Development of continuous NOx monitoring technology for spatially resolved, real-time SCR control

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Summary

Overview

Brand-Gaus, LLC has developed a close-coupled, fast-response method of simultaneously measuring nitric oxide (NO) and oxygen (O_2) concentrations from a gas-fired process on a hot/wet basis and in the presence of ammonia. A chemiluminescence-based solid-state detector is used for NO and a zirconium oxide cell is used for O_2. This sensor technology can be integrated into an instrument that is mounted directly on a duct port, requiring no sample conditioning, heated sample lines, or stream switching equipment. It is designed such that a fully independent unit can be installed at each point of a multipoint pre/post-SCR monitoring and control system, where response time, reliability, and repeatability are of utmost importance.

With the installation of several identical, autonomous instruments across a duct face, inlet and outlet NOx distributions can be mapped spatially. This information can be used in real time to control ammonia injection, and to monitor catalyst performance (i.e. detect long term catalyst degradation).

Historical Perspective

The benefits of real-time, continuous, spatially resolved measurements of NOx for SCR monitoring and control have been long postulated and are well understood. They are far superior to aggregate stack measurement or periodic manual profiling for SCR monitoring and control optimization. However, equipment providing these measurements must perform reliably with an absolute minimum of maintenance and calibration, and provide short response times to be viable for a closed-loop control system.

Previous solutions attempted for this application have been patterned around traditional architectures used for the regulatory Continuous Emissions Monitoring Systems (CEMS), most notably in situ optical instruments, extractive systems, or dilution-extractive systems. These systems have been costly, complicated, and highly maintenance-intensive. To reduce complexity and cost, stream switching has been incorporated, but these time-sharing systems have long response times and significant reliability issues.

Brand-Gaus has recently developed a close-coupled hot, wet NO-O_2 platform that entirely removes the need for sample conditioning or time-sharing. As a result, cost and complexity have been reduced so greatly that an analyzer based on this technology can be placed directly at each monitoring point. This approach appears very promising for effective, spatially resolved, multipoint measurement of NO and O_2 in SCR applications. However, additional field testing is necessary before this concept can be fully verified.

Technical Approach

For spatially resolved, continuous, real-time SCR monitoring and control, we propose using an ex-situ analyzer, where the measurement is made in a reaction chamber mounted directly on the end of the probe. A small amount of sample is educed down the probe length where it is measured on a hot, wet basis, eliminating the need for mechanical pumps, heated sample lines, water dropout equipment, dilution pneumatics, or instrumentation that must survive within the duct. All instrumentation would be contained within an industrial J-box enclosure, approximately one cubic foot in size, that mounts directly on a duct port.

The Brand-Gaus proprietary detection technology for NOx and O2 is uniquely well-suited to a simple, reliable ex-situ design for SCR optimization for the following reasons:

- The NOx and O_2 detector assemblies have been designed so that they can be directly operated at high temperature to prevent the deposition of sulfuric acid, nitric acid, and ammonia salts.
- The instrument makes use of the field-proven chemiluminescence detection method for NOx, the method of choice for NOx monitoring due to its inherent detection accuracy, repeatability, and linearity.
- The yttria-stabilized zirconium oxide oxygen detector is a modified next-generation automotive sensor that is extraordinarily fast, accurate, stable, and robust. It has been designed for long-life operation in harsh environments, and it greatly outperforms conventional zirconium oxide instruments.
- The NOx optical detector is a modified solid-state telecommunications device, with no photomultiplier tubes, high voltage power supplies, lamps, or exposed TE-coolers – some of the most common failure points found in other NOx analyzers.
- The entire system has no valves, pumps, or moving parts.

All indications are that this detection scheme will provide the sensitivity, stability, and precision necessary for SCR monitoring with no more than quarterly calibrations.

Development and Testing Plans

Brand-Gaus has completed the initial design of a flange-mounted point monitor and will begin testing it for gas-fired SCR applications in the coming months. In parallel with this testing, a sampling system for coal-fired applications that can withstand high particulate loading will be developed.

We plan to study the suitability of this monitoring technology and the use of real-time, spatially resolved NO_x and O_2 measurements for optimization of SCR operation, including minimization of ammonia usage and assessment of catalyst activity. We intend to focus on evaluation of feed-forward control of ammonia injection based upon inlet NOx concentration, feedback control of ammonia based on measured NOx reduction, as well as long term tracking of catalyst activity across the duct. We may investigate using the spatial information to control ammonia injection at several locations across the duct, which will allow the operator to achieve NOx target reductions with minimal ammonia slip in applications where significant stratification is present.