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**.

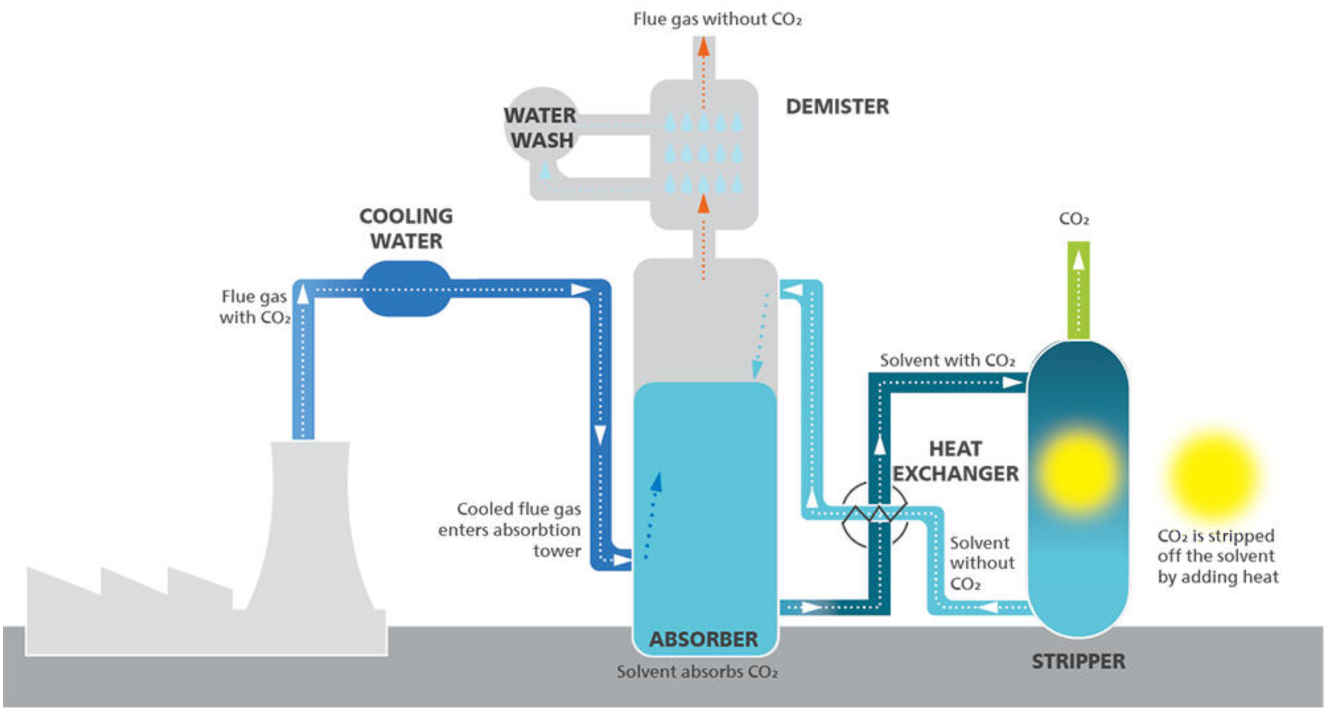

Figure 1. Illustrated diagram of the carbon capture and sequestration (CCS) process.

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.

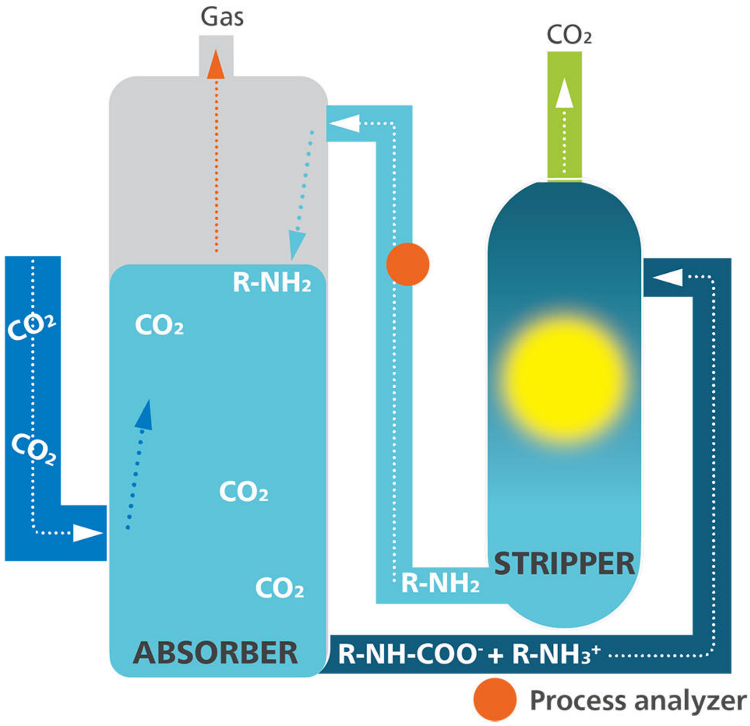

Figure 2. Illustration highlighting how the carbon dioxide absorbance process works in a CCP with suggested location for online process analysis.

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.

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CONFIGURATION

2060 Process Analyzer

2060 Process Analyzer 是一在湿化学分析,用于无数用。此程分析提供了一个新的模化概念,由一个称«主机»的中心平台成。

主机由部分成。上部包含触摸屏和工算机。下部含有柔性取部,其中放有用于分析的硬件。如果主取部容量不足以分析挑,那主机可以展多四个外的取部机,以保有足的空来具挑性的用。附加机的配置方式使每个取部机可以与具有集成(非接触式)液位的合使用,以增加分析的正常行。

2060 Process Analyzer 提供不同的湿化学技:滴定法、舍滴定法、光度定、直接量和准添加入法。

足所有目要求(或足的所有需求),可提供品理系,以保分析解决方案可靠。我可以提供任何品理系,如冷却或加、和脱气、等。