Trends and developments in gas analysis

Technical and digital developments are modernising the way gas analysers are built and used

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Technical developments to improve equipment functionality and an array of digital innovations are transforming the landscape of gas analysers and instrumentation in the oil and gas sector. These trends and developments are resulting in significant benefits for operators: reduced capex, simpler operations, and a lower cost of ownership.

Gas analysers are used for process control applications where repeatability and speed of response are essential. They are also mission critical for monitoring emissions to the air, a highly regulated area where data must be reported and a high level of gas analyser uptime is critical. Technical and digital developments in these areas are modernising the way gas analysers are built and used. The fundamental applications of level, temperature, and pressure measurement are also benefitting from the transformation that is taking place.

Low maintenance hardware

The right gas analysis hardware can make a big difference. Simplicity is a key driver for change. Combustion optimisation and continuous emissions monitoring systems (CEMS) in a steam methane reformer (SMR) producing hydrogen for hydrotreating in the refinery is a relevant example to consider. The supply of hydrogen to these processes is essential to produce clean-burning, low-sulphur fuels and biofuels. Existing solutions often bundle together all the gas analysers that a refinery would need for SMR safety control and emissions monitoring with a single module which results in improved simplicity. Nowadays, the oil and gas industry is equipped with selective catalytic reduction (SCR) for NOx removal. One way to monitor the effectiveness of the flue gas cleaning process is to monitor ammonia slip as a performance indicator of SCR process control. Ultimately, that translates to reduced operating and capex costs.

Furthermore, analysis of the total oxides of nitrogen (NOx) in emissions from a steam methane reformer is an area where the trend for gas analyser hardware is simplification. It has been common in the past to use the chemiluminescence analytical technique (CLD) to measure NOx. The instrument needs an ozone generator and a catalytic converter operating at 300°C to oxidise NO to NO_2 because the CLD technique cannot speciate between the two. That is a lot of technology to pack into an instrument intended for use in rugged industrial applications.

To meet modern NOx measurement requirements, a solution based on ultraviolet spectroscopic analysers is emerging as an attractive option. This kind of gas analyser ensures that NOx measurement is simple, using robust UV gas analysers that can speciate between NO and NO_2. At present, this gives an even greater level of visibility of environmental emissions than is generally required but, as legislation shifts, the purchase of a gas analyser which can perform at this level can be considered as future-proofing the investment.

Direct read IR gas analysers are ideal for the measurement of carbon dioxide (CO_2) and carbon monoxide (CO) for combustion control and CEMS applications. The levels of CO, CO_2, and oxygen in combustion exhaust gases are tell-tale indicators of whether the system is operating at maximum energy efficiency. Simultaneous measurement of CO and CO_2 is achieved by a non-dispersive infrared sensor (NDIR) type gas analyser. In contrast to the types of gas analyser that might alternate between measuring CO and CO_2, with NDIR sensors both gases are continuously measured. This means that essential process optimisation information is continuously available to feed into the DCS process control loops, resulting in improved hydrogen conversion yields and better energy efficiency.

UV and IR gas measurement technologies can also provide valuable information for combustion process control and optimisation of energy efficiency. Oxygen measurement is also essential for this application. Three main types of gas analyser are suitable for monitoring oxygen in the flue gases from a refinery process heater or steam boiler burner. With an extractive paramagnetic type analyser that features precision and appropriate sample conditioning, the set-up can tolerate difficult process sample streams. A zirconium oxide probe provides accurate and rapid reading. Also designed for continuous, in situ measurement, the laser-based analyser type offers fast response to process changes.

Measurement of flue gas oxygen concentration is an essential process control parameter to ensure stoichiometric combustion and full utilisation of energy contained in the fuel. Where an extractive system is preferred, the use of a paramagnetic oxygen analyser for combustion process control has been common for decades. Recent developments feature a solid state electronic 'microwing' to replace traditional gas-filled dumbbell oxygen sensor technology (see **Figure 1**). The result is higher accuracy and less drift, resulting in reduced calibration frequency. These factors feed through to improved process optimisation and reduced maintenance costs.

Whilst the extractive paramagnetic type analyser claims a reduced calibration interval, IR and UV gas type analysers have self-calibration features that eliminate the need for manual calibration. The gas analysers are fitted with cells that are filled with gas mixtures of known concentrations. These enable automated calibration without the need for external gas cylinders. This means the instruments can be maintained with low cost and complexity.

Figure 1 Magnos28 paramagnetic oxygen analyser with solid state microwing technology in operation *Photo: ABB*

Digitalisation of hardware

Guided wave radar is well established as a measurement technique. The equipment is robust, the technology is mature, and primary application niches have clearly emerged. However, the instrumentation has developed a reputation for being difficult to install. But digital algorithms embedded into the latest devices mean that the chances of getting the installation right the first time are increased.

The innovations are tapping into two trends: digitalisation and the scarcity of skilled labour. Modern devices with guided wave radar level measurement instrumentation are designed to provide fast installation times. Recently developed gas analysers and instrumentation can be installed by instrument technicians in a fraction of the time that previous models required and with the confidence that they will work from day one. This is especially important when fitting out a tank farm with four or six tanks because the instrument technician will want to complete the installation within a day and return to base.

The guided wave radar level measurement principle relies on the radar wave partially reflecting from the upper crude oil layer and partially penetrating to the oil-water interface, where it is then reflected from the water layer. Leveraging this phase boundary detection is a common application in crude oil storage tanks at remote oil well locations. These tanks receive a mixture of crude oil and water from the well-head and perform an initial physical separation between the two liquids.

Level monitoring in the crude storage tanks is essential to schedule crude oil collection efficiently. Good logistics management can avoid inefficient part-loads or production stoppages if the storage tanks become too full. Beyond that, measurement of the water level underneath the oil layer is important to ensure that the water can be pumped off and all the available tank storage capacity can be used for oil.

The accuracy achievable with guided wave radar level instrumentation exceeds 2mm. This is highly valued in inventory management. An example is the storage of liquid sulphur from the Claus process. With molten sulphur there are few choices for non-invasive level measurement and such applications are well suited to guided wave radar level instruments. However, with high-value products in large diameter tanks, a few millimetres of level difference can equate to several thousand dollars worth of inventory. So high precision measurement is essential to ensure reliable book-keeping and fair product transfer valuations and invoicing.

Moreover, guided wave radar instrumentation can 'see' through dense dust or thick misty vapours. This is one of its main advantages when compared to non-contact level measurement techniques. Attributes such as this have led to it being one of the fastest-growing instrumentation categories in various process industry sectors in recent years.

The versatility of the guided wave radar technique has, unfortunately, been a double-edged sword: setting up these instruments has been a technically complex task and that has been their main limitation since their introduction about two decades ago. Specialist expertise has generally been called in to do the installation, configuration and, in many cases, a follow-up trouble-shooting visit. All in all, the installation labour and service costs have often exceeded the instrument hardware cost by a factor of two.

This challenge can be rectified with suitable, built-in algorithms which allow the level transmitters to be configured for the input of basic information about the application. Significant set-up time and cost reductions are the results. This kind of intelligence will make this type of equipment easy to install, accurate, robust, and reliable, and will significantly widen its field of application and broaden its popularity and acceptance in existing applications.

Digitalisation of technical support

Modern gas analysis instrumentation incorporates cutting edge analytical chemistry. The level of miniaturisation that has been achieved in building rapid response and highly accurate gas analysers is remarkable. The technology that is wrapped up inside these instruments has immediate parallels to the electronics sector. With this background, it is no surprise that gas analysers are leveraging digitalisation. Augmented reality, cloud computing, and QR codes are three examples of digital developments which are helping service engineers to keep gas analysis hardware in good condition.

Developers of gas analysers and instrumentation have developed sets of software and units to build up integrated digital solutions. They allow an operator's instrument technician to communicate directly with an expert remotely.

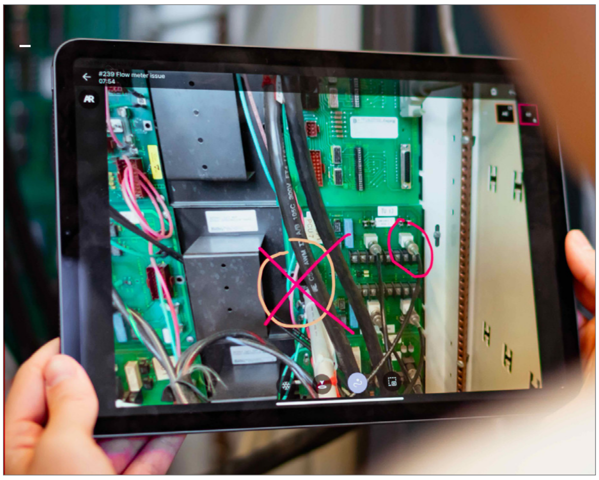

Figure 2 Video and voice augmented reality enables a refinery technician to share live information directly with the manufacturer *Photo: ABB*

This state-of-the-art technology is a two-way video and voice augmented reality interaction, enabled by a hand-held device such as a tablet computer (see **Figure 2**). This means that refinery instrument technicians can share what they are seeing directly with their counterparts at the manufacturer's office and get instant feedback about the best course of action. In the past, training, maintenance, troubleshooting, and repairs all resulted in a site visit from a service engineer. With the implementation of such a solution, there will be less travel required, meaning that operators will get faster support at lower cost.

Another solution is a cloud based remote access and collaborative platform. The concept is like the 'remote operations centres' implemented by many refiner with facilities around the world. The concept relies on condition monitoring of gas analyser diagnostics which let the refinery instrument engineer or the service team at the manufacturer's office know the status of the gas analyser. This data can be used to diagnose requirements for replacement of consumable materials or troubleshoot equipment faults. The goal is to guide the local operations team towards a speedy resolution.

The introduction of dynamic QR codes can help refinery operators get closer to 100% uptime for their gas analysis instrumentation (see **Figure 3**). This target is important for many process control applications but has special significance in a refinery's CEMS for environmental compliance. In many countries, emissions measurement data must be reported 98% of the time to avoid shutdowns and penalties. The dynamic QR code displays the latest system configuration data and real-time analyser status. This solution requires a smartphone app to scan the dynamic QR code. The operator can transmit real-time information so that a product engineer can offer advice immediately or follow up with a site visit to fix the issue.

Figure 3 QR code displayed on a gas analyser control panel for communication of diagnostic information via a smartphone or tablet *Photo: ABB*

Full lifecycle services

One of the most powerful trends for services bundled around refinery gas analysers is to integrate the services provided by people more closely with digital solutions. In one such case, low maintenance CEMS gas analysers and field service engineers teamed up to support a European operating company. The operator was aiming for immediate cost savings and looking for a reliable service provider to support its installed CEMS gas analyser base across 13 sites. To meet the cost-saving target, a holistic approach was offered, which included a standardised maintenance strategy across all sites with rapid response and optimised routine services.

Solutions that rely on a condition monitoring approach enable service teams to work remotely with a refinery's or gas processing plant's instrumentation engineers to review the health and status of their gas analysers. The concept means fixing small glitches in the gas analysers proactively before they escalate, and avoiding unnecessary maintenance if it is not required. All in all, condition based intervention saves time, reduces cost, and improves safety. The condition based monthly review of the CEMS devices also resulted in better emissions data reporting uptime and lower labour costs.

A further trend with services is simply to offer more, covering the full lifecycle of a gas analysis instrument. Services begin with product selection proposals, equipment installation, commissioning, and training. In the operational phase, the focus shifts to spare parts, consumables, maintenance, technical support, and repairs. As time moves on, extensions, upgrades, and retrofits are the order of the day. Replacement and end-of-life services round off the portfolio. Instrumentation suppliers offer a complete suite as a modular framework which allows each refinery to customise a service package from all the available options that focuses on their needs. That means that the service is there when the refinery or storage terminal needs it the most and operating costs can be controlled.

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