CLEANER PRODUCTION OPPORTUNITIES

IN

STEEL & IRON SECTOR
Indian Scenario of Iron and Steel Manufacturing Industries:

The Indian integrated steel industry consists of nine major plants located mostly in the eastern areas rich in both iron ore deposits and coal. The location of the plants was conceived with the intention of having them close to raw material sources. In the days of supply driven market which was also hedged from external competition, the emphasis was mostly on production and not on cost cutting or energy efficiency. With the change in the business environment where market driven forces became stronger and in view of the integration of global environment concerns with the national concerns a marked shift towards incorporating energy efficiency and environment protection in the business activities has taken place. Initially focus was on production technology and it was only recently in this process that energy efficiency concerns were seeded into the thinking of the respective managements. The plants have a wide range of facilities and this reflects in the energy consumption of the individual plants as well.

- Steel industry was delicensed and decontrolled in 1991 & 1992 respectively.
- Today, India is the 4th largest crude steel producer of steel in the world.
- In 2011-12 (prov), production for sale of total finished steel (alloy + non alloy) was 73.42 mt.
- Production for sale of Pig Iron in 2011-12 (prov), was 5.78 mt.
- India is the largest producer of sponge iron in the world with the coal based route accounting for 76% of total sponge iron production in the country (20.37 mt in 2011-12; prov.):

General Description of Industry Activities

The main methods used in steel and iron production include the blast-furnace / basic oxygen furnace (integrated steelworks), direct melting of scrap or pig iron (electric arc furnace), and the less frequently used method of Direct Reduction of Iron (DRI) process. Integrated steel works are a complex process and involve material and energy flows among various production units, including the sinter or pelletization plant, the coke oven plant, the blast furnace (BF), the basic oxygen furnace (BOF), and continuous casting. The cast steel is then rolled (cold and / or hot) to produce final products.

Sinter Plants

Physical and metallurgical preparation of the ore burden is undertaken in order to improve permeability and reducibility. Prior to the sintering operation, raw materials are blended and some flux materials may also be added. After blending, the ore blend is transferred from the preparation bunkers to storage bunkers. Coke breeze (small-grade coke with particle sizes of < 5 mm) is the most commonly used fuel for the sintering process. The ore
blend and the coke breeze are mixed and dampened to enhance the formation of micro pellets, which improve the permeability when placed on the sinter bed.

The sinter plant essentially consists of a large traveling grate of heat resistant cast iron. The material to be sintered is layered to form a 400-600 mm deep bed, although shallower beds are common in older plants, which is placed on top of a thin layer of recycled sinter. This bottom layer protects the grate from the direct heat of the burning mixture. The grate passes through a canopy of gas burners that ignites the coke breeze in the mixture, starting a down-draft process through the entire length of the sinter bed. As the sinter mixture proceeds along the grate, the combustion front is drawn downwards through the mixture. This generates sufficient heat (1300-1480°C) to sinter the fine particles together into a porous clinker referred to as sinter. Exhausted gases are treated to remove dust before being emitted to atmosphere. The produced sinter is then crushed and riddled to obtain the proper dimension for the burden of the blast furnace.

**Pelletization Plant**

Pelletization is another process for the preparation of iron oxide raw materials for primary iron and steel making. Pellets are formed from the raw materials (fine ore and additives of < 0.05 mm) into 9-16 mm spheres, using high temperatures, typically at the mining site or its shipping port.

The pelletization process consists of grinding and drying or dewatering, balling and induration. Prior to the pelletization, the ore is crushed and ground to achieve the necessary properties to form pellets. The moisture content is adjusted to 8–9 percent. The pellet feed is mixed with additives and then processed into 9 – 16 mm (green) balls followed by heating to approximately 1250 °C (induration) during oxidation and sintering to obtain high strength pellets. Before exiting the induration process, pellets are cooled by air. Undersize or broken pellets are generally recycled.

**Coke Making**

Integrated steel mills that manufacture steel by reducing iron ore in a blast furnace need a steady supply of coke. The primary function of coke is to chemically reduce iron oxide to iron metal in the blast furnace. Coke acts as a fuel, provides physical support, and allows the free flow of gas through the furnace. Coke manufacture is therefore closely connected to integrated steel mills that use iron ore. Coke is produced by the pyrolysis (e.g. heating in the absence of air) of suitable grades of coal. In the coke-making process, bituminous coal is fed into a series of ovens (batteries), which are sealed and heated at high temperatures, in the absence of oxygen. The operation comprises the following steps: coal charging, heating / firing of the chambers, coking, coke pushing, and coke quenching.

The individual coke oven chambers are separated by heating walls. These consist of a certain number of heating flues with nozzles for fuel supply and with one or more air inlet boxes. Usually, cleaned coke oven gas is used as a fuel, but other gases such as (enriched)
blast furnace gas can also be used. Regenerators are located under the ovens, to allow heating of combustion air and fuel gas by flue gas, and improve energy efficiency.

The carbonization process starts immediately after coal charging. Volatile organic compounds (VOC) are eliminated from the coal, and forms a coke oven gas (COG). The solid carbon which remains in the oven is the coke. Depending on oven width and heating conditions the coking process lasts for approximately 14 to 24 hours. The coke is pushed out of the oven into a container by the ram of a pusher machine. The container transports the hot coke to a quenching tower, where it is cooled by dry quenching which consists of circulating an inert gas (nitrogen).

If wet quenching is used (typically in older units), treated (phenol-free) effluent water should be used. The process also includes the treatment of the by-product coke oven gas (COG) to remove tar, ammonia (usually recovered as ammonium sulfate), phenol, naphthalene, BTX, light oil, and sulfur, before the COG can be used as fuel for heating the ovens or used elsewhere in the plant.

To reduce environmental impacts from coke production, green push (coal that is not fully carbonized) should be avoided and coals with low sulfur content or desulfurized (washed) coals are preferred. Gases and tar in the coke process should be collected and recovered and sulfur dioxide (SO2) gas cleaning should be applied, especially if coals with high sulfur content are used.

**Blast Furnaces (BF)**

A blast furnace (BF) is an enclosed system into which the raw materials enter at the top, while the products (molten iron and slag) are tapped from the bottom (the hearth). The raw material mixture of iron bearing materials (iron ore rubble, sinter and / or pellets) and additives (slag former, such as limestone) is called the "burden". The burden and the coke are fed into the top of the furnace via a sealed charging system to prevent furnace gases from escaping. The solid burden moves downwards, countercurrent of a rising stream of hot reducing gas. The hot reducing gas is provided by hot stoves and is needed to transfer heat to the solid burden in order to raise the temperature for reaction. The BF gas with residual calorific value is collected from the top of the furnace for treatment and use.

The blast furnace is periodically tapped to remove the molten pig iron and slag from the hearth. For this purpose a tap-hole is opened in the side wall of the hearth. The tapped metal has a temperature of approximately 1440-1500 °C. In modern blast furnaces, pig iron and slag are tapped together (typically the slag starts to run after the hot metal). The slag and pig iron from the furnace flows along refractory or low cement covered runners and they are subsequently separated at the skimmer in the cast house, after which each continues in a separate runner.

Molten pig iron is poured into ladles or torpedo cars. Slag flows in runners to a granulation plant, to slag ladles, or to an open pit. At the end of the casting cycle, the tap-hole is closed by injecting a heat resistant tap hole clay mixture, using a so-called "mudgun".
The main emissions from the BF occur during tapping operations and primarily constitute iron oxide particulates and graphite. These particulates are usually controlled by local hooding within the cast house and emissions are directed to a fabric filter. Variable quantities of hydrogen sulfide and SO2 are emitted from slag cooling and treatment. Some fugitive emissions, including iron oxides and graphite flakes, occur during hot metal transport to the steel melt shop. Collected dust and sludge from the gas cleaning system may be recycled to a sinter plant or sent to a solid waste disposal site.

Wastewater effluents result from BF gas cleaning, slag cooling, and processing operations. Recirculation is used and the remaining stream is treated to remove solids, metals, and oil before discharge. Slag is the main solid by-product. It can be processed in a variety of ways, including granulating and pelletizing, or it can be quench cooled, crushed, and screened. The slag is sold as a by-product, primarily to the cement and construction industries.

**Basic Oxygen Furnaces (BOF)**

The Basic Oxygen Furnace (BOF) and the electric arc furnace (EAF) processes comprise the commonly used methods to convert pig iron produced by BF into steel. Oxygen injection oxidizes undesirable impurities contained in the metallic feedstock. The main elements converted into oxides are carbon, silicon, manganese, phosphorus, and sulfur. Oxidation reduces the carbon content to a specified level (from approximately 4 percent to less than 1 percent, but often lower), and removes impurities. The production of steel by the BOF process is a discontinuous process including pre-treatment of hot metal (desulfurization); oxidation in the BOF (decarburization and oxidation of impurities); secondary metallurgical treatment after the BOF in the ladle furnace, and casting (continuous and / or ingot).

The desulfurization process is performed at separate treatment stations before the BOF. The most common hot metal desulfurization method is based on calcium carbide, blown through a lance into the hot metal with the aid of nitrogen. The sulfur is bound in the slag, which floats to the top of the hot metal. The slag is then removed. In some cases, a second slag removal is performed, using slag scrapers. The pig iron is then charged into the BOF.

The operation of a basic oxygen furnace (BOF) is a batch operation. A complete cycle consists of the following phases: charging scrap and molten pig iron; oxygen blowing; sampling and temperature recording; and tapping. In a modern steelworks, approximately 300 tonnes of steel are produced in a 30-40 minute cycle. During the process several additives are used to adapt the steel quality and to form slag. The energy required to raise the temperature and melt the input materials is supplied by the exothermic oxidation reactions when oxygen is blown, so that no additional heat input is needed and scrap or ore have been added to balance heat.

The amount of oxygen consumed depends on the composition of the hot metal (e.g. mainly carbon, silica and phosphorous content). When the steel quality meets the demands, the oxygen blowing is stopped and the crude steel is tapped from the BOF into a ladle.
The oxidizing process in the BOF is usually followed by posttreatment comprising diverse metallurgical operations, and referred to as "secondary metallurgy". This post-treatment phase was developed in response to increasing quality requirements. The main objectives of secondary metallurgy include mixing and homogenizing; adjustment of chemical compositions; temperature adjustment; deoxidation; removal of undesirable gases (e.g. hydrogen and nitrogen); and improvement of the oxidic purity by separating non-metallic inclusions. These operations are performed in the ladle or ladle furnace, in a vacuum system, or in specially designed furnaces. After post-treatment, the molten steel is transported to the casting machine.

**Electric Arc Furnaces (EAF)**

Steel can be produced from scrap steel in an electric arc furnace (EAF) in which the scrap is melted. The scrap is usually pre-heated in a specific furnace and loaded together with lime or dolomite, which are used as a flux for the slag formation. It is normal to charge about 50-60 percent of the scrap initially. The electrodes are then lowered to the scrap. Within 20-30 mm above the scrap they strike an arc. After the first charge has been melted, the remainder of the scrap is added.

During the initial period of melting, the applied power is kept low to prevent damage to the furnace walls and roof from radiation, while allowing the electrodes to bore into the scrap. As soon as the arcs have become shielded by the surrounding scrap, the power is increased to complete melting. Oxygen lances and / or oxy-fuel burners are frequently used to assist in the early stages of melting. Oxygen may be added to the liquid steel by specific nozzles in the bottom or side wall of the EAF. Fuels include natural gas and oil.

The fugitive emissions from scrap charging, oxygen blowing, tapping, hot metal transfer, and slag handling are usually collected by local hoooding and de-dusted in fabric filters. Minor emissions of particulates arise from ladle metallurgy processes and vacuum degassing and they are usually collected and cleaned by fabric filters.

Some wastewater effluent may be generated by the degassing process. The main solid wastes include steel skulls, slag, and waste refractories. Other solid wastes include the wastewater treatment sludge and dust from dry dust collectors. Dust may contain dioxins and furans due to largely external (dirty) scrap consumption. The steel skulls are usually recycled, the slag is crushed and screened for recycle or sale, and other solid wastes are recycled, when appropriate, or disposed of in a landfill site. The EAF uses a large amount of electric power. The open-hearth furnace technology, also known as the Siemens-Martins process, is outdated and no longer considered good industry practice. It has a detrimental effect on steel quality and significant environmental impacts.

**Direct Reduction**

In the direct reduction process, lump iron oxide pellets and lump iron ore are reduced (oxygen is removed) to metallic iron in the solid state by a reducing gas. Process temperatures are less than 1000°C. A solid product, called direct reduced iron (DRI), is
produced. The process is advantageous from an environmental point of view, largely because it allows the use of pelletized or lump ore, however, this process has primarily been used for special steel grades or where natural gas is available at competitive prices.

**Casting, Rolling, and Finishing**

Further steel processing includes casting, hot rolling, forming, pickling, cold rolling, wire drawing, and coating. The continuous casting process bypasses several steps of the conventional ingot process by casting steel directly into slabs or billets and typically achieves 10–12 percent higher yield. Hot steel is transformed in size and shape through a series of hot rolling and forming steps to manufacture semi-finished and finished steel products.

The liquid steel after secondary metallurgy is transported to the so-called “tundish” of the continuous casting machine (CCM). This is an intermediate ladle with controllable outlet. The ladles are preheated prior to accepting a liquid steel charge in order to avoid temperature stratification in the tundish. When the liquid steel has reached the desired temperature, it is poured into the tundish. From the tundish it passes to a short water-cooled copper mold in which no air is present and which performs oscillating movements to prevent the steel from sticking. The mold gives the metal the desired shape. When the metal leaves the casting mold, a "skin" of solidified steel has formed and a large number of rolls guide the cast steel with a gentle curve toward a horizontal position. At this point, the endless casting is cut in pieces with a torch cutter. Slabs, blooms and billets are cast in this way.

In ingot casting, the liquid steel is cast into casting molds. After cooling, the ingots are taken out of the casting mold and transported to the rolling mills. Subsequently, following pre-heating, the ingots are rolled into slabs, blooms or billets. Ingot casting is currently largely replaced by continuous casting except for products which require ingot casting to achieve the necessary quality (e.g. producing heavy weights for forging). The hot rolling process consists of slab-heating (as well as billet and bloom), rolling, and forming operations. Several types of hot forming mills (primary, section, flat, pipe and tube, wire, rebar, and profile) manufacture diverse steel products. Long products are manufactured by hot rolling billets into reinforcement bars, or for further rolling and drawing into wire rods and sometimes coating. To prepare the steel for cold rolling or drawing, acid pickling (inorganic acid water solutions with sulfuric or hydrochloric acid) is performed to chemically remove oxides and scale from the surface of the steel. Other methods to remove scale include salt pickling and electrolytic pickling.

Cold rolling follows hot rolling operations, for the manufacture of a thin strip or a strip with a high-quality finish. Lubricants emulsified in water are used to achieve high surface quality and to prevent overheating. Water, oil, or lead baths are used for cooling and to create desired features.

Air emissions of PM and metals arise during the transfer of the molten steel to the mold and cutting the product to length by oxy-fuel torches. Air emissions from hot forming
include gases generated by the combustion of fuel in the heating furnaces and VOC from rolling and lubrication oils. Other important air emissions include acid aerosols from the acid-pickling operations and the acid regeneration plant, if acid regeneration is used. Wastewater effluents are generated when cooling the hot metal and include scale particles and oil generated from the high-pressure water descaling of the hot steel, as well as suspended solids, oil, and grease. The major sources of wastewater effluents are the acid-pickling rinse water, acid fume scrubber, acid regeneration plant scrubber, and alkaline cleaning. Solid waste is generated while cutting the steel, but this is generally recycled within the plant.

![Diagram of Integrated Steel Production Processes](source)

**Figure: Integrated Steel Production Processes**
Figure: Integrated Steel Finishing Processes
Environmental issues in Iron and Steel Manufacturing Industries:

A. Air emissions
B. Solid waste
C. Wastewater
D. Noise

A. Air Emissions

Air emissions are generating from captive power plants fueled with by-product gas (e.g. coke oven gas [COG], blast furnaces [BF] gas, and basic oxygen furnace [BOF] gas).

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<thead>
<tr>
<th>Air Emission</th>
<th>Source</th>
<th>Cleaner Production Techniques</th>
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</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>Particulate matter (PM) may be generated in each of the process steps, and may contain varying concentrations of mineral oxides, metals (e.g. arsenic, cadmium, mercury, lead, nickel, chromium, zinc, manganese), and metal oxides. Sources include melting and refining activities (BF, BOF, EAF) and heating furnaces (depending of type of fuels used); mechanical actions (e.g. scarfing and grinding); and handling of materials (e.g. raw materials, additive, recycled and waste materials, and by-products). Additional sources of particulate matter (PM) emissions include coal storage, conveying, charging, coking, pushing, and quenching. Particulate matter emissions may arise from thermal processes including coke making, sintering, pelletizing, and direct reduction. Coke oven plants are another significant source of dust</td>
<td>• Installation of collection hoods for coke oven batteries;</td>
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</table>
emissions. Continuous particulate matter emissions may result from the under-firing process through the combustion stack. Intermittent and fugitive emissions may arise from a large number of sources including oven and leveling doors, valves, and charging holes. Other emissions may arise from pushing, quenching and screening (discontinuous emissions) and from coke oven gas (COG) treatment.

**Sinter plants** may generate the most significant quantity of particulate matter emissions in integrated steel mills. Emissions in the sinter plant arise primarily from materials-handling operations, which result in airborne particulate matter, and from the combustion reaction on the strand.

**The pelletization** of iron ore (an alternative to sintering) may generate dust and particulate matter emissions from grinding of raw material; from the firing zone of the induration strand; and from screening and handling activities.

- Maintenance and cleaning of all fugitive emissions sources associated with the coke oven (e.g. oven chamber, oven doors, leveling doors, valves and charging holes, and frame seals ascension pipes) are essential for clean and safe operation;
- Good operational management to achieve steady state operation to, for example, avoid green push;
- Adoption of “smokeless” charging measures; • Adoption of coke dry quenching (CDQ) system;
- Adoption of non recovery-coke battery;
- Reduction of the coke charge in the blast furnace, including use of pulverized coal injection.

- Implement partial or total recirculation of waste gas in the sinter plant, according to sinter quality and productivity;
- Use of electrostatic precipitator (ESP) pulse systems, ESP plus fabric filter, or adoption of pre-deducting (ESP or cyclones) in addition to high pressure wet scrubbing system for waste gas dusting. The presence of fine dust, which consists mainly of alkali and lead chlorides, may limit the efficiency of ESPs.

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| Particulate matter emissions from the **basic oxygen furnace** (BOF) arise from hot metal pre-treatment (including hot metal transfer, desulphurization and deslagging processes); charging operations; oxygen blowing to reduce carbon level and oxidation of impurities; and tapping operations. | Melting Activities: Particulate matter emissions generated by the blast furnace (BF) plant include emissions from the cast house (primarily iron oxide particulates and graphite) and the cleaning of BF gas leaving the top of the furnace. Particulate matter emissions from **EAFs** chlorides, may limit the efficiency of ESPs. Measures to prevent and control particulate matter emissions from the blast furnace include use of dedusting systems, typically including scrubbers and electrostatic precipitators (ESP), before reuse of the off-gas. In direct reduction (direct reduction is an alternative route in primary steel production and may reduce overall emissions of dust and other pollutants significantly), dust releases are of similar character, though less than those of blast furnaces. Use of primary controls for the flue gas of the BOF, including venturi scrubbers with or without complete combustion techniques; Installation of secondary controls to capture off-gas escaping from the BOF process; Encapsulation of metal pouring lines with fitted extractors. Electric arc furnaces (EAFs) generate particulate matter during melting; oxygen injection and decarbonizing phases (primary off gas emissions); and charging / tapping (secondary off-gas emissions). Quick cooling of gas followed by bag filters. The bag filters can be primed with absorbents (e.g. lime or carbon) to further capture volatile impurities; Use of direct off-gas extraction and canopy hood enclosures and cleaning. |
In the casting area (ingots and continuous casting), particulate matter and metals arise from the transfer of molten steel to the mold and from the cutting to length of the product by oxy-fuel torches during continuous casting. Exhausts should be fitted to filters and other relevant abatement equipment, especially in the casting and rolling, and finishing shops, where relevant.

Baghouse filters and ESP have higher particulate collection efficiency, whereas wet scrubbers also allow capturing watersoluble compounds (e.g. sulfur dioxide [SO2] and chlorides). Bag filters are typically installed to control melting shop emissions. They are often preceded by cyclones, which are installed to act as spark separators.

**Mechanical Actions:** Scarfing and grinding activities may generate particulate matter emissions. Exhausts should be fitted to filters chosen based on the specified activity.

**Raw Material Handling:** To reduce fugitive emissions of particulate matter during handling of materials, the following prevention and control techniques are recommended:

- Use indoor or covered stockpiles or, when open-air stockpiles are unavoidable, use water spray system (not sea water, see ‘Chlorides’ section below), dust suppressants, windbreaks, and other stockpile management techniques;
- Design a simple, linear layout for material handling operations to reduce the need for multiple transfer points;
- Maximize use of enclosed silos to store bulk powder;
- Enclose conveyer transfer points with dust-controls;
- Clean return belts in the conveyor belt systems to remove loose dust;
- Implement routine plant maintenance and good housekeeping to keep small leaks and spills to a minimum;
- Implement correct loading and unloading practices.

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<td>Fugitive emissions</td>
<td>Fugitive emissions of coal dust are a significant concern. Fugitive coal dust emissions occur during coal transfer, storage, and preparation.</td>
<td>• Minimize the height of coal drop to the stockpile; • Use of water spray systems and polymer coatings to reduce the formation of fugitive dust from coal storage (e.g. on stockpiles); • Use of bag filter or other particulate control equipment for coal dust emissions from crushing / sizing activities; • Installation of centrifugal (cyclone) collectors followed by high efficiency venturi aqueous scrubbers on thermal dryers;</td>
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<tr>
<td><strong>Nitrogen Oxides</strong></td>
<td><strong>Sulfur Dioxides</strong></td>
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<td>Nitrogen oxides (NOX) emissions are caused by high furnace temperature and the oxidation of nitrogen. NOX emissions are associated with sinter operations; pelletization plant operations; fuel combustion for coke oven firing, including the combustion of recycled coke oven gas; cowper and hot stoves in the BF process; the use of process gases or high air combustion temperature in the re-heating and annealing furnace; and from mixed acid pickling, among other sources.</td>
<td>Sulfur dioxide (SO2) emissions are mainly associated with combustion of sulfur compounds in the sinter feed, primarily introduced through the coke breeze. SO2 emissions may also result during the induration process in pelletization, and from coke oven firing. The SO2 emission level in waste gases from reheating and annealing furnaces depends on the sulfur-content</td>
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- Installation of centrifugal (cyclone) collectors followed by fabric filtration for pneumatic coal cleaning equipment and activities;
- Use of enclosed conveyors combined with extraction and filtration equipment to prevent the emission of dust at conveyor transfer points;
- Rationalizing transport systems to minimize the generation and transport of dust on site.

- Application of waste gas recirculation;
- Use of oven batteries with multi-stage air supply systems;
- Adoption of suppressed combustion in BOF.

- Selection of raw feedstocks with low sulfur content;
- Minimizing the sulfur content of the fuel;
- Addition of absorbents such as hydrated lime [Ca(OH) 2 ], calcium oxide (CaO), or fly ashes with high CaO content injected into the exhaust gas outlet before filtration;
- Installation of gas wet scrubbing systems in dedicated collecting and dedusting system;
- Use of a wet-scrubber injection of a slurry mix containing calcium carbonate (CaCO 3 ), CaO, or Ca(OH)2
| **Carbon Monoxide** | Sources of carbon monoxide (CO) include waste gases from the sinter strand, coke oven, BOF, BF and EAF. CO is generated from the oxidation of coke in smelting and reduction processes, and from the oxidation of the graphite electrodes and the carbon from the metal bath during melting and refining phases in EAFs. | • Full capture of off-gases from coke oven, BF and BOF; • Recycling gases containing CO; • Use of foamy slag practices in EAF process. |
| **Chlorides and Fluorides** | Chlorides and fluorides are present in the ore and tend to form hydrofluoric acid (HF), hydrochloric acid (HCl), and alkali chlorides during the sintering and pelletization processes. HF and HCl may arise from off gas in the EAF process, depending on the quality of the scrap charged. Hydrogen chloride emissions arise from pickling lines (HCl type), and necessitate use of HCl recovery systems. | • Use of dry dedusting or wet scrubbing techniques, which are also typically installed to control particulate matter and sulfur oxide emissions respectively; • Control the input of chlorine via raw materials through the materials selection process; • Avoid spraying with sea water; • If it is necessary to exclude chlorine from the system, the chlorine-rich fine fraction of filter dust should not be recycled to the sinter feed (although it is generally favorable to recycle all iron-bearing process residues). |
| **VOCs and Organic HAPs** | Volatile organic compounds (VOC) and polynuclear aromatic hydrocarbons (PAH) may be emitted from various stages in steel manufacturing including from off gas in the sintering and pelletization processes due to oil entering the sinter or pelletization feed (mainly through the addition of mill scale); from coke ovens, quenching, and the by-product plant; and from the EAF, especially when coal is added as a ‘nest’ to the scrap basket. | • Pre-treat mill scales through such practices as pressure washing to reduce oil content; • Optimize operation practices, particularly combustion and temperature controls; • Minimize oil input via dust and mill scale through use of “good housekeeping” techniques in the rolling mill; • Use of advanced emission collection and demisting systems (e.g. precoated bag filters); • Recirculation of off-gas; • Treat the captured off-gas through post |
PAH also may be present in the EAF scrap input, but may also be formed during EAF operation. Hydrocarbons and misted oil emissions may also arise from the cold rolling mill (tandem mill) operations.

Dioxins and Furans

Sinter plants are a significant potential source of polychlorinated dibenzodioxin and dibenzofuran (dioxins and furans or PCDD/F) emissions. PCDD/F may be produced if chloride ions, chlorinated compounds, organic carbon, catalysts, oxygen, and certain temperature levels exist simultaneously in the metallurgical process. In addition, high oil content in mill scale may give rise to higher emissions of PCDD/F. Another potential PCDD/F emissions source is off-gas in the EAF. The potential presence of polychlorinated biphenyls (PCB), PVC, and other organics in the scrap input (shredded scrap mainly obtained from old equipment) may be a source of concern, due to its high potential for PCDD/F formation.

- Recirculation of waste gases may reduce pollutant emissions and reduces the amount of gas requiring end-of-pipe treatment;
- Fine feed material (e.g. dust) should be agglomerated;
- In sintering plants: minimizing chloride input in the bed; use of additions such as burnt lime; and control of mill scale oil content (<1 percent); Exclude the chlorine-rich fine fraction of filter dust from recycling in the sinter feed; Use of clean scrap for melting;
- Use of post combustion of the EAF off gas to achieve temperatures above 1200°C, and maximizing residence time at this temperature. The process is completed with a rapid quenching to minimize time in the dioxin reformation temperature range;
- Use of oxygen injection to ensure complete combustion; Injection of additive powders (e.g. activated carbons) into the gas stream to adsorb dioxins before the dust removal by filtration (with subsequent treatment as a hazardous waste);
- Installation of fabric filters with catalytic oxidation systems.

Metals

Heavy metals may be present in off gas fumes from thermal processes. The amount of metal emissions depends on the particular process type and on the composition of raw materials (iron ore and scrap).

- Gaseous metal emissions are typically controlled through the cooling of gases followed by bag filters. Metal particulate emissions should be controlled with high efficiency dust abatement techniques applied to particulate emissions control as
Particulates from the sinter plant, BF, BOF, and EAF may contain zinc (which has the highest emission factor in EAFs, particularly if galvanized steel scrap is used); cadmium; lead; nickel; mercury; manganese; and chromium.

**Greenhouse Gases (GHGs)**

Steel manufacturing facilities are energy intensive and may emit significant amounts of carbon dioxide (CO2). GHG emissions from integrated steel mills are mainly generated from the combustion of fossil fuels such as coal for energy (heat), ore reduction, electrical energy production, and the use of lime as feedstock. The average value of carbon dioxide intensity in the sector is estimated at 0.4 t C/t of crude steel.

- Minimize energy consumption and increase energy efficiency through primary measures, including but not limited to:
  - Adequate surface insulation to limit heat dispersion
  - Control of the air / fuel ratio to reduce gas flow
  - Implementation of heat recovery systems
  - Use of waste gas through a heat exchanger to recover gas thermal energy, and as a combustion gas to produce hot water and air, and / or steam and power
- Implement good practice for combustion, such as oxygen enrichment or preheating of blast air and automatic control of combustion parameters;
- Preheat clean scrap;
- Reduce fuel consumption in heating and thermal treatment by using recovery gas and / or adopting good combustion control;
- Select fuel with a lower ratio of carbon content to calorific value, such as natural gas (CH4). CO2 emissions from the combustion of CH4 account for approximately 60 percent of the emissions from coal or pet-coke;
- Recover energy wherever possible, utilize all process gases (e.g. coke gas, blast furnace gas, basic oxygen furnace gas), and install a top gas pressure recovery turbine (TRT) in the blast
furnace;
- Optimize intermediate storage logistics to allow for a maximum rate of hot charging, direct charging or direct rolling, thereby reducing reheating needs;
- Use near-net-shape casting and thin slab casting processes, where feasible.

### B. Solid Wastes and By-products

Most waste residue from the integrated iron and steel sector is recycled to obtain added value from various types of byproducts, slag, scales and dust. Waste materials may include slag from BF; fine dust and sludge from BF gas cleaning; fine dust from BOF gas cleaning; some BOF slag; high alkali chlorides and heavy metal chlorides from the last field of electrostatic precipitators; and treatment of the off-gas from sinter strands.

**Slag**

Slag residues may be sold as by-products (e.g. slag from BF or from BOF for use in civil engineering, road construction, and in the cement industry). EAFs produce a significant amount of slag. Where reuse of EAF slag is not financially or technically feasible, it should be disposed of, along with the dust from the treatment of off-gas, in a landfill designed with consideration of slag and dust characteristics. Local geological conditions also should be considered when locating slag heaps.

**Metallic Waste**

Metallic waste and by-products from rolling and finishing operations (e.g. scarfing scale / swarf, dusts from scarfing, rolling mill scale, water treatment and mill scale sludge, grinding sludge, and oil / greases) should be reused in the process.

Some by-products (e.g. oily mill scale and grinding sludges from water treatment plants), should be conditioned before internal recycling, such as reduction of oil content and depending on process requirements. Metals from filter dust, slag, and waste metals should be recovered and recycled to sinter feed.

**Acids**

Pickling acid regeneration sludge can be recycled in steel plants (EAF and blast furnace) or processed for the production of iron oxides. The iron oxide from hydrochloride acid regeneration can be used in several industries as a high quality input (e.g. production of
ferromagnetic materials, iron powder, or construction material, pigments, glass and ceramics)

**Sludge Treatment**

Sludge from wastewater treatment may contain heavy metals (e.g. chromium, lead, zinc, and nickel) and oil and grease. Part of the sludge from wastewater treatment may be internally recycled or else deposited in special landfills. Sludge reuse may require a pretreatment stage, which typically consists of pressing, drying, and granulation.

**Decommissioning Waste**

Decommissioning wastes in steel manufacturing facilities may include insulation materials containing asbestos, as well as contaminated soil and groundwater media from areas such as the coal storage stockpiles, the coke oven and coke oven gas treatment plant.

**C. Wastewater**

Effluent streams normally present in the sector include cooling water, stormwater, rinse water, and several different process effluent streams. Cooling water is normally recycled within the process. Rinse water may contain suspended solids, dust, lubricating oil, and other pollutants depending on the process.

Cleaner production measures to prevent effluent generation from cooling and rinsing water activities include the following:

- Prepare a plant wide water recycling plan to maximize efficiency of water use. More than 95 percent recycling of water is normally achievable;
- Dry techniques for removal of dust from plant equipment and premises should be used where possible, and rinse water should be collected and treated before discharge or reuse;
- Collect spillages and leakages (e.g. using safety pits and drainage systems).

**Industrial Process Wastewater**

Process effluent sources include the coke oven plant, the rolling process, and the pickling plant.

**Coke Oven Plant:** Effluent streams generated in the coke oven plant include water from the tar / water separator (consisting of water vapor formed during the coking process and condensate water used in coolers and for cleaning the COG); water from wet oxidative desulphurization system; and water from the closed cooling system.
Effluent from the tar / water separator contains high concentrations of ammonia. This effluent should be treated with an ammonia stripper, and the resulting stream contains various organic (such as phenols) and inorganic compounds (such as residual ammonia and cyanides). A phenol-specific biological treatment should be employed at the coke plant. Batch emissions to water can in some cases be generated by wet coke quenching operations. Excess quenching water should be collected and used for the next quenching operation.

Effluent from the wet oxidative desulfurization processes may contain suspended solids (including heavy metals), PAHs, sulfur compounds, and fluorides / chlorides, depending on the adopted dedusting systems. This effluent stream may have a detrimental effect on the biological wastewater treatment plant. Indirect gas cooling water is recirculated and will not influence the wastewater quantity. In the case of direct gas cooling, the cooling water should be considered as washing liquor and eventually drained via the still.

**Rolling Process:** Effluent from scale removal contains suspended solids and emulsified oil, in addition to coarse scale. Treatment of effluent includes a sedimentation basin in which solids, mainly iron oxides, are allowed to settle at the bottom of the basin and the oil pollutants on the surface are removed by means of skimmers and discharged to collecting basins. Cooling water from rolling processes should be collected and treated prior to reuse.

**Pickling plants:** Pickling plants generate three streams of process effluent, including rinse water, spent pickle baths, and other wastewaters (e.g. water from fume absorbers of the pickling tank exhaust system and flushing water from plant cleaning). The largest volume of waste water derives from rinsing, whereas the most significant contamination load comes from the continuous or batch exchange of pickle baths.

Cleaner production techniques to prevent effluent from pickling plants include the following:

- Install acid recovery and recycling unit;
- Reduce effluent volume and minimize contaminant loading of the waste streams through optimization of the pickling process;
- Apply counterflow cascading and, in some cases, recycling of acid-pickling rinse water discharges to the acid regeneration plant.

**Process Wastewater Treatment**

Techniques for treating industrial process wastewater in this sector include source segregation and pretreatment of wastewater streams for (i) reduction in ammonia using air stripping, (ii) reduction in toxic organics, such as phenols using biological treatment and (iii) reduction in heavy metals using chemical precipitation, coagulation and flocculation, etc. Typical wastewater treatment steps include oil water separators or dissolved air floatation for separation of oils and floatable solids; filtration for separation of filterable solids; flow and load equalization; sedimentation for suspended solids reduction.
using clarifiers; dewatering and disposal of residuals in designated hazardous waste landfills. Additional engineering controls may be required for (i) advanced metals removal using membrane filtration or other physical/chemical treatment technologies, (ii) removal of recalcitrant organics using activated carbon or advanced chemical oxidation, and (iv) reduction in effluent toxicity using appropriate technology (such as reverse osmosis, ion exchange, activated carbon, etc.). Wastewater treatment methods typically include coagulation / flocculation / precipitation using lime or sodium hydroxide; pH correction / neutralization; sedimentation / filtration / flotation and oil separation; and activated carbons.

Through use of these technologies and good practice techniques for wastewater management, facilities should meet the Guideline Values for wastewater discharge.

**Other Wastewater Streams & Water Consumption**

Contaminated streams should be routed to the treatment system for industrial process wastewater. Contaminated stormwater may result from coal, coke and other material storage areas.

Soil surrounding outdoor coal storage areas may be impacted by highly acidic leachate containing polycyclic aromatic hydrocarbons (PAHs) and heavy metals. Industry-specific recommendations include:

- Store scrap and other materials, (e.g. coke and coal) under cover and / or in bunded area to limit contamination of stormwater and collect drainage;
- Pave process areas, segregate contaminated and noncontaminated stormwater, and implement spill control plans. Route stormwater from process areas into the wastewater treatment unit;
- Design leachate collection system and location of coal storage facilities to prevent impacts to soil and water resources. Coal stockpile areas should be paved to segregate potentially contaminated stormwater for pretreatment and treatment in the wastewater treatment unit.

**D. Noise:**

Integrated steel manufacturing facilities generate noise from various sources including scrap and product handling; waste or by-product gas fans; process cooling and draft fans; rotating equipment in general; dedusting systems; furnace charging; EAF melting processes; fuel burners; cutting activities; wire rod pay-off units; and transport and ventilation systems. General Cleaner Production techniques to reduce, prevent, and control noise include the following:

- Enclose the process buildings and / or insulate structures; • Cover and enclose scrap and plate / slab storage and handling areas;
- Enclose fans, insulate ventilation pipes, and use dampers;
• Adopt foaming slag practice in EAFs; • Limitation of scrap handling and transport during nighttime, where required.

Reference:
http://www.ifc.org/wps/wcm/connect/Topics_Ex Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Environmental,+Health,+and+Safety+Guidelines/