Cross section Area (m2)	0.453	0.246	0.341	3.363	0.246	0.4776	0.33	0.28	0.44	2.54	0.33
Dia (m)	0.76	0.56	0.66	2.07	0.56	0.78	0.65	0.60	0.75	1.80	0.65
Flue gas temp(°C)	42	40	41	210	43	88	4.9	34	34	150	35
Gas velocity (m/s)	7.39	7.25	7.56	7.94	6.48	6.82	4.62	10.2	11.28	6.43	14.62
Gas volume (Nm3/h)	11401.21	6112.90	8807.76	59308.78	5411.80	9679.66	5885.54	9980.19	17343.72	41421.24	16804.65
Percentage CO2	-	-	-	6.2	-	5.6	-	-	-	14.7	-
PM (mg/Nm3)	11.8	1566	3203	279	438	70	292	1988	1309	717	2717
Pollution Control equipment	BF	BF	BF	ESP	BF	Ventury scrubber	BF	BF	BF	ESP	BF

Contd…

Name of Plant	Amiya Steel			Sri Ram Rupai Balaji Steel			Maheswari Ispat (P) Ltd. Beldanga, P.S. Kanska,		
Address	Tarapara,Mejia			Banskopa, Rajbhad			Kansa,Panagarh P.O. Chotaramchandrapur		
Date of Monitoring	7/26/2004	7/27/2004		8/11/2004			8/18/2004		
Capacity	1x 100 tpd			2x 100 ptd			1x100tpd		
Stack connected to	100 tpd kiln	Product House	Cooler discharge	Cooler discharge	Kiln 100 tpd x 2	Product noise	Cooler discharge area	Kiln	Product House
Stack height (m)	30	15	15	17	32	17	13	35.5	22
Cross section Area (m2)	2.459	0.321	0.229	0.2917	2.54	0.2205	0.1554	2.7597	0.2826
Dia (m)	1.77	0.64	0.54	0.61	1.80	0.53	0.44	1.87	0.60
Flue gas temp(°C)	175	50	55	57	205	55	45	164	39.1
Gas velocity (m/s)	6.4	9.5	12.1	5.9	12.72	9.76	7.02	6.68	7.31
Gas volume (Nm3/h)	37685.93	10128.49	9062.87	5594.91	72512.30	7038.88	3680.27	45255.95	7100.92
Percentage CO2	18	-	-	-	10.2	-	-	11.6	-
PM (mg/Nm3)	1067	110	16	7.5	57	2.9	26.8	29.9	51
Pollution Control equipment	ABC, GCT ESP	BF	BF	BF	ABC, GCT, ESP	BF	BF	ABC, GCT, ESP	BF

CHAPTER - 6

6.0 ENVIRONMENTAL STANDARDS

Draft

GAZETTE OF INDIA
EXTRAORDINARY
PART-II-SECTION 3-SUB-SECTION I
PUBLISHED BY AUTHORITY
NO.] NEW DELHI, ……………………………………………

MINISTRY OF ENVIRONMENT & FORESTS
NOTIFICATION
NEW DELHI, Date ………………….

G.S.R. (E) - In exercise of the powers conferred by Sections 6 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following Rules further to amend the Environment (Protection) Rules, 1986, namely :-

(1) These rules may be called the Environment (Protection) Second Amendment Rules, 2006.

(2) They shall come into force on the date of their publication in the Official Gazette or otherwise as mentioned.

2. In the Environment (Protection) Rules, 1986 in schedule I:-

After Serial No.98 and entries relating thereto, the following serial No. and entries shall be inserted, namely :-

SCHEDULE-I

Sl. No.	Industry	Parameters		Standards
99.	**SPONGE IRON PLANTS**	1.0 Emission Standards		
		1.1 Stack Emission Standards for Kiln (Particulate Matter)	:	100 mg/Nm^3 (Coal based)* 50 mg/Nm^3 (Gas based) *12% CO_2 correction if monitored CO_2 level is less than 12%.
		Carbon Mono oxide (CO) (v/v)	:	Not to exceed 1% (Max.), volume / volume

The Kiln off-gas stack height should be calculated for proper dispersion of SO_2 (with the formula of $H=14Q^{0.3}$. Where Q=emission of SO_2 in kg/h) as per emission regulations Part III of CPCB. Sulphur percentage shall be the percentage of sulphur in coal. Permissible SO_2 emission level with reference to stack height is given below:

S. No.	**Q(emission of SO_2 in kg/h)**	**H (m)**
1.	12.68	30
2.	33.08	40
3.	69.60	50
4.	127.80	60
5.	213.63	70

SO_2 level need to be maintained using adequate control technology as per the stack height provided by the industry.

Sampling Portholes and Platforms etc shall be provided as per CPCB regulation.

1.2 Stack Emission Standards for de-dusting units

Particulate matter (PM) : 100 mg/Nm^3

All de-dusting units should be connected to a stack having a minimum stack height of 30 m. In case installation of 30 m height of stack is technically or otherwise not feasible for specific case, the stack height can be reduced but accordingly stringent Particulate Matter emission level required to be achieved by the industry using Particulate Matter dispersion formulae/ model so that ground level concentration of Particulate Matter should not increase beyond the incremental level as it would have been with stack height of 30 m.

Sampling porthole and platform etc. shall be provided as per CPCB emission regulation to facilitate stack monitoring. De-dusting units can also be connected to ABC Chamber and finally emitted through common stack with kiln off-gas emissions, provided separate arrangements are made for monitoring of emissions.

1.3 Fugitive Emission Standards

The fugitive emissions of suspended particulate matter (SPM) should not exceed 2000 $\mu g/m^3$ at a distance of 10 m (approx.) from the areas / sources, identified and mentioned below in table 1, where fugitive dust emissions are anticipated. However, the existing industry is allowed up to 3000 $\mu g/m^3$ of fugitive emission level of suspended particulate matter (SPM) till one year from the date of issue of the notification.

Table 1

S. No	Area	Monitoring Location
1.	Raw material handling area	Wagon tippler, Screen area, Transfer Points, Stock Bin area
2.	Crusher area	Crushing plant, vibrating screen, transfer points
3.	Raw material feed area	Feeder area, Mixing area, transfer points
4.	Cooler discharge area	Over size discharge area, Transfer Points
5.	Product processing area	Intermediate stock bin area. Screening plant, Magnetic Separation unit, Transfer Points, Over size discharge area, Product separation area, Bagging area
6.	Other areas	Areas as specified by State Pollution Control Board

2.0 Effluent Discharge Standards

(i) All efforts should be made to reuse and re-circulate the water and to maintain zero effluent discharge.

(ii) Storm water / garland drain should be provided in the plant.

(iii) In case of maintenance/ cleaning of the system the settling tanks effluent of wet scrubbing system or re-circulation system if require to be discharged, should be treated suitably to conform to the following standards:

pH	:	Between 5.5 to 9.0
Total Suspended Solids (TSS)	:	≤ 100 mg/l
Chemical Oxygen Demand (COD)	:	≤ 250 mg/l
Oil and Grease (O&G)	:	≤ 10 mg/l

Note (i) For facilitating the compliance of the standards and pollution prevention at source the guidelines / code of practice issued by the Central Pollution Control Board may be followed. The guidelines / code of practice issued by Central Pollution Control Board are not mandatory.

(ii) The standards will be applicable with effect from the date of notification to all new, green field units set up after the date of this notification and all expansion/ modernisation of existing units taken up after the date of the notification. However, the existing units shall install effective pollution control system within six months and shall conform to the standards, after six months of the date of notification.

CHAPTER - 7

7.0 GUIDELINES / CODE OF PRACTICE FOR POLLUTION PREVENTION FOR SPONGE IRON PLANTS

7.1 Air Pollution

7.1.1 Stack Emission from Kiln

(i) Suitable Air Pollution Control System shall be installed to achieve the prescribed stack emission standards. The following air pollution control system/combination of system are most commonly used in such type of industry:

- Electrostatic Precipitator (ESP)
- Bag Filter
- Wet Scrubber
- Cyclone / Multiclone

(ii) All Pollution control equipment may be provided with separate electricity meter and totaliser for continuous recording of power consumption. The amperage of the ID fan may also be recorded continuously. Non-functioning of Pollution control equipment should be recorded in the same logbook along with reasons for not running the Pollution Control Equipment.

(iii) The safety cap/emergency stack of rotary kiln type plant, which is generally installed above the After Burner Chamber (ABC) of feed end column should not be used for discharging untreated emission, bypassing the air pollution control device.

(iv) In order to prevent bypassing of emissions through safety cap and non-operation of pollution control device, software controlled interlocking facility should be provided on the basis of real time data from the plant control system, to ensure stoppage of feed conveyor, so that, feed to the kiln would stop automatically, if safety cap of the rotary kiln is opened or Air Pollution Control System is not in operation. The system should be able to take care of multiple operating parameters and their inter relations to prevent any possibility of defeating the basic objective of the interlock. The system should be foolproof to prevent any kind of tempering. The software based interlocking system, proposed to be installed by industry should be get approved by the concerned State Pollution Control Board, for its adequacy, before installation by the industry.

(v) Mechanical operated system for timely collection and removal of the flue dust generated in air pollution control device shall be installed.

7.1.2 Stack Emission from de-dusting units

All de-dusting units should be connected to a stack having a minimum stack height of 30 m. However, in specific cases stack height can be reduced as specified in the notified standards. Sampling porthole and platform etc. shall be provided as per CPCB emission regulation to facilitate stack monitoring. De-dusting units can also be connected to ABC Chamber and finally emitted through common stack with kiln off-gas emissions.

7.1.3 Fugitive Emission

The measurement may be done, preferably on 8-hour basis with high volume sampler. However, depending upon the prevalent conditions at the site, the period of measurement can be reduced.

7.2 Effluent Discharge

(i) All efforts should be made to reuse and re-circulate the water and to maintain zero effluent discharge.

(ii) Storm water / garland drain should be provided in the plant.

7.3 Noise Control

The industry should take measures to control the Noise Pollution so that the noise level standards already notified for Industrial area are complied.

7.4 Solid Waste Management

Char

Char should be mixed with coal or coal washery rejects and used as fuel for generation of power. It is techno-economic viable option for plants having capacity 200 TPD and above. Also the smaller capacity individual Sponge Iron Plants (Capacity upto 100 TPD) and operating in cluster can collectively install common unit for power generation. The Sponge Iron Plant are free to explore other options / possibilities to use char for generation of power. Char can be sold to local entrepreneurs for making coal briquettes. It can also be mixed with coal fines, converted to briquettes and used in brick kilns. The industry can explore other reuse / recycling techniques for Char.

Under no circumstances char should be disposed off in agricultural fields/other areas. Logbook for daily record, of Char production and usage must be maintained by the industry and the record shall be made available to officials of CPCB/SPCB/PCC during inspection.

Kiln Accretions

The kiln accretions are heavy solid lumps and can be used as sub- base material for road construction or landfill, after ascertaining the composition for its suitability and ensuring that it should not have any adverse environmental impact. The industry can explore other reuse / recycling techniques for Kiln Accretions.

Gas Cleaning Plant (GCP)/Scrubber Sludge

The sludge should be compacted and suitably disposed off after ascertaining the composition for its suitability and ensuring that it should not have any adverse environmental impact. The industry can explore other reuse / recycling techniques for Gas Cleaning Plant (GCP)/Scrubber Sludge
.

Flue Dust

Flue dust is generated from air pollution control system installed with kiln. Secondary flue dust is also generated from air pollution control equipment installed with Raw Material Handling, Coal Crusher, Cooler Discharge and Product house unit. The reuse/ recycling of the flue dust generated / collected may be explored and suitably implemented.

Fly ash

Fly ash is generated from Char / Coal based Captive Power Plant, if any. Fly ash brick making plant may be install for fly ash utilization. Fly ash can be utilized in cement making by Cement industry also. The industry can explore other reuse / recycling techniques for Flue Dust / Fly ash.

Bottom Ash

Bottom ash is generated from Char / Coal based Captive Power Plant, if any. Bottom ash may have objectionable metallic compounds, therefore should be stored in properly designed landfills as per CPCB guidelines to prevent leaching to the sub-soil and underground aquifer.

General

(a) Solid waste management program should be prepared with thrust on reuse and recycling. Solid waste disposal site should be earmarked within the plant premises. The storage site of solid waste should be scientifically designed keeping in view that the storage of solid waste should not have any adverse impact on the air quality or water regime, in any way.

(b) The various types of solid wastes generated should be stored separately as per CPCB guidelines so that it should not adversely affect the air quality, becoming air borne by wind or water regime during rainy season by flowing along with the storm water.

7.5 Raw Material handling and Preparation

(a) Unloading of coal by trucks or wagons should be carried out with proper care avoiding dropping of the materials from height. It is advisable to moist the material by sprinkling water while unloading.

(b) Crushing and screening operation should be carried out in enclosed area. Centralized de- dusting facility (collection hood and suction arrangements followed by suitable de-dusting units such as bag filter or ESP or equally effective method or wet scrubber or any other de-dusting unit and finally discharge of emission through a stack) should be provided to control Fugitive Particulate Matter Emissions. The stack should confirm to the emission standards notified for de-dusting units. Water sprinkling arrangement should be provided at raw material heaps and on land around the crushing and screening units.

(c) Work area including the roads surrounding the plant shall be asphalted or concreted.

(d) Enclosure should be provided for belt conveyors and transfer points of belt conveyors.

The above enclosures shall be rigid and permanent (and not of flexible/ cloth type enclosures) and fitted with self- closing doors and close fitting entrances and exits, where conveyors pass through the enclosures. Flexible covers shall be installed at entry and exit of the conveyor to the enclosures, minimizing the gaps around the conveyors.

In the wet system, water sprays/ sprinklers shall be provided at the following strategic locations for dust suppression during raw material transfer:

- Belt conveyor discharge/ transfer point
- Crusher/screen discharge locations

7.6 Waste Heat Recovery Boiler (WHRB)

Sponge Iron Plants of capacity more than 100 TPD kilns may use Waste Heat Recovery Boiler (WHRB) for generation of power. Installation of Waste Heat Recovery Boiler (WHRB) may qualify the industry for CDM benefits.

7.7 Cooler Discharge and Product Separation Unit

Permanent and rigid enclosures shall be provided for belt conveyors and transfer points of belt conveyors. Dust extraction cum control system to arrest product loss in cooler discharge and product separation area may be installed.

7.8 Char based Power Plant

For plant having capacity of 200 TPD of cumulative kiln capacity, the power generation using char as a part of fuel, is a viable option. Power generation using char as a part of fuel may be implemented in a phased manner targeting for 100% utilization of char.

Individual Sponge Iron Plants of capacity upto 100 TPD and located in cluster can install a common char based power plant collectively.

7.9 New Sponge Iron Plants

(i) No New Sponge Iron Plant will be commissioned without installation of Pollution control systems to achieve the stipulated Standards. The concerned State Pollution Control Board will accord consent to operate only after physical verification of the adequacy of the installed pollution control systems for meeting the standards and stipulated conditions in the consent to establish.

(ii) All new kilns shall have independent stack with the kiln or multi-flue stacks in case two or more kilns are joining the same stack for better dispersion of pollutants.

(iii) Any entrepreneur having more than 2x100 TPD kiln may install WHRB for power generation, as it's a technically viable option, which also qualify the industry for CDM benefits.

For plants having capacity of 200 TPD or more, power generation using char as part of fuel in boiler is techno-economic viable option, therefore, new plants may install power generation unit at the time of installation of the industry.

7.10 General Guidelines

(a) Extensive plantation/Green belt shall be developed along the roads and boundary line of the industry. A minimum 15 m width Green Belt along the boundary shall be maintained. However, the green belt may be designed scientifically depending upon the requirement and local and mix species of plants may be selected for the green belt.

(b) Monitoring of stack emissions, fugitive emissions, trade effluent and noise level shall be done as per CPCB regulations. On line stack monitoring facilities shall be provided and operated continuously to ensure compliance to stack emission standards. Calibration of the system to be carried out by a third party accredited laboratory. List of the accredited laboratory may be obtained from CPCB/SPCB.

(c) Pollution control systems shall be operated as an integral part of production to ensure minimum emissions. Pollution Control System shall start before conveyor operation/operation of plant. Similarly pollution control system shall be stopped only after completion of conveyor operation/operation of plant so that possibility of dust settlement in ducts can be eliminated. Continuous evacuation of dust from air pollution control systems such as Dust catchers, ESPs, Bag filter hopper etc. shall be organized.

7.11 Siting Guideline for Sponge Iron Plants

Siting of new sponge iron plants shall be as per respective State Pollution Control Board guidelines. However the following aspects shall also be considered:

(a) Residential habitation (residential localities/ village) and ecologically and/or otherwise sensitive areas: A minimum distance of at least 1000 m (1.0 km) to be maintained.

(b) If any plant/clusters of plants are located within 1 km from any residential area/ village they may be shifted by State Pollution Control Board/ State Govt. in a phased manner for which a time bound action plan is to be prepared by SPCBs.

(c) The location of Sponge Iron Plant should be at least 500 m away from National Highway and State Highway.

(d) Radial distance between two Sponge Iron Plants should be 5 km for plants having capacity 1000 TPD or more.

(e) Sponge Iron Plants can be established in designated industrial areas / Estates as notified by State Govt.

ANNEXURE I

QUESTIONNAIRE FOR ENVIRONMENTAL STATUS OF SPONGE IRON PLANTS

Note 1 :	All information may please be given in the form . If needed separate report/ annexures /drawings should be attached.

I. General Information

A. Name of the Plant
B. Address
C. Name of contact person for any clarifications
D. Tel No
E. E mail Number
F. Fax Number :
G. Plant Capacity (t/y)
H. Whether Gas Based or Coal based:
I. Working hours of plant in a year :
J. No of DRI kiln
K. Type of Kiln
L. Location of Plant

Village	Tehsil	District	State

II. Environmental Setting

A. Please indicate area earmarked for each of the following (in ha.)

1. Plant Facilities
2. Char Disposal
3. Storage (Coal)
4. Storage (Iron Ore)
5. Storage (Dolomite/Lime stone)
6. Storage (Hazardous Waste)
7. Storage (Hazardous Chemicals)
8. Storage (water)
9. Approach Road(s)
10.. Green Belt
11. Others (Please specify)

Total

B. Proximity to Infrastructure:

	Rail	Road NH/SH	Nearby City/ Town	River bodies	Other Water bodies like Sea/creek/lake etc. (Please specify)
Distance of site boundary (in m)					
Distance of plant facilities (in m)					

III. Manufacturing Process details

A. Raw materials :

List of raw materials	**'Physical and chemical nature of raw material**	**'Quantity (tonnes / year) at full produc-tion capacity**	**Source of materials**	**Means of transportation (Source to storage site) with justification**	**Requirement of raw material per tonnes of production**
Coal Washed Coal Iron Ore Natural Gas Dolomite Lime stone Any Other					

B. Brief description of the process

C. Material Balance and Flow Sheet

D. Brief description of Pollution control facilities :

E. Details of process technology know how/collaboration

F. Production profile (tonnes/year)

Name of Products, Byproducts and Intermediate Products	Total
DRI t/y	
DRI Gas. Nm3/h or GCAL	

G. Composition of DRI gas :

H. Temperature

DRI Gas	Rotary Kiln	Rotary Cooler

I. Whether DRI gas is used in Power Generation

J. Power Generation in MW per Kiln

K. Composition of Char :

L. Means of transportation of raw material and final products

Means of Transport	**Raw material** (in TPA)	**Final Product** (in TPA)
1. Road		
2. Rail		

IV. Water

A. Water Requirement (cum/day)

Purpose	Avg. Demand	Peak Demand	Source	Type Treated / untreated/ Fresh/ Recycled	Remarks
1. Project (i) Process (ii) Cooling water (iii) Dust Suppression (iv) Drinking (v) Green Belt (vi) Fire Service (vii) Power Generation (vii) Others TOTAL					

B. Source of Raw Water Supply

S. No.	Source	Cu.m./	Cu.m./day

		hr	
1			

**

C. Waste Water Management

1. Description of waste water treatment plan with flow chart
2. Daily discharge (m^3/day) from different sources

(a)	DRI Plant operation	
(b)	Cooling water	
(c)	Dust Suppression	
(d)	Domestic	
(e)	Power Plant	
(f)	Any other (specify)	
	Total	

4. Quantity of water recycled

(a)	(in %)	
(b)	(in cum/day)	

5. Details of recycling mechanism

6. Point of final discharge :

Final Point	Quantity discharged (in m^3/day)
(i) Green belt within the plant/township	
(ii) Agricultural land/ Fallow Land/ Forest Land	
(iii) River/Stream/ Lake	
(vii) Estuary/ Sea	
Total	

V. Solid Waste Management

A. Details

S. No	Source	Qty (TPM)	Form (Sludge/Dry/ Slurry etc.)	Compositi on
.1	Raw water treatment plant			
2	ETP			
3	Process Dust			
4	In plant dust			
5	Char			
6	Kiln accretion and Other waste			
7	Refractory			
8	Others (Pl. Specify)			

B. If waste(s) contain any hazardous/toxic substance/radioactive materials or heavy metals, provide data and proposed precautionary measures.

C. What are the possibilities of recovery and recycling of wastes?

D. Possible users of Solid Waste (s).

E. Method of disposal of solid waste (s)

	Method	Qty(TPM)
1.	**Landfill**	
2.	**Power Generation**	
3.	**Recovery**	
4.	**Downstream users**	

F. In case of landfill

1. Is solid waste amenable for landfill **YES** ☐ **NO** ☐

2. Dimensions of landfill ☐ ☐ ☐

3. Life of landfill years
4. Proposed precautionary and mitigative measures along with design features

VI. Noise Pollution Control and Management

A. Source
B. Level at Source (dB)
C. Level at project boundary Capacity (dB)
D. Abatement measures (give source-wise details)

VII. Fuel/Energy Requirements

A. Total Power Requirement (MW)

B. Source of Power (MW)

	SEB/Grid	**Captive power plant**	**DG Sets**
Total			

C. Details of Fuel used

S. No.	Fuel	Daily Consumption (TPD)	**Calorific value (Kcals/kg)**	**% Ash**	**% Sulphur**
1	DRI Gas				
2	HSD				
3	Fuel Oil				
4	Coal				
5	Char				
6	Natural gas				
7	Other (Pl. specify)				

E. Mode of Transportation of fuel to site

1. Trucks (numbers/day)
2. Pipeline (length in km.)
3. Railway Wagons (numbers/day)

VIII. Atmospheric Emissions

A. Size distribution of SPM at the top of the stack (If available)

S. No.	Range	% by weight
1	Micron	
2	1-10 Micron	
3	10-20 Micron	
4	<20 Micron	

B. Stack emission Details (All the stacks attached to DRI dedusting units, Waste Heat Boilers, captive power plant, D.G. Sets activity).

ff

Plant section	Stack No.	Height from ground level (m)	Internal Diameter (Top) (m)	Flow rate Nm^3/h	Temp. of Exhaust Gases (°K)	Exit Velocity (m/sec)	Exhaust Gas		
							SPM (mg/ Nm^3)	SO_2 (mg/ Nm^3)	NO_X (mg/N m^3)
	1st								
	2nd								
	3rd								
	4th								
	5th								
	6th								
	7th								
	& so on								

Note: SPM: Suspended Particulate Matter

C. Details of fugitive emissions (Indicate the points of fugitive emissions and quantities estimated)

Frequency of monitoring:

Concentrations (in μg/m3)

Pollutant(s)	Stock bin		Charging area		Discharging area		Product area		Other area	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
SPM										
RPM										
SO_2										
NO_x										
CO										

IX. Storage of chemicals (inflammable/explosive/hazardous/toxic substances)

S. No	Name	Number of Storage's	Capacity (TPD)	Physical and Chemical Composition	Consumption (in TPD)	Maximum Quantity of storage at any point of time	Source of Supply	Means of transpo r-tation

X. Occupational Health and Industrial Hygiene.

A. What are the major occupational health and safety hazards anticipated. (Explain briefly).

B. What provisions have been made/propose to be made to conform to health/safety requirements. (Explain briefly).

C. Details of personal protective equipment provided/to be provided to the workers.

D. Details of measures for control of fugitive emission/odour nuisance from different sources.

E. Details of fire protection and safety measures envisaged to take care of fire and explosion hazards.

XI. Pollution Control Aspects

A. Details of Pollution Control Systems :

S. No		Name of Equipment	Capacity	Input Parameters to Pollution control equipment
i)	**Air** DRI Kiln Dedusting Waste Heat Boiler Stack Stock pile/Yard of raw material Other area if any			
ii)	Water			
Iii)	Noise			
iv)	Solid Waste			

XII. Management Aspects

A. Number of persons employed [ ]

1. DRI plant [ ]

2. Other Unit [ ]

B. Details of organizational set up/cell for environmental management and monitoring.

C Clearance letter of State Pollution control Board (Copy enclosed)

XIII. Expenditure on Environmental Measures

A. Capital cost of the project (Rs. Lakhs) [ ]

B. Cost of environmental protection measures (Rs. Lakhs)

S. No.		Recurring Cost per annum	Capital Cost
1	**Air Pollution Control**		
2	Water Pollution Control		
3	Noise Pollution Control		
4	Environment Monitoring and Management		
5	Occupational Health		
6	Green Belt		
7	Others (Pl. Specify)		
	Total		

Your Views:

What Norms you will like to implement for your plant

1. Stack Emission
2. Waste water discharge
3. Work Place Air quality norms

Do you feel that Power generation from DRI Gas should be a must?

1.
2.
3.

Do you feel that Power generation from Char should be a must?

1.
2.
3.
4.

What type of Air Pollution control equipment you will like to implement for your plant

1. DRI Kiln dedusting -----------
2. Waste Heat Boiler -----------
3. Stock Bin
4. Storage yard

What type of clean technology/future technology you will like to implement for your plant

1.
2.
3.
4.