Application Note AN-PAN-1003

Online analysis of amines concentration in carbon capture plants

The levels of carbon dioxide (CO_2), a natural atmospheric gas, have risen sharply due to human activity. As a greenhouse gas, CO_2 traps heat, and higher concentrations in the atmosphere are threatening ecosystems via climate change and ocean acidification [1]. Industrial facilities like coal-fired power plants are developing technologies to capture CO_2 from exhaust (flue gas) after combustion. The captured CO_2 can be transformed for use in other sectors. These carbon capture systems can help industries achieve carbon-neutral or even negative emissions, reducing their environmental impact.

This Process Application Note describes amine and CO_2 analysis in the caustic absorbing solution from the carbon capture and sequestration (CCS) process in carbon capture plants (CCPs). The amine-based scrubbing technology is energy-intensive with significant operating costs. Therefore, optimizing the amine activity and usage via online analysis is a critical step in reducing overall costs and measuring the efficiency of CO_2 capture simultaneously.

INTRODUCTION

According to the International Energy Agency (IEA), global energy-related CO_2 emissions hit a new record in 2023, reaching 37.4 billion tons (Gt) [2]. This rise stresses the critical need for effective CCS technologies.

CCS involves the process of capturing waste carbon dioxide from large point sources (e.g., fossil fuel power plants), transporting it to a storage site, and depositing it where it will not enter the atmosphere again—normally within an underground geological formation.

The ultimate goal of CCS is to prevent the release of large quantities of CO_2 back into the atmosphere. CCS is a potential means of mitigating the contribution of fossil fuel emissions to global warming and ocean acidification.

The most used process for post-combustion CO_2 capture is made possible with *advanced amine-based scrubbing technologies* (Figure 1). A CO_2-rich gas stream, such as a power plant's flue gas, is «bubbled» through an amine-rich solution. The CO_2 bonds with the amines as it passes through the solution while other gases continue up through the flue. This is shown in Reaction 1.

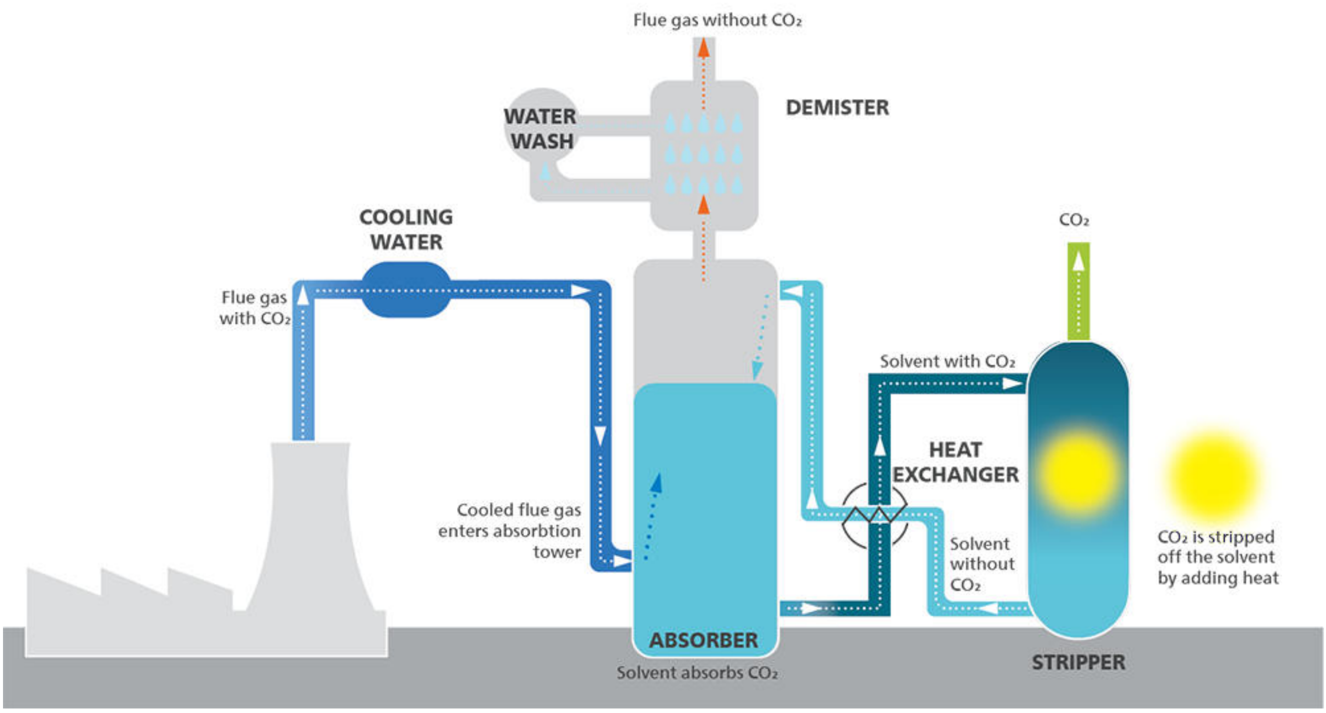

Figure 1. Illustrated diagram of the carbon capture and sequestration (CCS) process.

The CO_2 in the resulting CO_2-saturated amine solution is removed from the amines (Reaction 2), «captured», and is then ready for carbon storage (Figure 2, close-up of CO_2 absorbance).

$$2RNH_2 + CO_2 \rightarrow RNH_3^+ + RNHCOO^-$$

Reaction 1. Overall simplified carbon dioxide absorption reaction.

$$RNHCOO^- + RNH_3^+ + heat \rightarrow 2RNH_2 + CO_2$$

Reaction 2. Overall simplified amine regeneration reaction.

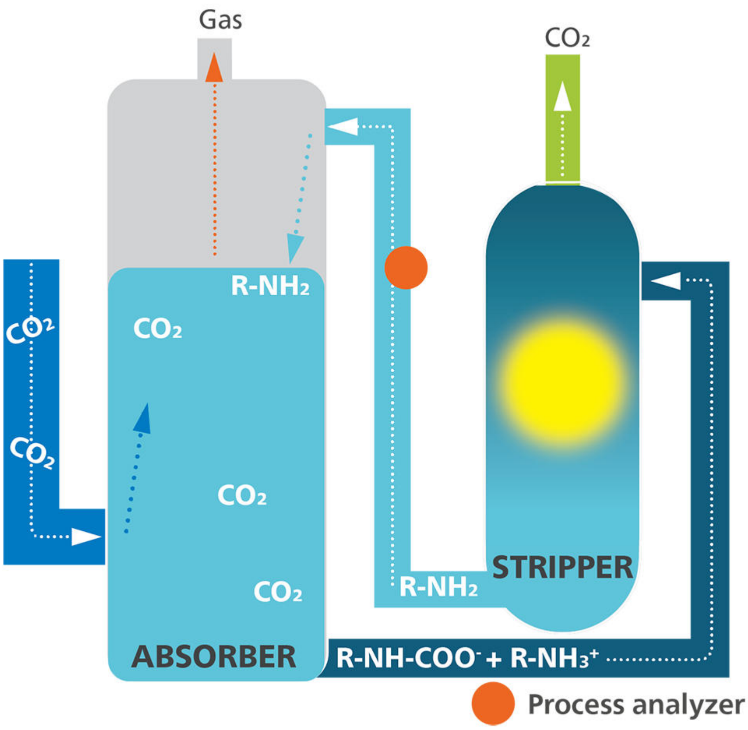

Figure 2. Illustration highlighting how the carbon dioxide absorbance process works in a CCP with suggested location for online process analysis.

While the amines used in carbon capture can be recycled, the process itself is energy-intensive, with significant operating costs. Optimizing amine activity and usage is therefore critical. This optimization not only reduces overall costs but also helps measure the CO_2 capture efficiency.

Traditionally, CO_2 capture efficiency was calculated based on manual laboratory titration from samples taken after the stripper. However, this method has some limitations. It only provides a snapshot of the process, making it difficult for operators to continuously optimize the process or identify deviations. Additionally, manual sampling can introduce some errors.

Online process analyzers help overcome these issues. By continuously measuring the amine concentration online in the absorbing solution, online process analyzers enable real-time monitoring of the carbon capture process, ultimately improving its efficiency.

For optimized carbon capture, monitoring key process parameters in near real-time is crucial. Metrohm Process Analytics offers a powerful solution: the 2060 TI Process Analyzer (Figure 3). This multi-parameter analyzer enables the simultaneous analysis of both amines and CO_2 within the caustic absorbing solution used in carbon capture plants.

APPLICATION

The 2060 TI Process Analyzer can effectively perform acid titrations for amines as well as free and total CO_2 in caustic (NaOH) absorbing solutions. It also offers automatic cleaning and validation, which reduces maintenance and minimizes downtime. This method has been tested with different absorbing solutions and is compatible with laboratory tests (Table 1).

Table 1. Parameters to monitor after the carbon dioxide stripping step in a CCS plant.

Parameters	[%]
Amine	0–100
CO_2	0–100

REMARKS

Metrohm Process Analytics offers additional solutions for coal-fired power plants, such as corrosion monitoring with the 2060 IC Process Analyzer. This powerful process analyzer enables the determination of various anions, including chloride, sulfate, and fluoride, which are key indicators of corrosion processes in these plants. By continuously monitoring these ions, plant operators can take preventive measures to minimize corrosion and ensure the safe and efficient operation of their facilities.

Additionally, the continuous online analysis of ultratrace iron and copper levels in the water-steam circuit of power plants is possible using the 2060 TI Process Analyzer (Figure 3). The analysis enables early detection of corrosion processes and peaks, and also monitors the formation and destruction of the protective oxide layer on the metal surfaces.

Figure 3. The 2060 TI Process Analyzer is suitable for monitoring multiple process parameters in carbon capture plants (CCP).

CONCLUSION

With the increasing urgency to address climate change, carbon capture technologies like amine-based scrubbing offer a promising solution. However, optimizing the efficiency and cost-effectiveness of these systems is crucial. The Metrohm Process Analytics 2060 TI Process Analyzer provides real-time data, enabling continuous process optimization and improved CO_2 capture efficiency. By implementing such advanced monitoring solutions, carbon capture plants can ensure optimal performance while contributing significantly to reducing greenhouse gases in the atmosphere.

REFERENCES

1. Deaconu, A. Carbon Dioxide Capturing Technologies | EPCM.
2. *Executive Summary – CO2 Emissions in 2023 – Analysis*. IEA. https://www.iea.org/reports/co2-emissions-in-2023/executive-summary (accessed 2024-05-21).

RELATED APPLICATION NOTE

AN-PAN-1038 Power generation: analysis of the m-number (alkalinity) in cooling water

BENEFITS FOR ONLINE PROCESS ANALYSIS

- **Fully automated diagnostics** – automatic alarms for when samples are out of specification parameters.
- **Higher output** by optimizing the amine activity.
- **Avoid unnecessary costs** by measuring multiple process parameters simultaneously.

CONTACT

Metrohm Vietnam
Phan Dinh Giot
70000 Herisau

info@metrohm.vn

CONFIGURATION

2060 Process Analyzer

The 2060 Process Analyzer is an online wet chemistry analyzer that is suitable for countless applications. This process analyzer offers a new modularity concept consisting of a central platform, which is called a «basic cabinet».

The basic cabinet consists of two parts. The upper part contains a touch screen and an industrial PC. The lower part contains the flexible wet part where the hardware for the actual analysis is housed. If the basic wet part capacity is not sufficient enough to solve an analytical challenge, then the basic cabinet can be expanded to up to four additional wet part cabinets to ensure enough space to solve even the most challenging applications. The additional cabinets can be configured in such a way that each wet part cabinet can be combined with a reagent cabinet with integrated (non-contact) level detection to increase analyzer uptime.

The 2060 process analyzer offers different wet chem techniques: titration, Karl Fischer titration, photometry, direct measurement and standard additions methods.

To meet all project requirements (or to meet all your needs) sample preconditioning systems can be provided to guarantee a robust analytical solution. We can provide any sample preconditioning system, such as cooling or heating, pressure reduction and degassing, filtration, and many more.