Review paper on investigation & improvement in steam package boiler efficiency

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***Abstract*- In the present scenario of energy demand overtaking energy supply top priority is given for energy conservation programs and policies. Most of the process plants are operated on continuous basis and consumes large quantities of energy. Efficient management of process system can lead to energy savings, improved process efficiency, lesser operating and maintenance cost, and greater environmental safety. With the growing need for energy conservation, most of the existing process systems are either modified or are in a state of modification with a view for improving energy efficiency. Any new proposal for improving the energy efficiency of the process or equipment should prove itself to be economically feasible for gaining acceptance for implementation. The focus of the present work is to study the effect of system modification for improving energy efficiency.**

Index Terms- Efficiency improvement, boilers etc.

I. BOILERS

A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care. The process of heating a liquid until it reaches its gaseous state is called evaporation. Heat is transferred from one body to another by means of radiation, which is the transfer of heat from a hot body to a cold body without a conveying medium, convection, the transfer of heat by a conveying medium, such as air or water and conduction, transfer of heat by actual physical contact, molecule to molecule.

A. Performance Evaluation Of Boiler

The performance parameters of a boiler, like efficiency and evaporation ratio, reduces with time due to poor combustion, heat transfer surface fouling and poor operation and maintenance. Even for a new boiler, reasons such as deteriorating fuel quality and water quality can result in poor boiler performance. A heat balance helps us to identify avoidable and unavoidable heat losses. Boiler efficiency tests help us to find out the deviation of boiler efficiency from the best efficiency and target problem area for corrective action. 1.2 Efficiency of boiler

Thermal efficiency of a boiler is defined as "the percentage of (heat) energy input that is effectively useful in the generated steam." There are two methods of assessing boiler efficiency: The Direct Method: the energy gain of the working fluid (water and steam) is compared with the energy content of the boiler fuel. The Indirect Method: the efficiency is the difference between the losses and the energy input

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II. DETAILS OF STUDY

The efficiency test and energy conservation study has been conducted in the boiler house of a leading Pulp & Paper Mill. After calculation, the sum of various heat losses and boiler efficiency comes to be

19.015% and 80.98%, respectively [Table 1]. On the basis of efficiency test conducted and further analysis of various heat losses, the following recommendations were proposed for energy efficiency improvement and energy conservation.

A. Coal Preparation and Handling

Sieve analysis of coal was carried out and the average value of Sieve analysis [7] comes to be 13.5%, which is on higher size and shows oversize coal. Because of this oversize coal, unburnt loss in bottom ash is quite high. To control this loss, Sieve analysis has to be carried out on a fixed time-frame basis (once in every shift) on coal coming out of the crusher. It is better to install one sieve analyzer in boiler house, so that sieve analysis can be carried out there itself and feedback can be sent to coal crusher people

Table 1: results of efficiency tests

Loss due to	kJ/ kg Coal	Percentage loss
Dry flue gas	1328.53	5.93
Moisture in fuel	256.03	1.14
Moisture from burning hydrogen	843.47	3.77
Combustibles in refuse	1347.03	6.03
Formation of CO	17.62	0.0785
Moisture in combustion air	56.65	0.255
Sensible heat in bottom ash	92.11	0.41
Radiation and convection	-	0.7
Blow down	-	0.7
Total losses		19.015%
Efficiency = 100 − total losses = 80.98%		

B. Excess Air

Boiler had been running at 75% excess air level and 8.8% oxygen in flue gas. This is on very high side. Operate boiler at lower excess air (around 40%-50%). Online oxygen analyzer [8] or oxygen trim system needs to be installed for proper control on excess air and oxygen content in flue gas. In the absence of online oxygen analyzer, it is recommended to conduct flue gas analysis after every 2 hour and adjust the combustion excess air, as condition changes.

Under grate air must be properly distributed for peak burning efficiency. It is important to ensure periodic surveillance and maintenance to replace worn or broken grate sections. Air infiltration to the furnace must be minimized. It takes place through furnace wall seam areas or through the stoker. Sealing the furnace at potential leak sites reduces air infiltration.

C. Soot Blower Operation

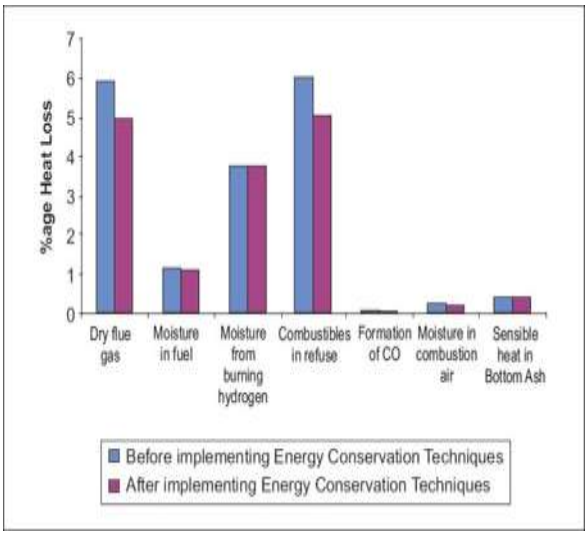
Installed soot blowers are not functioning since long because of soot blowers master steam control valve problem. It is recommended that the soot blower steam control valve needs immediate repair and in this regard valve supplier may be contacted and overhaul the valve, if needed. It is recommended to carry out the soot blower operation once in every shift. Soot blowing should also be carried out in economizer and air preheater.

D. Blow Down

It is observed that blow down from boiler is on continuous basis (CBD). Usually, the blow down is excessive, just to be sure. Automatic blow down system [9] can be installed, consist of continuous monitoring of conductivity, and an automatic blow down sequence at a preset level. This automatic system can save energy wasted by continuous system.

E. Insulation

It is observed that some boiler surfaces and valves are not properly insulated. One rule of thumb is that any surface above 120 ºF should be insulated, including boiler surfaces, steam or condensate piping, valves and fittings. All the damaged or worn out insulation should be changed on priority basis. Boiler casing should be checked for hot spots. Hot spots are an indication of excessive heat losses from the boiler enclosure. The temperature of surface of outer skin should not be more than 50 ºC.



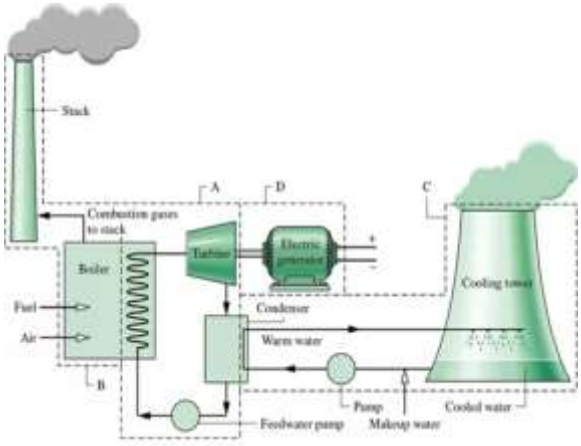
III. TYPES OF FUEL USED IN BOILER

There are many types of fuel used in boiler to generate necessary heat.

Coal	GCV(KCAL/KG)
A) Bituminous	4,500-6,500
B) Anthracite	6,500-7,700
C) Lignite	3,500-4,500
Furnace oils	10,500-11,700
Agro fuels	3,100-4,500
Nautral gas	8,200-8,600
Kerosene	11,100
LPG	11,600-11,700

IV. WORKING OF THERMAL POWER PLANT

Steam is generated in the boiler of the thermal power plant using the heat of the fuel burned in the combustion chamber. The steam generated is passed through steam turbine where the part of the it's thermal energy is converted into mechanical energy which is further used for generation electric power. The steam coming out of the steam turbine is condensed in the condenser and condensate is supplied back to the boiler with the help of the feed pump and cycle is repeated. The function of the boiler is to generate the steam .The function of condenser is to condense the steam coming out of steam turbine at low pressure. The function of the steam turbine is to convert part of heat energy of steam into mechanical energy. The function of feed pump is to raise the pressure of the condensate from the condenser pressure (0.015 bar) to boiler pressure (200 bar). The other components like economizer, super heater and steam feed heaters are used in the primary circuit to increase the overall efficiency of the thermal power plant.



V. HEAT LOSSES IN A BOILER PLANT

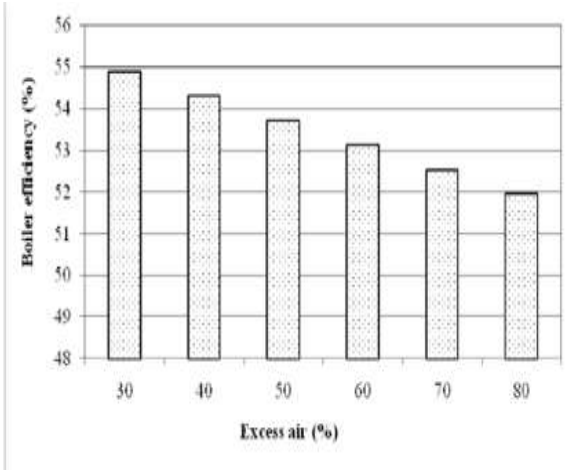
1. Heat used to generate steam, Q= ms (h1 – hf)
2. Heat lost to flue gases. The flue gases contain dry products of combustion and the steam generated due to the combustion of hydrogen in the fuel. Heat lost to dry flue gases, Q1 = m g c pg(Tg – Ta) m g = Mass of gases formed per kg of fuel c pg = Specific heat of gases T g = Temperature of gases, oC Ta = Temperature of air entering the combustion chamber of the boiler, oC
3. Heat carried by steam in flue gasesQ2 = ms1(hs1– hf1) ms1 = Mass of steam formed per kg of fuel due to combustion of H2 in fuel hf1= Enthalpy of water at boiler house temperature hs1= Enthalpy of steam at the gas temperature and at the partial pressure of the vapor in the flue gas
4. Heat loss due to incomplete combustion If carbon burns to CO instead of CO2 then it is known as incomplete combustion. 1 kg of C releases 10,200 kJ/kg of heat if it burns to CO whereas it releases 35,000 kJ/kg if it burns to CO2.
5. Heat lost due to unburnt fuel Q4 = mf1× C.V mf1= Mass of unburnt fuel per kg of fuel burnt

6. Heat unaccounted Q6 = Q– (Q1 +Q2 +Q3 +Q4 +Q5) Q = mf ×C.V = Heat released per kg of fuel

VI. BOILER TRIAL AND HEAT BALANCE SHEET

1. There are three purposes of conducting the boiler trial.
2. To determine and check the specified generating capacity. Of the boiler when working at full load conditions.
3. To determine the thermal efficiency of the plant.
4. To draw up the heat balance sheet so that suitable corrective measures may be taken to improve the efficiency.

5. The following measurements should be observed during the boiler trial.
6. The fuel supplied and its analysis.
7. Steam generated and its quality or superheat.
8. Flue gases formed from exhaust analysis.
9. Air inlet temperature and gases exhaust temperature.
10. Volumetric analysis of exhaust gases.
11. Mass of fuel left unburnt in ash.
12. Feed water temperature. The Heat balance sheet is a symmetric representation of heat released from burning of fuel and heat distribution on minute, hour or per kg of fuel basis.



VII. CONCLUSION

Thermal power plant heat rate is directly affected by boiler efficiency. From calculation it is found that 1% decrease in boiler efficiency increases the heat rate by 1%. Heat rate is increases as boiler efficiency decreases so to achieve desired heat rate boiler performance required to be improved. Boiler efficiency is approved by reducing various losses and controlling stack temperature.

REFERENCES

[1] P K Nag, Power plant engineering, Third Edition.
[2] "Energy performance assessment of boilers", Bureau of Energy Efficiency. pp. 1-22.
[3] Virendra Nagar , Dr. V. K. Soni , Dr. V. K. Khare , Boiler Efficiency Improvement through Analysis of Losses IJSRD
[4] Heat Rate Improvement Reference Manual, EPRI, Palo Alto, CA: 1998. TR-109546
[5] Energy and Efficiency Management System, NTPC