Geosyntec consultants

Technology Brief

Advanced Real-Time Monitoring of SO_2, SO_3, H_2O and NH_3

1300 S Mint St, Suite 110
Charlotte, NC 28203
704.227.0847
www.geosyntec.com

Background

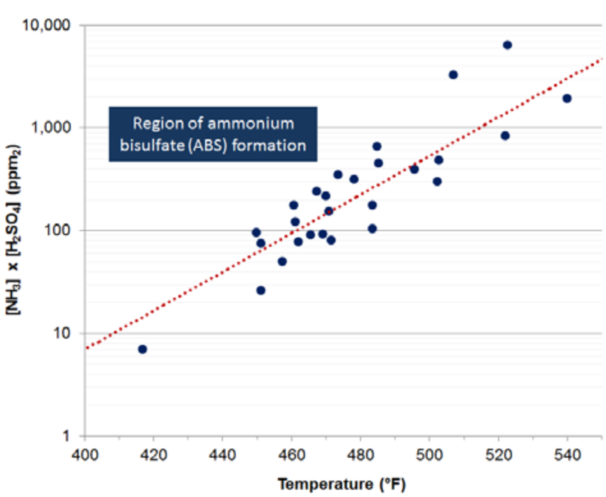
$$SO_2 + \tfrac{1}{2} O_2 \Leftrightarrow SO_3$$

$$SO_3 + H_2O \Leftrightarrow H_2SO_4$$

$$H_2SO_4 + NH_3 \Leftrightarrow (NH_4)HSO_4$$

Sulfur dioxide (SO_2) is generated in power plants from the oxidation of coal sulfur in the boiler. SO_2 can further oxidize to sulfur trioxide (SO_3) in the boiler (about 1% SO_2-to-SO_3 conversion) or downstream – 0.5-1.5% conversion in the selective catalytic reduction (SCR) reactor is not uncommon. Unfortunately, SO_3 reacts with water to make sulfuric acid (H_2SO_4) and the concentration may be high enough such that it reacts with ammonia (NH_3) from the SCR to form ammonium bisulfate (ABS). ABS, a sticky, white solid, combines with fly ash and coats air heater elements and other equipment.

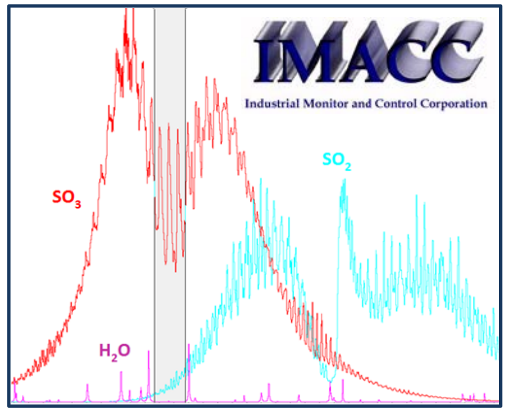
One recent report estimates that losses due to effects of sulfuric acid and ABS can be millions of dollars per year per plant after accounting for mitigation strategies, higher ΔP, load reduction, reduced thermal efficiency, faster corrosion, and more frequent outages. In addition, a combination of downstream equipment such air heaters, ESPs, baghouses, and/or FGDs cannot always remove enough SO_3/H_2SO_4 to prevent it from leaving the stack and forming "blue plume" due to sulfuric acid (H_2SO_4) aerosols.



Therefore, power plant operators need SO_2, SO_3, NH_3 and H_2O concentrations at key places in the flue gas duct to better understand, plan for, and control such issues. Plus, when the flue gas composition is better understood, the performance in the SCR, ESP, air heater and other equipment can be optimized. For example, the ammonia injection grid (AIG) can be tuned more frequently to reduce NH_3 slip at the SCR outlet; with an SO_3 mitigation system, ash collection efficiency in the ESP can be maximized when the SO_3 concentration is in the 3-5 ppm "sweet spot"; and the air heater could be controlled to just above the acid dewpoint temperature to reduce corrosion and plugging.

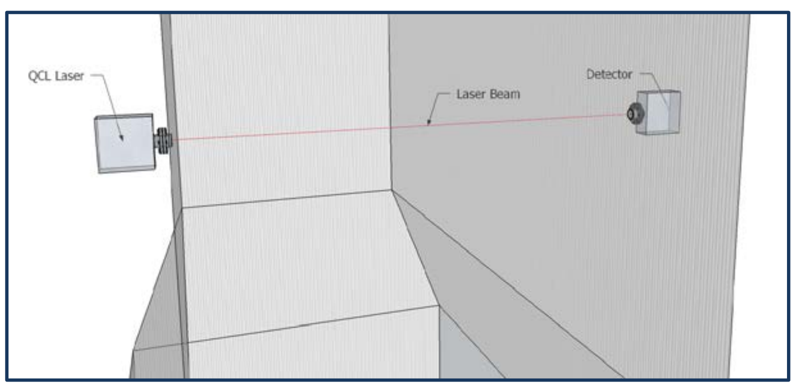
Until now, no commercial technology for direct, continuous, *in situ* simultaneous measurement of SO_2, SO_3, NH_3 and H_2O was available. For example, SO_3 measurement is often based on an extractive wet method using condensation coils, sampling from a single point in the duct with potential biases and long sample times (30-120 min) that do not capture transient behavior. Alternatively, acid dewpoint monitors are used to determine temperatures at which materials condense from the flue gas and then chemistry-based algorithms are applied to estimate flue gas composition. Tunable diode lasers (TDLs) work for NH_3 in some places but often cannot cope with dusty conditions present in many parts of the duct. This brief describes a novel, real-time monitoring technology that overcomes the inherent limitations of those conventional methods.

Invention



Geosyntec has partnered with Industrial Monitor and Control Corp (IMACC) to bring infrared (IR) absorption spectroscopy, using a quantum cascade laser (QCL) as the light source, into power plants in order to measure NH_3, SO_2, SO_3 and H_2O simultaneously. The QCL has three orders of magnitude more intensity than conventional IR sources and the QCL spectrometer operates at extremely high resolution in the mid-IR, a "fingerprint" region for many compounds, giving the strongest available absorption signals with no spectral interferences. Plus, mid-IR systems are less sensitive to light scattering from the fine particulates within fly ash that often plagues tunable diode lasers (TDLs) which use near-IR light. The figure at right illustrates how the intense focus of the QCL is used to resolve SO_3 absorption spectra with very little biasing from SO_2 & H_2O. Detection limits are about 250 ppb for NH_3 and SO_3 in dust-free (laboratory) environments and as low as 0.5-2.0 ppm in the field, with less than one minute sample times.

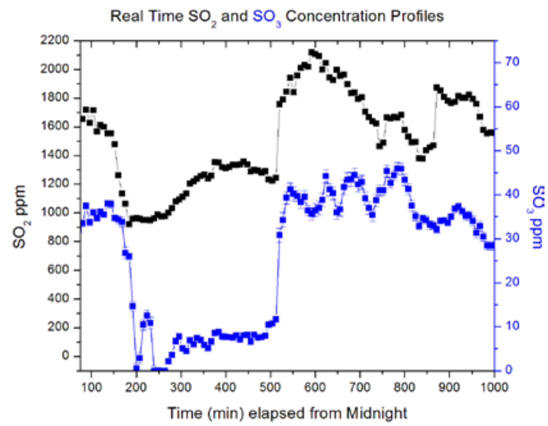
Deployment



The system was employed recently as part of an EPRI demonstration at a 400 MW coal-fired unit. Equipment was installed during normal plant operation. At right, the laser and detector are shown as deployed, sitting across from each other on either side of a 16' wide duct, just downstream of the SCR.

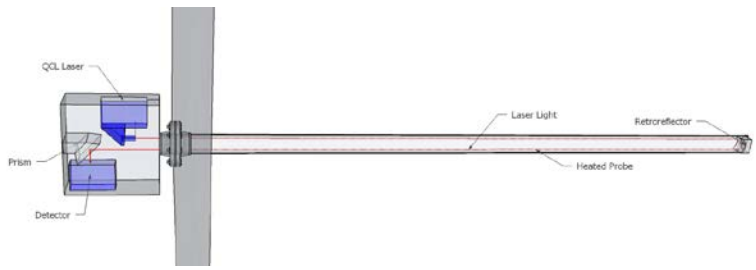
During operation, lime was injected upstream for SO_3 mitigation, meaning both fly ash and solid sorbent were present in the duct during testing. The analyzer ran unattended, with data sent wirelessly to a location offsite for processing and analysis.

An example of the plant data is plotted at right, showing SO_2 and SO_3 responses with changes in load and sorbent & NH_3 injection rates, which illustrates the challenge of observing such transients with conventional condensation coils.



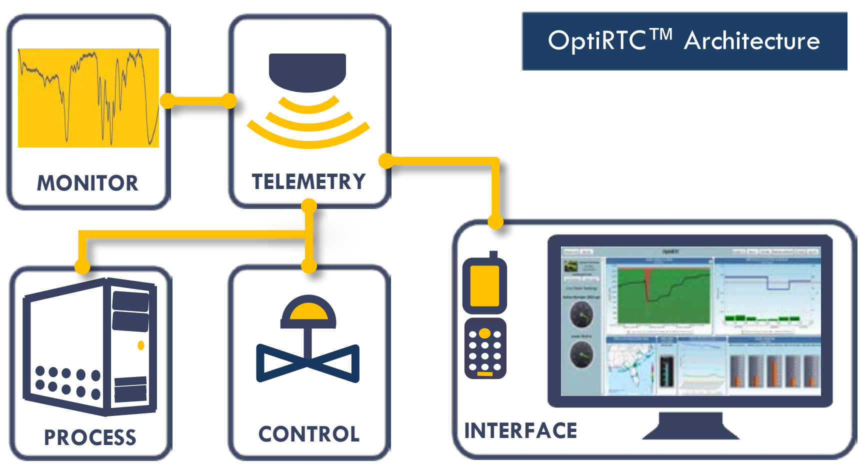
Probe Design

The technology is also available as a completely *in situ* (non-extractive) probe. The laser sits outside the duct, sends light down the length of the probe inserted into the duct, and the light is reflected at the end of the probe back to the detector, also located outside the duct. Gas is pulled into the probe from multiple points in the duct and then exhausted from an exterior pump. The probe design allows for increased sensitivity due to lower pressure and particle rejection. The probe is heated when it is used in low temperature locations (e.g. downstream of the air heater, including at the stack), giving plant operators the ability to quickly measure species' concentrations at multiple locations.



Service

Geosyntec is the exclusive distributor of the IMACC technology for power plant applications. As an added feature, the QCL analyzer can be coupled with Geosyntec's real-time, internet-based monitoring and control architecture (OptiRTC™) that incorporates recent advances in communications hardware and software.



With OptiRTC™, your data can be monitored from any internet connected-device (computer, smart phone, etc.). Plus, the system architecture allows for the integration of complex, real-time computing functionalities so that you can use the data to control other systems or simply process it automatically in real-time into visually appealing graphs and charts for operators, engineers, or other stakeholders.

###

About Geosyntec

Geosyntec is a specialized consulting and engineering firm that works with private and public sector clients to address their new ventures and complex problems involving the environment, our natural resources, and our civil infrastructure. Geosyntec has a staff of over 900 engineers, scientists, and related technical and project support staff located in more than 50 offices throughout the U.S., Canada, Europe, and the Far East. Our private sector clients come from a variety of industrial sectors including oil and gas, chemical, aerospace, pharmaceutical, diversified manufacturing, advanced technology, power and utility and environmental management. Our public sector clients are departments and agencies of municipal, state/regional, and national governments.

Geosyntec Consultants has built a record of successful client service by attracting some of the most creative scientists and engineers from the graduate programs of leading universities in the United States and Canada. Approximately 80% of our technical staff have advanced degrees in engineering, scientific, or business management disciplines. When clients select Geosyntec for a project, they are working with a team that is at the forefront of innovative, proven technology application.

With more than 20 in-house academic disciplines plus specialists in construction management, construction quality assurance, and computer-aided drafting and design, we have the breadth of technical expertise to ensure that every project we undertake is managed and performed by a team with a vested interest in client satisfaction.