Trace analysis delivers optimum steam boiler efficiency and cost savings

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In generating electric power for several hundred thousand residents, businesses and government facilities in the Southwestern U.S., a large multi-site electric utility takes great care to protect the steam boiler systems that drive its multiple turbine power generation units (Fig 1). The utility's process engineers and plant teams closely monitor trace dissolved oxygen (DO_2) and other corrosion sources, which can affect boiler maintenance and lifecycles.

The efficiency of boiler systems is important for a number of reasons. First, customers pay unnecessarily high electric bills when boilers operate inefficiently. They require more natural gas or coal to fuel them to produce enough steam to drive a plant's power producing turbines. They also require more intensive maintenance that requires technician labor—again increasing costs. There is also the possibility of unplanned downtime, which requires artificially high levels of system redundancy, or a shorter boiler lifecycle—again affecting cost.

Beyond higher costs, there are also three important environmental issues to consider. The extra natural gas or coal that fuels inefficient boilers results in higher greenhouse gas (GHG) emissions, which result in climate change. Many times boilers that are operating inefficiently consume more water than necessary, which is a problem in the arid Southwest. When the water is no longer suitable for use, then the treatment process also requires additional consumables to bring the water up to environmental standards prior to discharge.

Fig 1. Aerial view of electric power plant

The Problem

Industry experts calculate that problems caused by boiler corrosion cost the electric utility industry billions of dollars per year. Two common causes of corrosion are boiler feed water gases including dissolved oxygen and carbon dioxide (CO_2), as well as low levels of pH and alkalinity. They affect the hottest areas of the boiler system, including the water wall, screen and economizers. The result of the corrosion weakens metal surfaces causing mechanical stress and eventually failures.

Typically, boiler and feed water systems are constructed of carbon steel materials. Their components also may include copper alloy and/or stainless steel. All of these materials are subject over time to varying degrees of corrosion in the rugged high temperature, high pressure operating environment of boiler systems. Dissolved oxygen, in particular, is highly corrosive in water and leads to pitting that creates tiny holes in metal surfaces, which over often a relatively short period time can lead to part failures that require costly repairs or equipment failures.

To remove the oxygen, the boiler feed water is pretreated thermally with deaerator equipment and/or by chemically degassing it to achieve oxygen-free water. This state must be maintained throughout the steam cycle to protect equipment from harmful corrosion.

There are two types of deaerator equipment: known as the tray type and the spray type. Tray deaerators are designed with a vertical domed deaeration section with trays that sits over a cylindrical tank in the horizontal position, which stores the deaerated water. Spray type deaerators are designed with only the horizontal cylinder tank, which includes a deaeration baffle inside the tank and feed water storage.

The process engineering team at the electric utility needed a new higher accuracy, continuous monitoring solution to replace its existing trace DO_2 analyzer. The analyzer monitors the boiler feed water exiting the deaeration equipment and includes sensors to measure pH and conductivity in the boiler water.

They turned to the applications team at Electro-Chemical Devices (ECD) for guidance in replacing their aging analyzer equipment. After reviewing the application, the engineers at ECD recommended the company's DO90 Trace DO_2 Analyzer (Fig 2). The DO90 analyzer uses the T80 universal transmitter, the same transmitter used with the S80 pH and Conductivity Sensors. The DO_2 sensor provides users with a wide measurement range of 0.001 to 20.00 mg/l or ppm/ppb auto-ranging.

Fig 2. DO90 Analyzer (Sensor Only)

The Solution

Monitoring trace DO_2 requires a sophisticated analyzer unlike the typical DO sensors utilized in many other lower level industrial processes involving water. Continuous monitoring and reporting are required in this demanding near zero concentration environment, rather than the typical grab sampling process with a portable sensor that can lead to sampling errors of the kind that result in the need for additional expensive water treatment consumables.

To prevent these problems, the DO_2 analyzer features a rugged lead silver, galvanic, dissolved oxygen sensor with a durable PFA Teflon® membrane. The sensor is combined with an intelligent universal transmitter designed for continuous service. The sensor is housed in a heavy duty, 316L flanged stainless steel body developed for use in rugged industrial process environments.

Oxygen diffusing through the DO_2 sensor's membrane is reduced at the cathode, producing hydroxide ions that react with the lead ions in the electrolyte to form lead hydroxide. The anode dissolves more lead ions into the electrolyte, sending electrons to the cathode to reduce any oxygen present. The current flows from the lead anode to the cathode. Under constant temperature and pressure conditions, the current is proportional to the oxygen concentration of the medium.

The DO_2 sensor is a smart, digital device featuring a noise-free digital signal for communication to the T80 Transmitter, which easily integrated with the utility's distributed control system (DCS) for monitoring and control purposes. All data processing is internal to the sensor, and the calibration information is stored in the sensor's memory. It also provides integral temperature measurement and compensation.

The utility's plant team appreciated the fact that the DO_2 sensor is packaged with an easily replaceable electrode cartridge. This cartridge design eliminates the need for messy electrolyte/membrane replacement kits.

To support the utility's rugged operating environment in the hot Southwest, the DO_2 sensor operates at a process temperature range of –5 to 50℃ and a process pressure range of 0 to 15 psi maximum overpressure. Vacuum operation is not permitted. Highly stable over time, the DO_2 sensor, with its continuous polarization, drifts less than 1 percent per month.

The Model DO90 DO_2 sensor is compatible with ECD's T80 Universal Transmitter. It is a single or dual channel transmitter designed for the continuous measurement of DO, pH, ORP, pION, turbidity, conductivity or resistivity in a general purpose industrial environment. The transmitter digitally communicates with the DO_2 sensor or any intelligent sensor, automatically configuring the transmitter's menus and display screens to the measured parameter.

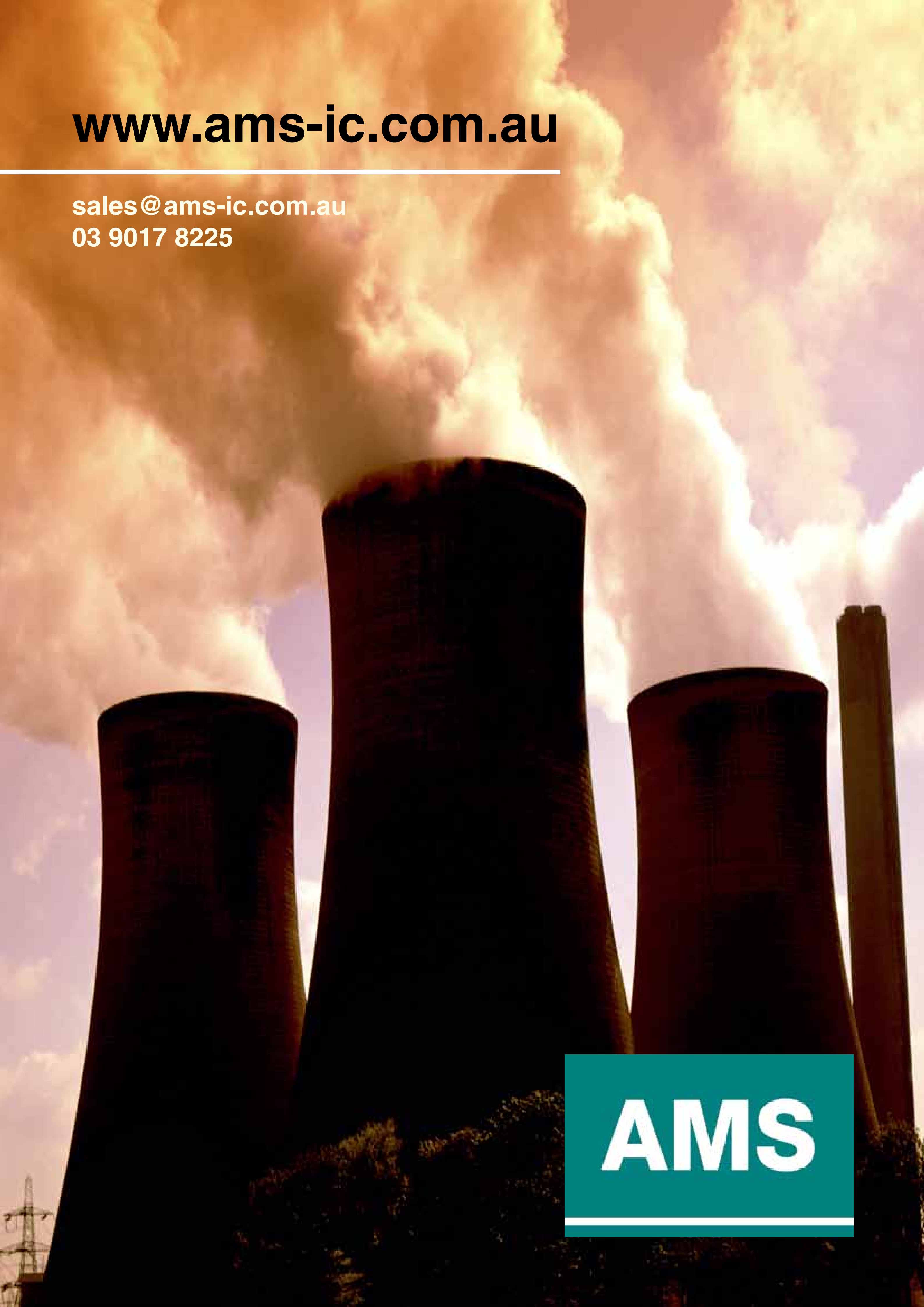
The DO90 flow cell and sensor have been specially designed for use high purity, low conductivity boiler water. The orientation of the inlet and the outlet sample lines automatically purges air from the flow cell. The measurement chamber is optimized for fast response and all wetted parts are 316L stainless steel.

To meet their requirements, the utility plant team chose ECD's complete plumb and play panel mounted DO_2 analyzer system (Fig 3). All that was necessary was to mount the panel (17-x- 12-inches), plumb 0.25-inch sample tubing to the tube fittings and provide power to the analyzer (either loop powered or 110/220 Vac). The system is also available as a complete kit, less the panel, for mounting to an existing water panel or all the individual components can be purchased separately as necessary.

Fig 3. DO90 Analyzer Complete Panel System

Conclusions

After installing the new trace DO_2 analyzer, transmitter and sensors for pH and conductivity, the utility process engineering team reports the boiler system is now operating at full efficiency. Having better process water data has allowed the plant team to reduce water treatment cycles and to increase the number of water re-use cycles prior to final treatment and disposal of system water, which is now consistent with best industry water management and pollution prevention practices.



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