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Performance Guarantee Test Assessment of CFBC Boiler

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Abstract

Performance guarantee test assessment is necessary terms for finding boiler efficiency and evaporation ratio. Efficiency improvement is better for fuel saving & energy cost. Day by fuel consumption is increase so use of this properly. Boiler use mainly coal as fuel, there are so many losses in boiler system which decrease performance of boiler and increase operation cost. Efficiency improvement is achieved by calculating of different reading by excel sheet analysis data are taken from measurement of many parameter of CFBC boiler at OCL, Chittapur, Karnataka.by calculating it is found that actual value of boiler efficiency is 82.45% and design value efficiency is 84.00%By observing all parameter major parameter affect moistwhich affect the boiler. Waste Heat is available from sources .By the use waste flue gas parameters to produce electricity as by-product using a special principle called Magneto Hydro Dynamic (MHD) principle.

Keywords: Performance Guarantee Test, Efficiency of CFBC Boiler,Various Heat Loses, Waste Heat Recovery, Magneto Hydro Dynamic (MHD)

I. INTRODUCTION

The study deals with the brief account of present energy scenario of India. The scope of the presented work towards better utilization of energy, statement of the problem, Objectives of study and Limitation of study are covered.

I. ENERGY SCENARIO IN A PROCESS INDUSTRY

The considerable rise in electricity demand throughout the world has resulted in enormous increase in power plant size installation and in their size. One must know the causes of poor efficiency and tools to rectify these trends. In India, present energy scenario indicates that demand is increasing at a rate of 9-10% p.a, generating capacity at a rate of 5-6% pa. So gap between demand and supply is increasing at a rate of 3-4% p.a. So it is necessary to conserve energy. As all know that “Every unit saved is equal to 2units generated”.Performance of the boiler, like efficiency and evaporation ratio reduces with time, due to poor combustion, heat transfer fouling and poor operation and maintenance. Efficiency testing helps us to find out how far the boiler efficiency drifts away from the best efficiency. Any observed abnormal deviations could therefore be investigated to pinpoint the problem area for necessary corrective action. Hence it is necessary to find out the current level of efficiency for performance evaluation, which is a pre requisite for energy conservation action in industry.

A. Scope ofTheStudy

Keeping in view of the above mentioned scenario, Cogeneration involving low pressure heat recovery systems for steam, chilling & power generation etc have been developed which utilize heat from engine exhaust there by combining generating power, steam & chilling. This in turn reduces the fuel consumption in the fired equipment by utilizing the waste heat of exhaust gases. Thus, the energy made available by the system is free of cost. The outlet temperatures of waste heat recovery boiler in these kinds of Cogeneration system is around 135-140° C depending upon the system. Generally temperatures in this range are considered to be a safe level limit of the flue gas temperature depending on the type of fuel used. Therefore, the development of such a technology for recovering the heat from the waste flue gases is good news particularly when fuel prices are spiraling up. There are many Cogeneration operating systems, which have improved the efficiency for a wide spectrum of industries by recovering heat from engine exhausts.

B. Objective Of Study

The objectives of flue gas recovery is to achieve and maintain optimum energy procurement and utilization of throughout the industry

- To minimize energy waste without affecting production and quality
- To minimize environmental effects.

C.Literature Review

The study deal with literature review about thermal power plant and heat transfer improvement method

MasoudAsadi et al., (2013), Fin plate heat exchanger are heat transfer. It use are seen in day to life. It is good for heat transfer performance .The geometry of heat exchanger is best for heat transfer process. As extended part of fin will absorb heat more as it got more surface area. This paper contains a new method for calculating total heat transfer area in a plate-fin heat exchanger with waviness surfaces. The surfaces with wavy pattern are used for heat transfer, as it is sinusoidal curve it need to consider many parameter for calculation, so it need more time and difficult too. To overcome such problem as per engineering point of view, paper contained method can be used in to optimization process. [1]

ZulfiqarKhattaket al., (2012), the waste heat is heat which is expelled out after process of combustion through chimney. Before releasing to atmosphere it contain still energy such as heat energy. This heat energy still can be reused, economics of industries can be improved and can save mother earth. This reuse of heat is also known as heat recovery, this heat recovery depend on industries ergonomics, waste gases temperature. The maximum quantity of hot flue gas is produced by boiler, kilns, oven and furnaces. If some amount of is recovered it will help in all prospect of industries .it can from fuel saving to production. The energy lost in waste gases cannot be fully recovered. The purpose of this work was to study the performance of the WHR technique in detail, so that useful measures have to be taken in order to fulfill the energy shortage problem. [2]

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S. Shanthakumara, et al.,(1991), the report contain about flue gas conditioning which help to increase efficiency in electrostatic precipitators (ESP), as flue gas contain harmful chemical as to be removed which is done by addition of some chemical additive and sprinkling of water to flue gas. Due to this process efficiency of electrostatic precipitator increases and reduction in level of SPM. . This process need to be investigating all parameter such as emission level, percent of carbon before in utilizing this method. Flue gas conditioning is better choice for improving performances of ESP in which sulphur trioxide and ammonia. The ammonia and sulphur trioxide are helpful agent for altering the properties of fly ash or dust particles. So it improves collection efficiency. [3]

Shi Chang Wuet al.,(2014), the flue gas from chimney of power station is waste gas but still it contain more heat energy compare to other recoverable unit .flue gas required more investigation as it contain harmful chemical. Decrease of flue gas temperature from 115°C to 40°C by heat recovery .this will help local humidity level and thermal NO_x. The dispersion of flue gas will be some around 160m away from ground level. NO_2 concentration increase in atmosphere with decrease in height .the potential effect of heat recovery vary from flue gas on surrounding air quality were can be investigated by simulation of gas dispersion using computational fluid dynamic technique in term of humidity and NO_x conversion. Decreased temperature may reduce the fluid buoyancy which acts in part as a driving force, and thereby decrease the emission rate at the end of the stack. It finally may deteriorate the discharging gas dispersion. [4]

SubodhPanda et al.,(2013), In power plant loss reduction can be done at blow down .this paper consider a design which control blow down ,to optimizes loss. Due to optimization of blow down will maintain TDS level and reduces indirect heat loss. Efficiency of any boiler can increased by minimizing of various heat loss of boiler , so that amount of energy input in boiler by burning the fuel can be maximum utilization for generation of steam cost of steam can be minimized ultimately. The advantage of this it can perform nonlinear mapping between input and outputs, by which control of process become easy, any problem be find soon. For handling of this does not required any expert person. [5]

III.THERMAL POWER STATION

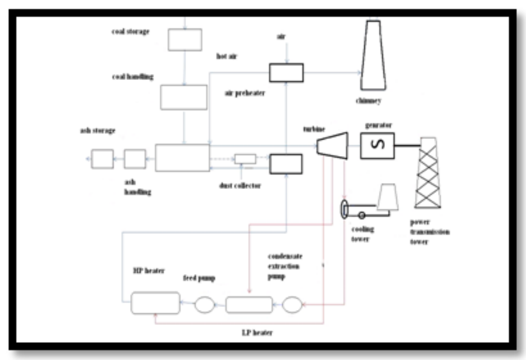

Fig 1: Schematic diagram of coal fired thermal power plant

It deal with the coal fired thermal power plant, in plant bobbling bed boiler is used .the chapter feature of bobbling bed boiler, in that fluidized bed combustion play vital role. In plant Circulating Fluidized Bed Combustion (CFBC) is in use it process and also advantages mentioned . The greatest variation in the design of thermal power stations is due to the different fossil fuel resources generally used to heat the water. Some prefer to use the term energy center because such facilities convert forms of heatenergy into electrical energy. Certain thermal

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power plants also are designed to produce heat energy for industrial purposes of district heating, or desalination of water, in addition to generating electrical power. Globally, fossil fueled thermal power plants produce a large part of man-made CO_2 emissions to the atmosphere, and efforts to reduce these are varied and widespread.

A.Fluidized Bed Combustion

The efficiency levels of India, however, were lower at 36 to 37 per cent. An alternative technology, Fluidized Bed Combustion (FBC), was developed to raise the efficiency levels. In this technology, high pressure air is blown through finely ground coal. The particles become entrained in the air and form a floating or fluidized bed. This bed behaves like a fluid in which the constituent particles move to and fro and collide with one another.Fluidized bed can burn a variety of fuels-coal as well other non-conventional fuels like biomass, petro-coke, and coal cleaning waste and wood.

There are three basic types of fluidized bed combustion boilers:

- Atmospheric classic fluidized bed combustion system (AFBC).
- Atmospheric circulating (fast) fluidized bed combustion system (CFBC)
- Pressurized fluidized bed combustion system (PFBC).

B. Circulating Fluidized Bed Combustion Process

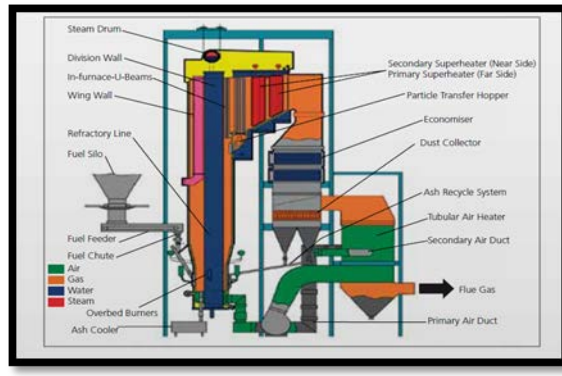

Fig 2.CFBC Process chart

The CFBC boiler is capable of burning fuel with volatile content as low as 8 to 9 percent (e.g. anthracite coke, petroleum etc. with minimal carbon loss). Fuels with low ash-melting temperature such as wood, and bio-mass have been proved to be feedstock's in CFBC due to the low operating temperature of 850-9000 C. The process employs a Circulating fluidized bed combustor that operates at a temperature of around 800-9000C. The fuel (crushed coal) along with the sorbent (limestone) is fed to the lower furnace where it is kept suspended and burnt in an upward flow of combustion air. The sorbent is fed to facilitate capture of sulfur from the coal in the bed itself resulting in consequent low sulphur emission. The combustion air is fed in two stages - Primary air direct through the combustor and Secondary air, way up the combustor above the fuel feed point.

IV. PERFORMANCE GUARANTEE TEST ASSESSMENT OF BOILERS

The indirect method testing, which help calculate losses in plant, it in plant many sources are there of energy which are consider waste. It contains observation, test condition and precaution for testing.

The chapter contain boiler efficiency and calculation by indirect method.

A. Boiler Parameters-

1) Capacity of each boiler – 94TPH
2) Superheated steam pressure at boiler main stop valve – 111 kg/cm2
3) Superheated steam temperature at boiler main steam stop valve – 540 deg C
4) Feed water temperature for at boiler economizer inlet – 235 deg C
5) Ambient temperature for the boiler performance test – 32 deg C & RH 60%
6) Each boiler shall be designed for 110% BMRC peak rating for 30 minutes in each eight hour (8 hrs) shift.
7) Twin bunker with effective storage capacity of minimum 2x300m3 for each boiler.
8) Boiler fans (FD, ID & PA) Configuration shall be 2X60% and all fans shall be provided with VVFD.
9) Bearing shall be with grease lubrication.
10) Boiler feed pumps configuration shall be 3x100% (2W+1S) for two boilers.

B.Indirect Method Testing

The efficiency can be measured easily by measuring all the losses occurring in the boilers using the principles to be described. The disadvantages of the direct method can be overcome by this method, which calculates the various heat losses associated with boiler. Thus if boiler efficiency is 90%, an error of 1% in direct method will result in significant change in efficiency. i.e. 90 ± 0.9 = 89.1 to 90.9. In indirect method, 1% error in measurement of losses will result in Efficiency = 100 – (10 ± 0.1) = 90 ± 0.1 = 89.9 to 90.1

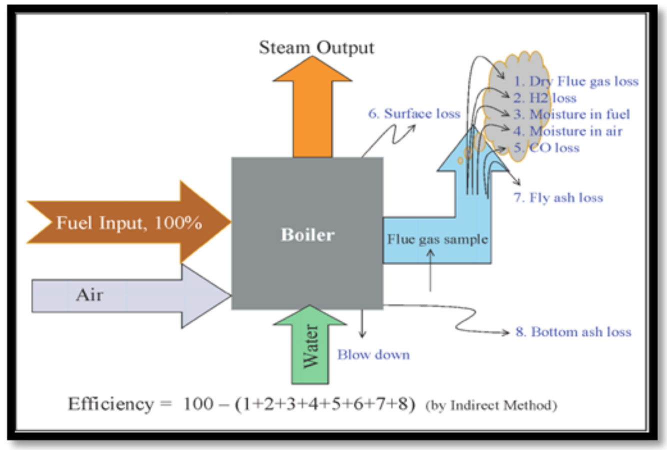

Fig 4. Various Heat Losses

The following parameters need to be measured, as applicable for the computation of boiler efficiency and performance.

a)Flue gas analysis
b) Flow meter measurements for
c) Temperature measurements for
d)Pressure measurements for
e)Water condition
f) Fuel analysis (in %)

C.Boiler Efficiency by Indirect Method:

1) Calculation Procedure and Formula

I. Heat loss due to dry flue gas

$$L_1 = \frac{m \times C_P \times (T_F - T_a)}{GCV\ OF\ fuel} \times 100$$

II. Heat loss due to evaporation of water formed due to H_2 in fuel (%)

$$L_2 = \frac{9 \times H_2 \times \{584 + C_P (T_f - T_a)\}}{GCV\ of\ fuel} \times 100$$

III. Heat loss due to moisture present in the fuel

$$L_3 = \frac{M \times \{584 + C_P (T_f - T_a)\}}{GCV\ of\ fuel} \times 100$$

IV. Heat loss due to moisture presentin air

$L_4 = \frac{AAS \times humidity\ factor \times C_p \times (T_f - T_a) \times 100}{GCV\ of\ fuel}$

V. Heat loss due to incomplete combustion

$$L_5 = \frac{\%CO \times C}{\%CO + \%CO_2} \times \frac{5744}{GCV\ of\ fuel} \times 100$$

VI. Heat loss due to radiation and convection

VII. $L_6 =$

$$0.548 \times \left[\left(\frac{T_s}{55.55}\right)^4 - \left(\frac{T_a}{55.55}\right)^4\right] + 1.957 \times (T_s - T_s)^{1.25} \times \sqrt{\left[\frac{(196.85\ V_m + 68.9)}{68.9}\right]}$$

7. Heat loss due to unburnt carbon in fly ash (%)

$$L_7 = \frac{Total\ ash\ collect\ /kg\ of\ fuel\ burnt \times G.C.V\ of\ fly\ ash \times 100}{GCV\ of\ fuel}$$

8. Heat loss due to unburnt carbon in bottom ash (%)

$$L_8 = \frac{TOTAL\ ASH\ COLLECTED\ PER\ KG\ OF\ FUEL\ BURNT \times G.C.V\ OF\ BOTTOM\ ASH \times 100}{GCV\ of\ fuel}$$

D.Boiler Heat Balance:

Various Heat losses in boiler

1. Dry flue gas loss= 1.21%
2. Loss due to hydrogen in fuel = 5.64%
3. Loss due to moisture in fuel= 1.569%
4. Loss due to moisture in air= 0.50%
5. Partial combustion of C to CO= 3.406%
6. Surface heat losses=0.45%
7. Loss due to Unburnt carbon in fly ash= 4.75×10^{-3} %
8. Loss due to Unburnt carbon in bottom ash= 4.78%

Total Losses in % =17.55 (i.e., 90069.717 kJ)

E. Coal Consumption per Shift (Eight Hour)

Length of grate =1.9 m

Width of grate = 0.85 m

Water evaporation rate = 5 kg/kg of coal

Coal burning rate = 120 kg /m^2/hr.

So, it burn in $1m^2$ about 120 kg of coal

$\therefore$ area of grate is $= 1.9 \times 0.85 = 1.615 m^2$

the coal buring rate in the area of grate $= 120 \times 1.651 = 193.8$

coal consumption per shift $= 193.8 \times 8 = 1550.4 kg$

coal consumption for one day $= 1550.4 \times 3 = 4651.2 kg$ of coal

V. MAGNETO HYDRODYNAMIC (MHD) POWER GENERATION

A.Working Principle

The MHD generator can be considered to be a fluid dynamo. This is similar to a mechanical dynamo in which the motion of a metal conductor through a magnetic field creates a current in the conductor except that in the MHD generator the metal conductor is replaced by conducting gas plasma. When a conductor moves through a magnetic field it creates an electrical field perpendicular to the magnetic field and the direction of movement of the conductor. This is the principle, discovered by Michael Faraday, behind the conventional rotary electricity generator. Dutch physicist Antonon Lorentz provided the mathematical theory to quantify its effects.

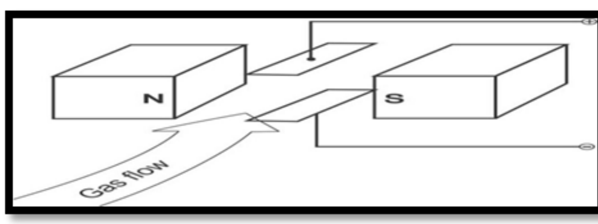

Fig 5.Magneto hydrodynamic (MHD) Power Generation[30]

B. MHD System

The MHD generator needs a high temperature gas source, which could be the coolant from a nuclear reactor or more likely high temperature combustion gases generated by burning fossil fuels, including coal, in a combustion chamber. The diagram below shows possible system components. The expansion nozzle reduces the gas pressure and consequently increases the plasma speed (Bernoulli's Law) through the generator duct to increase the power output (See Power below). Unfortunately, at the same time, the pressure drop causes the plasma temperature to fall (Gay-Lussac's Law) which also increases the plasma resistance, so a compromise between Bernoulli and Gay-Lussac must be found. The exhaust heat from the working fluid is used to drive a compressor to increase the fuel combustion rate but much of the heat will be wasted unless it can be used in another process.

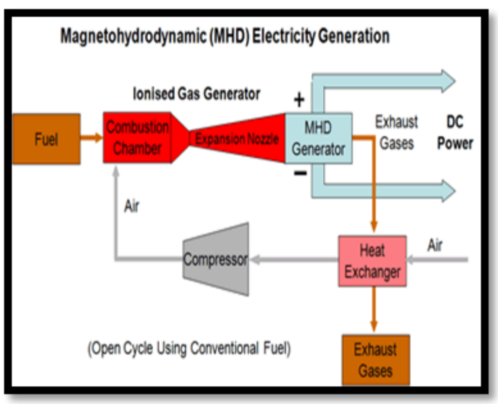

Fig 6. MHD Electricity Generations

C.MHD System & Working Fluid

1) Open Cycle MHD Power Generation

Combustion Gas (～3000 K) ＋ Seed （K_2CO_3～1%）

Thermal Equilibrium Plasma （$T_e \sim T_g$） $\sigma < 1 \sim 10$ S/m

- ➢ Efficient Coal Utilization

2) Closed Cycle MHD Power Generation

Inert Gas (～2000K) ＋ Seed （KCs 0.1-0.01%）

Non-Equilibrium Plasma ($T_e > T_g$) $\sigma \sim 100$ S/m

- ➢ Various Energy Source Utilization

VI CONCLUSION

It has been analyses that a part of energy loss occurs through flue gases. The carbon content in the coal has to be proper. The presence of moisture has a detrimental effect on overall efficiency. If we use the heat recovery system to recover the heat losses through flue gases then it will be more useful for us. The development of MHD for electric utility power generation is an objective of national significance. The practical efficiency of this type of power generation will not be less than 60%. Hence it will be most significant in upcoming decade .Further its principle can be developed and used in wide industrial applications like automobiles, power plant for high power generation. Implementation of this idea is simple which result in the extra power generation from the existing operation. To solve this (making MHD cost effective), will succeed. It is expected to overcome all the demerits.

Scope of future: The study on complete utilization of heat from power plant is to be made by use different technical. Care has to be taken to use corrosion-resistant materials since the condensate is relatively aggressive and the flue channel, and reduces cost as much as possible

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