THE ROLE OF COMBUSTION IN DECARBONIZATION STRATEGIES

Karen Gargallo, Head of Application and Development at Servomex, the UK-based global expert in gas analysis, looks at how combustion control can be used to reduce industrial carbon emissions

The global effort to reduce the impact of carbon emissions on our climate is growing rapidly, driven by the 2016 Paris Agreement, the 2021 United Nations Climate Change Conference, or COP26, in Glasgow, and increasingly demanding environmental regulations.

This has led many industries to search for ways to reduce – or prevent altogether – harmful emissions from their operations, with a particular emphasis on minimizing generation of the greenhouse gas carbon dioxide (CO_2).

Industrial operators are adopting clean air and decarbonization strategies that not only meet regulatory requirements but also help them achieve their carbon reduction targets.

These strategies rely heavily on gas analysis, which is used to measure the harmful emissions created and to help reduce emissions by improving the efficiency of the process.

In any clean air policy, controlling combustion efficiency plays an essential role, lowering the level of key pollutants emitted, reducing fuel consumption, and improving safety.

To achieve these goals, accurate measurements are required for the relative concentrations of oxygen (O_2) and combustibles (COe) in the reaction mixture, to keep the ratio between fuel and air at the optimum level.

Optimizing the combustion reaction

In the combustion process, fuel is mixed with O_2 – usually from air or an enriched oxygen feed – in a fired heater. This reaction creates heat energy which can then be used for power generation or as part of a wider industrial process such as chemical manufacturing. Typically, the combustion process needs a sizeable quantity of fuel, generates harmful byproducts as emissions, and creates possible safety hazards.

Prior to the widespread use of accurate gas analyzer technologies, fired heaters were usually operated with high excess air. This was highly inefficient and increased the level of fuel consumption, but helped to avoid unsafe, explosive conditions in the heater.

Excess air also means there is extra O_2 in the process to combine with nitrogen and sulfur from the fuel, creating unwanted emissions such as oxides of nitrogen (NOx) and sulfur (SOx).

By accurately measuring the levels of O_2 and COe – and particularly the combustible, carbon monoxide (CO) – operators can balance the air-to-fuel ratio to ensure process safety and achieve optimal fuel efficiency. Controlling the combustion reaction in this way can also significantly reduce emissions of NOx, SOx, CO, and CO_2.

The SERVOTOUGH FluegasExact 2700

Using Zirconia sensing for O_2 measurements

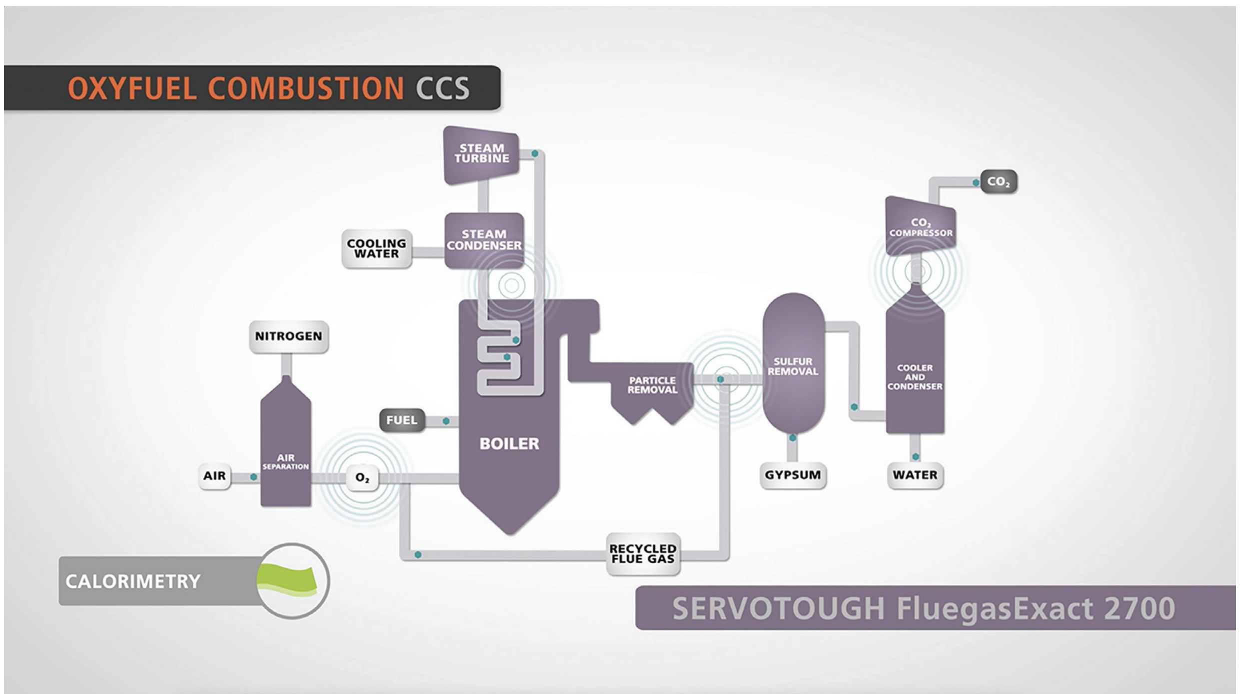
A solution based on long-established and highly trusted Zirconia sensing technology delivers reliable, accurate measurements of O_2 at parts-per-million (ppm) and percentage levels. It also has a fast response to changing conditions, making it ideal for combustion operations.

Servomex's Zirconia sensor is built around a cell made of ceramic zirconium oxide, which is stabilized with an oxide of yttrium to form a lattice structure. The measure and reference sections of the cell are covered with catalytic, porous, electrically conductive coatings that serve as electrodes on both sides of the lattice barrier between the sample and reference gas volumes.

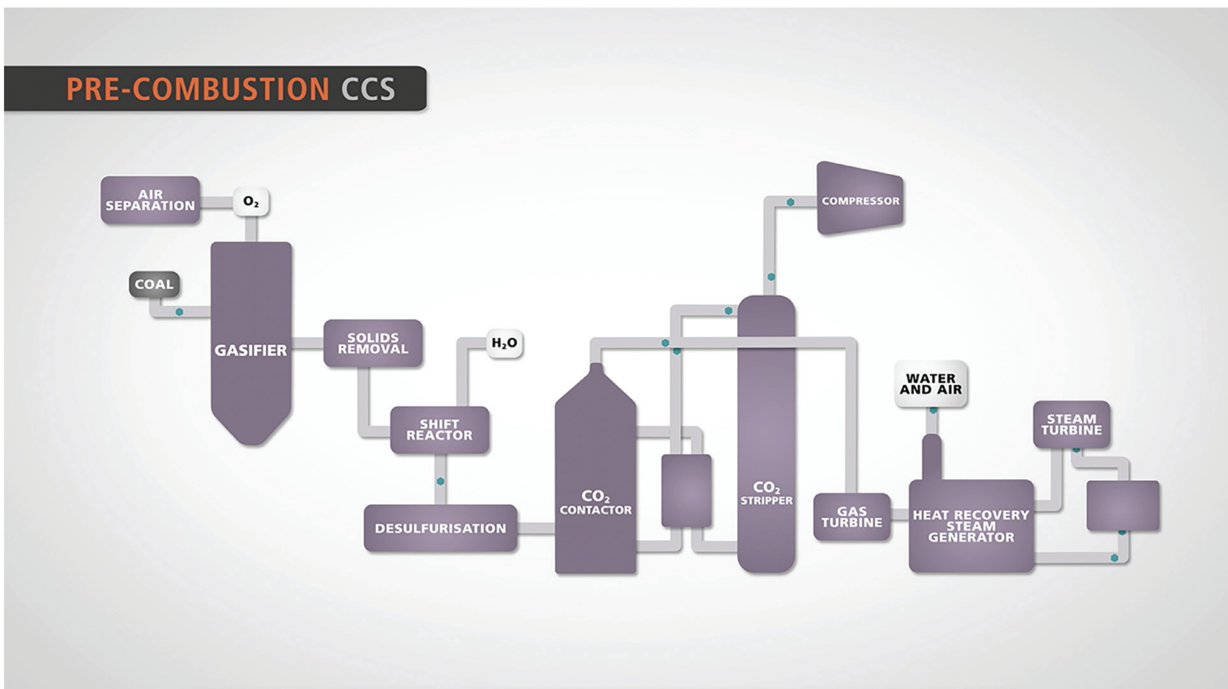
At elevated temperatures, negatively charged oxygen ions, formed at the catalytic electrodes, pass through the lattice at a rate dependent on the temperature and the difference in the O_2 partial pressures of the sample gas and the reference gas.

The passage of these ions generates a voltage across the electrodes, the value of which is a logarithmic function of the ratio of the O_2 partial pressures of the sample and reference gases.

A PTA facility



The Oxyfuel combustion process



The pre-combustion process

The partial pressure of the reference gas is predetermined, so the O_2 content of the sample gas can be determined from the voltage produced by the cell.

Servomex offers two variants of this sensor: a higher-temperature model designed to measure percentage O_2 in flue gas, and a lower-temperature version which has modified catalytic electrode properties for ppm O_2 measurements in purity applications.

The addition of a combustibles sensor

A combustibles sensor using Calorimetry technology – also known as Thick Film Catalytic sensing – can be added to a Zirconia-based gas analyzer, creating an all-in-one combustion control solution.

Calorimetry sensing provides sensitive, accurate measurements of combustibles based on the exothermic reaction of COe with O_2 over a catalytic platinum surface, which produces CO_2. The COe concentration is determined from the heat generated.

A four-quadrant bridge track is over-glazed to shield the circuit from the sample gas and two quadrants are then coated in a platinum catalyst. These quadrants form a Wheatstone bridge circuit, with the disc mounted in a cell heated to 300°C (572°F) or 400°C (752°F).

Upon the addition of a gas sample, any COe present in the sample will combust on the catalyst. This heats the respective quadrant and alters the output voltage of the Wheatstone bridge. The output voltage is directly proportional to the COe concentration, providing an accurate COe measurement.

Developing a single-device combustion solution

One of the leading examples of a combined gas analyzer for combustion efficiency is Servomex's SERVOTOUGH FluegasExact 2700 combustion analyzer. This combines both Zirconia and Calorimetry sensing in one compact device, providing effective measurements of both O_2 and COe in flue gases.

Meeting the most stringent requirements for combustion efficiency applications in the power generation and process industries, this device is easy to maintain and operate, and helps reduce flue gas emissions.

It has an integral sampling system which is custom-designed for operation in some of the hottest and most extreme industrial environments. This makes it ideally suited to the control of a wide range of combustion processes, including process heaters, utility boilers, thermal crackers, incinerators, and furnaces.

The FluegasExact 2700 uses aspirator interlocks to prevent samples from being drawn while the analyzer is heating or not up to optimum temperature. A Flowcube continuous flow monitoring sensor enables positive flow conditions to be validated, which assists in preventative maintenance.

This analyzer is designed for high-temperature processes up to 1750°C (3182°F), using an extractive measurement principle to keep both sensors out of the harsh process environment. This extends sensor lifespan significantly, and typically the Zirconia sensor will operate effectively for at least seven-to-eight years.

Rated for safe area, Zone 2/Div2 and ATEX Cat 3 locations, the FluegasExact 2700 also offers both direct and remote mounting options to ensure easier, safer access for personnel, even if the desired measurement point is not freely accessible.

There is also a specially designed sulfur-resistant Thick Film Catalytic sensor available, which is operated at a higher temperature to prevent the permanent deposition of sulfur on the sensor.

Not only does the FluegasExact 2700 create environmental benefits through its support of efficient combustion reactions, but it has also been proven to save up to four percent of fuel costs per year thanks to the accuracy and reliability of its measurements. This benefits the operator's bottom line and aids their sustainability goals by reducing the consumption of non-renewable fuels.

Using laser sensing for combustion

A more recent alternative sensing solution for combustion is Tunable Diode Laser (TDL) technology, which provides an even faster measurement for this application, particularly for carbon monoxide.

TDL analyzers provide an average result across the measurement path, rather than the single-point result given by a Zirconia analyzer, and so ensure a better overall picture of conditions within the fired heater. However, since TDL sensing is highly specific to the gas being measured, separate analyzers are required for O_2 and CO.

Servomex's SERVOTOUGH Laser 3 Plus Combustion TDL analyzer, for example, can be configured to measure either O_2 or CO. It can also be configured for a joint measurement of CO and methane, and provides a rapid-response measurement for safety in natural gas-fired heaters and boilers.

A wider strategy for decarbonization

Combustion is merely one part of any industry's decarbonization strategy; many different elements can contribute towards overall success, and gas analysis plays a key role in most of them. For example, increasing process efficiency means that fewer harmful emissions are likely to be generated.

Gas analysis is also important in gas cleaning, which removes the harmful substances from process gases that might otherwise be emitted by the plant. There are many gas clean-up processes, including DeNOx treatment, flue gas desulfurization, and carbon capture and storage.

Monitoring flue gas emissions will help determine the process efficiency and protect the environment. It also demonstrates compliance with necessary regulations. A continuous emissions monitoring system is required, measuring multiple flue gas components with the highest levels of sensitivity and accuracy.

Together, these stages – combustion and process efficiency, gas clean-up, and emissions monitoring – form a formidable and comprehensive strategy that delivers more efficient processes, supports the safe removal of pollutants, and monitors carbon emissions to the atmosphere.

Gas analysis technology will also be essential to the production of current and future cleaner energy sources, helping plants and refineries to fully address the impact of their operations on the global environment.

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