ABSTRACT
In USA, Clean Air Act (CAA) came into existence from 1963 onwards. Consent decrees, state implementation plans and Occupational Safety & Health Administration (OSHA) regulations were put in vogue for coke oven emissions in 1970s. These were different for different batteries. Progressively charging practices were changed and many developments were also carried in door, lid, and off-take arrangements. Extensive research (both technical and financial) was carried out for the development of regulatory alternatives in 1980s. Finally CAAA-1990 came into existence after lot of negotiations. Whereas in India, there were almost no standards (except CO and particulate matter emissions) existed before 1997. MOEF (Ministry of Environment and Forests, Govt. of India) had notified the emission standards and guidelines to maintain environment quality in work zone area for byproduct recovery coke oven plants.

KEYWORDS: Coke Oven, Pollutants, Health Effect Emission

INTRODUCTION
Emissions in cokeoven
The coke oven is a major source of fugitive air emissions. The coking process emits particulate matter (PM); volatile organic compounds (VOCs); polynuclear aromatic hydrocarbons (PAHs); methane, at approximately 100 grams per metric ton (g/t) of coke; ammonia; carbon monoxide; hydrogen sulfide (50–80 g/t of coke from pushing operations); polyaromatic hydrocarbons; hydrogen cyanide; and sulfur oxides, SOx (releasing 30% of sulfur in the feed). Significant amount of VOCs may also be released in by-product recovery operations.

For every ton of coke produced, approximately 0.7 to 7.4 kilograms (kg) of PM, 2.9 kg of Sox (ranging from 0.2 to 6.5 kg), 1.4 kg of nitrogen oxides (NOx), 0.1 kg of ammonia, and 3 kg of VOCs (including 2 kg of benzene) may be released into the atmosphere if there is no vapor recovery system. Coal charging, coke pushing, and quenching are major sources of dust emissions.

HEALTH IMPACT OF COKEOVEN EMISSIONS

Carcinogenicity
Coke-oven emissions are known to be human carcinogens based on sufficient evidence of carcinogenicity from studies in humans.

Cancer Studies in Humans
Before 1950, numerous case reports linked employment in coke production with cancer of the skin, urinary bladder, and respiratory tract. Since then, several cohort studies conducted have reported an increased risk of lung cancer in humans exposed to coke-oven emissions(1). Smoking was accounted for in some of these studies and was not found to be a significant confounding factor. A large cohort study of 59,000 steel workers published in 1969 reported that lung-cancer risk increased with increasing duration or intensity of exposure to coke oven fumes. Several studies of coking-plant workers reported an increased risk of kidney cancer. An excess of cancer at other tissue sites (prostate, large intestine, and pancreas) was reported in no more than one study for each site.

Cancer Studies in Experimental Animals
There is sufficient evidence for the carcinogenicity of coke-oven emissions from studies in experimental animals. Exposure to coke-oven emissions caused tumors in two rodent species, at two different tissue sites, and by two different routes of exposure. Coke-oven emission samples applied weekly to the skin of mice for up to 52 weeks caused skin cancer, and these samples also showed tumor-initiating activity in initiation-promotion studies in mice(2). In several studies, inhalation exposure to coal-tar aerosols generated from samples collected from coke ovens caused benign and malignant lung tumors in rats and mice and skin tumors in female mice.

RESULTS & DISCUSSION

Studies on Mechanisms of Carcinogenesis
Chemical analyses of coke-oven emissions revealed the presence of numerous known carcinogens and potentially carcinogenic chemicals, including several polycyclic aromatic hydrocarbons (PAHs), nitrosamines, coal tar, arsenic compounds, and benzene. In addition, coke-oven emissions contain several agents known to enhance the effect of chemical carcinogens, especially on the respiratory tract.

Emission Standards

<table>
<thead>
<tr>
<th>Norm Unit</th>
<th>Battery</th>
<th>New battery</th>
<th>Rebuilt Battery</th>
<th>Operating battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPM mg/Nm3</td>
<td>75</td>
<td>75</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>SO2 mg/Nm3</td>
<td>800</td>
<td>800</td>
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<tr>
<td>NOx mg/Nm3</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>PLO %</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>PLL %</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>PLD %</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Occupational Safety and Health administration (OSHA) regulations required equipment and work practice controls for coke oven emission but has not set a performance level in terms of visible emissions. At that time regulation varied from battery to battery with the most stringent limits applied to new batteries(3). Most of the existing batteries had limit that followed the guidance of EPA’s Reasonably Available Control Technology (RACT) with:

- Visible emission limit -: 25seconds per charge
- Percent leaking doors -: 10 to 12 PLD
- Percent leaking lids -: 3 PLL
- Percent leaking off-takes -: 10 PLO

Technology for the Control of Emission from Charging
Charging practices were progressively changed by the efforts of regulatory agencies and coke oven operators to reduce emissions. Previously, the most
common procedure was to isolate the gas-collection system from the oven and charge the coal into the red-hot ovens. When the wet coal enters the hot oven, it displaces the air. This displacement and immediate gasification of moisture and volatile components of the coal cause the oven pressure to rise sharply. Because the gas-collection system is blocked off, the only escape for the smoke, hydrocarbons, gases and steam is to the atmosphere through any opening(4). However, various control procedures were adopted progressively to control the charging emissions(5). Detailed analyses were done on many coke oven batteries and improvements brought in for charging.

- Stage or sequential charging
- Double mains
- Adequate aspiration
- Inspection and cleaning of goosenecks, standpipes, roof carbon buildup,
- steam nozzles and liquor sprays
- Charging car modifications
- Leveller bar seals

Technology for the Control of Door Leaks
Control techniques for coke oven door emissions were based on four categories:

- Oven door seal technology
- Pressure differential devices
- Hoods and sheds over doors
- Operating and maintenance procedures

To improve the performance of doors, major modifications were carried out in the Koppers & Wilputte doors.

Technology for the Control of Topside Leaks.
(Charging hole lids and off-takes)

- TOPside leaks were primarily controlled by
- Replacement of warped lids
- Cleaning carbon deposits or other obstructions from the mating surfaces of lids or their seals
- Patching or replacing of cracked standpipes
- Sealing lids after a charge or whenever necessary with a slurry mixture of clay, coal and other materials (commonly called lute)
- Sealing cracks at the base of a standpipe with the same slurry mixture

In addition, some changes in equipment design were required to keep the leaks sealed. Incorporation of heavier lids, lids with better sealing edges and automatic lid lifters are few of these modifications.

Modern Measures
In addition, modern measures had also been taken in some coke oven batteries either during first installation or during rebuilding for improvement of the performance as well as for reduction of emissions. These are

- Introduction of ceramic welding technology for repair of oven walls
- Introduction of dry gunniting technology for repair of oven walls
- Introduction of High Pressure Liquor Aspiration (HPLA) system for 'onmain' charging of coal
- Water sealed SP caps
- Hydro jet door cleaners at end benches
- Provision of magnetic lid lifting system

- Pusher cars with leveller muff, door and door frame cleaners
- Charging cars with screw feeders having telescopic chute for positive sealing
- Guide cars with door and door frame cleaners
- Computerized combustion control systems
- Water jet gooseneck cleaner
- Charging hole lid compatible magnetic lid lifter
- Mechanized lid lifting facility
- Hydraulic controller for regulation of askania
- Quenching tower with grit arrestor and auxiliary spray system
- Spillage coke conveyor on the service platform
- Conversion to double collecting main from single collecting main and vice-versa
- Steam aspiration system for on-main charging.
- Provision of additional capacity of decanter compatible with HPLA and
- double collecting mains
- Conversion to three charging holes from five charging holes

CONCLUSIONS
Coke oven batteries are considered to be one of the major contributors towards atmospheric pollution in the steel industry. The coal preparation, oven charging, pushing and quenching operations emit a lot of dust, gas, tar, tar fog into atmosphere that are considered to be harmful to the human system. Due to the large number of emission sources, their transient nature, long life of coke oven batteries etc., control of emission from coke ovens is a difficult task.

Over the years a large number of emission control measures in the coke ovens have been introduced by our SAIL in the form of water jet cleaning of doors, HPLA system to reduce charging emissions, group wise crushing of coals, new design doors, water sealing of stand pipe lids, introduction of effective combustion control system in coke ovens, etc.

REFERENCES
1) "Control of pollution in SAIL Coke Oven Batteries" prepared by CET in April 1999 for CPCB.
2) "Measurement of emissions from SAIL Coke Oven Batteries" prepared by RDCIS in April 1999 for CPCB.
3) The Environment (Protection) Rules, 1986