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Experimental Analysis of CFBC Boiler and AFBC Boiler with Different GCV, Boiler Loads and Excess Air

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Abstract: The main motive of this study is to experimental analysis of the Atmospheric fluidized bed combustion boiler and Circulating fluidized bed combustion boiler with different gross calorific value of coal, boiler loads and excess air. For this analysis, use textile waste as a primary fuel and calculate GCV with help of bomb calorimeter. Conduct energy calculation of the overall plant and determine the efficiencies and energy losses of all the major components of the thermal power station. The study was carried out at Thermal power station of Industry Yarns at Mandideep and boiler section of thermal power plant is considered for the purpose of exergy analysis. The boiler of a power plant is the most effective section in eliminating exergy. Calculate the efficiency of CFBC and AFBC Boiler with different GCV of Textile waste and it is clearly shows that efficiency of CFBC boiler is higher than AFBC boiler in same GCV of textile waste. The present investigation show results of 30 mw power plant. Experiments were conducted using 0%, 20 %, 30% and 40% of excess air and 65%,70%,75%,80%,85%,90%,95% ,100% boiler loads. In the present investigation boiler house gives the best results at 0% excess air with maximum boiler load as far as the boiler efficiency (75.2%) are concerned. 65% boiler load With 0% excess air the boiler efficiency is found to be maximum (75.2%), which gives minimum heat loss. Without excess air AFBC boiler is not capable to burn low grade fuels show it is clear that for low grade fuel maximum efficiency of thermal power plant achieved by CFBC boiler because low grade fuel completely burns with 0% excess air.
Keywords: Comparison of AFBC and CFBCs, Textile waste, Bomb calorimeter, Boiler loads, excess air, different gross calorific value of coal

I. INTRODUCTION

Power plant generates the electricity result of combustion of fuel into mechanical work and in thermal energy. The availability of electricity and its per capita consumption shows index of national standard of living in the present day and flourishing power generation. Industry is a sign of grooving gross national products which reflects prosperity of people i.e energy has synonyms with progress. Electricity is the only form of energy which is easy to produce, easy to transmission and easy to control and produced by conventional and non-conventional method. The role of efficiency monitoring lies in maximizing generation from power plants. It enhances energy efficiency of the power plant. In order to keep maximum output from a given input, the units must run at the maximum possible efficiency

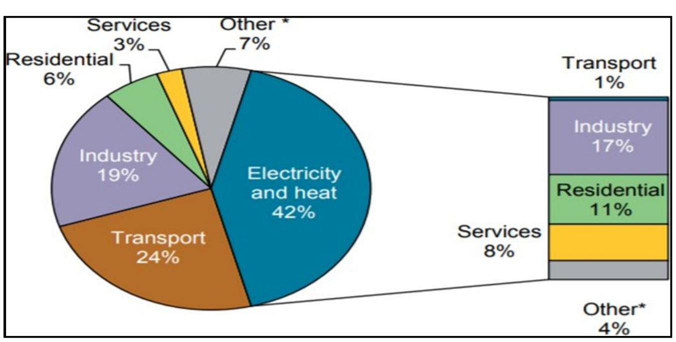

Figure1.1. World CO_2 emissions from fuel combustion, by section, in 2015

Power sector is one of the key sectors contributing significantly to the growth of country's economy. Power sector needs a more useful role to be played in defining, formulating and implementing the research projects with close involvement of all utilities like solar energy and other various non-conventional sources. The increase in energy consumption, particularly in the past several decades, has raised fears of exhausting the globes reserves of coal, petroleum and other resources in the future. The huge consumption of fossil fuels has caused visible damage to the environment in various forms. Every year human activity dumps roughly 8 billion metric tons of carbon into the atmosphere, 6.5 billion tones from fossil fuels and 1.5 billion from deforestation. The climate system has been warming over the period of 1880–2012, as stated by the International Panel of Climate Change (Wang et al. 2016). There is increasingly more evidence that global warming is mainly caused by human-generated greenhouse gases, carbon dioxide for the most part (Huang et al. 2012). Figure 1.1 by the International Energy Agency shows that in 2017, 61 % of global carbon dioxide (CO_2) emissions were generated by industry and production of electricity and heat. Emissions from biomass are not includedin the figure. As energy consumption in each of these fields is bound to rise in the future, cleaner ways of producing the energy must grow in number to hinder global warming.

Fluidized bed combustion has become one of the most environmentally friendly ways to burn solid fuel. Different fuels, even those of lower quality, can be burned with minor emissions, because the fuel burns efficiently and emission control is relatively easy. Even as the future prospects of fossil fuels are weak, fluidized bed combustion stays relevant in burning biomass. The world's largest biomass- only fluidized bed boiler of 299 MW_e starts its operation in 2020, in Teesside, UK. Biomass is a renewable energy source and, in many applications,, it canbe considered carbon neutral, meaning zero impact

A. Fluidization

This chapter explores the basics of fluidization and fluidized bed combustion. The purpose of this chapter is to build a general understanding of fluidization regimes and fluidized bed boilers. This is important for understanding the concepts of the CFB furnace,

Fluidization occurs when fluid is blown or pumped through a bed of small particles at a sufficient velocity. When fluidized, the bed expands and starts to behave like a liquid. This means for example good mixing of particles in the bed. Fluidization is used in numerous applications in different fields of technology, including drying or coating of particles, but perhaps the most notable application is fluidized bed combustion Fluidized beds can be divided into different types, depending e.g. on fluid velocity and particle size and density. This chapter introduces the main fluidization regimes but focuses mostly on bubbling fluidized beds (BFB) and Circulating Fluidized bed boiler (CFB).

B. Fluidized Beds

When gas flows upwards through a bed of fine solids at a low flow velocity, it flows in the gaps between the particles. The particles may vibrate, but the bed remains stationary. This is called a fixed bed,

Increasing the gas velocity increases drag force of the gas on the particles. Increasing the velocity enough makes the drag force counterbalance the weight of the bed and the bed becomes fluidized, The gas velocity needed for this is called the minimum fluidization velocity.

When gas velocity is further increased, gas bubbles begin to form in the bed and the bed reaches a state called bubbling fluidization, Figure 2.1c. For larger particles this happens immediately after minimum fluidization, but for finer particles the needed velocity can be several times larger than the minimum fluidization velocity. The BFB consists of two phases: gas bubbles and solid suspension. A portion of the gas keeps the solid suspension at minimum fluidization and the extra gas flows in the suspensionas bubbles.

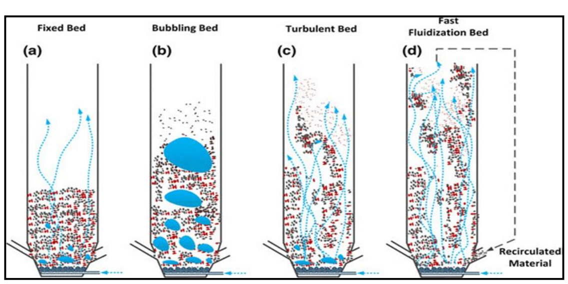

Figure1.2. Regions of fluidization

The bubbles travel upwards in the suspension due to buoyancy, passing by the solids. Bubbles pull some particles upwards in their wakes and as the bubbles reach the bedsurface, they erupt, throwing particles into the freeboard, the space above the bed Power plant is assembly of systems or subsystems to generate electricity. Increasing the gas velocity in a BFB, the bed reaches a point where the bubbles coalesce andbreak up vigorously and instead of bubbles in a coherent bed, there are solid clusters and voids of gas of many sizes and shapes. Solids are thrown into the freeboard, but only the finer particles in the solids are entrained with the gas. Massive migration of solids with the gas does not yet occur at this velocity and the vast majority of the particles fall back into thebed. This is called a turbulent bed, Increasing the gas velocity of a turbulent bed causes more and more particles to be entrainedwith the gas, until the gas reaches a velocity that is high enough to transport every particle from the bed. It then needs a return mechanism for the solids in order for the bed to keep onexisting. This kind of bed is called a fast bed.

C. Circulating Fluidized Bed Furnace (CFB Furnace)

This chapter covers features and physical phenomena of a CFB furnace. First, features and vocabulary of CFBs are discussed, after which each main physical phenomenon of a CFB are discussed separately. There are three main physical phenomena in CFB units, all of which affect each other

1) Fluid dynamics;
2) Reaction chemistry;
3) Heat transfer.

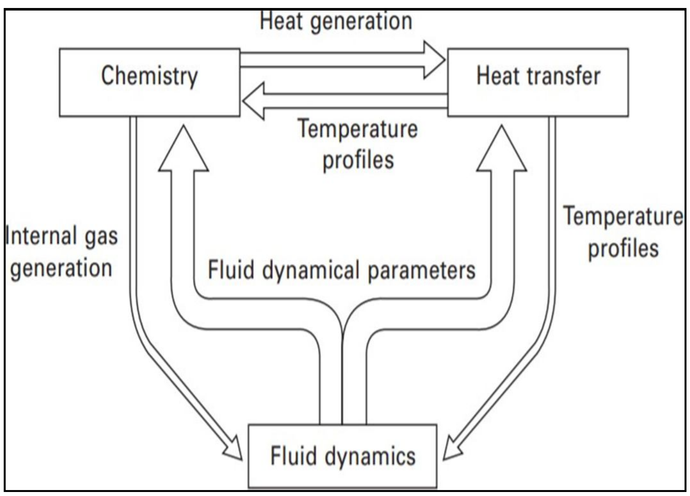

Figure1.3. Input output data exchange in circulating fluidized bed boiler

Figure 1.3 shows how sensitive each process is to one another, the arrow thickness indicatingthe sensitivity. The figure shows that fluid dynamics affects the reaction chemistry and heattransfer the most and is relatively insensitive to changes in the other two processes. Fluid dynamics should therefore be done very carefully and thoroughly. Fluid dynamics, or hydrodynamics, and heat transfer are discussed thoroughly in this chapter,

D. Working Principle Of Circulating Fluidiezed Bed Boiler (CFBC Boiler)

CFBC Heater is Flowing Fluidized bed Ignition Evaporator. CFBC Heater Turning out to be increasingly more well-known on the planet, overall CFBC Evaporator takes the biomass or Coal and other strong powers as its energizes. Kettle in which Biomass or Coal Consumed in a climate of high convergence of bed material (mineral matter) got from burning of coal held by utilizing typhoon. This bed material is fluidized by essential air (a piece of burning air). The high grouping of bed material alongside arranged air supply guarantees that mass burning temperatures don't surpass 9500C Making it climate well disposed (lesser creation of NOx) Method for using coal or biomass. In the CFBC Evaporator, Debris leaving with vent gas is recycled in burning zone. This Debris diminishes burning temperature. Due to recycling debris unburnt carbon gets consume.

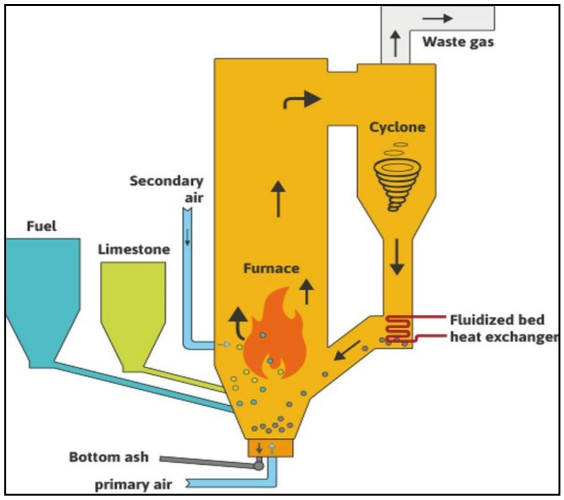

Figure1.4. Schematic of Circulating Fluidized Bed Combustion

II. LITERATURE REVIEW

As a general rule, the pace of reception of another innovation frequently keeps a guideline design. At the point when the pace of reception is plotted in total against time, the subsequent dissemination is in many cases S-molded (which is likewise named a calculated replacement or dispersion bend. As per Rogers, this pace of reception and bend are found for most new advancements. This bend can be partitioned into various stages. In the development stage no actual applications have been brought into the market. The delay among development and advancement can run somewhere in the range of 10 and 60 years. The pace of reception in the advancement stage is low and confined to the 'trend-setters'. Close to take on are the 'early adopters' and afterward the late larger part. The innovation has entered the commercialization stage and is presently completely business. The innovation diffuses quickly until the market is immersed and the pace of reception declines. The innovation is developed and market development is frequently minimal. The dissemination of the innovation is examined underneath as per this calculated structure.

The elaboration on verifiable market improvement will incorporate a few drivers, boundaries and significant achievements for additional perusing the creators might want to allude to broad distributions on the advancement of FBC by Watson and Michener et al. Likewise, Banales-Lopez and Norberg-Bohm played out an examination on approach prompted drivers and obstructions for FBC in-innovations in the USA

A. Invention To Invention

In 1922, the improvement of the FBC began with the Winkler patent for gasification of lignite. The innovation has been utilized for various applications from that point forward. Endeavors during the 1960s eventually brought about the plan of three coal firing test units. The first BFB test office was appointed in 1965. This test unit was utilized to direct trials to lay out the potential for controlling discharges of sulfur dioxide In that very year the Atmospheric FBC Program began in the USA. Subsequently, the USA established the Ecological Security Organization (EPA) in 1970, which gave the FBC innovation
With lower discharges the benefit over regular coal ignition advances. FBC could meet the new SO2 and NOx emanation limitations without the utilization of assistant hardware. The new limitations concerning ecological control in the USA were directed by the Spotless Air Act gave in 1971.

B. Innovation To Commercialization

Bubble Fluidized bed Heater (BFB) establishments (100 M-We) are utilized in the aluminum and paper fabricating industry starting around 1970. A few pilots and showing plants have been worked by different makers in the power section in the period 1976-1986. The first utilization of the Air pocket Fluidized bed Kettle (BFB) innovation in the utility (4100 M-We) fragment was in 1986, when a 117 M-We net exhibit plant began in Consumes ville5 (USA). Regardless of that, from that point forward most BFB establishments keep on falling in the little to-medium (25-100 M-We) limit range. Just few huge limit plants have been worked in for example Finland (110 M-We), USA (142 M-We) and Ireland (117 M-We). The BFB innovation is subsequently principally popularized for modern applications and not in the utility section.

The first business little size Circling Fluidized bed evaporator (CFB kettle)

(5 M-We net) began in 1979 and was produced by Cultivate Wheeler. In the utility section the first utilization of the CFB innovation began in 1985 with the activity of a 90 M-We Coursing Fluidized bed heater (CFB evaporator) in Duisburg (Germany).

C. Commercialization To Diffusion

Quick dissemination of Air pocket Fluidized bed Heater (BFB) happened in China, which professed to have north of 2000 Air pocket Fluidized bed Kettle (BFB) working in the mid 1990's. Be that as it may, the best part has a limit of under 10 M-Wth and point by point data isn't accessible. Different nations where Air pocket Fluidized bed Evaporator (BFB) innovation diffused are Balance land, Sweden, India and the USA. In Finland and Sweden, single generally huge scope (up to 50 M-We) BFB boilers are being utilized in the mash and paper industry. The dispersion of Air pocket Fluidized bed Kettle (BFB) began in Finland during the 1980s and for Sweden during the 1990s. The district Scandinavia varies from India and USA with regards to introduced units (~60 versus, separately, ~20 and ~20) and in the kind of fuel utilized. The establishments in Scandinavia are basically fired with biomass or modern waste and those put in India and the USA are principally coal-fired.

Circling Fluidized bed evaporator (CFB kettle) acquired acknowledgment for non-utility size applications in the USA in the mid 1980's. A main thrust for that was the trepidation for oil emergencies as they happened in 1973 and less significantly in 1979/80. As a result, research was performed on the likelihood to deliver power with elective fills. A significant Research and development exertion on FBC by the US government follows started by the Energy Re-search and Improvement Organization (ERDA) in 1976. The presentation of Public Utility Administrative Strategy Act (PURPA) in 1978 in the USA shaped a main impetus for the entrance of FBC for modern use. This act ordered utilities to buy power from specific kinds of limited scope (up to 80 M-We) power makers, called qualifying offices (QFs), which included modern co-generators and inexhaustible sources. The utilities should buy power at kept away from cost rates.

Gudimella Tirumala Srinivas, 2017 paper present "Efficiency of a Coal Fired Boilerin a Typical Thermal Power Plant". This paper mainly shows the boiler efficiency evaluation procedure by direct and indirect method. He obtain the result is 83.94% by Direct method and 91.96 % by Indirect method. The direct method helps the plant personnel to evaluate quickly the boilers efficiency with few parameters and less instrumentation.

Ashutosh Kumar, 2017 present an approach for the efficiency improvement of Atmospheric Fluidized Bed Combustion Boiler. Paper addresses the various approaches for efficiency improvement of a boiler. He find the Efficiency of boiler depends on flue gas outlet temperature i.e., APH outlet temperature and on decreasing the flue gas outlet temperature (i.e., 310°C), sensible heat loss increases by10°C on decreasing sensible heat loss, efficiencyimproved by 1% of the boiler.

Md. Amanulla Farhan, 2017 discuss on the "Investigation of boiler performance in power plant" AT different unit of boiler and find out the boiler efficiency of unit-3 and unit-4 after calculation is 82.03% and 82.35% respectively. It is calculated by Indirect or Losses Method which is accurate then Direct method.

T.Manikandan, 2017 present the paper on "Performance analysis of boilers". In this project performance analysis has been carried outby reducing the excess air contain oxygen at the time of combustion process, deterioration of fuel quality and water quality also leads to poor performance of boiler. Changes in admitting of oxygen in excess air nearly 4.7%, so percentage of excess air reduced to 29.62% and gets a more than 84.806% of thermal efficiency. So, 0.46% of efficiency can be increased by this analysis project. It improves the economic condition of operatingthat boiler nearly more than 30lakhs per annum.

P. Celen and H.H. Erdem, 2017 carried out "A case study for calculation of boiler efficiency by using indirect method". In this study the effects of increment moisture content of fuel and excess air coefficient on boiler efficiency is determined by using indirect method. Here results are obtaining as Increment of moisture content of lignite resulted in reduction of lower heating value so boiler efficiency decreased from 0.92 to 0.66, The boilerefficiency decreased from 0.92 to 0.90 with the increment of excess air coefficient up to 25%, Increment of moisture content has significant effect on boiler efficiency compared to excess air coefficient.

Abhinav Sahai, 2017 calculated the efficiency of boiler and implement the method for efficiency improvement in his paper. Efficiency for different GCV has been shown in paper for FBC boiler and this paper also gives the description of calculation of efficiency for FBC boiler. After calculation he state that the dry flue gas loss in is always higher than any other loss. Therefore, dry flue gas loss should be minimized by maximum heat extraction in the convective surfaces of the Boiler. Therefore, by decreasing hydrogen loss & dry flue gas loss efficiency can be improved.

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P. Papireddy, 2018 is conducted a research to find out the “Performance analysis of boiler in thermal power plant” of 210 MW. He is used Direct and Indirect method to calculate the boiler efficiency. He is also present the efficiency calculation of turbine, condenser and evaluation of various parameter to find losses. Here some optimization technique is mention in paper to minimize the losses. The experimental result indicates that main steam temperature and pressure, turbine cylinder efficiency should be increased and condenser vacuum, dry flue gas loss, moisture in fuel, heat rate should be decreased for better efficiency. Plant should be run at full load for maximum efficiency.

A.A. Nuraini and S. Salmi, 2018 project objective is “Efficiency and Boiler Parameters Effects in Sub- critical Boiler with Different Types of Sub-bituminous Coal”. The result indicates that coal with different CV and properties will exhibit different efficiency to the boiler. The results show that sub-bituminous coal with CV 5013 kcal/ kg performs similarly to designated coal with CV of 4852 kcal/kg.

The results convey that the coal type contributes to major energy losses during the combustion process in the furnace.

Wadhah H. Al- Taha, 2018 doing case study on “Performance Analysisof a Steam Power Plant”. He derives from the study is top thermal and total efficiencies unit generating at full load (100%) and decrease at partial load (40%) and the lowest rate of heat net unit obstetric gets the full load (100%) and increases when the partial load (70%) and continues increase when the partial load (40%), so it canbe recommended for operation at full load.

Vivek Khare, 2018 mentioned their study on “Performance Assessment of 2X250 MW Coal Based Thermal Power Plant”. Here he finds that the differences in the calculated efficiency from the designed efficiencies indicate the urgent need to control the parameters withinthe designed ratings and to evolve measures to improve the efficiency of the plant.

Ahmad Mahmoudi Lahijani, 2020 mentioned “A Review of Indirect Method in Fire Tube Steam Boilers”. In this paper, the efficiency analysis of fire tube steam boilers according to pertinentparameters is presented. From the study done by author he finds the result is the indirect method is the most accurate method to determine boiler efficiency and threeof the most effective parameters are flue gas temperature, ambient temperature, and the fuel type effect on efficiency.

Kumar, 2020 is done their research on “An Exergy Analysis of a 250 MW ThermalPower Plant”. The exergy analysis was carried out for the system components separately and the exergy destruction of various components in the plant was evaluated. The overall exergy efficiency of the plant was calculated to be 34.75%.

III. PROBLEM IDENTIFICATION

The main objective of previous research is to use Experiment on co-combustion of crop stalk and coal is carried out in a 260t/h CFB boiler, and the performance of the CFB boiler is tested under 4 mixing ratios of crop stalk to coal, 0%, 10%, 20% and 30%. The results show that under the 4 mixing ratios, the CFB boiler could run safely and stably with 85% MCR and the boiler thermal efficiency is almost the same but emissions of SO_2 decrease apparently.

The present work has been carried out on Experiment on co-combustion of textile waste with coal is carried out in a 135t/h Atmospheric fluidized bed combustion boiler Industry yarn mandideep. Calculate Efficiency of Atmospheric fluidized bed combustion boiler and Circulating fluidized bed combustion boiler for different GCV and compare results. The power output of Atmospheric fluidized bed combustion boiler is not to be exceeding above 80MW and also due to large numbers of unburnt particles, it has low combustion efficiency which results high pollution contents.

IV. OBJECTIVES

As per the literature review and research gap the objectives of this dissertation are as follows:

1) Calculate the performance of Circulating fluidized bed combustion boiler with the help of variation of boiler loads and excess air.
2) Calculate economic performance of Circulating fluidized bed combustion boiler over Atmospheric fluidized bed combustion boiler.
3) Calculate the efficiency of Circulating fluidized bed combustion boiler over Atmospheric fluidized bed combustion boiler for Different calorific value of coal.
4) By calculating all above-mentioned parameters, the overall objective of this dissertation is to minimize exergy losses and increase Revenue of the plant.

V. RESEARCH METHODOLOGY

A. *Performance Of Steam Generator*

1) *Evaporation Rate:* The quantity of water evaporated into steam per hour is called the evaporation rate. it is expressed as kg of steam/hour kg of steam /h/m^2 of heating surface, or kg. of steam/h/m^3 of furnace volume, or kg of steam/kg of fuel fired.
2) *Equivalent Evaporation:* It is the equivalent of the evaporation of 1 kg of water at 100^0 C to steam at 100^0 C. it requires 2256.9 kj = 2260 kj.
3) *Factor Of Evaporation:* The ratio of actual heat absorption above feed water temperature for transformation to steam (wet, dry, or superheated), to the latent heat of steam at atmospheric pressure (1.01325 bar) is known as factor of evaporation.

Then equivalent evaporation = Actual evaporation× Factor of evaporation
Where

$$m_e = [(h_1 – h_f) / h_{fg}]\times m_s = F \times m_s$$

h_1 = specific enthalpy of steam actually produced
h_f = specific enthalpy of feed water
h_{fg} = specific enthalpy of evaporation at standard atm. Pressure
m_s = actual evaporation expressed in kg/kg of fuel or kg/h of Steam
m_e = equivalent evaporation expressed in kg/kg of fuel or kg/h
F = factor of evaporation

B. *Performance Analysis*

The performance of a boiler may be explained on the basis of any of the following terms:
EFFICIENCY: It may be expressed as the ratio of heat output to heat input.
COMBUSTION RATE**:** It is the rate of burning of fuel in kg/m^3 of grate area/h.
COMBUSTION SPACE: It is the furnace volume in m^3/kg of fuel fired/h.
HEAT ABSORPTION: It is the equivalent evaporation from and at 100^{0}C in kg of steam generated/m^2 of heating surface.
HEAT LIBERATED: It is the heat liberated/m^3 of furnace volume/h.
CALORIFC VALUE OF COAL DETERMINATION BY BOMB CALORIMETER
The bomb calorimeter consists of a robust bomb vessel made of stainless steel that can endure high pressures. The bomb comes with a lid that can be tightly fitted onto the explosive.
A valve for letting oxygen in and two electrodes are provided on the lid. A ring is included with one of the electrodes to fit the silica crucible.
The bomb is put inside a copper calorimeter that contains water that has a known weight. To stop heat loss from radiation, an air jacket and a water jacket are placed around the copper calorimeter. A Beckman's thermometer and an electrical stirrer for stirring water are included with the calorimeter.

VI. TESTING PROCEDURE

The textile waste is weighed out and put into the silica crucible. Above the ring is a support for the crucible. The electrodes are covered with a thin magnesium wire that touches the fuel sample. A pressure of 25–30 atm is reached in the bomb after forcing oxygen supply there.
After complete stirring, the water's initial temperature in the calorimeter is noted. As soon as the current is turned on, the fuel in the crucible begins to burn and produce heat. During the experiment, an electric stirrer is used to agitate the water, which receives heat from the burning of fuel. The thermometer records the highest temperature it has ever read. The fuel's calorific value can now be determined using the formula below:
This paper shows the enervative ideas to update working process of thermal power plant by using circulating fluidized bed combustion boiler which is suitable for low grade fuel like as textile waste and give maximum efficiency as compared to atmospheric fluidized bed combustion boiler.
In this exergy analysis atmospheric fluidized bed combustion boiler give poor efficiency and more loses as compare to Circulating fluidized bed combustion boiler. Circulating fluidized bed combustion boiler also reduced emissions of harmful gases and unburn carbons

Fig: 1.5 Setup of bomb calorimeter

A. *Boiler Thermal Efficiency*

There are two methods to find out boiler efficiency.

1) *Direct Method*

Boiler efficiency is the ratio of heat absorbed by steam from the boiler per unit time to the heat liberated by the combustion of fuel in the furnace during the same time.

$$\text{Boiler efficiency, } \eta_b = \frac{[(h1 - hf) \times ms]}{m_f \times C.V}$$

Where –

m_s = mass of steam generated in kg/h

m_f = mass of fuel burned in kg/h

C.V = calorific value of fuel in kj/kg

2) *Indirect Method*

By this method, efficiency could be measured easily by measuring all the losses occurring in the boiler.

The following losses were applicable to all the fuel used, weather it is solid, liquid or gas fired boiler.

a) Heat used to generate steam,

$$Q = m_s (h_1 - h_f)$$

b) Heat lost to flue gases.

The flue gases contain dry products of combustion and the steam generated due to the combustion of hydrogen in the fuel.

Heat lost to dry flue gases,

$$Q_1 = m_g\, c_{pg}(T_g - T_a)$$

m_g = mass of gases formed per kg of fuel

c_{pg} = specific heat of gases

T_g = temperature of gases, ^{0}c

T_a = temperature of air entering the combustion chamber of the boiler, ^{0}c

c) Heat carried by steam in flue gases-

$$Q_2 = m_{s1}(h_{s1} - h_{f1})$$

m_{s1} = mass of steam formed per kg of fuel due to combustion of H_2 in fuel

h_{f1}= enthalpy of water at boiler house temperature

h_{s1}= enthalpy of steam at the gas temperature and at the partial pressure of The vapour in the flue gas

d) Heat loss due to incomplete combustion: If carbon burns to CO instead of CO_2 then it is known as incomplete combustion. 1kg of C releases 10,200 kj/kg of heat if it burns to CO whereas it releases 35,000 kj/kg if it burns to CO_2. if the percentages of CO and CO_2 in flue gases by volume are known, then

$$\text{Mass of C burnt to CO} = \frac{CO \times C}{CO + CO_2}$$

CO, CO2= % by volume of CO and CO_2 in flue gases

C= fraction of carbon in 1 kg of fuel

Heat lost due to incomplete combustion of carbon per kg of fuel,

$$Q_3 = \frac{CO \times C}{CO+CO_2} \times (35{,}000 - 10{,}200)$$

$$Q_3 = \frac{CO \times C}{CO+CO_2} \times (24{,}800)\ \text{kj/kg of fuel}$$

e) Heat lost due to unburnt fuel

$$Q_4 = m_{f1} \times C.V$$

m_{f1}= mass of unburnt fuel per kg of fuel burnt

f) Heat unaccounted

$$Q_5 = Q - (Q_1+Q_2+Q_3+Q_4)$$

$$Q = m_f \times C.V$$

= heat released per kg of fuel

B. Boiler Trial And Heat Balance Sheet

There are three purposes of conducting the boiler trial.

1) To determine and check the specified generating capacity. Of the boiler when working at full load conditions.
2) To determine the thermal efficiency of the plant.
3) To draw up the heat balance sheet so that

Suitable corrective measures may be Taken to improve the efficiency.

The following measurements should be observed during the boiler trial.

a) The fuel supplied and its analysis.
b) Steam generated and its quality or superheat.
c) Flue gases formed from exhaust analysis.
d) Air inlet temperature and gases exhaust temperature.
e) Volumetric analysis of exhaust gases.
f) Mass of fuel left unburnt in ash.
g) Feed water temperature.

The Heat balance sheet is a symmetric representation of heat released from burning of fuel and heat distribution on minute, hour or per kg of fuel basis. A Performa for heat balance sheet is given in table:

HEAT SUPPLIED	Kj	%	HEAT UTILIZATION	Kj	%
Heat supplied by fuel	$Q=m_f \times C.V$	100%	1. Heat used to generate steam.	$Q_1=m_s \times (h - h_{f1})$	$\frac{Q_1}{Q} \times 100$
			2. Heat carried dry flue gases.	$Q_2= m_s\, c_{pg}(T_g - T_a)$	$\frac{Q_2}{Q} \times 100$
			3. Heat carried by steam in flue gases.	$Q_3= m_{s1}(h_{s1} - h_{f1})$	$\frac{Q_3}{Q} \times 100$
			4. Heat lost due to incomplete combustion.	$Q_4= \frac{CO \times C}{CO+CO_2} \times C.V$	$\frac{Q_4}{Q} \times 100$
			5. Heat lost due to unburnt fuel.	$Q_5 = m_{f1} \times C.V$	$\frac{Q_5}{Q} \times 100$
			6. Heat unaccounted	$Q_6= Q - (Q_1+Q_2+Q_3+Q_4+Q_5)$	$\frac{Q_6}{Q} \times 100$
	Q	100%		Q	100%

Table: 1.1 Heat balance sheets

VII. RESULT & DISCUSSION

Industry yarn is a textile compony where availability of low grade fuels but using Atmospheric fluedized bed combustion boiler which is not suitable for using low grade fuels.now in this reasearch we have replace AFBC Boiler by using of CFBC Boiler

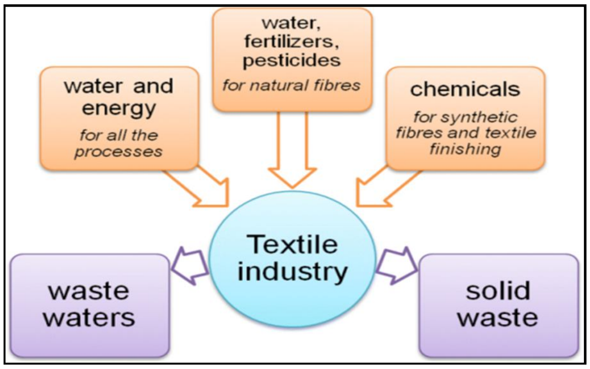

Figure 1.6 Representation of textile industry by line diagram

Following table represents the standard data obtaind from 30MW Thermal power plant with AFBC Boiler (Industry yarn mandideep) with capacity 135 ton/hr. These values are assumed to be constant during all calculation under different load conditions & varios percentage of exess air:

Sr. No.	Description	Properties
1.	Grass calorific value of coal	3500 kcal/kg
2.	Feed water temperature	180^{o}c
3.	% of oxygen in flue gases	5.5
4.	% of co_2 in flue gases	11
5.	Flue gas temperature	140^{0}C
6.	% Hydrogen in fuel	1.2
7.	Ambient air temperature	35^{0}C
8.	Humidity of air	0.018 kg/kg of dry air
9.	Theoretical air required for boiler	4.58 kg/kg of coal
10.	Actual mass of air supplied	5.95 kg/kg of coal
11.	Specific heat of superheated steam	0.5kcal/kg,k
12	Boiler pressure	96 bar
13.	Steam temperature	380^{0}C
14.	Enthalpy of steam	3060 kj/kg

Table: 1.2 Standard Values

Sr. No.	Description	Properties
1.	Boiler load	65%
2.	mass of steam	87.75tph
3.	mass of fuel	19.57tph

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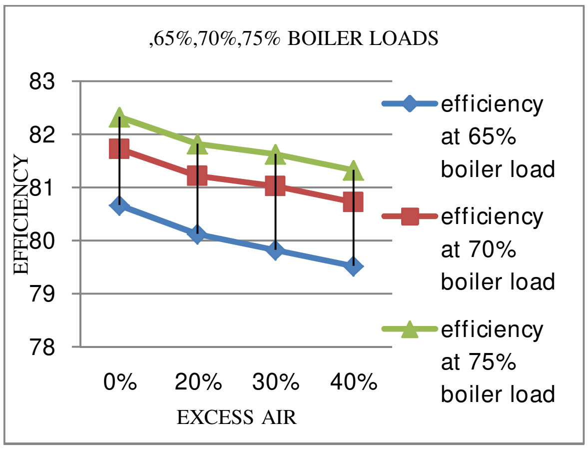
A. Comparison Between CFBC & AFBC Boiler

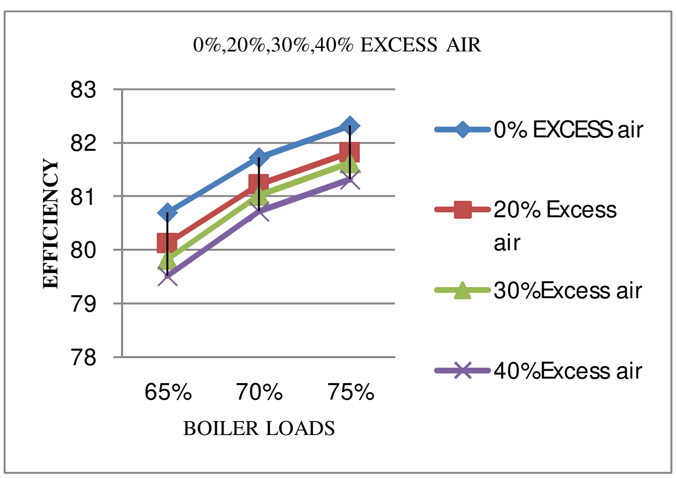
Sr. no.	PARAMETERS	CFBC BOILER	AFBC BOILER
1.	Quantity of Coal Used	87600 tonnes per year	1,66,4,40 tonnes per year
2.	Capacity	150MW	30MW
3.	Quantity of Low-Grade fuel used	78,8,40 tonnes per year	-
4.	Quantity of Fly Ash	24966 tonnes per year	49932 tonnes per year

B. Efficiency Variation with 65%,70%,75% Boiler Load



Graph: 1.1 Efficiencies Versus Excess Air

C. Efficiency Variation with 0%, 20%, 30%, 40% Excess AIR



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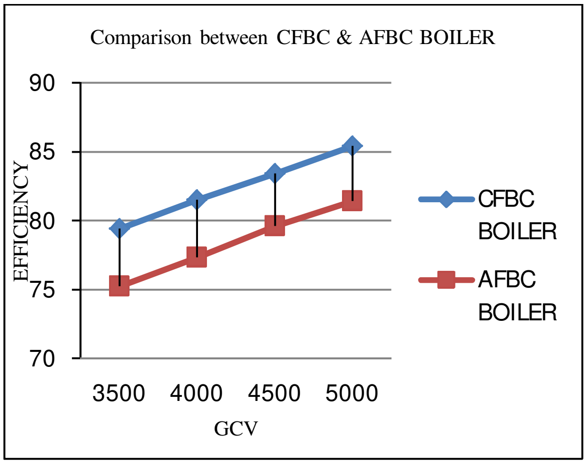
D. Comparison Between AFBC & CFBC Boiler With Variation Of GCV



VI. CONCLUSION

The following conclusions have been drawn from the experimental results: -

1) This study shows the working process of Industry yarn thermal power plant and indicates the Performance of Circulating fluidized bed combustion boiler over Atmospheric fluidized bed combustion boiler which can be clearly shown the major difference on the basis of cost parameters.

Sr. No.	COST PARAMETERS	CFBC BOILER	AFBC BOILER
1. 2. 3. 4.	Instalation Cost Coal Cast Maintenance cost of Low-grade fuel	81,25,600/- 43crore per year 15lac 1crore 97 lac	99,27,825/- 83crore per year 32lac -
	Total Cost	45,93,25,600/-	84,31,27,825/-

2) In this study show the variation of fuel consumption for various boiler loads and also steam generation also varies at different boiler loads.
3) In this study show the variation of excess air with fuel consumption and basically 0 % excess air use to reduce the loses and improve boiler efficiency.
4) In this study the calculation of efficiency based on 20%, 30%, 40% excess air which gives the reduction in boiler efficiency due to excess air.
5) In this study we are see that at minimum boiler load the efficiency of boiler is minimum in range which is show in graph and with the variation of boiler load efficiency of boiler range also vary which is clearly show in graph.
6) Boiler load and excess air variation help to improve the boiler efficiency in next graph we are see that at 0% excess air the boiler efficiency range is maximum and at 40 % excess air the boiler efficiency range is minimum.
7) By using of Circulating fluidized bed combustion boiler which is suitable to burn various types of low grade fuels like as textile waste due to that Coal reduced 30-40% of total requirement.
8) Due to Utilization of textile waste and reduction in Coal requirement Total Revenue from operation will increases by 40-45% as per discussion in Annual report.

Sr. No.	PARAMETERS	YEAR	CFBC BOILER	AFBC BOILER
1.	REVENUE (IN CRORE)	2018-19	8745	6415
		2019-20	8942	6325
		2020-21	9102	5926
		2021-2022	9215	5725
2.	EBITDA (IN CRORE)	2018-19	1526	1350
		2019-20	1604	1055
		2020-21	2124	955
		2021-2022	2558	945
3.	PAT (IN CRORE)	2018-19	712	696
		2019-20	845	545
		2020-21	1247	367
		2021-2022	1535	285
4.	Return on Net worth (IN CRORE)	2018-19	5100	4632
		2019-20	5324	5239
		2020-21	6724	5666
		2021-2022	7425	6139

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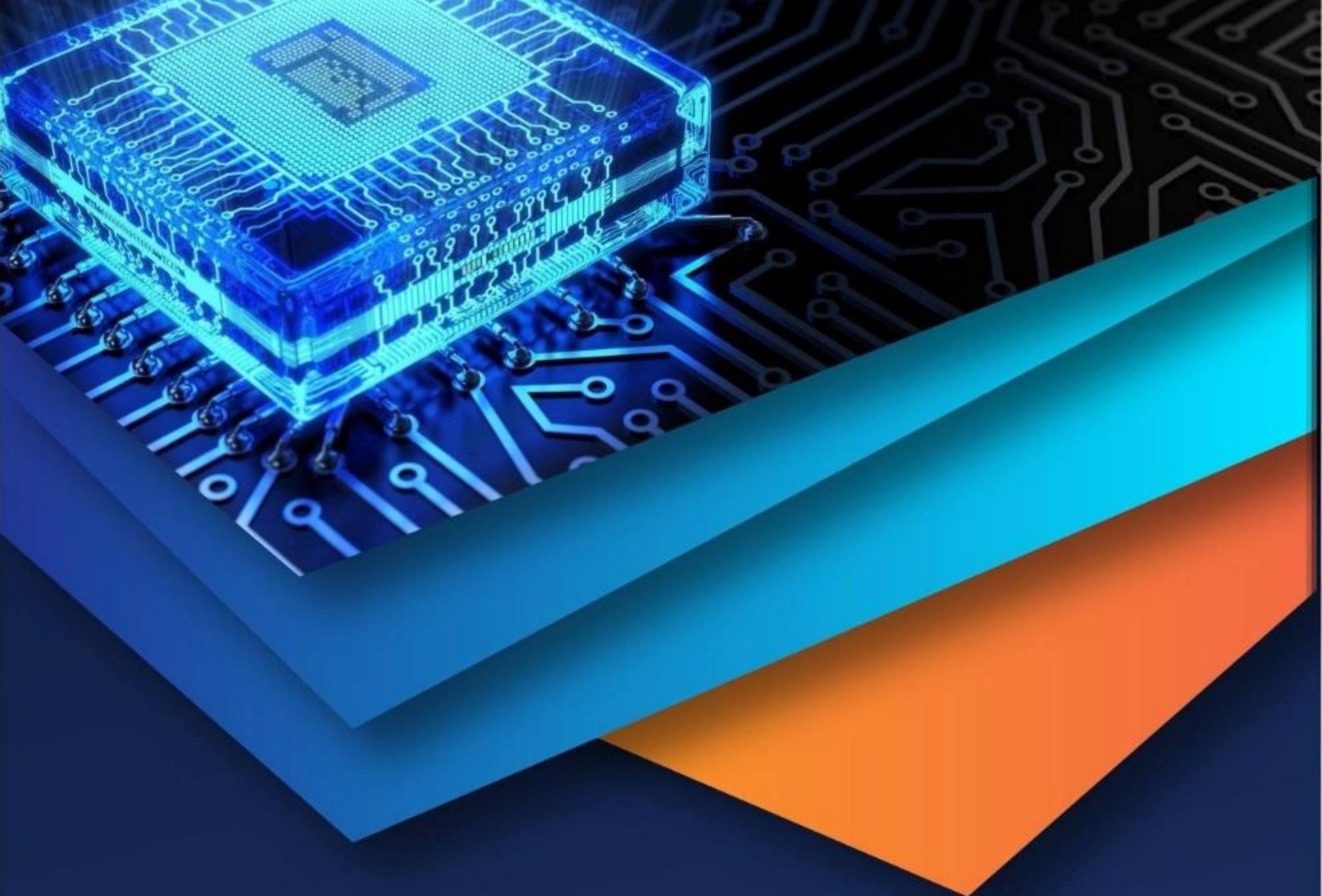

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