Silica Monitoring On Power Plant

TECHNICAL NOTE

Introduction

Extensive on-line chemical monitoring of both the water/steam cycle and the water treatment plant on modern power stations, is now a very well established practice. This enables careful control of the water chemistry to achieve peak efficiency and minimise downtime due to excessive boiler corrosion or scaling.

Although silica has no significant corrosive effect which other dissolved ions may create within the plant, it has a detrimental effect in the formation of extremely hard and dense scales within the boiler system and the turbine. This leads to thermodynamic deficiencies and mechanical problems.

As dissolved silica is only weakly ionised, it is difficult to detect by conductivity measurement. Dedicated silica analysers are therefore necessary if accurate information is to be obtained. This includes monitoring of silica in the water treatment plant.

This Technical Note highlights typical sample points for on-line silica monitors found on power stations, and describes the information that the measurement provides.

What is silica?

Silicon is the earth's second most abundant element after oxygen. It is not found free in nature, but as the dioxide (SiO_2), and as silicates which are compounds of silicon, oxygen and other elements. Although most silicon compounds are relatively insoluble, natural waters used as sources for power generating stations can contain up to 40 mgl^{-1} of these compounds.

Total silicon compounds in water can be divided into 'reactive' (dissolved) and 'non-reactive' (undissolved) compounds. Up to half the silicon compounds in the source water may be non-reactive, and so must be reduced significantly by the pre-treatment process, as non-reactive silica can be converted to reactive form in the boiler.

The on-line monitors respond only to the dissolved fraction and so in the present context, only the reactive form is referred to as 'silica'.

Sample Points

The typical sample points for chemical monitoring are as shown in Figs. 1 to 3. Details of specific sample points where on-line silica monitoring is carried out are as follows:

② – Anion Exchange Bed Outlet – Water Treatment Plant

The function of the Anion Exchange Bed is to exchange anions (negatively charged ions from dissolved solids) in the water with hydroxl ions (OH^-) in the resin. Anions found in the raw water include sulphate (SO_4^{2-}) and chloride (Cl^-). This process takes place until all the hydroxl ions on the resin are removed, known as bed 'exhaustion', when the levels of anions will rise in the water from the bed outlet. This is known as 'breakthrough'.

The passage of silica through the previous Cation Exchange Bed will have produced an ionised form; namely silicic acid, and it is this which is retained by the anion resin and exchanged with the hydroxl ions. The silica molecule is held relatively loosely and therefore becomes the first impurity to break through when the resin is near exhaustion.

Monitoring the silica content of the Anion Bed will give an early indication of bed exhaustion. At this point the bed is regenerated by passing alkaline solution through it to reinstate the hydroxl ions on the resin.

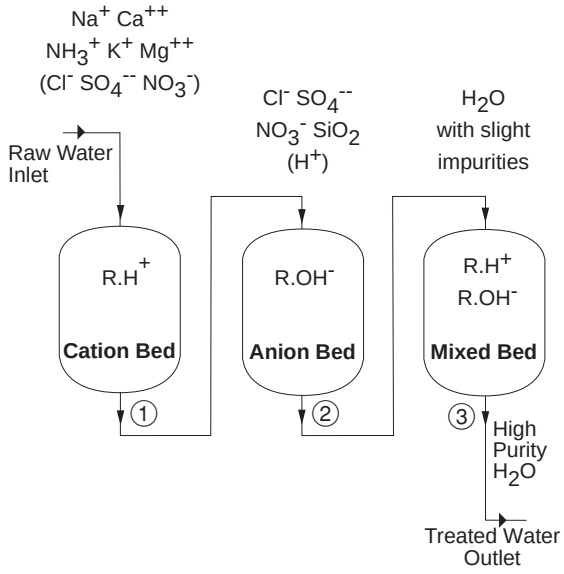

Fig. 1 Complete Demineralisation Process

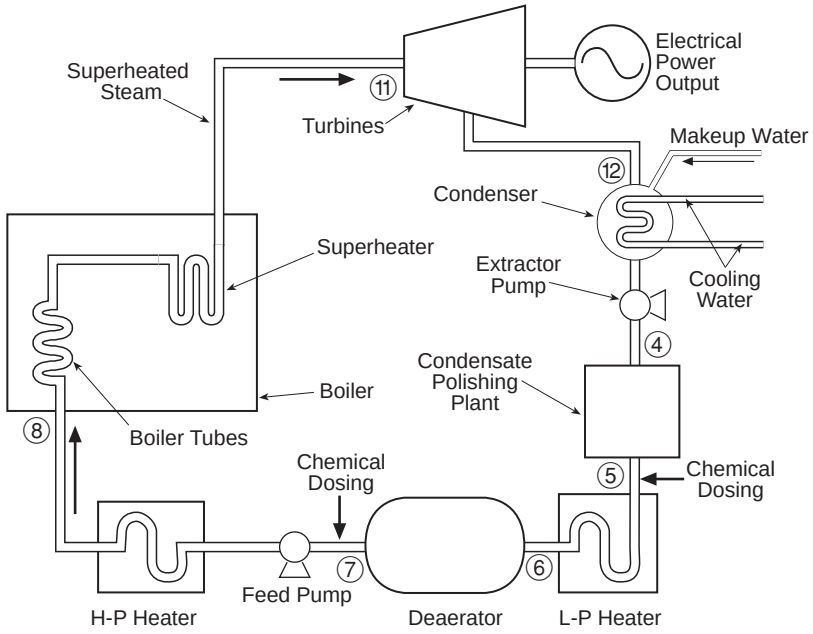

Fig. 2 Typical Generating Station Steam/Water Cycle for a Once-through Boiler

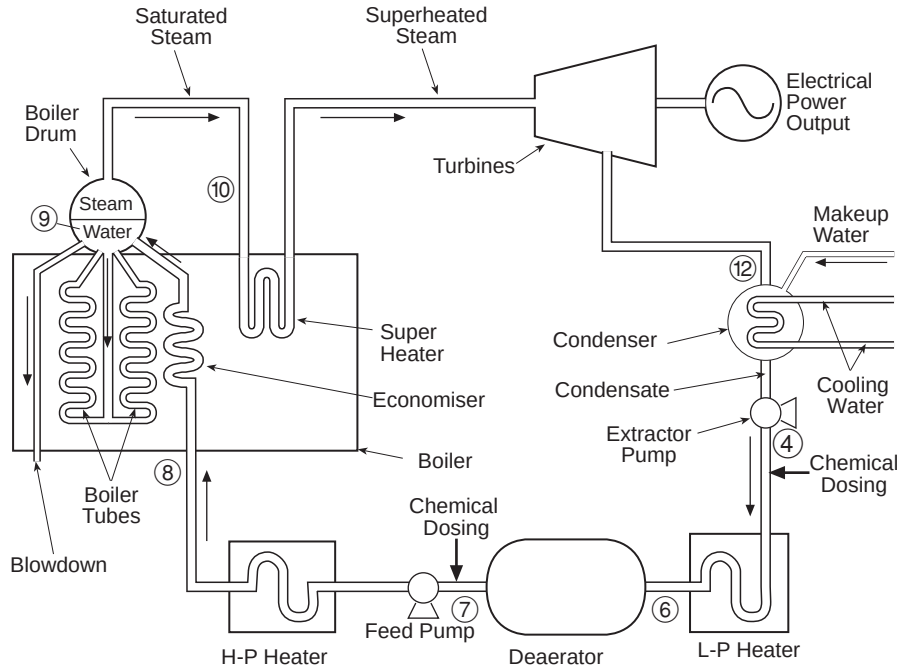

Fig. 3 Typical Generating Station Steam/Water Cycle for a Drum Boiler

③ – Mixed Bed Outlet – Water Treatment Plant

The Mixed Bed contains a mixture of both cation and anion exchange resins to reduce the dissolved solids concentration further, and produce the required treated water quality, which is then used as 'make-up' in the water/steam cycle.

Here, silica monitors are again used to monitor the final water quality, and detect exhaustion of the anion exchange resin. It is important that the final silica concentration is kept below 20μgl^{-1} to ensure that the concentration of silica in the steam presented to the turbine can be maintained at an acceptable level.

⑤ – Polishing Plant Outlet

The polishing plant is used mainly on once-through type boilers to reduce chemical contamination, which is far more critical on this type of boiler. Because the polishing plant is similar to the water treatment plant, silica monitors can be used again to detect resin exhaustion and monitor water quality. On some power stations the polishing plant is incorporated into the main water treatment plant.

⑧ – Boiler Inlet (Once-Through Boilers)

Comprehensive chemical monitoring of the final feedwater, including silica, on once-through boilers, is required as a final check on quality and acceptability.

Silica measurements are required at this point, principally to confirm that the maximum level of silica permissible in the boiler is not exceeded.

⑨ – Boiler Drum

Silica build-up is monitored inside the boiler drum.

The silica concentration is distributed between the water and vapour phases in a boiler. As the temperature and pressure are increased, more silica becomes present in the steam. In high pressure boilers, therefore, silica is appreciably concentrated in the steam and this is when 'carry-over' may occur, being deposited later, on the superheaters or turbine blades. Silica entering a high pressure boiler can concentrate very quickly. An impurity entering at a concentration of 2 mgl^{-1} in a boiler evaporating 1500 tons of water per hour, would collect in the boiler at a rate of 2 tons per month. Figure 4 illustrates the maximum boiler pressure permissible, given the concentration of silica found in the boiler.

Should the concentration of silica in the drum become too high, then a 'blowdown' is initiated. This is the removal of contaminated water from the boiler. Adequate control of the blowdown is very important. If it is allowed to occur too often, it becomes expensive and inefficient.

The silica monitoring in the boiler drum is one parameter which can be used to control blowdown.

⑩ and ⑪ – Steam

Silica monitoring provides a good indication of the overall steam purity level provided by the drum boiler, and subsequent action is required to avoid deposition of silica on the superheater and turbines. Where deposition takes place in the boiler, it is known as 'hide-out'. It has been found that no deposition occurs if the concentration of silica in the steam does not exceed 20 μgl^{-1}.

The same measurement can be carried out on once-through boilers, but because there are no separate superheaters, the sample is taken from the superheated steam prior to entering the turbine.

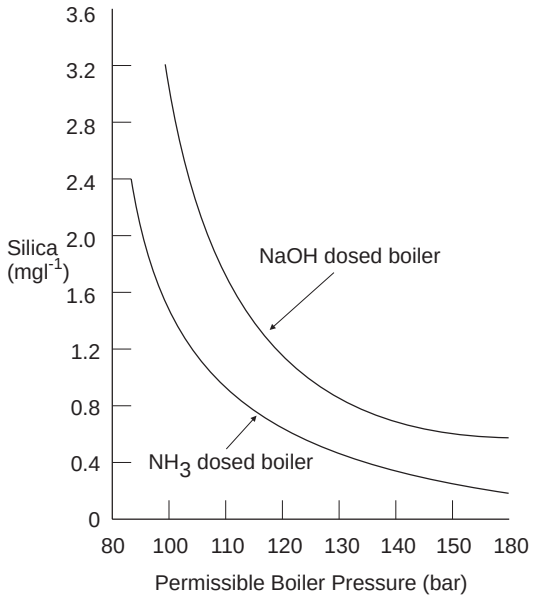

Fig. 4 Silica versus permissible boiler pressure