Investigation Method to Reduce Silica from Boiler Feed Water to Improve Boiler Performance of the Plant

Sajjanraddy[1] Kiran C H[2] Rajendra Prasad[3]
[1]PG Student [2]Assistant Professor [3]Manager
[1,2]Department of Mechanical Engineering
[1,2]AIET, Mijar [3]Steel Industry, Bellary

Abstract— During routine of boilers, water analysis of blast furnace, it was observed that, silica, conductivity & PH value increases as compared to normal value, also wheel chamber pressure & axial displacement of the impulse with reaction type turbine increases. After checking it is found that, the demineralised water plant has committed mistake during regeneration. The design specification of the boiler and DM plant has to provide DM water less than < 0.02 ppm (20 ppb) of Silica (Sio2), but it was providing water, more than > 0.02ppm (20 ppb) of Silica. Hence to achieve designed value, various parameters affecting the boiler performance are studied in detail. The best method after theoretically observation is found to be the method of Ultrafiltration. This filtration method provides water at designed rate & also results in decreased in silica level, conductivity, fuel consumption & steam generation is increased.

Key words: Ultrafiltration, Demineralization Plant, Conductivity, Silica

I. INTRODUCTION

Silicon is one of the earth's second more available after oxygen. It is not available free in nature, but it's have the dioxides like, SiO_2 and these silicates are the compounds of silicon, these compounds are relatively insoluble. The natural waters used in industries as a source which contains the silica upto the 100ppm.

The total silicon compounds are present in the water & these can be divided into two forms like, 'reactive' (dissolved) and 'non-reactive' (un-dissolved) silica. The half of the silicon compounds in the water source may be in the form of non-reactive (colloidal silica) and these also must be reduced significantly by the pre-treatment process, by converting non-reactive silica into the reactive silica form in the boiler. The silica is present in the water in reactive form or dissolved silica. In surface waters, a small quantity of the non-dissolved silica (colloidal silica) may also be present especially during the rainy season. The water may passes through and over the various soils of different locations finally comes into the lakes and rivers. Under this situation or due to this, the formation of carbon dioxide and organic acids may takes place and resulting from microbial activity & results in the acid degradation of the silicate components. This acid attacks the minerals will dissolves the iron, aluminium, etc and the interaction of these components with silica may results in formation of the non-reactive or colloidal silica.

Generally, the water treatment process involves the successive stages of filtration. In most cases, the chemical products are used in the physical-chemical treatment process. Ultrafiltration is a physical process in which, the two stages are carried out simultaneously. This filtration technique involves the passing of water through the porous membranes. The Ultrafiltration is the separation process in which, it uses the membranes with the pore sizes in the range of 0.1 to 0.001 micron. Typically, the Ultrafiltration process will removes the high molecular weight particles, colloidal materials. These membranes are present in the form of long hollows fibres. The feed water enters from the one side & leaves out from the other side. This Ultrafiltration process is one of the membrane fractionation process in which the water completely gets filtered with the removal of suspended particles, dissolved solids & macro molecules.

II. OBJECTIVES

- To study the parameters that affects the boilers performance.
- To study the parameter that affects the quality of boiler feed water
- The affects of various parameters on DM water in De-mineralisation plant is studied
- To investigate the methods to enhance silica level in feed water
- The affects on various operating and performance are to be analyzed, such as,
  - Quality of the steam
  - Steam production rate from the boilers
  - Chemical consumption of water treatment
- Effect of increased silica level on boiler accessories is studied.

III. METHODOLOGY

Ensure the membrane housing and terminator nuts are tight. Ensure the permeate tubing connections on the membrane shells are secure. Once the system has been checked and cleaned it is ready for operation. In the batch operation, process fluid is pumped from a large process tank through the Ultrafiltration system and back into the process tank. As the water permeates from the ultra filters, the process emulsion becomes more concentrated. When a predetermined concentration has been reached, the batch operation is completed. After each batch a proper cleaning of the Ultrafiltration system should be performed.

Ensure that all the valves are in the correct positions. Turn on the main disconnect. Fill the process tank with fluid and ensure that inlet valve is open. The filtered water (MB water outlet) shall be fed into the Ultrafiltration unit. The MB water should store in the UF feed tanks for further processing. In the Ultrafiltration process, the filtration membrane acts as a selective barrier, allowing the passage of water. The porous membrane is used to separate or reject the silica impurities.

If there is enough fluid in the process tank, the process pump will start when switched to the auto position.

The ultra filtration system starts filtering the water, when the water is enters the membrane the water gets filter & finally the filtered water should have the low silica impurities. The ultrafilterred water may feed into the DM water storage tanks & finally this water fed into the boiler side as a boiler feed water. The entire UF operation is an automatic through PLC.

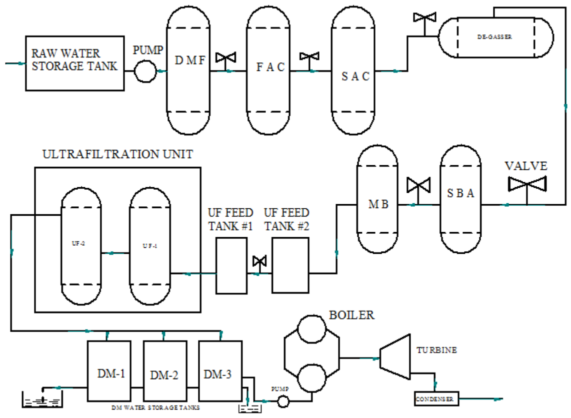

Fig. 1: Feed water to the Boiler after Modification

Modes of Operations are,

- Processing: It is the mode in which the filtration takes place, the water is fed to the modules, which passes through the membranes & is filtered in a dead end mode.
- Backwash: During processing, solids accumulate on the membrane surface and short cleaning or back wash with filtrate water is necessary to restore the membrane performance. Typically systems are programmed to backwash the membranes every 15 – 60 minutes. Chlorine or Hydrogen peroxide is typically added to the filtrate on selected backwashes to sterilize the membrane.
- Cleaning: the difference between the average feed pressure in the fibres & the permeate pressure gives an indication of the amount of fouling on the membrane surface. If the pressure difference reaches approximately 20 psi a cleaning of the membranes is required by taking the system offline & subsequent re-circulating low and high pH cleaning solutions.

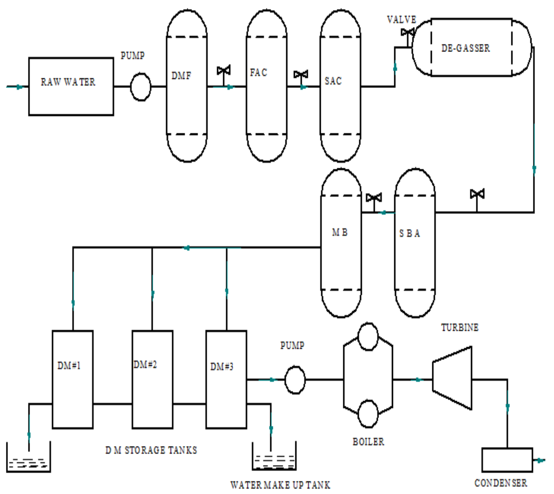

Fig. 2: Feed water to the Boiler before Modification

IV. CALCULATION

A. *Fuel Saving:*

$$= \frac{100\,(ta-tb)}{T+32-tb} \quad \text{............. (i)}$$

Where,
ta = feed water temperature after
tb = feed water temperature before
T = temperature of steam

$$= \frac{100\,(107-97)}{485+32-97} \quad \text{................ (ii)}$$

$$= 2.61 \text{ TPH}$$

A. *Boiler Efficiency:*

$$\eta_b = \frac{Q\,(H-h)}{q*GCV} \quad \text{................. (iii)}$$

Where,
Q = Steam flow rate in kJ/kg
H = Enthalpy of steam in kcal/kg
h = Enthalpy of feed water temperature
q = Fuel firing rate in TPH
GCV = Gross calorific value in kcal/kg

B. *Corex Gas using as an Fuel in Boiler,*

1) *Before:*

At 62 kg/cm^2 and 485^{0}C enthalpy of steam (H) is,
WKT, 1kg/cm^2 = 0.981 bar
At 62 bar & 485^{0}C, H = 3419.88 kJ/kg
Enthalpy of feed water temperature (h) = 105^{0}C
Steam flow rate (Q) = 80 TPH
Fuel firing rate (q) = 39.838 TPH

$$\eta_b = \frac{80(816.76-97)}{39.838*2000} \quad \text{................... (iv)}$$

$$= 72.26\%.$$

2) *After:*

Fuel firing rate (q) = 37.22TPH, after saving the fuel of 2.61 TPH.
Enthalpy of feed water temperature (h) = 107^{0}C

$$\eta_b = \frac{80(816.76-107)}{37.22*2000} \quad \text{..................... (v)}$$

$$= 76.27\%.$$

Therefore, increase in boiler efficiency is about 4.01%

C. *Blast Furnace Gas as an in Fuel in Boiler,*

1) Before*:*

At 62 kg/cm^2 and 485^{0}C enthalpy of steam (H) is,
WKT, 1kg/cm^2 = 0.981 bar
At 62 bar & 485^{0}C, H = 3419.88 kJ/kg
Enthalpy of feed water temperature (h) = 97^{0}C
Steam flow rate (Q) = 85 TPH
Fuel firing rate (q) = 109 TPH

$$\eta_b = \frac{80(816.76-97)}{109*820} \quad \text{...................... (vi)}$$

$$= 64.42\%.$$

2) *After:*

Fuel firing rate (q) = 106.39 TPH, after saving the fuel of 2.61 TPH.
Enthalpy of feed water temperature (h) = 107^{0}C

$$\eta_b = \frac{80(816.76-107)}{106.39*820} \quad \text{......................... (vii)}$$

$$= 65.08\%.$$

Therefore, increase in boiler efficiency is about 0.66%.

Hence, after reduced the silica content in the feed water, the boiler efficiency is increase about 4.01% by using

Corex as fuel and is about 0.66% increased using BFG as a fuel.

V. RESULT & DISCUSSIONS

Description	Units	Before	After
Silica in drum water	ppm	3.0825	0.6845
Silica in feed water	ppm	0.0237	0.0125
Feed water temp	^{0}C	97	107
Fuel firing rate (BFG)	TPH	109	106.39
Fuel firing rate (corex)	TPH	39.839	37.22
Boiler efficiency (BFG)	%	64.42	65.08
Boiler efficiency (corex)	%	72.26	76.27

Table 1: Before & After Modification

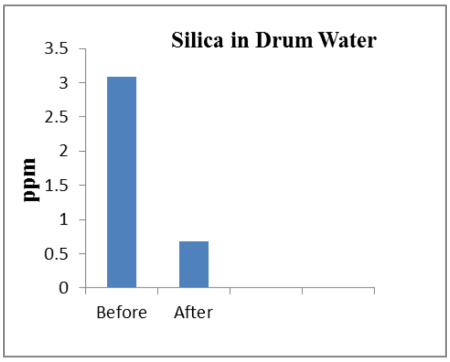

Fig 3: Silica level in Drum water

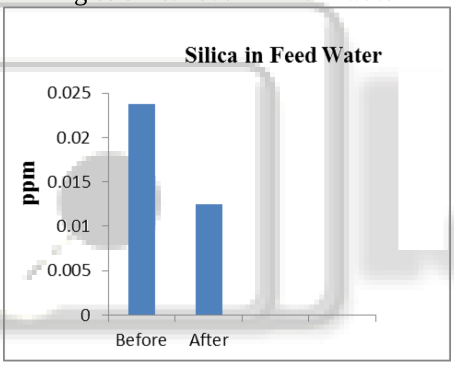

Fig 4: Silica level in Feed water

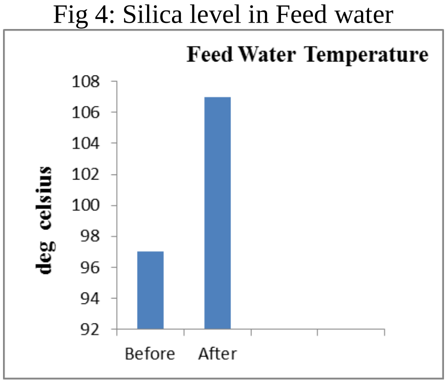

Fig 5: Feed water Temperature

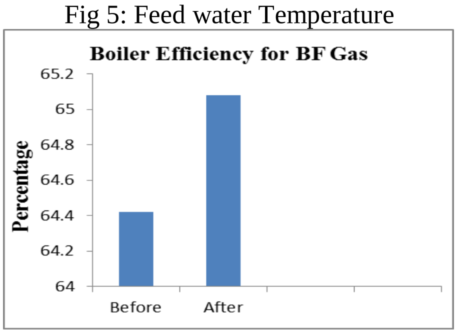

Fig 6: Boiler Efficiency for BF Gas

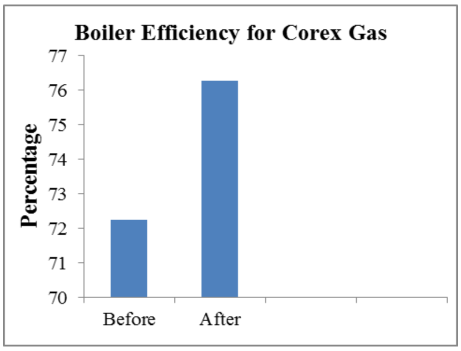

Fig 7: Boiler Efficiency for Corex Gas

VI. CONCLUSION

After adopting the above method the following improvement are observed,

- The chemical consumption of water treatment is reduced.
- The axial displacement of the turbines are comes under control.
- The corrosion and scale formation inside the boiler drum & boiler inner surface may reduce.
- The efficiency of the boiler increases up to 4.01% using Corex gas as a fuel & 0.66% using Blast Furnace Gas as a fuel.
- Helps to save the up to 2.61 TPH.
- Help in reducing the plant shutdowns to a minimum.

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