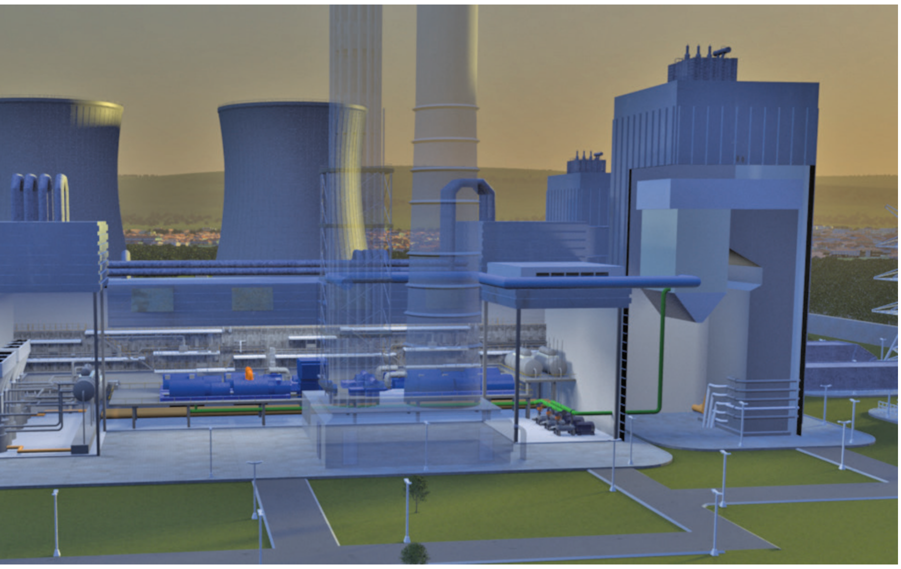
ABB MEASUREMENT & ANALYTICS | APPLICATION NOTE

Optimizing plant efficiency through balanced boiler chemistry

Hydrazine, sodium and dissolved oxygen measurement



The power of boiler chemistry

Measurement made easy

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Well-balanced water chemistry is vital for optimizing the efficiency steam raising and distribution plant

Introduction

Optimum positioning of analytical instruments at key points throughout the water and steam cycle and water treatment plant on modern power stations can provide operators with a valuable insight into improving plant efficiency and cost effectiveness. In this Application Note, we will look at the benefits of balanced boiler chemistry and how key contaminants can be kept in check to ensure a safe and efficient process.

The vast quantities of water used to produce steam in power generation applications means that achieving well-balanced water chemistry is vital also in order to optimize the efficiency steam raising and distribution plant.

The elevated temperatures and pressures inherent in power generation applications greatly increase the speed of chemical reactions taking place in a boiler. The American Society of Mechanical Engineers (ASME) advises that to control deposition and corrosion in the boiler, plant operators should ensure effective monitoring of makeup water, condensate, feedwater and boiler water qualities.

The absence of adequate monitoring and control will almost certainly lead to both increase costs and more frequent component failures. Evidence shows that allowing boiler chemistry to vary from specified limits can result in expensive plant outages, potentially incurring costs of over $1,000,000 per day.

By measuring and monitoring not just the water in the boiler but also the steam distribution loop and other areas around a power plant, it is possible to obtain a better overview of current conditions. When incorporated into a planned preventative maintenance program, this information can help to substantially reduce the risk of unplanned outages.

Why should I measure boiler chemistry?

A key culprit behind many boiler failures is the accumulation of scale and corrosion brought about by contaminated water entering the boiler.

Even in a well-controlled regime, it is not possible to totally eliminate the presence of potential contaminants present in boiler feedwater. For example, in a 500 megawatt boiler, around 1,500 tons of water is boiled off per hour, equating to one million tons per month. With most of the resulting contaminants that are present in the water remaining in the boiler, the need for close monitoring and control becomes apparent.

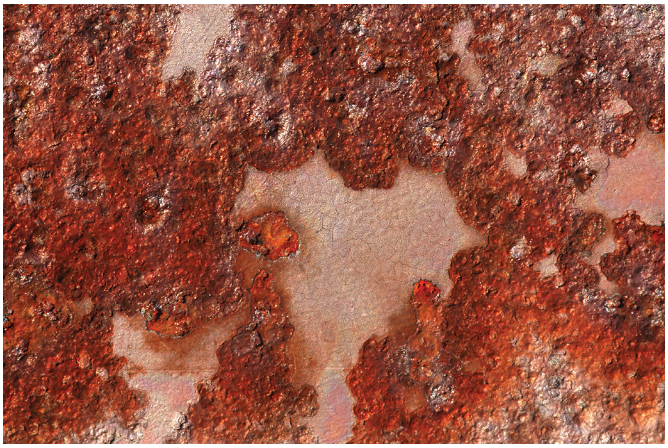
Extensive on-line chemical monitoring is now a very well established practice in the power industry and enables careful control of the water chemistry, to achieve peak efficiency and minimize down time due to excessive boiler corrosion or scaling.

Controlling contamination

Online analysis of the key parameters that can affect boiler water and steam quality enables operators to achieve a continuous picture of conditions in and around the steam raising and distribution loop. The following is breakdown of some of the key parameters that should be monitored and how they can be accurately measured using ABB's Navigator analyzers.

Dissolved oxygen

Dissolved oxygen is a major cause of corrosion in steam systems. Oxygen contamination of steam condensate can lead to inefficient or improper feedwater aeration, air leakage at pump seals, receivers and flanges, leaking heat exchangers and ingress into systems that are under vacuum. It can also promote localized pitting corrosion, which can cause rapid failure of critical equipment in the steam system.



In its dissolved form, oxygen is highly corrosive to most metals, especially the mild steel used for boiler tubes.

One way to control dissolved oxygen levels is by dosing boiler feedwater with oxygen scavenging chemicals, such as hydrazine. When these chemicals are used, operators can assess the efficiency of their dosing regime by measuring for dissolved oxygen at the economizer or boiler inlet, with any fluctuations able to be addressed by increasing or reducing the dose quantities.

The dramatic variations in oxygen levels during the load cycle of a plant, combined with the different levels required for different boiler chemistry regimes, require an analyzer that offers a fast response across both high and low dissolved oxygen concentrations. For example, ABB's Navigator 500 Low Level Dissolved Oxygen online analyzer uses a galvanic-type sensor to accurately measure dissolved oxygen levels in process feed water and can monitor dissolved oxygen concentrations up to 20 parts per million.

Hydrazine

As an oxygen scavenger, hydrazine is widely used to remove trace levels of dissolved oxygen in boiler feedwater, forming nitrogen and water. At high temperatures and pressures, it will also form ammonia, which increases the feedwater pH level, reducing the risk of acidic corrosion.

Hydrazine also reacts with soft haematite layers on the boiler tubes to create a hard protective magnetite layer which acts to protect the tubes from further corrosion.

Placing a hydrazine monitor at the feedwater inlet will help check that feedwater is being dosed with the correct amount of hydrazine. Too much hydrazine is both wasteful and costly, whilst too little will not be able to adequately control dissolved oxygen levels and will prevent adequate formation of magnetite. Typically, the most effective dosage of hydrazine is 3:1 parts hydrazine to the expected level of dissolved oxygen, which should result in a dissolved oxygen concentration level of five parts per billion.

To avoid over- or under-dosing of hydrazine, a continuous analyzer should be used to provide real time readings of feedwater conditions. The Navigator 500 Hydrazine provides a continuous measurement of the level of hydrazine in boiler feedwater, enabling the chemical dose to be controlled automatically. The information provided by the monitor enables the exact dose to be administered in response to the actual level of dissolved oxygen present. This avoids both the expense associated with overdosing and the costly corrosion damage caused by under-dosing.

An electro-chemical cell is used to accurately measure the amount of hydrazine in boiler feedwater. This accuracy is reinforced by temperature compensation, which, coupled with a fast response time, ensures that readings reflect the actual feedwater conditions.

The Navigator 500 features a separate sensor section and transmitter

The ability to add up to four sensors to one transmitter also enables measurement of samples from different points in the boiler feedwater line. This not only offers an economic and compact solution, but can also help to minimize the risk of under or over-dosing by providing a precise picture of hydrazine levels between the feedwater dosing and economizer inlet.

Sodium

As the sixth most abundant element on Earth, sodium is the root cause of many different types of corrosion in boilers, making it one of the most important parameters to measure in power plant applications. Traditionally, conductivity measurement was used to indicate the total dissolved solids. However, it lacks the sensitivity to measure sodium at low levels.

A particular problem with sodium is the cycle it undergoes during hydrolysis. During this process, sodium carbonate is turned into sodium hydroxide, which then attacks iron in the boiler. As iron dissolves, it forms sodium ferroate, which under hydrolysis regenerates into sodium hydroxide. Prolonged exposure to this cycle will put boiler components such as bends and joints under constant attack, causing them to become embrittled and increasing the risk of leaks and cracks.

If carried over in the steam, sodium can also build up on critical components as the steam condenses, including the steam turbine, where it can attack the turbine blades.

The importance of safeguarding against sodium means that operators should measure levels at key points in the steam generation and distribution loops. Sample points should include the water treatment plant, the condenser extractor pump, the polishing plant outlet and the saturated and superheated steam distribution loops.

At the water treatment plant, monitoring for sodium can be used to help identify any sodium breakthrough from the cation exchange and mixed bed outlets caused by exhaustion of the ion exchange beds.

As sodium is a monovalent ion, it is much more likely to break through first, providing an early indicator of bed exhaustion. As such, monitoring for sodium also acts as a useful measure of bed efficiency as well as a precursor measurement for potential sodium contamination further down the line.

On-line measurement of sodium after the extraction pump provides a useful indicator of condenser leaks. Operated under high vacuum, the condenser is prone to leaks that cause cooling water to become mixed with the condensate. A key concern here is the ingress of chloride and sulphate, which occur mainly in the form of sodium chloride and sodium sulphate. As sodium monitors have 10 to 100 times the sensitivity of on-line chloride measurement techniques, measuring sodium levels provides a good way of detecting for the presence of chloride and sulphate.

ABB's Navigator 600 Silica analyzer provides accurate monitoring over a wide range of concentrations (0 to 5000ppb)

Working in a similar way to water treatment plant, polishing plants can use sodium monitors to detect ion exchange bed exhaustion as well as for monitoring water quality. In some power stations, the polishing plant is incorporated into the main water treatment plant.

In high pressure boilers, any chemical contaminants present in the steam can quickly build up in the boiler drum and can be carried over in the steam to the turbine.

Monitoring for sodium in the saturated and superheated steam distribution loops helps to protect against corrosion and the formation of sodium salts on the superheater or turbines caused by steam carryover. By measuring the purity of the steam and comparing it to the measurements taken from the saturated steam before the superheater and condensate stages, operators can assess whether quality is being affected by issues such as deposition of sodium salts or condenser leaks. The same measurement can also be performed for Once Through boilers; however, as these have no separate superheaters, the sample is taken from the superheated steam before the turbine.

The Navigator 500 Sodium provides a continuous measurement of sodium concentrations. It uses an ABB sodium ion-selective electrode and reference electrode to measure the sodium ion concentration in demineralization plants and in the steam / water cycle of steam-raising plants. The Navigator 500 Sodium is an accurate, reliable instrument that requires very little maintenance and measures sodium ion concentrations within the range 1ppb to 10ppm. This accuracy is reinforced by automatic temperature compensation, ensuring that readings reflect the actual process conditions.

Featuring a separate sensor section and transmitter, the ABB Navigator 500 is available in both single stream and multiple stream versions.

In the multiple stream version, up to three sodium streams can be measured by a single wet chemistry section, with the resulting signals sent digitally to the transmitter.

Silica

Silica is a major culprit behind the build-up of hard and dense scale inside the boilers and turbines of power generation plants. It has a very low thermal conductivity and forms a dense porcelain-like scaling that cannot be removed even with acid. Even a 0.5mm build-up of silica can reduce thermal transfer by 28%, reducing efficiency, leading to hot spots and eventual rupturing, ultimately resulting in plant failure.

The only way to control silica build-up is through an effective monitoring regime. Like sodium, silica should be measured at multiple points around the steam system, including the demineralization plant, boiler feedwater, boiler drums, superheater and condenser outlets.

Measuring silica in the steam from the boiler, either at the superheater or at the entrance to the turbine, gives a good indicator of overall steam purity. Provided that the silica concentration remains below 20 parts per billion, the level of scale deposition should be minimal.

Unlike many other potential contaminants, dissolved silica is only very weakly ionized, so it cannot be detected using a simple conductivity measurement but instead requires a dedicated monitor.

ABB's Navigator 600 Silica analyzer provides accurate monitoring over a wide range of silica concentrations (0 to 5000ppb).The analyzer is available in single or multi-stream configurations, enabling operators to use just one device to monitor up to six streams sequentially.

Other parameters that operators may also wish to monitor for include phosphate, ammonia and chloride, using sensors that offer quick response times, are temperature tolerant and require minimal maintenance.

Tips for on-line monitoring

Any regime aiming to maximize the efficiency of on-line monitoring systems should include using instruments that can respond quickly to changes in boiler chemistry and which offer self-diagnostic capabilities where possible.

The location of monitoring equipment is a vital factor in ensuring the best return on investment in a power plant. Ideally, monitoring equipment should be situated in an environment that has less potential for damage, has easy access for maintenance and allows for enhanced measurement accuracy.

ABB's Navigator 500 analyzer range uses a separate sensor and transmitter design. All analysis and signal conditioning is conducted within the sensor section and transmitted digitally to the transmitter. Each transmitter can collect data from up to four sensing systems. This enables monitoring at multiple points without the cost associated with purchasing and installing separate transmitters. The four transmitter inputs can be used to collect signals on one parameter or can be mixed and matched, with multiple parameters being fed to one unit.

These units can simply be connected up to the power plant's existing sampling lines, greatly reducing the time, cost and disruption typically associated with installing and commissioning sampling systems. The added option of digital communications, including Ethernet capability, enables data to be relayed to a central control room, helping to open up the accessibility of the measurement data beyond the local operator.

ABB's Navigator 600 Silica analyzer substantially cuts the costs and maintenance associated with silica monitoring in power generation and other large-scale steam and water dependent applications.

Providing accurate monitoring over silica concentrations from 0 to 5000ppb, it requires just four 2.5 liter bottles of reagents, significantly reducing the annual costs associated with reagent consumption.

The combination of a carefully designed wet section with remote management, automatic calibration and cleaning functions, together with twice as many diagnostic messages as other units, help to further cut the costs and effort needed to maintain the device.

The analyzer is available in single or multi-stream configurations, enabling operators to use just one device to monitor up to six streams sequentially all with current loop, Ethernet or PROFIBUS® * outputs.

* PROFIBUS is a registered trademark of PROFIBUS and PROFINET International (PI).

Summary

The ability to gauge maintenance frequency, coupled with enhanced life cycle costs, offers a golden opportunity to improve reliability of supply and minimize unscheduled disruptions.

For this reason, it is important to ensure that on-line monitoring systems are themselves well maintained and that, where possible, they utilize the latest developments in technology to ensure they deliver maximum benefits.

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