Pollution and control in steel industry

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Steel industry is complex and highly pollution intensive. Way ahead, the sector is growing rapidly, so at every stage of steel making, better efficiency and pollution control is inevitable.

Indian steel sector is a strong element of the Indian economy. Since its commercial beginning, the industry has come a long way to reach a production of above 70 Mt steel today. The sector has seen a phenomenal growth after economic liberalisation in 1991. It is growing at an annual rate of 8% since then. At this rate, the sector is expected to produce nearly 325Mt of steel by 2030 (Green Rating Project, 2012, CSE). The conventional blast furnace-basic oxygen furnace (BF-BOF) route of steel making which is relatively efficient, currently accounts for 49% of the total steel production of the country and is growing at an annual 5.5% rate since last three decades. Relatively inefficient and highly polluting sponge iron-electric arc or induction furnace (DRI-EAF/EIF) route which accounts for the remaining steel production, is growing at 11 percent per year.

Indian steel sector is one of highest energy consuming and carbon dioxide (CO₂)emitting industry designated as one of the 17 highly polluting industries in India. It is highly raw material intensive which requires 3.5 - 5.0 tonnes of raw materials to produce only one tonne of crude steel. The balance amount of material (2.5 - 4.0 tonnes) from the process either comes out as by-products, wastes or emissions in air and water.

The entire steel making process integrates iron making, steel making and downstream processes. Iron ore and coal are main raw materials besides limestone and dolomites which are required in small amount as flux. Iron ore is agglomerated in sintering and pelletisation plant. Coal is an energy source and reducing agent. It is either used directly for making sponge iron (also called DRI) or converted into coke for iron making in blast furnace. Produced iron is refined further into steel in basic oxygen furnace or electric arc or induction furnace. An integrated steel industry may either adopt a particular route or a mixture of the routes for steel making. Accordingly, pollution potential can also vary at every stage starting from raw material handling & processing to iron making and steel making.

Pollution & control during raw material handling and processing

Millions of tonnes of raw materials are handled in an integrated steel plant. Therefore, whether it is unloading, crushing, storage, blending, screening, transfer or processing, if proper methods and control measures are missing, pollution and material loss is unavoidable.

Control of fugitive dust emissions from handling millions of tonnes of dry and powderized raw materials is a challenge for Indian steel industry. But there are solutions which have been adopted by many steel plants globally. These include dust suppression by water sprinkling, dry fog system, vacuum system with bag filter, frequent spillage cleaning etc. Systematic and covered storage, impermeable storage surface area with proper runoff control helps to minimise dust emissions and leaching problems. Covered conveyors and dust control systems at transfer points for raw material transfer reduces pollution during material transfer. Use of higher capacity equipments during stacking, reclaiming also minimises fugitive emissions. However, technology and equipments alone do not suffice if adequate methods of raw material handling are missing. These measures are yet to be adopted by many of the Indian steel plants.

Raw material processing includes sinter making, pellet making and coke making. Every stage has own pollution potential; therefore specific pollution control measures are required at every stage.

Sintering plant is a scavenger unit which also utilizes wastes from other units of an integrated steel plant. Air emission is the only significant issue in sinter plant, particularly, emissions of reddish dusts and carcinogenic dioxins and furans. Electrostatic precipitator (ESP) is the most common dust abatement device used here. Some best plants in the world have installed ESP upgraded with more number of fields, moving electrode system, micropulse discrimination system, space cleaner systems and various programmable logics, which ensure upto 99% dust emission reduction at sinter plant. For example, ArcelorMittal, Ghent (Belgium) has installed ESP with micropulse discrimination. Gwangyang Works, Posco (South Korea) and Thyssen Krupp Stahl, Duisburg (Germany), have installed energy pulse superimposition.

More waste reuse in sinter making is, however, considered good but it also makes the process a major source of dioxins and furans emissions. To control this, measures such as activated carbon use in fly gas stream, reduction of chlorine content in the feed and fabric filters with catalytic oxidations systems are used by many plants globally but, unfortunately, not by any Indian plants.

Pellets are required for DRI making. During pelletisation, particulate matter (PM) emission from common stack of the ignition hood, indurating furnace and wind box is significant. The exhaust gas from ignition hood and the dust...
laden air from the wind boxes are passed through an ESP for treatment before releasing into the atmosphere.

**Coke making is a highly pollution intensive process.** In India, by-product type coke ovens are largely installed within integrated steel plants whereas non-recovery type ovens are installed both with integrated steel plants and merchant coke producers. As coke oven gas is treated and chemicals are recovered in recovery type ovens, many pollutants are released in air and water. Non-recovery type ovens are environmentally better because produced coke oven gas is not treated but directly combusted in a boiler to produce electricity. In-fact, United States Environmental Protection Agency (USEPA) has, banned greenfield by-product coke ovens in USA; only non-recovery coke oven technology is being promoted.

Air emissions occur during coal charging, coking and coke discharge. Fugitive and leakage emissions from oven doors, lids, ascension pipes, battery top are also toxic in nature. Pollutants are also released in water when coke is quenched and chemicals are recovered during coke oven gas cleaning. Air pollutants are mainly PM, oxides of sulphur (SOx) and nitrogen (NOx), polycyclic aromatic hydrocarbon (PAH) compounds and benzo (a) pyrene etc. whereas water pollutants include ammonical nitrogen, oil and grease, cyanide and phenol etc.

Most of the Indian coke oven plants, specially the older ones, struggle to control pollution. The older coke oven batteries are required to rebuilt and refurbished. To control pollution from during coke making process a number best technologies and practices have been adopted by steel plants globally: larger capacity ovens, stamp charging of coal, dry quenching, high pressure ammonia liquor aspiration (HPLA) system, self and magnetic sealing of oven doors, high coke oven gas collection, variable pressure regulation technology, stationary land based pushing emission control, wet oxidative desulphurization and multi-stage waste water treatment systems etc. Some of the plants in India such as Vizag Steel, Vishakhapatnam, Tata Steel, Jamshedpur, JSW steel- Vijaynagar and SAIL Rourkela have adopted few of them. None of the Indian plants have so far installed the variable oven pressure regulation technology for charging emissions control in coke oven plants. This system has been operating in many coke oven plants in Germany, Brazil, China and South-Korea etc.

Coke making, being a hydrocarbon intensive process generates hazardous wastes such as tar decanter sludge, benzol muck, sulphur muck and wash oil etc. which need to be cautiously handled and disposed. Wastes with significant calorific value such as tar decanter sludge etc. can be recycled back into the coke ovens while others should be disposed in secured landfill sites.
Pollution control at iron making stage

About 65% of iron is produced through blast furnace (BF) route and remaining 35% by DRI route in India. DRI making is not as capital intensive as BF route, therefore, small DRI makers are mushrooming. But this is highly polluting.

In BF operation, stack house, hot blast stove and cast house are major emission sources. Here, dry fog system is installed for dust suppression and suction hood mechanism with bag filter or ESP for dust capture and cleaning. Many of the BFs in India still do not have cast house dusting systems. On top of that, the Indian norms are also lenient. Where PM emission standard for cast house dusting stack is 150 milligram per cubic meter (mg/Nm³) in India, World Bank-IFC standard is only 20 mg/Nm³. Fugitive emissions in BF area carry PM, CO and lead mainly. Plants are generally found unable to meet CPCB’s fugitive dust emission norms of 4,000 microgram per cubic meter (μg/Nm³) for existing BFs and 3,000 μg/Nm³ (for new BFs). They follow Factories Act, 1948 generic standard of 10,000 μg/Nm³. High concentration of CO in fugitive emissions can be lethal so regular proper monitoring is necessary.

BFs effluent is rich in cyanide, ammonical nitrogen oil & grease, suspended solids and metallurgical wastes, so its treatment is required at effluent treatment plants (ETP) before discharge. Metallurgical waste water generated during off gas cleaning which carries particles of iron, carbon and metals like zinc and lead. These pollutants should be separated into sludge and water should be recycled for gas cleaning again. However dry off gas cleaning can save water. It is installed with BF at Bhushan Power and Steel, Sambalpur.

Slag generated from BF operation is a valuable by-product which is granulated and used for cement production. Under charter of Corporate Responsibility for Environmental Protection (CREP), plants had committed to granulate and reuse 100% of BF slag. However, there are plants which are still dumping it as wastes.

**India is the largest DRI producer in the world.** The coal based DRI process is extremely polluting and energy consuming. Kiln exhaust gases, cooler discharge & separation areas are among the major air pollution points in a DRI plant. The process generates large amount of char or un-burnt coal (nearly half of the total wastes from a DRI plant), dusts and kiln accretion which are generally dumped. Indian DRI plants generate 225-461 kg of char per tonne DRI (Green Rating Project, 2012, CSE). Char is, however, a low calorific value waste but instead of dumping, can be fired in fluidised bed combustion boiler for electricity generation.

To control the dust emission from product separation and transfer points, a suction hood with bag filter mechanism is installed. In India, only Jindal Steel and Power’s has installed advance dust control systems in cooler discharge and product separation area. ESPs are generally installed for stack emission control; still most of the DRI plants are observed having high stack emissions. Proper functioning of ESP, limited ABC cap opening and pneumatic transfer of ESP dust are required for emission control from DRI plants.

**Natural gas based DRI plants are environmentally cleaner.** However, raw material screening, loading bin, by-product separation and DRI transfer area may have significant dust emissions which can be controlled using a bag filter. In India, only JSW Ispat, Raigad, Essar Steel, Hazira and Welspun Maxsteel, Raigad have natural gas based DRI making facility.

**Pollution control while making steel**

Conventional BOF steel making is most common steel making technology in world compared to EAF and EAF routes. Secondary emissions from steel making shops and utilisation of steel slag are the big issues here.

In BOF (also Linz Donawitz or LD) process, secondary emissions take place during charging, oxygen lancing and tapping. Metallurgical wastewater is generated during off gas cleaning. For fugitive dust control, a total housing or enclosure system (Dog House) installed for converter vessel captures the fugitive dust which is cleaned in a bag filter or ESP. The off-gas from BOF process (also called LD gas) is rich in energy (1800 kilocalorie per cubic meter) which can be used for reheating and power generation purposes. Nearly 2-4% of the energy required in steel plant is supplied by LD gas.

Metallurgical wastewater generated during off gas cleaning from BOF and BF which are mixed together and treated. Metals are recovered in sludge and water is recycled in the process.

**Electric route steel making process is growing worldwide.** The process is high electricity consuming, therefore, also accounts responsible for primary energy consumption and carbon emission of electricity generation. During process, nearly 95% of emission is primary off-gas emission, which can be captured using the 4th hole and 2nd hole in furnaces. Secondary emission from the process can be captured effectively using Doghouse and total building enclosures. The gas should be cleaned using a bag filter before release into the atmosphere.

Most of the Indian plants have adopted combination of off gas collection and treatment system. Yet the fugitive emissions are still high because of non-functional emission control system. High amount of CO₂ produced in can combusted in the furnace freeboard or in the 4th hole evacuation system conveying the off-gases to the bag house for cleaning. The oxygen jet lancing injectors in the furnace act as a
post combustion system enables 35-60 per cent of the energy recovery and emission control of dioxins and furans in off gas. Where EIF is used, huge amounts of hot fumes and gases are released from the open furnace vessels. The fumes should be captured by a properly designed suction hood. The hood should draw the entire exhaust gases which should be further cleaned through a bag filter before being let out into the atmosphere. Photo- Sanjeev K Kanchan, CSE

Figure 4. Metal recovery from steel slag at JSW Ispat, Raigad

Reuse of steel slag is a big problem for steel industry. Steel slag generation in Indian steel plants is very high, 96-180kg per tonne crude steel in BOF process and 140-280kg per tonne of crude steel in electric steel making which is mostly dumped. Due to high iron oxide content it cannot be used in cement making. Some quantities are used as liming agent in the sintering process where its limiting factor is phosphorous content. Road and rail making ballast are the main resources of steel slag reuse. The hazardous components of steel slag and their impacts on environment are yet to be explored. In India, Essar Steel, Hazira uses steel slag for making tiles, pavements, slabs etc. whereas JSW Ispat, Raigad recovers metal from steel slag.

Business-as-usual of steel sector is not sustainable.
The sector is the third highest CO₂ emitter after thermal power and cement sectors in India. On an average, a coal based Indian steel plant emits 2.7 tonne CO₂ per tonne of crude steel. At this rate, it will generate nearly 800 million tonne CO₂ annually by 2030 (Green rating Project, CSE, 2012). Where total tonne CO₂ emission of India is around 1.8 billion tonnes today, this much emission alone by steel sector is alarming.

Similarly, the sector consumes nearly 11 m³ water per tonne of crude steel. At this rate, as much as 3400million m³ water will be drawn by this sector alone (Green rating Project, CSE, 2012). Almost all the Indian steel plants depend on surface water, even the coastal plants. This indicates how terrible would be the water stress in future.
The industry generates huge quantity of wastes, nearly half amount of produced steel, majorly as slag, char, fly ash, sludge and dusts. With increasing steel production, wastes will also increase enormously. Steel slag alone will account for nearly 60 million tonnes annually by 2030. If avenues of reuse are not explored and haphazard dumping continues it will be a nightmare.

Pollution monitoring and regulation: yet to improve
Central and state pollution control boards regulate industrial pollution control activities as per the mandate under Environmental (Protection) Act. The issues of pollution with steel plants are manifold, therefore, proper regulation and monitoring protocol is also important besides technology adoption and best practices. A time targeted compliance to the notified norms needs to be ensured. Wherever required norms have to be tightened; if missing, has to be incorporated and if ambiguous, has to be uniform. Future of the sector demands for reduction in natural resource consumptions, more recycle & reuse and efficient land use. Simultaneously, this may need improvement in the regulatory mechanism and capacity building, research & development and assurance from industries to adhere the CREP commitments.