"PERFORMANCE ASSESSMENT OF 2 X 100 TPH AFBC BOILER OF 40 MW COAL BASED THERMAL POWER PLANT (M.P.)"

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Abstract:
Grasim is India's leading fibre manufacturer and the global leader in viscose staple fibre (VSF), a man-made, biodegradable fibre with characteristics akin to cotton. Grasim's VSF plants are located at Nagda in Madhya Pradesh, Kharach in Gujarat and Harihar in Karnataka, with an aggregate capacity of 333,975 TPA. Grasim's unit at Nagda is its largest unit producing a wide range of VSF.in this paper work performance assessments of boilers are performed and based upon data calculation result also be given in conclusion

Key skills: *Energy Consumption, Humidity, Evaporative Cooling, Model Design, Etc.*

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1. Introduction: Grasim Nagda has total 138.5 MW capacity captive power plants, which is used to meet requirement of both power and steam. A thermal power station is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which either drives a generator or does some other work, like ship propulsion. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle.

1.1 Steam Generation : In fossil-fuelled power plants, steam generator refers to a furnace that burns the fossil fuel to boil water to generate steam. The steam generating boiler has to produce steam at the high purity, pressure and temperature required for the steam turbine that drives the electrical generator. A fossil fuel steam generator includes an economizer, a steam drum, and the furnace with its steam generating tubes and super-heater coils. Necessary safety valves are located at suitable points to avoid excessive boiler pressure. The air and flue gas path equipment include: forced draft (FD) fan, air preheater (APH), boiler furnace, induced draft (ID) fan, fly ash collectors (electrostatic precipitator or bag house) and the flue gas stack.

1.2 Air Path

External fans are provided to give sufficient air for combustion. The forced draft fan takes air from the atmosphere and, first warming it in the air preheater for better combustion, injects it via the air nozzles on the furnace wall.
The induced draft fan assists the forced draft fan by drawing out combustible gases from the furnace, maintaining a slightly negative pressure in the furnace to avoid backfiring through any opening

1.3 Waste Heat

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then "dumped" into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its "value". The strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved. Large quantity of hot flue gases is generated from Boilers, Kilns, Ovens and Furnaces. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered.

2.0 Objective of project

The performance/ result benchmarking is recognised as an effective approach towards improvement in productivity, quality and other dimensions of performance that are determinants of competitiveness. The process would identify the best available technology for the 40 MW power generating units.

Description	Boiler # 1	Boiler # 2
Efficiency at running excess air	84.43	83.61
Efficiency at recommended excess air	85.35	84.66
% improvement in efficiency	0.92	1.05
Coal saving in TPD	2.61	5.11
Coal saving in year in tonnes	783*	1533*
Savings in Lacs	23.49	45.99

For APH

Description	Unit	Actual Boiler # 2	Improved
Flue gas temperature	^{0}C	156	136
Boiler efficiency	%	83.61	84.71
Coal Saved	TPD	-	5.35

3.0 Methodology:-

The following data is taken and recorded in the manner described.

a. **Flue Gas Analysis:** Flue gas sampling is performed at each air heater's flue gas inlet and outlet through penetrations in the ductwork for test probes. The analysis is done using either an oxygen analyser or an Orsat apparatus that measures oxygen and carbon dioxide.
b. **Flue Gas Temperature at the Air Heater Gas Outlets:** These temperatures are calculated by averaging the readings from the thermocouples at air heater's gas outlet.
c. **Flue Gas Temperature at the Air Heater Gas Inlets:** These temperatures are calculated by averaging the readings from the thermocouples at air heater's gas inlet.
d. **Combustion Air Temperature at the Air Heater Air Outlets:** These temperatures are calculated by averaging the readings from the thermocouples at air heater's air outlet.
e. **Combustion Air Temperature at the Air Heater Air Inlets:** These temperatures are calculated by averaging the readings from the thermocouples at air heater's gas outlet.

4.0 Measurements and performance analysis

The boiler efficiency is computed either by direct method from the heat input and output or by the losses (indirect) method. The reliability and accuracy of the fuel flow and steam flow measurements are critical for the direct method. In the indirect method, various losses are quantified for arriving at the boiler efficiency. Indirect method provides more accurate method for evaluating boiler efficiency and has been used for the plant. The heat losses from the boiler include the following:

1. Heat loss due to dry flue gas.
2. Heat loss due to evaporation of water formed due to H_2 in fuel.
3. Heat loss due to moisture present in fuel
4. Heat loss due to moisture present in air.
5. Heat loss due to partial conversion of C to CO.
6. Heat loss due to radiation and convection.
7. Heat loss due to un-burnt in fly ash.
8. Heat loss due to un-burnt in bottom ash.
9. Sensible heat loss in fly ash.
10. Sensible heat loss in bottom ash.

The parameters measured and/or data collected from plant for calculating efficiency of boilers by indirect method, are given below:

Measured Data	Unit	Boiler#1	Boiler#2
Oxygen	**%**	**7.12**	**7.06**
Carbon di oxide	**%**	**13.06**	**13.21**
Carbon-mono-oxide	**%**	**0.024**	**0.026**
Flue gas temperature at chimney inlet.	**^{0}C**	**138.6**	**156**
Un-burnt in fly ash	**^{0}C**	**12.32**	**12.1**
Un-burnt in bottom ash	**^{0}C**	**4.96**	**4.87**
Temperature of fly ash	**^{0}C**	**125**	**125**
Temperature of bottom ash	**^{0}C**	**950**	**950**
Average surface temperature	**^{0}C**	**70**	**70**

Table 4.1. Measured data for calculation

5.0 Calculations

(1) Air Heater Leakage = % AHL = ($O_{2\ outlet} – O_{2\ inlet}$) / (20.9 - $O_{2\ outlet}$) X 90

Where,

O_2outlet = Oxygen at air heater outlet on a dry basis, measured in %.

O_2inlet = Oxygen at air heater inlet on a dry basis, measured in %.

20.9 Constant, percentage oxygen in ambient air

90 = Empirical constant.

OR

Air Heater Leakage = % AHL = ($CO_{2\ outlet} – CO_{2\ inlet}$) / ($CO_{2\ outlet}$) X 90

Where,
CO_2outlet = CO_2 at air heater outlet on a dry basis, measured in %.
CO_2inlet = CO_2 at air heater inlet on a dry basis, measured in %.
90 = Empirical constant.

(2) No leakage exit gas temperature = T_{gnl}

$$T_{gnl} = T_{gl} + [\{\% AHL * (T_{gl} - T_{ref}) / 100\}]$$

Where,
T_{gnl} = Temperature of flue gas leaving air heater, corrected for leakage, ^{0}F
T_{gl} = Temperature of flue gas leaving air heater, measured, ^{0}F
%AHL = Air heater leakage expressed as percentage of gas entering air heater, %
T_{ref} = Test Reference Temperature, air entering the air heater, ^{0}F

(3) Gas side efficiency –

$$\eta_{ah} = [(T_{gi} - T_{gnl}) / (T_{gi} - T_{ref})] * 100$$

Where,
η_{ah} = Air heater gas side efficiency in %.

(4) Air Heater X-Ratio –

$$\text{X-ratio} = [(T_{gi} - T_{gnl}) / (T_{aol} - T_{ref})]$$

X-ratio = Air heater X-ratio, dimensionless.
T_{gi} = Temperature of flue gas entering air heater, measured, ^{0}F
T_{gnl} = Temperature of flue gas leaving air heater, corrected for leakage, ^{0}F
T_{aol} = Temperature of air leaving air heater, measured, ^{0}F
T_{ref} = Test reference temperature of air entering the air heater, ^{0}F

6.0 Findings and Results-

Description	Unit	Boiler#1	Boiler#2
Air heater leakage	%	8.19	8.07
No leakage exist gas temperature	^{0}C	146.66	165.94
Actual exist gas temperature	^{0}C	138	156
Gas side efficiency	%	54.86	48.49
X Ratio	Dimension Less	0.93	0.90

Figure 4.1 Findings and Result Data Table

From the above table, it can be seen that,

- There is a difference in the CO2 contents at inlet and outlet, which shows that leakages occur in the APH.
- The calculated flue gas exit temperature was marginally higher than the design value, indicating slight cold air ingress. The quantum of cold air leakage in to the APH is calculated to be about 8% as compared to the design level of 6.65%. The plant may focus on reducing air leakages by taking appropriate measures such as arresting port holes, leakages in ducts, replacing worn out ducts and expansion joints, etc.

- The temperature rise of the combustion air is lower by about 30^0C for APH#1 and for APH#2 it is 40 ^{0}C than the design temperature.
- Flue gas temperature drop is comparable in APH # 1 but in APH # 2 it less by 14 ^{0}C from the design value.
- Flue gas temperature in blr # 2 running on higher side which indicates the poor performance of APH. Main cause behind the high temperature is the blockage of large no of tubes in the APH.

7.0 Reference:

1. www.energymanager.com
2. www.cfri.com Central Fuel Research Institute, Dhanbad.
3. www.engineeringtoolbox.com
4. Energy audit reports of national productivity council
5. www.worldenergy.org
6. Energy Hand book, second edition, Von Nostrand Reinhold Company – Robert L. Loftness
7. Industrial boilers, Longman Scientific Technical 1999
8. Power Plant Engineering by Derbal L. F., Boston P. G.,Westra K. L., Erickson R. B.
9. Power Plant Performance by Gill A. B
10. Rahul Dev Gupta, Sudhir Ghai & Ajai Jain – Energy Efficiency Improvement Stategies for Industrial Boiler – Journal of Engineering & Technology Vol. 1. Issue 1. Jan-June 2011.
11. Ronald A Zeitz – Energy Efficient Handbook, Council of Industrial Boiler Owners (CIBO) BURKE.
12. Amit Kumar Tyagi – Hand Book of Energy Audits and Management, TERI Publisher.
13. Mohapatra, S., and Loikitis, D., "Advances in Liquid Coolant Technologies for Electronics Cooling," Proceedings of 21st SemiTherm Symposium, San Jose, CA, pp. 354-360, 2005.
14. Lee, D.Y., and Vafai, K., "Comparative Analysis of Jet Impingement and Microchannel Cooling for High Heat Flux Applications," Intl. Jour. of Heat and Mass Transfer, Vol. 42, pp. 1555-1568, 1999.
15. Gillot, C., Meysenc, Schaeffer, and Bricard, A., IEEE CPT, Vol. 22, No. 3, pp. 384-389, 1999.
16. Kandilikar, S., and Upadhye, H., "Extending the Heat Flux Limit With Enhanced Microchannels in Direct Single-Phase Cooling of Computer Chips," Proceedings of 21st SemiTherm Symposium, San Jose, CA, pp. 8-15, 2005.
17. Singhal, V., et al., "Analysis of Pumping Requirements for Microchannel Cooling Systems,"IPACK'03, Paper # 35237, 2003.
18. Mohapatra, S., and Loikitis, D., "Advances in Liquid Coolant Technologies for Electronics Cooling," Proceedings of 21st SemiTherm Symposium, San Jose, CA, pp. 354-360, 2005.
19. Lee, D.Y., and Vafai, K., "Comparative Analysis of Jet Impingement and Microchannel Cooling for High Heat Flux Applications," Intl. Jour. of Heat and Mass Transfer, Vol. 42, pp. 1555-1568, 1999.
20. Gillot, C., Meysenc, Schaeffer, and Bricard, A., IEEE CPT, Vol. 22, No. 3, pp. 384-389, 1999.
21. Kandilikar, S., and Upadhye, H., "Extending the Heat Flux Limit With Enhanced Microchannels in Direct Single-Phase Cooling of Computer Chips," Proceedings of 21st SemiTherm Symposium, San Jose, CA, pp. 8-15, 2005.
22. Singhal, V., et al., "Analysis of Pumping Requirements for Microchannel Cooling Systems,"IPACK'03, Paper # 35237, 2003.