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Optimising power plant efficiency by measuring silica

Pierre Guillou and Katrien Verhassel look at the problem of silica contamination in power plant water systems.

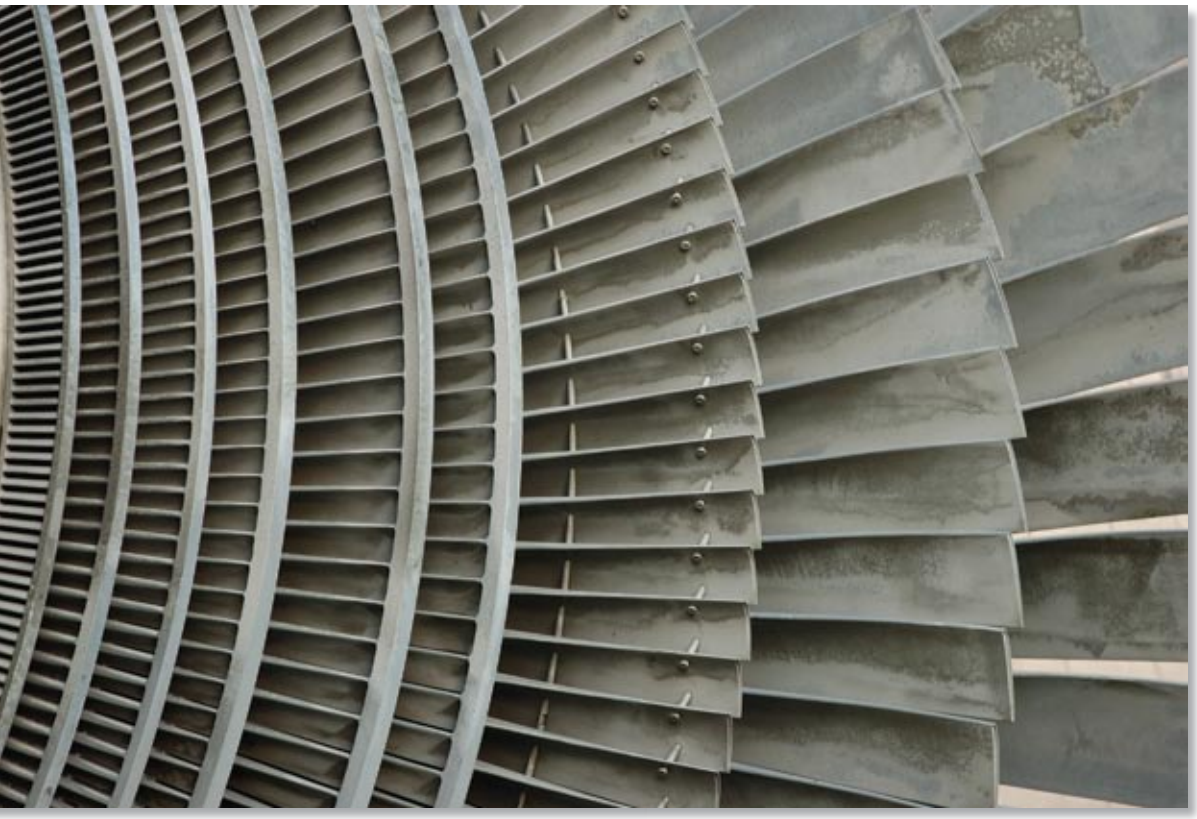

Fig. 1. Silica can deposit itself on turbine blades in a very short period of time. If it is not removed deposits can distort the shape of the blades.

Among many contaminants in the steam/water circuit, silica plays an important role in process monitoring, mainly because it is highly soluble in steam and extremely difficult to remove from steam/water. It is a contaminant that appears in many potential external and internal entry points.

External contamination could arise from: raw water ingress (demine plant) or drain line mix-up (wearing of seal or incorrect installation); use of silicon based lubricants and oils (result from leaky seals in the water system or turbine oil leaks or by silicon-based coatings on tubes used in replacement activity); feed water system (eg, un-reacted silicon) or chemical dosing of reagent problems (eg, caustic addition after resin bed regeneration).

Internal contamination is caused by: the condenser dust (a build-up of paint, quartz and grease; overhaul materials such as gasket materials, silicone sealants and kitty litter are potential sources of the condenser dust); oil spill absorbent materials (kitty litter, diatomaceous earth); in case of required replacement an open boiler tube could cause fly ash contamination or refractory material; blasting material (need to clean the LP turbine of scale from the process); accidental misplacement of materials (caused by work practices and poor housekeeping).

Altered steam velocities

If silica is not removed from the boiler feed water, it will concentrate itself on the drum and is carried over in steam to form adherent deposits in the steam passage way distorting the original shape of turbine nozzles and blades. This alters steam velocities and the pressure drops reducing the capacity and efficiency of the turbine.

Severe conditions can cause excessive rotor thrust while uneven deposition can unbalance the turbine rotor causing vibration problems. Turbine deposits can accumulate in a very short time when steam purity is poor and can only be removed by external service cleaning and blasting aluminium oxide on the surface.

Experience has enabled the power industry to specify allowable concentrations of SiO_2 in steam to avoid turbine damage.

For a 180 bar operating pressure, in order to get a maximum of 5 ppb of SiO_2 in the steam, the boiler water should not contain more than 100ppb of SiO_2 if ideal boiler conditions are met.

Any minor deviation of silica concentration on a power plant can have serious and expensive consequences in relation to performance, reliability, efficiency and safety, it is logical that this parameter should be monitored closely.

Silica concentration can be measured at the following process steps (which may vary from one plant to another depending on plant architecture and management methods):

- Boiler blow down (drum boilers only).
- Economiser outlet.
- Steam.
- Make-up water.
- Condensate polishing.
- Demineralisation plant.

Increase in steam production

Today, power plant processes have changed and steam usage has increased. The steam cycle is now more complex, it has to go through a higher number of application steps, such as heat transfer, cleaning and pressurising vessels to finally maintaining steam purity to recover heat in the main steam/water cycle.

The production of huge quantities of steam in the energy conversion process is also universal. For example, a typical fossil-fuel power station converts around 650tons of water into steam per hour, in each of four 160MW boilers.

This represents around two million tons of water usage per month. With such a large output of water in the steam process, the chemical quality of the water is critical.

A beneficial practice that should be considered when measuring silica in power plants is during the performance of anion exchangers and mixed-beds. Both the resin efficiency and exhaustion (break-through) can be monitored with high sensitivity and reliability here.

This practice allows operators to:

- Follow-up on the demineralisation process performance
- Make better use of resin capacity.
- And optimises regeneration cycles.

So, measuring silica in steam/water processes today is 'a must' for sustaining and increasing power plant process efficiency.

Paying attention to the so-called utility plant can also yield attractive returns. Improving water treatment programmes by preventing the formation of insulating boiler scale, namely silica, could save a typical power plant facility 10–12 per cent in steam-realted costs.

Measuring silica easily

Hach Lange, a supplier and producer of water analysis technology, recently launched the POLYMETRON 9210 Silica analyser. This analyser provides operators' the right means to measure silica in power plants.

It detects early stages of resin saturation due to its low 0.5 ppb detection limit which in turn reduces resin generation costs. The analyser's built-in sequencer (1 to 6 channels) optimises plant investments and favours the implementation of resin monitoring 'best practices'.

The innovative 'zero method' operation determines potential Silica deposits on turbine segments; it is performed automatically without the need of calibration solutions or resin cartridges – eliminating any potential human error. The unique grab sample feature ensures on the spot checking with reliable calibrations.

To maintain measurement accuracy an air bubble elimination in the photometric cell has been integrated and for smaller power stations that are not constantly running, to return on-line with the sample after interruptions is also an option now.

In order to reduce operating and maintenance costs to a minimum, this analyser has been designed to allow reagents to be made locally and only needs replenishment every 55 days (10 minutes cycle) or 84 days (15 minutes cycle).

Today, Hach Lange has 3500 POLYMETRON Silica analysers installed. Power plant operators are interested in analysers that can measure silica and run by themselves, having them be reliable and optimise plant process performance.

Operator feedback

The POLYMTERON 9210 Silica analyser meets all these criteria. Direct operator feedback confirms that many users appreciate the following advantages this analyser has to offer: zero method, using less reagents; built-in sequencer of one to six channels which optimises plant investments; unique grab sample feature allowing on the spot checking; easy to navigate menu structure; measurements are accurate and reliable.

The POLYMTERON 9210 can now easily be integrated into a nuclear or fossil power plant and will measure silica accurately, reduce demineralisation water plant costs and optimise overall plant process efficiency. ●

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