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Advanced Hybrid Laser Technology Breaks New Ground In Gas Analysis

In an interview with IAA, YeeTiong Koh, business development director, Emerson Automation Solutions discusses the technology behind the company's Hybrid Quantum Cascade Laser/Tunable Diode Laser Analyser system and its advantages.

YEETIONG KOH, Business Development Director, Analysers & Solutions, Asia Pacific, of Emerson Automation Solutions discusses with IAA some of the implications for this technology.

YeeTiong Koh
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Q Please tell us about this new advance in gas analysis.

YeeTiong Koh (YT): Changes in gas analysis technology do not usually come fast. The applications that require gas measurement — process control, product certification, and emissions monitoring — are so critical to industrial companies' bottom line that tried and true, proven technology is required. When a new technology significantly advances the state of the art without increasing risk, however, it is time to take notice. That is what is happening today with the Quantum Cascade Laser (QCL)/Tunable Diode Laser (TDL) hybrid laser analyser from Emerson.

The hybrid system is already seeing rapid adoption for ethylene production purity, continuous emissions monitoring, NOx reduction/ammonia slip, natural gas, and hydrogen purity in industries such as petrochemical, oil and gas, power, gas processing, and research and development.

Q Why are such risk averse industries considering an advanced technology such as laser?

YT: Quite simply, the new hybrid laser provides real-time measurement in industries where speed translates to profits and improved sensitivity is necessary to optimise the process control and comply with regulations. All these add up to a more profitable bottom line.

While laser technology has been around for a number of years in the form of tunable diode lasers, it can only measure gases with spectroscopic response in the near infrared range, so this limits the applications in which it can be used. The QCL/TDL hybrid laser from Emerson is another matter. It really qualifies as a revolution in gas analysis.

Q How does QCL technology work?

YT: Emerson's laser technology is a hybrid of Quantum Cascade Lasers and Tunable Diode Lasers. This combination has never been available before. The QCL detects and identifies a range of molecules in the mid-infrared wavelength range. Coupled with TDL spectroscopy, a single instrument is now able to provide greater insight and monitoring for gas molecules with spectral response in the near and mid-infrared range of spectroscopic light. This is one of the huge advances in the new technology.

Quantum Cascade Lasers are semiconductor devices that are fabricated to emit light at a desired wavelength and are made to scan a spectrum using a laser chirp technique. To start the process, a QCL is pulsed with electrical energy and heats up. As the temperature increases, the wavelength of the emitted light also increases. A laser chirp lasts about one microsecond and in this time a spectrum of between 1–3 wavenumbers is scanned.

The raw detector signal is then processed to convert it into a spectrum from which the concentration of analytes can be calculated. QCLs can be chirped at a frequency of up to 100 KHz, enabling many thousands of spectra to be gathered in a few seconds and processing these spectra gives a strong signal with a good signal-to-noise ratio. The wavelength region which is scanned is selected to enable measurement of the desired analytes and it is often possible to detect more than one compound with a single QCL device. An advanced signal processing procedure enables real-time validation of measurements and greatly reduces the need for calibrations.

There are some applications where laser is not suitable, such as in inert gases, for instance, helium, neon, argon, etc. This is because these inert gases do not have significant enough spectral response in the infrared or near infrared range. For such applications, traditional methods still apply.

Q What does this technology mean to the user?

YT: For one thing, the unique design allows up to six laser modules in a single device and the patented laser chirp technique isolates and analyses up to twelve unique gas components quickly with one-second update time. This means up to 12 gas components can be measured in one unit almost instantaneously. With previous technologies, multiple devices were required to analyse different gases increasing costs and footprint.

The hybrid system has been designed for measuring both in hot/wet and cold/dry applications allowing for representative sample analysis at up to 190 deg Celsius. Additionally, the modular design allows for easy infield service activities such as adding new gas components for measurement.

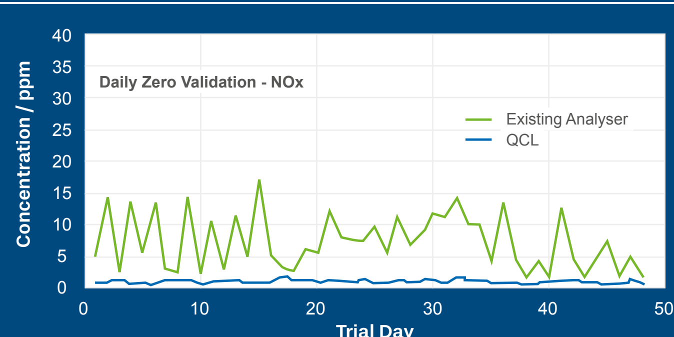
Lasers are inherently stable devices and with the support of best fit algorithms, the hybrid system experiences low drift, meaning calibration is rarely needed.

Refinery Tests QCL Laser Technology And Finds A Better Way To CEMS Compliance

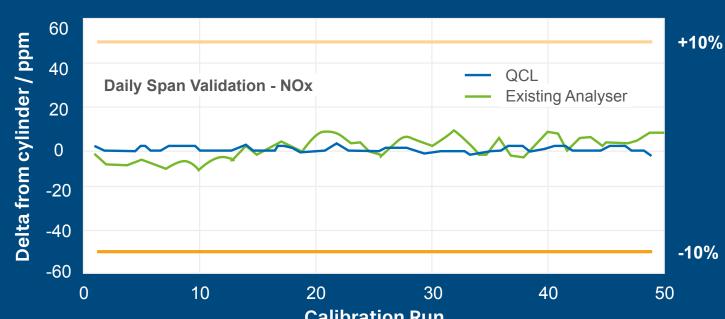
The idea of switching to a new technology for critical and potentially costly applications like emissions monitoring can be confronting to a manufacturer. The adage about not fixing it if it is not broken comes to mind. At the same time, that approach can limit the discovery of a more reliable, efficient, and cost-effective way of doing things. That is why this test performed by a large refinery is an interesting proof point for the use of an extremely high-tech solution like the QCL/TDL laser technology in continuous emission monitoring.

The refinery company had used TDL laser technology in the past and found the measurements to be reliable, fast, and repeatable. It had limitations, however, that reduced ROI. When the company heard that the QCL/TDL hybrid laser could measure multiple gases in a single unit, they were determined to test the device. They first set up the QCL CT5400 continuous gas analyser from Emerson to perform all of the refinery's CEMS measurements in a single unit. This included NO, NO_2, O_2, CO, CO_2, and SO_2. The CT5000 series has the ability to 'chirp' multiple lasers to fire sequentially with each chirp being under 1 millisecond, enabling thousands of spectra to be collected each second. They chirped six lasers through the entire range of their gases.

Stability Testing – NOx Daily zero / span



Zero drift QCL	-0.03%
Zero drift Existing Analyser	-0.36%
2δ noise QCL	0.47 ppm
2δ noise Existing Analyser	8.84 ppm



Span concentration	560 ppm
Span drift QCL	-0.10%
Span drift Existing Analyser	2.29%
2δ noise QCL	1.70 ppm
2δ noise Existing Analyser	10.9 ppm

Figure 1

With that set up, they chose to perform a rigorous round of stability testing and finally RATA (Relative Accuracy Test Audit) on the device. The operating permit for the tests was issued by the US EPA and state regulators who established the emissions limits and testing requirements. The requirements involved daily, quarterly, and yearly tests.

For stability testing, the system was set up to monitor flue gas from a calciner hearth. Its measurements were then compared on each gas to the established technology standard. For NO and NO_2 this was chemiluminescence, for CO_2 it was IR, for SOx, UV, and CO, it did not have an established technology. Using Fig 1 as an example, the QCL equaled or bettered the performance of the individual technologies in the measurement of each gas. Then the RATA was performed that compared CEMS data to that collected by an independent EPA test method. A RATA doesn't measure accuracy, but rather the ability to match the test method. As Fig 2 demonstrates, the QCL passed in each category.

Relative Accuracy Test Audit (RATA)

Results

Analyte	Reference Method/Spec	Reference Technology	Relative Accuracy	Specification Limit	Results
O2	EPA 3A / PS 3	Paramagnetic	6.7% 0.324%	20% RM 1% difference	PASSED
CO2	EPA 3A / PS 3	IR	1% 0.062%	20% RM 1% difference	PASSED
SO2	EPA 6C / PS 2	UV	10.3%	20% RM	PASSED
NOx	EPA 7E / PS 2	CLD	6.7%	20% RM	PASSED
CO	EPA 10 / PS4A	IR	0.59 ppmdv	5ppm Difference	PASSED

Figure 2

Ultimately, the extensive testing proved that the QCL is stable, meets US EPA specifications, requires fewer calibrations than other technologies, has lower maintenance requirements, and of course, performed all the measurements in a single system. Bottom line, the QCL is expected to provide greater data availability as a result of less downtime, and will be used in the refinery's next CEMS installation. By carefully vetting advanced technology, this refinery paved the way for all companies to save time, improve performance, and better meet compliance requirements in CEMS applications.

Q What else should users know about QCL?

YT: One of QCL's major advantages is its laser module. Rugged and compact, the packaged laser modules can be removed and easily serviced or replaced as needed. Attached securely to the analyser's optical bench, each module is preconfigured to detect up to two components simultaneously with no field alignment required. Knowing this is important to users who hear the word laser and assume delicate and hard to use. But the QCL is actually easier to install, use, and service than most traditional technology. Modular architecture makes it easily serviceable and upgradeable in the field while expert laser light alignment is factory set with no field alignment required.

Particularly exciting is the fact that the QCL is both extensively field proven and still being extended to new applications all the time. Users are so excited about the potential of this technology and Emerson is actively researching and developing new applications for laser technology.

Emerson And AspenTech Form Alliance To Deliver Digital Technologies

AUSTIN, TEXAS AND BEDFORD, MASSACHUSETTS, US: Emerson and AspenTech have announced they have teamed up to deliver asset optimisation software solutions along with global automation technologies and operational consulting services. Together, the two industry leaders will help customers optimise production and drive operational excellence.

AspenTech's broad suite of asset optimisation software creates value across all phases of the asset lifecycle – design, operate and maintain – in capital intensive and complex projects and operations, supporting Emerson's Project Certainty and Operational Certainty initiatives. Emerson's global footprint, automation engineering services and software, extensive large-scale project execution and consulting capabilities complement AspenTech's technology footprint. Collectively, these capabilities can be deployed as solutions in both conventional and cloud-based architectures.

The alliance will initially focus on three key areas: engineering software, including high-fidelity simulation to help validate project design and train operators before start-up; manufacturing and supply chain software, including advanced process control software designed for highly complex operations; and asset performance management software to improve plant reliability.

Together, the two companies will provide holistic optimisation strategies that rely on real-time data, advanced analytics enabled by machine learning, and rich process knowledge to bring measurable business improvements in production, as well as in the areas of reliability, safety and energy management