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Ash Cooler Heat Recovery Under Energy Conservation Scheme

Vikash R Gupta*, Lalatendu Pattanayak**
* Surat Lignite Power Plant, Nani Narolai, Mangrol, Surat, Gujrat, India
** Steag Energy Services India Pvt. Ltd, A-29, Sector-16, Noida, UP, India

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ABSTRACT

A healthy fluidization state in circulating fluidized-bed combustion (CFBC) combustor is attributed to proper quantity of hot bed material (ash), which acts as a thermal fly-wheel. It receives & stores thermal energy from the burning of fuel (lignite) & distributes uniformly throughout the combustor & helps in maintaining a sustained combustion. The quantity of bed ash inside the combustor or size of the bed, depends upon boiler load & subsequently upon combustor temperature, lignite feed rate and ash % in lignite. As these parameters varies during process continuously, sometimes it becomes necessary to drain out the ash from the combustor. As & when differential pressure across the bed is increased from a justified level, draining of hot bed ash starts into Ash Coolers. Bed ash is drained at very high temperature of 850 ^{o}C & it also contains burning particles of lignite. This paper describes the heat recovery from bed ash, unloaded from the combustor into ash cooler, by pre-heating the condensate water of turbine cycle in a 125 MW CFB boiler of Surat Lignite Power Plant in India. The thermal performance of ash cooler was derived by doing a heat balance calculation based on the measured temperature of ash and cooling water with different load. From the heat balance calculation influence of ash temperature and ash amount on heat transfer coefficient is determined. Simulation is carried out around main turbine cycle indicates improved thermal economy of the unit, higher plant thermal efficiency, lower plant heat rate and reduce fuel consumption rate. Also simulation result shows that the heat transfer coefficient increase with ash amount and decreases with increase in ash temperature.

Corresponding Author:

Lalatendu Pattanayak,
Departement of System Technologies,
Steag Energy Services India Pvt. Ltd,
A-29, Sector-16, Noida, UP, 201301, India.
Email: l.pattanayak@steag.in

1. INTRODUCTION

Circulating fluidized bed (CFB) combustion have found acceptance throughout the world over the past few years, in particular for power generation, but also as industrial power plants and combined heat and power stations [1]. CFB boiler is one of the best clean coal fired boiler for its merits, such as allowing the uses of broad range of fuels, meeting the environmental pollution norms without addition of add on equipment and better efficiency. In a CFB boiler, coal is fed into the furnace with a wide particle size distribution. After it is burned, ash is formed and ash particles become part of the bed material in the furnace [2]. As a key auxiliary device ash coolers are the boiler auxiliary installed at zero meter of combustor. Ash coolers are key auxiliary device connected at the bottom part of CFB combustor, which has a direct influence on economic operation of the CFB boiler [3], [4]. It is widely used in boilers based on CFBC technology for cooling of hot bed ash. Ash coolers are attributed to their high efficiency and excellent reliability. CFB boiler bottom ash contains large amounts of physical heat. The physical heat loss is up to 2 % without cooling the bottom ash while the boiler combusts a low calorie fuel with more than 30 % ash content. In addition the red hot bottom ash is not conducive to be mechanized for handling and transportation. Thus a bottom ash cooler is often used to treat high temperature bottom ash to reclaim heat, and to have the ash easily transported [5], [6].

A healthy fluidization state in CFBC combustor is attributed to proper quantity of hot bed material (ash), which acts as a thermal fly-wheel which receives & stores thermal energy from the burning of fuel (lignite) & distributes uniformly throughout the combustor & helps in maintaining a sustained combustion. The size of bed inside combustor or quantity of bed ash depends upon boiler load & subsequently upon combustor temperature, lignite feed rate and ash % in lignite. As these parameters varies during process continuously, sometimes it becomes necessary to drain out the ash from the combustor. As & when differential pressure across the bed is increased from a justified level, draining of hot bed ash starts into ash coolers. Bed ash is drained at very high temperature of 850 ^{o}C & it also contains burning particles of lignite. For cooling, bed ash is kept in fluidized state around the cooling coils carrying de-mineralized (DM) water. During cooling process of ash, a portion of heat gets recovered through the vent connected with the combustor. Another portion of heat gets wasted through cooling water circuit. Finally the cold ash unloaded in bed ash conveyor through rotary air lock feeders.

Wang et al. [7] developed a heat transfer model of the rotary ash cooler to predict the heat transfer characteristics in a commercial 300 MW CFB boiler. The result revealed that the heat-transfer coefficients of ash-air and air-water are close but much lower than that of ash-water, indicating that the heat transfer of ash-water dominates in the total heat transfer. B.Zeng et al. [8] in their study determines the influence of CFB boiler bottom ash heat recovery mode on thermal economy of unit based on heat balance calculation and analysis of three typical CFB power plants with FBAC or RAC to recover the heat of boiler bottom ash. W. Wang et al. [9] built a dynamic experimental system to measure the overall heat transfer coefficient in the rolling ash cooler and the influencing factors, such as ash size, ash amount and rotational speed using the orthogonal design. The result revels that the ash size has the greatest effect on heat transfer coefficient. Zhang et al. [10] researched a water-cooled waste heat recovery system in a 410 t/h CFB boiler, and analyzed the economic benefits gained by transferring the waste heat of high temperature bottom ash to the turbine regenerative system. In this study, effects on the plant thermal economy resulted from the parallel installation of BAC and different low-pressure heaters were also calculated by equivalent enthalpy drop method. However, the differences in thermal economy of units caused by different heat recovery modes were not included.

This paper describes the heat recovery from bed ash, unloaded from the combustor into ash cooler, by pre-heating the condensate water of turbine cycle in a 125 MW CFB boiler of Surat Lignite Power Plant in India. The thermal performance of ash cooler was derived by doing a heat balance calculation based on the measured temperature of ash and cooling water with different load. From the heat balance calculation influence of ash temperature and ash amount on heat transfer coefficient is determined. Simulation is carried out around main turbine cycle indicates improved thermal economy of the unit, higher plant thermal efficiency, lower plant heat rate and reduce fuel consumption rate. Also simulation result shows that the heat transfer coefficient increase with ash amount and decreases with increase in ash temperature.

2. PRESENT SCENARIO

Figure 1 illustrates the principle heat and mass balance diagram of 125 MW CFB power plant located in Surat, India. 125MW CFB combustor is a partially top and partially bottom supported boiler with re-heater system. Fluidized bed heat exchangers as integral part consisting reheater (RH), superheater (SH) and evaporator coils. It can deliver 390 t/h of main steam at 132 kg/cm^2 pressure and 535+ 5 ^{o}C temperature, with resident time of 5 seconds.

There are three chambers in a ash cooler, with refractory lined walls. First chamber called ‘empty chamber’ is connected with ash drain out of the combustor with fluidizing nozzles at the floor, other two chambers are provided with cooling coils carrying auxiliary cooling water (ACW), normally DM water and fluidizing air fed from the bottom through nozzles to keep hot ash in fluidizing state. This in turn results in cooling of ash unloaded from the combustor from time to time. The hot air vented in to the combustor and the cold ash finally unloaded in bed ash conveyor. Basic layout of CFB boiler is shown in Figure 2.

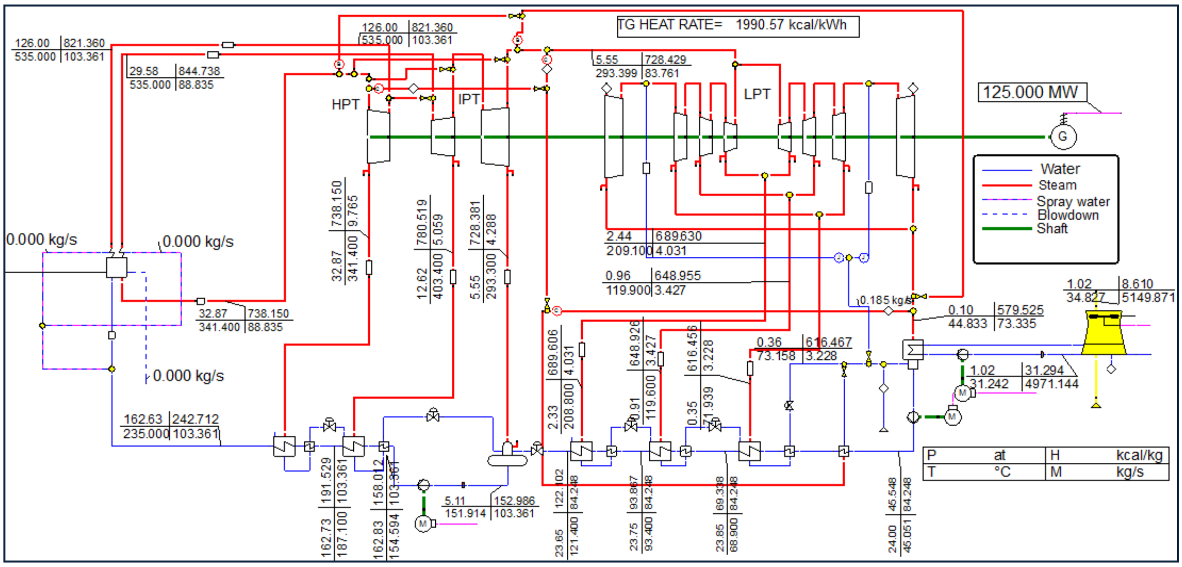


Figure 1. Heat and mass balance diagram based on manufacturer data.

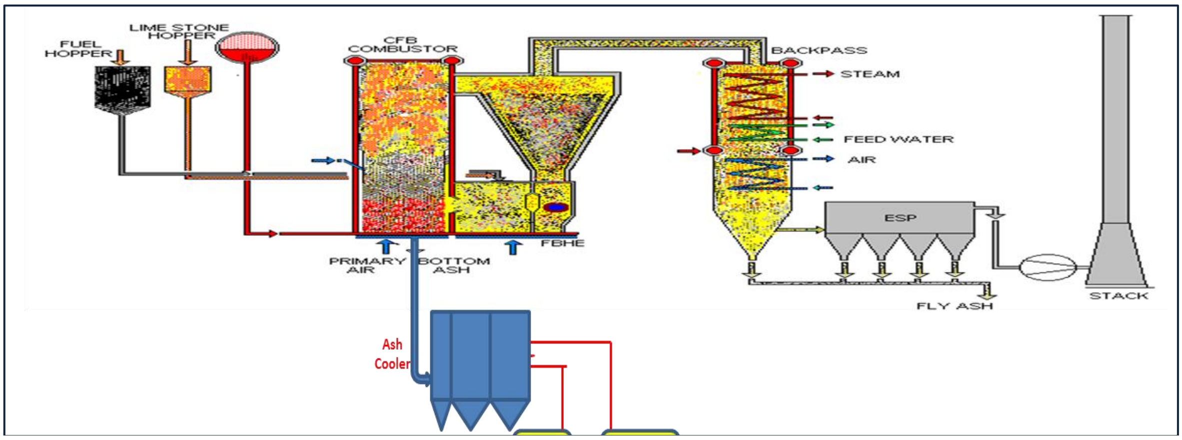


Figure 2. Basic lay out of the boiler.

Bed ash is being cooled in ash coolers with the help of ACW (180 t/h per ash cooler) , which in turn getting cooled by condenser cooling water (CCW) system and huge amount of heat is going waste through cooling tower via CCW system. Existing schematic diagram of the low pressure side is shown in Figure 3. General technical parameters and main design parameters of AC is shown in Table 1 and 2, respectively.

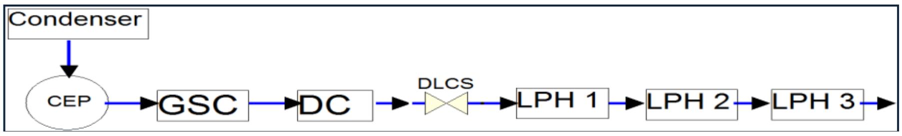


Figure 3. Existing scheme

3. PROPOSED SCHEME

Schematic diagram proposed for this study is shown in Figure 4. The scheme is to use condensate water in place of ACW, and is proposed to be diverted to ash cooler from drain cooler outlet & after circulation through ash coolers, fed it back at the inlet of low pressure heater (LPH 1). As & when temperature of condensate will rise due to bed ash unloading in AC, the flow of steam extractions from low pressure turbine (LPT) to LPH 1 & LPH 2, which was being used for condensate pre-heating, will be reduced automatically and this extra steam will be diverted towards LPT exhaust and in turn will produce more power.

Table 1. General Technical Parameters of 125 MW Surat Lignite Thermal Power Plant

Properties	Values	
Steam turbine parameters (rated power/Main steam pressure /Main steam temperature / temperature of reheat steam)	125 MW/126 at/535 °C/535 °C	
LPT Exhaust steam parameters (Pressure/Specific enthalpy)	0.097 at/ 579.525 kcal/kg	
Feed water temperature	235 °C	
Boiler parameters pressure of superheated steam/temperature of superheated steam/temperature of reheat steam)	126 at/540 °C/540 °C	
The amount of bottom ash	40% of total ash	
Make-up water rate	0 t/h	
Boiler efficiency,	80.17%	
TG heat rate	1990.57 kcal/kWh	
TG heat Rate (PG test)	2030 kcal/kWh	
TG heat Rate (Operating)	2060 kcal/kWh	
Coal Ultimate Analysis	Design	Operating
Carbon	43.30 %	38.84 %
Hydrogen	3.14 %	2.42 %
Nitrogen	0.81 %	0.4 %
Sulphur	1.2 %	0.45 %
Oxygen	8.53 %	5.8 %
Moisture	24 %	45 %
Ash	15.02 %	5.7 %
Lime	4 %	2 %
HHV (Higher heating value)	3000 kcal/kg	3268 kcal/kg

Table 2. The main parameters of Ash Cooler

Properties	Design	Operating
Inlet temperature of cooling water (°C)	36	36
Outlet temperature of cooling water (°C)	76-80	76-80
Inlet temperature of bottom ash (°C)	850 – 900	850-900
Outlet temperature of bottom ash (°C)	120	120

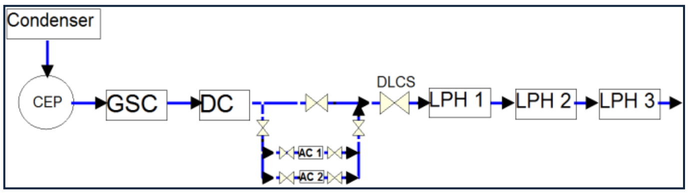


Figure 4. Proposed scheme

Based on the proposed scheme heat and mass balance calculation is performed using Ebsilon® *Professional* [11] collecting sample data from the plant distributed control system (DCS) during actual operating condition of plant in full load of 125 MW. Figure 5 depicts the heat and mass balance diagram based on the proposed scheme.

4. RESULTS AND DISCUSSION

The simulation carried out around main turbine cycle indicates improved thermal economy of the unit, higher plant thermal efficiency, lower plant heat rate and reduce fuel consumption rate. Simulation results show that the heat transfer coefficient increase with ash amount and decreases with increase in ash temperature. Figure 6 depicts the simulation results of the improvement of turbine cycle heat rate with extracting the heat from the bottom ash. It can be see that at 47.72 °C there is no heating takes place, i.e when there is no ash unloading, the turbine cycle heat rate is found to be 2060.83 kcal/kWh. When ash unloading takes place the condensate temperature rises and heat rate of turbine cycle improves to 2054.04 kcal/kWh. Which correspond to an increase in generation of 0.34 % as shown in Figure 6. As the condensate in the low pressure circuit is being heated by the utilization of heat from the bottom ash there is a reduction in extraction steam flow to the LPH 3 and LPH 2 is around 10.33% and 50%, respectively which ultimately increase the power output and LPT performance. Simulation results before and after modification is depicted in Table 3 for low pressure circuit. For each case the heat rate and total power generation improves by extracting the heat from unloading ash.

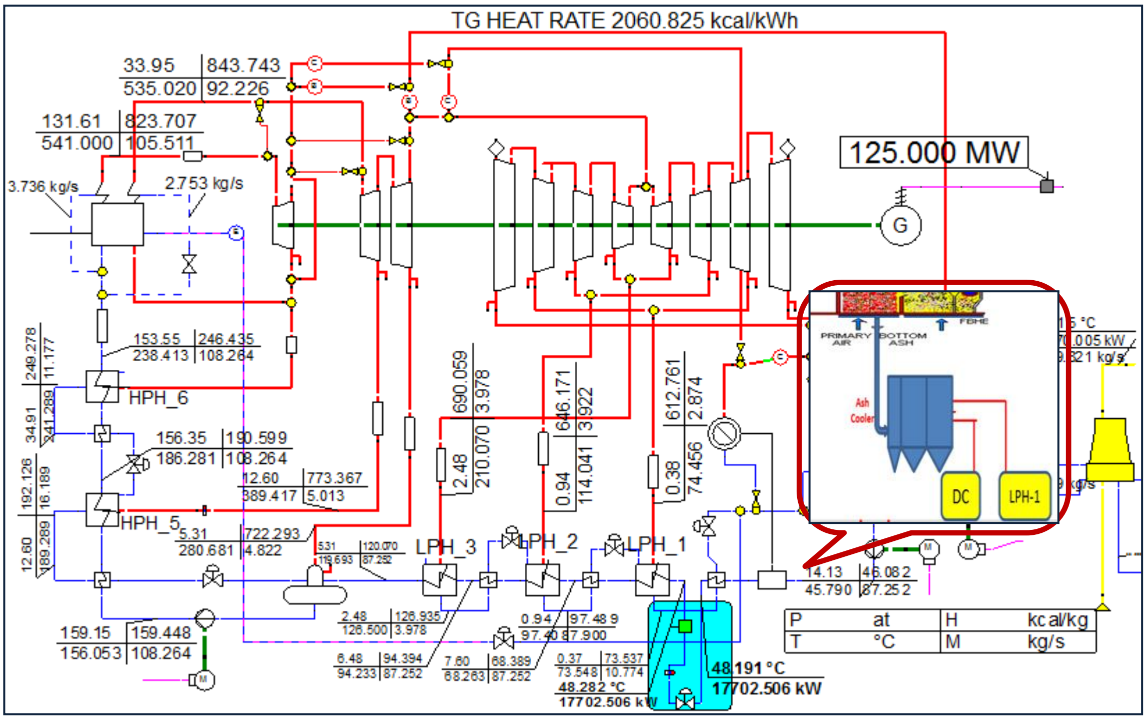


Figure 5. Proposed heat balance based on operating data

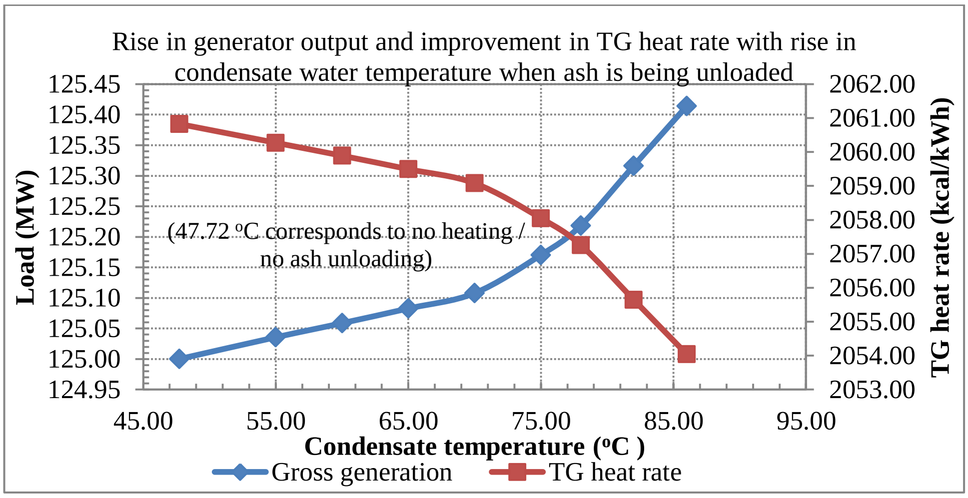


Figure 6. Gross turbine heat rate/ load vs condensate temperature

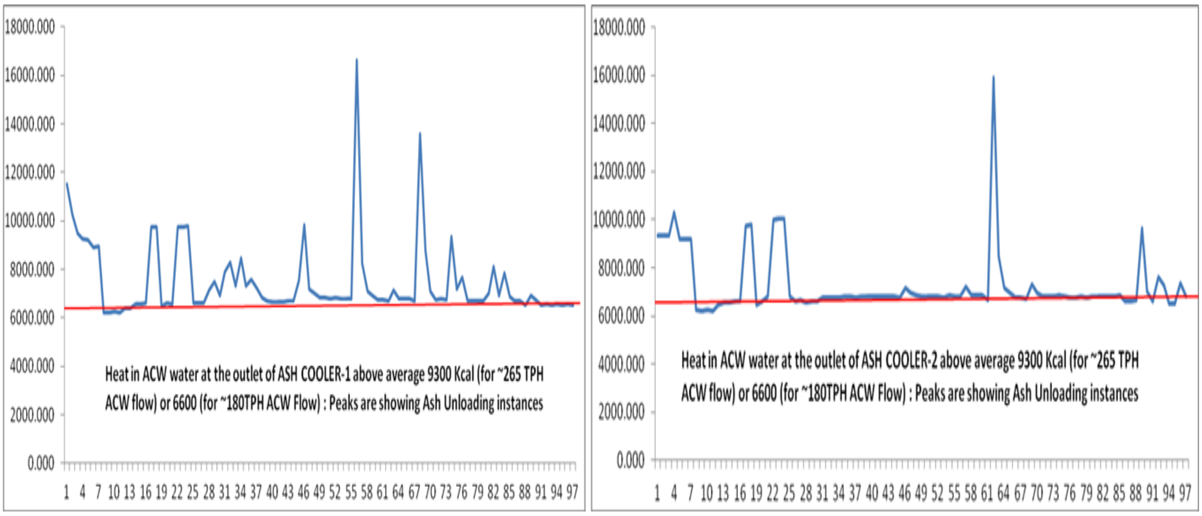
Main benefit of such arrangement is, the heat energy which was going waste which is in a huge amount (average for a month is around 19.47 MWhr) is saved and it is equivalent to extra generation of 2.6 MUs or saving of 2328 MT lignite over a period of 330 days in a year, assuming 40 % Turbine cycle efficiency. Other benefits achieved by extracting the heat from the bed ash in the ash cooler are found out as,

- After diverting condensate flow through ash coolers, the loading of 360 t/h (rated cooling water flow is 180 t/h per ash cooler) over the ACW pumping system will reduce, this will result into saving of at least 42 kW at pump shaft power. This is equivalent to 3.33 lacs kWh in 330 days in a year.
- CCW flow requirement to cool 360 t/h of ACW will be reduced on CCW system & in turn, heat loading on cooling tower will also be reduced.

- Unnecessary running of ACW & CCW pumps, when there is no ash unloading in to ash coolers will be saved.
- The extracted heat from the ash increases the loading of main cooling towers. This extra loading will be avoided.
- When ash is unloaded, it increases the ACW temp abruptly for a short period, this enhances the risk of tripping of other auxiliary which are sensitive to cooling water temp or running at just overload. This risk may be avoided.
- If this modification works, further step will be to stop or remove CCW pumps along with we can think of the relocation of plate heat exchanger (PHE) at zero meter.

Table 3. Simulation results before and after modification

Particulars	Parameters Before and After Modification							
	Before	After Modification - Full Load						
Load (MW)	125.00	125.04	125.06	125.08	125.11	125.17	125.32	125.42
Turbine heat rate (kcal/kWh)	2060.83	2060.27	2059.89	2059.49	2059.08	2058.05	2055.65	2054.04
Main Steam Flow (t/h)	379.84	379.84	379.84	379.84	379.84	379.84	379.84	379.84
Condenser Back Pressure (mbar)	99.36	100.44	101.18	101.94	102.71	103.42	104.40	105.00
Steam Quality at LPT Exhaust	0.9502	0.9508	0.9511	0.9515	0.9519	0.9522	0.9526	0.9529
Steam Quality at LPH-1 Inlet	0.9709	0.9716	0.9720	0.9725	0.9729	0.9733	0.9738	0.9742
CW Inlet temp (°C)	31.30	31.30	31.30	31.30	31.30	31.30	31.30	31.30
CW Flow Taken at (t/h)	15800	15800	15800	15800	15800	15800	15800	15800
LPH-1 Condensate Inlet Temp (°C)	47.72	55.00	60.00	65.00	70.00	75.00	82.00	86.00
LPH-1 Condensate Outlet Temp(°C)	67.60	69.41	70.64	71.89	73.16	75.90	82.02	86.02
Extraction Stm Flow to LPH-1 (t/h)	10.67	7.54	5.36	3.19	1.02	0.00	0.00	0.00
LPH-1 Drip to DC Temp (°C)	73.64	74.49	74.96	75.36	75.68	75.90	76.19	76.38
LPH-1 Drip to DC Pressure (at)	0.37	0.39	0.39	0.40	0.40	0.41	0.41	0.42
Saturation Temp at Drip Line (°C)	73.64	74.49	74.96	75.36	75.68	75.90	76.19	76.38
LPH-2 Condensate Inlet Temp (°C)	67.60	69.41	70.64	71.89	73.16	75.90	82.02	86.02
LPH-2 Condensate Outlet Temp (°C)	93.62	94.10	94.42	94.74	95.06	95.68	96.97	97.77
Extraction Stm Flow to LPH-2 (t/h)	14.26	13.53	13.03	12.52	12.00	10.82	8.13	6.34
LPH-2 Drip to LPH-1 Temp (°C)	97.50	97.86	98.09	98.33	98.56	98.97	99.77	100.22
LPH-2 Drip to LPH-1 Pressure (at)	0.95	0.96	0.97	0.97	0.98	1.00	1.03	1.04
Saturation Temp at Drip Line (°C)	97.50	97.86	98.09	98.33	98.56	98.97	99.77	100.22
LPH-3 Condensate Inlet Temp (°C)	94.29	94.76	95.07	95.38	95.70	96.31	97.57	98.35
LPH-3 Condensate Outlet Temp (°C)	119.80	119.96	120.07	120.18	120.28	120.48	120.90	121.16
Extraction Stm Flow to LPH-3 (t/h)	14.42	14.25	14.14	14.02	13.91	13.69	13.22	12.93
LPH-3 Drip to LPH-2 Temp (°C)	126.65	126.74	126.81	126.87	126.93	127.05	127.28	127.42
LPH-3 Drip to LPH-2 Pressure (at)	2.49	2.50	2.50	2.51	2.51	2.52	2.54	2.55
Saturation temp at drip line (°C)	126.65	126.74	126.81	126.87	126.93	127.05	127.28	127.42
De-Aerator Pressure (at)	5.34	5.34	5.35	5.35	5.36	5.36	5.38	5.39
Steam Flow to deaerator (t/h)	17.50	17.45	17.41	17.37	17.34	17.27	17.12	17.03
Load sharing HPT / IPT / LPT (MW)	33.93/ 47.1/ 45.89	33.93/ 47.09/ 45.94	33.93/ 47.08/ 45.97	33.93/ 47.07/ 46	33.93/ 47.07/ 46.03	33.93/ 47.05/ 46.11	33.93/ 47.02/ 46.29	33.93/ 47.01/ 46.4
Total Shaft power at Generator terminal (MW)	126.94	126.97	127.00	127.02	127.05	127.11	127.26	127.36



Total instantaneous heat extracted by the condensate from the bed ash

Total average heat extracted by the condensate from the bed ash

Figure 7. Heat available in ACW water at the outlet of ash cooler

Heat available in ACW water at AC 1 & 2 is shown in Fig. 7(a) & (b). Total heat extracted is calculated by calculating area under the curve above a datum of 9300 kcal for ACW flow of 265 t/h and/or datum of 6600 kcal_for ACW flow of 180t/h_respectively at 36 ^{o}C ACW outlet temperatures. Probable risk factors and its remedial action are depicted in Table 4.

5. CONCLUSION

In this paper, the influence of heat recovery from bed ash by the ash cooler in a 125 MW lignite fired coal plant is analyzed and its impact on thermal economy such as heat rate, generation and fuel consumption is evaluated based on heat and mass balance calculation.

- The data (instantaneous & average) on which this study is made are collected from the DCS system of a running unit, for a period of 33 days which covers all type of variations / changes occurred. In the data collected, we have found total 742 No. of occasions of ash unloading in to the ash coolers at different interval as well as quantity. From the data, various observations can be made like how much quantity of ash was unloaded in how much time; (here Combustor DP & bottom temperatures gives correct clue of ash quantity); what was the rate at which ACW outlet temp rise to max; in how much time it ceases down to normal etc.
- Maximum outlet temperature of ACW was observed at 85 ^{o}C / 119 ^{o}C in the Average / instantaneous temperature trend. This temp reaches to peak in average 15 minutes period after ash unloaded (it varies with the quantity of ash drained from the combustor & already available ash in ash coolers if previously unloaded ash is not cooled & drained in to conveyor.
- Maximum idle period during which ash was not unloaded from the combustor was found 10 hrs approximately.
- Total heat released into ACW water in AC-1&2, which found at average 797.53 kW per hour or 19.14 MWhr per day average.
- This is the actual amount of heat energy derived from the parameters obtained from DCS on daily average basis. It is higher than the heat calculated theoretically (*by considering 10% ash content in 2500MT lignite, burnt in a day, bed ash at 40 % of total ash and ash gets cooled from 850 ^{o}C to 120 ^{o}C, Sp. Heat of ash– 0.84kJ/kg*) due to some amount of carbon getting drained in burning state with ash.
- More ash content will result into more heat recovery.
- CEP discharge (condensate water) cannot be diverted before or after Gland Steam Cooler & Drain Cooler as it will disturb / block the Gland steam flow which is detrimental to turbine shaft & may leads to tripping of the Unit.

Observations from the heat balance study:

- Generator output increased by 0.34 MW at constant MS Flow, even though vacuum has been deteriorated by 4.0 mbar. If we could maintain the vacuum by switching off one CCW pump (this will stop the bypass flow by 1000 t/h & vacuum will improve) when Condensate temp is nearing to its maximum then additional gain in MW output at generator terminal may be achieved.
- The improvement in TG Heat-rate by 5.7 kcal/kWh corresponds to AC outlet temperature or LPH 1 inlet temperature is maximum at 86 ^{o}C. This is corresponds to the bed ash unloading in one ash cooler up to 20 mbar combustor dp.
- Generator output may be made constant by reducing main steam flow by 1.93t/h at peak temperature of condensate through ash cooler. This will save the steam consumption & in turn the fuel input.
- As condensate temperature starts increasing, load shared by low pressure turbine starts increasing, while it starts reducing in inter mediate pressure turbine. High pressure turbine output remains constant throughout. But there is an overall gain in generated MW.
- There will be a loss of 3.5 kW in generated MW, if we consider one degree loss of temperature of condensate, for idle hours when no ash is being unloaded.
- Extraction steam flow to LPH 1 becomes zero at 76 ^{o}C & above temps of condensate; extraction steam flow to LPH 2 never becomes zero while LPH 3 extraction steam flow remains unaffected.
- Final temperature gain in condensate water after LPH 3 remains unchanged.
- In any case of temperature rise in ash cooler, the pressure of water will always be well above saturation pressure, so there is no chance of steaming inside the coils.

Table 4. Risk factors and solution

Sr. No.	Risk Factors	Solution
1	LPT exhaust losses & inter-stage losses may be increased with deteriorated vacuum.	There is very minor change in wetness fraction of the steam at extraction points for LPH 1 & exhaust, however exact loss cannot be calculated.
2	Pulsating load may set up in LPT, which is not permissible.	Loading variation in LPT will be as per ramp given by OEM (2.5 MW /min). From the data analysis, whenever ash is unloaded, the peak temperature reached in 15 minutes period or more, depending upon the amount of ash. Any change taking place in LPT in 15 minute period cannot be termed as a pulsating load)
3	Vibrations may set up in LPH tubes as condensate temperature changes.	This condition may occur only when steaming (flash) takes place inside tubes, but it is not possible in this case at all loads, actual condensate pressure will always be is greater than saturation pressure.
4	Flash may occur in drip piping system / LPH tubes / LPH shell.	1. In the LPHs circuit, this possibility of flashing has been nullified by maintaining a height difference of @ 4.0 m (By installing DC at zero m level), so there is no question of drip flashing at any point. 2. Inside the LPH-1 shell, flash in drip water may occur if temp of condensate at inlet is higher than drip temp coming from LPH 2. This case can be avoided if we unload the ash in controlled manner so that condensate temp at LPH 1 inlet should not exceed from 78 deg C. There is no threat to LPT as drip line is connected to condenser via DC & LPFT, if any back pressure generates, it will go through the drip pipe to condenser. *However maximum temperature rise may be addressed while designing the new coils for ash coolers.*
5	LPH 1 condensate inlet temp exceeding than design.	Tube side design temperature is 150 ^{o}C and max condensate temp will be average out to 85^{o}C, when it will be mixed with Condensate outlet flow from other ash cooler, which is not in service.
6	Recovery of heat may be achieved by using any other idea / system – we should not disturb the original thermal system – it may have detrimental effect on the turbine life.	As ash unloading instances depend upon many other factors, there is no fixed interval between two instances of ash unloading. Hence, heat from the drained bed ash is non continuous nature. This inconsistent nature of heat availability will not be suitable to any recovery system because every system needs a regular, constant, reliable source of energy for proper & efficient functioning. Earlier we had thought of using it in VAM, but it was not suitable source. So only the turbine thermal cycle is the best place to recover this waste heat.
7	Due to pressure & temperature drop in the condensate circuit (After DC via Ash Cooler to LPH 1) loss of heat when no ash is being unloaded in the circuit may offset the saving.	There is a minor loss of enthalpy. It depends upon piping layout, no of bends, no of valves & valve type etc. It has been estimated at 880 kcal/hr - by assuming 1.2 at pressure & 1 ^{o}C temperature drop in condensate water, which will be lost during the period when no ash is unloaded. This amount of heat is so negligible when compared with 5 to 6.5 lac kcal hourly average heat. Suppose for the whole day, ash is not unloaded, there will be 21200.0 kcal will be lost and this is equal to 8.0

		units of electricity only, which can be recovered in a single smallest instance of ash unloading; however max idle period was found at 10 hrs from the collected data when ash was not unloaded.
8	When condensate will admitted into ash cooler, max temperature rise will be 123 °C (average 109 °C), this will limit the use of both ash coolers at a time. Also there are the chances of 'flash' in the system.	The temperature mentioned is well below the saturation temperature at that pressure, so there is no chance of 'flashing'. This situation will arise when heavy amount of ash is being unloaded, *certainly it will limit the use of both ash coolers at a time*. However such type of incidence is rare. Moreover, if ash is drained in both ash coolers simultaneously, combustor DP cannot be controlled.
9	There will be extended period of cooling cycle of hot ash in ash cooler after each incidence of ash unloading due to increased temp of cooling water(condensate, if modified).	However it is a minor variation, but can be sort out while designing the new tube nest of ash cooler. The cold ash temperature will be 15 °C higher than ACW. The loss due to which is negligible.
10	The ash cooler in which ash is being unloaded may need more water in case of heavy amount of ash to avoid any thermal stroke.	Through the ash cooler, which is not in service, condensate flow can be throttled to divert additional flow. To achieve this, additional valves (Motorized valves) may be provided so that thermal shock can be avoided.
11	At present ash cooler's coil design capacity to withstand pressure up to 10 kg/cm^2.	Condensate line pressure before de-aerator level control station is @ 16 kg/cm^2. So cooling coils capacity will have to be enhanced at 1.5 times than at present.
12	We will have to keep ACW system always available for situations like BTL & low load conditions or unforeseen situation for a while.	For some period of observation, ACW system may be kept as standby available. Later it may be abandoned.
13	Unforeseen situation creation in ash cooler like when speiss valve has become fully open & inoperative, leakage of coils etc.	Ash will accommodate in ash cooler up to its normal capacity only, after that the ash inflow will be stopped and temp will start reducing. The max rise in temp of ACW at outlet is found at 123 °C, and mix temp of ACW from both ACs max at 85 °C. However to minimize thermal shock, max condensate may be diverted through the ash cooler which is in problem.
14	What would happen when turbine is at low load?	When Unit is running at low load, ash unloading from combustor also reduced in quantity & occasions and condensate flow from CEP also reduced. In this case maximum flow may be diverted to one ash cooler.
15	Heat from the ash is of intermittent nature.	Heat from the ash is of intermittent nature as ash unloading instances depend upon many other factors. This inconsistent nature of heat availability is not useful for utilizing it in any other system like VAM; because every system needs a regular, constant, reliable source of energy for functioning, so thermal cycle is the best place to recover this waste heat.

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BIOGRAPHIES OF AUTHORS

Vikar R Gupta: Working as Manager (TS) at SLPP, having work experience of more than 22 years in operation and mentanance of thermal power plants. Holds a degree in Electrical engineering. Interest area of research in energy efficiency of energy systems.

Lalatendu Pattanayak: Working as DGM (System Technology dept.) at Steag Energy Services India Pvt. Ltd. Holds a M.Tech degree in Environmental Science and Engineering and Post graduate diploma in Thermal Power Plant Engineering. Interest area of research thermodynamic modeling, power plant optimization and energy efficiency in thermal power plants. Is a member in ASME since February 2014.