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Analysis of Boiler Losses & Efficiency Improvement

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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. This paper is concerned with calculating boiler efficiency as one of the most important types of performance measurement in any steam power plant. Thermal power plant converts the chemical energy of the coal into electricity. The heat rate of a conventional coal fired power plant is a measure of how efficiently it converts the chemical energy contained in the fuel into electrical energy Heat rate is expressed as kcal/kwh. The aim of monitoring boiler performance is to control the heat rate of plant.

I. INTRODUCTION

Boilers are considered to be as the key part in any generation station as it is the place where the fuel is used for producing the needed amount of heat. A boiler is an enclosed vessel that provides a means for combustion heat to be transferred to convert water into steam. It 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.

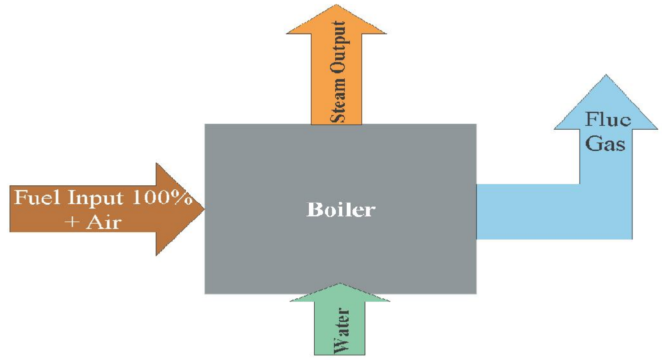
A. *Efficiency Of Boiler*

hermal efficiency of a boiler is defined as "the percentage of energy input that is effectively useful in the generated steam." There are two methods of assessing boiler efficiency:

1) *The Direct Method*: the energy gain of the working fluid is compared with the energy content of the boiler fuel.

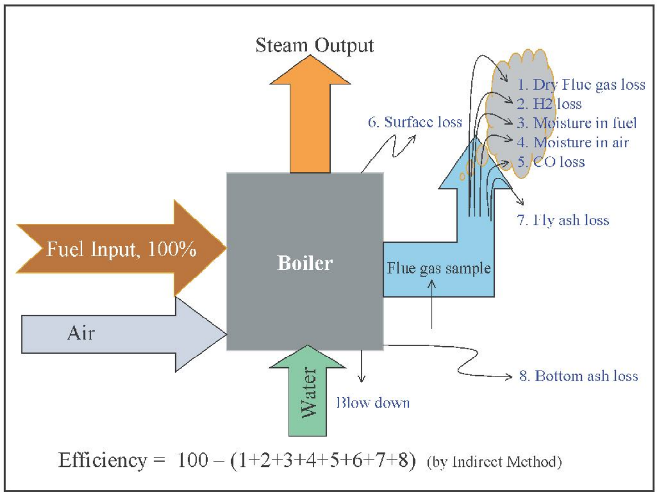
$$\text{Boiler Efficiency} = \frac{\text{Heat Input}}{\text{Heat Output}} \times 100$$

$$\text{Boiler Efficiency} = \frac{\text{Steam flow rate} \times (\text{steam enthalpy} - \text{feed water enthalpy})}{\text{Fuel firing rate} \times \text{GCV of fuel}}$$



2) *The Indirect Method:* the efficiency is the difference between the losses and the energy input.
3) *Boiler Efficiency*=100- (L1+L2+L3+L4+L5+L6+L7+L8) where,

L1-Loss due to dry flue gas (sensible heat)
L2- Loss due to hydrogen in fuel (H2)
L3- Loss due to moisture in fuel (H2O)
L4- Loss due to moisture in air (H2O)
L5- Loss due to carbon monoxide (CO)
L6- Loss due to surface radiation, convection and unaccounted
L7- Loss due to Unburnt in fly ash (Carbon)
L8- Loss due to Unburnt in bottom ash (Carbon)



B. Water Preheater

Input data
$T_1 = 212$, $T_2 = 146$
$t_1 = 102$, $t_2 = 145$
Assume,

Outer dia of tube = 0.019m

Internal dia of tube = 0.014m
0.025m inch square pitch

Take FT = 0.8

Now,

$$LMTD = \frac{(T1 - t1) - -(T2 - t2)}{\ln\{\frac{T1-t1}{T2-t2}\}}$$

Therefore, LMTD = 23.19 ^{o}C
LMTD = 296.33 K
Determining heat transfer coefficient,

$$A = \frac{Q}{U\ (assump)\ X\ LMTD\ X\ FT}$$

U = 2200 W / m^2K
Q = m x C_p x Δ t
After Calculations, A= 1.033 m^2

Calculating no. of tubes, $n_t = A/\pi D_o L_t$, where
N_t = No. of tubes
A = Area of heat transfer in sq. metre
D_0 = Outer diameter of tube; L_t = Length of tube in metre

$$No.\,of\ tubes = \frac{1.033}{\pi \times 0.019 \times 6}$$

N_t = 2.88
26 is th eclosest value in TEMA book, so take n_t = 26; Shell ID = 8" (TEMA Book)
Therefore velocity of fluid through tube,

$$R_e = \frac{4m_c(\frac{n_{pass}}{n_{tubes}})}{\pi \times d_{i \times}\mu_c}$$

$$= \frac{4 \times 6.93 \times \frac{2}{26}}{\pi \times 0.019 \times 0.000225} = 158768 > 10^4$$

Where,
R_e= Reynolds Number
$_c$ = Mass flow rate of cold water
n_{pass} = No. of passes = 2
n_{tubes}= No. of tubes
d_i= Inner iameter of the tube
μ_c = Dynamic Viscosity
Therefore,

$Velocity = \frac{Re \times \mu\,(water)}{Di \times \rho}$ = {(158768 x 0.000225) / (0.019 x 945)} = 1.98 m/sec

So the fluid velocity through the tube is in the optimum condition. So the best design parameters for tubes of water preheater is,

1) ¾ inch Od of tube.
2) Length of tube = 6 m
3) Internal diameter (ID) = 0.584 inch
4) Number of tube = 26
5) Shell id = 8 inch
6) *Scaph:*Input data,

T_1 = 212°C

T_2 = 111°C

t_1= 27°C

t_2 = 10°C

Mass flow rate of steam = 0.294 kg/sec Mass flow rate of air = 6.54 kg/sec

$$LMTD = \frac{(T_1-t_1)-(T_2-t_2)}{\ln(\frac{T_1-t_1}{T_2-t_2})}$$

$$\frac{(212-27)-(111-110)}{\ln(\frac{212-27}{111-110})}$$

= 35.24 °C

= 308 K

Area of the tube ,A = $\frac{Q}{U_{assm}*LMTD*FT}$

U of air = 25 W/m^2K

Assume fouling factor FT = 0.8

Q = ms*Cs*(T1-T2)

$$A = \frac{0.294\times2479\times374.15}{25\times308\times0.8} = 44.26m^2$$

Calculating no. of tubes, Nt = $\frac{A}{\pi*Do*Lt}$

$$= \frac{44.26}{\pi\times0.019\times8} = 92.68$$

So take n_t = 97 (according to TEMA book)
Reynolds no. of the fluid through the pipes,

$$R_e = \frac{4*m(air)*(\frac{np}{nt})}{\pi*Di*\mu(air)}$$ np = No. of pass

n_t = No. of tubes

D_i = Internal diameter of shell = 13.25 inch(0.336m)

μ = 20.59×10^{-6} Ns/m^2

$$R_e = \frac{4\times6.54\times(\frac{1}{97})}{\pi\times0.336\times20.59\times10^{-6}} = 12408.5$$

Velocity of the fluid through the tube,

$$\frac{Re*\mu(air)}{Di*\rho(air)} \frac{12408.5\times20.59\times10^{-6}}{0.336\times1.029}$$

= 0.73 m/s

II. CONCLUSION

The objective of the study was to analyze the overall efficiency and the thermodynamic analysis of boiler. There are many factors, which are influencing the efficiency of the boiler. The fuel used for combustion, type of boiler, varying load, power plant age, heat exchanger fouling they lose efficiency. Much of this loss in efficiency is due to mechanical wear on variety of components resulting heat losses. Therefore, it is necessary to check all the equipments periodically. Moreover, it is noticed that the overall efficiency of any boiler depends upon the technical difficulties under unpredictable conditions. Hence, a viable study is carried out to assess the performance of boiler plant in this context. The paper set to show the weakness of depending on energy analysis only boilers as a performance measure that will help improve efficiency.

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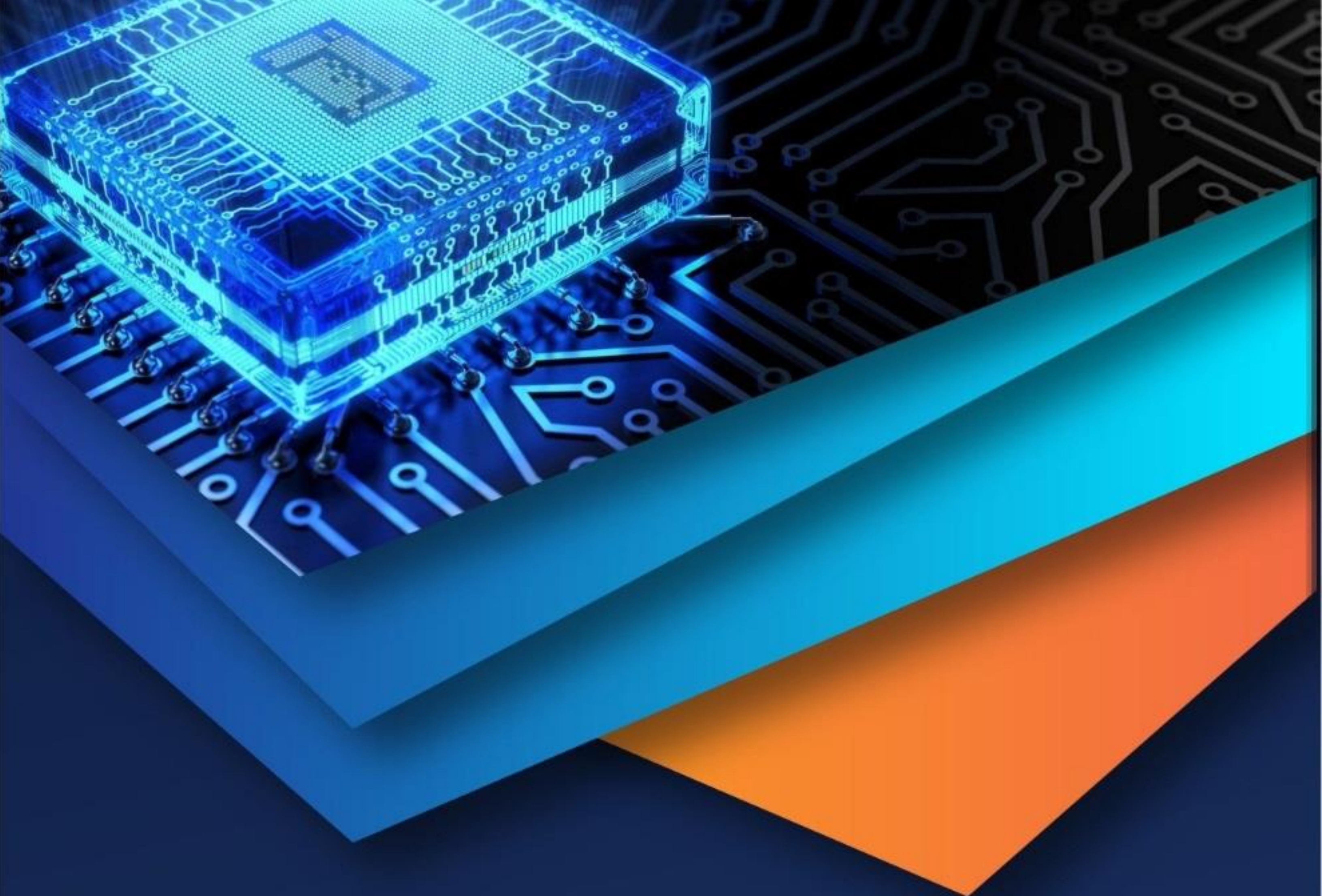

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