Volume 2, Issue 3

11/07/2015

ALTRET INDUSTRIES PRIVATE LIMITED

BOND—AN INTERNAL TECHNICAL MAGAZINE

Overlooked Area :

Colloidal Silica in Power Plant Water Chemistry

In power plant boilers most critical parameter of water chemistry is Silica in steam.

Steam purity is highly needed and is critical for consistent power generation. It is observed that surface water is being used by many power plant industries as makeup water. The surface water contains high amount of silica and specifically colloidal silica which is the main culprit for turbine deposition.

This article highlights the importance of water chemistry, Silica chemistry and how to control or prevent silica deposition in power boiler and turbine. Moreover the article also emphasizes the importance of accurate water chemistry analysis and common issues faced by industries and how to overcome those issues.

Need For Boiler Water Treatment at Power Plant

Water is the essential medium for steam generation. Conditioning it properly can increase the efficiency of boiler and as well as extend the boiler's life . Treating boiler water also insures safe and reliable operation: without proper treatment, severe problems can develop, some so severe that boiler itself can be destroyed.

Boiler water problem generally falls into classes: deposit related and corrosion related. Because the two often interact, it is very common to find a boiler experiencing both simultaneously. **There are many instances where deposit causes corrosion and corrosion causes deposits.**

The other problem is of steam purity. The live steam is contacted with turbine blade at specific temperature and pressure hence pure quality of steam is very much important to prevent turbine trouble free operation.

Therefore the aim of the boiler water treatment is

1) To prevent the formation of scales and deposits on heating surface

2) To prevent corrosion in the boiler and steam system.

3) To maintain high level of steam purity.

The water which directly enters a boiler is referred to as Boiler **feed water**. Boiler feed water may be made of Make up water and of one or more sources of Condensate return. *Make up water* is the original water which enters the industrial process as well water or surface water and is further purified for specific use in boilers . This should be viewed as "new" water which enters the boiler cycle. *Return condensate* is water which is passed through the boiler, evaporated to steam, served some purpose throughout the system and then been condensed back to liquid water and routed the boiler from where it came.

About 500 g of deposits distributed more or less evenly all over the blading section can bring down turbine efficiency by 1%.

Chemistry of Silica

Silica (SiO_2) exists in water in equilibrium with the bi silicate ($HSiO_3^-$) ion as a very weak acid. In the ionic form, silica can be removed by strong base anion exchange resins operated in the hydroxide cycle. Since the two forms exist in equilibrium, silica can be almost completely removed from solution. When present as a single unit of silica, in equilibrium with bi silicate, the compound is termed reactive silica.

Silica can also exist as a polymer, often referred to as colloidal silica. These long chains of individual silica units exhibit virtually no charged ionic character, and cannot be removed by the ionic process of ion exchange.

Silica Boiler Feed Water:

Silica is a problem for high pressure boilers. It exhibits enough volatility that high pressure boilers will have silica carry over to the vapor partition. **When the steam pressure is reduced in the turbines, the silica will precipitate on the blades as a glassy deposit which reduces efficiency.** Both types of silica, colloidal and reactive, can cause this problem as colloidal silica will break down and volatilize under high temperature and pressure.

Silica is tricky because colloidal silica may not show up in your feed water silica test (only reactive SiO_2 will, unless you do a more involved total silica test), yet the colloidal silica will break down to reactive silica in the hot boiler. So this may give you erroneously high results (dont understand your numbers, unless you really are at really low cycles). Besides, accuracy may suffer at << 1 ppm silica in feed water sample.

The measurement of total silica is generally considered an off-line procedure; in most cases, a water sample is transported to a lab for analysis.

In monsoon season the colloidal silica is higher compare to other season. Colloidal silica can be minimizing up to some extent with clarifier, Clarifier cannot eliminate silica @100%. . The success of coagulation process is depends on adequate contact of colloidal particle & coagulant. Organic matters associated with colloidal particle should be oxidized with any oxidizer before coagulation process start for successfully remove colloidal compound through coagulation process. Coagulation process is only effective under ideal condition and up to 80-90 % non reactive silica can be minimize with this physical process.

Colloidal silica is typically found in surface waters and has created problems for water treatment because of its stability as an un-ionized compound, making it difficult to remove using ion exchange processes.

Silica is at the lower end of selectivity for anion resins, creating a scenario where silica breakthrough is one of the first to occur. As a result, silica can be effectively removed only if the ion exchange resins are completely and properly regenerated. In fact, if one uses a conventional definition of colloidal silica as that which measures greater than 50 angstroms, even ultra filtration with a molecular-weight cutoff (MWCO) of 100,000 daltons is effective at removing colloidal silica.

Silica is generally found in water supplies in three different forms: **reactive, colloidal and suspended particles (e.g. sand),** with the reactive being that portion of the total dissolved silica that is readily reacted in the standard molybdate colorimetric test, and the colloidal being that which is not.

Total silica should be the sum of the reactive silica and colloidal silica. But total silica may not be expressed that way and colloidal silica may not show up on such tests.

Colloidal silica is insoluble and is something that can be filtered out with a whatman filter. Reactive silica is Dissolved. Colloidal silica is difficult to detect in low (ppb) concentrations, and not many labs are capable of providing analyses.

Main Impurities Found in turbine deposit are

- **Magnetite – Corrosion Product**
- **Sodium Chloride**
- **Silica**

Few Recommended Actions or Guidelines to Prevent Silica Deposition & to Maintain Correct Water Chemistry Parameters

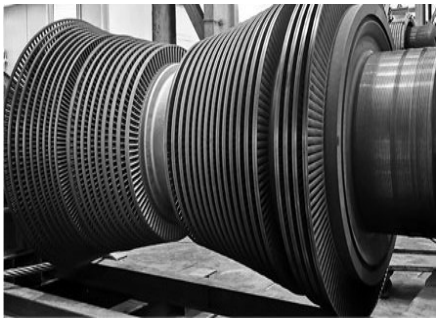
As we all must aware that prevention is better than cured. Here are some guidelines to prevent Power plant turbine & boiler free from Silica deposition and maintain other water chemistry parameters within specified limits. Obviously preventive action & its cost is relatively low in term of power generation or plant availability.

Installation

As describe earlier clarifier doesn't remove colloidal silicate effectively same way Microfiltration, s sand filtration, cartridge filtration, and diatomaceous earth filtration would not be effective in removing colloidal silica. Moreover one has to keep strong complex monitor, adding flocculent or other chemicals, depending on man power if decide to control colloidal silica by conventional mechanism. These type practices are also require experiences. There are many limitations of coagulation process also.

If Surface water is being used colloidal Silica may be culprit, Effective pre treatment is installation of Ultra filtration. The effective operation of Ultra filtration control colloidal silica. Ultra filtration system can be cost-effectively and efficiently used to eliminate colloidal silica and in that way prevent damage of turbine blades.

Ultrafiltration (UF) is a method used to separate extremely small particles and dissolved molecules based on their size. This process is achieved through the use of membranes. The morphology of a UF membrane is critical to its performance in any type of device. The asymmetric structure of the UF membrane causes particles larger than the molecular weight cutoff (MWCO) of the membrane to be retained on the surface while allowing smaller species to pass through the membrane substructure. The membrane's substructure provides rapid transport away from the selective layer and prevents fouling of the membrane. Ultra filtration is can be effectively remove non reactive, polymeric silica in addition with removing other suspended impurities. Ultra filtration can be installed at the outlet of the mixed bad unit.



Measurement & Monitoring

Generally in Industry contest there's an old saying that **'you can't control what you don't measure'** and there no exclusion to avoid silica in power generation it's crucial to keep it under tight control. Effective monitoring through on time Silica measurements at regular intervals is only solution. Silica should be measure at laboratory with proper devices by qualified chemist. It should be measure up to 10 ppb level. In feed water and source water before and after pretreatment Non reactive Silica can be measure as described earlier.

It's generally observed Many Captive power plants or Co-gen Power plant don't have separate laboratory which should be responsible to measure correct power plant water chemistry parameters or else specific measurement instruments are not available in laboratory. Many times we had observed that chemists of Common laboratory or quality control laboratory ignore the criticalness of water chemistry parameters. Some time it's also observed that because of lack of time, existing work load, give priority to process

testing and gives less importance to water testing may lead the substandard quality of water testing. The faulty or substandard testing may lead poor control on water chemistry parameters inside the boiler and ultimately lead deposition or corrosion in boilers and turbine.

It's also observed that lacking in coordination between departments such as quality control & power plant may lead poor control on water testing may lead problem of deposition or corrosion. Sampling is very importance in the case of control of water chemistry parameters or Silica control. The role of staff that is responsible to collect the water samples on right time and with right method in right sample collections pots is also very important.

In many power plants, because of long distance between sample collection points and testing laboratory, the collected sample may be not representing actual condition. The responsibilities of sample collection are headache between internal departments.

To overcome such issues author recommend specific water chemistry laboratory should be under control of power plant head. Same way sample collection is under control of power plant department.

Moreover, it is also experienced by author that pretreatment of source water is under control by process or manufacturing departments and power plant is only responsible feed water.

Recently there was incident that clarifier to treat surface water was undergone for maintenance for 20 days managed by water treatment department and reported to process manufacturer and but power plant authorities were not informed for the same.

It would be advisable that power plant authorities review pretreatment data of water quality if headed by different department.

To monitor Silica, online analyzer can be installed at different location such make up, feed, boiler and steam in addition with installation online conductivity TDS, D.O. analyzers.

There is a limitation of online silica analyzer such devises only measure dissolve constitutes of water neither suspended or colloidal forms silica.

ALTRET INDUSTRIES PRIVATE LIMITED

12/2881, ALTRET HOUSE,
SAIYEDPURA MAIN ROAD
SURAT-395003

Phone: 0261-2451807-808-809
Fax: 0261-2434517
E-mail: info@altret.com

Compiled By:

Zakirahmed Atashbajiwala

Vice President-Tech. & Mkt

Altret Industries Pvt Ltd

info@altret.com

Below are the probable reasons for **high Silica in boiler water and steam**.

1	**High Silica in MB water due to poor operation of MB/ DM water**
2	**High Silica in Condensate water due to condenser in leakage and cooling tower water mixes.**
3	**Poor water quality usage in HP/ LP dosing system for chemical dilution**
4	**Poor quality of chemicals / chemicals contains high silica.**
5	**Presence of Colloidal Silica in feed water / MB water.**

If Mixed bad unit over run, or resins are fouled, may chances of Silica excursion through MB and may cause deposit in boiler. Same way minute leakages may cause adulteration condensate quality, hence silica / high conductivity contains water enter to boiler drum. The best way to counter check any leakages in condensate is that checks water parameters of steam entering to condensers and condensate water after condenser.

It was notice that in some places operator / staff prepare chemical dozing solution in raw water!! But natural raw water contains high silicate & conductivity. The complete water treatment program may disturb in such ignorance. It's advisable to procure pure MB water very near to HP & LP dozing system. The injection rate, proper dilution and dozing frequency is also very important to maintain desire parameters.

Water Treatment Chemicals qualities are also play vital role for significantly disturb desire boiler & steam parameters. Technical or Industrial grade Trisodium phosphate (TSP) may become culprit. Instead of preventing scale may be disturb water chemistry because of impurities present in product. It is advisable use laboratory grade TSP from reliable sources. Also it is recommended to counter check purity of product at laboratory before injecting to the boiler.

Same way other water treatment chemicals purity should be always concern such as pH booster/ alkalinity builder (Ammonia/ Morpholene / oxygen scavenger (Hdyrazine hydrate/ DEHA/ MECO etc) . and phosphate conditioning and condensate corrosion preventive chemicals (Cyclohexyl Amine, DEA or other volatile amine and their blends)

If power plant industries either use basic / generic chemicals or product from water treatment chemicals manufacturer, specification and purity of each chemicals should be counter check. Generally all standard manufacturers are providing specification or COA along with every supply of products.

Role of Water Treatment Chemicals Supplier

There are many ways to approach the selection of a sound and effective internal boiler water treatment program. Above all, the best selection can be made with a proper understanding of system design, capabilities, water chemistry and common sense. Present boiler water technology provided by vendor should be efficient, cost-effective and reliable operative for industrial boiler systems. Selection of the best internal treatment program is a function of many factors. However, the ability to control the program should be the first consideration.

The water treatment supplier vendors provide chemicals along with services to maintain and control desire water chemistry parameters. The vendor also arrange customer awareness program, arrange management review meeting to evaluate existing performance and interact with plant people for scope of improvement.

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