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Boiler Blowdown Analysis In An Industrial Boiler

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Abstract:- *In this paper boiler blow down analysis and energy savings study has been carried out in an industrial establishment. Steam boilers need to be blow down to control the level of TDS in the boiler water. Feed water with a relatively low TDS level then replaces the discharge boiler water. The objective of this paper is the blow down analysis of 33TPH water tube boiler in the plant and analyse the annual savings obtained from the simple payback calculation. By conducting separated case studies on TDS measurement calculation on boilers in KMML, the savings that could be achievable from corrected systems and operations in place considering the average TDS level. Since the system is being done manually without any actual online measurements, the boiler water TDS varies. Since the condensate recovery from the plant varies, and steam demand also leading to variation in requirement of blow down quantity*.

Keywords*: *Boiler, Energy Savings, Boiler Blow down, TDS, Boiler Efficiency

I. INTRODUCTION

As steam is generated, water is evaporated in its pure form leaving practically all of the dissolved minerals behind. Steam is essentially distilled water. Thus the remaining boiler water contains the minerals which are left behind by the evaporating steam. As these minerals concentrate in the boiler, they too begin to cause problems and must be removed. Problems noted is the carryover of boiler water into the steam causing wet steam which has a lower overall BTU content and thus requires the generation of even more steam to provide the desired heating. This results in the loss of additional fuel. The additional water in the steam must be removed by the steam traps which can be seriously over worked and damaged, thus shortening their life. Finally it is possible for the wet steam to leave behind mineral deposits that insulate the steam side of heat exchangers preventing efficient heat transfer. To avoid unnecessary losses of heat, blow down should be kept as low as possible and part of this loss can be recovered by heat exchanger monitoring and the useful heat being used to preheat feed water heat.[1] Boiler blow down is water intentionally wasted from a boiler to avoid concentration of impurities during continuing evaporation of steam. The water is blown out of the boiler with some force by steam pressure within the boiler. Bottom blow down used with early boilers caused abrupt downward adjustment of boiler water level and was customarily expelled downward to avoid the safety hazard of showering hot water on nearby individuals.

II. BOILER BLOWDOWN AND TYPES

Blowdown occurs when water is removed from a steam boiler while the boiler is operating. Boilers are "blown down" to remove suspended solids and bottom sludge from steam boilers. Removal of suspended solids helps insure the boiler generates high quality steam. It also prevents foaming at the water surface which can lead to unstable water levels and excessive carryover of liquid in the steam. When blowdown water is taken from a boiler, it is at the boiler operating temperature and pressure. For example, a boiler operating at 100 psig would discharge blowdown water at 338oF. When this water is discharged to a drain at atmospheric pressure some of the water will flash into steam in order to give up enough energy to drop the temperature to 212oF. If not controlled, this flash steam could cause safety problems and housekeeping problems in the boiler room. [2]

$$\text{Blowdown \%)} = \frac{feed\ water\ TDS\ X\ \%\ makeup\ water}{maximum\ permissible\ TDS\ in\ boiler\ water} \quad (1)$$

Boiler Blow down Benefits

- Less water, fuel and treatment chemicals needed;
- Less maintenance and repair cost (minimized carryover and deposits);
- Saves manual supervision for other tasks (with automatic control);
- Cleaner and more efficient steam;
- Reduced operating cost (reduction in consumption, disposal, treatment and heating of water)
- Minimized energy loss from boiler blow down can save about 2 percent of a facility's total energy use with an average simple payback of less than one year.

There are two sources of blow down from a steam boiler; bottom blow down and surface blow down. Bottom blow down is the removal of the sludge which accumulates in the bottom of a fire tube boiler, or in the mud drum of a water tube boiler. The sludge is removed regularly to prevent build up which could foul the heat transfer surfaces and lead to vessel or tube failure. Bottom blow down is always done on an intermittent basis, usually once a day or once a shift. The valve(s) is opened manually for a brief period of time to allow the accumulated sludge to pass from the vessel.

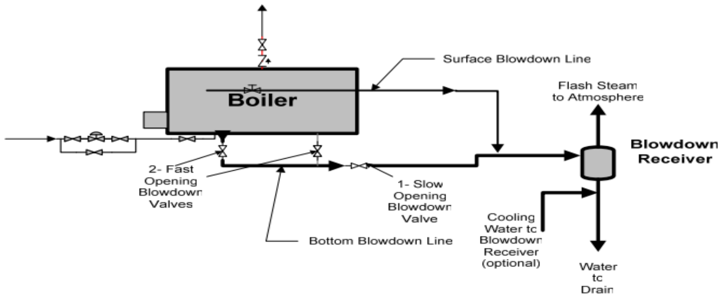

Fig: 1 boiler blow down

Surface blow down is the removal of the suspended solids from the surface of the water in a steam boiler. The amount of suspended solids will depend on the water quality. The more impurities and the more chemical treatment required, the greater the amount of surface blow down required. If the amount of make-up required increases, the need for surface blow down will also increase because greater amounts of impurities are introduced to the system on a continuous basis.

2.1 Types Of Blow Down

Since it is tedious and time consuming to measure total dissolved solids (TDS) in boiler water system, conductivity measurement is used for monitoring the overall TDS present in the boiler. A rise in conductivity indicates a rise in the "contamination" of the boiler water. Conventional methods for blowing down theboiler depend on two kinds of blowdown - intermittent and continuous.

2.1.1 Intermittent Blowdown

The intermittent blown down is given by manually operating a valve fitted to discharge pipe at the lowest point of boiler shell to reduce parameters (TDS or conductivity, pH, Silica and Phosphates concentration) within prescribed limits so that steam quality is not likely to be affected. In intermittent blowdown, a large diameter line is opened for a short period of time, the time being based on a thumb rule such as “once in a shift for 2 minutes”. Intermittent blowdown requires large short-term increases in the amount of feed water put into the boiler, and hence may necessitate larger feed water pumps than if continuous blow down is used. Also, TDS level will be varying, thereby causing fluctuations of the water level in the boiler due to changes in steam bubble size and distribution which accompany changes in concentration of solids. Also substantial amount of heat energy is lost with intermittent blow down. Intermittent manual blowdown is designed to remove suspended solids, including any sludge formed in the boiler water. The manual blowdown take-off is usually located in the bottom of the lowest boiler drum, where any sludge formed would tend to settle.

Properly controlled intermittent manual blowdown removes suspended solids, allowing satisfactory boiler operation. Most industrial boiler systems contain both a manual intermittent blowdown and a continuous blowdown system. In practice, the manual blowdown valves are opened periodically in accordance with an operating schedule. To optimize suspended solids removal and operating economy, frequent short blows are preferred to infrequent lengthy blows. Very little sludge is formed in systems using boiler feedwater of exceptionally high quality. The manual blowdown can be less frequent in these systems than in those using feedwater that is contaminated with hardness or iron. The water treatment consultant can recommend an appropriate manual blowdown schedule. Blowdown valves on the water wall headers of a boiler should be operated in strict accordance with the manufacturer's recommendations. Usually, due to possible circulation problems, water wall headers are not blown down while the unit is steaming. Blowdown normally takes place when the unit is taken out of service or banked. The water level should be watched closely during periods of manual blowdown.

2.1.2 Continuous Blow Down

Continuous blowdown, as the term implies, is the continuous removal of water from the boiler. It offers many advantages not provided by the use of bottom blowdown alone. For instance, water may be removed from the location of the highest dissolved solids in the boiler water. As a result, proper boiler water quality can be maintained at all times. Also, a maximum of dissolved solids may be removed with minimal loss of water and heat from the boiler. Another major benefit of continuous blowdown is the recovery of a large amount of its heat content through the use of blowdown flash tanks and heat exchangers. Control valve settings must be adjusted regularly to increase or decrease the blowdown according to control test results and to maintain close control of boiler water concentrations at all times. When continuous blowdown is used, manual blowdown is usually limited to approximately one short blow per shift to remove suspended solids which may have settled out near the manual blowdown connection. [2]

III. BLOWDOWN CONTROLS

If an economical blowdown rate is to be maintained, suitable boiler water tests must be run frequently to check concentrations in the boiler water. When sodium zeolite softened makeup is used, the need for boiler blowdown is usually determined by measurement of the boiler water conductivity, which provides an indirect measure of the boiler water dissolved solids. Other boiler water constituents such as chlorides, sodium, and silica are also used as a means of controlling blowdown. The alkalinity test has been used as a supplementary blowdown control for systems in which boiler water alkalinity can be particularly high.

3.1 Total Solids

From a technical standpoint, gravimetric measurement provides a satisfactory way to determine boiler water total solids; however, this method is rarely used because the analysis is time-consuming and is too difficult for routine control. Also, a comparison of the total solids content of boiler water with the total solids content of feedwater does not necessarily provide an accurate measure of the feedwater concentration within the boiler, because of the following:

- the boiler water samples may not show a representative suspended solids content due to settling or deposit formation
- internal treatment can add various solids to the boiler water
- breakdown of bicarbonates and carbonates can liberate carbon dioxide gas and lower the total solids in the boiler water

3.2 Dissolved Solids

The specific conductance of boiler water provides an indirect measure of dissolved solids and can usually be used for blowdown control. However, establishing the rate of blowdown on the basis of the relative specific conductance of feedwater and boiler water does not give a direct measure of the feedwater concentrations within the boiler. Specific conductance is affected by the loss of carbon dioxide with steam and by the introduction of solids as internal chemical treatment. Moreover, the specific conductance of feedwater (a dilute solution) and boiler water (a concentrated solution) cannot be compared directly. The specific conductance of a sample is caused by ionization of the various salts present. In dilute solutions, the dissolved salts are almost completely ionized, so the specific conductance increases proportionally to the dissolved salt concentration. In concentrated solutions, ionization is repressed and the ratio of specific conductance to dissolved salts decreases. The relationship between specific conductance and dissolved solids is determined most accurately through measurement of both parameters and the establishment of a correlation factor for each system. However, the factor may be estimated. The solids content of very dilute solutions such as condensate may be calculated with a factor of 0.5-0.6 ppm of dissolved solids per microsiemens (micromho) of specific conductance. For a more concentrated solution such as boiler water, the factor can vary between 0.55 and 0.90 ppm of dissolved solids per micro siemens of specific conductance. The hydroxide ion present in many boiler waters is highly conductive compared to the other ions. Therefore, it is common practice to neutralize the caustic with an organic acid prior to measuring conductivity. Although Gallic acid is conventionally used to neutralize the phenolphthalein alkalinity in samples with high specific conductance, boric acid may be used in samples of low and high specific conductance with minimal impact on the correlation factor between dissolved solids and specific conductance. [3]

3.3 Automatic Blow Down Controls

There are two types of boiler blow downs: manual and automatic. Plants using manual blow down must check samples many times a day or according to a set schedule, and adjust blow down accordingly. With manual boiler blow down control, operators are delayed in knowing when to conduct blow down or for how long. They cannot immediately respond to the changes in feed water conditions or variations in steam demand. An automatic blow down control constantly monitors boiler water conductivity and adjusts the blow down rate accordingly to maintain the desired water chemistry. A probe measures the conductivity and provides feedback to the controller driving a modulating blow down valve. An automatic blow down control can keep the blow down rate uniformly close to the maximum allowable dissolved solids level, while minimizing blow down and reducing energy losses. Purchasing and installing an automatic blow down control system can cost from $2,500 to $6,000 with a mostly 1- to 3- year payback period on the investment. A complete system should consist of a low- or high-pressure conductivity probe, temperature compensation and signal condition equipment, and a blow down-modulating valve. Changing from manual blow down control to automatic control can reduce a boiler's energy use by 2 – 5 percent and reduce blow down water losses by up to 20 percent.

The benefits of automatic TDS control are:
- The labour saving advantages of automation.
- The close control of boiler TDS levels.
- Potential savings from a blowdown heat recovery system (where installed)

Table 1 provides some broad guidelines on the maximum permissible levels of boiler water TDS in certain types of boiler. Above these levels, problems may occur. [3]

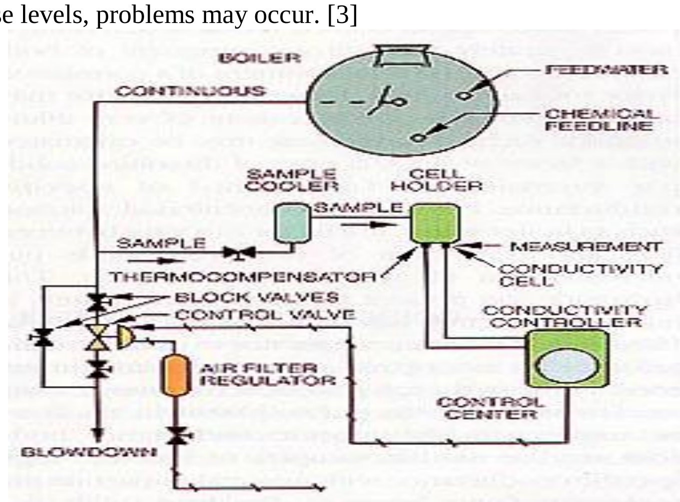

Fig: 2 Automatic blow down system

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Table 1: Boiler water TDS level

Boiler type	Maximum TDS level (ppm)
Lancashire	10000
2 pass economic	4500
Package and 3 pass economic	3000 – 3500
Low pressure water tube	2000 – 3000
Medium pressure water tube	1500
Coil boilers and generators	2000

IV. BOILER BLOWDOWN ANALYSIS

A reduction in boiler water blowdown can result in significant fuel and water savings. In some installations, boiler water solids are lower than the maximum level permissible. Through improved control methods, including automatic boiler blowdown equipment, boiler water blowdown can be reduced to maintain the solids close to but not above the maximum level permissible. The rate of blowdown required depends on feedwater characteristics, load on the boiler, and mechanical limitations. Variations in these factors will change the amount of blowdown required, causing a need for frequent adjustments to the manually operated continuous blowdown system. Even frequent manual adjustment may be inadequate to meet the changes in operating conditions. The boiler water analysis is carried out at the 33TPH water tube boiler at Kerala Minerals & Metals Ltd, Kollam. Presently the boiler water TDS is being controlled manually. The 33 TPH boiler has the 25NB continuous blow down line. This valve is kept crack open to maintain the TDS level in the boiler. [4]

Table 2: Average water analysis of 33 TPH boilers for one month

DATE	FEED WATER			BLOW DOWN WATER		
	PH	CONDUCTIVITY	TDS	PH	CONDUCTIVITY	TDS
6	8.5	12	6	9.9	260	176
5	9.2	14	12	10.2	300	210
4	9.5	34	17	10.9	380	231
3	9	16	8	11	720	399
2	8.7	12	6	11.8	1330	545
29	8.1	12	6	11.6	1190	495
28	9.4	31	15	10.8	1826	575
27	9.7	32	16	11.7	1482	636
25	9.3	18	9	11.6	1708	700
24	8.4	12	6	11.5	1270	616
23	9.2	14	7	11.6	1328	714
22	8.4	14	7	11.2	1452	610
21	8.7	14	6	11.3	1872	920
20	8.2	12	5	11.3	1600	781
19	8.98	40	20	11.3	1645	720
18	8.1	12	6	11.2	1893	794
AVERAGE	8.8	18.8	9.6	11.2	1257	572

From last one month it is obvious that the average TDS level maintained in the boiler is about 572ppm which is lower than the recommended level of 2200ppm. Since the system is being done manually without any actual online measurements, the boiler water TDS varies. Since the condensate recovery from the plant varies and steam demand also leading to variation in requirement of blow down quantity. Low level of boiler water TDS means higher the heart loss. Also considering the good quantity feed water of 10ppm, will generate lower boiler water TDS. An effective automatic blow down control system works to measure the TDS of the blow down continuously and maintains the boiler water TDS near to the optimum/recommended level avoiding any bad effect on boiler tubes or on heat loss. The following calculations indicate the savings that could be achievable. [4]

The actual dissolved solids concentration at which foaming may start will vary from boiler to boiler. Measurement of the dissolved solids may be done by chemical methods, by accurate density measurement using a hydrometer or by measuring the electrical conductivity of the boiler water using a conductivity meter. Here we use the conductivity method to detect the TDS measurement. The electrical conductivity of water depends on the type and amount of dissolved solids it contains. Since acidity and alkalinity have a large effect on the electrical conductivity, it is necessary to neutralize the sample of boiler water before measuring its conductivity. The procedure is as follows:

- Add a few drops of phenolphthalein indicator solution to the cooled sample (< 25°C).
- If the sample is alkaline, a strong purple colour is obtained.
- Add acetic acid (typically 5%) drop by drop to neutralize the sample, mixing until the colour disappears

Table 3: Blowdown energy analysis

Blow down quantity by manual	
Steam flow rate (S)	612610kg/day
Feed water TDS (F)	9.62 ppm
Average TDS maintained in boiler (B)	572 ppm
Blowdown quantity	= (S X F)/(B – F) = 10474 kg/day
Average TDS maintained in boiler (B)	2200 ppm
Blow down quantity	2690 kg/day
Excess amount of blow down	10474 – 2690=7783kg/day
Blow down preassure	20 kg/ cm^2g
Sensible heat in blow down	214 kCal/kg
Feedwater temperature	106^0C
Heat loss from excess blowdown	840873 kCal/kg
No. Of operating days per annum	330 days/yr
Efficiency of boiler	66.62%
GCV of fuel	10355 kCal/kg
Loss of fuel/annum	40.22 Ton

Cost of fuel	39.3 Rs/litre
Monetary savings	15.8 Lacs
Treated water cost	18 Rs/KL of water
Excess water treatment cost/yr	0.46 Lacs
Total savings	16.27 Lacs/yr

The TDS in ppm is approximately then as follows:-

TDS (ppm) = (conductivity in µs/cm) x 0.7

Where the present method is solely manual blowdown from the bottom of the boiler, by looking at past water treatment records it may be possible to obtain some idea of how much the boiler TDS varies over a period of weeks. By inspection an average TDS figure can be established. Where the actual maximum is less than the maximum allowable figure, the average is as shown. Where the actual maximum exceeds the maximum allowable, the average obtained should be scaled down in proportion, since it is desirable that the maximum allowable TDS figure should never be exceeded. Figure 3, below, shows that the average TDS with a well operated manual bottom blowdown is appreciably below the maximum allowable. For example the maximum allowable TDS may be 2200 ppm and the average TDS only 572 ppm. This means that the actual blowdown rate is much greater than that required. The comparison between present manual blowdown and futurly installed automatic blowdown is shown below graphically. The blowdown rate for each case was calculated using average and feed water TDS values. And the difference between them was about 1.28% approximately. From the observation result we strongly recommended the implementation of automatic TDS system to the 33TPH boiler in KMML having 25NB blowdown line. So we have to increase the boiler efficiency, mainly indirect efficiency to the rated level. From the calculation and survey , it should be clearly about 70%.

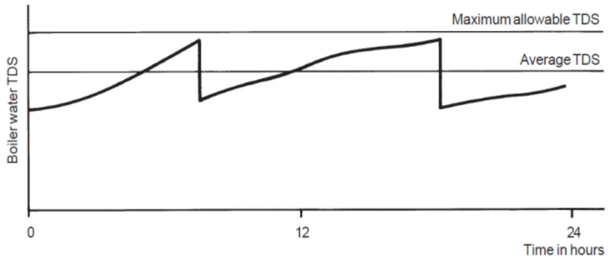

Fig.3: Manual blow down

Calculation of blow down rate

Average TDS = 572 ppm

Feed water TDS = 9.62 ppm

Blow down rate = $\frac{9.62 \ x \ 100\%}{572 - 9.62}$ = 1.71%

By installing an automatic TDS control system the average boiler water TDS can be maintained almost equal to the maximum allowable TDS as shown below.

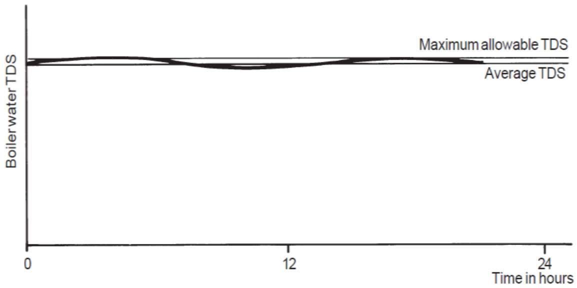

Fig.4: Automatically blow down

Calculation of blow down rate

Average TDS = 2200 ppm

Feed water TDS = 9.62 ppm

Blow down rate = $\frac{9.62 \ x \ 100\%}{2200 - 9.62}$ = 0.43%

The blowdown rate is reduced by 1.28 percentage points by raising the average boiler water TDS.

V. CONCLUSION AND RECOMMENDATIONS

Boiler blowdown is the removal of water from a boiler. Its purpose is to control boiler water parameters within prescribed limits to minimize scale, corrosion, carryover, and other specific problems. Blowdown is also used to remove suspended solids present in the system. These solids are caused by feedwater contamination, by internal chemical treatment precipitates, or by exceeding the solubility limits of otherwise soluble salts. The blowdown can range from less than 1% when an extremely high-quality feedwater is available to greater than 20% in a critical system with poor-quality feedwater. In plants with sodium zeolite softened makeup water, the percentage is commonly determined by means of a chloride test. In higher-pressure boilers, a soluble, inert material may be added to the boiler water as a tracer to determine the percentage of blowdown. The primary purpose of blowdown is to maintain the solids content of boiler water within certain limits. This may be required for specific reasons, such as contamination of the boiler water. In this case, a high blowdown rate is required to eliminate the contaminants as rapidly as possible.

The blowdown rate required for a particular boiler depends on the boiler design, the operating conditions, and the feedwater contaminant levels. In many systems, the blowdown rate is determined according to total dissolved solids. In other systems, alkalinity, silica, or suspended solids levels determine the required blowdown rate. An automatic blowdown control system continuously monitors the boiler water, adjusts the rate of blowdown, and maintains the specific conductance of the boiler water at the desired level. This paper details about the blow down energy conservation analysis of KMML on January 2015. Based on our survey it is recommended to have the implementation of automatic blow down control system for the 33 TPH boiler to maintain the boiler water TDS to the recommended level. This will ensure the boiler to operate near to its rated efficiency.

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