International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 06 Issue 04
April 2019

Purpose of purifying industrial boiler water

Udara S. P. R. Arachchige[1], Sakuna Sandupama P.W[2]
[1,2]Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka

Abstract:

Industrial boilers are the heart of the industry to perform the production process. However, the most common type of failure is boiler tube corrosion due to improper treatment of feed water. Therefore, feed water of the boiler process should be mechanically or chemically treated to maintain the proper boiler operation. Water softener unit, de-mineralization unit can be added before the boiler inlet as external treatment and chemical treatments can be added to the boiler as internal treatment. By maintaining properly treated water, it allows boiler operation to perform smoothly.

Keywords

Boiler, Steam generation, Hot water, water treatment, scale formation

1. Introduction

Industrial steam boilers and hot water generators play vital role in the industrial process. It is necessary to generate the high pressure steam to continue the production process in most industries. However, feed water supply to the boiler should be in good condition to maintain the boiler with highest efficiency.

Water in industries is consumed for many purposes including boiler make-up, processing, product treatment and cleaning, cooling. Boilers are used to produce hot water, steam, or hyper-thermal water based on the production process. Generally speaking, the feed water uses for the boilers must be at least non-corrosive and non-scale forming in the boiler and in the heat exchange piping, or power generating system [1].

The quality of the boiler feed water is essential to avoid the damages to the boiler tubes and shell. Boiler feed water may contain varieties of impurities. Moreover, it is contained a high amount of dissolved oxygen which directly cause for corrosion impact. The purpose of the clean treated boiler feed water can be summarized below [2].

•Prepare the boiler water before it goes to the boiler.
•Maximize the potential of condensate.
•Provide internal boiler protection.
•Maintain clean internal boiler surfaces.
•Avoid problems and shutdowns.
•Extend the equipment life.

2. Problems of water

There are four main types of water streams in the boiler operation. These are make-up water, feed water, condensate water, and blow down water.

Makeup water - The raw water, softened water or de-mineralized water which is required for steam generation.

Condensate water - After steam transfers its heat to the process, it reverts to a liquid phase called condensate. Condensate water very pure and does not require additional treatment to reuse.

Blow down water - The purposely drained water to limit the level of impurities to an acceptable level.

Feed water - The combination of condensate return and make up water which is aggregated and fed to the boiler to make inlet water stream.

There is an enormous amount of water used daily for industrial boiler operation. All raw water contains a number of impurities. The common impurities of water are summarized below in Table 1.

Table 1: Common impurities of water

Name	Description
Turbidity	Finely suspended matter which does not settle
Color	Generally due to decayed organic matters
Suspended solids	Exist in water as suspended particles. They can be mineral or organic particles.
Dissolved solids	There are scale forming and non scale forming dissolved solids in water. The principal ones are calcium and magnesium carbonates and sulphates which form scales when heated.
Hardness	Calcium and Magnesium salts
Acidic compounds	Free Hydrogen ions which cause for acidity of the water
Alkalinity	Bicarbonate and Carbonate and Hydroxyl ion which cause for alkaline situation of the water
Silica	Normally exist in water as an anion or as a colloidal suspension
Dissolved gases	Oxygen and Carbon dioxide which dissolved in water

3. Common problems of boiler operation by Improper water treatment

Mainly three types of common problems are facing due to improper treatment of feed water stream.

- pH and Alkalinity of the water
- Oxygen content
- Hardness and Scale deposits

pH and Alkalinity of the water

The pH of the water is a measure of the degree of acidity of the water. The pH scale varies from 0 to 14 with 0 represent the most acidic condition. The control of pH is essential for boiler water operations due to corrosion problems. According to the standards, the pH of the boiler water must be maintained around 9.5 to ensure that the proper chemical reaction occurs between calcium and magnesium ions and phosphate ions. Low values of pH lead for corrosion effects on boiler tubes and the shell. Therefore, maintaining pH in the acceptable level is highly important. When the pH is below the recommended level, the chances for corrosion increases and when the pH is above the recommended level, chances for scale deposits increased.

Alkalinity represents the carbonate and bicarbonate ions in the water. Carbonate and bicarbonate ions can combine with the Calcium and Magnesium ion to form stable salts as scale in the boiler. Which can deposit on the boiler tubes and cause for resistance to proper heat transfer.

Oxygen content

The most common types for corrosion inside the boiler is due to dissolved oxygen [3]. The presence of oxygen promotes the formation of Hematite or Red Iron Oxide which is non-protective and causes directly for pitting corrosion.

Hardness and Scale deposits

Water is referred to be a hard or soft based on the calcium and magnesium-free ions in the water. Hard water contains scale forming impurities such as Mg^{2+} and Ca^{2+}. Water impurities such as these calcium and magnesium ions, as well as Silica, found in water precipitate at high temperature and form a dense coating of material on the waterside of the boiler tubes. This layer of coating knows as scale formation and will affect the heat transfer mechanism. The scale typically has a thermal conductivity of an order of magnitude less than the corresponding value for bare steel. Therefore, a thin layer of scale acting as an effective insulator for heat transfer mechanism. In that case, to provide the heat required to generate the steam is drastically going up and cause for thermal cracking in the boiler tubes. In addition to the insulating layer of heat transfer, scale progressively narrow the pipe internal diameter and impede the proper flow of water. Moreover, scale causes for the metal temperature to rise and increase the flue gas temperature and overheating conditions in the tubes. Finally, scale leads to fuel wastage and economical impact on the steam generation for the industry.

4. Treatment methods to purify the water

There are several ways of doing boiler water treatment to maintain the boiler at the proper condition. It can be done by external treatment or internal treatment methods.

There are two methods of boiler water treatment, external treatment and, internal treatment. External treatment can be defined as the water purification and prepared for use as boiler feed water. It can be done by clarification, softening, ionization, filtration, de-alkalization, de-mineralization, dearation etc. After the purification step, treated water can be directly supplied to the boiler as the feed water. Internal treatment can be defined as adding chemical dosage to purify the water inside the boiler. In that case, pH booster to increase the pH of the water, sulfite base chemical to remove oxygen as oxygen scavenging, and phosphate base chemical to remove carbonate as calcium carbonate or magnesium carbonate can be considered. This will minimize the potential problems and avoid any catastrophic failure of the boiler operation.

The principal factors should considering for proper boiler operation are listed below.

•Maintains calcium, magnesium and silica content in the feed water.
•Maintain alkalinity and pH of the water.
•Maintain TDS content of the boiler.
•Maintain dissolved oxygen content in the boiler.
•Maintain proper blow down procedure.

The maintain of calcium, magnesium and silica content of the feed water can be externally treated by adding water softener, de-ionization unit, reverse osmosis plant to pretreated the feed water. However, the most common method is to apply water softener to remove calcium and magnesium ions. The silica content of the water cannot be removed by softener, that can only be removed by reverse osmosis plant. Due to the high installation and operating cost of reverse osmosis, it is not regularly applied in the industries.

The softening media is commonly called resin or zeolites which is polystyrene resin. The negative charge resin has the ability to attract positive charges to itself. The negatively charge beads will already be attached with sodium atoms due to the regeneration

process. However, magnesium and calcium positively charge atoms in the feed water replaces the sodium atom as divalent ions are powerful than monovalent cations. In effect, sodium (Na^{+}) is exchanged with calcium and magnesium (Ca^{2+}, Mg^{2+}) ions. The results of this exchange process are soft water flowing out of the softener process unit.

The dearation can be used to remove the dissolved oxygen in the feed water. However, dearation process only is not enough to maintain the oxygen content in the water which causes corrosion. The remainder must be reacted with oxygen scavengers such as sodium sulfite. Sodium sulfite is the most common oxygen scavenger to remove the oxygen from the process water. In that reaction, sulphite attaches the oxygen atoms and converted to sulphate by removing the free oxygen from the water. It is important to keep in mind that Sulfite and other oxygen scavengers should be fed into the storage section of the upstream from the boiler. This allows for it reacts with oxygen before the oxygen gets into the boiler and it also helps to protect feed water lines.

Boiler blow down is the removal of water from a boiler, to control boiler water parameters within prescribed limits to minimize scale, corrosion, carryover, and other specific problems. Blow-down is also effective on removal of suspended solids present in the boiler [4]. Benefits of Blow-down can be described as , Lower pre-treatment costs, Less make-up water consumption, Reduced maintenance downtime, Increased boiler life, Lower consumption of treatment chemicals [5]. When it is added chemicals to remove the calcium and magnesium salts from the boiler water, it will settle as calcium phosphate and magnesium phosphate. Once blow down is carrying out, settled phosphates will leave the boiler with downstream.

5. Conclusion

A suitable water softener plant of base exchange type and chemical dose are essential for proper conditioning of boiler feed water. For any installation of the boiler, feed water should be analyzed and decide the type of treatment method to install. The most important factors of maintaining proper boiler operation are pH of the feed water, oxygen content of the water, TDS value and hardness of the feed water. It is useful to maintain those values within the acceptable limit to control corrosion of boiler tubes and maintain scale formation in the boiler tubes. That will allow industry to perform smooth boiler operation with a minimum operating cost. The blow down procedure should be maintained with proper intervals to remove the sludge which form due to gravity settlement or chemical reactions. That can be performed as intermittent blow down and continuous blow down to carry out smooth process.

6. References

[1] Yasumoto M, Industrial water , Water Quality and Standards – Vol. I.

[2] https://www.pdhonline.com/courses/m165/m165content.pdf, accessed 23 rd April 2019.

[3] Sensorex, Boiler water treatment, https://www.sensorex.com/docs/white_papers/AppNoteBoilerWaterTreatment.pdf , Accessed in 24th April 2019.

[4] Keerthi R.L., Vandana S.P, Boiler Blow down Analysis In An Industrial Boiler, IOSR Journal of Engineering (IOSRJEN) , Vol. 05, Issue 07 (July. 2015), ||V3|| PP 22-28 .

[5] Amit K.J, An Approach towards Efficient Operation of Boilers, International Journal of Scientific & Engineering Research, Volume 3, Issue 6, June-2012.