Gas analysis instrumentation for CCTUS

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Carbon capture is the foundation of carbon dioxide (CO_2) capture and storage, or utilisation. Since the CO_2 must be transported from the capture site to the utilisation or storage site, the phrase carbon capture, transportation, utilisation and storage, or CCTUS, is helpful to describe the full value chain.

Capturing CO_2 from a flue gas stream often relies on a solvent or solid adsorbent material that is sensitive to other chemicals in the raw flue gas such as sulfur dioxide (SO_2). So, the CO_2 separation, or capture, is often the last stage in a complex arrangement of flue gas treatment (FGT).

Measurement and control of the CO_2 purity through the CCTUS process and the analysis of critical impurities relies on gas analysis instrumentation. Some of the gas analysers are like those that have been used in continuous emissions monitoring (CEM) for decades. However, the measurement of CO_2 purity is an emerging requirement.

In addition to analysis of the gas purities, accurate measurement of the CO_2 transfer flow rate is essential. The ownership of captured CO_2 is often transferred from the emitting plant to another facility where it may be utilised or sequestered. Fiscal metering will become more important in the future to claim tax credits or carbon removal certificates.

In the case of utilisation, the CO_2 may have commercial value and invoicing will be required. In the case of sequestration, the CCS scheme operator is likely to charge a fee based on the amount of CO_2 transferred. In either case, precise flow measurement enables fair commercial practices.

Flue gas treatment

Much of the CO_2 captured from industrial processes today relies on a liquid amine solvent. It is a twin tower process where CO_2 from the flue gas is absorbed into the solvent in the first tower. The CO_2-lean flue gas then flows to atmosphere.

The CO_2-rich amine is pumped to a second tower where heat is used to strip the CO_2 out of the amine solvent. The regenerated, CO_2-lean amine solvent is pumped back to the absorber tower to collect more CO_2 and the process operates continuously with the solvent being recirculated from the absorber to the stripper.

Variations of the amine-based carbon capture process use chilled ammonia, methanol, or potassium bicarbonate as the solvent to absorb the CO_2. In each case, the process configuration is similar.

Over time, the amine solvent is degraded through reactions with oxygen and other impurities in the flue gas such as SO_2 which is present in emissions from coal or heavy fuel oil combustion. Removal of SO_2 is already implemented on many combustion plants in developed nations, to avoid the problem of acid rain. However, flue gas desulfurisation (FGD) is not universal, and it is only recently that developing nations such as China and India have implemented regulations to ensure that SO_2 emissions are reduced. It is likely that for some operators, implementation of CO_2 capture will require implementation of upstream SO_2 capture through FGD.

© SICK AG | **GMS800 gas analyser**

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© SICK AG | **FLOWSIC600-XT flow meter**

Aurélie Moll, Strategic Industry Manager CCUS at SICK in Germany, says that "we have been supporting industry with high precision gas analysers such as the MCS200HW for continuous emission monitoring (CEM) including SO_2 monitoring for many years. The same range of products will have direct relevance to the needs of CO_2 capture and any flue gas pre-treatment that may be required."

The MCS200HW is a hot/wet extractive multicomponent gas analyser commonly used in continuous emissions monitoring systems. It uses gas filter correlation or interference filter correlation to monitor up to ten components, including CO_2 and SO_2. It can also measure ammonia and oxides of nitrogen for process control of selective and non-selective catalytic reduction flue gas DeNOx systems.

CO_2 purity measurement

"In addition to the measurement requirements between the raw flue gas and the CO_2 amine solvent absorption system, we recommend the GMS800 extractive cold/dry gas analyser for CO_2 purity measurement as capture efficiency control after the Amine desorber," adds Moll. When fitted with SICK's UNOR NDIR sensor, it can accurately measure CO_2 purity in the 95-100% range."

SICK also offers in-situ gas analysers for process control and CEMS applications. These have probes that are fitted into the flue stack to avoid the cost and complexity of sample extraction and conditioning. The GM35 was chosen for use at the Leilac-1 pilot plant. This is a groundbreaking CO_2 capture demonstration project at a HeidelbergCement production plant in Lixhe in Belgium. An innovative externally heated calciner, developed by Calix, has been undergoing field trials.

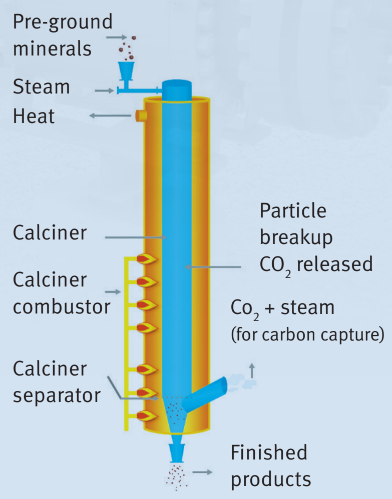
"The requirement for Leilac was to measure the CO_2 concentration and the moisture impurity simultaneously," confirms Moll. The Calix calciner generates very pure CO_2 and typical post-combustion gases such as SO_2 or oxides of nitrogen are not present. However, moisture is present, and this must be monitored to control downstream processes such as CO_2 drying, liquefaction, or compression.

After capture, CO_2 can be purified and liquefied for transportation by road, train, or ships to other commercial utilisation applications or for permanent storage. Prior to liquefaction, the CO_2 is dried on a regenerative dryer bed to avoid moisture freezing and blocking the cryogenic liquefaction system.

Gas analysis and flow metering for CO_2 pipelines

The alternative CO_2 transportation mode is compression to a supercritical fluid at around 90 bar and then transmission in a high-pressure steel pipeline. "As with liquefaction, CO_2 and moisture analysis for pipeline transmission is essential," says Moll. If moisture is present, it can react with CO_2 to form a corrosive acid which could damage the steel pipeline.

Drying takes place during the compression stages to remove the moisture. Most of the water is condensed in the intercoolers between the multiple gas compression stages. Prior to the last



© Calix | **Calix calciner**

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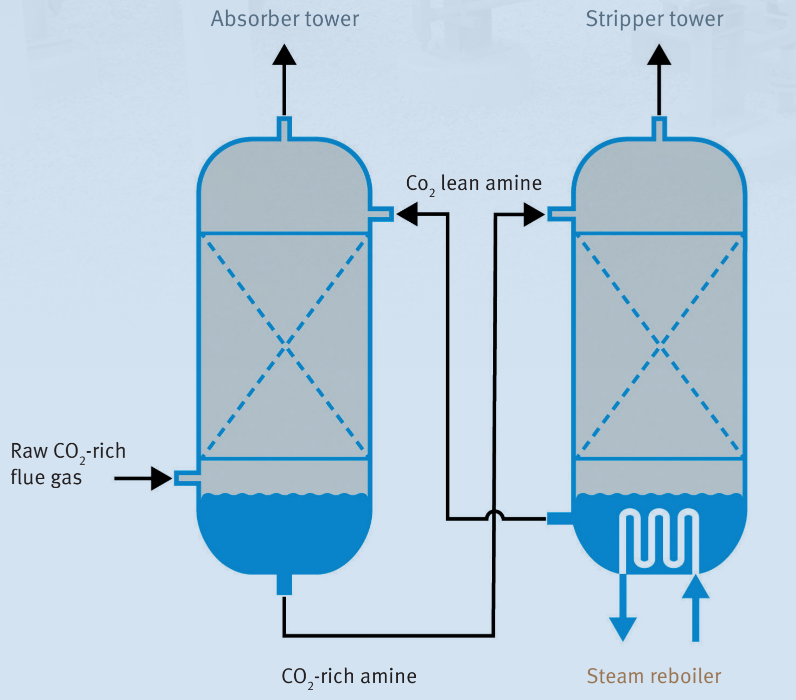

© sbh4 consulting | **CO_2 Capture with amine solvent.**

stage of compression, mono-ethylene glycol (MEG) can be used as a solvent to remove the final traces of moisture. Analysis of moisture and CO_2 at critical points in the drying process is vital.

The other critical measurement at this stage is the CO_2 flow rate in the pipeline. The transmission of captured CO_2 to an underground injection and sequestration location may be over many hundreds of kilometres and may cross international boundaries or change ownership. At several points, accurate flow measurement may be required.

Inside the pipeline, CO_2 exists as a supercritical fluid. This can be compressed like a gas but has a density and other physical properties like a liquid. Moll says that "the FLOWSIC600-XT is ideal to measure CO_2 in either gaseous or high-pressure supercritical phases It uses ultrasonic technology with multiple measurement paths to ensure fiscal accuracy."

This device from SICK is built for maximum reliability and operability in long pipeline systems that may cross remote locations. In the event of mains power failure, it will use PowerIn Technology™ to remain in service for up to three weeks. For trouble shooting and diagnostics it is also fitted with SICK's i-diagnositcs™ system.

"The FLOWSIC600-XT gas flow meter is also designed for use in natural gas transmission with hydrogen content of up to 30% and operates with a metrologically approved custody transfer accuracy level," adds Moll. "We believe that CCTUS and hydrogen will both be important pillars of decarbonisation and our product range has been developed to support both applications."

The Porthos CO_2 transport and storage project in Rotterdam will offer permanent CO_2 sequestration under the North Sea. The CO_2 will be captured from several steam methane reformers (SMRs) which produce hydrogen for refineries in the port region.

Multiple CO_2 streams will combine into a single pipeline which goes out to the sub-sea CO_2 sequestration location. To ensure that each SMR operator is fairly charged for the CO_2 storage service, accurate metering of the amount of captured CO_2 that each SMR has transferred into the network is required.

Direct Air Capture (DAC) of CO_2 for storage or utilisation

Production of e-fuels and e-chemical such as e-kerosene or e-methanol involves the combination of green hydrogen and CO_2 to build hydrocarbon molecules. Green hydrogen is produced in a sustainable way using renewable electrical power and electrolysis.

In many cases, it is being proposed that additional renewable electricity is generated to operate a direct air capture (DAC) facility to ensure that the CO_2 in the e-fuels is also fully sustainable. DAC is a promising negative emission technology that will help to reach the climate target.

Monitoring of the CO_2 purity between the DAC unit and any downstream catalytic processes is essential to ensure that high purity CO_2 is used in these sensitive reactors. Flow metering may also be required, especially in the case that the DAC operator is capturing the CO_2 and selling that on to the e-fuels process operator.

DAC will also be used for major CO_2 sequestration schemes with underground geological storage. Projects such as 1PointFive in Texas's Permian Basin and Project Bison in Wyoming in the US are examples. As alternatives to e-fuels production, the business case for such schemes can be driven by utilisation of the CO_2 for enhanced oil recovery or the sale of carbon removal credits to other businesses. "In such situations, accurate metering of CO_2 flows is mission critical," concludes Moll. gw