Combustion optimization by fast excess air control

In-situ laser gas analyzer monitors O₂ in real-time

Excess air value and combustion efficiency

Combustion is the conversion of primary chemical energy contained in fuels into heat through the process of oxidation at high temperatures. The oxygen required for the combustion is supplied as part of the combustion air that is fed to the process. In ideal (stoichiometric) combustion, the amount of oxygen supplied to the process is just sufficient to burn all combustibles completely. In real combustion, however, an excess volume of oxygen (air) must be supplied due to insufficient mixing of fuel and oxygen. This additional air volume is called Excess Air. Too high oxygen content will cause increased NOx content and energy losses through dilution with cool air. Too low oxygen content will cause increase of CO. Therefore, the excess air value is an important parameter for an optimal combustion process and economic plant operation.

In-situ laser gas analyzer

In combustion control, fast and continuous monitoring of the excess air content is a key issue for efficient plant operation. It is done by measuring the O₂ concentration in the combustion zone.

The in-situ measuring principle is best suited for this task because it provides measuring data directly from the combustion zone and in real-time for immediate reaction. The in-situ laser gas analyzer offers all capabilities for this application. It delivers fast and accurate O₂ concentration data directly from the combustion that can be further processed and used for combustion control.

This Case Study presents details of this application.
Excess air concentration indicates combustion process efficiency

**Application task**
A very important factor when optimizing a combustion process is the amount of excess air in the combustion zone, resulting in residual oxygen concentration in the flue gas.

The combustion is efficient if the fuel is burnt out to a very high extent. If too much air is fed into the combustion zone, unnecessary cooling - connected also with increased NOx emissions - is taking place. In the opposite case, i.e. under conditions of an oxygen shortage, an increase of CO emissions would be the consequence. Additional drawbacks then also would be the existence of unburnt fuel and enhanced corrosion of the vessel walls and steam tubes.

For these reasons, optimizing and continuously adjusting the amount of excess air is important for keeping the combustion process efficient. This task involves many parameters, but controlling the oxygen concentration and the combustion temperature from in-situ measurements directly in the hot combustion zone gives many opportunities.

**The analyzer LDS 6**

LDS 6 (fig. 1) is a diode laser-based in-situ gas analyzer for measuring specific gas components directly in a process gas stream.

LDS 6 consists of a central unit and up to three pairs of cross duct sensors in a transmitter/receiver configuration. The central unit is separated from the sensors by using fiber optics. Regardless of how hostile the environment is, the analyzer can always be placed outside any hazardous areas. Measurements are carried out free of spectral interferences and in real-time enabling proactive control of dynamic processes. Full network connectivity via ethernet allows remote maintenance.

**Key features include:**
- In-situ principle, no gas sampling
- Three measuring points simultaneously
- Temperature up to 1200 °C
- Ex-version available (option)

LDS 6 is designed for fast and nonintrusive measurements in many industrial processes.

**Measuring components include:**
O2/Temp., NH3/H2O, HF/H2O, HCl/H2O, CO/CO2, low ppm H2O, ...

![Fig. 1: LDS 6 in-situ laser gas analyzer](image)

**Measuring conditions**

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**Notice**
User lists are available for different fields of application. Please contact the addresses on back.

*Table 1: LDS 6 measuring conditions for combustion control*
Fast \( O_2 \) and temperature measurement directly in the combustion zone

**Application solution**
By using laser gas analyzers for in-situ measurements directly in the hot combustion zone, the oxygen concentration and the gas temperature are derived almost in real-time. Oxygen concentration and gas temperature are measured simultaneously in the same gas volume from the same set of absorption lines. The sensor pair is measuring in a path length of several meters, resulting in highly representative measurement values directly from the combustion zone. The robust sensors are connected via fiber optic cables to the central unit, which can be located several hundred meters away from the measuring point.

**User benefits**
The list of user benefits includes
- Higher process efficiency, since less excess air has to be heated up.
- Cost savings by decreased consumption of electric power on combustion air and flue gas fans.
- Less NOx emissions, less volume flows and therefore less costs for gas cleaning.
- Costs saving by detecting potential high temperature corrosion rapidly.

**In-situ laser gas analyzer advantages for combustion control**
The design of the in-situ laser gas analyzer makes it an ideal analytical tool for control of combustion processes:
- No gas sampling - the measurements take place in-situ
- All channels measure in real time for high dynamic process control
- The sensors are designed to withstand very rough industrial environments
- \( O_2 \) and temperature can be measured with the same instrument
- Up to three measurement points can be controlled simultaneously with only one instrument

**Measuring method based on \( O_2 \) single line spectroscopy lead to pure gas temperatures without contributions of particle radiation and wall effects**

**Line-of-sight measurement across the combustion zone to derive highly characteristic measurement values**

**Highest reliability and lowest cost of ownership: no consumable parts**

**Very low maintenance demands, no calibration necessary in the field**

**No cross interferences due to highly specific single absorption line measurement and dynamic dust load compensation**

**Large temperature range**

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**Fig. 2: LDS 6 measuring position for excess air control**
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