Emission Control through Coke Oven Door – A Case Study of BSP

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***Abstract* - Coke is a crucial raw material and a fuel used in blast furnace iron making. However, the coking industry with coal as the primary raw material is characterized by a relatively low energy utilization rate, high energy consumption per unit, complex process flows, abundant pollution–producing links, and it's being a large source of highly polluting matters. Therefore, the coking industry is considered a highly polluting industry. The exhaust gas pollutants generated during coking include total suspended particulate matter (TSP), particulate matter with aerodynamic diameters less than or equal to 2.5 µm (PM2.5), sulfur dioxide, nitrogen oxides, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs). The coking industry is also a substantial contributor to greenhouse gas emissions. Long-term exposure to coke oven emissions results in inflammation of the skin and inner eyelids and lesions in the lung and stomach. The United States Environmental Protection Agency (US EPA) classifies coke oven emissions as Group A carcinogens and links them to lung cancer (US EPA, 1999).**

***Index Terms* - Associated Emission Levels, Best Available control Technology, The Clean Air Act, Clean Development Mechanism, Environmental Protection Agency, Environment Management System, Maximum Achievable Control Technology, Percentage Leakages thro Doors.**

I.INTRODUCTION

Presently, coke used in metallurgical industries (including the steel industry) is mainly produced through the coking of coal. The ability to reduce emission for air pollutants is a crucial factor for overall pollution prevention and control in the coking industry. Reducing and better monitoring the emissions of air pollutants from coke ovens is required to improve ambient air quality, maintain a sufficient level of coke production, and meet ongoing new regulations. Therefore, the emissions of typical primary air pollutants from the coking industry is considered included TSP, PM2.5, SO2, NOx, VOCs, PAHs, CO, and CH4. The future emissions reduction potential was projected based on scenario analysis to provide a theoretical basis and technical support for emission controls and the implementation of emission standards in heavily polluting industries.

Coke is produced by the destructive distillation of coal in coke ovens. Specially prepared coal blend comprising of various types of coals of desired coking parameters is heated in an oxygen-free atmosphere (coked) until most volatile components in the coal are removed. The process is carried out in battery, which contains twenty or more tall, wide and narrow ovens arranged side by side. After charging, a coke oven is heated for twelve or more hours, during which a variety of volatile compounds evolves from coal.

The coke production industry provides an informative case study because it has been subjected to technology-based regulation of fugitive emissions. This report examines how well the approach has worked in the control of coke oven emissions and how it might have worked better. Although the coke production process is complex and unique, we believe it offers some general insights relevant to today's legislative and technological efforts to maintain the emission norms as per CPCB.

Critical study of continuous improvement technologies adopted in past as well as ongoing technologies, environment management system, and legislative control measures in force in Coke Ovens of Bhilai Steel Plant and its effectiveness so as to meet the requisite norms and fulfill obligation. Further to this study also throws some light on the other innovative measures developed and implemented by the practitioner during working in this area as manager.

The Bhilai Steel Plant, a unit of Steel Authority of India Ltd. and a public sector undertaking was conceived under aegis of Indo-USSR Treaty in the 2nd Five-year plan in 1959. The plant is located at the central position of India, which is one of the major iron belts of India and is about 40 kilometers from Raipur, capital of the newly born state of Chhattisgarh. With a production capacity of 7.0 million tons of steel, it is the largest steel plant in India. Besides the major marketable product, which is good quality steel, it also produces important by products, such as, coke, Coal tar, Naphthalene and Benzol.

1.1 Coke oven plant operation

Coke oven plants are complex technological plants, which comprise of different technological sites, where coal preparation, coking and coal by-product recovery and upgrading occurs. The scheme of coke oven plant is presented in figure.

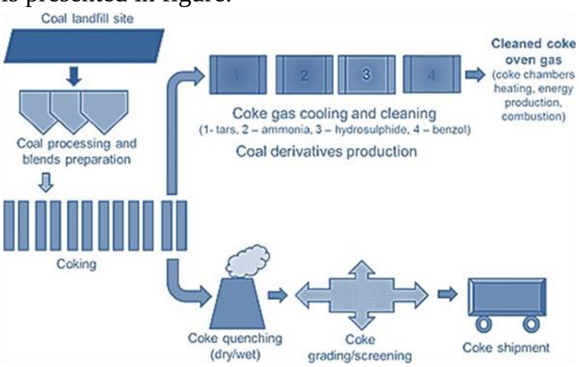

Fig. 1: The basic scheme of coking plant

Emission sources from conventional coking plants: Typical emission sources with regard to battery operation are shown below. These are directed and fugitive emission sources. Fugitive emissions mainly occur from leaks at the closed openings of the coke oven batteries (doors, charging hole lids and off takes) or are caused by non-captured emissions during coke pushing and coal charging. These emissions cannot be avoided completely, also when considering closure facilities according to state of the art in technology and being under best state of maintenance, and contain dust, polycyclic aromatic hydrocarbon compounds (PAH) and Benzene as most relevant components. Carcinogenic Benzo (a) pyrene is very often used as guide substance for the group of PAHs.

Emissions from directed sources are created at the stack for the off gas from battery under firing. The most important compounds which are emitted here are dust, NOx, SOx and CO2. Dust is emitted also by the off gas of the pushing emission control as well as during coke quenching. Emissions caused at preparation of charging coals, and at classification of coke, respectively, are not addressed here because well-proven dust removal systems are available to cope with them.

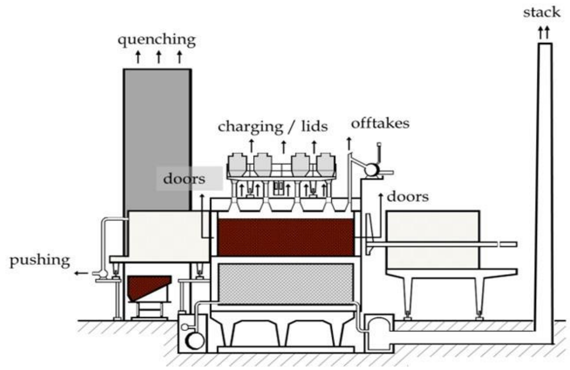

Fig. 2: Schematic drawing of typical emission sources at a conventional coking plant

II. EMISSION TYPES AND THEIR CAUSES

- Charging emission: Splutter when coal is placed in the heated oven. This contains both particulate matter and PAH compounds.
- Diffuse emission: Due to high pressure of volatile matter inside oven during heating gas leaks out.
- Combustion emission: When volatile matter is wholly burnt and coke remains, dust is emitted.
- Pusher emission: When coke is done and is pushed out of ovens into the pusher car, soot blows out.
- Quenching emission: When Coke Oven Gas is quenched with water, water evaporates into steam with particulate matter, SO2, NOx and CO.

2.1 Emissions are of two kinds

Fugitive: They happen due to high pressure generated in the ovens and decanters:

- Fugitive emissions happen due to gas leaks.
- This may contain both combusted and incompletely combusted matter.
- Incomplete combustion has traces of PAH levels measured by the concentration of benzene pyrelene in the emission.

- They are PAH compounds found in air, water or sludge.
- Tar sludge, benzol sludge.
- Usually hazardous.

Process:

- Usually wholly combusted matter in the form of dust, namely PM, NOx, SO2 and CO
- Is cleaned and distilled in coke byproduct plant.
- Usually nonhazardous.
- Completed processes.

Table 1: Types Emission and their Causes

Due to incomplete combustion	Due to combustion of coal
PAH compounds, carcinogenic.	Particulate matter
During distillation of by product.	SO_2
During Treatment of wastewater	CO
	NO_x

2.2 Methods of controlling coke oven emissions

2.2.1 Technological and Operational Process Modification

1. By sequentially charging the ovens in a battery, and by putting scrubbers on larry cars (these scrubbers ride under larry cars, surround open topside lids during charging, and direct the gas to a receptacle on the larry car).
2. Proper Maintenance and Operating Procedures - Topside leaks which occur while topside lids are closed, and the coal is heating are combated.
3. Tight sealing of doors-Several methods (e.g., coke oven sheds, fume hoods, maintenance and operating procedures) exist for controlling side door emissions, but the most common method is to assure the tight sealing of the doors through various techniques such as wet clay sealing (luting) and metal-to-metal sealing.
4. Negative pressure ovens-. Such designs include negative pressure ovens which trap all gases inside the oven by keeping the oven pressure lower than the surrounding air pressure.
5. Brand new designs for coke oven component parts are also promising (these include improvements in virtually every part of the coke oven).
6. Dry coal charging- Cleaner methods of dry-coal charging (most procedures now mix the bunker coal with some water), and better methods for recycling the waste gases.

2.2.2 Enforcement of Regulatory Programs

The Ministry of Steel through various schemes and regulations of the Government is facilitating reduction in energy consumption and emission of environmental pollution in steel plants. Some of the steps/initiatives taken by the Ministry of Steel through various forums and in steel plants are:

Charter on Corporate Responsibility for Environment Protection (CREP): This is an initiative of the Ministry of Environment and Forests (MoEF)/Central Pollution Control Board (CPCB) in association with the Ministry of Steel and the main/major steel plants to set mutually agreed targets with the purpose to go beyond the compliance of regulatory norms for prevention and control of pollution.

A National Task Force in CPCB reviews the compliance of CREP action points and targets. The areas where environmental performance are particularly monitored are:- fugitive emissions from coke ovens; secondary emission control in steel melting shops; use of BOF slag for treatment of acidic soils; Effective operation of coke oven by product effluent treatment plants; and monitoring of ambient air quality.

Regulatory action to control coke oven emissions evolved originally from the power of CPCB to deny operating permits for coke oven batteries operating in the county. Later, the CPCB was empowered to set specific emission standards for manufacturing facilities such as coke batteries. Thus, it is important to recognize that a coke oven emission in the country is under some regulatory control.

Clean Development Mechanism (CDM) under Kyoto Protocol: Under this scheme, the Ministry of Steel is facilitating, through the National CDM Authority in the MoEF, adoption of energy efficient clean technologies in iron and steel plants. A large number of iron and steel plants have obtained approvals for availing carbon credit by adopting energy efficient clean technologies.

UNDP-Global Environment Facility (GEF) Steel Project: Under this project, a scheme has been developed with contribution from the United Nations Development Programme (UNDP) and the Ministry of Steel to facilitate diffusion of energy efficient low carbon technologies in steel re-rolling mills in the country to bring down energy consumption, improve productivity and cost competitiveness together with a reduction in Green House Gas (GHG) emission and related pollution levels. Towards this objective, 67 model units have been identified and so far, technology packages have been commissioned in 30 units.

Implementation of Environment Management System (EMS) Linked to ISO 14001: Environmental Management System (EMS) linked to ISO 14001 is a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency. Implementation of EMS has helped SAIL's Plants and Mines to ensure that their performance being always within the applicable regulatory requirements.

During the Financial Year 2018-19, implementation of EMS (ISO-14001:2015) has been completed at IISCO Steel Plant and Gua Ores Mine. Re-certification of EMS (ISO 14001:2015) was done at Meghahatuburu Iron Ore Mine, Kiriburu Iron Ore Mine, Bolani Ores Mine, Barsua Iron Mine and Dalli Mechanised Mine. Six warehouses (Dankuni, Faridabad, Kalamboli, Chennai, Delhi and Vishakhapatnam) of CMO.

2.2.3 Legislation on emission control

In Germany, the most important legal rule with regard to industrial emission control represents the Technical Instruction for Air Quality Control – Technische Anleitung zur Reinhaltung der Luft – the so-called TA Luft. The first issue of TA Luft was enacted in 1964 and was amended for several times in the following years. The TA Luft is the most essential guide for implementation the demands of the German Federal Immission Control Act - Bundes-Immissions schutzgesetzes (BImSchG) – which was released in 1974.

Table 2: Emission limit values for battery operation according (TA Luft, 2002);

*: sulfur content of the heating gas before combustion

Process	Emission	Limit value
Stamp charging battery under firing	dust:	10 mg / Nm^3
	dust	10 mg / Nm^3
	NO_x	0.5 g / Nm^3
	sulfur*	0.8 g / Nm^3
	dust	5 mg / Nm^3
Pushing	dust	5 g / t coke
Quenching dry, wet (new plants) wet (existing plants)	dust	15 mg / Nm^3
	dust	10 g / t coke
	dust	25 g / t coke

As a measure for precaution the TA Luft sets standards for the technical equipment for emission control on industrial plants and specifies how to operate the plant in a most environment-friendly way. Following technique contains the most important techniques and work practice standards to apply on the coke oven batteries with regard to the TA Luft amendments of the year 2002 (TA-Luft, 2002). Most of the standards of the German TA Luft were adopted by the BREF-document of the European Union (EU, 2012) nearly complete.

European Union: In the European Union, there are in principle two directives that influence coke plant operation:

- ED Directive" (EU, 2010) on industrial emissions (integrated pollution prevention and control).
- Air Quality Directive" (EU, 2008).
- The IED-Directive addresses the conditions for plant operation and sets standards for emission control.

This directive stipulates that the "best available technique BAT" which has to be applied is to be described in a so-called BREF document ("Best available technique Reference" document) for certain industrial plants. For coking plants, the set-up of such a BREF document was finalized in the year 2000. An amendment was promulgated in 2012 (EU, 2012), and it assigns "Associated Emission Levels AEL" to the BATs. BAT-AELs give ranges for emission levels which can be achieved by application of emission control techniques according BAT. AELs which are relevant for coke making operation are described on Table below.

Table 3: BAT associated emission levels (AEL) as described in the BREF document (EU, 2012)

Process	Emission	AEL / BAT	Unit of measurement	Remark
Charging	Dust	<5 or <50	g / t coke or mg / Nm^3	-
	Visible emission	< 30	sec	Duration of visible emissions per charge

Process	Emission	AEL / BAT	Unit of measurement	Remark
Off gas from battery under firing	SO_x	<200 to 500 (as SO)2	mg / Nm^3	Depending on the type of gas for under firing
	NO_x	<350 to 500 (as NO)2	mg / Nm^3	For new plants
	NO_x	500 to 650 (as NO)2	mg / Nm^3	For existing plants which are equipped by primary measures for NO_x reduction
Pushing	Dust	< 1 to 20	mg / Nm^3	
	Dust	< 10 to < 20	mg / Nm^3	Depending on filter type
Quenching wet	Dust	< 25	g / t coke	Existing plants
Wet	Dust	< 10	g / t coke	New plants
Dry	Dust	20	mg / Nm^3	
Battery operation	Visible emission	< 5 to 10	%	From leaks at doors
	-	Adequate oven pressure regulation	-	-
	-	Work practice standards	-	-
Desulphurization of COG	H_2S	< 300 to 1000	mg / Nm^3	Applying absorption processes
	H_2S	< 10	mg / Nm^3	Applying wet oxidationprocesses

The Air Quality Directive (EU, 2008) and its so-called 4. Daughter Directive (EU, 2004) describe the targets and principles of the air quality policy pursued by the European Union. Ambient air standards which are important for coke making operation are given in table here.

Table 4: Ambient air quality standards (limit values) of the EU (EU, 2008) as an annual average with reference to coking plant operation; *: (EU, 2004)

Emission	Limit value	Remark
Benzene	5 µg / m^3	-
Particulate Matter PM10	40 µg / m^3	-
	50 µg / m^3	A daily average for max. 35 days
Particulate Matter PM2.5	25 µg / m^3	from 2015
Benzo(a)pyrene *	1 µg / m^3	from 2012

USA Clean Air Act: The Clean Air Act (CAA) of the United States of America was passed in the year 1990. This act of law describes standards for air quality, which exert a very strong influence on the requirements which have to be fulfilled for obtaining the permit to run an industrial plant. The so-called Residual Risk Standard (RRS) should provide an ample margin of safety to protect public health and to reduce the risk to cause cancer to a minimum.

For existing conventional coking plants, the Residual Risk Standard, which is still open, has to be reached from 2020. It is to assume that the relevant legal demands will be very ambitious. During the recent 20 years the US coke oven plant operators had the chance to approach this target on different tracks, which specify different compliance timetables (Ailor, 2003; US-EPA, 1993a). While the MACT-track (Maximum Achievable Control Technology) allows less stringent standards for a long period to fulfill the highest lewel of emission standards already in 2005, operators who have chosen the LAER-track (Lowest Achievable Emissions Rate) got an extension to reach this standard only in the year 2010.

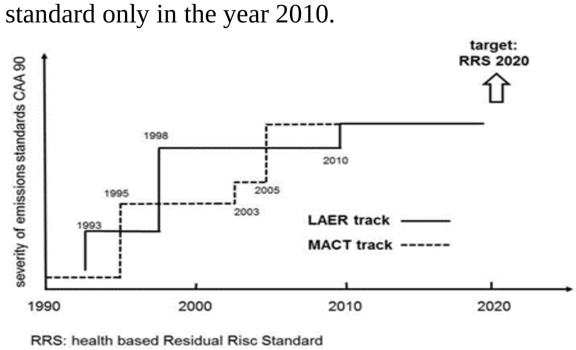

Fig. 3: Timetable to comply with the legal demands of the US Clean Air Act

The relevant standards for the allowed visible emissions are shown on Table. Estimates of visible emissions should be based on the results of daily visible emission inspections using EPA Method 303 (US-EPA, 1993b).

Table 4: Standards for visible emissions according MACT- and LAER-track respectively for conventional coking plants

Source	MACT	LAER	Remark
	from 01.01.2003	from 01.01.2010	
Doors	5.5 %	4 %	≥ 6 m
Doors	5.0 %	4 %	foundry coke
Doors	5.0 %	3.3 %	< 6 m
Lids	0.6 %	0.4 %	all plants
Off takes	3.0 %	2.5 %	all plants
Charging secs per charge	12	12	all plants

It is easily to understand that operators of older plants would have preferentially followed the MACT track as their coking plants will be no longer in operation in the year 2010, probably. After all there were only 5 conventional batteries which have to comply with emission standards equivalent to the 2010-LAER-standard in 2005. On the other hand, operators of new plants, which were equipped with modern techniques for emission control on the date of their track choice, or for which a modernisation was planned, would have preferred the LAER-track. Based on information given in the year 2003 (Ailor, 2003) the LAER-track was chosen for 40 conventional batteries.

In case of coking plants, amongst others, standards are set for the allowed number of visible emissions (leaking rates as %) from battery operation to reach this goal, as described by the US EPA (US-EPA, 1993a, 2005). For the construction of new coke plants at the green site, the CAA calls for zero visible emissions from battery operation. That means in practice, that in the USA, the non-recovery technology is the only one, which is allowed by the US EPA for new green field plants because of the prevailing negative pressure and consequently of the prevention of leaks at the ovens.

Emissions from pushing, quenching, and combustion stacks are addressed in (US-EPA, 2003a). The most relevant figures of this rule are given on Table. The local authority can make an order on more stringent limits than given on Table on special reason and can set emission standards for other emitted compounds than given on Table with regard to the allowed annual mass flow.

The relevant standards for the allowed visible emissions are shown below. Estimates of visible emissions should be based on the results of daily visible emission inspections using EPA Method 303 (US-EPA, 1993b).

Table 5: Emission standards for coking plants according to (US-EPA, 2003a)
* determination of opacity is made by Method 9 given by US EPA (US-EPA, 1996)

Process	Emission	Limit value	Unit of measurement	Remark
Pushing Fugitive (not captured) emissions	Opacity*	< 30 / 35	%	Depending on oven height *
Outlet of dedusting device	Dust	0.01 – 0.04 (5 – 20)	lb / t short coke (g / t coke),	Depending on type of control device
Battery under firing stack for off gas	Opacity*	< 15 / 20 %	%	Depending on coking time
Quenching Outlet of quench tower	Dissolved solids	< 1.1	mg / l	Quench water

German and European legal regulations set no standards for opacity. Therefore, only the 0.02 lb / t short (10 g / t) limit for pushing emissions from the stack when applying a moveable hood with a stationary control device can be compared with the relevant figure of 5 g / t coke set by German TA Luft for this technique.

In addition to the limit values as described before, the US environmental legislation sets work practice standards. These standards, for example, describe techniques which have to apply with regard to emission control and to emission monitoring, or how to operate the coking plant in a most environmentally friendly way.

Technologies:

1. Gravity charging: Emission free charging by transfer of charging gases to the main and into the neighbor oven, as an option.
2. Stamp charging: Combustion of non-transferred gases.
3. Doors with technical gas-proof sealing's.
4. Water-sealed lids at off takes.
5. Single chamber pressure control should be applied.
6. Coke side emission control including a mobile hood and a stationary control device.
7. Coke quenching by dry or wet quenching mode.

Work Practice Standards:

1. Additional sealing of lids of charging holes.
2. Regularly, and preferential automatic, cleaning of closure facilities.

2.2.4 Quantification of visible emissions

The philosophy of EPA's rules for visible emissions caused from coke oven operation is based on a chain of causalities between:

- Number of visible emissions, and
- Mass flow of the emitted hazardous compound, and
- Concentration of the emitted hazardous compound in ambient air, and
- Ambient air quality and cancer risk

Type of leak	kg BSO /h/leak	mg BaP/h /leak
Leaks observed according EPA 303 from the yard	0.019	159
Leaks observed from the bench*	0.011	92
Without visible emissions	0.002	17

Applying a 4% leaking rate (according EPA method 303) at the doors (post-NESHAP control standard according (US-EPA, 2008b)) the total BSO emissions of a model battery with 62 ovens (124 doors) can be calculated as follows:

[(124 x 0.04) method 303 leaks x 0.019 kg / h / leak
+ (124 x 0.06) bench leaks
x 0.011 kg BSO / h / leak
+ (124 x 0.90) no visible leaks
x 0.002 kg / h / leak)]
x 8760 h / a = 3 498 kg BSO / a.

Considering a coke plant with a coal input of 492000 t / a (344000 t coke / a) a specific emission factor of 0.0071 kg BSO / t (coal) results for door emissions. By using a conversion factor for BaP / BSO of 0.00836 (US-EPA, 2008b) the specific BaP emissions from the doors amounts to 59.4 mg / t coal and 84.8 mg BaP / t coke, respectively. By comparable evolutions emission factors for leaks at lids and off takes as well as for charging can be received. It is obvious that the doors are the dominant emission source out of all leaks at the battery.

Table 7: Specific emissions at doors according (US-EPA, 2008b)

US-EPA standard	Charging kg/t coal	Doors kg/t coal	Lids kg/t coal	Off takes kg/t coal
POST-NESHAP	BSO			
	0.00025	0.0071	0.000044	0.00015
POST-NESHAP	BaP			
	2.09	59.36	0.37	1.25
POST-NESHAP	BaP			
	2.99	84.79	0.53	1.79

2.2.5 The problem-fugitive Emission of gases and their control

As stated above, most of the gas in a coke oven is recycled and reused. However, some emissions do escape during the charging, coking, and pushing phases. That is, topside lids, push side doors, quench car side ("coke side") doors, and general cracks do leak to a small extent. The amount of such "fugitive" emissions depends on numerous factors such as the design, age and condition of the battery operating, and maintenance practices employed.

Emissions are a yellowish-brown gas containing upwards of 10,000 compounds, e.g., gases, vapours, and particulates. Several of these constituents are known carcinogens. Especially problematic are benzene, polycyclic organic matter, respirable particulate matter, and coal tar pitch volatiles.

Typical emission sources with regard to battery operation are described in Chapter 1. These are directed and fugitive emission sources. Fugitive emissions mainly occur from leaks at the closed openings of the coke oven batteries (doors, charging hole lids and off takes) or are caused by non-captured emissions during coke pushing and coal charging. These emissions cannot be avoided completely, also when considering closure facilities according to state of the art in technology and being under best state of maintenance, and contain dust, polycyclic aromatic hydrocarbon compounds (PAH) and Benzene as most relevant components. Carcinogenic Benzo (a) pyrene is very often used as guide substance for the group of PAHs.

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To control these emissions, it is necessary to identify the source, quantify and measure so that it can be controlled and managed effectively.

Two Major methods for measuring coke oven emissions are:

1. Measuring the opacity of visible emissions, measured as PLD and PLO.
2. Measuring concentrations of BSFTPM (benzene soluble fraction of total particulate matter).

It is difficult, however, to correlate these two measurement methods and hence only focused on visible emission measured as PLD & PLO.

Major area of emission under study is from closure facilities especially from oven doors; visible emissions which are measured on daily basis and PLD is calculated for each set of batteries. Thereby performance parameters of controls such as regulating pressure, charging process, closure facilities viz. door performances are measured, and suitable corrective actions are initiated.

While operational and process parameters are immediately verified and rectified, closure facility i.e., Door performance are measured instantly but rectification take more time since the doors has to be taken out from the oven and rectification is carried out after complete dismantling and reassembly.

To carry out and identify rectification and measure the performance each doors is numbered sequentially and record is maintained when it is taken out for repair and again fixed in the oven. The time period between the two successive in and out measures the performance life of the doors.

Battery wise PLD were collected and compared for the performance of the door diaphragm (attached at Annexure 1). The data shows that the battery no. 5 & 6 PLD is more on higher side as compared to others where IKIO-KBK doors are installed. Therefore, it is chosen for design and material quality change as desired.

2.2.6 Problem identified with respect to BATTERY#5&6 oven doors were as follows

1. Improper inspection and problem identification.
2. Mean time delay in revisioning and refixing of doors.
3. Non availability of door spares in time.
4. Poor quality of door spares.
5. Poor quality of door repair
6. Delay in outsourcing of door repairs.
7. Poor workmanship and technical knowhow of door repair technique.
8. Frequent damages of door diaphragm during closing opening of doors.
9. Ineffective door diaphragm edge design and its material quality.

Since listed causes are many and beyond the control of mechanical maintenance purview where the improvement in diaphragm design may results in substantial performance improvement in controlling the fugitive emission from the doors, hence it is chosen for the study.

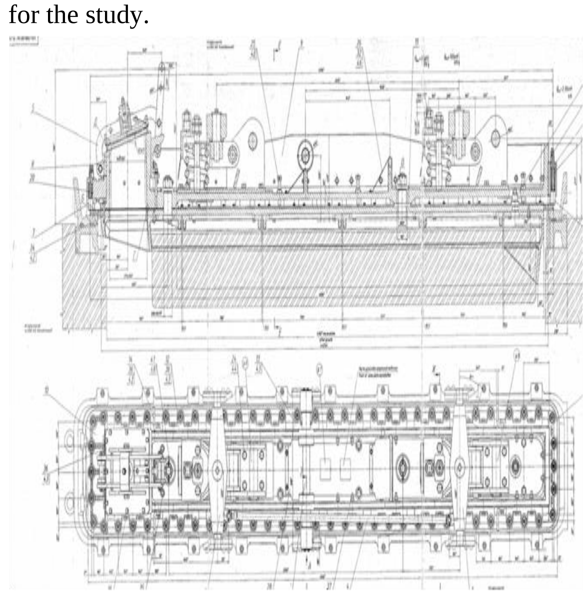

Fig. 4: Door body assembly cob 5, 6

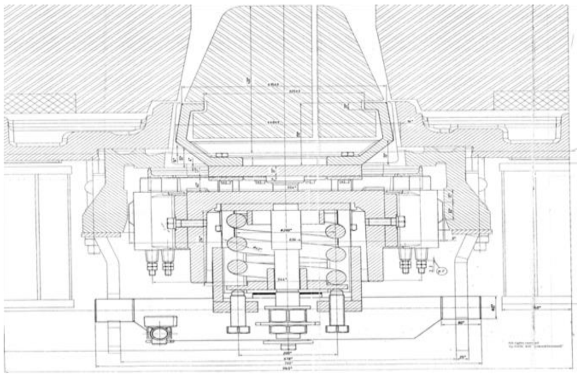

Fig. 5: Door body assembly section view

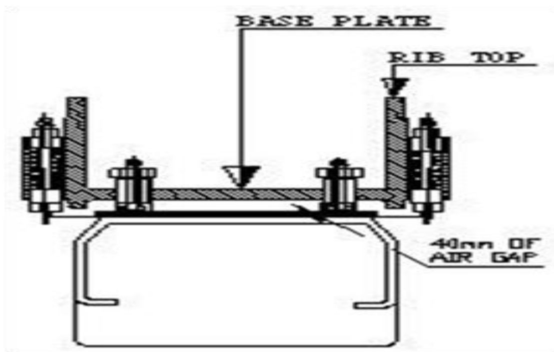

Fig. 6: Coke Oven door cross section view-old, designed door diaphragm

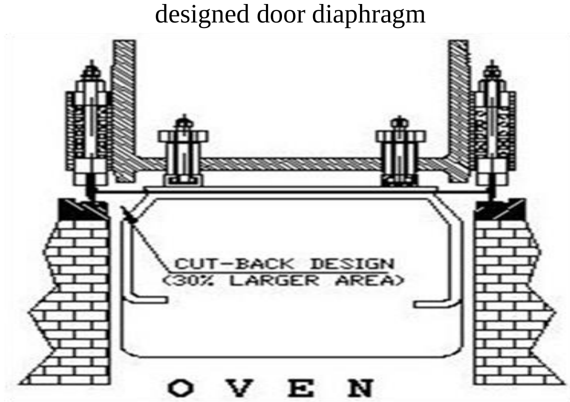

Fig. 7: Coke Oven door cross section view new design diaphragm

III. METHODOLOGY

The problem identification starts with study and comparison of technology adopted, operational parameters, regulation standard and work practices by different coke oven plant in production and operation of coke oven to control emission. Since the study is based on BSP coke oven plant, it is imperative to study the existing equipment's, technology, processes, practices and operating parameters followed to achieve the desired emission standard as per CPCB.

The data collected and shown at various stages for reference were secondary data and collected from the Bhilai Steel Plant, coke oven battery no 5 where the experiment were conducted and Environment Management Department, to justify the results achieved by adopting the combined operational processes and technologies to fulfill the environment regulation in force and also to maintain the healthy work environment for the entire population and community at large.

The activities followed for modification and correction of problematic doors are:

1. Collecting and analysing the past PLD data and arriving at conclusion to redesign door diaphragms.
2. Design drawings were developed in consultation with department personnel.
3. As per the decision for changing the design of the door diaphragm and its material quality, first searched for manufacturer which can supply the desired diaphragm within short period and in desired no of quantity i.e. 5 nos. for each side (coke side and pusher side).
4. Agreed manufacturer were called and order were placed for supply of those diaphragms.
5. After receipt of diaphragm it is assembled and fixed in oven with suitable identification to measure the performance.
6. Every day the performance parameter namely the PLD was observed and noted for the months.
7. After successful findings the new design diaphragm were procured from the manufacture for complete replacement of battery 5 doors diaphragms (130 nos.).
8. Planned for replacement of damaged door frames in a phased manner in battery 5.
9. PLD were monitored again for the months together and found reduced from the old one.

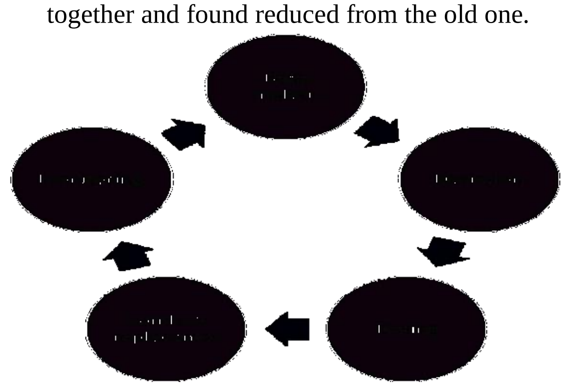

Fig. 8: Implementation methodology

Table 8: Battery wise Average (%) PLD emission observed in BSP 2013-20

Battery	Battery wise Average (%) PLD							
	2013	2014	2015	2016	2017	2018	2019	2020
B1	3.9	4.1	4.3	4.3	4.5	4.7	5.0	4.7
B2	2.8	4.2	4.4	4.6	1.2	-	-	-
B3	7.3	4.8	0.8	-	1.6	4.0	5.1	4.1
B4	5.6	3.5	2.3	2.4	0.4	4.8	4.9	4.0
B5	5.5	4.8	4.8	4.4	4.5	5.1	4.9	4.0
B6	5.4	4.2	4.7	4.5	4.7	5.4	5.2	5.0
B7	5.8	4.2	1.2	-	-	-	-	-
B8	0.5	0.8	0.6	0.6	0.9	3.3	2.3	1.1
B9	-	-	-	-	1.7	0.7	1.3	1.9
B10	4.8	3.9	4.0	4.1	-	-	-	-
B11	-	-	1.7	4.0	5.6	5.9	5.8	5.6

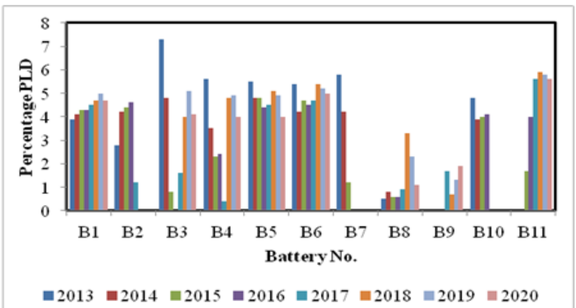

Fig. 9: Battery wise Average (%) PLD emission observed in BSP 2013-20

IV. RESULTS AND DISCUSSIONS

The emission from the doors were observed after fixing the new designed diaphragm in door body assembly during last 12 months which is tabulated below and is self-explanatory.

From the data observed it is found that the new designed door diaphragm is performing well and emission were in lower side as expected, hence it is proposed that the modified diaphragm should also be fixed in battery no 6 to further lower the emission rate at the work site.

Further it is expected that the other methods which supports in diminishing the emission should also be continued for better and long-lasting results.

Table 9: Observed emission levels comparison before and after

Month Recorded	% PLD battery 5 original diaphragms	% PLD battery 5, after fixing new design diaphragm
Jul19	5.3	4.9
Aug19	5.2	5
Sept19	5.3	5
Oct19	5.2	4.9
Nov19	5.3	4.8
Dec19	5.2	4.7
Jan 20	5.6	4.3
Feb20	5.6	3.9
Mar 20	5.3	4.2
Apr20	5.5	3.8
May20	5.6	3.5
Jun 20	5.3	3.4
Jul20	5.5	3.3

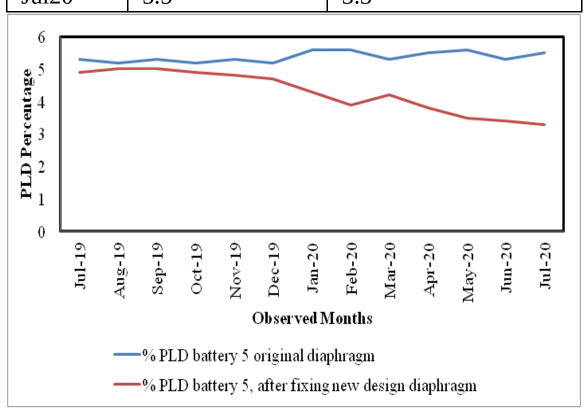

Fig. 10: Observed emission levels comparison before and after

There are several methods of controlling fugitive coke oven emissions. Emission leaks during charging were controlled in the past by using schemes for sequentially charging the ovens in a battery, and by putting scrubbers on Larry cars (these scrubbers ride under Larry cars, surround open topside lids during charging, and direct the gas to a receptacle on the

Larry car). Topside leaks which occur while topside lids are closed, and the coal is heating are combated through proper maintenance and operating procedures. Several methods (e.g., coke oven sheds, fume hoods, maintenance and operating procedures) exist for controlling side door emissions, but the most common method is to assure the tight sealing of the doors through various techniques such as wet clay sealing (luting) and metal-to-metal sealing on routine basis improve the results.

Further improvement is emission can be achieved by:

1. Operational standard viz. battery pressure should be maintained as per norm.
2. Increasing the door repair and changing frequency to quarterly.
3. Proper cleaning of doors and door frame is ensured during each opening and closing.
4. Ensure quality door spares in time that repair work do not interrupt.
5. Continuous monitoring of door repair work and regulation during shift operation.
6. Time bound overhauling of complete doors after 5yrs of service.

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