International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

OVERCOMING THE ENERGY LOSSES FROM A BOILER THROUGH CONSERVATION- A CASE STUDY ON ENERGY OPTIMIZATION

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Abstract— the aim of my project is to increase efficiency and decrease the energy losses in the boiler. More has been focused on the major energy devastation areas heat losses which are taking place through the boiler as it accounts for around 6-7 percentage increase in efficiency and to air pre-heater and economizer. The plant in which using biomass fuel (rice peel) my project work is going on. It project work based on the literature review on prevention of energy in boiler furnace. The energy conservation is powerful energy use, different from which refers to using less energy for a invariable service. The short conversancy of general conservation of energy techniques in boilers is presented here. The device on which main focus on condensate pumps feed water pumps, boiler heat exchangers hot water circulating pumps, and boiler draft fans. Some literature attached to the energy audit has been enquiry and presented here. Particular literature based on the past research by different researcher on boilers and its various devices are also talk about here. The limitations and problems with the available literature are identified and listed. A boiler is an enclosed vessel that provides a means for combustion heat to be exchange into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for exchanging the heat to a process. When water is boiled into steam its volume increases about 1500 -1600 times, gunpowder as producing a force that is about as detonative. Water is a useful and cheap medium for exchanging heat to a procedure.

1. INTRODUCTION

An energy audit is a feasibleness study to establish and quantify the cost of various energy inputs to, and flows within, installation or organization over a given period. The overall aim of an energy audit is to identify viable and cost effective energy measures which will bring down operating costs. Energy audit can take a assortment of forms but the process usually involves aggregation data from energy invoices and meters, and undertaking appraises of plants, instrument and buildings, as well as collecting information from under the guides and other staff. An energy audit should be viewed as the foundation on which any energy management program is built.

2. ENERGY AUDIT

The Energy audit comprise following modules for auditing the overall system to take appropriate maintenance determination at the right time which is imperative for controlling the unique energy consumption and hence the operating expense. This border on is based on the latest modular conception, some methods of which are as follows:

A. Preliminary audits:

The Preliminary energy audits are sought to entrenched quantity and cost of each form of energy used in a installation or in an organization. The main procedures involved in such an audit are:

- Collecting data
- Analyzing data
- Presenting data
- Demonstrate priorities and making testimonial.

B. Targeted audits:

The Targeted audits often result from preliminary energy audits. They provide data and detailed analytic on specific targeted projects.

C. Comprehensive audits:

The Comprehensive energy audits involve detailed energy review of plant, device and the fabric of buildings, which is a time overwhelming and expensive process.

Total system audit: It is a total system by a detailed analysis as the total energy data is entered in a master data base in file approach analyses. This contains design data and also the observed data. A difference is made with mention to the base data. This method requires rigorous data entry and analysis.

3. ADVATAGES OF USING ENERGY AUDIT

- Operational improvements from impact can be supervised.
- Corrective action of identifies energy losses.
- Decries the unique energy consumption and operating costs by regular analysis.
- Increase the overall performance of the total system and the gainfulness and productivity.
- Avoid device failure.
- No comprehensive calculations are involved.
- Decries consultancy accuse drastically.

A. Energy wastage in plants:

Energy is wasted in plants because of these main factors:

(i) Poorly design buildings and installations
(ii) Inadequate control systems
(iii) Poor control settings
(iv) Poor operating and working practices

The Energy audit is usually a two step procedure. In the first step process, detailed questionnaires are circulated to accumulate data. Due to the fast depletion of conventional fuels there is increasing demand for using non- conventional sources of energy and use of biomass appear to be an alternative to non-renewable fuels in generating power.

The use of biomass fuels supply substantial benefits as far as the environment is concerned. Carbon dioxide biomass absorbs during growth, and omits it during combustion. The main stream biomass technologies are:

- Thermal conversion of biomass and waste.
- Biomass power for generating electricity by direct combustion or gasification and paralysis.
- Coffering with coal.

For the present work, study has been conducted at Balaji Power Pvt. Ltd, Belsonda, Mahasamund (Chhattisgarh) has two boilers (30 tph and 55 tph) with which steam is generated which in turn is used to produce electricity. The steam generated is also used to manufacturing of iron. Raw material for iron production is manganese, silicon, chromium. Fuel used for combustion in the boiler is rice husk. Energy consumption at 55 tons per hour's boiler is sources and studied of wastage are identified.

4. LITERATURE REVIEW

In this thesis a structural as well as thermal study has been done on a conservation of energy loss between a boiler and decries losses of energy. As mentioned in previous chapter that this type of process is used in many applications like but in this thesis a energy conservation has been considered which is used in fuel boiler of biomass thermal power plant like FBC boiler which are being used by electricity generate.

In research energy analysis on a boiler is done according to the method used by Rosen (1999) and Aljundi (2009). In this paper Saidur et al. [1] studied the useful concept of energy and energy utilization is analyzed, and applied to the boiler system. It has been found that heat transfer and combustor are the main parts that contributed loss of energy and also that the method of heat recovery from flue gas is one of the effective ways to save energy in a boiler.

Kaya et al. [2] has performed the energy efficiency research on a industrial boiler which is mixed-fueled (solid + gas) type. In this study the boiler is operated with different fuels as coal, coke gas, blast furnace gas at a pressure of 70 bar and temperature of 505 C and with a nominal capacity of 100000 kg/hr. The boiler efficiency is obtained by measuring the pressure, velocity working temperature, and combustion gas measurements at boiler operation conditions. To completely avoid air leakage is impossible and there is no model available to calculate wall heat.

This paper published by Dexter et al. [3] investigates the potential for energy saving in heating systems that can be achieved through improving boiler controls. This investigation was carried out through reviews, simulation and experimental research. Twenty-five heating systems in the UK were surveyed and the results show that most of these systems are not operating properly due to the problematic control of boilers, demonstrating a big potential for energy saving.

Kumar T.A., Chandramouli R. et al. [4] studied the energy and energy flow of each component of the system in order to identify the areas of major energy loss. The plant components are grouped under three subsystems. The energy loss in the turbine is estimated to be around 8.3%. The energy efficiency of the boiler system is estimated to be 43.09% with respect to total energy supplied to the plant. The overall energy efficiency of the plant is found to be 29.29%. Therefore the study gives a frame work for the power plants to conduct energy efficiency studies in future.

Sulaiman M.A.,Fadare D.A. et al.[5] conducted energy and energy analysis for a vegetable oil refinery in the Southwest of Nigeria. The plant, powered by two boilers and a 500 kvA generator, refines 100 tons of crude palm kernel oil (CPKO) into edible vegetable oil per day. The production system consists of four main group operations: neutralizer, bleacher, filter, and deodorizer. The suggestion may help the company to reduce its high expenditure on energy and thus increase the profit margin.

According to Mekhilef S. et al. [06] fossil fuels such as oil, coal and natural gas present the prime energy sources in the world. In this review, several aspects which are associated with burning biomass in boilers have been investigated such as composition of biomass, estimating the higher heating value of biomass, and other fuels, combustion of biomass, coffering of biomass and coal, impacts of biomass, economic and social analysis of biomass. It has been found that utilizing biomass in boilers offers many economical, social and environmental benefits such as economical net saving, conservation of fossil fuel resources, job opportunities creation and CO_2 and NO_x emissions reduction.

5. METHODOLOGY

The overcoming energy losses energy optimization estimating energy saving potential of any plant a detailed energy audit has to be conducted

A. Research Design

For our study we will take up descriptive study design as it answers the question what is going on? A good description is a fundamental to the research enterprise and it adds immeasurable of the shape and nature of the society. [10]

- Secondary Phase: - Based on the outcome of the preliminary phase; a detailed questionnaire will be developed to collect data for the research.
- Sampling Technique: - The sampling technique is all these data will help in formulating very comprehensive case study. The methodology which will be used for carrying out the report is as follows:-

Type of Data Sources: For present research work, secondary data will be used.

B. Testing methodology

- The Direct methodology Testing:- This is conjointly called "input-output method" thanks to the fact that it desires solely the helpful output and also the heat input for evaluating the potency. This boiler potency is evaluated development the formula given higher than and also the heat flow within the boiler.

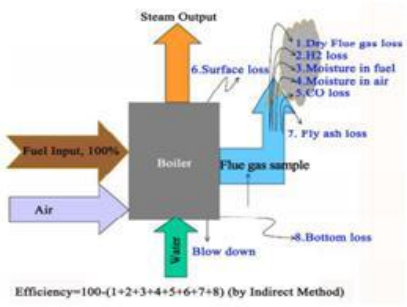

Fig. 1: Heat flow in boiler

Exploitation the method of direct testing is shown within the figure.

The Indirect technique Testing**:** The disadvantages of the direct technique will be overcoming by this technique, which calculates the varied heat losses associated with boiler. The varied losses that had occurred in the boiler are shown within the Figure. The potency can be acquired, by subtracting the warmth loss fractions from a hundred. An important advantage

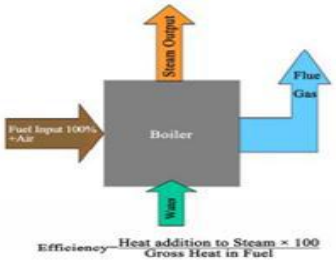

Fig 2: Losses occurring from boiler

of this method is that the errors in measuring don't build significant modification in potency.

C. Instruments used for energy audit

There were different type instruments which were used while carrying out the energy audit process at Balaji Power Pvt. limited located at Belsonda, mahasamund, Chhattisgarh. These include thermometer, flue gas analyzer, laser gun, flow meter, wattmeter and pressure gauge meter. These devices were issued from the laboratories of the university and were very carefully carried to the plant for the work.

- **Flue gas analyzer**

The Flue gas analyzer was used for determining the compactness of the products of combustion going out of the chimney. The products of combustion considered were oxygen, carbon monoxide, carbon dioxide and nitrogen. Fluid efficiency monitor is available in different models. It can either be portable.

- **Laser gun**

Measures surface temperature and it was used to measure the surface temperature of boiler furnace wall, both inlet and outlet surface temperature of economizer air pre-heater, electrostatic precipitator and chimney Invisible thermometers are a subset of instruments known as "thermal radiation thermometers".

Admission losses

Admission losses in practice the flow of steam through nozzle, but accompanied with losses which diminish the kinetic energy of steam coming out of the nozzle.

The diminish in kinetic energy is due to the reasons as follows-

- Heat loss from steam before entering the nozzle.
- Viscous forces between steam particles
- Deflection of flow in the nozzle
- Boundary layer improvement in the nozzle
- Turbulence in the nozzle

Leakage losses:

Leakage losses is steam leaves the boiler and reaches the condenser after passing through the main valve, regulating valves, nozzles, clearance spaces between nozzles and moving blades, diaphragm and rotating shaft etc. Further there is large pressure difference between inside of

steam turbine and the ambient and also from one location to another location across these devices.
Therefore steam leakage takes place through

- Regulating valve and Main valve.
- Glands and Seals.
- Spaces between nozzles and moving blades
- Spaces between diaphragm and shaft of turbine

6. CALCULATION

A. Heat given by fuel

This is the heat which is supplied by the fuel on combustion. The better the caliber of fuel the more heat it will emancipate after burning and the percentage of carbon in ash will be very less. There are other factors by which we can increase the heat given by fuel. Other is by supplying nearly exact amount of air which is required for proper burning of fuel.

Heat given by fuel = m× calorific value of fuel

$$= \frac{30\times100\times100\times13030}{24\times3600}$$

Heat given by fuel = 45243.055 kW
where,
Gross calorific value of fuel in kilo joule per kg = 13030
Number of trucks coming to the plant per day (1 truck = 10 tons) = 30
Quintals of rice husk loaded per truck = 100

B. Loss estimation in flue gas

The loss occurs when the temperature of the flue gases going out of the chimney is very high. This temperature shall be controlled and brought within a specified range so that the efficiency of the boiler can be increased. Furthermore some agreement should be made in such a way that this excess heat which is going out of the chimney can be used.

$hl_{fg} = w_{fg} \times c \times (t_{fg} - t_r)$
$hl_{fg} = 2.1\times1.073\times(125 - 18) = 241.1031$ kW
Where,
hl_{fg} = Heat loss in dry flue gas, kW

W_{fg} = Weight of dry flue gas per kg of fuel fired
C = specific heat of flue gas in kilo joule per kg per °C
t_{fg} = Flue gas temperature entering the chimney °C
t_r = Reference temperature in °C

C. Losses due to moisture

The fuel is kept in open inside the plant as a result it absorbs a small quantity of moisture from the atmosphere. So more heat has to be given to the fuel which leads to the decrease in efficiency Water is formed due to the oxidation of hydrogen present in the fuel into water which is estimated by the following equation.

$h_{wc} = W_c \times L$
$h_{wc} = 0.56 \times 2100 = 1176.28$ kW
where
Wc = Weight of moisture formed in kg per kg of dry fuel
L = Latent heat of vaporization at the dew point of flue gas, kJ/kg
h_{wc} = Heat loss due to water of combustion, kW

D. Losses due to fuel moisture

Moisture present in the fuel is also gone to the atmosphere from the chimney. This is given by the following equation. This loss designates the amount of excess heat given to the fuel due to the moisture present in the fuel. The more good quality the fuel is the less moisture will be present per kg of fuel.

$h_w = W \times L$
$h_w = 0.165 \times 2100 \times 3.42 = 1185.03$ kW
Where
W = Weight of moisture present in kg per kg of dry fuel
L = Latent heat of vaporization at the dew point of flue gas, kJ/kg
h_w = Heat loss due to water present in fuel, kW

E. Blow-down losses

Boiler blow-down is the remotion of water from a boiler. Its purpose is to control boiler water parameters within prescribed limits to minimize scale, corrosion, carryover, and other specific problems. Hence blow-down losses can be estimated by the following relationship. To maintain the hardness of water blow-down is necessary. If the temperature of the blow-down water is more it carries away large amount of useful heat with it.

$h_{bd} = W_{bd} [h_{bw} \times h_{fw}]$
$h_{bd} = 0.067\times (2836.14 - 990.778) = 123.01$ kW
where
h_{bd} = The blow-down of losses in kilo watt
W_{bd} = Blow-down rate in kg per sec
h_{bw} = Enthalpy of boiler water at drum pressure and temperature in kilo joule per kg
h_{fw} = Enthalpy of boiler feed water in kilo joule per kg
$w_f = W_s + W_{bd}$ (w_f = feed water, W_s = steam generated, W_{bd} = blow-down)

F. Radiation losses

Radiation losses is , convention and miscellaneous losses are those losses which are taking place from boiler furnace walls, air pre-heater walls economizer walls, electrostatic precipitator walls, chimney wall etc. These losses can be minimized by proper insulation and proper maintenance of temperature at various places. The radiation losses account for about 2% [8].

Boiler efficiency (by indirect method)

$$\text{Efficiency} = \frac{\text{Heat given by the fuel} - \text{energy losses}}{\text{heat given by the fuel}} \times 100$$

So, efficiency = 64.96%

7. Second law of thermodynamics boiler using Energy analysis:

To have a more accurate idea of the energy analysis of the boiler components, energy analysis has been performed on three boiler components i.e. turbine, air pre-heater, and economizer. The indirect method has been discussed above by which the efficiency of the boiler came out to be 64.96%. The formulas taken for calculating the energy analysis has been taken from the book "engineering thermodynamics" [8].

A. Air Preheater

An air pre-heater (APH) is a general term used to describe any device designed to heat air before another process with the primary objective of increasing the thermal efficiency of the process. As a consequence, the flue gases are also conveyed to the flue gas stack at a lower temperature, allowing simplified design of the conveyance system and the flue gas stack. It also allows control over the temperature of gases leaving the stack.

Ψ_1 = initial energy of the products

$= (h_1 – h_o) – T_o \times (s_1 - s_o)$

$= Cpg \times (Tg1 – T_o) – T_o \times Cpg \times \ln Tg_1/To$

Where;

$Tg_1 = 290$, $T_o = 18$, $Cpg = 1.073$ (from steam table)

$= 1.073 \times (562 – 291) – 291 \times 1.073 \times \ln 562/291$

$= 85.83$ kJ/kg

Ψ_2 = initial energy of the products

$= (h_2 – h_o) – T_o \times (s_2 - s_o)$

$= Cpg \times (T_{g2} – T_o) – T_o \times Cpg \times \ln \frac{Tg2}{To}$

Where;

$Tg_2 = 190$, $T_o = 18$, $Cpg = 1.073$ (from steam table)

$= 1.073 \times (462 – 291) – 291 \times 1.073 \times \ln 462/291$

$= 49.419$ kJ/kg

Decrease in energy of the products

$= \Psi_1 – \Psi_2$

$= 36.411$ kJ/kg

Increase in energy of air

$= m_a \times [(h_2 – h_1) - T_o \times (s_2 - s_1 – R \times \ln P_2/P_1)]$

$= m_a \times Cpa\ (T_{a2} – T_{a1}) – T_o \times (Cpa \times \ln Ta_2/Ta_1 – R \times \ln P_2/P_1)]$

Where;

Ta2 = 142, Ta1 = 18, $T_o = 18$, $Cpa = 1.005$, $P_1 = 811$ mm of WC,

P_2 = 713 mm of WC, $R = 0.274$, $m_a = 11.66$ kg/sec (from steam table)

= 364 kW

The available energy of the air pre-heater can be improved by blowing of the suit get gets accumulated over the air pre-heater tubes. Timely keep up of the air pre-heater plays a very important role in reducing the overall losses of the boiler. Furthermore mass flow rate of the air should also be kept optimum.

B. Economizer -

The economizer is a large duct of the rectangular form in which circular hollow tubes are present. Inside the tubes water is flowing and outside it flue gas is present. The water gains heat from the flue gases which are at a temperature of around 390. The economizer has 25 numbers of tubes. Inside the tubes water at 120 is flowing. The diameter of the tubes which are present within the economizer is 25 mm and the thickness of the tubes is 3.5mm. The economizer is decently insulated which prevents the heat loss from the economizer walls.

Ψ_1 = initial energy of the products

$= (h_1 – ho) – To \times (s_1 - so)$

$= Cpg \times (Tg_1 – To) – To \times Cpg \times \ln Tg_1/To$

(Assume constant velocity of water at inlet and outlet of economizer tubes)

Where;

$Tg_1 = 390$, $To = 18$, $Cpg = 1.073$ (from steam table)

$= 1.073 \times (663 – 291) – 291 \times 1.073 \times \ln 663/291$

$= 142.046$ kJ/kg

$\Psi 2$ = initial energy of the products

$= (h2 – ho) – To \times (s2 - so)$

$= Cpg \times (Tg2 – To) – To \times Cpg \times \ln Tg2/To$

(Assume velocity of water at inlet and outlet of economizer tubes to be constant.)

Where;

$Tg2 = 290$, $To = 18$, $Cpg = 1.073$ (from steam table)

$= 1.073 \times (563 – 291) – 291 \times 1.073 \times \ln 563/291$

$= 85.79$ kJ/kg

Decrease in energy of the products

$= \Psi 1 – \Psi 2$

$= 56.256$ kJ/kg

Increase in energy of water

$= mw \times [(h_2 – h_1) – To \times (s_2 – s1)]$

Where;

$m_w = 15$kg/sec, $h2 = 990.3$ kJ/kg, $h1 = 503.7$ kJ/kg, $To = 18$, $s2 = 2.610$ kJ/kg K,

$s_1 = 1.528$ kJ/kg K (from steam table)

$= 2576.08$ kJ/kg

The available energy of the economizer can be increased by keeping a check on fouling and scaling which happens on the economizer tubes.

C. Turbine

A steam turbine is a instrument that extracts thermal energy from pressurized steam and uses it to do mechanical functioning on a rotating output shaft. The turbine provided at the plant has a capacity of 8.5 MW. An ideal steam turbine is considered to be an isentropic process, or constant entropy process, in which the entropy of the steam entering

the turbine is equal to the entropy of the steam leaving the turbine.

Energy of steam entering the turbine

$\Psi 1 = (h1 - ho) - To \times (s1 - so)$

h_1 = 3416.18 kJ/kg, ho = 75 kJ/kg, To = 18, s1 = 6.83 kJ/kg K, so = 2.67 (from steam table)

= 2130.63 kJ/kg

Energy of steam leaving the turbine

$\Psi_2 = (h_2 - h_o) - T_o \times (s_2 - s_o)$

h_2 = 2905.08 kJ/kg, s_2 = 7.33 kJ/kg K (from steam table)

= 1474.03 kJ/kg

Maximum work per kg of steam entering the turbine

$$W_{rev} = \Psi_1 - \frac{m2}{m1} \times \Psi_2$$

m_2 = 13.8 kg/sec, m_1 = 15 kg/sec

= 774.53 kJ/kg

Irreversibility

$I = T_o \times (w_2 s_2 - w_1 s_1) - Q$

w_1 = 15 kg/sec, w_2 = 13.8 kg/sec, Q = 25 kJ/min (from boiler log sheet)

I = 222.87 kW

E. Fuel used

The fuel used in this boiler is biomass fuel which is rice husk. Rice husk is used because of its easy availability and low cost. The proximate, ultimate analysis and calorific value of the fuel used are shown in the following tables.

Table 7.1 Proximate analysis

S.No.	**Parameters**	**Unit**	**% by weight**
1	Total Moisture	%	53.34
2	Inherent Moisture	%	10.13
3	Ash Content	%	17.6
4	Volatile Matter	%	16.8
5	CO_2 in flue gas	%	14.6
6	O_2 in flue gas	%	5.6
7	Gross Calorific Value	Kcal/kg	2990
8	Fixed carbon	%	8.6

Table7.2 Ultimate analysis

S.No.	**Parameters**	**Unit**	**% by weight**
1	Moisture	%	16.62
2	hydrogen	%	3
3	Ash Content	%	17.6
4	Volatile Matter	%	16.8
5	Nitrogen	%	0.98
6	O_2 in flue gas	%	24.43
7	Gross Calorific Value	Kcal/kg	3100
8	carbon	%	37.6

F. Ash sample analysis

The ash sample from the site was collected and analyzed in the laboratory. It was found that the ash contained 8.6% carbon. The ash sample analysis was carried out in the following way:

Sample I
Crucible weight = 26.592 gm
Weight of crucible + Husk ash = 26.3175 gm
Therefore weight of ash = 0.8225 gm
After complete combustion
Crucible + Pure ash = 25.3325 gm
Pure ash = 0.7392 gm
Percentage ash = 91%
Therefore percentage carbon = 9%
Sample II
Crucible weight = 32.467 gm
Weight of crucible + Husk ash = 33.3475 gm
Therefore weight of ash = 0.8892 gm
After complete combustion
Crucible + Pure ash = 33.3675 gm
Pure ash = 0.8016 gm
Percentage ash = 93%
Therefore percentage carbon = 8%
Average carbon = 8.6%

7. ENERGY SAVINGS

The energy audit discussed in this report is known as "Detailed Energy Audit". This type of audit is the most comprehensive and time-consuming type of energy audit. This includes the use of device to measure the energy use of energy systems within the industry.

A. Explorative audit:

For the explorative audit a walk through review was conducted. On the basis of the information gathered, a detailed questionnaire was prepared and it was circulated to get data. This data helped in finding out highlighted major device, energy costs, and wastages which need detailed study.

The analyzing the information collected through the questionnaire it was observed that at Balaji power pvt. limited use rice husk as a fuel in their boiler which is a biomass fuel. The plant produces steam with the help of which it generates electricity. The surplus electricity is exported to the Chhattisgarh electricity board at a settled price. It was observed that ash coming out of the boiler is black and it has retained even its grain structure. This was a clear indication of incomplete combustion in the boiler.

B. Boiler audit

The boiler used at the plant is fluidized bed combustion boiler. It has got 8.5 MW turbines and 9 MW alternators. The differentiation of induced draught fan are 220 hp and 740 rpm, 1400 rpm and feed pump are 430 hp and 3000rpm, and forced draught fan are 220 hp. Above header is air box in which forced air is sent.

Fuel Savings Analysis

For a fuel saving analysis in power plant we should know the ways to achieve the fuel savings. Waste heat recovery

system is one the economical way to increase the efficiency and fuel savings in boiler industries.

Observations are worth recording:

1. Induced draught and forced draught motors are constant rpm motors. To control the amount and flow of air inside the furnace dampers are provided.
2. Economizer is provided for down out heat from outgoing flue gases. It is used for raising the temperature of feed water from 120°C up to 230°C The color of the ash which is collected in the hoppers or ash collectors was black in color which designate a large percentage of incombustibles.

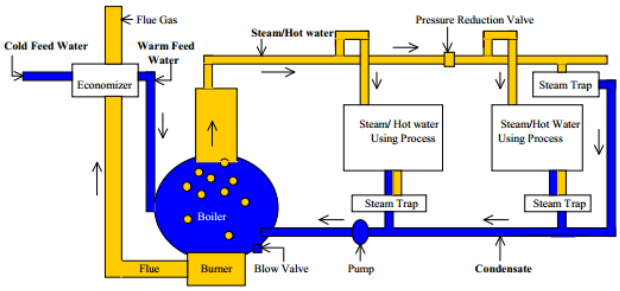

Figure 4.1: Plant Layout

8. Energy audit at Balaji Power Pvt. Limited

A. Boiler leakage (major loss)

Boiler leakage losses are the cause of major energy destruction in an industrySometimes if the plant is shutdown for long period the maintenance cost becomes more than the overall profit. Survey at the plant showed the following results.

(Reports to justify the below five major losses at Balaji power Pvt. Limited, Belsonda, Mahasamund, Chhattisgarh)

Work stopped for seven days
Number of engineers = 4
Daily wage of one engineer = Rs 1000
So, 4 × 1000 = Rs 4,000
Number of helpers = 9
Daily wage of one helper = Rs 500
So, 7× 500 = Rs 3,500
Total = 4000 + 3500 = Rs 7500
For seven days = 7500 × 7 = Rs 52,500
Loss due to stopping of boiler =Rs 31,50,000 per day
For seven days = 33,50,000 × 7 = Rs 23450000
Welding, Sealing and Equipment cost = Rs 10,60,000
Total loss = 1060000 + 23450000 + 52,500 = Rs 24562500

After maintenance same steam production was achieved but with 381 tons of fuel instead of 411 tons of fuel. i.e. 30 tons per day of rice husk will be saved daily.

Cost of 1 ton of rice husk = Rs 4,500
So, 30 × 4500 = Rs 1,35,000 saved per day
Payback period = 182 days

B. Leakage at the entrance of two rice husk feeders

Two rice husk feeders at the company are not operating properly due to which large quantity of rice peel is going waste. If these are removed with the new ones this wastage can be stopped and the steam generation of the plant can be increased. As much as 10 tons of rice husks are wasted per day due to this leakage of rice husk feeders. With the help of the plant engineer the following calculations were carried out.

2 new rice husk feeder
Cost of one rice husk feeder = Rs 13,25,100
2 × 1325100 = Rs 26,50,200

Wastage of rice husk per day due to leakage in the feeders = 10 tons
Cost of 1 ton of rice husk =Rs 4,500
So, 10 × 4500 =Rs 45,000 saved per day
Payback period = 65 days

C. Storage tank

The storage tank No insulation is provided on storage tank. With the passage of time the insulation of the storage tank has come down and rusting has also taken place. The steam saved can be exported to Chhattisgarh state electricity board which will add up to the overall profit of the plant. Moreover if the insulation is provided on the storage tank rice husk consumption will also be decreased.

Dimensions = 2.6 m diameter, 6.1 m high (as per data provided by plant)
Insulation = 2.1 mm thick metal sheet and 9.1 cm thick glass wool (measured)
Insulation cost =Rs 5,75,100 After insulation 19 tons of steam saved per day
1 ton of steam requires = 221.29 kg of rice husk
So, 20 × 221.29 = Rs 4,425.8 kg of rice peel saved per day
Cost of 1 kg of rice husk = Rs 4.4
So, 4425.8 × 4.4 = Rs 19,473.52 saved per day
Payback period = 33 days

9. RESULTS AND SUGGESTIONS

A part from these suggestions there are different other parameters in the plant which needs further study and analysis. After the detailed audit has been conducted the different energy saving potentials were identified. These are being quantified along with the measures to achieve better performance in the following ways.

A. Suggestions for improving boiler efficiency

From the results of the field data and ideal conditions it has been observed that there is substantial scope of savings. The following measures are suggested for improving the efficiency of the boiler.

(1) Controlling excess air

For biomass the ideal excess air is 45-55% which implies about 7.2% oxygen gases and 4.2% carbon residue in ash. For monitoring excess air Fuel Efficiency Monitor (FEM) is required which costs about 0.5 lakh.

(a) Using of Dampers

Use of dampers (manual and mechanical) is a time tested and inexpensive method of controlling the amount of air going into the furnace.

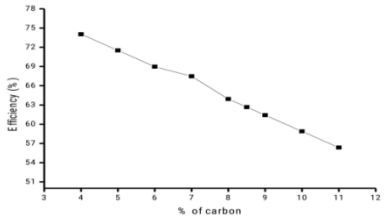

Figure 9.1: Boiler efficiency on Effect of excess air (O_2 in flue gas = 8.7%, carbon percentage = 4.2 to11.2%)

(2) Fluidized bed combustion (FBC)

At used as fluidized bed combustion in power plant. In this plant a simplest furnace is used for burning the rice peel. The flue gases are taken around the boiler before disposing off into the chimney.

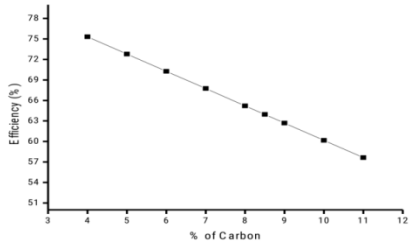

Figure 9.2: Effect of percentage of carbon on boiler efficiency (Carbon percentage = 4.2 to11.2%, flue gas temp. = 125℃)

(3) Using pet coke alternatively of rice husk

1 ton of rice husk produces = 3.2 ton of steam
Steam produced from rice husk = 1297 ton per day
1297 ÷ 3.2 = 398.75 tons of rice husk used daily
Cost of 1 ton of rice husk = Rs 4,300
So, 398.75 × 4300 = Rs 17,97,675.2 per day
Now, pet coke;
1 ton of pet coke produces = 8.6 ton of steam
1297 ÷ 8.6 = 150.8139 tons of pet coke will be used daily to produce same amount of steam.
Cost of 1 ton of pet coke = Rs 8,100
So, 150.8139 × 8100 = Rs 12,21,592.59 per day
Savings = Rs. 17,97,675.2 – 12,21,592.59 = Rs 1,67,55,159.41 per day
Installation cost =Rs 50,00,000
Limestone cost per ton = Rs 4,100
Transportation = same as rice husk
Storage = same as rice husk
Payback period = 1 month

Moreover petcock can be reinvested once i.e. the ash which is produced by burning petcock can be shoot once more in the furnace through two ash inlet points which are made while proper combustion for modifying the furnace.

The authorities have agreed to some of the points mentioned above in the suggestions and had started functioning on them for the improvement of the industry. The overall investment and profit analysis that has been carried out in this whole study has been made given below in the table 9.1.

Table 9.1: Analysis of cost

S.No.	Measure	Investment, Rs	Savings/month, Rs
1	Leakage problem	26,50,110	12,60,100
2	Tank Storage insulation	5,75,100	5,44,180.2
3	Boiler losses	2,29,61,400	37,80,100
4	Fuel feeding	5,00,000	90,000
5	Variable speed drive	5,50,100	1,19,073.94
	Total	2,72,36,710	57,93,454.14

10. CONCLUSION

Energy analysis gives entropy generation, irreversibility percentage energy loss and second law efficiency. The energy loss or irreversibility is supreme at boiler. Thus to know about actual flow of energy in the cycle thermodynamic analysis based on second law is suitable. In the present work a energy analysis of operating condition of boiler has been carried out based on mass and energy balance. It has been found that maximum energy devastation come about due to combustion process. Also there is significant energy destruction occurs in the boiler pressure parts.

(i) Storage tank on a no insulation provided. With the passage of time the insulation of the storage tank has come down and rusting has also taken place. If insulation is provided on storage tank steam used in the desecrator can be saved.

(ii) Two rice peel feeders at the company are not operating properly due to which large quantity of rice husk is going waste. If these are changed with the new ones this wastage can be stopped and the steam generation of the plant can be increased.

(iii) Feeding of rice husk in the vibrating screens at the plant is done manually. If a tractor is used

alternatively of laborers time as well as money can be saved which will overall improve the profit of the factory.

11. FUTURE SCOPE

This thesis report details the methodology for conducting and evaluating energy conservation and audit for a cogeneration plant of 8.5 MW capacities. In future a comparative study can be done among the captive cogeneration plants of analogous capacities with the plants having latest technologies like organic Rankin cycle, ash water rehabilitation, decentralization of compressed air system, high pressure roller mills, etc.

(i) To decries the heat loss through the furnace walls by proper insulation.

(ii) Standard controls should be establish on the boilers which give correct reading on even very small variations so that the boiler operation can be incised losses can be minimized.

(iv) Timely maintenance of the air pre-heater so that air leakage can be forbade and efficiency of the boiler can be improved.

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