Middle-East Journal of Scientific Research 12 (12): 1675-1677, 2012
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2012.12.12.23

Improvement of Boiler Efficiency in Thermal Power Plants

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Abstract: Boilers in a Thermal power plant are to be operated efficiently to achieve higher plant efficiency in the present day market economy. Many of the boilers operating today are performing at efficiencies that are less than 60 percent. Hence there is huge potential for energy improvements and cost savings leading to higher profits. To achieve this objective, the performance of the boilers is to be assessed and based on which rectification measures are to be incorporated. Because of steep rise in fuel prices and other resources, the optimum use of the resources is very much essential. This can be done by estimating the heat losses occurring in boilers and thereafter finding suitable ways for reduction of losses and the same is dealt by the present paper.

Key words:

INTRODUCTION

In a thermal power plant the least efficient component is Boiler. A captive Thermal power plant (TPP) in a heavy industry has to supply uninterrupted power and process steam for various critical requirements. The TPP has five boilers of 330 T/hr steam capacity and 101 ATA and 540 C each. The coal is pulverised in Bowl mills and fired in the furnace. Normally 4 boilers are kept in service to produce 247.5 MW of power and supply steam to process needs. Boiler output flue gas is passed through Electrostatic precipitators to control air pollution. The flyash and bottom ash generated are pumped in slurry form to ash pond through on ground pipe lines. The clarified water is re-circulated back to ash system. The hot circulating gas is passed through waste heat boilers in which steam is produced at 40 KSCA pressure and 440 C and 25 T/hr.

Evaluation of the Performance of Boiler: The steam supply to the Turbo generators is from 5 boilers with a capacity of 330 T/hr, 101 ATA. The 12 nos waste heat recovery Boilers are of capacity 25 T/hr, 40 ATA. Auxiliary steam requirements of the plant are from 13 ATA and 7 ATA steam buses throughout the plant. Performance of the boiler like efficiency and evaporation ratio reduces with time due to poor combustion,heat transfer, fouling and poor operation and maintenance. Deterioration of fuel quality and water quality also leads to poor performance of the boiler. Efficiency testing helps to find out how far the Boiler efficiency drifts away from the best efficiency (norms). Any observed abnormal deviations could therefore be investigated to pinpoint the problem area for necessary corrective action. Hence the present level of efficiency is to be determined. The purpose of the performance test is to find out the efficiency of the Boiler. The present efficiency (Actual performance) is to be compared with design values (Norms).

The Direct Method Testing: In this method, for assessment we need the heat input (i.e fuel) and the useful output (steam) for determining the efficiency. Hence this method is known as 'input-output method'. The formula is given below:

$$\text{Boiler efficiency} = \frac{\text{Steam flow rate x (Steam enthalpy - feed water enthalpy)}}{\text{Fuel firing rate x GCV}} \text{x}100$$

The Indirect Method Testing: The disadvantages of direct method can be overcome by this method which calculates the various heat losses associated with the boiler. The various losses that had occurred in the boiler

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are as shown below. The efficiency can be arrived at by subtracting the heat losses from 100. An advantage in this method is the errors in measurement do not make significant changes in efficiency. The losses that occur in the boiler are

- Dry flue gas loss
- Hydrogen loss
- Moisture in fuel
- Moisture in air
- Co loss
- Boiler surface loss
- Flyash loss
- Bottom ash loss

The above losses are conveniently related to the amount of fuel burnt. Theoretical (Stoichiometric) air-fuel ratio and excess air supplied are to be determined first for computing the Boiler losses.

Efficiency = 100 – (1+2+3+4+5+6+7+8)

Experimentation: The parameters for calculation of efficiency by indirect method are obtained from the shift operators logbooks from control rooms of the power plant. They are as shown below:

- Fuel firing rate = 2560 Tons/hr
- Steam generation rate = 330 T/hr
- Steam pressure = 101 ATA
- Steam temperature = 533 C
- Feed water temperature = 196 C
- Percentage of CO2 in flue gas = 12
- Percentage of CO in flue gas = 0.50
- Average flue gas temperature = 190 C
- Ambient temperature = 236 C
- Humidity in air = 0.0204 kg per kg of dry air
- Surface temperature of Boiler = 165 C
- Wind velocity around Boiler = 3.5 m/s
- Total surface area of Boiler = 7397 sqm
- GCV of Bottom ash = 600 kcal/kg
- GCV of Flyash = 452.5 kcal/kg
- Ratio of bottom ash to fly ash = 80:20

Fuel Analysis (%)

- Ash content = 40.19
- Moisture in coal = 44.93
- Hydrogen content = 2.64
- Nitrogen content = 1.56
- Oxygen content = 14
- GCV of coal = 2850 kcal/kg

RESULTS AND DISCUSSION

Performance Improvement: From the above, we find that a lot of heat energy is wasted from flue gas loss due to moisture content in fuel. Hence we have to extract sensible heat from flue gases and use it various purposes. At the same time, it has to be kept in mind that decreasing the flue gas temperature will increase acid corrosion at the cold end of the Boiler.

Heat Recovery from Flue Gas: The temperature of the flue gas leaving the boiler is commonly reduced in air pre-heaters (APHs) and Economisers (ECOs) in the convective pass of the Boiler where the sensible heat in the flue gas leaving the furnace is used to preheat the combustion air in APHs and feed water in ECOs.This preheating of combustion air and feed water greatly enhances the Boiler efficiency. The convective heat transfer surfaces such as the air preheaters and economizers where the heat of the exit flue gases from the furnaces are extracted are to be free of any deposition of soot and ash.These deposits will impede convective heat transfer from flue gases leading to increase in its temperature.The formation of these deposits are mainly due to improper combustion in the furnace and high ash content in the fuel The convective heat transfer surfaces are to be cleaned for efficient heat transfer. Hence these convective heat transfer surfaces are to be inspected periodically. They are cleaned with high pressure service water when the boiler is under shut down and inspected after cleaning. This will greatly reduce the exit flue gas temperature and thus the heat loss. Further soot blowers are to be installed in the flue gas path to clean the heat transfer surfaces of economizers and air heaters online. In case they are available with the original installation, the periodicity of online cleaning is to be increased.The maximum extent that the flue gas temperature can be decreased is just above the acid dew point, for prevention of acid corrosion. Due to the above, the exit flue gas temperature can be reduced to at least to 150 deg C, which increases the heat absorption in the Boiler, leading to increase in Boiler efficiency to more than 80 percent.

CONCLUSION

The flue gas loss in a Boiler is always higher than any other loss. The flue gas loss is minimized by maximum heat extraction in the convective surfaces of the Boiler. The efficiency calculation by indirect method is the best way to account all the Boiler losses. The important step to improve the performance of Boilers is the detailed study of the Boiler in the plant and then performing the efficiency calculation. Moreover with regardto the coal (fuel), it should be ensured that it is of higher calorific value, low moisture and low ash content. When the flue gas loss is reduced, efficiency of the Boiler can be as high as 80 percent.

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