PRACTICAL APPROACH TO SOx and NOx MEASUREMENT

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The sustainment of all living things is due to a combination of gases in defined proportion that collectively form the atmosphere. Any increase or decrease in percentage of these gases will cause imbalance and can be harmful for survival. Emission of gases that contain Sulphur oxides (SOx) and nitrogen oxides (NOx) are the main source of the acidifying substances in the environment. The pollution norms for these are becoming stricter day by day. In recent years the emission norms for SOx and NOx for Thermal power plants have been revised to 100 mg / Nm^3 for all plant installed from 1st January 2017. In view of this, accurate measurement of SOx and NOx in the flue gases is very important.

The principles which are being commonly utilised for measurement of SOx and NOx are

- Infrared (for analysing SOx, NOx, CO and CO_2)
- Chemiluminescence (for analysing NOx)
- Ultraviolet florescence (for analysing SOx)

When a molecule of sample gas is exposed to infrared light, it absorbs some of the light and thus gains energy to vibrate and rotate. As a result, the infrared absorbing gas expands. The wavelength region in which a gas absorbs light is unique to each gas. By measuring the intensity of infrared light that travels through the gas the concentration of a gas can be determined. The analysers with infrared technique are generally used when concentration of SOx and NOx to be measured is relatively high (> 100 ppm). Analysis of CO and CO_2 is mostly carried out using infrared principle.

Chemiluminescence technique is used to analyse NOx. Total oxides of nitrogen (NO_x) can be measured using this technique by passing the sample over a heated catalyst to reduce all oxides of nitrogen to NO. NO will oxidize to NO_2 in the presence of O_3 as it is relatively unstable molecule. Certain quantity of light is produce for each NO molecule which is reacted in this reaction. This light can be measured using a photodiode tube and associated amplification electronics. The intensity of light in the measurement cell is proportional to the mass flow rate of NO_2. The chemiluminescence reaction of NO to NO_2 is

$NO + O_3 ==> NO_2 + O_2 + Light$

Ultraviolet florescence method is used for analysing SO2. This method is based on the principle that SO2 molecules absorb ultraviolet (UV) light and become excited at one wavelength,

SO2 + UV light at one wavelength = $SO2^{\#}$ (Excited)

Then decay to a lower energy state emitting UV light at a different wavelength.

$SO2^{\#}$ = SO2 + UV light at another wavelength

The intensity of fluorescence is proportional to the SO2 concentration. The sample gas is passed through the hydrocarbon scrubber which removes hydrocarbons contained in sample gas, which are excited with UV light and consequently emit fluorescence. The SO2 molecules pass through the hydrocarbon scrubber unaffected.

There are various criteria which governs the mounting arrangement for analysers. Two types of mounting arrangements are practiced in the industries i.e. In-situ and Remote.

In in-situ the sample probe along with complete analyser is mounted near the measurement location in field i.e. on the stack. In remote arrangement the sample probe is mounted at the point of measurement, the sample is transported to an analyser mounted remotely in analyser shelter, sample is conditioned and then presented to the analyser.

Both the arrangements have some pros and cons. In-situ type of measurement have advantages such as

- It takes the advantage of temperature of sample gas contained within the stack.
- It is lower in cost compared to the remote arrangement
- It does not have any filter or sample conditioning components to be maintained
- As we are not removing the moisture from the sample it reduces the risk of water soluble components which can affect the measurement

Some of the disadvantages of in-situ arrangement are

- As the complete assembly is very bulky, it is difficult to remove without proper handling arrangement.
- Its window needs to be cleaned quite often
- As the ambient temperature near the stack is quite high, the performance of analyser may be affected.
- It is very difficult to carry out maintenance in harsh environment near the analyser.
- In-situ components may not be available for all harsh measurement tasks.
- When sulphur content in the sample is very low (< 100 ppm) the in-situ analyser becomes more bulky hence not preferred.

Remote type of analyser system has following features

- They are more complex and costly compare to in-situ arrangement.
- We have to install sample line to bring sample from stack to analyser located remotely in analyser shelter.
- As the analyser is mounted in shelter away from stack, it is much easier and safe to perform maintenance on the analyser.
- Response time is slow compared to in-situ arrangement as sample has to be transported to analyser located remotely.
- Remote type of arrangement involves two methods for getting the sample to analyser.
  - ✓ Hot extraction and
  - ✓ Dilution

In hot extraction method the sample is extracted through sample probe and transported using sample tube. The sample is passed through the sample conditioning skid before it is presented to analyser. Moisture in the sample can create significant problems. If the moisture is not condensed properly and removed it may forms acid mist and may lead to corrosion or plugging in sampling system. The sample tube needs to be heated so that no condensation occurs in sample tube. It involves generally high maintenance compared to dilution method.

In dilution method clean dry air and eductor is used to extract diluted sample, this diluted sample is transported to analyser located remotely in analyser shelter. It is not necessary to

remove the moisture from the flue gas sample prior to analysis by the analyser; because the problem of condensation which occurs during analysis at ambient temperature is avoided as the sample is sufficiently diluted. This method involves low maintenance and is more reliable compare to hot extraction method.

There are some general guidelines which can be considered for selecting in-situ or remote type.
In-situ type of analyser may be appropriate where.

- Proper approach and platform is available,
- Where the ambient temperature & environment condition near point of measurement is not very harsh,
- Where sulphur content in sample is high (> 100 ppm).
- Proper handling arrangement is available for inserting / removal of analyser from stack.
- Response time required is fast.
- In-situ analysers generally work on infrared principles. Hence concentration of components to be measured in the sample should be on higher side (> 100 ppm), as infrared principles are generally not suitable for low concentrations.

Remote type of analyser may be appropriate where ease of maintenance is required, the ambient temperature & environment condition near point of measurement is very harsh, proper approach and platform is not available.

When concentration of the components to be measured is high (>100 ppm), dilution method may be deployed. When concentration of the components to be measured is low, hot extraction method is preferred. In addition to the guidelines mentioned above there may be many other factors which will influence selection of type of analyser mounting and also sample extraction. The selection has to be made after thorough analysis of all the factors for specific application.

TCE has been recommending and implementing SOx and NOx measurement for various projects engineered in different sectors such as thermal power, chemical units, steel & metal industries etc.