

Environmental Control Measures in Sponge Iron Industry with Particular Reference to Tata Sponge Iron Limited

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ABSTRACT

Direct reduced iron or sponge iron technology was developed as an alternate route for steel making and is considered as a clean technology. The waste generation and gas emissions from this route of steel making are far less when compared to the conventional blast furnace route. The paper details the efforts of Tata Sponge Iron Limited to make the process a clean technology without affecting its surroundings and natural resources.

Key Words : Sponge iron, pollution control, equipment, gas cleaning.

INTRODUCTION

The Direct Reduction - Electric Arc Furnace (DR-EAF) combination provides an alternative route to Blast Furnace - Basic Oxygen Furnace (BF-BOF) route. The DR-EAF route is considered to be more ecofriendly technology than the other route. In fact, BF-BOF growth has faced set backs in developed countries due to stricter environmental regulation affecting coke and sinter production (Fig. 1 shows US coke production and consumption). This has opened up new areas for developing alternate technology with emphasis on cleanliness. BF-BOF technology has also had serious setback in terms of economic viability which is evident from the increase share of secondary steel making process (Fig. 2 shows the trend in India). However, the blast furnace is a very efficient ironmaking unit and it will remain the predominant method for the foreseeable future. Due to the need to tackle the environmental problems of sinter plants and coke ovens, the blast furnace will become more of a melting furnace in the future. The green house gas emissions for coal based DR-EAF and BF-BOF are shown in Fig. 3 (the figures assume use of 100% DRI in EAF; as usually this is not the case with some percentage of scrap being used, the emission levels will be lower than what is shown in the graph).

DIRECT REDUCTION TECHNOLOGY

The basic concept of direct reduction (DR) dates back to some 3000 years, but the first commercial plant became operational in 1952 in Sweden. (Fig. 4 shows growth of sponge iron in the world). In India, the pioneering work was done by NML, SIIL and TISCO. The first commercial-cum-demonstration plant was established using coal based technology during 1980's by Sponge Iron India Limited. In the year 1989, ESSAR steel made a beginning in production of sponge iron through gas based technology (Fig. 5 shows growth of DR industry in India).

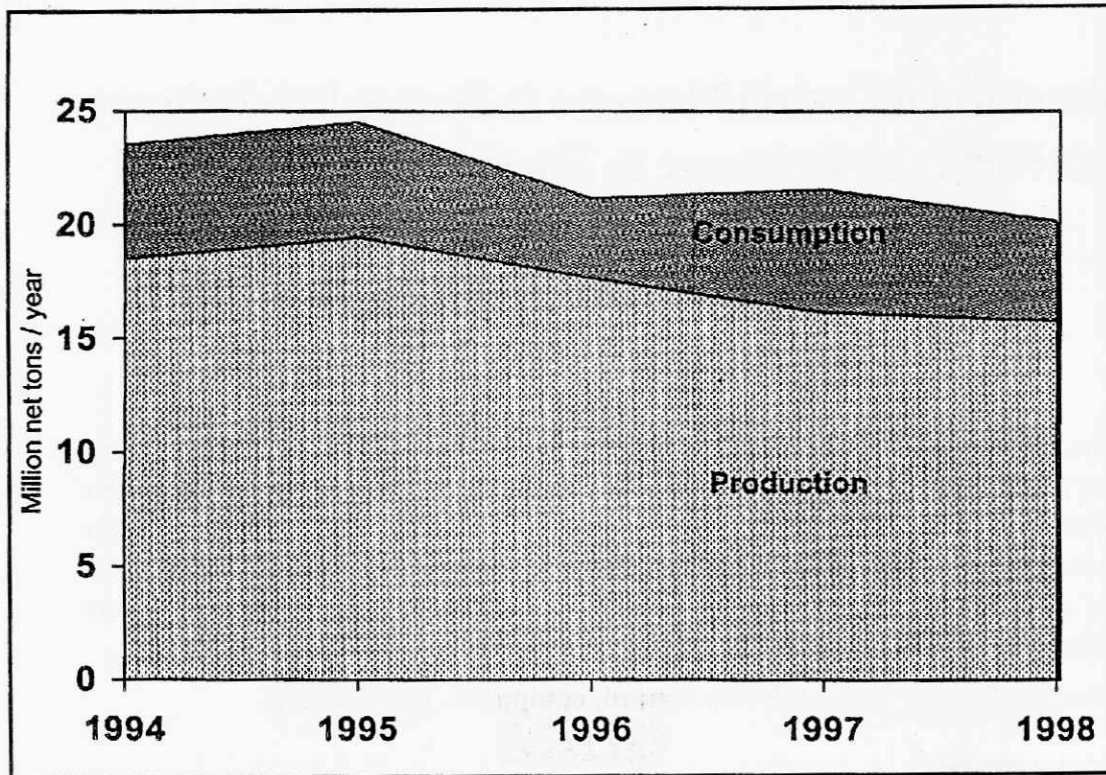


Fig. 1 : US coke production and consumption
(Source : AISI/DIRECT from MIDREX)

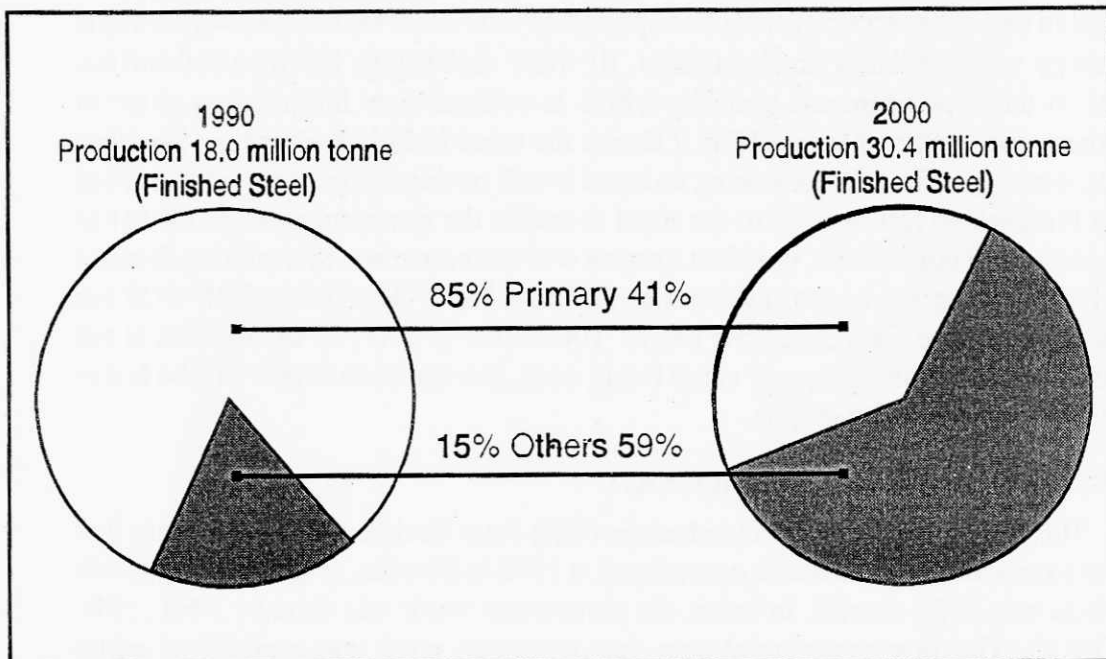


Fig. 2 : Domestic steel production - share of primary producers and others
(Source : The Hindu Business Line 12/8/2001)

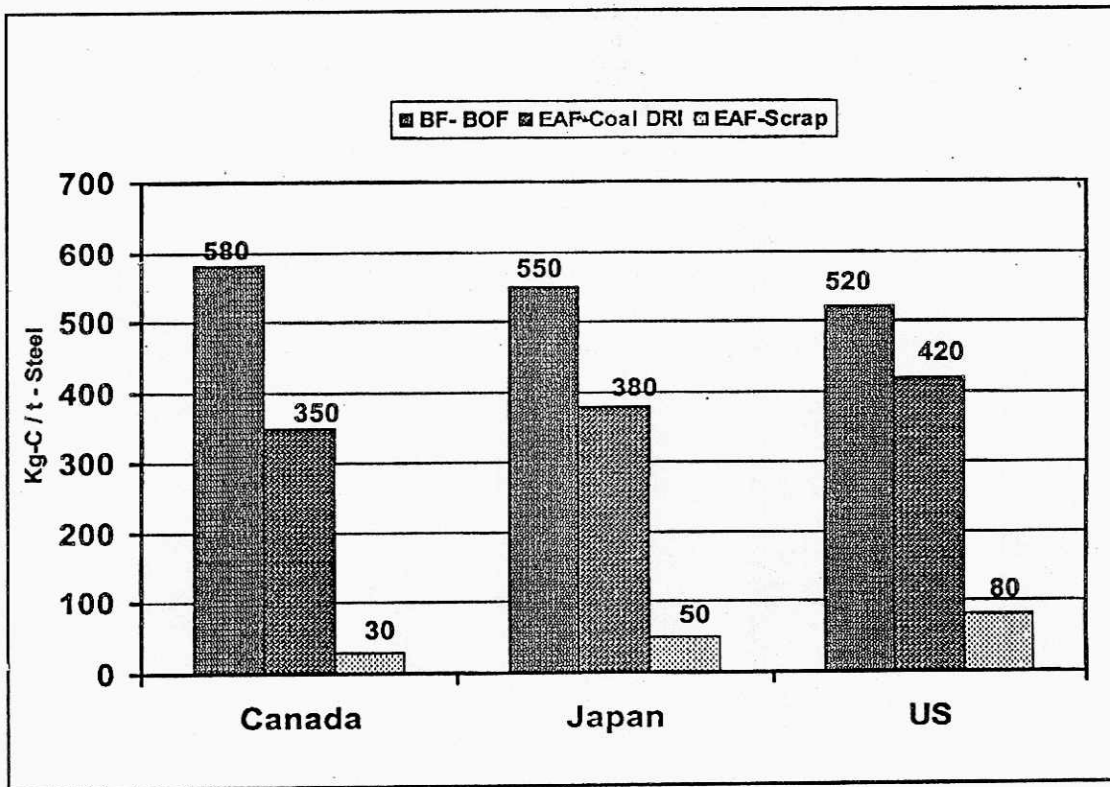


Fig. 3 : Greenhouse gas emission for selected iron making/steel making processes
(Source : AISI/DIRECT from MIDREX)

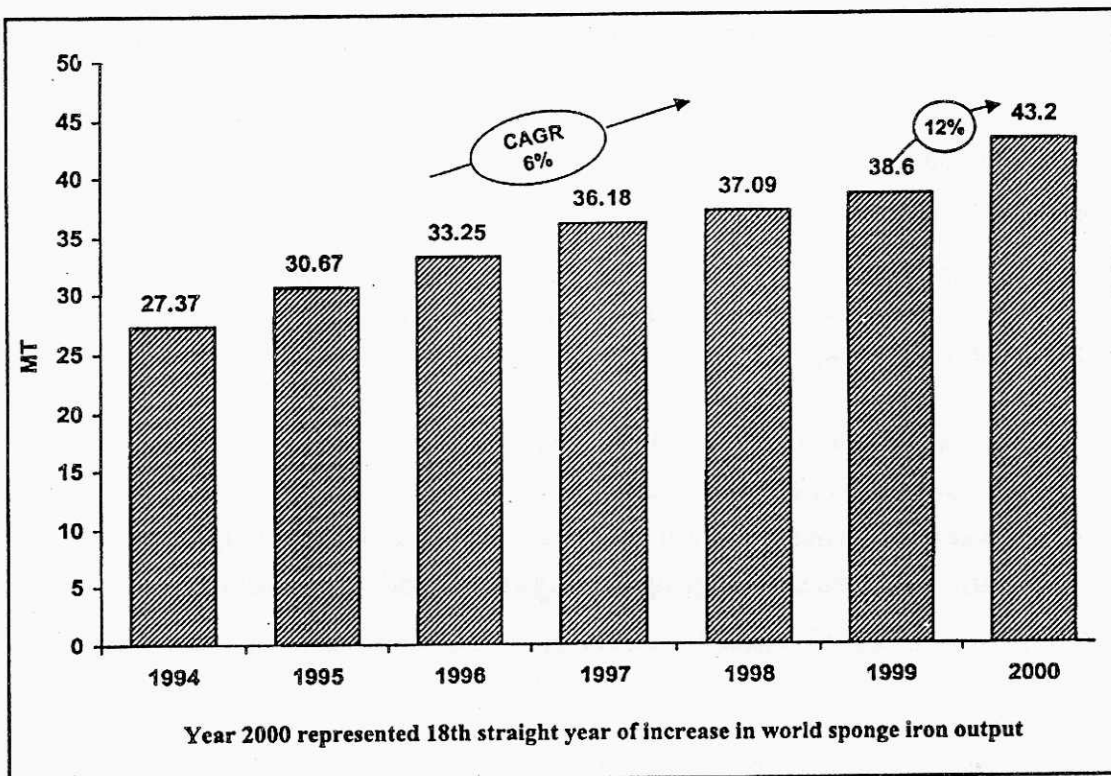


Fig. 4 : World sponge iron production (million tonnes)
(Data Source : MIDREX)

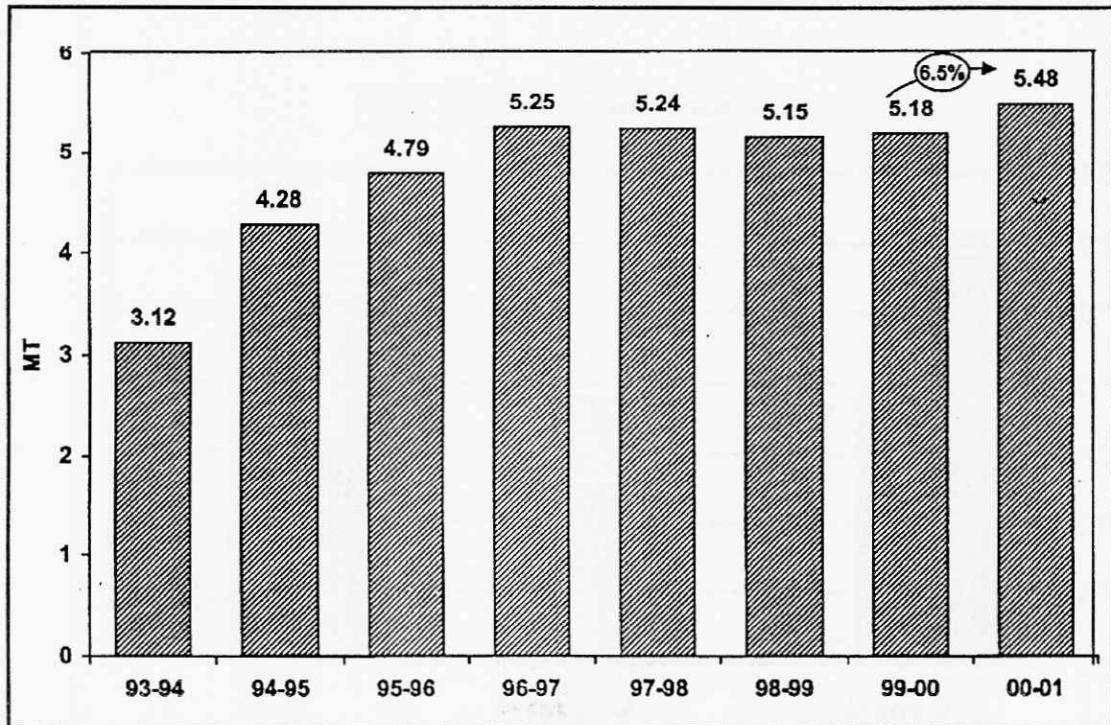


Fig. 5 : Sponge iron production in India (million tonnes)
(Data Source : SIMA)

Tata Sponge Iron Limited has the distinction of being one of the early players in sponge iron industry. As such it was the first commercial plant based on indigenous technology and was set up by Tata Iron and Steel Company way back in 1985. During those days even though environmental concerns were secondary, due consideration was given and investments were made in various pollution control equipments for making the technology environment friendly.

ENVIRONMENTAL ASPECTS IN COAL BASED DR INDUSTRY

The coal based DR industry utilises coal as a reductant and also to provide the necessary energy for the reduction process. Iron ore is converted into sponge iron in solid state condition, during the processing following are the generation of waste and dust :

- Waste gases containing minute dust particles.
- Non magnetics usually referred to as char.
- Dust generation during handling of raw materials and product in the circuits.
- Fugitive dust generated during loading and unloading operations.

The above mentioned wastes can easily be contained with proper commitment, planning, designing of the system and investment. It should also be noted that most of the above wastes could be utilised, thereby fulfilling the other side of environment that is conservation. The commitment should be from the management and refers to the moral responsibility to become an ideal corporate citizen by preserving the environment of the plant and the surroundings.

Development of Pollution Abatement Equipments for DR Industry

In the former years, the waste gases were normally dedusted in multiclones which were not performing satisfactorily. This was primarily due to unfavorable condition of soot formation (while using high volatile coals). There were no provisions for waste gas burning prior to the cyclones and this generated dust loads of about 20g/m³ (normal, wet). Later on Lurgi GmbH of Germany (Leader in coal based technology) embarked upon intensive research during 1968 in their laboratory and plants to find the most reliable and economic process considering the following important aspects:

- Strict adherence to environmental regulations of the state as per local and international standards
- Economical operation of the installation, that is reduction of investment and operation costs to a minimum.
- Ease of operation.

Considering the above aspects, various dust collecting methods depending on local conditions were designed. Conservation in terms of waste heat utilisation and of other wastes were also developed. At present, with the operational experience gathered at different locations and with different types of raw materials used (Coal, Ore and Dolomite), efficient systems are available indigenously to suit DR Plant requirements. In the following pages, development and experiences of various process are explained (Fig. 6 shows graphic representation of different process regarding efficiency and energy).

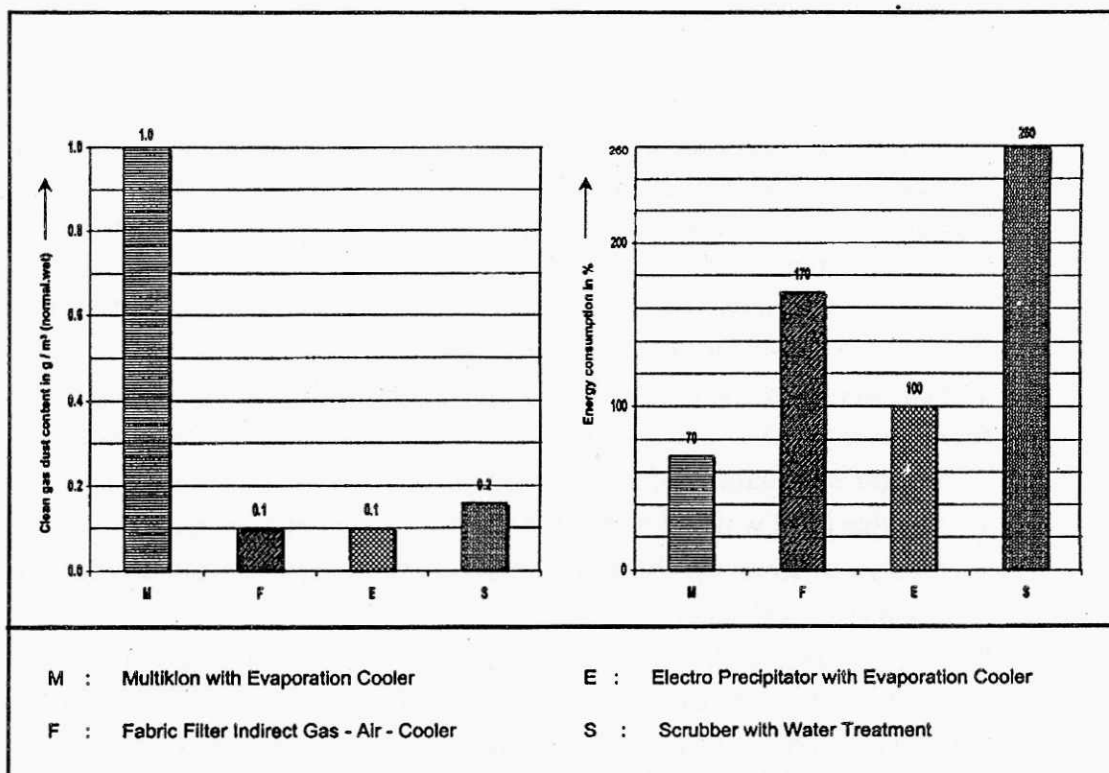


Fig. 6 : Pollution control systems for sponge iron industry

Multiclones

Due to poor collection efficiencies the process has become obsolete. The disadvantages were mainly due to formation of soot while using high volatile coals. The stack emission usually contained a dust load of 20 g/m³.

Bag filter

Bag filters are designed based on the local conditions for continuous operation. It can be installed for collecting dust from hot waste gases and also for dedusting of product and raw material handling circuits.

- a) Waste gas stream : Bag filters made of filter glass fabric are designed to withstand temperature of 250-300°C. While installing bag filters care should be taken to operate the preceding waste gas cooler reliably to avoid damages to filters due to high temperature. During interruption to the process, kiln is taken on hold whereby temperatures are lowered to safeguard the kiln. In such cases discharge of water droplets which stick to the filter cloth and decreases the efficiency of cleaning cannot be avoided. Even through this problem was overcome by providing an air cooler preceding the filter, the process was not successful due to high operating costs of regularly changing the filters bags and the stoppages required for it. The energy requirements for cooling air fan was also high.
- b) Dust collection during material transportation : In coal based sponge iron plants there is considerable dust generation during conveying of raw materials and product, as well as in certain region of kiln inlet and cooler outlet areas has to be included in the pollution control system plan.

The dedusting system is to protect the plant operating personnel against dust nuisance. The dust emitting equipment and conveyor systems are fitted with cowlings from which the dusty air is exhausted by way of suction nozzles. The collection of the suction air volumes arising at the various dust sources requires a complex duct system which, united by way of connection lines, leads into the deduster inlet. The dust laden air is cleaned in the deduster and then passed into the atmosphere through stack utilising a fan.

The calculation of the required suction volumes at the various suction points is based on experience and after consideration of the following parameters:

- Nature and quantity of the handled medium.
- Heights from which the handled medium is dropped in chutes.
- Design of cowlings for belt conveyors, screens, vibro-feeders and other plant equipment.

The duct system is dimensioned to guarantee a sufficient handling velocity of the dusty air in order to prevent deposits on the one hand and to ensure that a maximum speed is not exceeded in order to minimize pressure drop and wear on the other hand. The cost for energy and maintenance are thus reduced to a minimum.

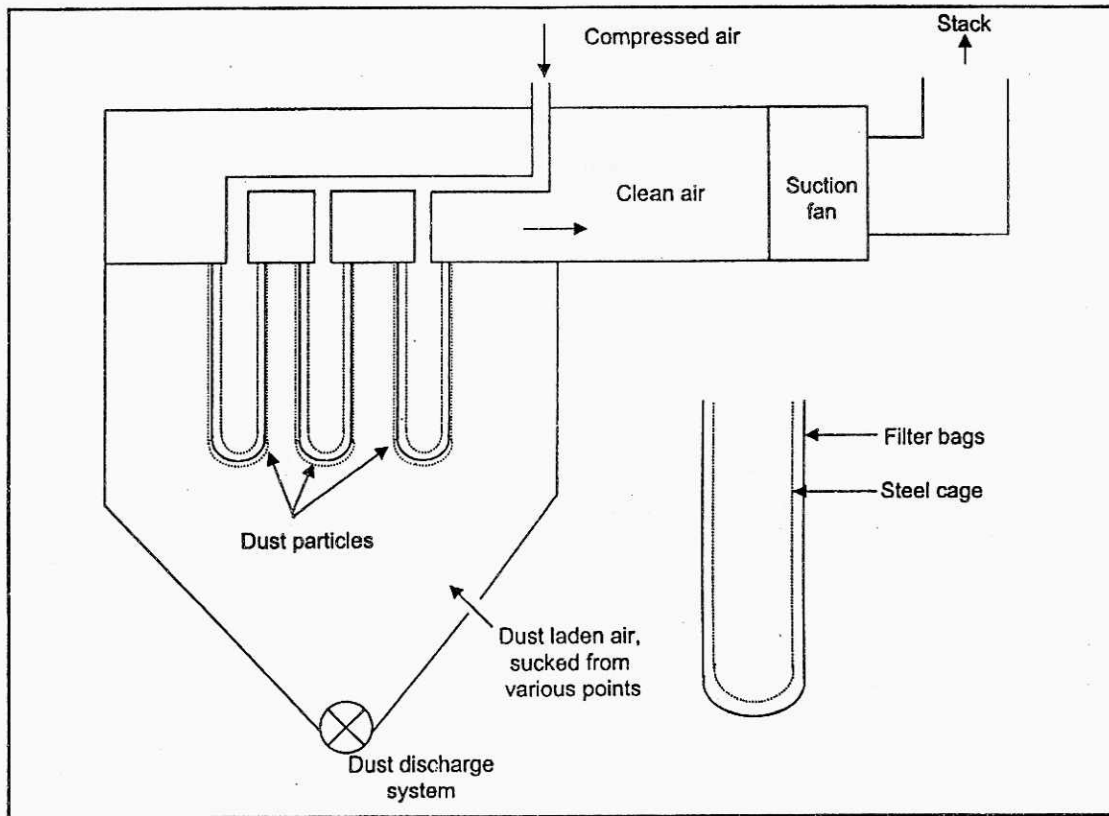


Fig. 7 : Pulse jet air cleaning system

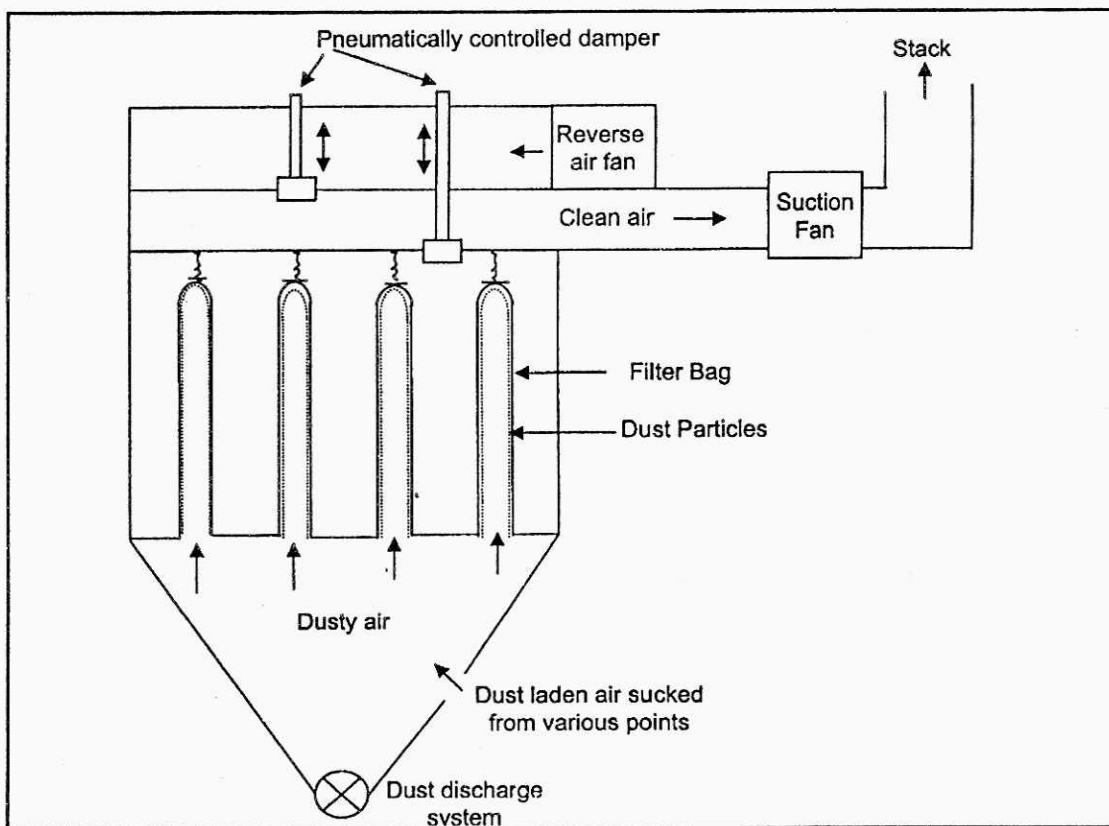


Fig. 8 : Reverse air cleaning system

In order to meet these requirements, each individual suction point is fitted with a damper device by which the various pressure drops are compensated in the piping strands of various lengths.

The bag filters that are available are of two types : a) Pulse jet air cleaning system (Fig. 7); and b) Reverse air flow cleaning system (Fig. 8).

- a) Pulse jet air cleaning system : The system works on "ON LINE" cleaning system. The dust-laden air enters the chamber and passes through the filter bags and the dust hence, sticks to the outer surface of the bag. Cleaning of filter bags is accomplished through a compressed pulse air system installed on top of each bag, which injects compressed air into the bags due to which the bags expand and the dust collapses. Cycle time of cleaning the bags can be controlled by installing a timing system on the compressed air line depending on the dust loads. However, this system does not work efficiently as the dislodged dust from the bags have a tendency to stick to the bags again due to continuous suction. For effective use of this system it will be required to stop the system thereby collapsing the dust for collection during which time there will be no dedusting in the plant. The stoppages can be planned during maintenance of the circuits or during any planned stoppages. Recent development in this field are based on number of modules, whereby each individual module can be isolated for cleaning without affecting plant dedusting system.
- b) Reverse air flow cleaning system : This is a better designed system with facility to take off individual module for cleaning from a cluster of modules. It has further advantages over the previous system as mentioned below
 - Does not require compressor and piping system.
 - Ease of operations, the filter bags are not inserted on to a wired cage.
 - Isolation of individual module for maintenance and cleaning without affecting plant dedusting.

The size of modules and bags are designed as per local conditions. Care should be taken while selecting the bag texture quality based on the dust particle size and the moisture content. The dust laden air enters into the module and passes through the bag, whereby the dust sticks to the inner surface of the bags. Periodically the individual module suction damper closes cutting off the suction and reverse air fan damper opens. During this period there is a positive pressure in the module which dislodges the dust from the bags. Each module is fitted with differential pressure gauges outside, which clearly indicate the condition of the bags inside and used for changing of bags and for maintenance.

The dust so dislodged (in both pulse and reverse air systems) is usually transported into a storage bin. A dust pugging system is fitted below the bin which conditions the dust with water for easy disposal.

After gaining experience in waste gas handling and dust handling there were further development in the conditioning of the gases as it exits from the kiln. Special consideration was given to the following facts :

- At the kiln outlet, the waste gas is after-burnt in a combustion chamber in order to avoid environmentally undesirable CO emissions and to prevent an ignitable gas mixture in the electro-static precipitator (ESP). By after-burning, the soot contained in the dust is burnt simultaneously and this contributes to the safety in design of the electrostatic precipitators with regard to their collection efficiency so that they become virtually independent of the coal used. The CO content of the waste gases with the above measures is always less than 1% thereby protecting the safety of the ESP
- After the combustion chamber, an evaporation cooler is built where finely dispersed water is injected. By this means the waste gas temperatures are reduced from 1000°C to 200°C. Care should be taken so that temperatures below 75°C are not reached which is the dew point temperature. Also the precipitated water together with the dust in the form of sludge can be removed from the bottom of the cooler using mechanical chain conveyors.

Scrubbers

Due to the development of after burning chamber, exit gases of the Kiln can be conditioned efficiently in the scrubbers (Fig. 9). In this system, the gases are first quenched by means of water and are forced to pass through a venturi. This leads to

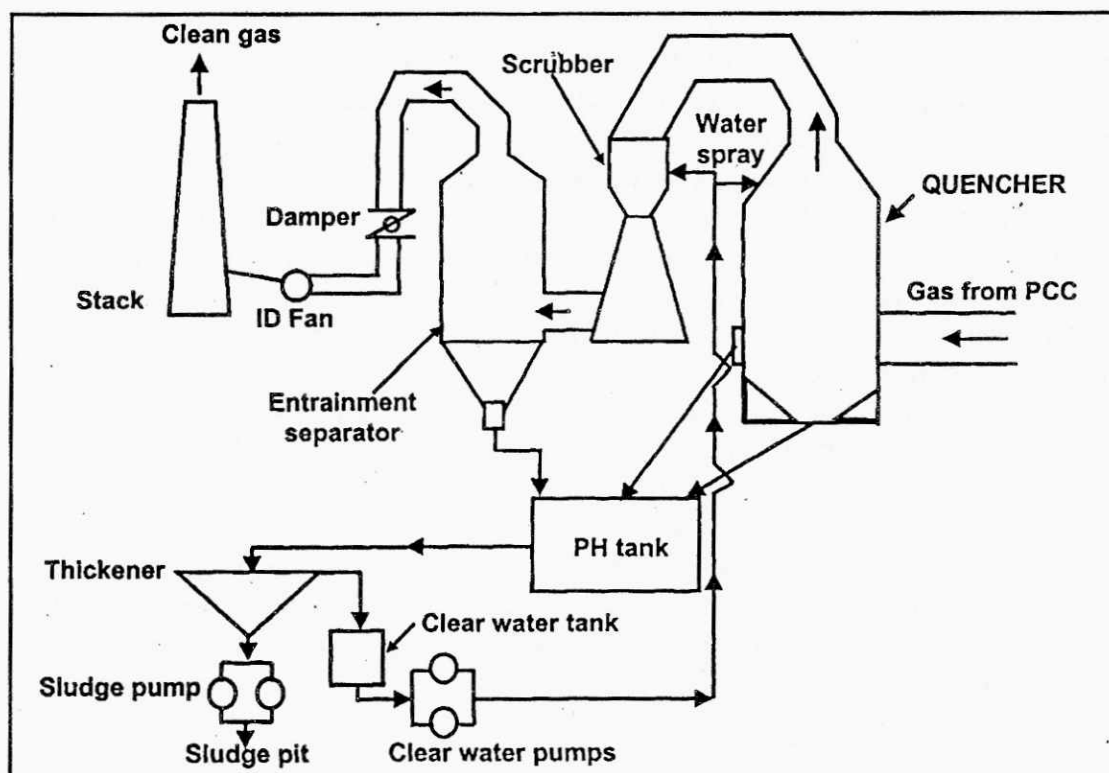


Fig. 9 : Layout for kiln waste gas cleaning through scrubber

intensive mixing of gases and water due to which dust particles get entrapped with water droplets. The water used in the unit now gets converted to slurry, which is taken to a thickener for separation. Clear water is recirculated and the sludge is disposed separately. Scrubbers have an advantage over other gas cleaning systems as they will also absorb the gaseous pollutants such as SO₂, HCl, etc. However the water used in the system becomes acidic and requires neutralisation. One disadvantage of the system is when fine grained limestone/dolomite is used as desulphuriser, gypsum deposits were seen built up on the walls of the system after prolonged use and needed to be cleaned.

Electrostatic precipitators (ESP)

As the awareness of environment and standards went up there was a requirement to further improve upon the existing systems and there was a look out for more efficient equipment. Electrostatic precipitators were working efficiently and were well established in cement industry. Sponge iron industry also started looking towards ESP (Fig. 10). Lurgi was again the leader in installing the ESPs in sponge iron kilns as they had better understanding of the process, composition and behavior of kiln waste gases. From their experience they knew that it is of great importance for the collection efficiency that both the CO content of the waste gas and the coal particles in the dust be burnt in the after burning unit. The after burning unit preceding the ESP has been designed with air input nozzles for burning above which water spray nozzles are positioned. Temperature sensing thermocouples are also placed in synchronization for better control of the temperatures for proper burning (Fig. 11). As per the gas composition, the numbers of air/water rings and levels are determined. Once the gases are purified it flows into a cooler. The gases are cooled from approximately 1000°C to approximately 200°C through finely atomized water injected into the hot gas stream. In order to prevent the temperature from dropping below the dew point and causing corrosion at the precipitator walls, adequate thermal insulation is done till the exit stack. The ESP primarily works on the principle that dust should be supplied with sufficient charge and to be collected by a strong electrostatic force. The ESPs normally have an inlet gas distribution system to have uniform gas flow. The gases pass through a number of collecting and discharge electrodes placed in parallel. The discharge electrodes are normally designed in the shapes of fish bone needles for stable discharge so that dust particles can be sufficiently charged. The discharge electrodes are on high voltage direct current, the gas molecules are ionized with the result that a negative corona discharge is created. The dust and mist particles suspended in the gas gets electrically charged by the absorption of negative gas ions. The charged dust or mist particles are attracted by the earthed collecting electrodes under the effects of the electrostatic field prevailing simultaneously between discharge and collecting electrodes. The collecting electrodes collect the dust and through a rapping mechanism the dust is dislodged and collected at the bottom. The charging of discharge electrodes and rapping frequencies are adjusted as per the local requirements considering the dust load and nature of dust.

Water spray on conveyors

Generation of dust while the raw materials and product are in transit in the belt conveyors and other modes is inevitable. Fogging nozzles and chemicals are available

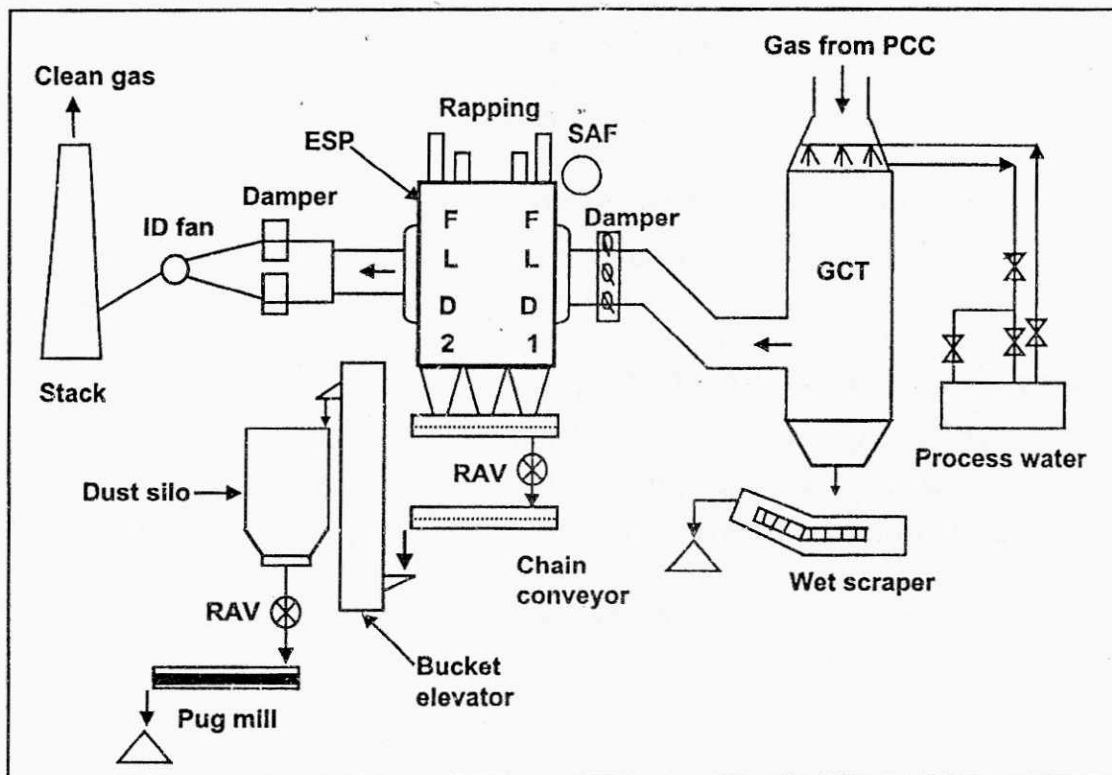


Fig. 10 : Layout of kiln waste gas cleaning through ESP

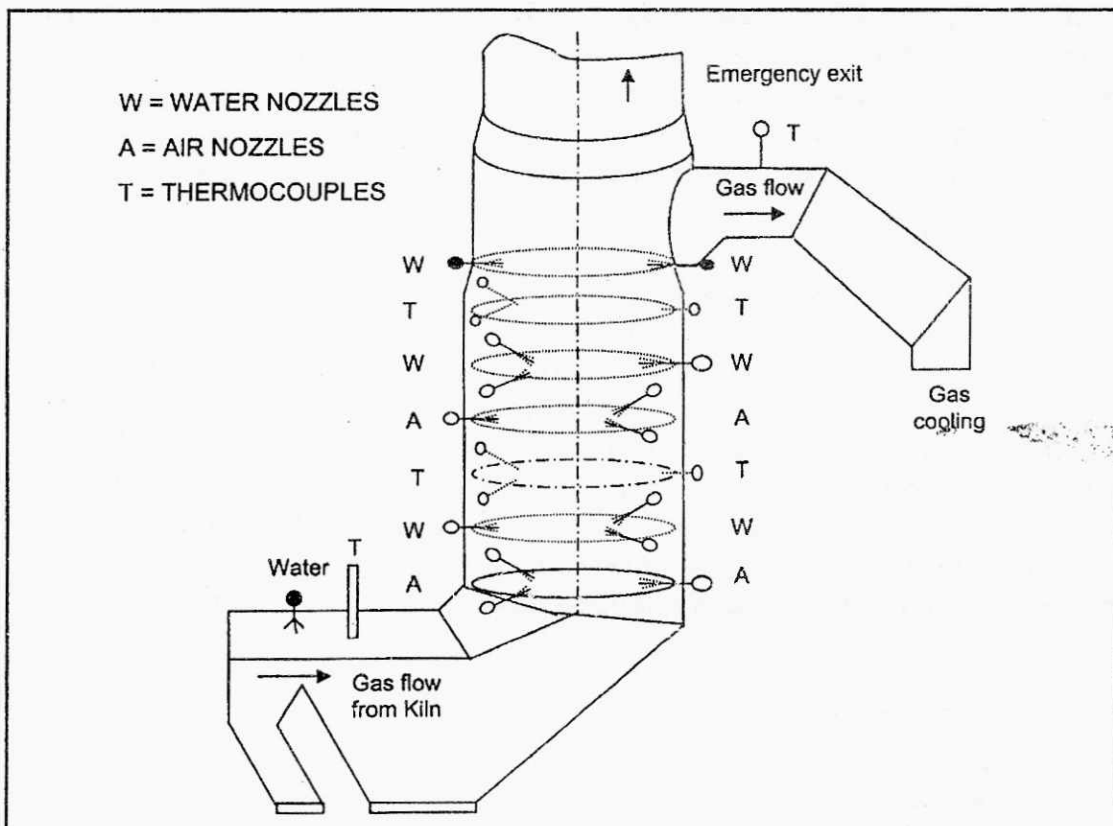


Fig. 11 : Conditioning of kiln exit gases

for effective control of fugitive dust. Nozzles are available specially designed for moving conveyors and sprinklers for stacks. The experience gained indicate very effective control of fugitive dust particularly in coal handling.

POLLUTION CONTROL AT TATA SPONGE IRON LIMITED

The following are the major pollution control equipment installed at TSIL since startup of plant operations. The investment made on these equipments were nearly 11% of the total plant investment, annually about Rs. 3.2 Crores is also spent on power exclusively on pollution equipments.

1. Gas cleaning plant - Wet system for kiln-1
2. Gas cleaning plant - Dry system for kiln-2 (ESP - Electro Static Precipitator)
3. Dust extraction system for product handling of both the kilns. (Bag filter system)
4. Dust suppression system for Iron Ore and Coal handling circuit (Chemical dosing system)

Gas Cleaning Plant I

For kiln-1 which was commissioned in 1986, a wet gas cleaning plant was installed. The unit comprises of a quencher to cool the gases from around 900°C to less than 80°C, a scrubber to remove fine dust particles, and entrainment separator to release only the steam going into atmosphere. Water used in the above system which has now become dust laden due to washing effect is sent to a thickener from where clear water is separated and recirculated. The thickener under flow which is a thick sludge is taken to a battery of setting ponds from where further recovery of water is done for use in the gas cleaning plant. Sludge, after drying is sent to waste dump yard.

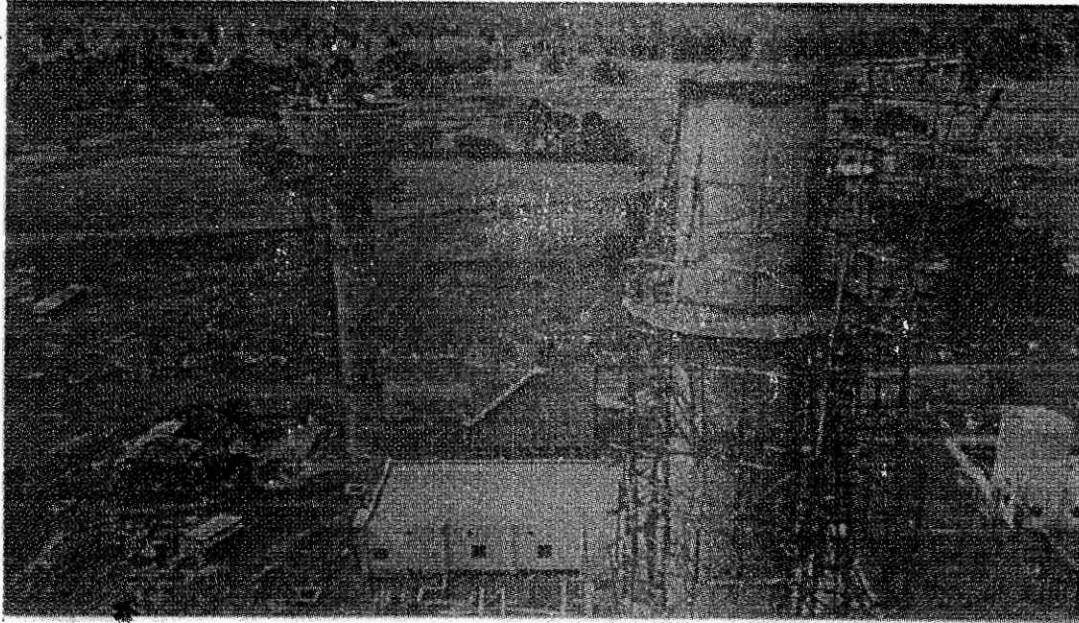
Gas Cleaning Plant II

For kiln-2, which was commissioned in 1998, less power intensive, new technology electrostatic precipitator (ESP) was chosen. It is the most modern pollution control equipment, extensively used now all over the world. Also a waste heat boiler recovery system has been installed to generate power utilising the heat from waste gases, thereby conserving the natural resources. Gases leaving the kiln at around 900°C enter a boiler first and then sent to ESP. Here by applying high intensity electric charge, dust particles are ionised and separated from gas stream. Separated dust particles come down due to gravity and transported to a silo by means of chain conveyors and bucket elevator. From the silo the dust is disposed off to waste dump yard after pugging with water.

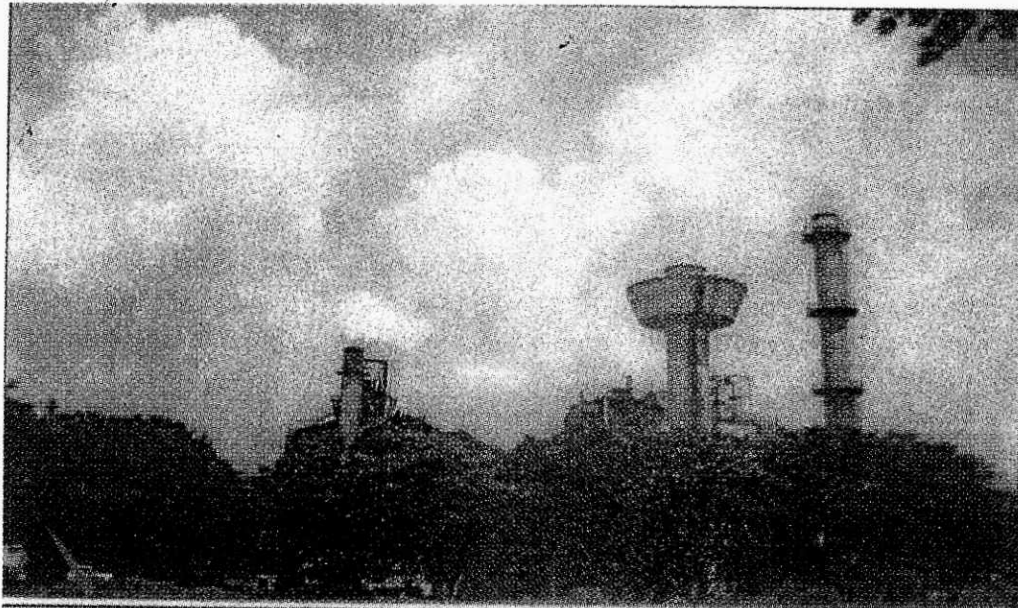
Dust Extraction System

The product leaving the cooler comprising of Sponge Iron and Char of size 0-20 mm generate dust at the transfer points due to fall of material from one point to another. To remove this fugitive dust, suction is applied through a bag filter by means of an induced draft fan. Dusty air while passing through bag filter gets cleaned and

entrapped dust is collected in a hopper which is subsequently conditioned with water in a pug mill before shifting to waste yard. In Plant I, three units of dedusting system have been provided catering to different parts of finished product circuit at three different locations. For kiln-2 centralised dedusting system has been provided so that dust is collected and handled at one point.



A panoramic view of the plant under construction, in 1985



Current view of the plant, completely covered by trees

Fig. 12 : Environmental improvement at Tata Sponge Iron Ltd.

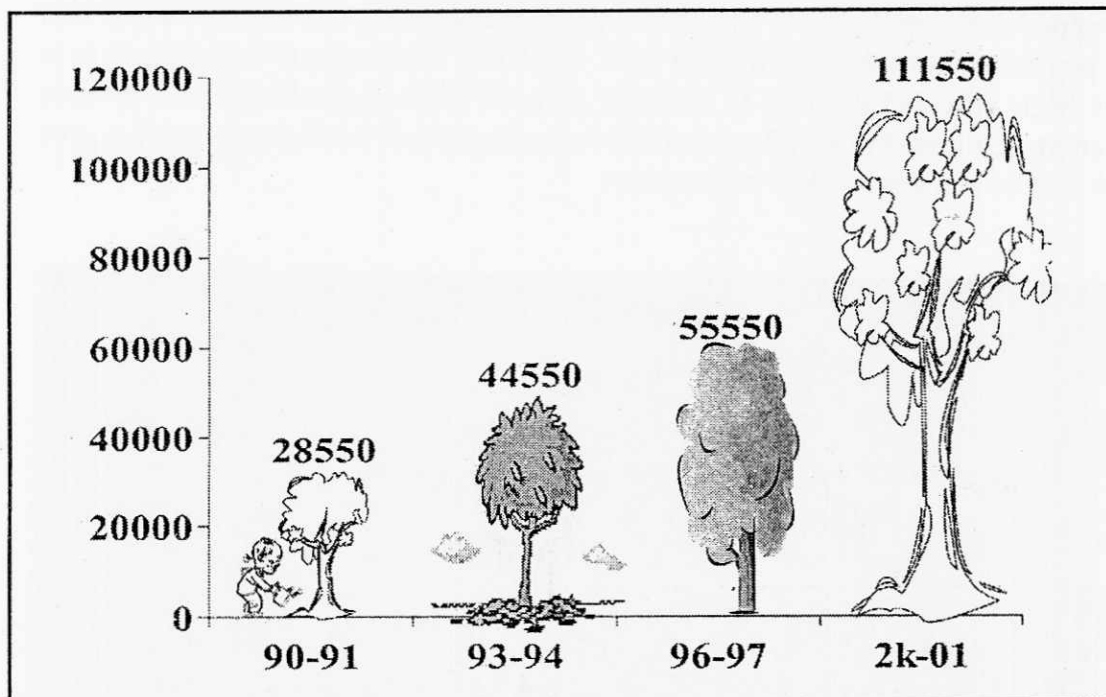


Fig. 13 : Trees population in Tata Sponge Iron Ltd. over the year

Dust Suppression System

In raw materials handling plant, a dust suppression system has been installed. In this system high pressure water spray with chemicals of the order of 0.5% is sprayed at transfer points due to which an adhesive water film settles on the material, thus preventing the dust to fly.

Additional Measures

All the plant drain water is routed to common pond from where clear water is recirculated for use in plant and dust deposited at bottom is shifted to waste yard. In this way no water is discharged to the river. To prevent dust due to plant vehicular movement, roads have been earmarked for material movement and these roads are kept damp by water spray using a dedicated tractor/tanker combination. In addition high pressure water spray systems have been installed at strategic points to control fugitive dust.

Tata Sponge Iron Limited has an environmental policy and also follows the TATA group environmental policy. There is an open dialogue with all the stakeholders in the region of its operation, a commitment and desire to spread environmental awareness among the region. Figs. 12-13 speak of our efforts in this aspect.

ACKNOWLEDGEMENT

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