ENERGY CONSERVATION IN BOILER

A
Thesis

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Master of Engineering (M.E.)

In
Thermal Engineering

Submitted by
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UNDER THE GUIDANCE OF

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CERTIFICATION

I, Kabir Gaurav, declare that this thesis report entitled "***Energy conservation in boiler***", submitted towards fulfillment of the requirements for the award of Master's Degree in Thermal Engineering, in Mechanical Engineering Department of Thapar University, Patiala, is entirely my own work. This document has not been submitted for any degree in any other institution.

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ABSTRACT

The topic of my thesis is energy conservation in boiler. My aim is to reduce the energy losses in the boiler and to increase its efficiency. Also the plant in which my thesis work is going on is using biomass fuel (rice husk).More has been focused on the heat loss which is taking place through the boiler furnance as it accounts for around 8% increase in efficiency and to focus on major exergy destruction areas such as economiser and airpreheater.This study is based on the literature survey of energy conservation in power plant. The brief introduction of general energy conservation techniques in boilers is presented here. The equipments on which main focus is given are feed water pumps, condensate pumps, hot water circulating pumps, boiler draft fans and heat exchangers. Some literature related to the energy audit has been studied and presented here.Specific literature based on the past studies by different researcher on boilers and its various equipments are also discussed here. The problems and limitations with the available literature are identified and listed. The possible scopes of further research that can be done to overcome the limitations of existing research are identified. A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled into steam its volume increases about 1,600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care.

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CHAPTER – 1

INTRODUCTION

An energy audit is a feasibility study to establish and quantify the cost of various energy inputs to, and flows within, a facility or organization over a given period. The overall aim of an energy audit is to identify viable and cost effective energy measures which will reduce operating costs. Energy audit can take a variety of forms but the process usually involves collecting data from energy invoices and meters, and undertaking surveys of plants, equipment and buildings, as well as collecting information from managers and other staff. An energy audit should be viewed as the foundation on which any energy management program is built.

Types of energy audit

Energy audit contains the following modules for auditing the total system to take appropriate maintenance decisions at the right time which is imperative for controlling the specific energy consumption and hence the operating cost. This approach is based on the latest modular concept, some methods of which are as follows:

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

Comprehensive audits**:** Comprehensive audits involve detailed energy surveys of plant, equipment and the fabric of buildings, which is a time consuming and expensive process.

Preliminary audits: Preliminary energy audits seek to establish quantity and cost of each form of energy used in a facility or in an organization. The main processes involved in such an audit are:

(i) Collecting data

(ii) Analyzing data

(iii) Presenting data

(iv) Establishing priorities and making recommendations

Walk through audit:This method is used for identifying the overall energy performance of the industry by actually visiting the plant and getting certain chosen observations. This approach uses certain thumb rules for various energy consuming equipment and estimates the order of magnitude on energy consumption without involving rigorous estimates or calculations.

Total system audit:This approach analyses the total system by a detailed analysis as the total energy data is entered in a master data base file. This contains design data and also the observed data. A comparison is made with reference to the base data. This approach gives the energy performance of the total system and identifies areas of improvement on energy cost or energy quantity basis. This method requires rigorous data entry and analysis.

Steam system audit:This approach analyses the total steam system from steam generation/consumption data and makes a steam balance of the total system. It identifies the energy loss due to steam leaks, blow down, efficiency loss etc. This information may be very vital for identifying the performance of various steam consuming equipments like compressor, turbine, ejectors etc.

Electrical system audit:Electrical system also constitutes a major energy centre in process industries. This audit analyses the total electrical system from the electrical power consumption data of each equipment for the observed mechanical load and calculates the efficiency of the system. If the consumption is within acceptable limits, the performance is taken as perfect else the deviation is highlighted for remedial action. This identifies reasons for power losses such as transmission loss, low efficiency etc.

Cooling systems audit:This audit estimates the cooling water system used in cooling towers. The program evaluates the cycles of concentration from the data and analyses the performance and suggests standard methods for improvement. The quality of water and its impact on fouling or corrosion is also identified in this audit for the total system.

Insulation audit:This audit analyse the insulation effectiveness of various sections of the process unit such as steam lines, refractory lined walls, tank insulation etc. for improving the energy efficiency of the total system.

Benefits of using energy audit are:

(i) Identifies energy losses for corrective action.

(ii) Impact of operational improvements can be monitored.

(iii) Reduces the specific energy consumption and operating costs by systematic analysis.

(iv) Improves the overall performance of the total system and the profitability and productivity.

(v) Averts equipment failure.

(vi) Estimates the financial impact on energy consumption projects.

(vii) Serves as a very good self-auditing cum correction system for performance improvement.

(viii) No extensive training/calculations are involved.

(ix) Reduces consultancy charges drastically.

Energy wastage in plants

Energy is wasted in plants because of these main factors:

(i) Poorly design buildings and installations (buildings may be poorly insulated and ventilation ducts may be undersized resulting in high fan power consumption).

(ii) Inadequate control systems (heating systems may be installed without any optimum start control).

(iii) Poor control settings (time clock controllers may be incorrectly set so that buildings are heated when not in use).

(iv) Poor operating and working practises (lights are often left on in buildings when they should be switched off).

Energy audit is usually a two step process. In the first step, detailed questionnaires are circulated to collect data. On the basis of this information, energy costs and wastages are highlighted in major equipments and processes. In the second step, a detailed audit may be conducted lasting upto ten weeks and using a detailed audit instrument kit. Here all the departmental heads have to be informed in advance and their involvement is essential even during the course of work. The involvement and commitment of top management is essential for achieving the final objectives. Energy audit attempts to balance the total energy inputs with its use and serves to identify all the energy streams in the systems and quantifies energy usages according to its discrete function. Energy audit helps in energy cost optimization, pollution control, safety aspects and suggests the methods to improve the operating and maintenance practices of the system.

Energy audit covers the overall process of data collection and carrying out technical and financial analysis to evoluing specific energy management action of each process/power industry comprises a number of energy consuming and generation centres. The specific energy consumption is a function of various parameters. With the passage of time, efficiency of each energy consuming equipment deteriorates, which is conventionally restored back by equipment maintenance and/or replacement. Energy audit identifies the performance of each equipment and compares it with the base case or design conditions and sets priorities by ABC analysis for immediate action. This approach saves valuable resources such as time, money, manpower, and effort and above all improves the productivity of the system as a whole.

In case of macro systems like a vast process industry, it is humanly impossible to know the energy performance of the individual equipment or sub-system. Systematic analysis by energy audit helps industries in taking the right decision at the right time and cost. In competitive situations, the self auditing mechanism is imperative to control the operating cost s effectively which in turn improves the profitability of the enterprise. From the National point of view, this conserves substantial quantity of energy. The methodology adopted by energy audit is very simple. Selected options for such audits are either energy costs or are quantum of energy in kcal, kilo joule, etc. The program can be developed to evaluate the existing system to generate output for immediate action. This helps the decision makers to take corrective actions for reducing energy consumption by adjusting the existing parameters, retrofitting/revamping, maintenance of low efficiency devices, adding new energy consumption schemes etc. Reports generated by such audits can help in taking investment decisions on energy consumption schemes and in prioritizing activities. Energy activity is a critical activity in the developing as well as developed countries owing to constraints in the availability of primary energy resources and the increasing demand for energy from the industrial and non-industrial users.

Energy consumption is a vital parameter that determines the economic growth of any country. It is a proven fact that per capita energy consumption determines the gross net profit of the country and thereby its economic status. Energy cost, which forms the major chunk of operating costs, is one of the controllable parameters that determines the profitability of the industry. In the free economy, many energy inefficient industries will perish on account of competitive edge in product pricing, which is directly related to energy cost and volume of production. With emerging complex technologies, the need for energy control has become crucial. Industries like petroleum refining, petrochemicals, fertilizers and power generation, which consume substantial quantum of energy, warrent effective control for survival. Endless energy inefficiency may result in closure of many units, which unlike in the past are operating in a very competitive environment now.

Biomass based steam power plants use fuels like rice husk, groundnut shell, fire wood, coconut and other agro waste & municipal solid waste (instead of conventional fuels like coal) burnt in biomass fired boiler to generate steam at high pressure. Due to the rapid depletion of conventional fuels there is increasing demand for using renewable sources of energy and use of biomass seems to be an alternative to conventional fuels in generating power. Analysis is done to increase the profit of the industry by saving the fuel and electricity generated. The analysis uses parameters of a working biomass based steam power plant of 55tph capacity. Most of the plants are analyzed and reported in literature are pertaining to either plants of more than 100 MW capacity or it is less than 1MW capacity. Plants of the capacity less than 1 MW are mostly of academic interest and outcome of the reports indicate the total efficiency. As per the recent studies conducted on exergy analysis of plants are either directly coal fired plants or large capacity gas turbine plants. As on today to overcome the fast depletion of fossil fuels and support the renewable energy options for power generation there is a scope for biomass based power plants. Biomass can be used for either direct combustion in the specially designed waste recovery boiler or can be converted into useful syn gas by Thermo chemical gasification.

Biomass fuels potentially include wood wastes (e.g. sawdust, planer shavings, chips, bark, firewood plantations, forestry residues, urban wood wastes), short rotation woody crops (e.g. hybrid poplar), agricultural wastes (e.g. rice hulls, straws, orchard and vineyard prunings, corn stover, out-of-date corn seed), short rotation herbaceous crops (e.g. switchgrass), animal wastes and a host of other materials. Biomass is only an organic petroleum substitute that is renewable. The woody materials tend to be low in nitrogen and ash content, while agricultural materials can have high nitrogen and ash contents. The use of biomass fuels provides substantial benefits as far as the environment is concerned. Biomass absorbs carbon dioxide during growth, and omits it during combustion. The main current biomass technologies are:

1.Thermal conversion of biomass and waste (gasification, pyrolysis, carbonization).
2.Biomass power for generating electricity by direct combustion or gasification and pyrolysis.
3.Cofiring with coal.

Biomass offers important advantages as a combustion feedstock due to the high volatility of the fuel and the high reactivity of both the fuel and the resulting char. However, it should be noticed that in comparison with solid fossil fuels, biomass contains much less carbon and more oxygen and has a low heating value. Also, the chlorine contents of certain biofuels, like straw, can exceed the levels of coal. In combustion applications, biomass has been fired directly, either alone or along with a primary fuel. Some of the biomass technologies have met with limited technical success. The limitations were primarily due to relying on biomass as the sole source of fuel, despite the highly variable properties of biomass. The high moisture and ash contents in biomass fuels can cause ignition and combustion problems. The melting point of the dissolved ash can also be low, which causes fouling and slagging problems. Because of the low heating values, biomass is accompanied by flame stability problems. It is anticipated that blending biomass with higher quality coal will reduce the flame stability problems, as well as minimize corrosion effects. Chlorine, which is found in certain biomass types, such as straw, may affect operation by corrosion. The high chlorine and alkali content of some biomass fuels raise concerns regarding corrosion. Energy conversion and management concern focuses on high temperature corrosion of superheater tubes induced by chlorine on the surface. The amount of biomass available for cofiring is not easily estimated. The total amount of available biomass exceeds 25% of our current coal consumption on an energy basis.

As it is well known, energy production from fossil fuels and their usage cause many environmental problems, such as air, water, and soil pollutions, ocean acidification, habitat destruction, global warming, climate change, sea level rising, and greenhouse effect, etc. According to The International Energy Agency's 2012 edition of Energy Technology Perspectives, recent environmental, economic, and energy security trends demonstrate that major challenges as energy related carbon dioxide (CO_2) emissions are at an outstanding high, the global economy remains in a brittle state, and energy demand continues to increase. Today's energy production systems are typically using gas turbines, steam turbines, internal combustion engines, fuel cells, etc. The share of 40% of world energy demand is met by the pulverized coal-fired steam boilers and rankine cycled steam turbines. The small thermal efficiency increase plays a very important role to reduce fuel consumption in these systems. In addition, the increase of energy efficiency is the key for energy production and environmental security and the competition over energy sources. Steam is the most widely used fluid in rankine cycle. For this reason, it has some desired physical characteristics, such as having high evaporation enthalpy and being easily available. Steam is produced by boilers or waste heat recovery unit by transferring the heat of exhaust gases to the water.

For the present work, study has been conducted at Chandigarh distillers and bottlers limited, banur. Chandigarh distillers and bottlers limited has two boilers (55 tph and 30 tph) with which steam is generated which in turn is used to produce electricity. The steam generated is also used to prepare alcohol. Raw material for alcohol production is molasses and grain. Fuel used for combustion in the boiler is rice husk. Energy consumption at 55 tons per hour boiler is studied and sources of wastage are identified.

CHAPTER - 2

LITERATURE SURVEY

Kaya et al. [1] has performed the energy efficiency study 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,blastfurnance 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 working temperature, pressure, velocity and combustion gas measurements at boiler operation conditions.Sahin et al.(2011) investigated the energy and exergy analysis as reported by Kaya et al.(2014) which applied to the power plant in an Iron and Steel Works Co. and found out that the major energy efficiency losses have been determined as: air leakage at rotary air heaters, operating boilers at high excess air coefficients, heat losses of the surface, and insulation losses. To completely avoid air leakage is impossible and there is no model available to calculate wall heat.

In another study exergy analysis on a boiler is done according to the method used by **Rosen (1999) and Aljundi (2009**). In this paper **Saidur et al. [2]** studied the useful concept of energy and exergy utilization is analyzed, and applied to the boiler system. Energy and exergy flows in a boiler have been shown in this paper. The energy and exergy efficiencies have been determined. In a boiler, the energy and exergy efficiencies are found to be 72.46% and 24.89%, respectively. It has been found that the combustion chamber is the major contributor for exergy destruction followed by heat exchanger of a boiler system. Several energy saving measures such as use of variable speed drive in boiler's fan energy savings and heat recovery from flue gas are applied in reducing a boiler energy use. There are different methods that can be used to reduce boilers energy uses. However in this paper, boiler energy savings using variable speed drive in reducing speed of boiler fan and energy savings by heat recovery from flue gases in a boiler have been considered. It has been found that heat exchanger 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.

In another study done by **Zheng G. et al. [3]** centrifugal heat pump has to be coupled with gas boiler to supply high temperature water in radiator heating system. Regarding to hybrid heating system (HHS), operation strategy has significant impact on its annual energy consumption and cost. In this paper, the optimal operation strategy of the HHS composed of sewage-source centrifugal heat pumps and gas boilers was analyzed. Firstly, the performance models of the system components, including terminal radiator, heat pump, gas boiler and water pump were established respectively. Secondly, with the aim at minimizing the operating cost of the system the optimal operation strategy of the system was analyzed. Finally, the annual operating cost and energy consumption of the HHS were compared with these of coal-fired boiler heating system.

The results indicate that the HHS offers significant reductions in energy consumption (45.2%) and operating cost (13.5%). Therefore, the HHS has a promising application prospect, the results provide reference for scientific operation of the HHS. This paper presents a method for analyzing the optimal operation mode of a HHS. The operation strategy analysis for a HHS can provide simple and reasonable technical support for improving energy efficiency and decreasing operating cost.

This paper published by **Dexter et al. [4]**investigates the potential for energy saving in heating systems that can be achieved through improving boiler controls. This investigation was carried out through surveys, simulation and experimental study. Through the surveys, typical boiler control schemes widely used in current practice were identified. The performance of some systems surveyed was monitored through the survey. The data obtained is used to demonstrate the problems associated with the control of boilers in heating systems. These typical control schemes identified through surveys were studied using a simulator that had been rigorously validated. An experiment was carried out to demonstrate how the overall performance of a heating system could be improved by using a better boiler controller. The result shows that improving boiler controls can lead to up to 20% of energy saving and a significant improvement in thermal comfort. The problems associated with the control of boilers in heating systems has been rarely mentioned in the literature. In practice, the approach to improving the energy efficiency in heating systems has never placed priority on the control of boilers. Therefore a survey was carried out to identify the scope of the problem. 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. [5] studied the energy and exergy flow of each component of the system in order to identify the areas of major exergy loss. The plant components are grouped under three subsystems. The analysis was first made in the subsystems individually and as a whole. From the exergy analysis, it has been found that the boiler system utilises 88.41% of the total energy supplied to the plant and nearly 6.7% of heat supplied is carried away by the exhaust gases. The overall energy efficiency of the plant is found to be 31.15%. It has been nticed that the maximum exergy loss occurs in the furnance combustion chamber i.e. 54.1% of the exergy supplied to Circulating Fluidised Bed. The exergy loss in the turbine is estimated to be around 8.3%. The maximum loss of exergy that occurs in boiler combustion chamber is due to irreversibility of the combustion process. The exergy efficiency of the boiler system is estimated to be 43.09% with respect to total exergy supplied to the plant. The overall exergy efficiency of the plant is found to be 29.29%. Therefore the study gives a frame work for the power plants to conduct exergy efficiency studies in future.

Bakhshesh M.,Vosough A. et al. [6]studied the useful concept of energy and exergy utilization is analyzed, and applied to the boiler system. Energy and exergy flows in a boiler have been shown in this paper. The energy and exergy efficiencies have been determined as well. In a boiler, the energy and exergy efficiencies are found to be 89.21% and 45.48%, respectively. A boiler energy and exergy efficiencies are compared with others work as well. It has been found that the combustion chamber is the major contributor for exergy destruction followed by heat exchanger of a boiler system. Modifications are examined to increase gas-fired steam power plant efficiency by reducing irreversibilities in the steam generator, including decreasing the fraction of excess combustion air, and/or the stack-gas temperature. Overall-plant energy and exergy efficiencies both increase by 0.19%, 0.37% respectively when the fraction of excess combustion air decreases from 0.4 to 0.15, and by 0.84%, 2.3% when the stack-gas temperature decreases from 137°C to 90°C.

Sulaiman M.A.,Fadare D.A. et al.[7]conducted energy and exergy analysis for a vegetable oil refinery in the Southwest of Nigeria. The plant, powered by two boilers and a 500 kVA generator, refines 100 tonnes 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 performance of the plant was evaluated by considering energy and exergy losses of each unit operation of the production process. The energy intensity for processing 100 tonnes of palm kennel oil into edible oil was estimated as 487.04 MJ/tonne with electrical energy accounting for 4.65%, thermal energy, 95.23% and manual energy, 0.12%. The most energy intensive group operation was the deodorizer accounting for 56.26% of the net energy input. The calculated exergy efficiency of the plant is 38.6% with a total exergy loss of 29,919 MJ. Consequently, the exergy analysis revealed that the deodorizer is the most inefficient group operation accounting for 52.41% of the losses in the production processes. Furthermore, a critical look at the different component of the plant revealed that the boilers are the most inefficient units accounting for 69.7% of the overall losses. Other critical points of exergy losses of the plant were also identified. The increase in the total capacity of the plant was suggested in order to reduce the heating load of the boilers. Furthermore, the implementation of appropriate process heat integration can also help to improve the energy efficiency of the system. The suggestion may help the company to reduce its high expenditure on energy and thus improve the profit margin.

Rashidi M.M., Aghagoli A. et al.[8]investigated a steam cycle with double reheat and turbine extraction is presented. Six heaters are used, three of them at high pressure and the other three at low pressure with deaerator. The first and second law analysis for the cycle and optimization of the thermal and exergy efficiencies are investigated. An exergy analysis is performed to guide the thermodynamic improvement for this cycle. The exergy and irreversibility analyses of each component of the cycle are determined. Effects of turbine inlet pressure, boiler exit steam temperature, and condenser pressure on the first and second laws' efficiencies are investigated. Also the best turbine extraction pressure on the first law efficiency is obtained. The results show that the biggest exergy loss occurs in the boiler followed by the turbine. The results also show that the overall thermal efficiency and the second law efficiency decrease as the condenser pressure increases for any fixed outlet boiler temperature, however, they increase as the boiler temperature increases for any condenser pressure. Furthermore, the best values of extraction pressure from high, intermediate, and low pressure turbine which give the maximum first law efficiencies are obtained based on the required heat load corresponding to each exit boiler temperature.

According to **Vuckovic G. D. et al. [9]** exergy analysis is a universal method for evaluating the rational use of energy. It can be applied to any kind of energy conversion system or chemical process. An exergy analysis identifies the location, the magnitude and the causes of thermodynamic inefficiencies and enhances understanding of the energy conversion processes in complex systems. Conventional exergy analyses pinpoint components and processes with high irreversibility. To overcome the limitations of the conventional analyses and to increase our knowledge about a plant, advanced exergy based analyses are developed. These analyses provide additional information about component interactions and reveal the real potential for improvement of each component constituting a system, as well as of the overall system. In this paper, a real industrial plant is analyzed using both conventional and advanced exergy analyses, and exergoeconomic evaluation. Some of the exergy destruction in the plant components is unavoidable and constrained by technological, physical and economic limitations. Calculations related to the total avoidable exergy destruction caused by each component of the plant supplement the outcome of the conventional exergy analysis. Based on the all-reaching analysis, by improving the boiler operation (elimination of approximately 1 MW of avoidable exergy destruction in the steam boiler) the greatest improvement in the efficiency of the overall system can be achieved.

Naik R.J. et al. [10] studied the concept of exergy analysis and said that it provides a mean to evaluate the degradation of energy during a process, the entropy generation, the lost of opportunities to do work and offers an another approach for improvement of power plant performance. This paper present work Biomass based steam power plant (BBSPP) the results of an exergy analysis performed on a 4.5MW steam power plant in Karempudi. The results of the exergy analysis indicate that the boiler produces the highest exergy destruction. Exergetic efficiency is compared with Thermal Efficiency(based on Energy) and it is observed that thermal efficiency of the plant about 18.25% and exergetic efficiency is 16.89%.Biomass Based Steam Power plants use fuels like Rice husk, Groundnut shell, Fire wood, coconut and other Agro waste & Municipal solid waste (instead of conventional fuels like coal) burnt in biomass fired boiler to generate steam at high pressure. Due to the rapid depletion of conventional fuels there is increasing demand for using renewable sources of energy and use of biomass seems to be an alternative to conventional fuels in generating power. The object of this paper is to discuss Rankine Cycle and to introduce exergy analysis of Rankine cycle to enable us to find exergetic efficiency and component-wise losses.

Faaij A. et al. [11]gave an overview of the state of the art of key biomass conversion technologies currently deployed and technologies that may play a key role in the future, including possible linkage to CO2 capture and sequestration technology (CCS). In doing so, special attention is paid to production of bio fuels for the transport sector, because this is likely to become the key emerging market for large scale sustainable biomass use. Although the actual role of bio energy will depend on its competitiveness with fossil fuels and on agricultural policies worldwide, it seems realistic to expect that the current contribution of bio energy of 40–55 EJ per year will increase considerably. A range from 200 to 300 EJ may be observed looking well into this century, making biomass a more important energy supply option than mineral oil today. A key issue for bio energy is that its use should be modernized to fit into a sustainable development path. Especially promising are the production of electricity via advanced conversion concepts (i.e. gasification and state of the art combustion and cofiring) and modern biomass derived fuels like methanol, hydrogen and ethanol from lingocellulosic biomass, which can reach competitive cost levels within 1–2 decades (partly depending on price developments with petroleum). Sugar cane based ethanol production already provides a competitive bio fuel production system in tropical regions and further improvements are possible. Flexible energy systems, in which biomass and fossil fuels can be used in combination, could be the backbone for a low risk, low cost and low carbon emission.

Hupa M. et al. [12] made a comparison between three different types of techniques to predict the bed agglomeration tendency of a FBC (fluidized-bed combustor) was performed. The three techniques were the standard ASTM ash fusion test, a compression strength based sintering test and a lab-scale combustion test. The tests were performed on 10 different types of biomasses. The results showed significant differences in the predicted bed agglomeration temperatures depending on which technique was used. The ASTM standard ash fusion test generally showed 50-500 °C higher temperatures than the sintering tests or the lab-scale FBC combustion tests. The sintering test showed, in five cases, 20-40 °C lower sintering temperatures than what was detected as he bed agglomeration temperature with the lab-scale FBC. In two cases, a significantly lower sintering temperature than the bed agglomeration temperature was detected, and in three cases, a significantly higher sintering temperature was detected than the bed agglomeration temperature. The detailed results and their relevance is discussed here.

Backman R. et al. [13] discussed the in-bed behaviour of ash-forming elements in fluidized bed combustion (FBC) of different biomass fuels was examined by SEM/EDS analysis of samples collected during controlled agglomeration test runs. Eight fuels were chosen for the test. To cover the variations in biomass characteristics and to represent as many combinations of ash-forming elements in biomass fuels as possible, the selection was based on a principal-component analysis of some 300 biomass fuels, with respect to ash-forming elements. The fuels were then combusted in a bench-scale fluidized bed reactor (5 kW), and their specific agglomeration temperatures were determined. Bed samples were collected throughout the tests, and coatings and necks formed were characterized by SEM/ EDS analyses. On the basis of their compositions, the corresponding melting behaviours were determined, using data extracted from phase diagrams. The bench-scale reactor bed samples were finally compared with bed samples collected from biomass-fired full-scale fluidized bed boilers. In all the analyzed samples, the bed particles were coated with a relatively homogeneous ash layer. The compositions of these coatings were most commonly constricted to the ternary system K_2O-CaO-SiO_2. Sulphur and chlorine were further found not to "participate" in the agglomeration mechanism. The estimated melting behaviour of the bed coating generally correlated well with the measured agglomeration temperature, determined in the 5 kW bench-scale fluidized bed reactor. Thus, the results indicate that partial melting of the coating of the bed particles would be directly responsible for the agglomeration.

Baxter L.L. et al. [14] studied the design of new biomass-fired power plants with increased steam temperature raises concerns of high-temperature corrosion. The high potassium and chlorine contents in many biomasses are potentially harmful elements with regard to corrosion. This paper condenses the current knowledge of chlorine-induced, high-temperature corrosion and describes the potential corrosion problems associated with burning biomass fuels either alone or in blends with coal, for electricity production. Chlorine may cause accelerated corrosion resulting in increased oxidation, metal wastage, internal attack, void formations, and loose non-adherent scales. The partial pressure of Hcl in a biomass-derived flue gas, is not high enough to cause severe gasphase corrosion attacks, but may provide scale failure and increased sulfidation of water walls in areas where locally reducing conditions occur due to poor combustion and flame impingement. The most severe corrosion problems in biomass-fired systems are expected to occur due to Cl-rich deposits formed on superheater tubes.

According to **Demirbas A. et al. [15]** biomass is an attractive renewable fuel to supplement coal combustion in utility boilers. Coal cofiring was successful with up to a 20% biomass mix. Results of extensive applications have shown that cofiring of biomass with coal have accomplished the following: (1) increased boiler efficiency, (2) reduced fuel costs and (3) reduced emissions of NOx and fossil CO2. Every ton of biomass cofired directly reduces fossil CO2 emissions by over 1 ton. Woody biomass contains virtually no sulphur, so SO2 emissions are reduced in direct proportion to the coal replacement. Biomass is a regenerable biofuel. When a fossil fuel is replaced by a biofuel, there is a net reduction in CO2 emissions. Biomass can contain considerable alkali and alkaline earth elements and chlorine, which, when mixed with other gas components derived from coal such as sulphur compounds, promotes a different array of vapor and fine particulate deposition in coal fired boilers.

Wooldridge M. et al [16] gave an overview on co-firing of coal with biomass fuels. Here, the term biomass includes organic matter produced as a result of photosynthesis as well as municipal, industrial and animal waste material. Brief summaries of the basic concepts involved in the combustion of coal and biomass fuels are presented. Different classes of co-firing methods are identified. Experimental results for a large variety of fuel blends and conditions are presented. Numerical studies are also discussed. Biomass and coal blend combustion is a promising combustion technology; however, significant development work is required before large-scale implementation can be realized. Issues related to successful implementation of coal biomass blend combustion are identified.

According to **Mekhilef S. et al. [17]** fossil fuels such as oil, coal and natural gas represent the prime energy sources in the world. The expected environmental damages such as the global warming, acid rain and urban smog due to the production of emissions from these sources have tempted the world to try to reduce carbon emissions by 80% and shift towards utilizing a variety of renewable energy resources (RES) which are less environmentally harmful such as solar, wind, biomass etc. in a sustainable way. 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, comparison between biomass and other fuels, combustion of biomass, cofiring 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 financial net saving, conservation of fossil fuel resources, job opportunities creation and CO_2 and NO_x emissions reduction. However, care should be taken to other environmental impacts of biomass such as land and water resources, soil erosion, loss of biodiversity and deforestation. Fouling, marketing, low heating value, storage and collections and handling are all associated problems when burning biomass in boilers.

CHAPTER - 3

METHODOLOGY AND CALCULATIONS

For estimating energy saving potential of any industry a detailed energy audit has to be conducted. For this purpose certain instruments are required with the help of which field data has to be collected. For analyzing this data certain formulations are to be used. Alist of instruments and formulae are required are being complied in this chapter.

3.1 Instruments used for energy audit

There were various instruments which were used while carrying out the energy audit process at Chandigarh distillers and bottlers limited located at Banur. These include thermometer, flue gas analyser, laser gun, flowmeter, wattmeter and pressure gauge meter. These instruments were issued from the laboratories of the university and were very carefully carried to the plant for the work.

3.1.1 Laser gun

Laser gun measures surface temperature and it was used to measure the surface temperature of boiler furnance wall, both inlet and outlet surface temperature of air preheater, economizer, electrostatic precipitator and chimney. The laser gun which was used for the required purpose had a range of 0°Cto 500°C. The laser gun was taken to the plant and the required surface temperatures of various equipments were taken. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined. Infrared thermometers are a subset of devices known as "thermal radiation thermometers".

3.1.2 Flue gas analyser

Flue gas analyser was used for determining the concentration of the products of combustion going out of the chimney. The products of combustion considered were oxygen, carbon monoxide, carbon dioxide and nitrogen. Oxygen was tested to assure proper excess air. Other instruments include fuel efficiency monitor (FEM) which gives percentage oxygenand have a choice of solid, liquid and gaseous fuels. FEM is available in different models. It can either be portable or fixed.

3.1.3Thermometer

A simple thermometer was used to record the ambient temperature at the plant. Ambient temperature at the plant varies during summer and winter season. The process of taking readings was carried out in the month of march and the reference or ambient temperature which came out at that time was 18℃.

3.1.4Other instruments

Wattmeter, flowmeter and pressure gauge meter are some of the other instruments which were required and were taken to the plant to carry out the study.

3.2 Formulae for energy calculations:

The formulae which are being used for the calculation of losses are taken from the book “optimizing energy efficiencies in industry” [25].These are the standard formulas for calculating the various energy losses in the boiler. By minimizing them the efficiency of the boiler can be increased. The formulations given below are although well known but are still being compiled for the sake of convenience.

(1) Heat given by fuel

This is the heat which is supplied by the fuel on combustion. The better the quality of fuel the more heat it will liberate 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. One factor is by spraying the fuel properly inside the furnance so that complete combustion takes place. Other is by supplying nearly exact amount of air which is required for proper burning of fuel.

Heat given by fuel = m × C.V. of fuel = $\frac{30\times100\times100\times13020}{24\times3600}$

Heat given by fuel = 45208.33 kW

where,

Gross calorific value of fuel in kilo joule per kg = 13020

Number of trucks coming to the plant per day (1 truck = 10 tons) = 30

Quintals of rice husk loaded per truck = 100

(2) Loss estimation in flue gas

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

$hl_{fg} = w_{fg} \times c \times (t_{fg} - t_{r})$

$hl_{fg} = 2.1\times 1.073\times(125 - 18) = 837.163$ kW

where

hl_{fg} = Heat loss in dry flue gas, kW

W_{fg} = Weight of dry flue gas per kg of fuel fired

C = Average specific heat of flue gas in kilo joule per kg per ℃

t_{fg} = Flue gas temperature entering the chimney in℃

t_r = Reference temperature in ℃

(3) Losses due to moisture

Water is formed due to the oxidation of hydrogen present in the fuel into water which is estimated by the following equation. 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.

$h_{wc} = W_c \times L$

$h_{wc} = 0.54 \times 2100 \times 3.47 = 3439.98$ kW

where

W_c = Weight of moisture formed in kg per kg of dry fuel

L = Latent heat of vaporisation at the dew point of flue gas, kJ/kg

h_{wc} = Heat loss due to water of combustion, kW

(4) Losses due to fuel moisture

Moisture present in the fuel is also lost to the atmosphere from the chimney. This is given by the following equation. This loss indicates 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.

$h_w = W \times L$

$h_w = 0.166 \times 2100 \times 3.47 = 1209.642$ kW

where

W = Weight of moisture present in kg per kg of dry fuel

L = Latent heat of vaporisation at the dew point of flue gas, kJ/kg

h_w = Heat loss due to water present in fuel, kW

(5) Loss due to incomplete combustion of carbon to carbon monoxide

This loss occurs when sufficient amount of air is not provided to the fuel for combustion. This results in incomplete combustion of the fuel which leads to decrease in the boiler efficiency as well as higher carbon content in ash. Also if the ash is black in color it is a clear indication that incomplete combustion is taking place.

$h_{co} = [\ CO / (CO + CO_2)\ ] \times C \times 5636.7 \times 3.47 \times 4.2$kW

$h_{co} = [\ \frac{0.004}{0.004 + 0.122}\ ] \times 0.375 \times 5636.7 \times 3.47 \times 4.2 = 977.96$ kW

where

CO = Volume % of carbon monoxide in flue gas

CO_2 = Volume % of carbon dioxide in flue gas

C = Carbon content in fuel in kg per kg fuel

h_{co} = Heat loss due to incomplete combustion, kW

(6) Loss due to presence of combustibles in refuse

Some quantity of energy is also lost due to the presence of combustibles in the refuse in case of solid fuels and soot in case of other fuels. This can be calculated by the following equation. Due to the accumulation of soot on the boiler tubes the heat transfer rate is reduced due to which boiler efficiency decreases.

$h_{rf} = W_c \times 7837 \times 4.2 \times 3.47$

$h_{rf} = 0.085 \times 7837 \times 4.2 \times 3.47 = 9708.39$ kW

where

W_c = Weight of carbon in the refuse in kg per kg of fuel

h_{rf} = Heat loss due to presence of carbon in refuse, kW

(7) Blow-down losses

Boiler blow-down is the removal 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. Blow-down is also used to remove suspended solids present in the system.In normal boiler operation the steam generated is less than the boiler feed water quantity, the difference being due to blow-down. 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.

$h_{bd} = W_{bd} \times [\ h_{bw} \times h_{fw}\ ]$

$h_{bd} = 0.066 \times (2836.17 - 990.877) = 123.01$ kW

where

h_{bd} = Loss in kilo watt due to blow-down

W_{bd} = Blow-down rate in kg per sec

h_{bw} = Enthalpy of boiler water in kilo joule per kg at drum pressure and temperature

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)

(8) Radiation losses

Radiation, convention and miscellaneous losses are those losses which are taking place from boiler furnance walls, economizer walls, air preheater 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%[25].

(9) Boiler efficiency (by indirect method)

$$\text{Efficiency} = \frac{\text{Heat given by fuel} - \text{Losses}}{\text{Heat given by fuel}} \times 100$$

So, efficiency = 63.95%

3.3 Exergy analysis of boiler using second law of thermodynamics

To have a more accurate idea of the exergy analysis of the boiler components, exergy analysis has been performed on three boiler components i.e. air preheater, economizer and turbine. The indirect method has been discussed above by which the efficiency of the boiler came out to be 63.95%. The reason for using indirect method here is that it is more accurate and precise method of calculating the boiler efficiency than the direct method. The formulas taken for calculating the exergy analysis has been taken from the book "engineering thermodynamics" [25].

1) Air Preheater

An air preheater (APH) is a general term used to describe any device designed to heat air before another process (e.g. combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process. They may be used alone or to replace a recuperative heat system or to replace a steam coil. In particular, this article describes the combustion air preheaters used in large boilers found in thermal power stations producing electric power from e.g. fossil fuels, biomass or waste. The purpose of the air preheater is to recover the heat from the boiler flue gas which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gas. As a consequence, the flue gases are also conveyed to the flue gas stack (or chimney) 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 (to meet emissions regulations).

Ψ_1 = initial exergy of the products

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

$= C_{pg} \times (T_{g1} - T_o) - T_o \times C_{pg} \times \ln T_{g1}/T_o$

where; $T_{g1} = 290℃$, $T_o = 18$ ℃, $C_{pg} = 1.073$ (from steam table)

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

$= 85.79$ kJ/kg

Ψ_2 = initial exergy of the products

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

$= C_{pg} \times (T_{g2} - T_o) - T_o \times C_{pg} \times \ln T_{g2}/T_o$

where; $T_{g2} = 190℃$, $T_o = 18$ ℃, $C_{pg} = 1.073$ (from steam table)

$= 1.073\times(463 - 291) - 291\times1.073\times\ln 463/291$

$= 49.416$ kJ/kg

Decrease in exergy of the products

$= \Psi_1 - \Psi_2$

$= 35.3$ kJ/kg

Increase in exergy of air

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

$= m_a\times [C_{pa}\times(T_{a2} - T_{a1}) - T_o\times(C_{pa} \times \ln T_{a2}/T_{a1} - R\times\ln\times P_2/P_1)]$

where; $T_{a2} = 142$℃, $T_{a1} = 18$℃, $T_o = 18$ ℃, $C_{pa} = 1.005$, $P_1 = 811$mm of WC,

$P_2 = 713$ mm of WC, R = .274, $m_a = 11.66$ kg/sec (from steam table)

= 364 kW

The available energy of the air preheater can be increased by blowing of the suit get gets accumulated over the air preheater tubes. Timely maintenance of the air preheater plays a very important role in reducing the overall losses of the boiler. Moreover mass flow rate of the air should also be kept optimum.

2) Economiser

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 flue gas which is formed due to the combustion of fuel goes out of the boiler furnance into the economizer section. The economizer has 25 number of tubes. Inside the tubes water at 120℃ is flowing. The temperature of the water inside the tubes rises from 120℃ to 230℃ before it enters the steam drum. The water gains heat from the flue gases which are at a temperature of around 390℃. The diameter of the tubes which are present inside the economizer is 25 mm and the thickness of the tubes is 3.5mm. The economizer is properly insulated which prevents the heat loss from the economizer walls.

Ψ_1 = initial exergy of the products

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

$= C_{pg}\times(T_{g1} - T_o) - T_o\times C_{pg}\times \ln T_{g1}/T_o$

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

where; T_{g1} = 390℃, T_o = 18 ℃, C_{pg} = 1.073 (from steam table)

= 1.073×(663 – 291) - 291×1.073×ln 663/291

= 142.046 kJ/kg

Ψ_2 = initial exergy of the products

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

= $C_{pg} \times (T_{g2} - T_o) - T_o \times C_{pg} \times \ln T_{g2}/T_o$

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

where; T_{g2} = 290℃, T_o = 18 ℃, C_{pg} = 1.073 (from steam table)

= 1.073×(563 – 291) - 291×1.073×ln 563/291

= 85.79 kJ/kg

Decrease in exergy of the products

= $\Psi_1 - \Psi_2$

= 56.256 kJ/kg

Increase in exergy of water

= $m_w \times [(h_2 - h_1) - T_o \times (s_2 - s_1)]$

where; m_w = 15kg/sec, h_2 = 990.3 kJ/kg, h_1 = 503.7 kJ/kg, T_o = 18℃, s_2 = 2.610 kJ/kg K,

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

= 2576.07 kJ/kg

The available energy of the economiser can be increased by keeping a check on fouling and scaling which happens on the economiser tubes. Total Dissolved solids and PH of water should be checked on hourly basis so that the tubes of the economiser do not get corroded which leads to decrease in the heat transfer from flue gas to water.

3) Turbine

A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. The turbine provided at the plant has a capacity of 8.25 MW. Non-condensing or back pressure turbines are most widely used for process steam applications. The exhaust pressure is controlled by a regulating valve to suit the needs of the process steam pressure. These are commonly found at refineries, district heating units, pulp and paper plants, and desalination facilities where large amounts of low pressure process steam are needed. 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

Exergy of steam entering the turbine

$\Psi_1 = (h_1 - h_o) - T_o \times (s_1 - s_o)$

h_1 = 3416.18 kJ/kg, h_o = 75 kJ/kg, T_o = 18℃, s_1 = 6.83 kJ/kg K, s_o = 2.67 (from steam table)

= 2130.62 kJ/kg

Exergy 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)

= 1474.02 kJ/kg

Maximum work per kg of steam entering the turbine

$W_{rev} = \Psi_1 - m_2/m_1 \times \Psi_2$

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

= 774.52 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 = 222.86 kW

3.4 Electrical section

The formulae which are being used for the electrical section analysis are noted down from the factory standard log book. For more accuracy these formulas were counter checked from research paper "energy audit and energy saving measures in pulp and paper mills" published by Amandeep Gupta. With the help of below formulae we can calculate exact potential of savings in any industry. Only a few of these are used for the present work done to increase the efficiency of the boiler and to carry out energy audit in the plant.

3.3.1 Formulae for load analysis

(a) $E = K_h \times P_t \times C_t \times n$

where,

E = electric energy used in period P in kWh

K_h = meter constant, kWh per revolution

P_t = Potential transformer ratio

C_t = Current transformer ratio

n = number of revolutions of meter disk

(b) $L = \frac{E}{P}$

where,

L = average load in kW

E = electric energy used in period p in kWh

P = period of time used to determine load demand, electricity

use (normally one hour, day, month, or year measured in hours)

(c) $DV = \frac{Dm1+Dm2+Dm3+\cdots\ldots\ldots}{Dmax}$

where,

DV = diversity factor

D_{max} = maximum demand inperiod p in kW

D_{m1}; D_{m2}; D_{m3};etc = maximum demand of individual loads in kW

(d) $D = \frac{E}{P}$ and $D_{max} = \frac{Emax}{P}$

where,

D = demand in period P in kW

E_{max} = maximum energy used during period P in kW

E = electric energy used in period P in kWh

(e) DF = $\frac{\text{Dmax}}{C.L.}$

where,

DF= demand factor for period P in hours

CL = connected load in kW

(f) HUOD = $\frac{E}{\text{Dmax}}$

where,

HUOD = hours use of demand during period P in hours

E = electric energy used in period P in kWh

(g) LF = $\frac{E}{\text{Dmax (p)}} = \frac{HUOD}{P} = \frac{L}{\text{Dmax}}$

where,

LF = Load factor during period P

3.3.2 Transformers

(a) Transformer capacity

Capacity of transformer ≥ combined max load

Or ≥ $\frac{TotalSumofAmountingLoadXDemandFactor}{DiversityFactor}$

(b) Transformer losses

Loss of Transformer = Capacity of transformer in kVA×(1-efficiency)

= iron loss + copper loss

Note :

(i) Iron losses are constant as long as supply voltage is constant.

(ii) Copper losses are proportional to the required of load current.

(iii) At full load iron loss to copper loss is 1:4.

(c) Energy saving by improving power factor.

Annual saving in power in kWh = $P \times (1\text{-}n) \times 0.8\ ((L_2/P\text{-}L_1/P)) \times h$

where,

P= output capacity of transformer in KVA

η = efficiency of transformer

0.8 = copper loss factor

L1 = load after improving the power factor in KVA

L2 = load before improving the power factor in KVA

h = working hours per year

3.3.3 Motors

(a) Load and motor losses

Loss per year in kWh = $((0.44 \times I) + (0.56 \times I) \times (P_1/P)^2)) \times h$

where,

I= loss of motor at full load in kW

= P (1- n)

P = rating of input power of motor in kW

= rating of output power of motor divided by n

ɳ = efficiency of motor at full load

P = input power of motor in kW

Iron loss factor of motor = 0.44

Copper loss factor of motor = 0.56

h = working hours per year

(b) Energy saving by changing motor

(i) Based on efficiency of motors

Loss per year in kWh = $L \times (1/n_1 - 1/n_2) \times h$

where,

L = load on motor in kW

N_1 = efficiency of existing motor

N_2 = efficiency of changed motor

h =working hours per year

(ii) Based on iron loss and copper loss

Losses of existing motor in kW, $L_1 = 0.44 \times I_1 + 0.56 \times I_1 (i_1/I_1)^2$

Losses per year in kWh = $L_1 - L_2 \times h$

Losses of changed motor in kW, $FlF_2 = 0.44 \times I_2 + 0.56 \times I_1 (i_1/I_2)^2$

Losses of existing motor in kW, $L_1 = 0.44 \times I_1 + 0.56 \times i_1 (i_1/I_1)^2$

Losses of existing motor in kW, $L_2 = 0.44 \times I_2 + 0.56 \times I_2 (i_2/I_2)^2$

where,

I_1 = loss of existing motor at full load in kW

I_2 = loss of changed motor at full load in kW

i_1 = corresponding current of load on existing motor in ampere

i_2 = corresponding current of load on changed motor in ampere

I_1= rating current of existing motor in ampere

I_2 = rating current of changed motor in ampere

3.5Fuel 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 3.1: Proximate analysis

S.No.	**Composition**	**% by weight**
1	Fixed Carbon	8.50
2	Moisture	16.60
3	Volatile Matter	57.40
4	Ash	17.50

After having done the proximate analysis of the fuel, the ultimate analysis of the fuel was done and the following readings were taken. The rice husk sample was taken from the plant and was carried to the university laboratory where the ultimate analysis of the sample was carried out. With the help of the ultimate analysis the composition of the fuel i.e. carbon, oxygen, nitrogen etc. was determined. The moisture and ash content of the fuel was found out to be quite high because of which the factory is planning to change the fuel to petcoke whose ash as well as moisture content were found out to be quite lower than rice husk.

Table 3.2: Ultimate analysis

S. No.	**Composition**	**% by Weight**
1.	Carbon	37.50
2	Hydrogen	3
3	Oxygen	24.42
4	Moisture	16.60
5	Sulphur	0
6	Nitrogen	.98
7	Ash	17.50
8	G.C.V(kcal/kg)	3100

3.6 Ash sample analysis

The ash sample from the site was collected and analysed in the laboratory. It was found that the ash contained 8.5% carbon. The analysis was carried out in the following way:

Sample I

Crucible weight = 24.595 gm

Weight of crucible + Husk ash = 25.4176 gm

Therefore weight of ash = .8217 gm

After complete combustion

Crucible + Pure ash = 25.3355 gm

Pure ash = .7396 gm

Percentage ash = 91%

Therefore percentage carbon = 9%

Sample II

Crucible weight = 32.4569 gm

Weight of crucible + Husk ash = 33.3366 gm

Therefore weight of ash = .8797 gm

After complete combustion

Crucible + Pure ash = 33.2575 gm

Pure ash = .8006 gm

Percentage ash = 92%

Therefore percentage carbon = 8%

Average carbon = 8.5%

CHAPTER-4

ESTIMATION OF 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 instruments to measure the energy use of energy systems within the plant. This energy audit process is an organized approach to identify energy waste in the plant and determining how this waste can be eliminated at a reasonable cost with a suitable time frame.

4.1 Preliminary audit

For the preliminary audit a walk through survey 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 energy costs, wastages and highlighted major equipments which need detailed study.

On analyzing the information collected through the questionnaire it was observed that at Chandigarh distillers and bottlers limited use rice husk as a fuel in their boiler which is a biomass fuel. The raw material which is used at the plant for the production of alcohol is molasses. But nowadays due to the coming of modern technologies the sugar present in the molasses is very less for the preparation of alcohol. So the factory has shifted to using grain to prepare alcohol instead of molasses. 340 kilolitres of extra neutral alcohol is prepared every day. 30 trucks full of rice husk arrive at the plant daily. The packing of alcohol in the bottles is done at the plant itself. 50 percent of the bottles are new and 50 percent of the bottles are recycled. Recycled bottles are the ones which are collected from all over the city as waste. These bottles are properly washed and cleaned and then alcohol is filled into them. The plant produces steam with the help of which it generates electricity. The surplus electricity is exported to the Punjab 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.

4.2 Boiler audit

The boiler used at the plant is fluidized bed combustion boiler. It has got 8.25 MW turbine and 9 MW alternator. The specifications of induced draught fan are 220 hp and740 rpm, forced draught fan are 220 hp and 1400 rpm and feed pump are 430 hp and 3000rpm. Above header is air box in which forced air is sent. Nozzles are mounted DB plate which is placed above air box.3600 number of nozzles are mounted on DB plate. The riser tubes are 17 in number and the 4 inches in dia. The diameter of the water wall tubes is 2 inches. In the steam drum 50% is steam and 50% is water. The link tubes are 16 in number. The air preheater duct has got 1200 number of tubes and their diameter is 2 inches. Inside the tubes flue gases are flowing and outside is forced draught air. Three pumps are there to pump water from feed tank to deaereator tank or dome tank but to pump only one is more than sufficient. Rice husk is thrown inside the boiler with the help of screw feeders. Secondary air is used along with it to spread the husk properly in the boiler so that combustion takes place properly inside the furnance. Nozzles are used to cause bubbling in the boiler. The bed of the boiler is filled with sand upto 5cm. Forced draught air is passed through the holes in the nozzles. The feed pressure with which water is pumped inside the furnace by the feed pump is 100 kg/cm^2. The temperature of steam in primary superheater is raised from 350°Cto 450°Cand in secondary superheater is raised from 450°Cto 500°C. The preheater and economizer have a temperature raise of 100°C. All these equipments and auxillaries were selected so that detailed study can be done on them. 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.

4.2.1 Following major observations are worth recording:

1. Forced draught and induced draught motors are constant rpm motors. To control the amount and flow of air inside the furnance dampers are provided.
2. Economizer is provided for extracting heat from outgoing flue gases. It is used for raising the temperature of feed water from 120℃upto 230℃. The color of the ash which is collected in the hoppers or ash collectors was black in color which indicated a large percentage of incombustibles.
3. Whenever the steam requirement rate decreased it caused a rise in boiler pressure. Observing this husk feed rate is decreased but dampers are seldom operated. This causes flying out of unburnt or partially burnt rice husk granular.
4. Significant amount of heat loss in the air preheater because of airleakages which goes unchecked due to lack of operation and poor maintenance of the air preheater.

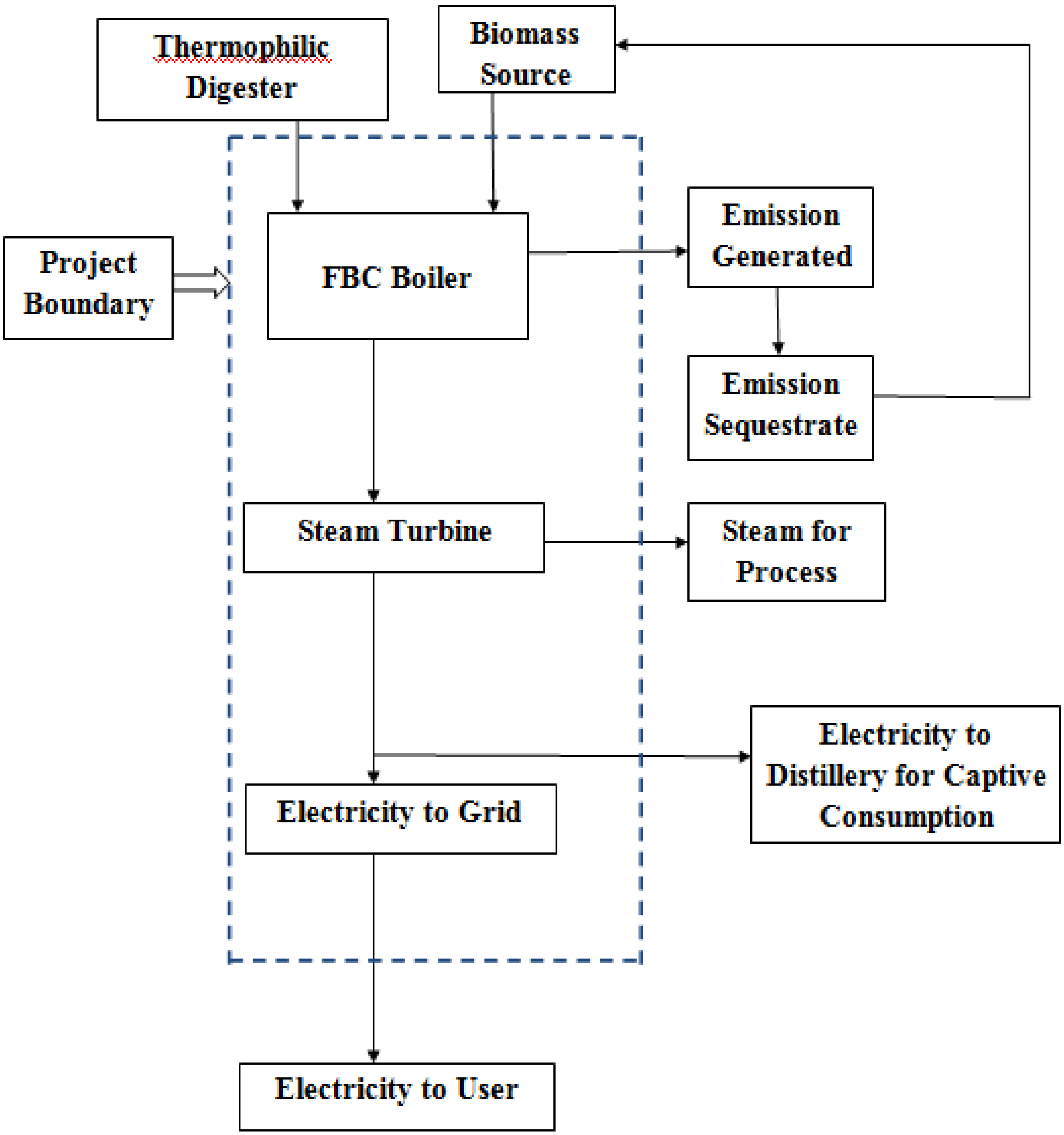

Figure 4.1: Plant Layout

As the aim of this study is to improve the efficiency of the boiler the data and thermophysical parameters of the fluidized bed combustion are used. This boiler is having the following specifications:

Table4.1: Specifications of boiler

Specification	Units	Value
NCR Evaporation (Gross)	tons/hr	42
Peak evaporation (half an hour in a shift)	tons/hr	42
Steam pressure at main steam stop valve outlet	kg/cm^2	66
Steam temperature at main steam stop valve outlet	℃	495
Feedwater temperature at inlet of economizer	℃	130
Steam temperature control range	%	75-100

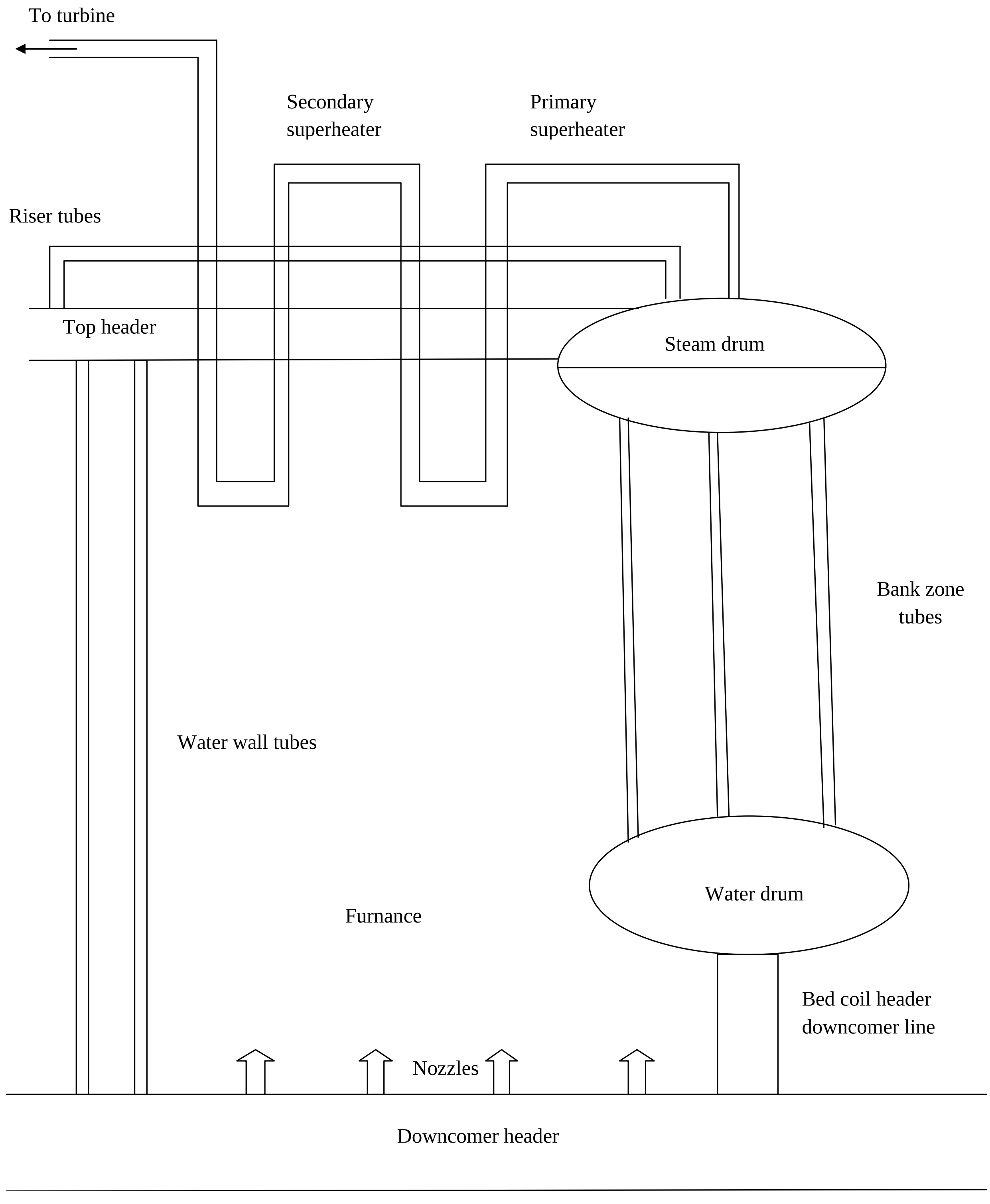

Figure 4.2: Energy flow in boiler

The flue gases which are coming out of the boiler are analysed by using flue gas analyser and the composition of the flue gases obtained are shown in the following table:

Table 4.2: Flue gas analyser results

S. No	Composition	Percentage
1	Carbon dioxide	12.2
2	Carbon monoxide	0.4
3	Oxygen	8.6
4	Nitrogen	78.8

$$\text{Excess air} = \frac{8.6}{21 - 8.6} \times 100$$

Excess air = 69.35%

As per the percentage of oxygen shown by the flue gas analyser, the calculated excess air percentage going along with the flue gases out of the chimney comes out to be 69.35%. To control the amount of excess air in the flue gases variable speed drive motor must be installed. Savings in the electricity consumption by upto 30% of the factory will be witnessed and an increase in the efficiency of the boiler will also be seen. In the theoretical and actual products of combustion going out of the chimney the variation was mainly witnessed in the percentage of CO_2 and O_2 level. In theoretical analysis whole carbon should get converted into carbon dioxide and carbon monoxide should not be formed. Moreover stiochiometric air should be sent inside the furnance so that the percentage of oxygen going out of the chimney should be zero and the same was witnessed in the table 4.3. However in actual practice it is very difficult to obtain the theoretical results. But efforts are constantly made in any power house to minimize the losses and to use the raw material in the best possible manner so that maximum output can be achieved. From the table above the actual composition of the flue gases going out of the chimney is known to us. The analysis of the flue gases if complete combustion takes place are shown in the following table 4.3.

Table 4.3: Theoretical results

S. No.	Composition	% by weight
1	Carbon dioxide	12.9
2	Water	0.4
3	Oxygen	0
4	Nitrogen	82.7

CHAPTER - 5

ENERGY AUDIT

An energy audit is a feasibility study to establish and quantify the cost of various energy inputs to, and flows within, a facility or organization over a given period. The overall aim of an energy audit is to identify viable and cost effective energy measures which will reduce operating costs. Energy audit can take a variety of forms but the process usually involves collecting data from energy invoices and meters, and undertaking surveys of plants, equipment and buildings, as well as collecting information from managers and other staff. An energy audit should be viewed as the foundation on which any energy management program is built.

5.1 Types of energy audit

a) Preliminary audits: Preliminary energy audits seek to establish quantity and cost of each form of energy used in a facility or in an organisation.

b) Comprehensive audits: Comprehensive audits involve detailed energy surveys of plant, equipment and the fabric of buildings, which is a time consuming and expensive process.

c) Targeted audits: Targeted energy audits often result from preliminary audits. They provide data and detailed analysis on specific targeted projects. The main processes involved in such an audit are:

- Collecting data
- Analysing data
- Presenting data
- Establishing priorities and making recommendations

5.2 Energy wastage in plants

Energy is wasted in plants because of these main factors:

- Poorly design buildings and installations(buildings may be poorly insulated and ventilation ducts may be undersized resulting in high fan power consumption).
- Inadequate control systems(heating systems may be installed without any optimum start control).
- Poor control settings(time clock controllers may be incorrectly set so that buildings are heated when not in use).

5.3 Energy audit atChandigarh distillers and bottlers limited

(1) Boiler leakage (major loss)

Boiler leakage losses are the cause of major exergy destruction in an industry. It is caused due to leakages in the boiler. These losses are very difficult to calculate but after having a detailed survey of the plant, one can calculate the approximate cost. If these accounted losses are minimized the efficiency of the boiler can be increased upto 8%. The reason why these losses are commonly ignored in an industry is due to the fact that the industries work on the principle of continuous production and to minimize boiler leakage losses the plant has to be shutdown. Sometimes if the plant is shutdown for longer 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 Chandigarh distillers and bottlers limited has been attached in Appendix: A1)

Work stopped for seven days

Number of engineers = 3

Daily wage of one engineer =Rs 800

So, 3×800 =Rs 2,400

Number of helpers = 7

Daily wage of one helper =Rs 400

So, 7×400 =Rs 2,800

Total = 2400 + 2800 =Rs 5,200

For seven days = 5200 × 7=Rs 36,400

Loss due to stopping of boiler =Rs 31,25,000 per day (Appendix: A1)

For seven days = 3125000× 7 =Rs 2,18,75,000

Welding, Sealing and Equipment cost =Rs 10,50,000

Total loss = 1050000 + 21875000 + 36400 =Rs 2,29,61,400

After maintenance same steam production was achieved but with 380 tons of fuel instead of 410 tons of fuel(as per final report reading attached in Appendix: A1) i.e. 30 tons per day of rice husk will be saved daily.

Cost of 1 ton of rice husk =Rs 4,200

So, 30 × 4200 =Rs 1,26,000 saved per day

Payback period = 183 days

(2) Leakage at the entrance of two rice husk feeders

Two rice husk feeders at the company are not working properly due to which large quantity of rice husk is going waste. If these are replaced 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 husk is 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 13,25,000 (Appendix: A1)

2 ×1325000 =Rs 26,50,000

Wastage of rice husk per day due to leakage in the feeders = 10 tons (as per fuel final report reading attached in Appendix: A1)

Cost of 1 ton of rice husk =Rs 4,200

So, 10× 4200 =Rs 42,000 saved per day

Payback period = 64 days

(3) Storage tank (no insulation)

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. If insulation is provided on storage tank steam used in the deaerator can be saved. The steam saved can be exported to Punjab state electricity board which will add up to the overall profit of the factory. Moreover if the insulation is provided on the storage tank rice husk consumption will also be decreased.

Dimensions = 2.5 m diameter, 6 m high (as per data provided by factory)

Insulation = 9 cm thick glass wool and 2 mm thick metal sheet (measured)

Insulation cost =Rs 5,75,000 (Appendix: A1)

After insulation 19 tons of steam saved per day (as per deaerator final report reading attached in Appendix: A1)

1 ton of steam requires = 222.27 kg of rice husk

So, 19 × 227.27 =Rs 4,318.13 kg of rice husk saved per day

Cost of 1 kg of rice husk =Rs 4.2

So, 4318.13 × 4.2 =Rs 18,136.14 saved per day

Payback period = 32 days (exact)

(4) Variable frequency drive motor

Variable speed drive motor is not working at the factory for the past 5 years which leads to increase in the current load of the plant. Moreover excess air is going in the furnace due to which lot of rice husk is going out of the chimney unburnt. If variable speed drive motor is installed at the plant the efficiency of the boiler can be further increased and the oxygen amount in the flue gases can be controlled. Variable speed drive motor minimizes the electricity consumption of the plant by upto 30 %. (Appendix: A1)

Before installation of variable frequency drive motor

$P = V \times I$

V = 230 volts, I = 399 amperes (from boiler log book)

P = 91.770 kW

FD fan motor wattage before VFD = 91.770 kW

Electricity consumed per day = 91.770×24 = 2202.48 kWh

After installation of variable frequency drive motor

$P = V \times I$

V = 230 volts, I = 279.5 amperes (from boiler log book)

P = 64.239 kW

FD fan motor wattage after VFD = 64.239 kW

Electricity consumed per day = 64.239×24 = 1541.736 kWh

So, electricity saved per day = 2202.48 kWh - 1541.736 kWh

= 660.744 kWh

Cost of 1 kWh exported = Rs 6 (from human resource department of plant)

So, 660.744×6 =Rs 3,964.464 saved per day

For one month =Rs 1,18,933.92 saved per month

Installation cost of VFD =Rs 5,50,000 (as per general manager and power house engineer of factory)

Payback period = 139 days

(5) Feeding is manual

Feeding of rice husk in the vibrating screens at the plant is done manually. If a tractor is used instead of laborers time as well as money can be saved which will overall increase the profit of the company. As the rice husk is kept in open in the plant there will be no problem in feeding the rice husk with the help of a machine.

Daily 10 persons are employed to do the work which a tractor alone can do.

Daily wage of one helper =Rs 400

So, 400×10 =Rs 4,000per day

Diesel cost =Rs 1,000 per day

Profit =Rs 3,000 per day

Tractor cost =Rs 5,00,000 (approx.)

Payback period = 166 days (exact)

5.4 Discussions of results& suggestions

After the detailed audit has been conducted the various energy saving potentials were identified. These are being quantified along with the measures to achieve better performance in the following ways. If these ways are followed the production as well as the overall profit of the plant will definitely increase. Apart from these suggestions there are various other parameters in the plant which needs further study and analysis. For more growth of the industry these parameters are taken into consideration and further analysis should be done on them. Some of these parameters are mentioned for future scope.

5.4.1 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 40-50% which implies about 7% O_2 in the gases and 4% carbon residue in ash. For monitoring excess air Fuel Efficiency Monitor (FEM) is required which costs about 0.5 lakhs. The payback period is about half month. Once we know the excess air we have two options for controlling the excess air.

(a) Use of dampers

Use of dampers (manual and mechanical) is a time tested and cheap method of controlling the amount of air going into the furnace. But as it has been noted that it depends upon the willingness of the operator to operate the dampers these are seldom operated. Certain boiler operators keep a continuous opening of about 50%.

(b)Variable speed motor

If air flow is controlled with the help of damper it will help only in improving the efficiency of the boilers. But if we go for variable aped motors it will result in savings in electric power as well. Saving which will result by controlling excess air to about 50% of stiochiometer air can be as high as Rs. 1,18,933.92/- per month. A graphical representation has been obtained by varying percentage of excess air in flue gases from 40 to 85%. The figure 5.1 shows the effect of excess air on efficiency of the boiler.

The management has agreed to install variable speed drive motor and the work for that is already in progress.

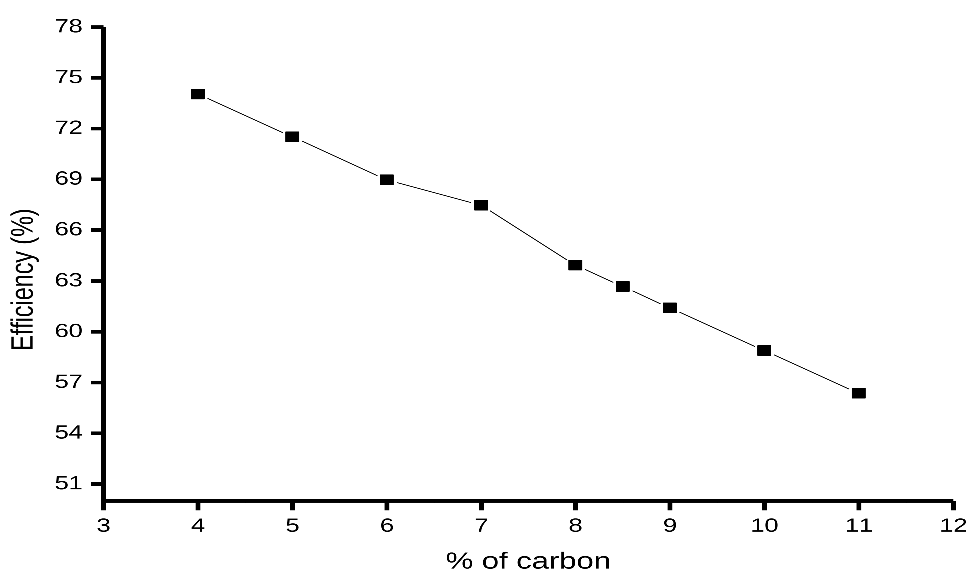

Figure5.1: Effect of excess air on boiler efficiency

(O_2 in flue gas = 8.6%, carbonpercentage = 4 to11%)

(2) Fluidized bed combustion

At Chandigarh distillers and bottlers limited fluidized bed combustion is used. In this plant a simplest furnance is used for burning the rice husk. The flue gases are taken around the boiler before disposing off into the chimney. With fluidized bed combustion it is possible to achieve about 4% unburnt carbon in the ash. This will result in improvement of efficiency from 63.95% to 75.32%. The furnace is provided with fluidized bed controlled at 4% to 11%. But because of poor operating skill and use of only forced draught fans percentage of carbon is very high. Figure 5.2 has been drawn by varying percentage of carbon in ash from 4% to 11%. This depicts the effect of residue carbon on boiler efficiency.

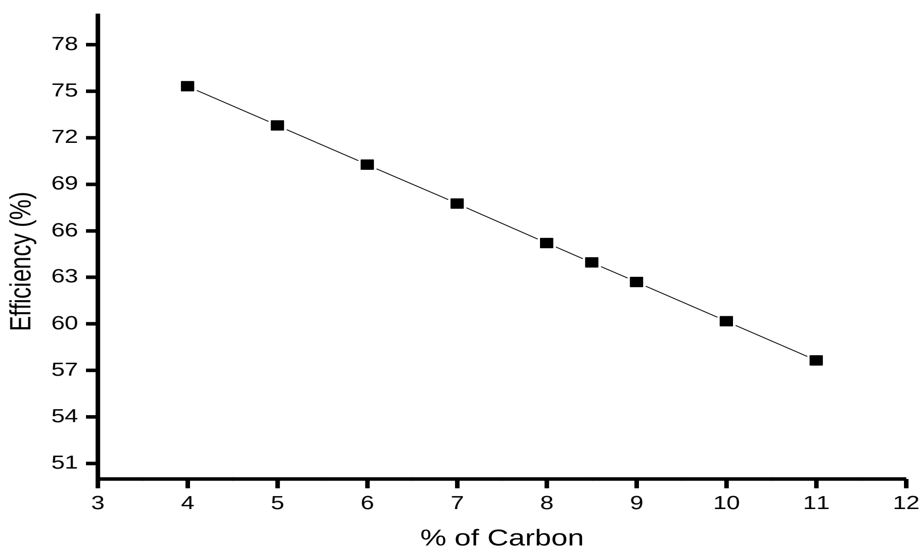

Figure5.2: Effect of percentage of carbon on boiler efficiency

(Carbon percentage = 4 to11%, flue gas temp. = 125℃)

(3) Avoiding clinker deposition

Efficiency of the boiler can also be increased by minimizing clinker deposition and maintaining proper bed temperature.In fluidized bed boilers bubbling bed is present. There are some places on the bed where proper bubbling does not take place. This leads to clinker deposition. To avoid clinker deposition fuel should be sprayed properly so that it does not accumulate at one place. Moreover sand should be changed after every 12 hours i.e. new sand should be thrown inside the furnance. Normally the size of sand particles is 1 mm. Generally what happens due to continuous combustion the size of the sand reduces and the sand particles are carried away by flue gases. So the amount of sand on the furnance bed reduces. So new sand has to be thrown inside the furnance accordingly. If bulk density of the sand is more then also bubbling drops. The alertness of the workers play a very important role for the bubbling phenomena to take place properly.

(4) Maintaining proper bed temperature

Efficiency of the boiler can also be increased by maintaining proper bed temperature. This can be achieved by increasing the supply of secondary air so that proper combustion takes place inside the furnance. Sometimes if more unburnt fuel is going out i.e. ash contains more unburnt particles then the feeding rate is decreased, and so is draught rate, by closing the dampers.Moreover terminal velocity plays a very important role for proper combustion. It should be kept 6m/sec for underbed and 4.2m/sec for overbed. If this velocity is kept then 4% carbon in the residue can be achieved and the efficiency of the boiler goes upto 75.32%.

(5) Using petcoke instead of rice husk

1 ton of rice husk produces = 3.1 ton of steam

Steam produced from rice husk = 1296 ton per day

1296 ÷ 3.1 = 418.064 tons of rice husk used daily

Cost of 1 ton of rice husk = Rs 4,200

So, 418.064 × 4200 =Rs 17,55,868.8 per day

Now, petcoke;

1 ton of petcoke produces = 8.5 ton of steam

1296 ÷ 8.5 = 152.470 tons of petcoke will be used daily to produce same amount of steam.

Cost of 1 ton of petcoke = Rs 8,000

So, 152.470 × 8000 =Rs 12,19,760 per day

Savings =Rs 1755868.8 **-** 1219760 =Rs 5,36,108.8 per day

Installation cost =Rs 50,00,000

Limestone cost per ton =Rs 4,000

Transportation = Same as rice husk

Storage = Same as rice husk

Availability = Bathinda, Gujrat

Payback period = 1 month

Moreover petcoke can be reinjected once i.e. the ash which is produced by burning petcoke can be injected once more in the furnance through two ash inlet points which are made while modifying the furnance for its proper combustion. This will help in increasing the efficiency of the boiler and the unburnt particle left will be minimal as the same fuel is burnt twice.

Earlier sand was used on the furnance bed. Now limestone will be used on the furnance bed.

Only thing which has to be done is modifying the furnace a bit. For the petcoke injection inside the furnance 5 petcoke inlet points and 2 ash inlet points in the square form of the dimension 20cm×20cm have to be made on the furnance of capacity 55 tons per hour.The management has agreed to modify the furnance so that the fuel used at the plant can be changed from rice husk to petcoke and for that the work is already in progress.

After conducting a detailed energy audit study at the plant the overall profit of the factory was increased and the efficiency of the boiler was also improved. Various suggestions were presented to the managerial level officials in the form of a power point presentation. The authorities have agreed to some of the points mentioned above in the suggestions and had started working on them for the betterment of the factory. The overall investment and profit analysis that has been carried out in this whole study has been made given below in the table 5.1.

Table 5.1: Cost analysis

Measure	Investment, Rs	Savings/month, Rs
Storage tank insulation	5,75,000	5,44,084.2
Leakage problem	26,50,0000	12,60,000
Fuel feeding	5,00,000	90,000
Boiler losses	2,29,61,400	37,80,000
Variable speed drive	5,50,000	1,18,933.92
Total	2,72,36,400	57,93,018.12

CHAPTER - 6

CONCLUSION

(i) 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. If insulation is provided on storage tank steam used in the deaerator can be saved.

(ii) Feeding of rice husk in the vibrating screens at the plant is done manually. If a tractor is used instead of laborers time as well as money can be saved which will overall increase the profit of the company.

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

(iv) Variable speed drive motor is not working at the factory for the past 5 years which leads to increase in the current load of the plant. Moreover excess air is going in the furnace due to which lot of rice husk is going out of the chimney unburnt. If variable speed drive motor is installed at the plant the efficiency of the boiler can be further increased and the oxygen amount in the flue gases can be controlled.

(v) Moreover if the fuel which is currently used in the plant i.e. rice husk is replaced by petcoke the overall profit of the factory will go up as the gross calorific value of petcoke is much higher than rice husk. Also petcoke can be reinjected twice leaving behind minimal unburnt particles in ash.

(vi) There are many other parameters which play a very important role in increasing the efficiency of the boiler. One such parameter is the quality of fuel which is being fed inside the furnance. The fuel should have minimal moisture and impurities in it. Timely blow-down should be performed so that the hardness of the water is properly maintained.

FUTURE SCOPE

(i) To reduce the heat loss through the furnance walls by proper insulation.

(ii) Timely maintenance of the air preheater so that air leakage can be prevented and efficiency of the boiler can be increased.

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

(iv) Major exergy destruction areas such as combustion chamber and heat exchanger should be focused more upon because 8% and 3% respectively.

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APPENDIX: A1

Table A1: O_2 in Flue Gas = 8.6%, Carbon %age = 4 to11%

Carbon (%)	**Efficiency (%)**
4	74.04
5	71.51
6	68.98
7	67.46
8	63.93
8.5	62.67
9	61.40
10	58.88
11	56.35

Table A2: Carbon percentage = 4 to11%, Flue Gas Temp. = 125℃

Carbon (%)	**Efficiency (%)**
4	75.32
5	72.79
6	70.26
7	67.74
8	65.21
8.5	63.95
9	62.69
10	60.16
11	57.63

CHANDIGARH DISTILLERS & BOTTLERS LTD.

1 Boiler Shutdown Loss = 31·25 lakh/day

2 Rice Husk Feeder Cost = 13·25 lakh/assembly

3 Storage tank Insulation = 5·75 lakh
(- Glass wool + Metal Sheet -)

4 Saving of electricity using VFD = 30% (approx.)

Sandeep
01/04
(Manager)

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STEAM CONSUMPTION DAILY REPORT 14.1.2009

PLANTS	I.R.	F.R.	NET CONSUMPTION	UP TODATE	REMARKS
Excel Plant					
RS	4621	4974	353		
ENA	5563	5991	428 } 826		
Analayser	1027	1072	45		
ENA 60			156		
Grain plant	24037	24217	180		
Deareator	3384	3478	124		
Fermentation			1		
CO_2 PLANT	712	722	10		
Molasses Tank					
E.T.P.					
Venting					
Dryer- 1	805	957	304		
Dryer- 2					
Total Losses			81		
Total Steam			1701		
Biogas/CH4 %					
Husk Consumption	TODAY	Upto Date			
	4100	55350			
Deduction (Moist./Poor Qlty.)	138	1878			
Moisture %age	15.21	–			
Net Husk Consumption	3962	53472			
Steam to Husk Ratio(S. Heated)	3.76	3.89			
Steam to Husk Ratio(Saturated)	3.92	4.09			
Husk to Production Ratio	1.50	1.41			
Grain Production	–	–	POWER EXPORT		62710 Kwh
T otal steam	1701	24283	UPTODATE		768250 Kwh
	TO DATE	UP TO DATE	TOTAL UNITS :	3 MW	8.25 MW
Steam 55 T BOILER	1196		TODAY	24170	140050
Steam 30 T BOILER	437		UP-TODATE	329560	2003040
Total Steam	1633		PRE. BAL. HUSK	355.30	
D.SUPER HEATING	124		HUSK REC	4201.65	
Net TOTAL	1757	24788	TOTAL	4556.95	
			CONSUMPTION	4100	
			BALANCE	456.95	
DRYER NO-1	21.40 hrs				
DRYER NO-2	23 hrs				
OLD GRAIN	19 hrs				
NEW GRAIN	23½ hrs				
POWER EXPORT	62710 Kwh				
PSB UNIT	10000 Kwh				

(Assis. Manager)

(Manager)

STEAM CONSUMPTION DAILY REPORT 14.11.2012

PLANTS	I.R.	F.R.	NET CONSUMPTION	UP TODATE	REMARKS
Excel Plant					
RS	5327	5676	349 }		
ENA	6422	6846	424 } 811		
Analayser	1105	1143	38 }		
ENA 60			85	2226	
Grain plant	24374	24546	172	2738	
Deareator	3610	3708	128	2310	
Fermentation			1	22	
CO_2 PLANT	722	732	10	81	
Molasses Tank					
E.T.P.					
Venting					
Dryer- 1	1116	1264	148 } 296	4953	
Dryer- 2			148 }		
Total Losses			75	1300	
Total Steam			1578	27529	
Biogas/CH4 %					
Husk Consumption	TODAY	Upto Date			
	3800	63150			
Deduction (Moist./Poor Qlty.)	69+15=84	2082			
Moisture %age	13.85%				
Net Husk Consumption	3716	61068			
Steam to Husk Ratio(S. Heated)	3.80	3.89			
Steam to Husk Ratio(Saturated)	3.89	4.08			
Husk to Production Ratio	1.48	1.41			
Grain Production	–	–	POWER EXPORT		43410
Total steam	1578	27529	UPTODATE		863190
:	TO DATE	UP TO DATE	TOTAL UNITS :	3 MW	8.25 MW
Steam 55 T BOILER	1166		TODAY	19740	136920
Steam 30 T BOILER	389		UP-TODATE	370960	2275350
Total Steam	1555		PRE. BAL. HUSK	873.35	
D.SUPER HEATING	117		HUSK REC	3726.50	
Net TOTAL	1672	28175	TOTAL	4599.85	
			CONSUMPTION	3800	
			BALANCE	799.85	
DRYER NO-1	24 hrs				
DRYER NO-2	24 hrs				
OLD GRAIN	19½ hrs				
NEW GRAIN	22 hrs				
POWER EXPORT	43410				
PSB UNIT	NIL				

N Tiwari
(Assis. Manager)

Sandeep
(Manager)

STEAM CONSUMPTION DAILY REPORT 19.1.2013

PLANTS	I.R.	F.R.	NET CONSUMPTION	UP TODATE	REMARKS
Excel Plant					
RS	5676	6036	360 }		
ENA	6846	7246	430 } 840		
Analayser	1143	1193	50 }		
ENA 60			90		
Grain plant	24546	24616	170		
Deareator	3700	3805	135		
Fermentation			1		
CO_2 PLANT	732	742	10		
Molasses Tank					
E.T.P.					
Venting					
Dryer- 1	1274	1434	160 } 341		
Dryer- 2			181 }		
Total Losses			80		
Total Steam			1667	29196	
Biogas/CH4 %					
Husk Consumption	TODAY 3900	Upto Date 67250			
Deduction (Moist./Poor Qlty.)	74+19=93	2175			
Moisture %age	14.85%				
Net Husk Consumption	3807	65223			
Steam to Husk Ratio(S. Heated)	3.78	3.87			
Steam to Husk Ratio(Saturated)	3.85	4.04			
Husk to Production Ratio	1.51	1.44			
Grain Production	–	–	POWER EXPORT		61640 Kwh
T otal steam	1667	29196	UPTODATE		924830
	TO DATE	UP TO DATE	TOTAL UNITS :	**3 MW**	**8.25 MW**
Steam 55 T BOILER	1192		TODAY	21840	138405 Kwh
Steam 30 T BOILER	391		UP-TODATE	392800	2413755
Total Steam	1583		PRE. BAL. HUSK	799.85	
D.SUPER HEATING	122		HUSK REC	3807	
Net TOTAL	1705	29880	TOTAL	4606.85	
			CONSUMPTION	3900	
			BALANCE	706.85	
DRYER NO-1	20.40 hrs				
DRYER NO-2	22 hrs				
OLD GRAIN	19½ hrs				
NEW GRAIN	23½ hrs				
POWER EXPORT	61640				
PSB UNIT	10000				

(Assis. Manager)

(Manager)

STEAM CONSUMPTION DAILY REPORT 15.3.2015

PLANTS	I.R.	F.R.	NET CONSUMPTION	UP TODATE	REMARKS
Excel Plant					
RS	4974	5327	353 }		
ENA	5991	6422	431 } 817	12854	
Analayser	1072	1105	33 }		
ENA 60			140	2141	
Grain plant	24217	24274	157	2566	
Deareator	3497	3610	143	2171	
Fermentation			1	21	
CO_2 PLANT	722	722	–	71	
Molasses Tank					
E.T.P.					
Venting					
Dryer- 1	957	1116	159 } 320	4657	
Dryer- 2			181 }		
Total Losses			79	1225	
Total Steam			1657	25940	
Biogas/CH4 %					
Husk Consumption	TODAY	UptoDate			
	4000	59350			
Deduction (Moist./Poor Qlty.)	113+7=120	1998			
Moisture %age	14.57				
Net Husk Consumption	3880	57352			
Steam to Husk Ratio(S. Heated)	3.74	3.88			
Steam to Husk Ratio(Saturated)	3.89	4.08			
Husk to Production Ratio	1.48	1.41			
Grain Production	–	–	POWER EXPORT		51530
T otal steam	1657	25940	UPTODATE		819780 Kwh
	TO DATE	UP TO DATE	TOTAL UNITS :	3 MW	8.25 MW
Steam 55 T BOILER	1177		TODAY	21660	135390
Steam 30 T BOILER	418		UP-TODATE	351220	2138340
Total Steam	1595		PRE. BAL. HUSK	457.50	
D.SUPER HEATING	120		HUSK REC	4415.85	
Net TOTAL	1715	26503	TOTAL	4873.35	
			CONSUMPTION	4000	
			BALANCE	873.35	
DRYER NO-1	21.20hrs				
DRYER NO-2	24 hrs				
OLD GRAIN	18.20hrs				
NEW GRAIN	19.20hrs				
POWER EXPORT	51530				
PSB UNIT	4900 Kwh				

M Tiwari (Assis. Manager)

Sandeep (Manager)

Chandigarh Distillers & Bottlers Ltd., Banur

55 T.P.H. BOILER

Date : 29.4.2010

	9AM	10AM	11AM	12AM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM
FLOW (Ton/Hr.)																								
1. Steam Flow	48	49	48.5	44	43	45	44	45	49	46.5	46.6	44.1	45.3	40.2	41.6	46.6	48.4	47.9	48.7	52.4	49.9	49.1	48	47
2. Water Flow	48	47	52	40	46.6	45	50	42	45.4	44.4	49.6	42.4	45.4	45.6	39.5	44.4	45.6	48.4	49.2	51.1	45.8	55.4	46	35
3. Steam Flow Totaliser	68160	30	79	132	166	211	256	306	349	395	443	490	538	568	632	675	719	763	805	852	903	952	1006	1020
4. Water Flow Totaliser	66436	30	79	133	166	211	257	307	349	396	443	491	539	586	633	676	720	764	888	853	904	959	1008	1050
5. Attemprator Flow	.87	.86	.86	.86	.85	.83	.8	.85	.84	.84	.84	.84	.85	.85	.85	.85	.85	.85	.85	.85	.83	.84	.84	.88
6. Attemprator Flow Totaliser	1225	1.4	1.4	1.4	3.14	4.2	4.8	5.8	6.4	7.4	8.2	9	9.9	9.99	11	12	13	14	15	16	17	18	18.4	19.9
PRESSURES (Kg/Cm²)																								
1. Boiler Drum	75	75.4	74.7	75	74.2	73.8	74.4	75.9	75.1	75.1	74.1	74.1	74.1	73.2	74.4	74	74.2	74.4	74.6	74.2	75.1	74.2	75.3	75
2. Super Heater outlet																								
3. Main steam line	67.1	67.3	67.4	67.6	67.7	67	67.8	67.2	67.4	68	67.1	67.2	66.6	66.7	67.4	66.9	66.8	66.6	67.2	67.3	67.1	67.6	67.4	67.9
4. Feed Pump Section	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
5. Feed Pump Discharge	86.3	86.6	86.7	86	94	93.4	93	95.6	90.7	91.4	93.3	92.9	94	95	93	93.2	91.9	92.5	91.5	90.6	91.4	90	91	90.6
6. Dearator Pump discharge	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7. Dearator Pressure	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
8. Instrument Air Pressure	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
WATER STEAM TEMP. (Deg. Centigrades)																								
1. Dearator Water Inlet temp.	76	77	78	77	75	76	77	77	84	72	84	76	78	77	76	79	78	83	75	68	69	78	77	76
2. Dearator Temp.	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117
3. Water Economiser Inlet	119	119	119	119	119	119	119	119	119	119	119	119	119	119	118	118	118	119	118	119	118	119	119	118
4. Water Economiser Outlet	220	209	208	212	210	208	207	215	217	220	224	213	215	216	217	217	218	225	224	221	220	209	208	219
5. Primary Super Heater Outlet	400	400	402	406	404	409	410	404	410	415	416	415	411	412	413	415	416	416	409	408	405	407	409	411
6. Attemprator Outlet																								
7. Secondary Super Heater Outlet	486	490	486	499	485	481	482	488	491	459	484	462	481	488	490	495	492	489	496	468	509	491	390	490
SCREW FEEDER SPEED (RPM)	470	476	[illegible]	472	470	476	477	480	477	476	470	470	471	474	475	478	477	476	476	475	470	471	473	479
1. Screw Feeder No. 1	714	714	713	715	714	714	709	706	706	709	713	715	714	706	711	714	714	714	708	711	710	709	708	707
2. Screw Feeder No. 2	608	578	525	579	547	564	553	678	671	624	535	627	620	547	509	687	615	616	658	661	670	535	615	616
3. Screw Feeder No. 3	611	600	542	545	549	546	556	557	668	613	627	538	566	547	529	631	670	660	611	662	655	623	640	636
4. Screw Feeder No. 4	634	610	538	545	570	579	582	575	695	636	653	577	582	515	508	609	630	605	676	631	616	620	631	559
5. Screw Feeder No. 5	294	295	202	201	220	201	203	207	267	34	192	194	191	190	191	191	190	190	191	191	161	161	191	577
BIO GAS PRESSURE (mm of WC)																								
1. Main Line Pressure																								
2. Over Bed Burner Inlet Pressure																								
3. Flow (by meter)																								
4. Totaliser																								
5. Difference (Flow/Hrs.)																								
6. Avg. Bio-Gas Per Day																								
7. Under Bed Inlet Pressure																								
8. Flow (By Meter) Dearator	4.42	4.12	3.95	4.12	4.46	4.57	4.19	4.69	4.14	4.18	4.45	4.40	4.35	3.81	3.8	4.62	5.16	4.45	4.34	4.19	3.95	3.46	4.53	4.60
9. Totaliser Dearator	11354	4.41	9.16	12.3	17.7	20.8	25.9	30.6	33.4	42.3	50	54	58	62	66	69	76	79	83	87	90	93.6	97.8	101.60
10. Difference (Flow/Hrs.)																								
11. Avg. Bio-Gas Per Day																								
DROUGHTS (mm of WC)																								
1. Primary Air Comp No. 1	470	465	460	475	474	476	473	476	479	465	470	466	467	466	463	467	462	467	466	469	467	463	467	470
2. Primary Air Comp No. 2	470	465	460	475	474	477	476	471	469	457	462	459	462	462	460	460	464	466	471	474	474	473	469	469
3. Primary Air Comp No. 3	462	460	457	468	471	477	477	462	459	462	462	464	458	458	460	460	458	456	456	470	471	468	470	471
4. Primary Air Comp No. 4	457	453	451	466	469	467	464	465	466	454	457	453	454	454	457	453	450	466	465	460	470	464	464	471
5. Primary Air Comp No. 5	451	450	445	445	460	466	456	464	443	447	446	448	449	445	446	447	447	446	456	466	455	445	496	446
6. Secondary Air Control Room Side																								
7. Secondary Air Feeder Side	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8. Secondary Air Over Bed Side	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9. Secondary Air Back Side																								
10. Furnace Drought	1	-.5	-.6	-.9	-.2	-.5	-.9	-.1	-.2	-1.3	2	-.4	-1	.2	-.2	-2	-2	.6	-.7	1.9	1.9	1.2	1	.7
11. Boiler Outlet	-9	-8	-7	-9	-9	-9	-8	-9	-9	-9	-8	-8	-7	-9	-9	-9	-9	-8	-7	-9	-10	-10	-9	-8
12. Economiser Outlet	-31	-36	-31	-30	-30	-29	-30	-30	-29	-30	-30	-38	-30	-30	-30	-30	-31	-31	-31	-30	-29	-26	-31	-30
13. APH Outlet	-56	-56	-56	-56	-56	-56	-57	-55	-56	-56	-56	-55	-55	-55	-55	-57	-56	-56	-57	-57	-55	-56	-57	-57
14. ESP Outlet																								
15. ID Inlet	-69	-66	-62	-65	-67	-64	-65	-70	-65	-66	-69	-75	-70	-65	-67	-65	-69	-70	-71	-71	-72	-72	-70	-69
BED TEMPERATURES (Deg. Cent)																								
1. Comp No. 1 (1)	661	606	579	580	606	606	713	614	636	617	618	614	630	636	648	645	632	603	617	618	600	602	606	611
(2)	552	550	522	472	436	552	566	579	567	546	556	559	584	579	584	557	557	580	584	575	519	513	522	530
2. Comp No. 2 (1)	573	516	516	507	527	522	535	536	509	566	520	567	530	526	551	556	554	557	550	557	570	535	545	556
(2)	622	620	607	416	416	600	590	603	621	589	571	600	660	590	568	601	610	618	670	650	651	646	553	550
3. Comp No. 3 (1)	676	655	661	640	649	660	669	684	676	641	645	694	680	681	658	662	700	706	714	680	711	643	673	680
(2)	78	71	73	70	73	85	90	96	98	110	116	91	77	78	76	78	79	75	77	103	104	106	80	103
4. Comp No. 4 (1)	596	590	586	535	574	570	576	610	614	600	628	614	624	612	614	615	650	628	640	606	652	640	636	630
(2)	89	84	91	92	86	104	104	113	123	100	56	30	92	94	96	89	95	111	111	118	110	116	102	98
5. Comp No. 5 (1)	–	–	–	–	–																			
(2)	163	160	155	166	153	152	152	150	151	157	155	164	163	162	166	159	157	157	155	151	164	162	161	160
6. Bed Condition	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
S.P.M	46	49	55	55	56	62	60	58	50	55	58	60	44	58	50	52	48	55	62	54	56	57	62	66
FLUE GAS TEMP. (Deg. Cent)																								
1. Secondary Super Heater Inlet	722	720	719	713	719	733	752	756	760	740	740	775	780	780	760	795	760	763	765	740	735	752	759	765
2. Secondary Super Heater Outlet	585	580	562	570	582	575	548	573	580	575	575	580	543	555	565	560	565	586	595	548	584	560	575	590
3. Primary Super Heater Outlet	488	476	476	476	478	478	476	480	480	476	476	480	413	485	485	490	491	460	495	465	468	488	465	470
4. Boiler Oulet	446	447	441	439	439	452	451	450	452	450	446	430	428	450	485	455	495	455	440	480	490	488	470	460
5. Economiser Outlet	332	315	315	305	305	302	310	315	317	330	340	320	320	324	330	324	340	329	329	320	335	327	324	315
6. APH Inlet	185	186	182	186	185	184	185	186	184	184	184	184	184	184	184	181	189	184	184	184	184	184	184	184
7. APH Outlet	109	109	110	110	110	109	110	110	109	109	109	109	109	110	110	110	110	110	109	109	110	109	110	110
8. Hot Air Primary Outlet	145	144	145	145	141	142	142	142	145	141	143	143	142	144	145	145	141	141	142	144	143	143	141	145
9. ESP Inlet																								
10. ESP Outlet																								
11. ID Inlet	94	90	92	92	91	89	88	90	94	93	91	90	90	91	94	93	88	89	89	90	93	91	94	91
12. O2% in Flue Gas																								
OPENINGS																								
1. F.D. Fan Damper No. 1	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2. F.D. Fan Damper No. 2	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3. Comp. No. 1	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
4. Comp. No. 2	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
5. Comp. No. 3	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
6. Comp. No. 4	50	50	50	50	50	53	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	53	50	50
7. Comp. No. 5	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
8. I D Fan Damper	76	76	77	77	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76
9. Feed Water Control Valve																								
10. Dearator Control Valve (Water)																								
11. Dearator Control Valve (Steam)																								
12. Gas Blower Air Section Damper																								
13. Over Bed Burner Damper																								
CURRENT (Amps.)																								
1. F.D. Fan No. 1	153	154	155	153	153	154	154	154	155	150	151	151	152	154	148	149	151	150	150	151	151	154	155	154
2. F.D. Fan No. 2	138	136	138	138	140	141	145	138	136	130	131	132	134	135	140	141	138	136	132	130	132	131	138	138
3. I.D. Fan	270	277	278	278	273	277	278	274	274	274	277	278	280	274	274	277	274	278	274	274	278	276	276	276
4. Feed Pump No. 1			Run	Run	Run																			
5. Feed Pump No. 2	358	376	–	–	–																			
6. Dearator Pump No. 1																								
7. Dearator Pump No. 2																								
8. Gas Blower																								
ESP																								
1. T R1 KV/MA	3013	3013	2713	2613	2813	2613	2713	2713	2613	2913	2913	3013	2813	2713	2913	3013	3013	2813	2913	2713	2513	3013	3013	2813
2. T R2 KV/MA	50135	50135	50135	50135	43135	40135	40135	41135	44135	50135	50135	50135	48135	49135	50135	49135	46135	46135	50135	51135	51135	48135	50135	40135
3. T R3 KV/MA																								
LEVELS																								
1. Dearator Level	54	53	52	57	53.2	53.9	54	53	52	53	53	55	54	55	55	54	53.9	54	55.5	55	54	53.9	53.2	53
2. Boiler Drum Level	44	44	45	46	42.9	43	44	44.4	45	43.4	43.2	43.2	42.9	41	41	42	40	44	43	43	43	44	45.9	46
3. MOD Level	40	40.5	40.5	41	41	41	41	40.5	40	40	40	40	40	41	41	40	40	41	41	41	40.5	40.5	40.5	41
4. Storage Tank Level	92	53	66.6	73.6	75	70	70	70.4	71	72	68	69	70	67	80	80.4	84.4	81	79	70	84	89	85	84

OILER ATTENDANT A [signature] B [signature] C [signature]

SHIFT ENGINEER A [signature] B [signature] C [signature]

SR. MANAGER [signature]

BIO-GAS (Over Bed)	BIO-GAS (Under Bed)	Water	Attemp (Water)	Steam
F. R.	F. R.	F. R. 1100+16	F. R.	F. R. 1105+18
I. R.	I. R.	I. R.	I. R.	I. R.
TOTAL	TOTAL	TOTAL 1116	TOTAL 21	TOTAL 1123

BIO-GAS (Fill and Draw)

Chandigarh Distillers & Bottlers Ltd., Banur

55 T.P.H. BOILER

Date : 10.3.2015

	9AM	10AM	11AM	12AM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12PM	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM
FLOW (Ton/Hr.)																								
1. Steam Flow	54	54	53.6	54	53	51	52	52	53	54	53	53	54	54	54	53	52	51	51	52	52.5	53	53	54
2. Water Flow	43	55	55	50	53.6	50	50	51	51	52	53	54	54	53	53	51	52	52	52	51	53	54	53	52
3. Steam Flow Totaliser	31426	31486	31532	31592	31642	31695	31725	31765	31815	31847	31887	31925	31965	32008	32049	32085	32117	32150	32198	32240	32281	32338	32387	32435
4. Water Flow Totaliser	73276	73346	73386	73440	73488	73540	73590	73640	73680	73740	73770	73810	73850	73840	73940	73980	74030	74080	74130	74170	74200	74240	74290	74330
5. Attemprator Flow	.78	.8	.82	.8	.82	.8	.8	.82	.81	.82	.82	.8	.8	.8	.81	.81	.8	.79	.8	.81	.82	.8	.8	.81
6. Attemprator Flow Totaliser	4019	4020	4021	4022	4023	4023	4024	4025	4025	4026	4027	4015	4029	4030	4030	4031	4032	4033	4033	4034	4035	4036	4037	4037
PRESSURES (Kg/Cm²)																								
1. Boiler Drum	75.2	75.6	75.6	75.6	75.7	75.1	75.1	75.1	75.1	75.4	75.6	75.6	75.1	75.4	75.1	75.1	75.2	75.2	75.3	75.7	75.7	75.6	75.1	75.3
2. Super Heater outlet	68	67	67.2	67.4	67.7	67.3	67.3	67.4	67.3	67.8	67	67	67	68	67.1	67.1	67.3	67.6	67.9	68	67.9	67.9	67.1	67.3
3. Main steam line	2.1	2.1	2.1	2.1	2	2	2	2	2.1	2	2	2.1	2.1	2.1	2.1	2	2.1	2.1	2	2.1	2.1	2	2	2
4. Feed Pump Section																								
5. Feed Pump Discharge	88	89	90	89	91	91.1	90	91	89	89	88	87	88	89	90.5	91.5	91.5	90	89	88	89	90	90.5	91
6. Dearator Pump discharge	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7. Dearator Pressure	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
8. Instrument Air Pressure	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.8	5.9	5.9	5.9	5.8	5.8	5.8	5.9	5.9	5.8	5.9	5.8	5.8	5.9	5.9	5.8	5.9
WATER STEAM TEMP. (Deg. Centigrades)																								
1. Dearator Water Inlet temp.	77	75	77	75	72	64																		
2. Dearator Temp.	118	118	118	117	118	117																		
3. Water Economiser Inlet	119	119	119	119	119	118	118	118	119	119	119	119	118	119	118	119	119	119	118	118	118	119	118	119
4. Water Economiser Outlet	233	232	235	233	232	229	232	232	235	235	230	231	229	228	230	231	232	234	235	231	230	229	229	231
5. Primary Super Heater Outlet	412	409	412	410	409	409	409	410	410	410	409	408	405	410	410	409	409	408	406	406	410	410	405	406
6. Attemprator Outlet																								
7. Secondary Super Heater Outlet	490	492	488	494	492	485	487	489	490	490	481	480	492	492	485	499	498	489	492	490	495	499	500	493
SCREW FEEDER SPEED (RPM)	480	480	475	481	477	475	477	475	480	480	470	475	480	480	485	490	485	488	478	475	481	487	490	481
1. Screw Feeder No. 1	534	535	500	539	500	531	530	530	520	515	510	515	510	535	540	545	539	530	525	595	540	545	535	540
2. Screw Feeder No. 2	591	577	545	596	558	586	590	580	585	575	577	570	560	565	570	580	590	595	590	585	580	550	540	545
3. Screw Feeder No. 3	586	570	542	588	556	578	580	550	575	576	576	580	585	590	588	588	580	575	570	560	556	556	565	570
4. Screw Feeder No. 4	616	600	586	619	581	608	610	615	620	615	640	645	630	619	619	615	610	609	601	600	590	595	599	600
5. Screw Feeder No. 5	579	562	536	579	546	574	570	572	571	565	560	565	567	570	575	576	580	570	575	570	569	550	545	551
BIO GAS PRESSURE (mm of WC)																								
1. Main Line Pressure																								
2. Over Bed Burner Inlet Pressure																								
3. Flow (by meter)																								
4. Totaliser																								
5. Difference (Flow/Hrs.)																								
6. Avg. Bio-Gas Per Day																								
7. Under Bed Inlet Pressure																								
8. Flow (By Meter) Deaerator	4.99	5.26	5.05	5	5.45	5.11	5.17	5.2	5.4	5.3	5.25	5.3	5.3	5.2	5.3	5.4	5.45	5.45	5.3	5.2	5.26	5.26	5.15	5.05
9. Totaliser Deaerator	3832	3838	3843	3847	3858	3865	3870	3876	3880	3885	3886	3891	3896	4001	4007	4012	4017	4022	4027	4033	4039	4044	4050	4056.5
10. Difference (Flow/Hrs.)																								
11. Avg. Bio-Gas Per Day																								
DROUGHTS (mm of WC)																								
1. Primary Air Comp No. 1	463	466	463	463	456	453	454	453	456	457	457	456	454	455	456	451	450	450	455	458	460	461	463	466
2. Primary Air Comp No. 2	456	460	456	456	455	450	450	450	450	454	455	460	458	458	460	460	460	458	458	460	455	454	450	451
3. Primary Air Comp No. 3	458	460	453	454	455	452	454	450	451	452	448	450	456	456	458	458	460	458	460	458	456	454	450	448
4. Primary Air Comp No. 4	450	454	452	452	445	446	445	450	452	452	454	450	450	450	454	451	445	446	450	452	452	451	450	446
5. Primary Air Comp No. 5	439	445	443	445	440	437	437	440	440	445	444	445	440	440	440	439	439	439	440	445	444	443	440	439
6. Secondary Air Control Room Side																								
7. Secondary Air Feeder Side	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8. Secondary Air Over Bed Side	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9. Secondary Air Back Side																								
10. Furnace Drought	.5	.9	.6	.9	1	.9	.9	.9	.5	.4	.6	.7	.9	.9	.8	.8	.9	1	1	.9	.8	.7	.5	.8
11. Boiler Outlet	-10	-10	-10	-9	-9	-9	-9	-9	-10	-10	-10	-10	-10	-9	-9	-9	-10	-9	-9	-10	-9	-10	-10	-9
12. Economiser Outlet	-32	-32	-32	-32	-31	-31	-31	-31	-31	-31	-32	-31	-32	-32	-32	-32	-31	-32	-31	-31	-32	-32	-31	-31
13. APH Outlet	-56	-56	-57	-53	-52	-51	-52	-52	-51	-49	-50	-52	-51	-54	-55	-57	-57	-58	-54	-51	-52	-53	-53	-54
14. ESP Outlet																								
15. ID Inlet	-85	-86	-83	-77	-74	-70	-74	-75	-80	-81	-75	76	-71	-79	-80	-81	-83	-82	-85	-86	-86	-80	-81	-79
BED TEMPERATURES (Deg. Cent)																								
1. Comp No. 1 (1)	607	609	612	639	660	562	570	572	579	579	590	590	585	589	600	605	609	610	602	602	579	585	590	590
(2)	340	356	357	342	349	350	342	342	350	357	356	350	340	345	345	350	360	357	358	354	350	335	340	342
2. Comp No. 2 (1)	370	386	392	372	377	377	372	372	377	380	370	375	375	380	382	388	391	391	385	384	388	390	390	386
(2)	590	602	600	566	575	573	566	577	590	595	580	598	610	615	630	630	615	610	605	602	618	645	645	639
3. Comp No. 3 (1)	579	647	651	610	609	616	600	610	615	615	610	605	599	590	595	595	615	605	606	620	640	645	640	649
(2)	143	145	143	144	149	143	143	143	144	143	145	145	148	148	144	144	142	142	141	145	146	146	144	145
4. Comp No. 4 (1)	422	519	521	497	499	500	490	490	500	490	485	482	480	470	475	[illegible]	479	485	489	480	470	450	445	440
(2)	251	366	277	246	256	250	250	254	260	260	270	265	265	260	270	272	273	277	278	270	269	265	268	265
5. Comp No. 5 (1)	–	–	–	–	–	–																		
(2)	200	222	200	222	200	146	180	190	195	200	205	200	200	205	210	220	210	210	205	202	200	190	200	205
6. Bed Condition	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
FLUE GAS TEMP. (Deg. Cent)																								
1. Secondary Super Heater Inlet	739	742	740	761	760	730	740	745	746	749	750	755	754	753	757	762	760	750	749	749	750	745	745	742
2. Secondary Super Heater Outlet	545	546	542	558	557	550	555	558	556	550	545	545	549	549	544	544	540	546	548	545	549	550	555	556
3. Primary Super Heater Outlet	490	489	487	497	497	487	497	490	490	493	493	490	485	485	482	480	481	484	485	490	495	491	491	485
4. Boiler Oulet	483	480	482	486	485	472	472	480	480	485	485	475	475	480	480	480	485	485	480	484	484	480	482	482
5. Economiser Outlet	426	420	416	424	420	393	394	400	405	405	410	411	411	419	419	424	423	423	423	414	414	410	410	415
6. APH Inlet	190	184	187	189	188	188	188	189	189	190	190	190	189	189	190	190	189	188	188	188	189	190	190	190
7. APH Outlet	112	112	112	113	112	111	111	111	112	111	111	111	112	112	112	112	112	111	111	112	112	111	111	112
8. Hot Air Primary Outlet	142	138	138	140	139	142	140	140	142	138	138	138	140	139	139	140	141	142	140	140	140	139	138	138
9. ESP Inlet																								
10. ESP Outlet																								
11. ID Inlet	86	87	86	86	91	92	92	91	91	91	92	89	88	87	87	87	86	85	86	86	90	91	93	92
12. O2% in Flue Gas																								
OPENINGS																								
1. F.D. Fan Damper No. 1	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
2. F.D. Fan Damper No. 2	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
3. Comp. No. 1	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
4. Comp. No. 2	40	40	40	40	40	40	40	40	40	40	41	40	40	41	45	40	40	39	40	40	43	42	40	40
5. Comp. No. 3	42	42	42	42	42	42	42	42	43	42	42	45	48	44	43	50	48	40	42	42	42	44	44	45
6. Comp. No. 4	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
7. Comp. No. 5	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
8. I D Fan Damper	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
9. Feed Water Control Valve																								
10. Dearator Control Valve (Water)																								
11. Dearator Control Valve (Steam)																								
12. Gas Blower Air Section Damper																								
13. Over Bed Burner Damper																								
CURRENT (Amps.)																								
1. F.D. Fan No. 1	213	216	213	212	210	208	208	208	209	211	213	213	213	210	210	209	208	207	209	209	210	26	213	213
2. F.D. Fan No. 2	186	187	184	185	184	183	187	187	187	186	185	184	183	186	186	186	187	187	184	183	182	187	186	186
3. I.D. Fan	287	285	287	287	285	279	279	280	260	261	261	284	284	285	283	283	283	283	280	279	279	279	282	285
4. Feed Pump No. 1																								
5. Feed Pump No. 2																								
6. Dearator Pump No. 1																								
7. Dearator Pump No. 2																								
8. Gas Blower																								
ESP																								
1. T R1 KV/MA	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711	2711
2. T R2 KV/MA	51135	52135	52135	50135	52135	52135	52135	52135	52135	51135	52135	51135	50135	50135	50135	49135	49135	50135	52135	51135	51135	52135	49135	50135
3. T R3 KV/MA	251100	261100	251100	271100	261100	261100	261100	261100	271100	261100	271100	251100	261100	251100	251100	261100	261100	271100	271100	271100	261100	251100	261100	271100
LEVELS																								
1. Dearator Level	53	52	53	52	53	52	52	52	53	52	53	54	53	53	52	52	52	53	54	54	54	53	52	53
2. Boiler Drum Level	46	47	46	46.1	47	47	47	47	46	46	47	46	46.1	46.1	47	47	47	47	48	47	46	45.9	46	46
3. MOD Level	40.9	41	40	41	41.2	40.1	40.5	41	41.9	41.9	41.9	41	41	41	40.5	40.9	41	41	41	41.9	41.9	41.9	41	40.5
4. Storage Tank Level	62	60	62	76	79	92.4	69	70	79	79	70	65	62	63	68	68	69	75	76	70	71	69	70	72

OILER ATTENDENT A Kumar B [signature] C K Singh

SHIFT ENGINEER A [signature] B [signature] C Gupta

SR. MANAGER Sandeep

BIO-GAS (Over Bed)	BIO-GAS (Under Bed)	Water	Attemp (Water)	Steam
F. R.	F. R.	F. R. 1110+22	F. R.	F. R. 1109+20
I. R.	I. R.	I. R. 1132	I. R.	I. R.
TOTAL	TOTAL	TOTAL 1132	TOTAL 24	TOTAL 1129

BIO-GAS (Fill and Draw)