

CHAPTER 11

AIR POLLUTION CONTROL

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Air Pollution Control

Introduction

Most of anthropogenic activities generate contaminants that pollute the air with potential adverse effects on human health and the environment. To overcome this problem appropriate air pollution control measures have to be developed and implemented. This Chapter gives a general overview of air pollution control from industrial sources.

The setting of standards as provided by appropriate legislation and the administrative processes achieving those targets are briefly discussed. Selected desulphurisation methods are given as examples of sulphur dioxide reduction from coal-fired power station. The reduction of nitrogen oxides also discussed.

General Overview

The economy of most nations around the globe is dependent on the use of fossil fuels and/or the exploitation of mineral resources. These activities create air pollution problems that have potential adverse effects on humans and the environment.

Studies have shown that people living in polluted air are likely to contract certain diseases as compared to those living in clean air conditions. Air Pollution has been linked to lung cancer and other respiratory diseases. Asthmatics are known to have their problems aggravated by exposure to low levels of certain air pollutants.

The *weathering* of stone wall and *corrosion* of metals by acid deposition is another example of how air pollution can damage property. Adverse effects of *acid rain on forest and aquatic life* has been documented in North America and Europe. The *major precursor of acid rain is sulphur dioxide emissions* from the combustion of fossil fuels. It is therefore *important to control air pollution for the protection of human health and the environment.*

This Chapter gives *an overview of controlling air pollution from industrial sources.* It briefly describes the regulatory and technological aspects of air pollution control. It should be pointed out that air pollution control technology is quite expensive and is often economic to install on big plants. A precaution should also be taken that an air pollution is not transformed into another problem that might even be more detrimental to the environment.

Controlling Air Pollution

Strategies

Efforts to control air pollution can only be meaningful under the provisions of an appropriate legislation and policies. Legislation forms a basis for the establishment of an air pollution regulatory agency. This agency would then be responsible for development and implementation of air pollution control programmes which will include among other things, the following key issues:

- i) Standard Setting;
- ii) Compliance Enforcement and Monitoring; and
- iii) Environmental Evaluation Process.

Standards

The regulated community needs to know exactly what is required of them by the regulatory agency. This need is best met by *setting air pollution standards*. The standards may be *generalised to apply to categories of similar facilities* or it may be *in the form of guidelines* that will be used by the regulatory agency how to develop and apply the standards to individual industry on case-by-case basis. This is usually achieved through a permitting process.

Botswana uses this approach. Standards may be classified as ambient, emission or discharge, and design standards. Environmental Law Institute explains these standards as shown below.

Design Standards: The design standards prescribe technologies to be used in particular industrial operations. These standards have advantages and disadvantages of their own.

Advantages

- Set clear requirements that apply to the regulated entity;
- The results are predictable; and
- Relatively easy to enforce.

Disadvantages

- Not flexible as to how the air pollution goal should be met;
- Do not allow for innovation which might be essential for pollution prevention;

- ❑ If the prescribed technology is not of the desired level of capability, environmental quality may not be achieved; and
- ❑ Embody a lack of incentive for voluntary compliance.

Ambient Standards: The *ambient standards or air quality standards express the desired level of the quality of the ambient air which the particular pollutant or pollutants should not exceed.* These standards usually refer to the concentration of the pollutant in the air as it is taken up by the receptor. For this reason it is necessary to determine what emission quantities from a source will ensure that these standards are complied with. This is achieved through the use of air pollution dispersion models. The models simulate the physical processes in the atmosphere and calculate ground level concentrations. The input data into the model comprise of height of discharge point above ground, temperature of the waste gases, exit velocity and meteorological parameters such as wind speed and atmospheric stability.

Advantage

- ❑ They are related directly to the environment to be protected.

Disadvantages

- ❑ Difficult to determine what industrial process resulted in the violation of the standard;
- ❑ It is often difficult to determine what level of discharge is required to meet the standard; and
- ❑ Because of the above disadvantages ambient standards are difficult to enforce on their own.

For these and other reasons, ambient standards are always used in combination with more specific design or emission standards. They are often used in determining design and emission standards. In addition, if design or emission standards are not sufficient to keep an individual emission – or group of emissions – from violating the ambient standard, stricter limits will be imposed that will ensure that the ambient standard is not violated. This combination of standards help to ensure both that the ambient environment is not excessively polluted and that a predictable and enforceable standard can apply to each regulated entity.

Emission Standards: Standards may be expressed in terms of what pollutants may be released into the environment by a particular source. These standards measure the amount of pollution permissible at the “end of the pipe” – ie, at the point when the pollutants are discharged by the source into the

atmosphere. The advantages and disadvantages of emission standards are listed below.

Advantages

- The make compliance and enforcement is quite straightforward;
- Indicate a clear point where the level of pollution can be measured; and
- Dictate exact performance expectations for the regulated entity.

Disadvantages

- Determination of appropriate emission standards is not straightforward; and
- The standards are linked to the receiving environment by extrapolation.

Practice

Once the standards have been set, air pollution can be controlled in three ways to meet those standards:

- Preventing pollutant from forming at source;
- Dispersing the pollutants in the atmosphere in such a way that ground level concentrations are within acceptable levels; and
- Removing the pollutant from the waste gases before discharging them into the atmosphere.

(a) *Air Pollution Prevention:* This may be achieved in several ways:

- Changing the raw materials.
- Changing the production process.
- Changing the equipment.
- Improving operation and maintenance practices.

(b) *Dispersing the Pollutants:* The aim of this approach is to dilute pollutant concentrations to acceptable levels before they reach the exposure unit. This may be achieved by:

- increasing the chimney height; and
- moving the plant.

(c) *Pollutant Removal:* The pollutant is removed or collected from the waste gases.

It is often necessary to use more than one method in order to meet the

standards.

Controlling Gaseous Emissions

Industrial emissions are predominantly sulphur dioxide (SO₂) and nitrogen oxides (NO_x) from the combustion of fossil fuels. The SO₂ arises from the oxidation of sulphur contained in the fuel. There is no other source of SO₂ from the combustion of sulphur containing fuel other than the oxidation of the sulphur itself. With NO_x the situation is somewhat different. There is the oxidation of the fuel nitrogen to nitric oxide (NO) of course, but there is also the oxidation of the combustion air leading to the formation of nitrogen dioxide (NO₂). This depends on temperature and the amount of excess air used.

Several control measures for SO₂ and NO_x exist. These may be *preventive* (addressing the problem at the source) or *end-of-pipe techniques*. The following is a brief description of selected methods.

Preventive methods for SO₂: These may entail the removal of sulphur from the fuel. Perhaps the simplest one is coal beneficiation. The sulphur in the coal is in two forms:

- ❑ Pyritic sulphur, which is associated with the mineral impurities (usually iron pyrite in the coal); and
- ❑ Organic sulphur, which is the one chemically combined with the carbon in the coal.

The sulphur associated with mineral impurities is removed by cleaning the coal. The coal is crushed into fine particles and passed through a heavy media separator. Because of differences in specific gravity the coal floats on top of the separating medium and the mineral impurities sink to the bottom. How much sulphur containing mineral impurities can be removed this way depends on the amount and form of sulphur present. This varies widely with the origin or location of the coal deposit.

The organic sulphur can be removed only by changing the chemical structure of the fuel.

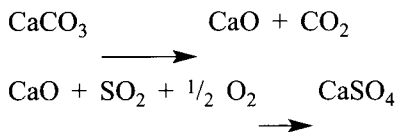
Desulphurisation During Combustion: The reduction of SO₂ emission may be achieved by the addition of limestone into the boiler together with coal. The alternative stages of limestone introduction (CaCO₃) into the system is shown in Figure 11.1. The addition of CaCO₃ into the boiler represent desulphurisation during combustion and the addition at the scrubbing representing flue gas desulphurisation (FGD).

Desulphurisation: After Combustion the flue gases may be treated to reduce

their SO₂ content to acceptable levels in an FGD plant. The main requirement of the plant is that the flue gases be brought into intimate contact with the absorber material which is usually in the form of a liquid or slurry. This is usually achieved by a counter-current flow system where the flue gases are introduced through the bottom of the absorption tower and the absorbing material at the top. These FGD scrubber plants are designed such that they meet specific SO₂ removal requirements which are influenced to some extent by plant size.

In its simplest form an SO₂ absorption unit will have a tower which may be packed with a suitable material. However, in industrial application the plant may be more complex than this, since there are interfering components that have to be removed before the SO₂ removal process could begin. Sometimes a unit operation for the regeneration of the absorbing material for recycling may be required adding further complexity to the FGD plant. The regeneration unit produces concentrated SO₂ gas for the manufacture of sulphuric acid or elemental sulphur. The plant configuration, however, may be dictated by operating conditions.

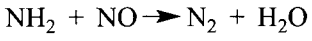
There are several FGD systems in the world but the limestone/gypsum process seems to be the most favoured for a large combustion plant. A slurry of limestone in water is used as an absorber and the SO₂ in the flue gas reacts with the limestone to form calcium sulphate or gypsum which is a marketable product. Sulphur removal efficiencies of 90% and over are normally achieved (2). The gypsum is used for the manufacture of plaster boards and other building materials.



NO_x Control: The control of nitrogen oxides can be achieved by changing the combustion conditions and burner design as well as by flue gas denitrification. Staged combustion can reduce NO_x in flue gas. In this process the fuel is initially burned with less air than stoichiometrically required. Secondary combustion air is introduced at a later stage to complete the combustion. Low NO_x Burners used in utility boilers employ this technique. There are several ways of NO_x removal from the flue gases.

Ammoniate Infection: Nitric Oxide (NO) is converted to molecular nitrogen as shown by the following simply reaction.

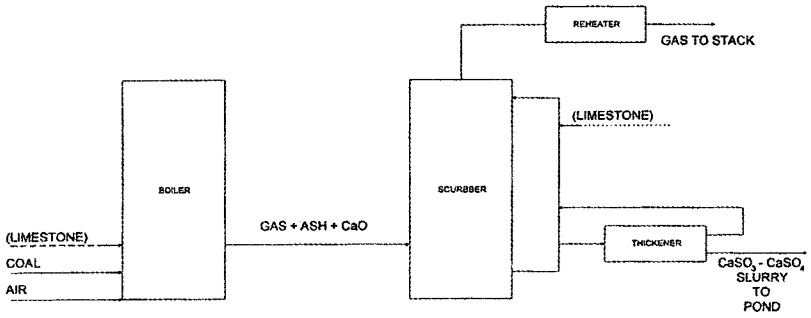




This process is temperature sensitive and will operate between 900 - 1100°C.

FIGURE 11.1

REMOVAL OF SO₂ FROM FLUE GASES BY LIMESTONE SCRUBBING



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