ABB MEASUREMENT & ANALYTICS | APPLICATION NOTE

Gas analysis
for flue gas denitrification (DeNOx) plants

Components to be measured
– NO, O_2, NH_3

ABB Solutions
– LS4000 plus ACX

Measurement made easy

Background
When burning coal, petroleum products, natural gas as well as domestic and hazardous waste for energy production pollutants are created, that are emitted with the flue gas. During the combustion process significant amounts of nitrogen oxides (NO_x), one of the main pollutants, are formed. For these reasons almost, all industrialized countries have adopted laws to restrict NO_x emissions.

Typically affected:
- power plants
- waste incinerators (municipal, hazardous and sewage sludge)
- cement plants
- nitric acid plants

Gas analysis

for flue gas denitrification (DeNOx) plants

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01 Schematics of the flue gas line in a power plant

NOx Reduction - Primary measures
To reduce the formation of NO_x during combustion, the use of advanced low NO_x burners in combination with other primary measures such as flue-gas recirculation, staged combustion (air-staging), reburning, etc. can result in a reduction rate of ≤ 30 %. The use of primary measures tends to cause incomplete combustion, resulting in a higher level of unburned carbon in the fly ash and some carbon monoxide emissions.

NOx Reduction - Secondary measures
Secondary measures are end-of-pipe techniques to reduce the nitrogen oxides already formed. They can be implemented independently or in combination with primary measures such as a low NO_x burner. Most flue-gas technologies to reduce NO_x emissions rely on the injection of ammonia (NH_3), urea or other compounds, which react with the NO_x in the flue-gas to reduce it to molecular nitrogen (N_2). Secondary measures can be divided into selective catalytic reduction (SCR) and selective non catalytic reduction (SNCR).

Selective catalytic reduction (SCR)
NO_x, formed in combustion processes are efficiently reduced to water and nitrogen (N_2) in the SCR process. Ammonia (NH_3) or urea ($CO(NH_2)_2$) is introduced to the flue gases upstream of a heterogeneous catalyst where the reduction takes place. Depending on the amount of dust, type and concentration of acidic gas components in the flue gas, the SCR process is normally operated in the temperature range of 300 °C to 400 °C. As its conversion efficiency and buffer capability is high, the NH3 slip behind a SCR catalyst is normally very low, e. g., in the range of 1 ppm or below.

Selective non-catalytic reduction (SNCR)
In the SNCR process, usually ammonia (NH_3) or urea ($CO(NH_2)_2$) is introduced to flue gases in hot combustion zone where reduction of NO_x takes place spontaneously. Depending on the type of the used reducing agent, the SNCR process is usually operated in the temperature range of 800 to 1100 °C. Above the optimum temperature oxidation of ammonia to NO_x is getting significantly high and the process produces NO_x. At temperatures below the optimum, the reaction rate is reduced, thereby ammonia slip is formed.

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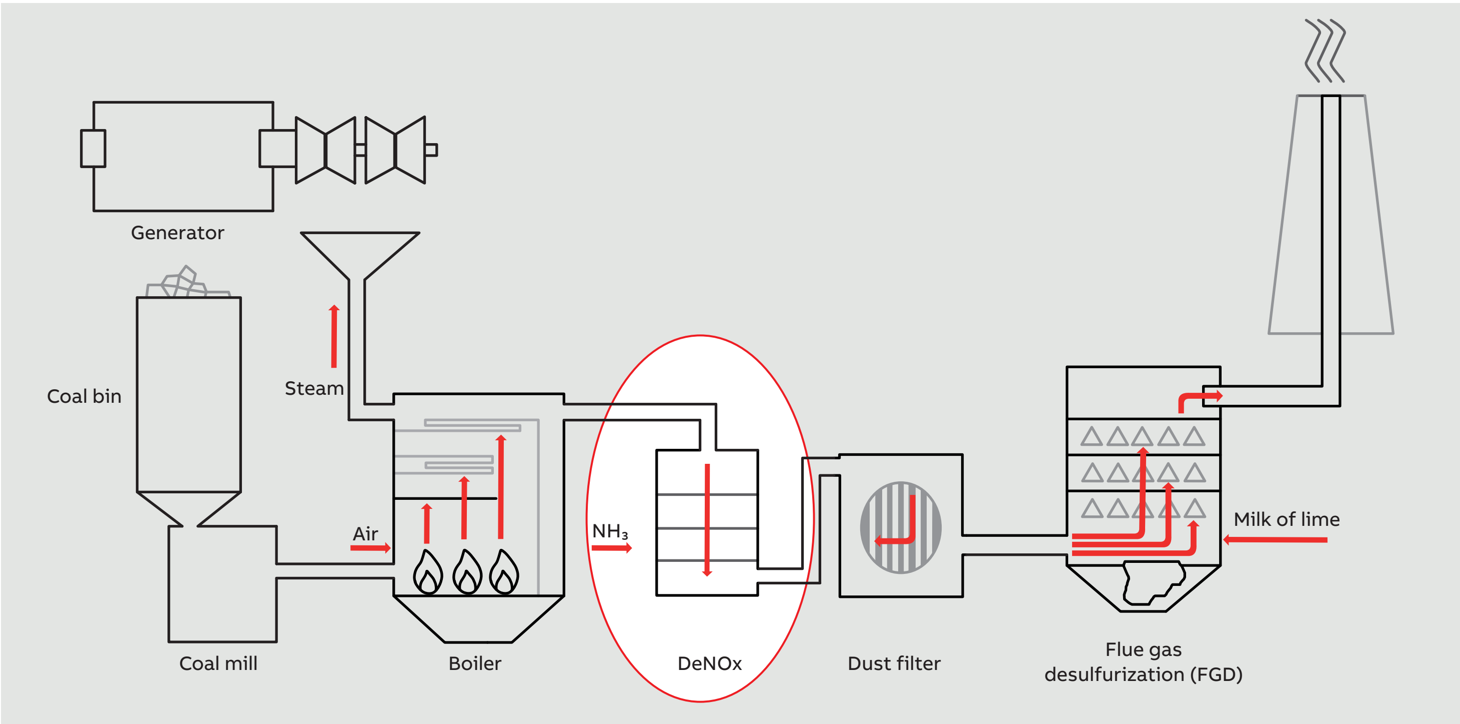

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02 Typical set-up for a SCR $DeNO_x$ plant
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03 ABB solutions

Ammonia slip

Ammonia slip occurs in further flue gas process to the formation of ammonia salts and can lead to secondary problems thereby. It has detrimental/negative impacts on equipment downstream of the SCR reactor (e. g. air preheater pluggage) and fly ash contamination. Fly ash has to fulfill requirements, if the fly ash does not fulfill the required quality it cannot be sold and is declared as waste. Typically, the ammonia slip for SCR plants is < 2 ppm; for SNCR < 30 ppm. So, the target is to minimize the ammonia slip. As the catalyst activity degrades and ammonia slip increases, a point is reached where either additional catalyst must be added to the reactor, or a portion of the existing catalyst must be regenerated or replaced with new material. If the SCR reactor is operated below the minimum operating temperature Ammonium Bisulfate (ABS) can deposit on the catalyst, resulting in reduced catalyst activity and reactor potential. Fortunately, this process is generally reversible (→ full-load operation).

Motivation

Optimum $DeNO_x$ plant control with maximum efficiency to comply with environmental regulations (minimal use of reagent and catalyst condition monitoring). Additionally, prevent harm from downstream equipment (e. g. prevent preheater clogging due to ammonia slip) and produce fly ash that can be sold because it fulfills the required quality.

Task: $DeNO_x$ Control Process

Two parameters are required for NO_x control. Measurement of:

- NO_x before catalyst (to capture fast changes)
- NO_x after catalyst

Additionally, oxygen is measured to detect leakages.
The NH_3 dosage is derived from NO_x values before and after the $DeNO_x$ plant. The NO_x and NH_3 react on a 1:1 basis. The NH_3 slip, must be minimized for several reasons.

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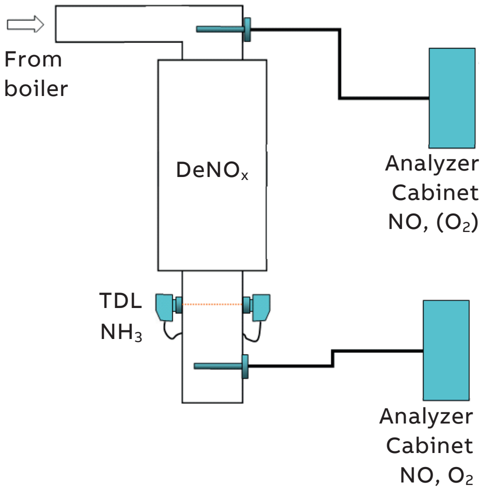

Typical measuring ranges:

before $DeNO_x$	NO:	500 to 2000 mg/m^3
	O_2:	0 to 10 / 25 Vol %
after $DeNO_x$	NO:	100 to 500 mg/m^3
	O_2:	0 to 10 / 25 Vol %
	NH_3:	0 to 10 / 30 ppm (SCR)
	NH_3:	0 to 50 / 100 ppm (SCNR)

ABB Solution

ACX is a complete system for extractive continuous gas analysis. The system can be fully operated from the outside. Inside, the well established reliable analyzers of the Advance Optima series work with the proven components for sample conditioning. The ACX system is particularly easy to maintain as a result of the standardized design.
Comprehensive digital communication allows global remote maintenance and control with Analyze^{IT} Explorer.
ACX is the ideal solution for both the upstream and the downstream measurement. In the downstream measurement the LS4000 is employed for the NH_3 measurement.

LS4000 is an in-situ laser analyzer which selectively measures the NH_3 concentration in the low ppm range.
The laser operates according to the principle of single-line spectroscopy. For measurement purposes a single absorption line is selected from the gas to be measured in the near infrared spectral range, at which no cross-sensitivity from other gases occurs. The absorption line is scanned and the receiver located opposite detects the absorption caused by the sample gas and calculates the gas concentration from this.
LS4000's cross-stack installation ensures more representative measurement than single point measurement. Local concentration spots in the duct can be detected.
Even if high dust loads might make the cross-duct measurement difficult as the light is attenuated due to scattering effects, ABB offers special technical solutions. Insertion tubes, for example, are used in order to reduce the impact of high dust loads. Please contact for a detailed feasibility check and advice.

Customer benefits

- improved efficiency
- secured economics

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LS4000

ACX

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