Boiler Efficiency Measurement and Energy Saving Steam Distribution System – A Case Study

Sumeet M. Sanghvi
PG Student
Department of Mechanical (Thermal Science) Engineering
Faculty of Technology & Engineering, M.S.University of Baroda, Vadodara

Vijay M. Parmar
Assistant Professor
Department of Mechanical Engineering
Faculty of Technology & Engineering, M.S.University of Baroda, Vadodara

Abstract

Conventional energy sources are limited in the world and energy conservation is necessary now a days. Thermal Efficiency improvement is necessary for saving fuel and energy cost in modern coal based power plant. A boiler is the key part of the plant and its operation with optimum efficiency is very important. An assessment of boiler efficiency by using standard method and compare it with design value is necessary for its improvement. Numbers of feasible methods are available to improve thermal efficiency of boiler; by applying them one can easily improve it. Other thing is steam distribution system used in the power plant in which by varying insulation thickness improvement in energy saving, fuel saving and decrease in cost, surface loss is possible. In this paper, boiler efficiency of three boilers with same steam producing capacity of 30 TPH at one of the leading chemical industry is calculated and also analyze steam distribution system at various thickness of insulation.

Keywords: Boiler efficiency, Steam distribution system, Thickness of insulation, Energy conservation

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I. INTRODUCTION

IBR Steam Boilers means any closed vessel exceeding 22.75 liters in capacity and which is used expressively for generating steam under pressure and includes any mounting or other fitting attached to such vessel, which is wholly or partly under pressure when the steam is shut off. The performance parameters of boiler, like efficiency and evaporation ratio reduces with time due to poor combustion, heat transfer surface fouling and poor operation and maintenance. Boiler efficiency tests help us to find out the deviation of boiler efficiency from the best efficiency and target problem area for corrective action.

II. METHODOLOGY TO CALCULATE THE BOILER EFFICIENCY

A. Boiler Efficiency

According to burrow of energy efficiency thermal efficiency of boiler is defined as the percentage of heat input that is effectively utilized to generate steam. There are two methods of assessing boiler efficiency.

1) The Direct Method Testing:

In this method the energy gain of the working fluid is compared with the energy content of the boiler fuel. This is also known as 'input-output method' due to the fact that it needs only the useful output and the heat input for evaluating the efficiency. Major drawback of this method is that it does not give clues to the operator as to why efficiency of system is lower and also not calculate various losses accountable for various efficiency levels.

2) The Indirect Method Testing

Indirect method is also called as heat loss method. The efficiency can be arrived at, by subtracting the heat loss fractions from 100. The advantage of indirect efficiency method is that each boiler can be checked independent of other boilers in operation Cause of an individual loss can be independently determined or rectified for improving boiler efficiency. The disadvantages of direct method are overcome here by using direct method.

The various heat losses occur in the boiler are

- Heat loss due to dry flue gas
- Heat loss due to moisture in fuel
- Heat loss due to moisture in the combustion air
- Heat loss due to hydrogen in the fuel
- Heat loss due to CO
- Heat loss due to radiation & convection
- Heat loss due to un burnt in fly ash

- Heat loss due to un burnt in bottom ash
- Blow down loss
- Unaccounted losses

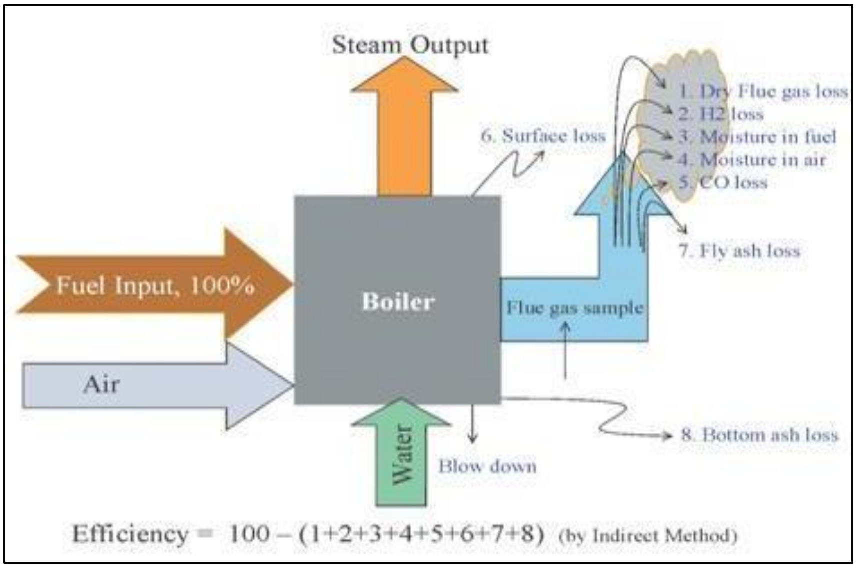


Fig. 1:

The company has two spreader stoker boiler and one Fluidized bed combustion boiler of Thermax made with same capacity of 30 TPH for making steam at 56 kg/cm^2(g) pressure. Following table indicates the measured date of all three boilers to find out boiler efficiency and other performance parameters.

Boiler 3	*Boiler 2*	*Boiler 1*	*Measured Data*
28800 kg/hr	*28800 kg/hr*	*28800 kg/hr*	*Steam generation rate*
54 kg/cm^2 (g)	*54 kg/cm^2 (g)*	*54 kg/cm^2 (g)*	*Steam pressure*
460 °C	*460 °C*	*460 °C*	*Steam temperature*
105 °C	*105 °C*	*105 °C*	*Feed water temperature*
217°C	*221 °C*	*223 °C*	*Average flue gas temperature*
36 °C	*36 °C*	*34 °C*	*Ambient temperature*
0 .014kg / kg dry air	*0 .011 kg / kg dry air*	*0.016 kg / kg dry air*	*Humidity in ambient air*
95 °C	*95 °C*	*90 °C*	*Surface temperature of boiler*
3.5 m/s	*3.5 m/s*	*3.5 m/s*	*Wind velocity around the boiler*
187.7 m^2	*187.7 m^2*	*187.7 m^2*	*Total surface area of boiler*
7200.00 kg/hr	*7200.00 kg/hr*	*7200.00 kg/hr*	*Fuel firing rate*
Ash Analysis (Analyzed In Laboratory)			
750 kCal/kg	*900 kCal/kg*	*1050 kCal/kg*	*GCV of Bottom ash*
448.5 kCal/kg	*450 kCal/kg*	*460 kCal/kg*	*GCV of fly ash*
90:10	*90:10*	*90:10*	*Ratio of bottom ash to fly ash*
Ultimate Analysis of Coal (Analyzed In Laboratory) in %			
10.15	*14.2*	*14.4*	*Ash content in fuel*
30.6	*21.2*	*21.1*	*Moisture in coal*
42.55	*45.3*	*44.8*	*Carbon content*
3.15	*4.4*	*4.3*	*Hydrogen content*
1.8	*1.5*	*1.5*	*Nitrogen content*
2.75	*3.3*	*3.2*	*Sulpher content*
9.0	*10.1*	*10.7*	*Oxygen content*
4311 kCal/kg	*4311 kCal/kg*	*4311 kCal/kg*	*GCV of Coal*
Flue Gas Analysis with Flue Gas Analyzer			
13.4	*14*	*12*	*%CO2 in Flue gas*
0.48	*0.45*	*0.55*	*%CO in flue gas*
8.12%	*8.12*	*8.12%*	*% O_2 in flue gas*
600 ºC	*600 ºC*	*600ºC*	*Max. Flue gas temperature*
Feed Water Analysis (Analyzed In Laboratory)			
160 ºC	*160 ºC*	*160ºC*	*Feed water temperature*
200ppm	*200ppm*	*200ppm*	*TDS*
7.1	*7.1*	*7.1*	*Ph*

3) Table 1: Measured Data of Boilers

By using this measured data and standard indirect method following results are get for all three boilers.

4) Table 2: Thermal Efficiency of Boiler by Indired Method from Measured Data

Some recommendations for improvement in boiler efficiency are as follows.

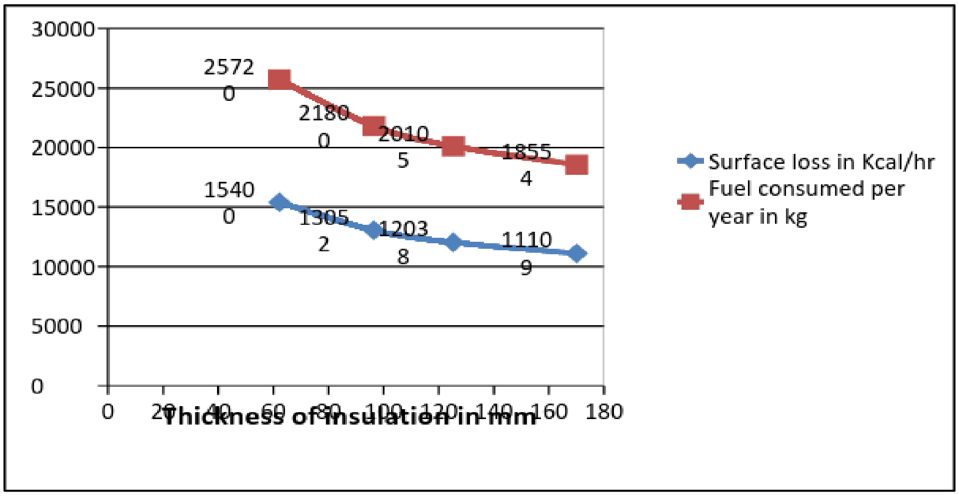
1) Install a high turndown burner
2) Add variable speed drive controls
3) Incorporate parallel positioning
4) Include O2 trim
5) Integrate lead/lag
6) Incorporate an economizer
7) Recover and repurpose heat from blow down
8) Use exchangers to preheat inlet water

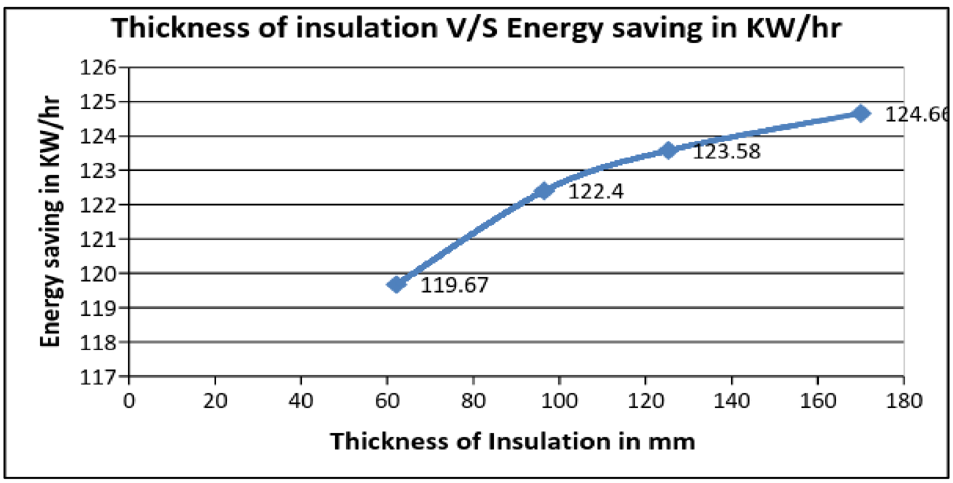
B. Cost Saving

Annual cost saving S = P x operating hours x energy cost
Total insulation cost (material + labor) C = C1 x A
NPV of annual O & M cost for service life of 5 years NPV = $\sum_{i=1}^{n}$ [CF / (1+i)]
Total insulation cost C_T = Material cost+Labour cost+NPV O & M
Net saving S' = S - C_T
Payback period PP = (Capital cost / Net annual savings)

III. GRAPHICAL ANALYSIS OF CALCULATIONS

Thickness of Insulation V/S surface loss V/S Fuel consumed per year in kg**.** Figure shows chart of thickness of insulation v/s surface loss v/s fuel consumed per year in kg. It shows that as the thickness of insulation is increased the surface heat loss is decreases. As the thickness of insulation is increased, more energy is being saved and due to that there is an increasing in fuel savings.





A. Thickness of Insulation V/S Energy saving

Figure shows the graph between thickness of insulation and energy savings. From this graph it is easily mention that as the thickness of insulation is increased, the energy savings is also increased.

IV. CONCLUSION AND FUTURE WORK

1) By using indirect method, the boiler efficiency for two spreader stoker boilers and one FBC boiler are 70.12%, 72.39% and 77.79% respectively. As the management of the company argued that they do not want major changes in the plant, so from above recommendations oxygen trimming is one of the appropriate methods for implementation. Almost no changes are necessary for this method and this method efficiently works on part load and full load.
2) In steam distribution system they currently used 60mm thickness of insulation. From above analysis if thickness is further increased then more fuel saving, energy saving is possible.

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