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# Experimental Study on Heat Recovery from Continuous Blow down Water And Reduced Feed Water Consumption By Utilizing It In CFBC Boiler

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**ABSTRACT**
Waste heat is heat which is generated in a different process i.e by combustion of fuel, by chemical rection. The important of heat is its value not quality. The planning of how to recover this waste heat depends in part on the temperature of waste heat gases. The energy lost in waste heat can not be fully recovered but maximum quantity of heat can be recovered and loss is minimized. Generally higher the temperature, higher the quality and then more cost effective is the heat recovery.
Lots of heat is lost by blow down so it is necessary to recover this heat by addition of heat exchanger in between this process. So this waste heat could be utilized to heat boiler water before going to de-aerator. By applying this process we can easily reduce loss of heat and heat required to heat boiler water is reduced. Also this blow down water we can utilized as feed water so consumption of feed water is also reduced. But this blow water we cant utilized as boiler water because we rejected due to high TDS. If we utilized then TDS level in boiler is increased. So it is beneficiary to use this at the starting of demineralization.
***Keywords*: dearator, demineralization, recover, TDS, waste heat**

## I. INTRODUCTION

Bottom blow down is the Blowdown occurs when water is removed from a steam boiler while the boiler is in operation. 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. Due to blow down it prevent foaming occur on surface in water. If foaming occurs we can't see actual water level in drum which causes carryover.
There are two main sources of blow down from a steam boiler a.) Bottom blow down and b.) Surface blow down.

a.) Removal of the dissolve solid which gather in the bottom of a mud drum of a water tube boiler or in the fire tube boiler. The dissolve solid is removed regularly to prevent formation which could reduce the heat transfer surfaces and lead to boiler tube failure. Bottom blow down is always given on an intermittent basis, usually once a day or once a shift. The valve is opened manually for a long period of time to allow the total dissolve solid to remove from the vessel.
b.) 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 used in boiler. If more impurities then 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 of greater amounts of impurities are introduced to the system on a continuous basis.

## II. TYPES OF BLOW DOWN

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

### A. Intermittent Blow Down

The intermittent blown down is given by manually operating a valve connected to discharge pipe at the lowest point of boiler drum to reduce water parameters (TDS or conductivity, pH, Silica and Phosphates concentration) within our prescribed limits so that steam quality is likely to improve. In intermittent blowdown, a large diameter line is opened for a short period of time, the time being depend on a thumb rule such as "once in a shift for 2 minutes". Intermittent blow down requires large amount of water to be feed into the boiler so may be required to start another feed pump. Also, TDS level can be alter, thereby causing fluctuations of the water level in the boiler drum 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 blow down is designed in such way that to remove suspended solids, sludge formed in the boiler water. The manual blow down is usually located in the bottom of the lowest water tube boiler drum, where any sludge lead to be 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 regularly in connection 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 high quality boiler feed water. The manual blowdown can be less frequent in these systems than in those using feed water 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. Blow down 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.

**B. Continuous Blowdown**

Continuous blowdown, as the term indicate, it is the continuous removal of water from the boiler. It gives many advantages not provided by the use of bottom blow down only. 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.

## III. PROBLEM FORMULATION

J.K Paper ltd. Is the foremost paper manufacturer in India, it operates its unit at Fort-songadh, Gujarat. It consists of CFBC boiler of 88kg/cm2 operating pressure and 510 0 C superheated steam temp. Superheated steam from the boiler used for production of paper as well as for power generation The boiler is a new kind mixed fuel boiler with high efficiency and low pollution which adopts circulating fluidized bed combustion technology with wide range of many kinds of fuel, such as lignite, Indian ,imported and others with lower calorific value. Its combustion efficiency is as high as 92-94%, especially it can burn high sulfur content fuel. By feeding limestone into the boiler, it can obviously reduce the discharge of SOx and NOx, and reduce corrosion of sulfur on devices and pollution of flue gas. Ash residue is active enough to be used as aggregate of materials such as cement. The boiler is a natural circulating water-tube boiler and which adopts circulating combustion system formed by vortex cyclone separator. Its furnace is of membrane wall structure; its separator is of high-temperature adiabatic type. The super heater system is composed of screen, high and low temperature ones, between which two-grade vertical spray desuperheater is arranged. At the back-end surfaces, two grades of economizer, primary and secondary air preheaters are arranged.

Due to continuous evaporation of boiler water, salt concentration in the boiler water increase. Also due to phosphate treatment, some non adherent sludge is formed, so total dissolve solid (TDS) level of boiler water increase. To adjust this total dissolved solid level, some quantity boiler water is removed from the boiler and the same quantity fresh boiler water is added. By doing so, concentration of non desirable dissolved salts is maintained. This process is called blow down process and water drain out is called blow down.

Blow down quantity in a boiler is calculated by the following formula:

Percentage blow down= $\frac{TDS\ IN\ DM\ WATER}{TDS\ IN\ BOILER\ WATER - TDS\ IN\ DM\ WATER} X\ 100$

So as shown in above permissible limit of the boiler water TDS of 70 t/hr boiler operating at 88 kg/cm$^2$ is 50mg/L. if the TDS of dm water is 5 mg/L then

Percentage blow down= $\frac{5}{70-5} X\ 100$

Percentage blow down=7.7%

Blow down quantity= $\frac{percentage\ \ blow\ \ down}{100} X\ Evaporation\ quantity$

Blow down quantity= $\frac{7.7}{100} X\ 70X1000$

Blow down quantity= 5390 kg/hr

As only 28% boiler BD is flashed to steam so 100-28 = 72% of blow down is available for exchanging heat to heat exchanger.

Since blow down rate = 5380 x 0.72

= 3880.8 kg/hr

= 3.9 t/hr

Blow down water which is not flashed is discharge into drain. therefore fraction of the heat load of bow down water from the flash tank is lost to sever.

Hence heat lost to severe per unit mass of water discharge
= 4.187 (kJ/kg.k) x (363-303)
= 251.22 kJ/kg
= 252.22 MJ/t
Blow down rate to drain = 3.9 t/hr
Hence heat loss to the drain
= 252.22 x 3.9 x 24
= 23607.792 MJ/day
It means per day 23607.792 MJ heat is lost.
In present blow water is pass through flash tank and then drain. that's why we remove flash steam heat.

## IV. STRATEGY OF RECOVER HEAT

To recovered this heat we have to install heat exchanger in between this process so bolier water is go in one side and blow down water is go in another side so boiler water can take heat from blow down water. So we need to design heat exchanger for this.

By using LMTD we calculate flow of pump required for transfer water at required rate by assume outlet temp. of blow down water and dm water. So we get pump capacity

In order to design a heat exchanger following assumption is made:

1. The flow condition is steady.
2. There is no loss of heat to the surroundings; due to heat exchanger is perfectly insulated.
3. There is no change of phase either of the fluid during heat transfer.

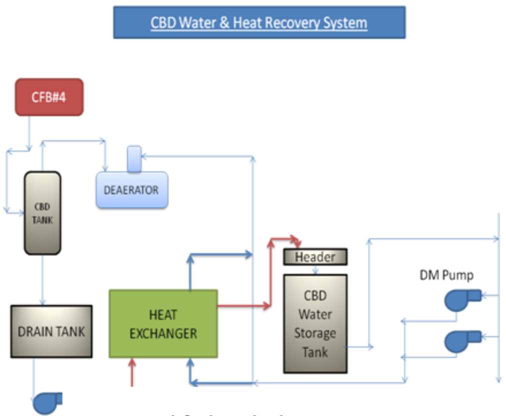


Figure 1 modified method

4. The changes in potential and kinetic energies are negligible.
5. The flow is counter flow
   We design heat exchanger by using following parameter.

a. Feed water temperature: the inlet temperature of feed water $T_{c1}$ in heat exchanger which is $30^0$ C.
b. Blow down water temperature: inlet temperature of blow down water $T_{h1}$ in heat exchanger which is $90^0$C
c. Overall heat transfer coefficient U: we assume overall heat transfer coefficient for feed water heater is 1200 $W/m^{2.}$
d. Feed water flow $m_f$ : 60000 Kg/hr. (16.67 Kg/ sec) Figure 1 modified method

Energy balance in heat exchanger we have
Heat given up by hot fluid

$Q = m_b Cp (T_{h1}-T_{h2})$

Heat picked up by the cold fluid

$Q = m_c Cp (T_{c1}-T_{c2})$

Total heat transfer rate in the heat exchanger $Q = UA\Theta_m$

Where ,
U = overall heat transfer coefficient between the two fluid
A = effective heat transfer area in $m^2$
$\Theta_m$ = appropriate mean value of temperature difference or logarithmic mean temperature difference (LMTD)
Cp = specific heat of fluid

Calculating area of heat exchanger
First of all we balance the heat (assume oulet temperature of hot fluid is 60°C and cold fluid is 40°C)

Heat given up by hot fluid = Heat picked up by the cold fluid

$m_b Cp (T_{h1}-T_{h2}) = m_c Cp (T_{c2}-T_{c1})$

$m_b$ kg/sec x 4.187kJ/kg (90-60) = 16.67 kg/sec x 4.187 kJ/kg (40-30)

$m_b$ kg/sec x 125.61 = 697.97

$m_b$ = 5.56 kg/sec

Now we calculate Logarithmic mean temperature difference (LMTD) is given by

$$\Theta_m = \frac{\Theta 1-\Theta 2}{\ln \Theta 1/\Theta 2}$$

$$\Theta_m = \frac{(Th1-Tc1)-(Th2-Tc2)}{\ln (Th1-Tc1)/(Th2-Tc2)}$$

$$\Theta_m = \frac{(90-40)-(60-30)}{\ln (90-40)/(60-30)}$$

$\Theta_m$ = 39.15°C

For the heat exchanger
Q = Heat given up by hot fluid = Heat picked up by the cold fluid
$Q = UA\ \Theta_m$
$m_b Cp (T_{h1}-T_{h2})$ = 1200 $W/m^2$ x A x 39.15°C (for feed water we assume U = 1200 $W/m^2$)
5.55 kg/sec 4.187kj/kg (90-60) = 46980 x A
697.17 x $10^3$ = 46980 x A
A = 14.83 $M^2$

From above calculation we proved that we required pump having capacity aprrox.20 $m^3$/hr. and required heat exchanger having area upto 14 $M^2$.

After designing heat exchanger we pass feed water into the heat exchanger so this feed water get heat from drain water then feed water is passed into dearator. In dearator oxygen is removed from feed water and pump feed water to boiler by using boiler feed pump. In many power plant blow water is directly drain. If we drain blow down water lots of heat is loss. To recover this heat loss we will pass this water into duel media filter unit and then activated carbon filter. If this water is used as feed water then we required less feed water to make up, so we reduce consumption of feed water.

## V. INSTALLATIONOFHEAT XCHANGER AND PUMP

In our company we found one scrap plate type heat exchanger having following data
Heat exchanger has following description

Table 1 heat exchanger description

| Sr. no. | Description | |
|---|---|---|
| 1 | No. of passes on fluid 1 side | 1 |
| 2 | No. of passes on fluid 2 side | 1 |
| 3 | Design pressure fluid to fluid | 6/6 $kg/cm^2$ |
| 4 | Design temp fluid to fluid | 110/110 °C |
| 5 | Heat transfer area | 12.69 $M^2$ |
| 6 | Plate size ( width x Height) | 3850x 940 mm |
| 7 | No. of plates | 49 |
| 8 | Plates thickness | 0.5 mm |
| 9 | Nozzle size for fluid to fluid | 150/150 NB |
| 10 | Flange type | ANSI B 16.5 |
| 11 | Rating fluid 1 | 150# |
| 12 | Rating fliud 2 | 150# |
| 13 | Over all size ( length x width x height | 641 X 460 X 1265 mm |

Figure 2 heat exchanger

By using above parameter we conclude that it is best suited for our work hence Heat exchanger area is more than our requirement means it can beneficial for us So we take decision to install this heat exchanger, but before installation of this heat exchanger it is necessary to clean. we shift heat exchanger to dearator floor now it is ready to install. Without shut down we cant install heat exchanger because we have connect heat exchanger in feed water line and blow down line. Also install one pump to transfer this blow down water from heat exchanger.

## VI. EXPERIMENTAL STUDY

After installing heat exchanger and pump we take in operation by opening suction and discharge valve of dm pump and blow down pump i.e. new pump. We start pump and note down reading are as follows.

Table 2 flow reading

| parameter | units | inlet | outlet |
|---|---|---|---|
| Condensate fluid flow | kg/hr | 30000 | 30000 |
| Dm water flow | kg/hr | 60000 | 60000 |
| Condensate temp T | °C | 90 | 40 |
| Dm water flow t | °C | 31.5 | 54.7 |
| Condensate pressure P | $Kg/cm^2$ | 4.6 | 1 |
| Dm water pressure p | $Kg/cm^2$ | 2.5 | |

From reading given in table 3
From above we calculate thermal data
Heat transfer area=12.69 $m^2$

1. heat duty:
   for condensate water
   $Q = m_b Cp (T_{h1}-T_{h2})$
   $Q = 30000 \times 4.187 \times (90-40)$
   $Q= 1744.58$ kw
   For dm water
   $Q = m_c Cp (T_{c1}-T_{c2})$
   $Q = 60000 \times 4.187 \times (54.7-31.5)$
   $Q = 1618.97$ kw
2. Temperature range of condensate water
   Temperature range = $(T_{h1}-T_{h2}) = (90-40) = 50°C$
3. Temperature range of dm water
   Temperature range = $(T_{c2}-T_{c1}) = (54.7-31.5) = 23.2°C$
4. Effectiveness
   Effectiveness = $(T_{c2}-T_{c1})/ (T_{h1}- T_{c1})$
   $= (54.7-31.5)/ (90-31.5)$
   $= 0.39$
5. LMTD
   $$LMTD = \Theta_m = \frac{(Th1-Tc1)-(Th2-Tc2)}{\ln(Th1-Tc1)/(Th2-Tc2)}$$
   $$\Theta_m = \frac{(90-40)-(54.7-31.5)}{\ln(90-40)/(54.7-31.5)}$$
   $$\Theta_m = 34.9°C$$
6. Overall heat transfer coefficient
   $U = Q/A (T_{h1}-T_{h2})$
   $= 1744.58/12.69 (90-40)$
   $= 2.749 \ kw/m^2$
   So overall heat transfer coefficient is more than our assumption. It means it satisfy our condition

## VII. UTILISATION OF BLOW DOWN WATER

Before going to this we must know basic water chemistry. In our plant fresh water is feed by using feed pump in duel media filter. In duel media filter remove suspended solid. After dual media filter it pass in activated carbon filter where we remove chlorine, lead, unpleasant odour. After this water is pass into cation unit. In cation unit remove salt like Ca, Mg and Na. now this water is pass into degassifier where $Co_2$ is remove then it passed into anion unit. Anion unit remove $Co_3$, $So_4$, Cl, and $Sio_3$. Now water is ready to go in mix bed filter where both cation and anion are remove. Now outlet of mix bed filter is used as Dm water.

Now we focus on how this blow down water is utilized we can utilize this water. Bur we should have to check that it has adverse effect on quality of water or not. So we check sample of activated carbon filter and dual media filter. We check TDS and PH. of sample water. Report was normal it means no effect on quality of water.

## VIII. TOTAL COST OF PROJECT

Installation cost of project

| Sr. no | Description | Cost (Rs) |
|---|---|---|
| 1 | Material cost | 56194 |
| 2 | Manpower cost | 38083 |
| 3 | Pump cost | 56800 |
| 4 | Insulation cost | 1600 |
| | Total cost | Rs.152677 |

## IX. OUTCOME OF PROJECT

Heat recoverd
= 4.187 KJ/kg x (363-313)
= 209.35 kJ/kg
Blow down rate to drain = 3.9 t/hr
= 209.35 x 3.9x 24
= 19595.16 MJ/day
Saving with heat recovery
% heat recovered = 19595.16/ 23607.792
= 83%
Now we calculate saving interms of coal
Amount of coal required to heat dm water
Gross calorific valve x mass of coal = $m_c$ Cp ($T_{c1}$-$T_{c2}$)
Gross calorific value of coal is 3590 kcal/kg
3590 x mass of coal = 60000kg/hr x 1 x (54.7-30)
3590 x mass of coal = 1482000
Mass of coal = 412.81 kg/hr
Mass of coal per day = 9907.52 kg = 9.9 t
It means by using heat recovery we save 9.9 t of coal per day
Calculate cost of water
Cost of water = 21 Rs per liter= 21000 per cubic meter
Blow down rate is 3.9 t/hr means $3.9m^3$/hr
Saving = 21x 3.9 x 1000
= 81900 Rs per hour
= Rs 1965600 per annum
Total water saving
Per day condensate water $3.9m^3$ means per annum 28080 $m^3$ water we can save

## X. CONCLUSION

Blow water has maximum heat energy and by using heat exchanger we can save about 83% heat. It mean we can save 9.9 t/day coal and $3.9m^3$ water we can save. It very important in the area where water is very less available. By using this system we can save drainage heat energy.

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Table 3 experimental reading

| **D.M.PLANT - PHE PERFORMANCE TRIAL ON 1/7/2015** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D.M.WATER | | | | | | CONDENSATE WATER | | | | | | REMARK |
| TIME | Q | t1 | t2 | P1 | P2 | Kcal | Q | T1 | T2 | P1 | P2 | Kcal | |
| 11.55PM | 84 | 31.0 | 43.0 | 2.85 | NA | | 20.0 | 80 | 37.0 | 5.60 | NA | | |
| **2.47PM** | **60** | **31.5** | **54.7** | **2.5** | **NA** | | **30** | **90** | **40.0** | **4.60** | **NA** | | |
| 3.07PM | 60 | 31.5 | 41.0 | 2.4 | NA | | 23/25.3 | 68 | 37.0 | 5.20 | NA | | |
| 4.00PM | 60 | 31.5 | 45.0 | 2.4 | NA | | 23/25.86 | 66 | 38.0 | 5.20 | NA | | |
| 4.06PM | 60 | 31.5 | 46.0 | 2.3 | NA | | 26.5/30.48 | 66 | 41.0 | 4.80 | NA | | |
| 4.23PM | 60 | 31.0 | 45.0 | 2.4 | NA | | 23.5/26.9 | 66 | 39.0 | 5.00 | NA | | |
| 4.44PM | 70 | 31.0 | 45.0 | 2.4 | NA | | 30/34 | 70 | 41.0 | 4.60 | NA | | |
| 4.48PM | 75 | 31.0 | 45.5 | 1.6 | NA | | 30/34 | 70 | 41.0 | 4.60 | NA | | |
| 4.53PM | 90 | 31.0 | 44.0 | 2.9 | NA | | 30/34 | 70 | 40.5 | 4.60 | NA | | |