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Energy and Exergy Analysis of Boiler in 6mw Cogeneration Coal Power Plant

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Abstract*: Based on several research activity and local power plant experience some key observation has made and the aim of this work is to be find out amount and source of irreversibility generated in boiler of 6 MW captive power plant and also calculate the losses of boiler by using first law and second law of Thermodynamic i.e. Energy and Exergy analysis, compare the efficiency of both Energy and the Exergy efficiency of boiler so that any process in the system that having largest energy destruction can be identified that help designer to re-design the system components. The aim of exergy analysis is to identify the losses in boiler in order to improve the existing system like boiler, economizer super-heater, furnace, boiler tube, air pre-heater, boiler feed pump.
Keywords*: Irreversibility, Exergy Analysis, Energy analysis, Coal based Thermal Power Station, Fossil fuels, Irreversibility, Second Law of Thermodynamics.

I. INTRODUCTION

A. Energy Scenario

Energy consumption is the most important problem in the today's era. In the present scenario per capita energy consumption determines the level of development of the nation. With the increased awareness that the world's energy resources are limited has caused many countries to reassess their energy policies and take measures for eliminating the waste. It has also ignited the interest in the scientists and researchers to take a close look at the energy conversion devices and to develop new techniques for better utilization of the available resources. The First Law deals with the amounts of energy of various forms transferred between the system and its surroundings and with the changes in the energy stored in the system. It treats work and heat interactions as equivalent forms of energy in transit and offers no indication about the possibility of a spontaneous process proceeding in a certain direction. The first law places no restriction on the direction of a process, but satisfying the first law does not ensure that the process can actually occur. This inadequacy of the first law to identify whether a process can take place is remedied by introducing another general principle, the second law of thermodynamics. The Exergy method of analysis is based on the Second law of thermodynamics and the concept of irreversible production of entropy. The fundamentals of the Exergy method were laid down by Carnot in 1824 and Clausius in 1865. The energy-related engineering systems are designed and their performance is evaluated primarily by using the energy balance deduced from the First law of thermodynamics. Engineers and scientists have been traditionally applying the First law of thermodynamics to calculate the enthalpy balances for more than a century to quantify the loss of efficiency in a process due to the loss of energy. The Exergy concept has gained considerable interest in the thermodynamic analysis of thermal processes and plant systems since it has been seen that the First law analysis has been insufficient from an energy performance stand point. Keeping in view the facts stated above, it can be expected that performing an analysis based on the same definition of performance criteria will be meaningful for performance comparisons, assessments and improvement for thermal power plants. Additionally, considering both the energetic and exergetic performance criteria together can guide the ways of efficient and effective usage of fuel resources by taking into account the quality and quantity of the energy used in the generation of electric power in thermal power plants. The purpose of this study presented here is to carry out energetic and exergetic performance analyses, at the design conditions, for the existing coal and gas-fired thermal power plants in order to identify the needed improvement. For performing this aim, we summarized thermodynamic models for the considered power plants on the basis of mass, energy and Exergy balance equations. The thermodynamic model simulation results are compared. In the direction of the comprehensive analysis results, the requirements for performance improvement are evaluated

B. Layout of Power Plant

In general power plant consist of four main components starting from boiler also know as steam generator where the heat energy absorbed by water and converted into steam. This heat energy is then stored in boiler as potential energy and then is allow to flow and expand on turbine through nozzles this steam is then redirected to the condenser for increasing the efficiency of overall plant.

The condensate their after is again fed back in to boiler for reuse.

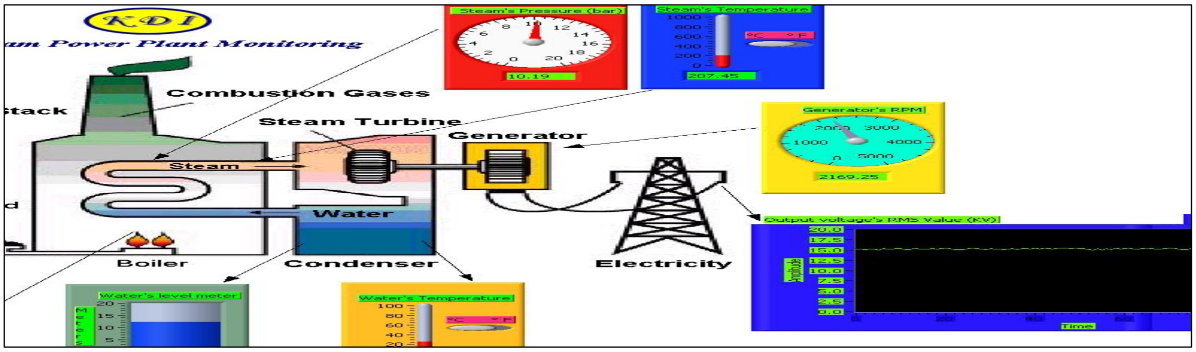

Fig 1 General Layout of working power plant

1) Boiler : -It is use to generate the steam
2) Generator :- It is use to generate the electric from steam turbine
3) stack steam:- flue gases remove into the atmosphere
4) Turbine : basically turbine is coupled with the Generator use for produce the electric city
5) Condenser :- to condense the steam in the condenser and use condensate as a feed water in order to reduced the water consumption
6) Water level indicator :- It is use to give a proper indication of water inside the boiler in order to prevent overheating

II. OBJECTIVE

A. To compare the energy and exergy efficiencies.
B. To reduce the loss of energy.
C. To increase the overall performance of thermal power plant.
D. Reduced the coal consumption
E. Reduced the auxiliary power consumption
F. Increase the plant load factor

III.ENERGY ANALYSIS

Basically Boiler efficiency can be tested by the following methods:

A. Direct Method or Input Output Method:

Direct method compares the energy gain of the working fluid (water and steam) to the energy content of the fuel. This is also known as „input-output method" due to the fact that it needs only the useful output (steam) and the heat input (i.e. fuel) for evaluating the efficiency

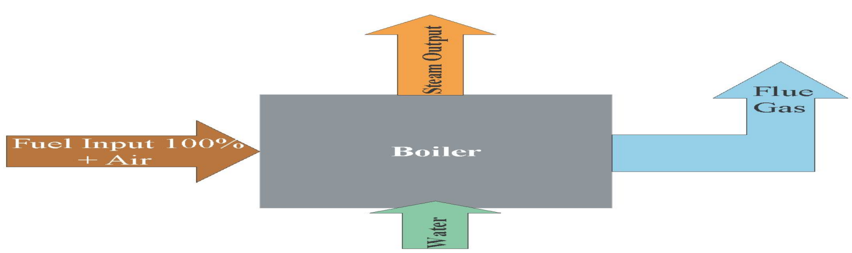

Fig. 2 Direct Method or Input Output Method

$$Boiler\ Efficiency\ (\eta) = \frac{Heat\ Output}{Heat\ Input} \times 100$$

$$Boiler\ Efficiency\ (\eta) = \frac{\text{Steam Flow Rate} \times (\text{steam enthalpy} - \text{feed water enthalpy})}{Fuel\ firing\ rate \times Gross\ calorific\ value} \times 100$$

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Where,
Ƞ = boiler efficiency in %.
SFR= steam flow rate in kg/hr.
SE= steam enthalpy in kCal/kg.
FEW= feed water enthalpy in kCal/kg.
FFR= fuel firing rate in kg/hr.
GVC= gross calorific value of coal in kCal/kg.

B. Indirect Method or Heat Loss Method:

In the heat loss method the efficiency is the difference between the losses and the energy input. In indirect method the efficiency can be measured easily by measuring all the losses occurring in the boilers using the principles to be described. The weaknesses of the direct method can be overwhelmed by this method, which calculates the various heat losses associated with boiler. The efficiency can be arrived at, by subtracting the heat loss percentages from 100. An important advantage of this method is that the errors in measurement do not make significant change in efficiency. The indirect method does not account for Standby losses; Blow down loss, energy loss in Soot blowing, and energy loss running the auxiliary equipment such as burners, fans, and pumps.

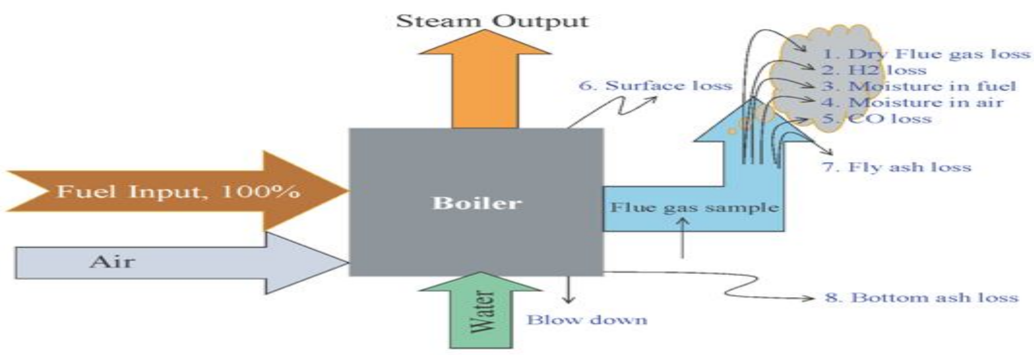

Fig.3 Indirect Method or Heat Loss Method

Valid losses incorporate with to coal fired boiler

1) Heat loss due to dry flue gas (L1)
2) Heat loss due to evaporation of H_2 in fuel (L2
3) Heat loss due to moisture present in fuel (L3)
4) Heat loss due to moisture present in air (L4)
5) Loss due to surface radiation (L5)
6) Heat loss due to bottom ash (L6)
7) Unaccountable losses (L7)

Total Losses= L1+L2+L3+L4+L5+L6+L7

Boiler efficiency by indirect method:

Boiler Efficiency= 100- Total Losses

Energy analysis is done by calculating losses of the boiler by using indirect method Coal energy is the main source of thermal power plant for that we require the ultimate analysis of coal as well as proximate analysis of coal

Table 1. Ultimate analysis of coal

Coal constituent	Unit	Coal sample
carbon (c)	%	51.9
hydrogen (h_2)	%	3.46
nitrogen (n_2)	%	1.37
oxygen (o_2)	%	11.6

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sulfur (s)	%	0.5
ash	%	10.1
moisture	%	20.60
total		99.53%

Table 2. Proximate analysis of coal

Coal constituent	Unit	Coal sample
ash	%	33.11
moisture	%	20.63
volatile matter	%	19.59
fixed carbon	%	26.57
calorific value	kcal/kg	3334
total		100.00%

Table 3. Observation Table

Sr. No.		1	2	3	4
Date		140817	140817	200817	260817
Time		12.30	15.30	12.30	12.30
Load	MW	3.514	2.756	5.478	5.501
Inlet Steam Flow	TPH	21.29	18.61	30.60	32.63
Inlet Steam Pressure	Kg/cm^2	63.05	65.04	63.74	62.77
Inlet Steam Temperature	^0C	486	477	490	494
Feed Water Temp. Eco. I/L	^0C	143	162	167	166
Feed Water Temp. Eco. O/L	^0C	227	235	233	232
Air Temp. at AIRHTR O/L	^0C	125	115	143	144
Flue Gas at ESP O/L	^0C	130.13	140.76	136.47	136.57
Feed Water Transmitter	TPH	28.04	22.24	32.08	33.41
Saturated Steam Temp.	^0C	281	281	283	282
Air Consumption	TPH	21.96	17.22	34.13	34.38
Belt Weigher	TPH	4.21	2.30	6.57	6.60
Flue Gas Flow	TPH	52.05	40.16	81.52	81.86
Ambient Temp.	^0C	33	31	29	31
Oxigen Analyser	$\%O_2$	3.99	5.94	3.89	3.28

C. Heat Loss due to Dry Flue Gas (L1)

Theoretical air required

$$\text{Air (Th)} = \frac{1}{23}\left[2.67C + 8\left(H_2 - \frac{O_2}{8}\right) + S\right] \quad \text{kg/kg of coal}$$

$$\text{Air (Th)} = \frac{1}{23}\left[2.67 * 51.9 + 8\left(3.46 - \frac{11.6}{8}\right) + 0.5\right] \quad \text{kg/kg of coal}$$

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Air (Th) = 6.7456 kg/kg of coal

EA = Excess air required $= \dfrac{o_2\%}{21-o_2\%}$ kg/kg of coal

EA $= \dfrac{3.99\%}{21-3.99\%}$ kg/kg of coal

EA = 0.234568 kg/kg of coal

Actual mass of air supplied

AAS = (1+ Excess air/100) × Theoretical air required in kg/kg of coal

AAS = (1+ 0.234568/100) × 6.7456 kg/kg of coal

AAS = 6.761423 kg/kg of coal

Total mass of flue gas (m)/kg of fuel

m = mass of actual air supplied/kg of fuel + 1 kg of fuel

m = 6.761423 + 1 kg/ kg of fuel

m = 7.761423 kg/kg of fuel

This is the greatest boiler loss and can be calculated with the following formula:

Heat loss due to dry flue gas L1 = $\dfrac{mass \times Cp \times (Tf - Ta)}{G.C.V.of\ fuel} \times 100$

$$L1 = \frac{7.761423 \times 0.23 \times (130.13-303)}{3334} \times 100$$

L1 = 5.20064 %

Where, L1 = % Heat loss due to dry flue gas

m = Mass of dry flue gas in kg/kg of fuel

= Combustion products from fuel: CO_2 + SO_2 + Nitrogen in fuel + Nitrogen in the actual mass of air supplied + O_2 in flue gas.

(H_2O/Water vapour in the flue gas should not be considered)

Cp = Specific heat of flue gas in kCal/kg°C

Tf = Flue gas temperature in °C

Ta = Ambient temperature in °C

D. Heat Loss due to Evaporation Of H_2 in Fuel (L2)

The combustion of hydrogen causes heat losses because the product of combustion is water. This water is converted to the steam and this carries away heat in the form of its latent heat

% Heat loss due to evaporation of water formed due to H2 in fuel (L2)

$$L2 = \frac{9 \times H2 \times \{584 + Cp(Tf - Ta)\} \times 100}{GCV\ of\ coal}$$

$$L2 = \frac{9 \times 0.0346 \times \{584 + 0.45(130.13 - 33)\} \times 100}{3334}$$

L2= 5.8628 %

Where, L2 = % Heat loss due to dry moisture in fuel

H_2 = kg of hydrogen present in fuel on 1 kg basis

Cp = Specific heat of superheated steam in kCal/kg°C

Tf = Flue gas temperature in °C

Ta = Ambient temperature in °C

584 = Latent heat corresponding to partial pressure of water vapour

E. Heat Loss due to Moisture in The Fuel (L3)

Moisture entering the boiler with fuel leaves as a superheated vapour, this moisture loss made up of sensible heat during the to bring the moisture to the boiling point ,the latent heat of evaporation of the moisture ,the loss can be calculated by Following formula , taken from paper energy performance assessment of boiler.

$$\% \text{ Heat loss due to moisture in fuel (L3)} = \frac{M\times\{584+Cp(Tf-Ta)\}\times 100}{\text{G.C.V. of fuel}}$$

$$L3 = \frac{0.2063\times\{584+0.45(130.13-33)\}\times 100}{3334}$$

$$L3 = 3.8841\ \%$$

Where, L3 = % Heat loss due to dry moisture in fuel
m = kg moisture in fuel on 1 kg basis
Cp = Specific heat of superheated steam in kCal/kg°C
Tf = Flue gas temperature in °C
Ta = Ambient temperature in °C
584 = Latent heat corresponding to partial pressure of water vapour

F. Heat Loss due to Moisture Present in Air (L4)

Vapors in the form of humidity in the incoming air, is superheated as it passes through the boiler, since heat passes through the stack, it must be included as a boiler loss to related the losses to the loss of coal burned, the moisture content of the combustion air and the amount of air supplied per unit mass of coal must be known

%Heat loss due to moisture present in air (L4)

$$L4 = \frac{AAS\ x\ sp.humidity x\ Cp\ x\ (Tf-Ta)\ x\ 100}{GCV\ of\ coal}$$

$$L4 = \frac{6.761423\ x\ 0.0204 x\ 0.45\ x\ (130.13-33)\ x\ 100}{3334}$$

$$L4 = 0.1808\ \%$$

Where, L4 = % Heat loss due to dry moisture in air
Cp = Specific heat of superheated steam in kCal/kg°C
Tf = Flue gas temperature in °C
Ta = Ambient temperature in °C
AAS = Actual mass of air supplied per kg of fuel
Sp. Humidity = kg of water/kg of dry air

G. Heat Loss due to Radiation (L5)

As per the boiler company manual, radiation loss would be considered as a 0.8 % after proper insulation done. **(**Above value taken from literature also**)**

H. Heat Loss due to Bottom Ash (L6)

Carbon particle are found in the boiler bank bottom, when flue gas is flowing from boiler to stack heavy particle of ash containing coal particles fallen in the boiler bank and remaining small size of ash practical are gone to stack and then atmosphere

%Heat loss due to unburnt carbon in bottom ash (L6)

$$= \frac{Total\ ash\ collected\ per\ kg\ of\ coal\ burnt * GCV\ of\ bottomash * 100}{GCV\ of\ fuel}$$

$$L6 = \frac{0.29799*365*100}{3334}$$

$$L6 = 3.2623\ \%$$

GCV of bottom ash changes according to the load because heavy particle of coal which is not burn during the combustion is found in the bottom or boiler bank, and loss of ignition changes.

I. Unaccountable Losses (L7)

These losses include heat loss due to unburnt fly ash, convective heat loss, etc; are taken as 1.5 %.

J. Boiler Efficiency

Boiler efficiency can be calculated as

=100- (L1+L2+L3+L4+L6+L7)

= 100 - (5.20064+5.48921+3.8841+0.1808+0.8+3.2623+1.5)

= 79.68%

able 4. Boiler efficiency

Sr. No.	Load (MW)	∑ Losses	Boiler efficiency
1	3.514	20.32	79.68
2	2.756	21.97	78.03
3	5.478	21.22	78.78
4	5.501	21.17	78.77

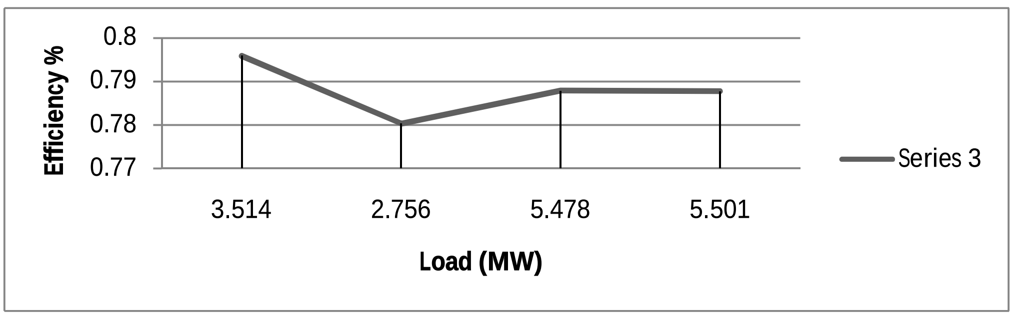

Fig.4. Boiler efficiency

IV. EXERGY ANALYSIS

The exergy analysis can be evaluated for the following:

A. Exergy of Feed Water (Ɛw)

Before entering the water into the economizer, the water is allowed to get heated in the deaerator thus the temperature of feed water is increased to higher temperature, the temperature of water at economizer inlet from above table.

Exergy of feed water can be calculated by

$$\mathcal{E}w = (C_{pw})\ \{(T_w - T_a) - T_a \ln(\frac{T_w}{T_a})\} \text{ kJ/kg of water}$$

= 4.187{(143-33)-306ln(416/306)} kJ/kg of water

= 67.1065 kJ/kg of water

= 54.4835418 kJ/kg * 7.7889 kg/s

= 522.68598 kW

Where, C_{pw} = Specific heat of water kJ/kgK

T_w = Temperature of feed water °C (ECOO/L)

T_a = Temperature of ambient temperature °C

B. Exergy of Fuel ($\mathcal{E}_f$)

Exergy of fuel can be calculated by the equation proposes by shieh and fang for calculating the Exergy of fuel.

$\mathcal{E}_f$ = 34183.16(C) + 21.95(N) + 11659.9(H) + 18242.90(S) + 13265.90(O) ----------(1)

According to the T.J kotas say that the ratio of Exergy of fuel to caloric value of the fuel lies between 1.15 to 1.30. According to the ultimate analysis we get Exergy of the fuel is = 17683.84 kj/kg and calorific value is 17585.4 kj/kg thus ratio we get is 1.01 that is nearer to T.J kotas ratio.

$\mathcal{E}_{f=}$ 34183.16(0.519) + 21.95(0.0137) + 11659.9(0.0346) + 18242.90(0.005) + 13265.90(0.0116) KJ/kg of coal

$\mathcal{E}_f$ = 19774.8521 KJ/kg of coal

$\mathcal{E}_f$ = 19774.8521 KJ/kg × 1.2611 kg/s

$\mathcal{E}_f$ = 24938.0659 kW

C. Exergy of Steam Formed ($\mathcal{E}_s$)

Exergy of steam formed can be calculated by the relation

$$\mathcal{E}_s = (h - h_0) - T_0 (S - S_0)$$

Where,

h = enthalpy of Steam formed KJ/Kg = $h_f + h_{fg} + C_{ps} (T_{sup} - T_{sat})$

= 2780.4 + 1.8828 (486-281)

= 3166.384 kJ/kg

h_0 = enthalpy of feed water KJ/Kg = $C_{pw} (T_{ECOO/L} - T_0)$

= 4.187(227-33)

= 812.278 kJ/kg

T_0 = Ambient temperature K = 306 K

S = Entropy of Steam formed KJ/Kg K = $S_f + S_{fg} + C_{ps} \ln (T_{sup}/T_{sat})$

= 5.858 + 1.8828ln(759/554)

= 6.450775kJ/kgK

S_0 = Entropy of feed water KJ/Kg K = $C_{pw} \ln (T_{ECOO/L}/T_0)$

= 4.187ln(500/306)

= 2.05591 kJ/kgK

$\mathcal{E}_s$ = (3166.384-812.278) - 306(6.450775-2.05591) KJ/Kg

$\mathcal{E}_s$ = 1009.2788 KJ/Kg

$\mathcal{E}_s$ = 1009.2788 KJ/Kg × Mass flow rate of steam Kg/s

$\mathcal{E}_s$ = 1009.2788 KJ/Kg × 5.9138 Kg/s

$\mathcal{E}_s$ = 5968.6797 kW

D. Exergy of Air Supplied ($\mathcal{E}a$)

The Exergy of air can be calculated by following

$$\mathcal{E}a = (C_{pa})\ (T_2 - T_a) - T_a \ln(\frac{T_2}{T_a})$$

$$\mathcal{E}a = 1.005(125 - 33) - 306 \ln(\frac{399}{306})$$

$\mathcal{E}a$ = 12.1988 kJ/kg of air supplied

$\mathcal{E}a$ = 12.1988 kJ/kg * 6.1006944 kg/s

$\mathcal{E}a$ = 74.4214 kW

Where, C_{pa} = Specific heat of air kJ/kgK

T2 = Temperature of air of combustion at AIRHTR O/L °C

T_a = Ambient temperature °C

E. Exergy of Flue Gas ($\mathcal{E}g$)

$$\mathcal{E}g = (C_{pg})\ (T_g - T_a) - T_a \ln(\frac{T_g}{T_a})$$

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$$\mathcal{E}g = 1.005(130.13-33) - 306 \ln\left(\frac{130.13+273}{306}\right)$$

$\mathcal{E}g$ = 12.8376282 kJ/kg og flue gas

$\mathcal{E}g$ = 12.8376282 kJ/kg*14.4569 kg/s

$\mathcal{E}g$ = 185.6192 kW

Where, T_g = Temperature of flue gas °C

T_a = Temperature of Ambient °C

F. Total Irreversibilities in the Steam Boiler

Total Irriversibilieties in the steam Boiler

Total Irriversibilieties in the steam boiler are given by ,

I_b = Total exergy entering the boiler - Total exergy leaving the boiler

$I_b = (\mathcal{E}_w + \mathcal{E}_f + \mathcal{E}_a) - (\mathcal{E}_s + \mathcal{E}_g)$

I_b = (522.68598+24938.0659+74.4214) – (5968.6797+185.619)

I_b = 19380.8745 kW

Table 5. Boiler Irreversibilities

Sr. No.	Load (MW)	I_b (kW)
1	3.514	19380.87
2	2.756	16399.67
3	5.478	28120.09
4	5.501	27718.62

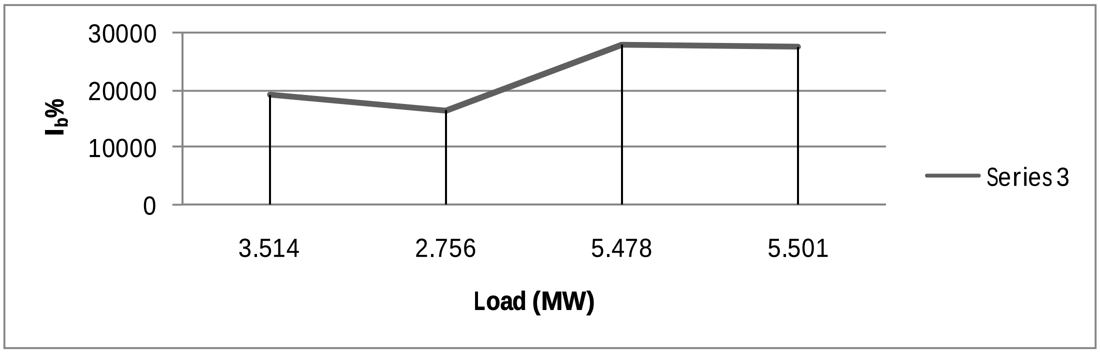

Fig. 5. Boiler irreversibilities

G. Second Law Efficiency (Exergetic Efficiency) of the Boiler

Second Law efficiency (Exergetic efficiency) of the Boiler is given by

η_{II} = Total Exergy leaving the boiler / Total Exergy entering the boiler

(Exergetic efficiency) of the Boiler η_{II} = 34.978 %

As load increase total Exergy of drum gain by the steam increase, it is sum of Exergy rise in economizer and super heater

Table 6. Boiler efficiency

Sr. No.	Load (MW)	η_{II}
1	3.514	24.101
2	2.756	24.010

3	5.478	24.285
4	5.501	25.661

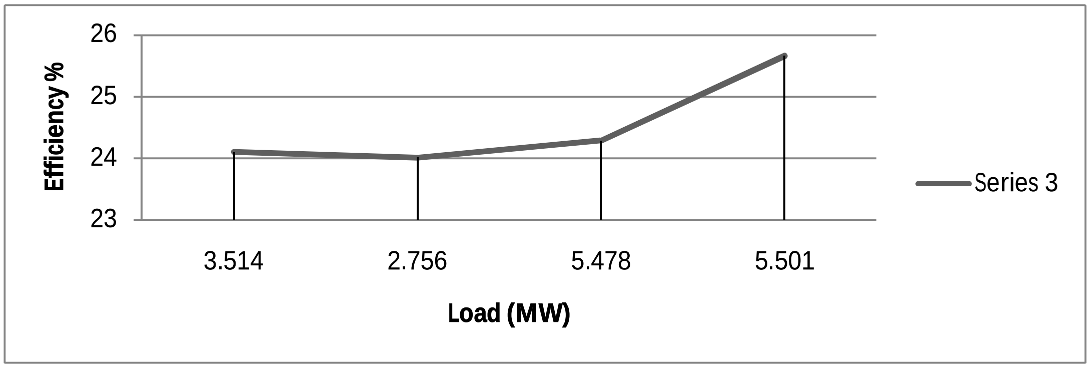

Fig.6. Boiler efficiency

V. DISCUSSION ON RESULTS OF DIFFERENT EXERGY - ENERGY STUDY OF CO-GENERATION POWER PLANT

A. *Energy Analysis*

1) Heat loss due to dry flue gas increases as load decreases. At load 5.501 kW losses are 5.650188% and at 2.756 kW losses are 5.8851% which is maximum. For minimizing this losses run the plant at pick load.
2) Heat loss due to evaporation of H_2 in fuel is again increases as load decreases. At load 5.501 kW losses are 5.89835% and at 2.756 kW losses are 5.91596% which is maximum. For minimizing this losses use coal of higher GCV value.
3) Heat loss due to moisture present in the coal is again maximum at load is minimum. At load 5.501 kW losses are 3.9076% and at 2.756 kW losses is 3.9192% which is maximum. For minimizing this losses combustion air temperature should be more as well as coal should be selected in such mine whose moisture percentage should be less, another way is to dry the coal first before feeding it to furnace.
4) Heat loss due to moisture present in the air is again maximum at load is minimum. At load 5.501 MW losses are 0.196448% and at 2.756 MW losses are 0.2046% which is maximum. For minimizing these losses combustion air temperature should be more as well as proper maintenance of air pre-heater is needed.
5) is the only way to reduced the heat loss due to bottom ash, for AFBC boiler coal should be crushed up to 6 mm otherwise heavy particle of coal content in carbon found in the bottom ash
6) As per our above discussion it is now found that load increases boiler losses reduces, so that plant should be run in the Pickup load. In 5.501 MW the boiler efficiency is 78.78% and 2.756 MW it is 78.03%, the skilled operators are required for operating the boiler, then only it is possible to reduce the losses. It is also found that energy losses at full load is 21.17% and energy loss at 2.756MW is found 21.97 %, this also shows that at minimum load there is maximum energy losses, and at pick load there is minimum energy losses.

B. *Exergy Analysis*

1) Graph indicates that as load increases the exergy of fuel also increases, so the plant should always be run at pick load, at 2.756 MW exergy is 20963.32 kW and at 5.501 MW exergy is 36259.168 kW. So the plant should always be run at pick load.
2) Graph indicates that as load increases the exergy of feed water also increases, at 2.756 MW exergy is 570.904 kW and at 5.501 MW exergy is 904.9356 kW. Also exergy of feed water depends on atmospheric temperature.
3) The exergy of air is dependent upon the combustion of air temperature as well as flue gas temperature. So exergy of air at 2.756 MW is 47.2726 kW and at full load 5.501 MW is 122.947 kW.

4) The exergy of steam formed also increases as load increases at 2.756 MW exergy of steam formed is 5001.86 kW and at 5.501 MW exergy of steam formed is 9226.69 kW, but in some cases exergy of steam formed is reduced as load increases due to steam flow reduction, as it depends upon the extraction steam or process steam.
5) As load increases exergy of flue gas increases at 2.756 MWexergy of flue gas is 179.965 kW and at 5.501 exergy of flue gas is 341.734 kW, but it is again dependent upon the temperature of flue gas and boiler load. Sudden decrease in load cause the loss of exergy, so irreversibility will be more.
6) Irreversibility increases as load increase, at 2.756 MW irreversibilities are 16399.67231 kW and at 5.501 MW irreversibilities are 27718.625 kW . To reduce the irreversibility heat transfer rate should be high, but it is again dependent upon the various parameters and boiler load, at 5.478 MW irreversibilities are 28120.098 kW which is more than at 5.501 MW is 27718.625 kW. Sudden decrease in load cause the loss of exergy, so irreversibility will be more. So maintaining proper combustion air temperature as well as flue gas temperature and load we can reduce the irreversibilities.
7) As per our above discussion it is now found that load increases the exergetic efficiency of boiler increases, at 2.756 MW exergetic efficiency is 24.0104 % and at 5.501 MW exergetic efficiency is 25.6615 % so that plant should be run at pick load.

VI. CONCLUSIONS

A. As load increases boiler losses reduces, so that plant should be run in the Pickup load. In 5.501 MW the boiler efficiency is 78.78% and 2.756 MW it is 78.03%, the skilled operators are required for operating the boiler, then only it is possible to reduced the losses. It is also found that energy loss at full load is 21.17% and energy loss at 2.756MW is found 21.97 %, this also shows that at minimum load there is maximum energy loss, and at pick load there is minimum energy loss.
B. Lot of precaution already taken for reducing the heat loss like insulation of boiler, boiler mountings and accessories ,but still from the observations, boiler seem to be the most exergy destruction component in steam power plant.analysis indicate that the boiler has exergy destruction at load 2.756 MW is 16399.67231 kW, the exergy destruction is found to be 75.98 % of the total exergy input to the boiler.
C. For highest load 5.501 MW, exergy destruction is 27718.627 kW the exergy destruction is found to be 74.33 % of the total exergy input to the boiler
D. As load increases the exergetic efficiency of boiler increases, at 2.756 MW exergetic efficiency is 24.0104 % and at 5.501 MW exergetic efficiency is 25.6615 % so that plant should be run at pick load.
E. Thus efficiency of 1st law and 2nd law increases with load ,which indicates that plant should be operate on full load. The observations shows increase in irreversibility with increase in load. By optimizing the factors which are responsible for irreversibilities, the performance of the boiler can be improved and the irreversibility losses can be reduce.

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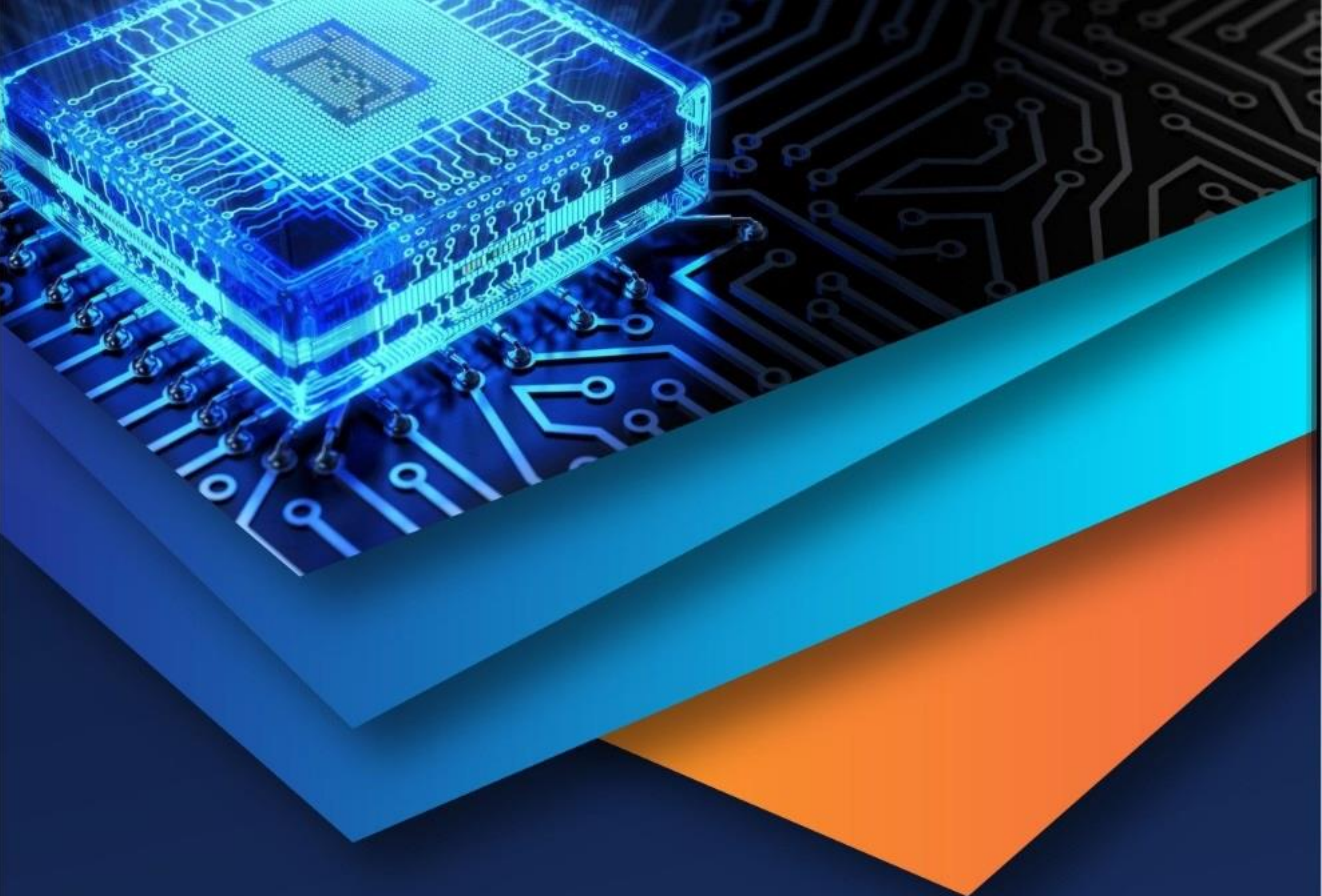

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