The oil industry is a major emitter of pollutants

Effects of Climate Change on Industrial Ventilation System Design

By Prakash Kumar, S. G. Saha, C. D. Goswami and Kamal Sarkar
MECON Limited, Ranchi

Abstract

Environmental quality is the main goal of Pollution Prevention and Control Policies. Due to the need to preserve a certain level of environmental quality, the industry has to adopt environmentally and commercially established technologies/ techniques for reducing discharges and emissions, taking into account their economic feasibility.

Although the Best Available Techniques (BAT) usually depend upon the size of the plant, type and amount of discharge and the prerequisites, some of the technologies/ techniques suggested for application are discussed in this article. An effort has also been made to focus on source-of-pollution control methodology to maintain Indoor Air Quality (IAQ) and to meet the upcoming challenges of climate change and regulatory requirements of different industrial stack emission and fugitive emission limits in work zones. The key suggestions made include a simulation study to predict the possible future effect on IAQ; emphasis has been laid on research work for development of clean and energy efficient technology.

Introduction

Pollution is one of the most important factors contributing to climate induced damage to industrial, commercial and residential building and cultural heritage. Assessments of the indoor climate, especially the room temperature, relative humidity and pollutant levels are necessary to analyze the causes and impacts of climate change externally and internally.

Every aspect of environmental pollution creates serious problems for human health and well-being. The impact of environmental factors like air, water and noise pollution on human beings and ecology is well known.

The design needs of an industrial ventilation system can be placed in a hierarchy based on the same principles as Maslow's hierarchy of human needs:

About the Authors

Prakash Kumar is a B. Tech. from NIT Nagpur.

S. G. Saha, a B. Tech. from Calcutta University and M. Tech. from IIT Kharagpur, is DGM Fluid System & Piping Division.

C. D. Goswami, a B. Tech. and M. Tech. from NIT Durgapur, is a BEE Certfied Energy Auditor and heads Environment Engineering as DGM.

Kamal Sarkar is a B. Tech. from B. E. College and M. Tech. from, BIT Mesra, Ranchi.

Figure 1: Increasing temperature of the surroundings affects indoor air quality

- Energy Efficiency
- Reliability
- Control
- Safety

Safety is the lowest level and fundamental consideration. Energy efficiency is the last of the design needs, but is nowadays being focused as an important aspect while taking a procurement decision, considering its life cycle effects.

The indoor climate is often directly influenced by the outdoor climate. Computer simulation is one of the methods which can support this comprehensive investigation, and its results can be used to predict what the future risks will be for built heritage, cultural collections and quality of life.

Aspects of Indoor Housing Environment

The internal housing environment which consists of heat, ventilation, water supply, sanitation and so forth affects the physical, emotional and mental states of the occupants. An individual living in a house needs to be protected against the elements of heat, cold, diseases, insects, harmful chemicals and other hazardous substances present in the house.

Apart from these, the other notable factors that affect indoor climate[1] and environment include temperature of walls, floor, ceiling, furniture, air, moisture, heat radiation, light and sound.

Factors Affecting Indoor Air Quality (IAQ)[2]

Heat Waves

Higher air temperatures have many consequences for the indoor environment. They lead to heat waves, increased use of air conditioning and higher ozone concentrations.

Figure 2: Climate change may force change of habitats for several species

Figure 3: Pollutant emission from a thermal power plant

Increase in the use of air conditioning increases energy uses and consequently, the carbon footprint. Therefore, there is a need to use air conditioning as effectively and efficiently as possible and to explore alternatives to the use of traditional air conditioning.

Climate Change

Climate change may worsen existing indoor environmental problems and introduce new problems. There are opportunities to improve public health while mitigating or adapting to alterations in indoor environmental quality induced by climate change.

Climate change can affect these factors in various ways:

- Changes in the outdoor concentration of a pollutant due to alterations in atmospheric chemistry or atmospheric circulation affect its indoor concentration.
- Measures to reduce energy use in buildings, such as lowering ventilation rates, may cause higher exposure to pollutants emitted from indoor sources[3].
- Additionally, power outages – caused by power cuts, heat waves or other extreme weather events – could lead to the use of portable electricity generators that burn fossil fuels and emit poisonous carbon monoxide.

Major Pollutants

Many major pollutants can trace their origins to the Industrial Revolution. Some of the critical pollutants are described below:

Allergens

Elevated carbon dioxide (CO_2) concentrations and higher temperatures can promote growth and earlier flowering of some

Figure 4: Particulate matter waiting to be inhaled

plant species, greatly extending the pollen season. Pollen is an important trigger (and possible cause) of asthma.

Gaseous pollutants, particulates, microorganisms and ionized radiation are some major elements that have a severe impact on air quality affecting indoor environment.

Diesel

Diesel pollution can be identified in the form of black exhaust coming out of a vehicle. Diesel is a mixture of more than 40 toxic chemicals and substances that have been linked to cancer, asthma and other health conditions.

Formaldehyde

Formaldehyde is commonly used in the manufacture of pesticides, insulation and disinfectants. It has been linked to cancer, and possibly leukemia and asthma. Much of the formaldehyde emission comes from the lumber industry, which uses adhesives to make plywood. If products containing formaldehyde are being used, the area should be ventilated; wood or wood fixtures with particleboard should be laminated or coated.

Particulate Matter (PM)

Inhaled microscopic bits of particulate matter invade the lungs and impair their proper functioning. Also known as soot, particulate matter is mainly produced by burning fossil fuels including oil, diesel, coal and gas. The worst offenders are usually wood stoves, vehicles, power plants, industrial boilers, iron and steel plants.

Benzene

It is a carcinogen used in items such as motor fuels, solvents, detergents and pesticides. It has been known to cause leukemia and other illnesses. It is found at gas stations and in cigarette smoke, including passive smoke zone. People who work in plants and refineries are often exposed to high amounts of benzene, which is used as a solvent for other chemicals. One way to reduce exposure to benzene is to step away from the gas pump when filling the tank.

Table 1: National Ambient Air Quality Standards[4]

S. No.	Pollutant - annual weighted average	Industrial, residential, rural and other area – annual average	Ecologically sensitive area – annual average
1.	Sulfur dioxide (SO_2), µg/m³	50	20
2.	Nitrogen dioxide (NO_2), µg/m³	40	30
3.	Particulate matter (size less than 10µm or PM10 µg/m³	60	60
4.	Particulate matter (size less than 2.5µm or PM2.5 µg/m³	40	40
5.	Ozone (O_3) µg/m³	100	100
6.	Benzene (C_6H_6) µg/m³	5	5

(Source: Ministry of Environment and Forests [MOEF]-2009)

Table 2: Industrial Emission Standards[5]

Steel Plant		
Parameter	**Existing units**	**New units**
(i) Stack Emission		
PM (mg/Nm³) - dedusting	100	50
SO_2 (mg/Nm³)	250	200
NO_x (mg/Nm³)	150	150
CO (vol/vol)	1%	1%
(ii) Power Plant		
Particulate matter (mg/Nm³)	150	150
Power plant less than 62.5 MW	350(mg/Nm³) Installed before 1982	-
(iii) Fugitive Emission (Work Zone Pollutant Level in Steel Sector)		
Particulate matter (mg/Nm³)	4000	3000
SO_2 (µg/Nm³)	200	150
NO_x (µg/Nm³)	150	120
CO (µg/m³) - 8 hours average	5000	5000
Lead (µg/m³)	2	2

(Source: MOEF-2009)

Ground-level Ozone

The ozone layer in the sky has served as a protective layer from harmful sun exposure. However, ground-level ozone causes pollution and can lead to health problems. It forms when nitrogen oxides and other pollutants emitted by fossil-fuel burners like vehicles and power plants react with sunlight to form smog.

Allowable norms of pollutants in ambient air as well as in industrial steel and power plants as per Central pollution Control Board (CPCB) guidelines are described in *Table 1* and *2*.

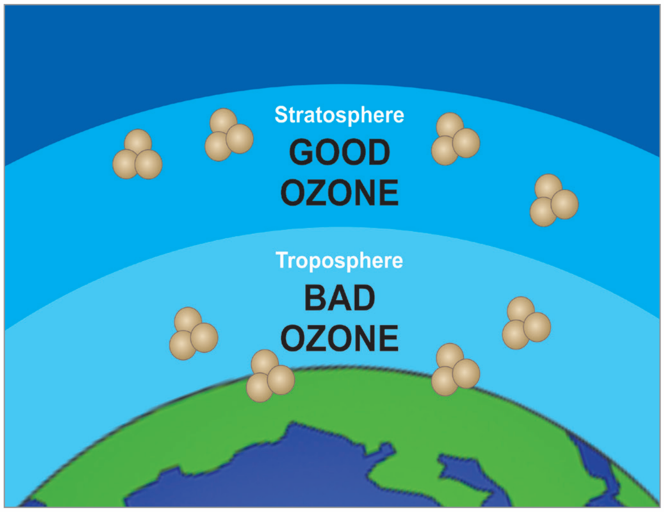

Figure 5: Ozone in the stratosphere protects the earth, but is harmful in the troposphere

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In general the height of each process stack should be a minimum of 30 meters or as per the formula $H=14(Q)^{0.3}$ (whichever is more), where

$Q=SO_2$ emission from stack in kg/hr

H= Height of stack in m

For coal based power plants of 500 MW, a stack height of 275m and for 200 ~ 500 MW, a stack height of 220m is stipulated.

Control Methodology for IAQ

Industrial pollution and consequent human effect is controlled fundamentally by three methodologies i.e. source, transmission path and receiver control. The best way to control the source is by improvement in technology. Research and innovations are encouraged for improvement in technology to minimize pollution at source. In India, the power and steel sectors are focused as the major contributors to climate change. Policy measures are taken to minimize the effect on environment and consequent indoor air quality. Some of the policy measures introduced for the power and steel sectors for environmental performance improvement are discussed below.

Power Sector

The high ash content in India's coal affects the potential emissions of thermal power plants. Therefore, MOEF has mandated the use of beneficiated coals whose ash content has been reduced to 34% (or lower) in power plants in urban, ecologically sensitive and other critically polluted areas. Coal beneficiation plants have rapidly grown in India, with current capacity topping 90 MT. *Table 3* explains the environmental performance improvement with beneficiated coal.

Table 3: Performance of beneficiated coal w.r.t run of mine coal[6]

Parameters	Run of Mine Coal	Beneficiated Coal	Improvement
Plant utilization factor	73%	96%	31.51%
Specific coal consumption	0.77 kg/ kWh	0.533 by kWh	28.15%
ESP dust load gm/Nm³	ESP inlet 29.78	ESP inlet 17.23	42.14%
Dust emission mg/Nm³	ESP outlet 157	ESP outlet 29.9	80.96%

The emphasis for coal-based projects will be on supercritical and ultra supercritical. The benefits of supercritical and ultra supercritical power plant are explained in *Table 4*.

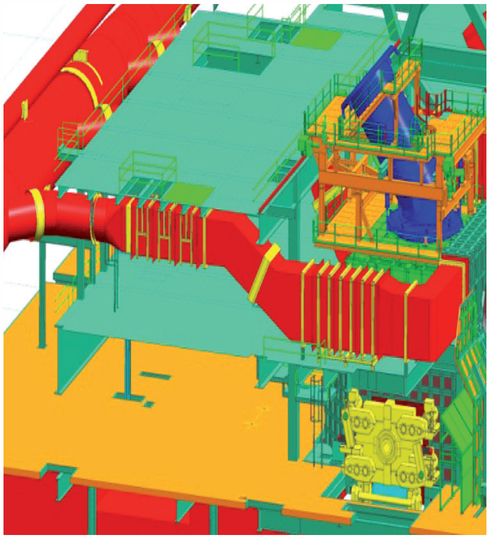

Figure 6: Modern fugitive emission control in basic oxygen furnace at Bhilai Steel Plant

Figure 7: Existing practice of steel making is a cause of fugitive emission

Table 4: Performance improvement of supercritical and ultra supercritical power plant[6]

Parameters	Subcritical	Supercritical	Ultra super critical
Plant efficiency (%)	34	37	41
Fuel consumption reduction	0	8	17
CO_2 emissions, gm/kWh	1008	926	835
NO_x emissions, gm/kWh	2.41	2.22	2
SO_x emissions, gm/kWh	7.43	6.82	6.16
Particulates, gm/kWh	0.19	0.17	0.15

Natural gas could be considered the most environmentally friendly fossil fuel, because it has the lowest CO_2 emissions per unit of energy and is suitable for use in high efficiency combined cycle power stations.

Steel Sector[7]

The following policy measures are considered as best available technology (BAT) in the Iron and Steel sector for environmental mitigation measures:

- By-product fuel gas cleaning plant (GCP) – coke oven gas (tar and sulphur removal)[8], blast furnace and Basic Oxygen Furnace (BOF) gas (particulate matter removal) with efficient scrubbing, and wet ESP installation. There is a recent trend towards installing dry GCP with bag filters or ESP for improving efficiency and conserving energy.
- Installation of Top Recovery Turbine (TRT) for blast furnace, heat recovery of stove waste gas heat for combustion air preheating.
- Recovery type BOF converters to be installed in new plants or expansion projects.
- In respect of Electric Arc Furnaces and Induction Furnaces, provision to be made for collecting the fumes before

discharging the emissions through the stack.

- It is essential that the stack constructed over the cupola beyond the charging door and emissions be directed through the stack, which should be at least six times the diameter of the cupola.
- Slag treatment, preferably by means of granulation where market conditions favour. Condensation of fumes or equally effective method to be used, if odour reduction is required.

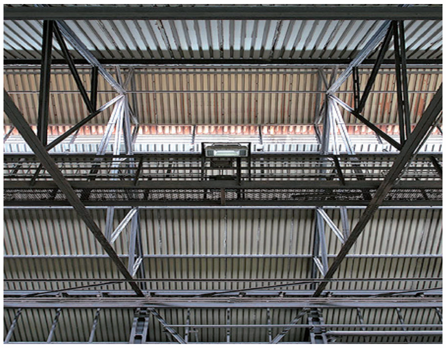
Figure 8: Natural ventilation of blast furnace cast house


Figure 9: Forced ventilation and fume extraction of cast house

Control of Fugitive Emissions

- Fugitive emissions from material handling, conveying and screening operations to be evacuated in closed systems and extracted by dual fluid dust suppression system, fabric filters, ESPs or equally effective methods.
- Existing pollution control systems to be operated as an integral part of production to ensure minimum emissions. Timely evacuation of dust (from dust catchers, ESPs, bag filter hoppers etc.) should be routinely organized.
- Fugitive emissions should be controlled by controlled wetting and/or the use of crust formers for open stock pile bed.
- Blast furnace flue dust and power plant ESP dry dust collected within the dust catchers should be evacuated using closed vessels or by employing equally effective methods to minimize fugitive dust.

Ventilation

Proper ventilation is now a basic necessity in all types of houses. It helps in maintaining the thermal environment that allows adequate heat loss from the body, removes unnecessary gaseous chemicals, smoke and dust and permits proper aesthetic sensibility within the home environment. Heat loss is controlled by air temperature, relative humidity, air movement and mean radiant temperature of the surrounding walls. Odours that are not removed in a poorly ventilated area affect the well being of the individuals.

In several houses, particularly in less developed countries and rural areas, there is no provision of ventilation in the kitchen. This creates a serious situation of indoor pollution affecting the health of women working in the kitchen. The other parts of the house are also polluted by this.

Air Pollution Control Systems

Ventilation does not solve all the problems, but source control must be implemented as a primary measure to control exposures, both as regards outdoor air (to be cleaned with relevant filtering) and indoor air (emissions from building to be controlled). Ventilation is then an ultimate measure to reduce exposures when all other possible measures to reduce health risks have been implemented. It is also important that the ventilation system be kept clean; ventilation should not become a source of pollution.

Industrial process systems consist of the process equipment that generates the pollutants, the air pollution control equipment that removes them, and the fan that moves the gas stream. The process equipment and the air pollutant control devices do not work independently; the operating conditions of all the system components are closely linked together by the fans, hoods, and ductwork.

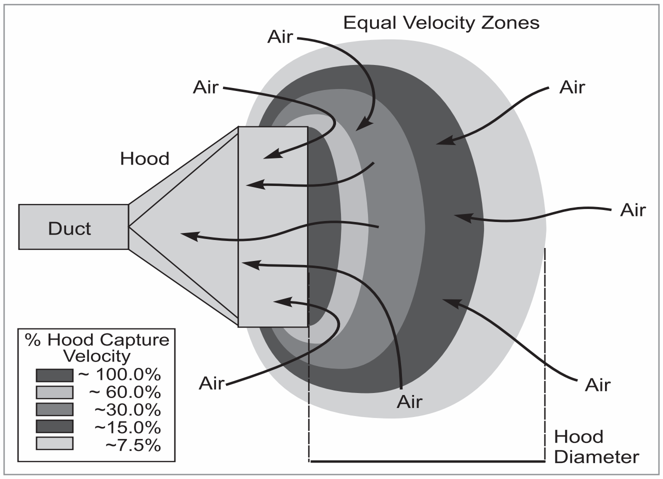

Figure 10: Conventional hood capture velocity

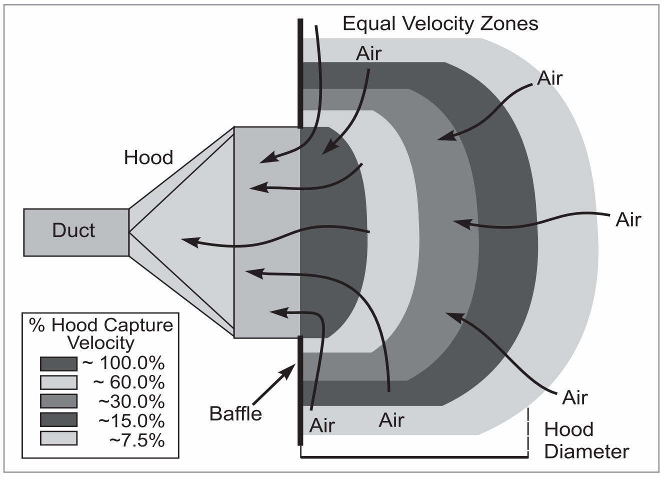

Figure 11: Improved hood capture velocity

Hoods and fans can influence the efficiency of the air pollution control equipment and the release of fugitive emissions from the process equipment.

The capture velocity of a hood is defined as the air velocity at any point in front of the hood or at the hood opening necessary to overcome opposing air currents and to capture the contaminated air at that point by pulling it into the hood.

Hoods and fans can influence the efficiency of the air pollution control equipment and the release of fugitive emissions from the process equipment. In a conventional open hood suction approximately one-hood-diameter away from the hood entrance, the gas capture velocities are often less than 10% of the velocity at the hood entrance *(Figure 10)*. Side baffles or flanges can be used to restrict the flow of clean air into the hood *(Figure 11)* and improve the capture velocities almost twice.

Other Factors

Daylight from the sun and the heat provided by it are crucial factors for placement of the structure on the site. At least one hour of sunlight exposure per day per room on a clear day is a must to make indoor environment of the house healthy.

In site selection and house building, it is essential to have free circulation of air in and around the building. It helps to improve the indoor thermal environment by induced natural ventilation and reduce the cost of air conditioning and exhaust. Site selection must also take into account the external noise sources. A site where the noise level crosses 50 dB(A) in the outside environment should not be preferred.

Conclusions

Further investigation is required to be carried out to build a better methodology to predict the accepted indoor environment. Identification of the most important agent of deterioration due to indoor environmental changes starting from the early stage can help to mitigate and reduce the risk of predicted damage process in the future. Further, potential adaptation strategies can be proposed for future safeguarding purposes on the selected objects.

Climate change influences indoor environmental quality, warranting attention and action.

Awareness of the many connections between climate change and Indoor Air Quality is relatively new. The changes in climate may necessitate changes in the way that we manage indoor environments in new and existing commercial and public and residential housings.

In particular, the challenge will be to manage indoor air in the face of generally warmer outdoor air temperatures without increasing our carbon footprint, thereby exacerbating climate change.

Now on air pollution control technology, implementation of hybrid dedusting i.e. ESP, bag filer or scrubber in combination, will be a real challenge for the industry to maintain the regulatory requirement for stack emission.

For sustainable development of the country with inclusive growth, Indoor Air Quality and Climate Change Control mitigating measures are the prerequisites. This can be ensured only with an approach of due emphasis on the 5 Es: Energy, Equity, Environment, Efficiency, and Enterprise – for maximizing the common good and improving the quality of life.

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