Advance Physics Letter

"Analysis of Performance of Coal Fired Boiler in Thermal Power Plant"

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Abstract : The era after Second World War (1945-1973) was a period of cheap and abundant energy, especially oil. Large oil reserves were discovered in the Middle East during this period. Oil consumption increased from 0.5 Gigaton in 1950 to 3.0 Gigaton in 1970. Energy consumption in the industrial, transport, agricultural and residential sectors increased sharply. In the industrial sector, new energy intensive industries like petrochemicals and fertilizers flourished. Extensive expansion took place in textiles, cement, engineering and other industries. In design and operation of industrial processes and equipment, energy efficiency was not a very important criterion. In the residential sector, use of new gadgets like color TVs, refrigerators, washing machines and air-conditioners increased sharply; again energy efficiency was not an important factor in their design. The transport sector saw the growth of road transport sector resulted in low energy efficiency and high-energy consumption.

The realization that the world's energy resources are finite and fast depleting has simulated interest in the efficient use of existing resources. This renewed interest has led to a greater emphasis on concepts of thermodynamics and kindled efforts to apply these principles to improve industrial process efficiency.

The energy resources in India are limited. While coal resources may last for about 100 years, oil and gas may last only few decades. India has 1% of the total world's energy resources, but is home to 16% of the world's population. Since independence and even today, the energy policy is oriented towards increasing the supply of coal, oil and electricity. Our oil consumption has increased fivefold in the past 25 years after the energy crisis of 1973. About 65% to 70% of the oil is imported. This is going to be difficult in future due to our large foreign debt and the falling value of the rupee. In most developed countries the oil consumption has stabilized or increased only marginally. In all sectors (industrial, Transport and residential), the maximum energy consumption is due to refrigerators, air-conditioners etc. A refrigerator in India consumes about 50% more energy than some international brands. There are no standards for efficiency of equipment like boilers, motors, fans, compressors etc. A concentrated effort is required to improve energy efficiency and reduce dependence on imported oil.

The power sector in India faces peculiar problems. With highly subsidized agricultural rates, most electricity boards are making heavy losses. The electricity boards have no money to invest in new power plants, while foreign investors as well as institutions like the World Bank are reluctant to lend to loss making electricity boards. To a certain extent, energy efficiency improvement can help this matter. The electricity price for industrial consumers is already Rs. 4/kWh in most states and may soon reach Rs. 5.5/kWh.

The above fact will realize everyone that the world's energy resources are finite and fast depleting energy reserves has simulated interest in the efficient use of existing resources. This renewed interest has led to a greater emphasis on concepts of thermodynamics and kindled efforts to apply these principles to improve industrial process efficiency. The efficiency improvements have been initiated in major energy intensive industries. Even though there is a greater degree of awareness in India today than ever before regarding the importance of energy conservation measures and its efficient use, the result achieved so far are insignificant. The primary objective of energy conservation measures in the industry is to lower energy costs by reducing the need for purchased energy.

Energy, being a conserved quantity, is not a scarce resource. Thus energy does not represent the potential to cause change and is not the commodity of interest the potential to cause change and is not the commodity of interest for evaluating process efficiency. In order to analyze process irreversibility, it is essential to rely on the second law of thermodynamics. The second law constrains the direction in which any energy transformation can occur. The first law efficiencies, based on the ratio of product energy to fuel energy are generally faulty to a degree that depends on the kind of the system to which they are applied. Basically, worth of first law efficiencies is proportional to how well it approximates the second law efficiency.

The in depth thermodynamic analysis (first law and second law) can certainly lead to truly achievable energy conservation measure and help not only to reduce energy costs but also reduce the pollution which is an associated evil with higher energy consumption. Analysis of multi component plant (like combine cycle power plant, cogeneration plant) based on this concept indicates the total plant irreversibility distribution amongst the plant components, pinpointing those contributing most to overall plant inefficiency. Such an estimate only will help in planning the future course of the energy system design.

I. INTRODUCTION

The concept of energy was first introduced by Newton in mechanics when he hypothesized about potential and kinetic energies. Today the concept of energy is so familiar to us that it is intuitively obvious, yet we have difficulty in defining it exactly. Energy cannot be observed directly, it is a scalar quantity but can be recorded and evaluated by indirect measurements. The absolute value of energy of system is difficult to measure, where as its energy change is rather easy to calculate. The sun is the major source of the earth's energy.

One of earliest procedure in the evaluation of power cycle using energy analysis was due to J. K. Salibury Significant features of his method, generally known as heat deviation method, were to use the analytic description of the turbine cycle in order to reduce the required input data and computational time. In this method he introduced a single variable as a criterion of thermodynamic index of performance of feed water heating system under a given set of boundary conditions. The work of Salisbury formed the basis of a plant monitoring system that has since been widely used for simple system.

II. LITERATURE REVIEW

The present chapter reviews the work carried out by various investigators on energy analysis. The work reviewed is detailed in separate sections giving details of methodologies their relative merits and applications to various industries viz. Steam and Gas Turbine Plant, Co – Generation Plants and chemical and process Industries. More emphasis is given on the power generation industries as it is the aim of the present study.

ENERGY ANALYSIS

The concept of energy was first introduced in mechanics by Newton when he hypothesized about kinetic and potential energies. The concept of energy is so familiar to us today that it is intuitively obvious, yet we have difficulty in defining it exactly. Energy is a scalar quantity that can not be observed directly but can be recorded and evaluated by indirect measurements. The absolute value of energy of system is difficult to measure, where as its energy change is rather easy to calculate. The sun is the major source of the earth's energy. It emits a spectrum of energy that travels across space as electromagnetic radiation. Energy is also associated with the structure of matter and can be released by chemical and atomic reactions. Throughout history, the emergence of civilizations has been characterized by the discovery and effective application of energy to society's needs.

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Energy balances treat all forms of energy as equivalent, without differentiating between the different grads of energy crossing the system boundary. Thus heat transfer to the environment from a pipe carrying high temperature steam will be treated in the same way as low grade thermal energy rejected in the condenser of a steam plant. Results from energy balance on cryogenic systems can be baffling since here the loss of thermal energy is desirable while gaining thermal energy as a result of a heat transfer from the environment is to be avoided. In general energy balances provide no information, about internal losses. An energy balance for an adiabatic system such as throttling valve, a heat exchanger or a combustion chamber, could lead one to believe that these processes are free of losses of any kind.

Hadi Rostamzadeh [2017] has been investigated that one can obtain a higher PESR by increasing of the generator pressure and ejector mass entrainment ratio or by decreasing of the evaporator pressure and condenser temperature. It is also found that increasing of the generator pressure and ejector mass entrainment ratio or Decreasing of the evaporator pressure and condenser temperature will increase the thermal efficiency.

Yang Cao [2017]has been investigated that The maximum energy losses destructions are found in the CO2 capture units. *R*OC of 0.75, *R*SC of 0.06 and *T*RR of 850 oC are recommended as the optimum operation parameters based on the sensitivity analyses.

Ningning Si [2017] analyzed the performance of a 1000 MW double reheat ultra-supercritical power plant.Results show that the highest energy loss in furnace is as high as 85%, which caused by the combustion of fuel and heat exchange of water wall. The VHP and the two LPs suffer the highest energy losses, namely 1.86%, 2.04% and 2.13% respectively. The regenerative heating system has an energy loss rate of 2.3%. The condenser suffers a heat loss of 999 MW, but its energy is as low as 20.49 MW.

Shihe Chen[2017] The energy-loss of large independent disturbance was calculated based on global variable condition calculation method. Through calculating the energy-loss caused by the classified disturbance factors, the relative errors between the theoretical value and operation value were -3.00% for100%THA (turbine heat acceptance), -9.75 for 75%THA and 16.47% for 50%THA

Meryem Terhan [2017] In this study, energy analyses of natural gas fired boilers in a district heating system are performed. In the boilers, energy or heat losses are exanimate, and the biggest of these is identified as the heat loss of flue gases the ratio of flue gas energy losses in the boilers are 16.81% and 6.14%, respectively. The energy efficiencies of the boilers are found to be 82% and 32.78%. The location, where the maximum of the irreversibility in the boilers is noticed as combustion chamber and adiabatic combustion temperature is calculated as 1846 °C

Harun Geokgedik [2016] The total energy efficiency of the system is found to be 9.60%. Its efficiency can be increased up to 15.40% by making improvements in the overall components. Although the heat exchangers had lower energy and modified energy efficiencies, their energy improvement potentials were high. Finally, in the plant, the old technology is believed to be one of the main reasons for low efficiencies

Rauf Terzi [2016] In accordance with the analyses, much energy loses have been found in reactor pressure vessel units. In addition, condenser, turbines and steam Generators also contribute at the energy loss. While the thermodynamic efficiency of the NPP is found as 30%, the irreversibility of pressure vessel and steam generator have been Calculated as 49% and 13%. There exist also irreversibility within the amount of 6% in turbines, condensers and heaters.

Hui Hong [2016] By using the derived expressions, we examine a typical hybrid solar system with 330 MW coal-fired power plants and evaluate thermal performance of solar-to-power. In addition, the influences of key operation parameters on the solar thermal performance are disclosed such as solar irradiation, incident angle and turbine load. The results obtained here would be expected to provide a possibility for designing and evaluating practical hybrid solar and coal-fired power plant.[9].

Chao Fu[2015] The irreversibility are caused by the combustion reaction, heat transfer between flue gas and water/steam, low temperature heat losses, the steam cycle, and other factors. Different measures to increase the thermal efficiency of the reference plant by 0.1% points are presented. The minimum thermal efficiency penalty related to CO_2 capture is 2.92–3.49% points within an air factor range of 1.0–1.4 when the CO_2 is 100% recovered.

Ahmet Ege [2014] Results of the black box method showed that uncertainties varied between 1.82–1.98% for energy efficiency and 1.32–1.43% for energy efficiency of the plant at an operating power level of 40–100% of full power. It was concluded that LHV determination was the most important uncertainty source of energy efficiency of the plant. The uncertainties of the extreme case analysis were determined between 2.30% and 2.36% for energy efficiency while 1.66% and 1.70% for energy efficiency for 40–100% power output respectively. Proposed method was shown to be an approach for understanding major uncertainties as well as effects of some measurement parameters in a large scale thermal power plant.

Mayer et.all, [2014].

The observations were as follows:

- All industrial process occur in the terrestrial environment which is an in exhaustible source (or sink) of energy, work & matter.
- Natural resource is substance which is not in equilibrium with atmosphere and which can produce work by changing their thermodynamics.
- The thermodynamics state of a resource can be reduced to a state in equilibrium with the atmosphere. No further useful processes are possible.

The cycle is analyzed in terms of thermal efficiency of the plant, defined as the ratio of the useful available energy output to the heat added and the thermal efficiency of the heat added, which is the ratio of increase in availability of steam (in the boiler) to heat added. Availability balance, using these expressions, has been carried out for various typical cycle configurations with single reheat and double reheat. Mayer Et. AL concluded that the availability balance can point out the loss distribution throughout the plant and predicted that this method is likely to be more widely used in future.

Matrida & Stecco (2008) A methodology for second law analysis based on exergy modules for heat dissipation to the environment, heat transfer with finite temperature difference, viscous dissipation, non-ideal mixing processes and combustion. To illustrate the procedure an exergy loss analysis based on these modules leads sufficiently accurate results.

III. INTRODUCTION OF BOILER SYSTEM, FUELS AND COMBUSTION

A Boiler is a main part or Heart of the various industries as well as power plant industries because the steam is the main blood for the working media for power plant industries or other various processes. So that Boiler is very important or most useful equipment.

Boiler Specification

The heating surface is any part of the boiler metal that has hot gases of combustion on one side and water on the other. Any part of the boiler metal that actually contributes to making steam is heating surface. The amount of heating surface of a boiler is expressed in square meters. The larger the heating surface a boiler has, the more efficient it becomes.

The quantity of the steam produced is indicated in tons of water evaporated to steam per hour. MCR is the hourly evaporation that can be maintained for 24 hours. F & A means the amount of steam generated from water at 100°C to saturated steam at 100°C.

BOILERSYSTEMS

The boiler system comprises of: feed water system, steam system and fuel system. The feed water system provides water to the boiler and regulates it automatically to meet the steam demand. The steam system collects and controls the steam produced in the boiler. Steam is directed through a piping system to the point of use. Throughout the system, steam pressure is regulated using valves and checked with steam pressure gauges. The fuel system includes all equipment used to provide fuel to generate the necessary heat. The equipment required in the fuel system depends on the type of fuel used in the system.

The water supplied to the boiler that is converted into steam is called feed water. The two sources of feed water are:

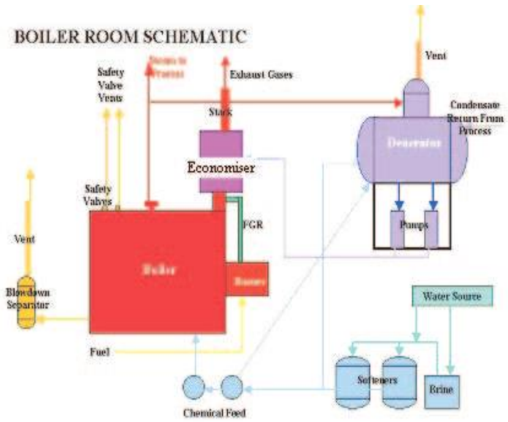

Figure 3.1 BoilerRoomSchematic

(1) Condensate or condensed steam returned from the processes. and

(2) Make up water which must come from outside the boiler room and plant processes. For higher boiler efficiencies, the feed water is preheated by economizer, using the waste heating the flue gas.

BOILER TYPES AND CLASSIFICATIONS

Parameter	Lignite (Dry Basis)	Indian Coal	Indonesian Coal	South African Coal
GCV(kJ/kg)	1882*	16743	23023	25116

Boilers are generally divided into two categories:

Fire tube or "fire in tube "boilers; contain long steel tubes through which the hot gasses from a furnace pass in side this tubes and around which the water to be converted to steam circulates. The Heat is transferred in this type of boiler is conduction mode between hot gases and metal of the tube which is contact with surrounding water and transfer the heat and change the phase of the water into steam. Fire tube boilers, typically have a lower initial cost, are more fuel efficient & easier to operate, but they are limited generally to capacities of 25 Tons/hr &pressures of 17.5 bar.

Water tube or" water in tube" boilers in which the conditions are reversed with the water passing through the tubes and the hot gasses passing outside the tubes. These boilers can be of single or multiple drum type. These boilers can be built to any steam capacities and pressures, and have higher efficiencies than fire tube boilers.

PROPERTIES OF COAL

A good coal should have the following properties:

- Low ash content.
- High caloric value.
- Small percentage of sulphur (< 1%).
- Good burning characteristics.
- High grind ability index for pulverizing purposes.

Physical Properties of coal.

Heating Value

The heating value of coal varies from coal field to coal field. The typical GCVs for various coals are given in the Table 3.1.

*GCV of ligniteon'as received basis's 10465– 12558

Analysis of Coal

There are two methods: Ultimate analysis and proximate analysis. The ultimate analysis determines all coal component elements, solid or gaseous and the proximate analysis deter- mines only the fixed carbon, volatile matter, moisture and ash percentages.

The ultimate analysis is determined in a properly equipped laboratory by a skilled chemist, while proximate analysis can be determined with a simple apparatus.

Proximate Analysis

Proximate analysis indicates the percentage by weight of the Fixed Carbon, Volatiles, Ash ,and Moisture Contenting coal. The amounts of fixed carbon and volatile combustible matter directly contribute to the heating value of coal. Fixed carbon acts a sambaing heat generator during burning. High volatile matter content indicates easy ignition of fuel. The ash content is important in the design of the furnace grate, combustion volume, pollution control equipment & ash handling systems of a furnace. A typical proximate analysis of various coals is given in

TABLE 3.2: TYPICAL PROXIMATEAN ALYSIS OF VARIOUS COALS (INPERCENTAGE)

Parameter	**Indian Coal**	**Indonesian Coal**	**South African Coal**
Moisture	5.98	9.42	8.4

Ash	38.63	13.98	16
Volatile matter	20.70	29.78	23.27
Fixed Carbon	34.69	46.78	51.21

Typical ultimate analyses of various coals are given in the Table.

TABLE 3.3: TYPICAL ULTIMATEAN ALYSIS OF COALS

Parameter	**Indian Coal,%**	**Indonesian Coal,%**
Moisture	5.9	9.42
MineralMatter(1.1×Ash)	38.63	13.98
Carbon	41.11	58.95
Hydrogen	2.76	4.15
Nitrogen	1.22	1.01
Sulphur	0.41	0.55
Oxygen	9.89	11.87

Conversion relation for Ultimate analysis to Proximate Analysis

TABLE3.4: RELATIONSHIP BETWEEN ULTIMATE ANALYSIS AND PROXIMATE ANALYSIS

	%C	=	0.97C+0.7(VM-0.1A)–M(0.6–0.01M)
	%H	=	0.036C+0.086(VM–0.1xA)-0.0035M2 (1–0.02M)
	%N2	=	2.10 –0.020VM
Where	C	=	%of fixed carbon
	A	=	%of ash
	VM	=	%of volatile matter
	M	=	%of moisture

Note: The above equation is valid for coal containing grater than 15% Moisture content.

The proximate and ultimate analysis of various coals.

TABLE 3.5: PROXIMATEANALYSISOFTYPICALCOAL

	Lignite	**Bituminous coal (Sample)**	**Bituminous Coal (Sample II)**	**Indonesian Coal**
Moisture(%)	50	5.98	4.39	9.43
Ash(%)	10.41*	38.65	47.86	13.99
Volatilematter(%)	47.76*	20.70	17.97	29.79
Fixedcarbon(%)	41.83*	34.69	29.78	46.79

*DryBasis

TABLE 3.6: ULTIMATEANALYSISOFVARIOUSCOALS

	Bituminous Coal (Sample I)	**Bituminous Coal (Sample II)**	**Indonesian Coal**
Moisture(%)	5.98	4.38	9.42
Mineralmatter(%)	38.63	47.85	13.98
Carbon(%)	42.11	36.21	58.95
Hydrogen(%)	2.76	2.63	4.15
Nitrogen(%)	1.22	1.08	1.01
Sulphur(%)	0.41	0.54	0.55
Oxygen(%)	9.89	7.24	11.87
GCV(kCal/kg)	4000	3501	5501

IV. METHODOLOGY

ENERGY ANALYSIS

An Energy analysis is carried out for a Boiler in captive power plant of "NILKANTH CONCAST PVT LTD, ANJAR." The analysis is carried out on full load condition. The analysis of this power and steam generating plant is important for the proper functioning of the plant. Here 1st law as well as 2nd law analysis of Boiler plant has been presented. All the necessary data for the calculation are taken from control room and plant.

ENERGY ANALYSIS

The energy analysis of a boiler plant is carried out in order to calculate energy losses and energy distribution in the system. For this law of conservation of mass and energy are applied to each control volume of the system. The boiler is selected as one of the primary control volume.

Basically Boiler efficiency can be tested by the following methods:

- **The Direct Method:** Where the energy gain of the working fluid (water and steam) is compared with the energy content of the boiler fuel.
- **The Indirect Method:** Where the efficiency is the difference between the losses and the energy input.

The Direct Method Testing

The Direct method is old method and is considered as a standard. 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. This efficiency can be evaluated using the formula:

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

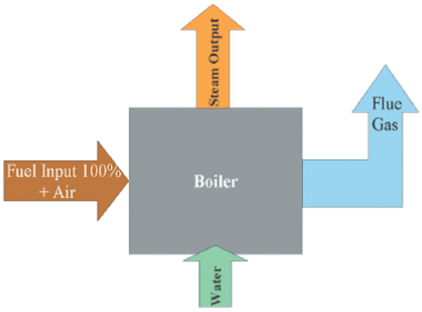

Figure 4.1 Direct Method Testing

$$Efficiency = \frac{Heat\ addition\ to\ Steam \times 100}{Gross\ Heat\ in\ Fuel}$$

$$Boiler\ Efficiency = \frac{\text{Steam flow rate x (steam enthalpy – feed water enthalpy)}}{\text{Fuel firing rate x Gross calorific value}} \times 100$$

Parameters to be monitored for the calculation of boiler efficiency by direct method are:

- Quantity of steam generated per hour (Q) in kg/hr.
- Quantity of fuel used per hour (q) in kg/hr.
- The working pressure (in bar) and superheat temperature (K), if any
- The temperature of feed water (K)
- Type of fuel & gross calorific value of the fuel (GCV) in kJ/kg of fuel

$$Boiler\ Efficiency\ (\eta) = \frac{Q\,x\,(h_g - h_f)}{q \times GCV} \times 100$$

Where,

hg – Enthalpy of saturated steam in kJ/kg of steam

hf – Enthalpy of feed water in kJ/kg of water

Merits and Demerits of Direct Method

Merits

- Plant people can evaluate quickly the efficiency of boilers
- Requires few parameters for computation
- Needs few instruments for monitoring

Demerits

- Does not give clues to the operator as to why efficiency of system is lower
- Does not calculate various losses accountable for various efficiency levels
- Evaporation ratio and efficiency may mislead, if the steam is highly wet due to water carryover

Boiler Efficiency by Indirect Method: Sample Calculation Procedure and Formula for Indian coal:

In order to calculate the boiler efficiency in direct method, all the losses that occur in the boiler must be established. These losses are conveniently related to the amount of fuel burnt. In this way it is easy to compare the performance of various boilers with different ratings. Now, from the Annexure II. The Proximate Analysis of the fuel is given and its converts in to Ultimate Analysis as following relation given in formula.

Conversion formula for proximate analysis to ultimate analysis

	%C	=	0.97C+0.7(VM+0.1A)–M(0.6-0.01M)
	$\%H_2$	=	$0.036C+0.086(VM–0.1xA)-0.0035M^2(1-0.02M)$
	$\%N_2$	=	2.10- 0.020VM
Where	C	=	%of fixed carbon
	A	=	%of ash
	VM	=	%of volatile matter
	M	=	%of moisture

Where,

C = %of fixed carbon = 27.46.

A = %of ash = 43.73.

VM = %of volatile matter = 23.10.

M = %of moisture = 12.79.

%C = 0.97C+0.7(VM+0.1A)-M (0.6-0.01M)

= 0.97 x 27.46+0.7(23.10+0.1x43.73)–12.79(0.6-0.01x12.79)

= ***39.82***

%H2 = $0.036C+0.086(VM-0.1xA)-0.0035M^2*(1-0.02M)$

= $0.036*27.46+0.086(23.10-0.1*43.73)-0.0035*(12.79)^2$ (1-0.021*12.79)

= ***2.175.***

%N2 = 2.10- 0.020VM

= 2.10 – 0.020 * 23.10.

= ***1.638.***

Table4.1: Calculation Data of Indian coal

Steam generation rate	=	180 T/hr
Steam pressure	=	98 bar
Steam temperature	=	783 °K
Feed water temperature	=	459 °K

%CO2in Flue gas	=	14
%Co in flue gas	=	0.55
Average flue gas temperature	=	424K
Ambient temperature	=	304K
Humidity in ambient air	=	0.0204kg/kgdryair
Surface temperature of boiler	=	348K
Wind velocity around the boiler	=	3.8m/s
Total surface area of boiler	=	90m2
GCV of Bottom ash	=	2982.52 kJ/kg
GCV of fly ash	=	1894.16kJ/kg
Ratio of bottom ash to fly ash	=	70:30
Fuel Analysis **(in%)**		
Ash content in fuel	=	43.73
Moisture in coal	=	12.79
Carbon content	=	39.82
Hydrogen content	=	2.175
Nitrogen content	=	1.638
Oxygen content	=	9.89
GCV of Coal	=	13995.47kJ/kg

V. RESULT AND DISCUSSION

RESULT AND DISCUSSION ON ENERGY ANALYSIS

The efficiency of the Boiler is calculated after finding out the various losses, which take place in a Boiler. First law analysis shows the efficiency of the Indian coal fired Boiler is 76.54%, 83.03%, 80.60% and 88.20%. This causes loss of 23.46%, 16.97%, 19.40% and 11.80% respectively. In the table gives the energy distribution and losses of various thermodynamic states of Boiler with various fuels used.

By assuming that the plant is operating under full load condition, total fuel energy utilized by every unit is taken as 100 units for reference purpose for the energy analysis of Boiler unit. The energy utilized at different points has been shown as percentage of the energy supplied to every Boiler unit.

In the Sankey Diagrams for Boiler which is gives the graphical representation of the various losses of the energy distribution which is maximum in dry flue gases (stack losses). We can show that in the diagrams 100% energy of fuel supply and at the last 15% to 25% of the energy is losses and then remaining energy is supplied to steam. Show that maximum energy losses in the stack exhausts.

Energy analysis and heat balance has been done as per sample calculation of Indian coal for another fuel like imported coal, 60% imported + 40 % Indian coal and L.S.H.S. oil. The result on energetic efficiency and heat balance is shown in following table.

ENERGY DISTRIBUTION AND LOSSES IN INDIAN COAL FIRED BOILER

Components	Symbol	Quantity In KJ / Kg	Quantity In Units
Heat Input		13995.47	100
Losses in Boiler			
Dry flue gas	L_1	827.11	5.91
Loss due to Hydrogen in fuel	L_2	512.19	3.66
Loss due to Moisture in fuel	L_3	334.46	2.39
Loss due to Moisture in air	L_4	23.77	0.17
Partial combustion of C to CO	L_5	361.04	2.58
Surface heat losses	L_6	64.33	0.46
Loss due to Unburnt in fly ash	L_7	247.68	1.77
Loss due to Unburnt in bottom ash	L_8	912.46	6.52
Total		3283.04	23.46

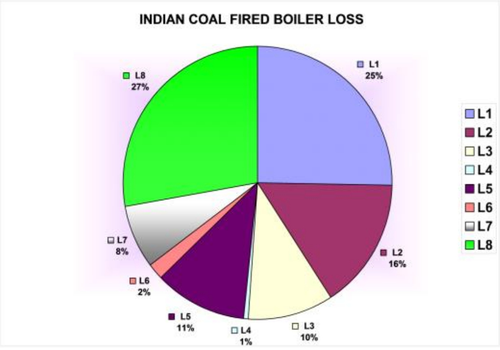

Figure: 5.1 PIE chart for Energy losses in Indian Coal Fired Boiler

ENERGY DISTRIBUTION AND LOSSES IN IMPORTED COAL FIRED BOILER

Components	Symbol	Quantity In KJ / Kg	Quantity In Units
Heat Input		19043.99	100
Losses in Boiler			

Dry flue gas	L_1	987.26	5.58
Loss due to Hydrogen in fuel	L_2	719.82	3.78
Loss due to Moisture in fuel	L_3	289.46	1.52
Loss due to Moisture in air	L_4	30.43	0.16
Partial combustion of C to CO	L_5	460.83	2.42
Surface heat losses	L_6	62.83	0.33
Loss due to Unburnt in fly ash	L_7	129.47	0.68
Loss due to Unburnt in bottom ash	L_8	476.07	2.5
Total		3231.75	16.97

Figure:5.2 PIE chart for Energy losses in Imported Coal Fired Boiler

ENERGY DISTRIBUTION AND LOSSES IN (60% IMP + 40% IND) COAL FIRED BOILER

Components	Symbol	Quantity In KJ / Kg	Quantity In Units
Heat Input		17024.58	100
Losses in Boiler			
Dry flue gas	L_1	995.84	5.85
Loss due to Hydrogen in fuel	L_2	670.76	3.94
Loss due to Moisture in fuel	L_3	306.45	1.80
Loss due to Moisture in air	L_4	28.92	0.17
Partial combustion of C to CO	L_5	432.24	2.54
Surface heat losses	L_6	62.95	0.37
Loss due to Unburnt in fly ash	L_7	171.91	1.01
Loss due to Unburnt in bottom ash	L_8	633.29	3.72
Total		3302.75	19.40

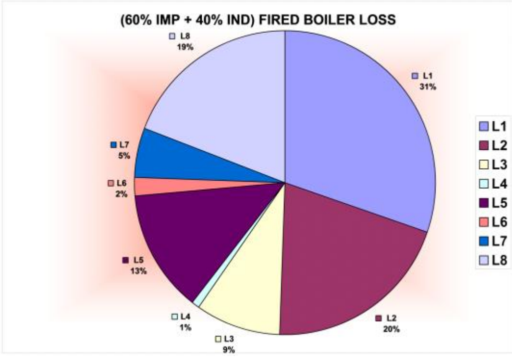

Figure:5.3 PIE chart for Energy losses in (60% Imp + 40% Ind) Coal Fired Boiler

ENERGY DISTRIBUTION AND LOSSES IN LSHS OIL FIRED BOILER

Components	Symbol	Quantity In KJ / Kg	Quantity In Units
Heat Input		44371.60	100
Losses in Boiler			
Dry flue gas	L_1	2342.82	5.28
Loss due to Hydrogen in fuel	L_2	2640.11	5.95
Loss due to Moisture in fuel	L_3	10.63	0.024
Loss due to Moisture in air	L_4	109.58	0.247
Partial combustion of C to CO	L_5	0.00	0
Surface heat losses	L_6	136.21	0.307
Loss due to Unburnt in fly ash	L_7	0.00	1.01
Loss due to Unburnt in bottom ash	L_8	0.00	3.72
Total		5239.23	11.80

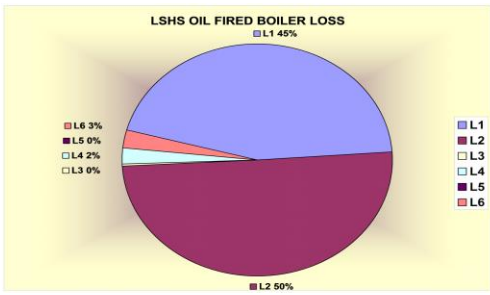

Figure: 5. PIE chart for Energy losses in LSHS OIL Fired Boiler

Efficiency of Various fuel used in Boiler

Fuel	L1	L2	L3	L4	L5	L6	L7	L8	Total	Efficiency
Indian Coal	5.91	3.66	2.39	0.17	2.58	0.46	1.77	6.52	23.46	76.54
Imported Coal	5.58	3.78	1.52	0.16	2.421	0.33	0.68	2.5	16.97	83.03
(60% Imp + 40% Ind) coal	5.85	3.94	1.8	0.17	2.54	0.37	1.01	3.72	19.4	80.60
LSHS Oil	5.28	5.95	0.024	0.247	-	0.307	-	-	11.80	88.20

Figure: Graph between different types of fuel

CONCLUSION

The following conclusions are drawn from the energy analysis of the Boiler plant

- From the energy analysis of the Boiler Plant (Indian coal, imported coal, 60% imp + 40% ind. Coal and L.S.H.S.oil as a fuel), it is seen that the energy analysis attributes all the inefficiencies to losses as 23.46%,16.97%,19.40% and 11.80 respectively.
- In general operating the boiler at proper air – fuel ratio, supplying fuel – air mixture at higher temperature use of suitable combustion catalyst selection of appropriate size of coal, proper insulation, reduction in steam and gland leakages and adoption of absorption cooling to utilize heat of condensing steam may help in improving overall energetic efficiency of the plant.
- From the present exercise, we have obtained the energetic efficiency of various fuels used in boiler; we conclude that imported coal to be used in view of the efficiency.

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