Application Note AN-PAN-1016

Online analysis of silica in boiler feed water of power plants

Due to increasing industry demands for more efficient energy production as well as the increase in operating pressures in modern boilers, the necessity to measure and control silica (Si) concentrations is more crucial than ever. Excessive silica concentrations in the boiler feed water can lead to deposits on turbine blades and on boiler tubes. These deposits cause localized hot spots which reduce the heat-transfer efficiency and must therefore be avoided.

This Process Application Note details the online analysis of silica in boiler feed water. This is accomplished via differential photometry using a cutting-edge thermostatic cuvette module to avoid sample contact at the detector. This method offers different concentration ranges for silica: 0–50 µg/L and 0–1 mg/L or higher.

In combination with the power plant's Distributed Control System (DCS), online monitoring of this analyte using a process analyzer ensures that scaling can be controlled before it affects the power plant efficiency, ultimately decreasing downtime and lowering maintenance costs.

INTRODUCTION

Silica, known as silicon dioxide, comprises more than 10% by mass of the earth's crust [1]. It is used in a variety of applications from microelectronics (in wafer production) to components used in the food industry. In the power industry, silica is not so appreciated and is considered one of the major impurities to cause boiler scale and deposits on steam turbine blades. Boiler scale is caused by impurities precipitating out of the water and forming deposits on heat transfer surfaces. As the scale builds up over time, it reduces heat transfer rates. This leads to local hot spots which cause the boiler tubes to overheat and rupture, resulting in costly boiler outages. In addition, untreated boiler scale lowers the boiler efficiency by heat retardation and increases running costs by unscheduled and more frequent boiler blowdowns. Scaling on stator turbine blades causes changes in steam flow velocities and a reduction in pressure that decreases the efficiency and output capacity of a steam turbine.

Due to increasing industry demands for more efficient energy production and the increase in operating pressures in modern boilers, the necessity to measure and control silica concentrations is more crucial than ever. Boiler feed water is the most critical monitoring point, and the higher the pressure in the boiler, the lower the concentration of silica should be. Other sampling points (Figure 1) include the inside of drum boilers and water returning to the boiler from the condenser to ensure silica limits are within specification. Silica also plays an important process control role at the demineralization plant where demi-water is produced and polished from groundwater or surface water. An increase in silica concentration or a breakthrough of silica suggests an exhausted ion-exchange bed and is a control indicator for timely regeneration.

Metrohm offers a wide range of process analyzers that are suitable to monitor silica from low ppb (µg/L) to high ppm (mg/L) levels. The 2029 Process Photometer from Metrohm Process Analytics (Figure 2) is the most straightforward and easy-to-use tool to do so online.

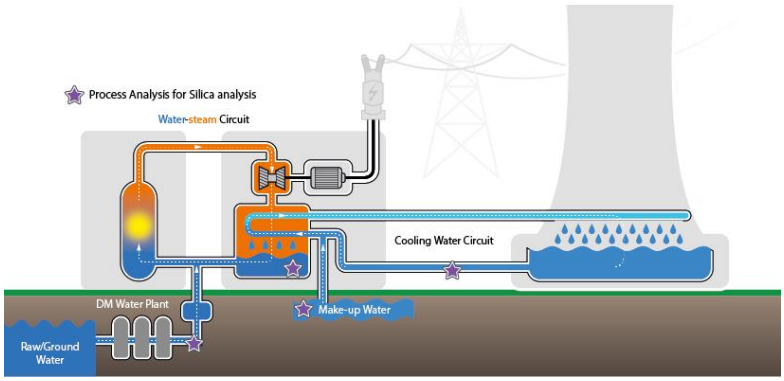

Figure 1. Schematic diagram of a thermal power plant with stars noting areas where online process analysis can be integrated into the system.

Figure 2. 2029 Process Photometer.

APPLICATION

Online monitoring of the silica content is possible with either the 2029 Process Photometer (Figure 2) or the 2060 TI/2035 Process Analyzers (Figures 3 and 4, respectively) from Metrohm Process Analytics. Silica is determined by differential photometry with the molybdenum blue method. All of these process analyzers use a cutting-edge thermostated cuvette module to avoid sample contact at the detector.

Figure 3. 2060 TI Process Analyzer.

Figure 4. 2035 Photometric Analyzer.

Table 1. Silica measurement parameters for photometric analysis.

Parameters	Range
Silica	0–50 µg/L (ppb) or 0–1 mg/L (ppm)

REMARKS

Process analyzers from Metrohm Process Analytics can be combined with smart, versatile accessories (e.g., sensors) for multi-parameter requirements: namely hardness, chlorine, chloride, sodium, ammonia, pH, conductivity, and metals like iron, aluminum, and copper, to name a few.

RELATED APPLICATION NOTES

AN-PAN-1038 Power generation: analysis of the m-number (alkalinity) in cooling water
AN-PAN-1056 Online monitoring of sodium in industrial power plants
AN-PAN-1040 Ammonia in cooling water of thermal power plants
AN-PAN-1045 Online monitoring of copper corrosion inhibitors in cooling water

BENEFITS FOR TITRATION IN PROCESS

- Save money by reducing downtime: analyzer sends alarms for out-of-specification values which inform the operator sooner
- Protect valuable company assets (e.g., pipes, PWR, and turbines, which are prone to scaling)
- High accuracy for lower detection limits of silica

REFERENCES

1. Flörke, O. W.; Graetsch, H. A.; Brunk, F.; et al. Silica. In *Ullmann's Encyclopedia of Industrial Chemistry*; Wiley-VCH Verlag GmbH & Co. KGaA, Ed.; Wiley-VCH Verlag GmbH & Co. KGaA: Weinheim, Germany, 2008; p a23_583.pub3. https://doi.org/10.1002/14356007.a23_583.pub3.

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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.

2035 Process Analyzer - Photometric

The 2035 Process Analyzer for Photometric Measurements includes a compact photometer module which is stable over a large concentration range, and is thermostated with stirrer capabilities. This analyzer is offered with two options: a cuvette system or a fiber optic dipping probe. The cuvette system is compact in order to reduce reagent consumption, yet it offers a long optical path length for high sensitivity. The fiber optic immersion probe broadens our application range substantially by making the accurate measurement of high concentration samples simpler through the use of internal sample dilution steps and a smaller light path than the cuvette system.

Photometric analysis is a common, widely-used technique which can determine ions such as ammonia, manganese, and iron in drinking water or even calcium and magnesium in brine solutions. Undesired sample matrix effects such as sample color or turbidity can be removed with differential measurements, taken before and after the addition of a color reagent.

2029 Process Photometer

The 2029 Process Photometer performs sensitive photometric absorption measurements in the visible light range. Detection limits in the low ppb range make this an attractive instrument for a variety of applications.

At the heart of the analyzer is a high performance compact photometer module ready for 24/7 online measurement. It comprises a thermostated cuvette with 3 cm light path and LED technology, ensuring stable, accurate measurements no matter the environment. The color development stabilization is automatically detected by making use of differential absorbance measurements. Photometric laboratory methods can be easily transferred to the 2029 Process Photometer, eliminating any bias in results for improved process validation.

Several markets are a perfect fit for the 2029 Process Photometer such as chemical, environmental, semiconductor, petrochemical, food and beverage, potable water, and energy/power.

Selected applications include:

- Phosphate
- Silica
- Chlorine
- Nickel
- Zinc
- Copper
- Chromium
- Ammonia
- Nitrate
- Nitrite
- Hardness
- and more