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Review Paper on Energy Audit of a Boiler in Thermal Power Plant

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Abstract— The world over energy resources are getting scarcer and increasingly exorbitant with time. In India bridging the ever-widening gap between energy demand and supply by increasing supply is an expensive option. The share of energy costs in total production costs can, therefore improve profit levels in all the industries. This reduction can be achieved by improving the efficiency of industrial operations and equipments. Energy audit plays an important role in identifying energy conservation opportunities in the industrial sector, while they do not provide the final answer to the problem; they do help to identify potential for energy conservation and induces the companies to concentrate their efforts in this area in a focused manner.

Keywords— Thermal Power Plant, Boiler, Boiler efficiency, Audit, Direct Method, Indirect Method, Coal.

INTRODUCTION

About 70% of energy generation capacity is from fossil fuels in India. Coal consumption is 40% of India's total energy consumption which followed by crude oil and natural gas at 24% and 6% respectively. India is dependent on fossil fuel import to fulfill its energy demands. The energy imports are expected to exceed 53% of the India's total energy consumption. In 2009-10, 159.26 million tones of the crude oil is imported which amounts to 80% of its domestic crude oil consumption. The percentage of oil imports are 31% of the country's total imports. The demand of electricity has been hindered by domestic coal shortages. Cause of this, India's coal imports is increased by 18% for electricity generation in 2010.India has one of the world's fastest growing energy markets due to rapid economic expansion. It is expected to be the second largest contributor to the increase in global energy demand by 2035. Energy demand of India is increasing and limited domestic fossil fuel reserves. The country has ambitious plans to expand its renewable energy resources and plans to install the nuclear power industries. India has the world's fifth largest wind power market and plans to add about 20GW of solar power capacity. India increases the contribution of nuclear power to overall electricity generation capacity from 4.2% to 9%. The country has five nuclear reactors under construction. Now, India became third highest in the world who is generating the electricity by nuclear and plans to construct 18 additional nuclear reactors by 2025, then India will become second highest in the world.

M. J. Poddar, Mrs. A.C.Birajdar (2013) [7]:
As per the study carried out by M. J. Poddar and Mrs. A.C.Birajdar, the share of energy costs in total production costs can get improves profit levels in all the industries. It can be achieved by improving the efficiency of industrial operations and equipments. Energy audit plays an important role in identifying energy conservation opportunities in the industrial sector, while they do not provide the final answer to the problem, they do help to identify potential for energy conservation and induces the companies to concentrate their efforts in this area in a focused manner. Energy audit is a vital link in the entire energy management chain. The overall program includes other managerial and operational activities and responsibilities. However, the audit process is the most important part of the program and is essential to the program's implementation. In this project, the study is mainly targeted at identifying, sustainable and economically viable energy cost saving opportunities in boiler section of Unit-III of Parli Thermal Power Station, Parli-Vaijanath. The study shows that, there is a significant cost saving opportunities and recommendations have been made to realize this potential.In the methodology, types of energy audit are provided. Factor affecting the operating efficiency of boiler The factor affecting the operating efficiency of boiler are mentioned, initially the coal where it is available with wider variations in specification, from the designed ones. The effects due to variations are highlighted in this paper. Next major factor is total air quality. With the reduction in total air indicated by percentage increase in carbon dioxide, the stack losses would reduce and air temperature will fall at air heater outlet. The fan power (ID and FD) will decrease, but the unburnt material will increase and also after a certain point unburnt gas may appear leading to increase in loss. The variation in coal characteristics has not much effect on optimum percentage of carbon dioxide, but the variation in load do have effect, primarily because the mixing of the fuel and air is not good.
Typical losses in boiler By using various formulae the losses are evaluated here such as dry flue gas loss, wet flue gas loss including moisture in fuel loss, moisture in combustion air loss. In this way efficiency evaluation of FD, PA & ID fans is done at two different loads i.e. at 185mW and 180mW. The comparative study has been done. From the audit it is concluded that the major reasons for having lower efficiency are poor quality of coal and air leakages. Efficiency of the boiler is increased by 0.27% by reducing air leakage about 6% in air heater.

Moni Kuntal Bora & S. Nakkeeran(2014) [10]:
As per the study carried out by Moni Kuntal Bora & S. Nakkeeran, coal fired Boiler is one of the most important components for any Thermal Power Plant. The prominent Performance parameter of a boiler is "Boiler Efficiency". Boiler Efficiency affects the overall performance of the electricity generation process and as well as plant economy. Boiler efficiency is affected by many factors. It reduces with time, due to various heat losses such as loss due to unburnt carbon in waste, loss due to dry flue gas, loss due to moisture in fuel, loss due to radiation, loss due to blow down, and loss due to burning hydrogen, etc.. Boiler efficiency tests help us to calculate deviations of boiler efficiency from the design value and identify areas for improvement. The current paper puts forward an effective methodology for the efficiency estimation of a coal fired boiler, comparison with its design value and enlists some of the factors that affect the performance of a boiler. This study will help to increase overall boiler efficiency and as a result, annual monetary savings of the thermal power plant.
Basically Boiler efficiency can be tested by the following methods:
A. Direct Method or Input Output Method.
B. Indirect Method or Heat Loss Method.

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.

$$\text{boiler efficiency}, \eta = \frac{\text{heat output}}{\text{heat input}} \text{x} 100\%$$

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.
Valid losses incorporate with to coal fired boiler:

1. Heat loss due to dry flue gas as sensible heat (L1).

2. Heat loss due to moisture in the coal (L2).

3. Heat loss due to moisture from burning of hydrogen in coal (L3).

4. Heat loss due to moisture in air (L4).

5. Heat loss due to formation of carbon Monoxide- partial combustion (L5).

6. Unburnt losses in fly ash as carbon (L6).

7. Unburnt losses in bottom ash as carbon (L7).

8. Loss due to surface radiation and convection (L8).

$$\text{Total loss in \%} = \sum_{i=1}^{8} L_i$$

Boiler efficiency by indirect method:

$$\text{Boiler efficiency, I]} = 100 - (\text{Total loss in \%})$$

Maintenance of boilers:

Effective maintenance can also highlight potential problems quickly and enable corrective action to be taken before there is a major impact on performance. This will improve performance of boilers. Perform regular servicing, analyze flue gas, soot removal, minimize limescale build-up, produce
a maintenance plan, manual and logbook, boiler replacement, these are some ways for the good maintenance of boiler. The feasibility study should examine all implications of long-term fuel availability and business growth plans. All financial and engineering factors should be considered. Since boiler plants traditionally have a useful life of well over 25 years, replacement must be carefully studied.

This paper is convergent on the diverse aspects of the operation of Boiler efficiently. Efficient operation of boiler is likely to play a very big role in following years to come. Industries all over the world are going through increased and powerful competition and increased automation of plants. The suspension cost of such system is expected to be very high. To get away with this challenge, it is clearer by this paper. We have to use the advanced technology and management skills in all spheres of activities to perform its effective role in the turnover of the company.

Mr. Nilesh R. Kumbhar & Mr.Rahul R. Joshi(2013) [9]:
As per the study carried out by Mr. Nilesh R. Kumbhar & Mr.Rahul R. Joshi, growing concerns arise about energy consumption and its adverse environmental impact in recent years in India, which cause manufactures to establish energy management groups. The energy auditing is the key to successful running of an industry with saving energy & contributing toward preserving national recourses of energy. "Managing energy is not a just technical Challenge but one of how to best implement those technical Challenges within economic limits, and with a minimum of disruptions. In this paper importance of energy auditing and process of energy audit is discussed. Energy auditing is an official method of finding out the ECO's. Ii is the official survey / study of the energy consumption / processing / supply aspects related with of industry or organization. Purpose of energy auditing is to recommend steps to be taken by Management for improving the energy efficiency, reduce energy cost and saving the money on the energy bills.
Methods of energy auditing:

Energy audits can be carried outs in different ways. Depending on time span invested auditing can be classified in as:

i) Walk Through Audit

ii) Intermediate Audit

iii) Detailed / Comprehensive Audit

Basic components of every auditing:

The Energy Audit Process starts by collecting information about facilities Operation and its past record of utility bills. This data is then analysed to get Picture of how the Facility uses and possibly wastes energy, as well as to help the auditor learn that areas to examine to reduce energy cost. Specific changes called Energy Conversion Opportunities (ECO) are identified and evaluated to determine their benefits and their cost effectiveness. These ECOs are accessed in terms of their costs & benefits and economic comparison is made to rank various ECOs. Finally an action plan is created whether certain ECOs are selected for implementation and the actual process of energy saving & saving money begins
Auditor's tool box: To obtain the best information from a successful energy cost control program the auditor must make some measurement during audit visit.

Preparation for audit visit: Some preliminary work must be done before the auditor makes actual energy audit.

Conducting the audit: Once the information on energy bills, faculty equipments and facility operations has been obtained, the audit equipment can be gathered up and actual visit is to be started. Following are some important steps in audit Introductory meeting audit team should meet facility manager & maintenance manager to brief about purpose of audit Audit interview getting correct information on facility equipment and operation is important, if the audit is going to most successful in identifying ways to save money on energy bills. Auditor must interview with floor supervisor and equipment operator to understand building and process problems. Walk through audit a walk through tour of facility or plant should be arranged by facility/ plant manager and should be arranged to the auditor or audit team can see major operational and equipment features of facility. Post audit analysis after visit data collected should be examined , organized and reviewed for completeness ant thing missing data items should be obtained from facility of re-visit.

Energy audit report: Next step in energy auditing process is to prepare a report which details the final result and recommendation.

Energy action Plan: The last step in audit process is to recommend an action plan for facility. Energy audit is an effective tool in identifying and perusing a comprehensive energy management program. A care full audit of any type will give the industry a plan with which it can effectively manage the industrial energy system at minimum energy cost. This approach could be useful for an industry in combating essential energy cost and also raps several other benefits like improved production, better quality, higher profit and most important satisfaction of heading towards contributing in world energy saving.

Raviprakash Kurkiya, Sharad Chaudhary(2012) [8]:
As per the study carried out by Raviprakash Kurkiya, Sharad Chaudhary, energy analysis helps designers to find ways to improve the performance of a system in a many way. Most of the conventional energy losses optimization method are iterative in nature and require the interpretation of the designer at each iteration. Typical steady state plant operation conditions were determined based on available trending data and the resulting condition of the operation hours. The energy losses from individual components in the plant is calculated based on these operating conditions to determine the true system losses. In this, first law of thermodynamics analysis was performed to evaluate efficiencies and various energy losses. In addition, variation in the per-centage of carbon in coal content increases the overall efficiency of plant that shows the economic optimization of plant. In boiler, efficiency has a great influence on heating related energy savings. It is therefore important to maximize the heat transfer to the water and minimize the heat losses in the boiler. The thermal power plant is based on a simple Rankine cycle; steam is used as the working fluid, steam generated from saturated liquid water (feed-water). This saturated steam flows through the turbine, where its internal energy is con-verted into mechanical work to run an electricity generating system. Not all the energy from steam can be utilized for run-ning the generating system because of losses due to friction, viscosity, bend-on-blade, heat losses from boilers i.e. hot flue gas losses, radiation losses and blow-down losses etc. Energy analysis of a thermal power plant is reported in this paper. It provides the basis to understand the performance of a fluidized bed coal fired boiler, feed pump, turbine and con-denser. The various energy losses of plant, through different components are calculated which indicates that maximum energy losses occur in turbine.

Following conclusions can be drawn from this study: The coal type affects the first law efficiency of the sys-tem considerably. It has been also analysed that a part of energy loss oc-curs through flue gases. The carbon content in the coal has to be proper. The presence of moisture has a detrimental effect on overall efficiency. If we use the heat recovery system to recover the heat losses through flue gases then it will be more useful for us. With the growing need of the coal, which is an non renewable source of energy and depleting with a very fast pace, it is de-sirable to have such optimal techniques (better quality of coal) which can reduce the energy losses in the coal fired boiler and improves its performance these create impact on production and optimizations uses of energy sources. In addition this study shows the better quality of coal giving the high per-formance of plant and even though the consumption of coal is been reduced that creates economic condition for overall plant.

Shashank Shrivastava, Sandip Kumar, Jeetendra Mohan Khare(2013)
As per the study carried out by Shashank Shrivastava, Sandip Kumar, Jeetendra Mohan Khare, A frequent criticism of energy audits is that they overestimate the savings potential available to the customer. This paper addresses several problem areas which can result in over-optimistic savings projections, and suggests ways to prevent mistakes. Performing an energy and demand balance is the initial step a careful energy analyst should take when starting to evaluate the energy use at a facility. These balances allow one to determine what the largest energy users are in a facility, to find out whether all energy uses have been identified, and to check savings calculations by determining whether more savings have been identified than are actually achievable.
Method description

Detailed energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase

Phase II - Audit Phase

Phase III - Post Audit Phase

Industry-to-industry, the methodology of Energy audits needs to be flexible. Following steps are adopted methodology for detailed energy audit

Step 1 : In this step study of process and energy uses are taken from employees, this understanding helps in planning the resources available and time required for conducting energy audit.

Step 2 : In this step importance of energy uses are discussed with the section officers so that awareness could be build this will also help in future cooperation. (Kick off meeting)

Step 3 : In this step collect the plant data and electric bill find out the more energy uses of area, which are using and work properly for different process and collect name plate review and some data use with the help of measurement device.

Step 4 : In this step measurement are taken with the help of portable instrument such as lux meter, techo meter, power analyzer etc. The energy is mainly being use in pumping and other process for purification of water. This data is compare with operating design data and baseline energy use is determined.

Step 5 : In this step calculation of all performance data (standard parameters) involve in the process is prepared and present performance data is compared with baseline data (design). Based on technology availability and compression, recommendations are proposed to save /conserve energy. These recommendations are as investment grade (payback period). Reduction in energy consumption will take place after implement of recommendations.

Step 6 : In this step flow up the methodology & technical advice on the plant than rapid will be concur best result.

Energy auditing is not an exact science, but a number of opportunities are available for improving the accuracy of the recommendations. Techniques which may be appropriate for small-scale energy audits can introduce significant errors into the analyses for large complex facilities. We began by discussing how to perform an energy and demand balance for a company. This balance is an important step in doing an energy use analysis because it provides a check on the accuracy of some of the assumptions necessary to calculate savings potential. We also addressed several problem areas which can result in over-optimistic savings projections, and suggested ways to prevent mistakes. Finally, several areas where additional research, analysis, and data collection are needed were identified. Once this additional information is obtained, we can all produce better and more accurate energy audit results.

CONCLUSION

From the overall literature review it get concluded that there are so many ways to reduce the energy consumption, energy cost reduction etc. which we are getting from energy auditing . Hence there is a need to prefer energy auditing of every plant once in an year. For the research, it is found that it is also possible to do auditing at different load conditions and by comparison we get the actual consumption as well as wastage.
Hence the energy auditing of a boiler at SLCM captive power plant is decided to do for energy and coal wastage.

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