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Boiler Water Treatment for removal of dissolved impurities in Water

KEYWORDS: Softening, Demineralization, Hardness, Reverse Osmosis

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ABSTRACT *Boiler efficiency is greatly affected by quality of makeup water. Dissolved impurities in boiler water at higher operating temperature produces scale on heat transfer surface in boilers which reduces its efficiency and even damage the boilers. Varieties of treatments are given for removal of dissolved ionic impurities we know as hardness of water according to the operating pressure and temperature of boiler. Continuous monitoring and treatment of water quality increases working life of boilers and provide safe working environment.*

1. Introduction

Rain water is very pure without impurities but on receiving on earth surface and flowing further becomes impure by dissolving and suspending impurities in it. These impurities are known as turbidity, colour, suspended solids, dissolved solids, total solids, hardness, alkalinity, dissolved gases, free mineral acidity, odour. These impurities can be removed by various types of water treatments. Water usage in boiler creating problem like corrosion and scale formation on heat transfer area. This scale is poor heat conductor increases fuel consumption in boilers and not monitored properly can result in boiler failure. Removal of scale forming hardness or dissolved impurities results in higher boiler efficiency and trouble free operation. In low pressure boilers water treatments like water softening and reverse osmosis plant and in high pressure boilers demineralization plant are used for removal of hadness in form of ionic impurities. This treatments are briefly discussed here.

2. Water Softening Treatment

Raw water contains calcium and magnesium ions which form salts that are not very soluble at higher temperature. These cations are called together hardness ions. When the water evaporates even a little, these cations precipitate. This is what you see when you let water evaporate in a boiling kettle on the kitchen stove. Strong acidic cation exchange resins used in the sodium form remove these hardness cations from water. Softening units, when loaded with these cations, are then regenerated with sodium chloride. This treatment is suitable for low pressure boilers having range 10 bar to 30 bar.

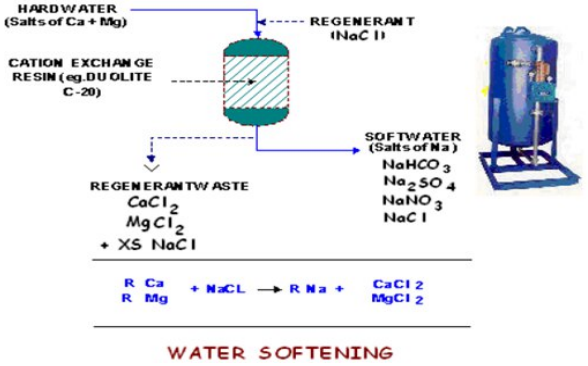

Figure 1. Schematic of Water Softening Treatment

3. Reverse Osmosis Treatment

Osmosis is natural phenomenon in which water passes through a semipermeable barrier from the side with lower concentration to the higher concentration side. As shown in figure water flow continues until chemical potential equilibrium of the solvent is established. At equilibrium, the pressure difference between the two sides of the membrane is equal to the osmotic pressure of the solution. To reverse the flow of water a pressure difference greater than the osmotic pressure difference is applied as a result, separation of water from the solution occurs as pure water flows from the high concentration side to the low concentration side. This phenomenon is termed reverse osmosis.

Reverse Osmosis membrane acts as the semipermeable barrier to flow in the Reverse Osmosis process, allowing selective passage of water while partially or completely retaining other water. Chemical potential gradients across the membrane provide the driving forces for solute and solvent transport across the membrane.

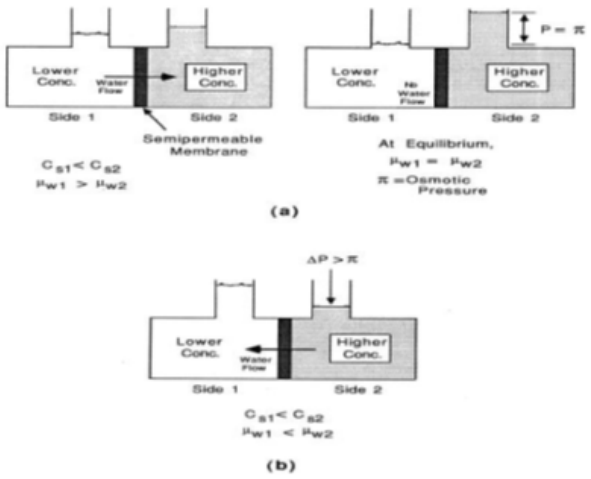

Figure 2. Schematic of Osmosis and Reverse Osmosis Phenomena

4. Demineralization Treatment

For High Pressure Boilers dissolved impurities in form of ions in

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the water must be removed compppletely. In particular, when water is heated to produce steam, any impurity can precipitate and cause damage. There are cations and anions in the water, we must use two different types of resins, a cation exchanger and an anion exchanger. This combined arrangement produces pure water. Demineralisation is also called deionisation. The cation resin is used in the hydrogen form (H^+) and the anion resin in the hydroxyl form (OH^-), so that the cation resin must be regenerated with an acid and the anion resin with an alkali.

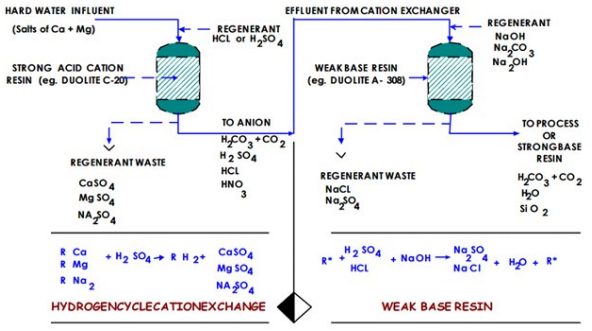

Figure 3. Schematic of Demineralization Treatment

As shown in figure first consider a simple demineralisation system comprising a strong acid cation exchange resin in the H^+ form and a strong base anion exchange resin in the OH^- form. The first step is decationisation as shown above.

$$2\ R_{SAC}\text{-}H + Ca^{++} \rightleftharpoons (R_{SAC})_2\text{-}Ca + 2\ H^+$$

In the second step, all anions are removed with the strong base resin.The weak acids created after cation exchange, which are carbonic acid and silicic acid (H_2CO_3 and H_2SiO_3) are removed in the same way.

$$R_{SBA}\text{-}OH + HCO_3\text{–} \rightleftharpoons R_{SBA}\text{-}HCO_3\text{–} + OH^-$$

Finally, the H^+ ions created in the first step react with the OH^- ions of the second step to produce new molecules of water. This reaction is irreversible.

$$H^+ + OH^- \longrightarrow H_2O$$

5. Conclusion

Boiler efficiency can be improved by utilizing dissolved impurities in ionic form by water softening, reverse osmosis and demineralization treatments. Treatments should be selected on the bases of quality of raw water and operating parameters of boilers. Efficient monitoring of water treatment palnt remove almost all ionic dissolved impurities and provide long and safe working life for boilers.

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