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Study the Steps of Improving the Boiler Efficency using Combution Air and its Requirements

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Abstract— Air pre-heater and economizer are warm move surfaces in which air temperature and water temperature are raised by exchanging heat from other media, for example, flue gas. Hot air is important for fast ignition in the heater and furthermore to dry coal in processing plants. So a fundamental evaporator frill which fills this need is air pre-heater. The air pre-heater isn't required for task of steam generator, however they are utilized where an investigation of expense demonstrates that cash can be spared or effective ignition can be acquired by their utilization. The choice for its appropriation can be made when the budgetary points of interest is weighed against the capital expense of heater. The effectiveness of the boiler increments with the expansion in the temperature of the combustion air utilized in the furnace. This is accomplished by the expanded temperature of the vent gas noticeable all around preheater and economizer zone. This paper manages the diverse approaches to acquire the maximum heat from the flue gas going through the air preheater and the economizer zone to enhance the boiler ability. [1].

Keywords- *Air pre-heater; heat transfer; steam generato, financial advantages, preheater, boiler efficiency*

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I. INTRODUCTION

Air heater is a vital Boiler helper which fundamentally preheats the combustion air for quick and effective ignition in the furnace. The air heater recuperates the waste heat from the active flue gas of a Boiler and exchanges the equivalent to the combustion air. In a utility Boiler the flue gas leaves the economizer at a temperature of around 3800C. As every 550C drop in flue gas temperature improves the Boiler efficiency by about 2.5%, having an air heater in the downstream of economizer the Boiler efficiency is considerably improved. Further the air heater may also be used for heating the air to dry the coal in the pulverizing plant [2].

II. TYPES OF AIR PREHEATER

There are two types of air preheater .These are as follows:

- Regenerative air preheater
- Recuperative air preheater

A. REGENERATIVE AIR PREHEATER (RAPH)

Rotating plate type regenerative air preheater (RAPH) is used in large capacity boiler due to its compactness .It captures the heat of exhaust flue gas by passing it over the heat absorbing metallic element and then, dissipates this heat to the combustion air. Heat absorbing elements are installed within [9] a casing that is divided into two (bisector),three (tri sector) or four (quad sector) sectors. The elements placed in the sector housing are renewable. Rotor of the air heater is rotated at slow speed by a motor .Elements alternately come in contact with hot flue gas and cold inlet air (from FD fan). These heat transfer elements pickup heat from the hot flue gas and dissipate it to the cold air.

Whole air preheater casing is supported [10] on the boiler supporting structure and connected to the flue gas duct through expansion joints. The vertical rotor is supported on thrust bearings at the lower end. Sealing arrangement is done to avoid leakage of flue gas or air between the sectors or between the duct and the casing while in rotation. To avoid uneven expansion and contraction, it is required to start the rotation of RAPH before starting of the boiler and keep it rotating for some time after the boiler is stopped.

Tri sector RAPH is commonly used in a pulverized boiler. Here, a single heat exchanger is used to heat both primary air and secondary air.

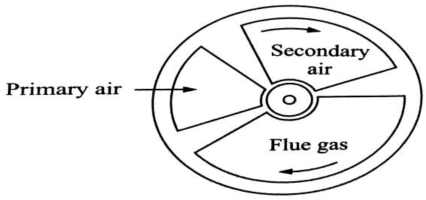

Figure 1-Trisector regenerative air preheater

B. RECUPERATIVE AIR PREHEATER

Recuperative air pre heater is generally called static air pre heater .This is a shell and tube type heat exchanger. The flue gas flows inside the tubes and air flows at the shell side. Due to very low heat transfer co-efficient between the flue gas and air, the transfer surface of the air heater is large [7] [8].

A very simple air heater is shown in fig 2 this is a single flow type air heater. To get an optimal air velocity, baffles are placed .In some cases split flow type air heater is used.Here,air is distributed into two or more separate flows. Air box is required where there is a change in the direction of air flow .Cold air from the FD fan enters to the air heater at the exhaust end of the flue gas and leaves at the inlet end of the flue gas (cross flow). The air flow path is partitioned to get an optional air velocity. Flue gas flows in in single flow or split flow scheme depending upon the boiler capacity

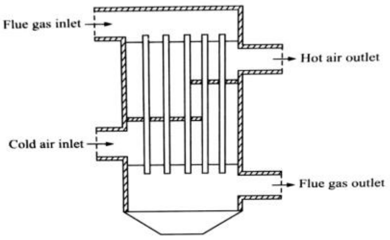

Figure 2- Recuperative or static air preheater

III. STEAM AIR HEATER

As discussed earlier, the flue gas temperature at the exit end of air heater is low, as cold air enter this end. This end is prone to severe corrosion due to sulphuric acid dew point. So, it is required to heat the air to some extent before entering it into the air heater. Steam coil air preheater (SCAPH) [11] is the best solution in this case.

In this method, air is preheated by low temperature steam .Combination of steam air heater and air heater is called as combined air heating. Low temperature corrosion at the air heater can be avoided in this arrangement.

In steam heater, steam at around 120C to 150C is used. Steam flows in the coil and air passes over these coils and get heated .The steam after cooling is condensed. This condensate is collected and reused in the boiler. The steam used here is normally of low pressure and is obtained from the turbine bleed or process waste.

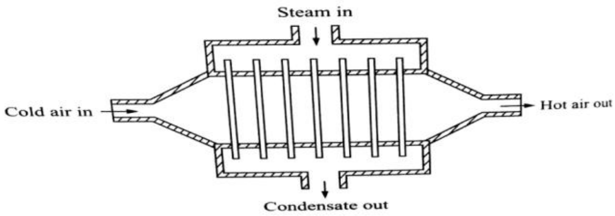

Figure 3-Steam air heater

IV. PRIMARY AND SECONDRY AIR

Oxygen is necessary for combustion and it is obtained from atmospheric air. Total air supplied to the boiler combustion chamber is divided into two parts. The first part is called as primary air. Primary air supports the flame and takes part in the initial combustion process. The second part is called as secondary air. This air is admitted into the furnace to create turbulence and ensure complete combustion of the fuel.

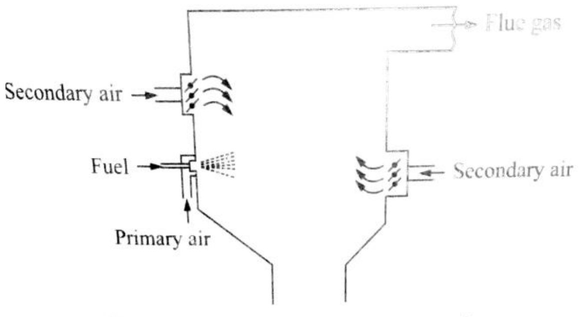

Figure 4-Primary and secondary air

In case of pulverized coal-fired boiler, primary air is used to carry the pulverized coal into the furnace.

In FBC boiler, primary air is required to carry the fuel and secondary air is supplied to wind box for fluidization. In case of oil and gas-fired boilers, primary air supports the flame and secondary air is used for entire combustion of fuel . In stoker and grate-fired boilers, primary air is supplied below the fuel bed.

V. EXCESS AIR

It was discussed earlier that to burn certain amount of fuel, some theoretical air is required [3].

It is given by

$$4.35[(8/3 C + 8 H2 + S) – O2] kg$$

This is the theoretical air required. But, in practice, some more air or extra air is supplied to ensure complete combustion of the fuel [4].

If more air is supplied, then there will be a cooling effect and the efficiency will decrease. Also, if air sis supplied, then complete combustion will not take place. Combustible substances will escape from the stack. Again, there will be a loss in efficiency. So, it is required to adjust the air supply in such a way that complete combustion will take place without much extra or excess air

Excess air supplied can be measured by an oxygen analyzer that measures the oxygen percentage in the flue gas. It should be monitored online for better control. Excess air monitoring is done for efficient use of fuel.

Excess air percentage can be calculated as:

Excess air percentage = Oxygen percentage in flue gas x 100 / (21- Oxygen percentage)

For 4 % oxygen, excess air percentage = 4 x 100 / (21-4) = 23.5 %

Excess air requirement of different boiler is not same. This is mentioned in Table.

Type of Boiler	Excess Air	Oxygen Percentage (by volume)
Gas - fired	5% -10 %	1 % - 2 %
Oil – fired	10 % - 15%	2% - 3%
Pulverized coal – fired	15% - 20 %	3% - 3.5 %
Stoker – fired	20% - 30%	3.5% - 5%

Table1 Excess Air Requirements of Different Boilers

VI. ECONOMIZER

Economizer is used to utilize the fuel economically or make the boiler economical. Hot exhaust flue gas from the boiler which would have gone to the atmosphere, is used to increase the efficiency of the boiler. This is a medium of heat transfer in which flue gas flows in a shell organize with water tubes. Heat of flue gas is utilized to increase the temperature of water so as to increase sensible heat of water.

It is found that by decreasing the exhaust flue gas temperature by 16 C, boiler ability increase by 1 %. Also by increasing the feed water Temperature by 6 C, boiler efficiency increased by 1 %. With the help of an economizer, exhaust flue gas temperature can be decreased and feed water temperature can be increased. After economizer, hot flue gas get into the air heater. The temperature drop is permissible to such an extent so that the flue gas temperature does not come down below the dew point.

VII. STEPS TO IMPROVE BOILER EFFICIENCY

Boiler Efficiency is of prime significance to the procedure plants. Enhancing the boiler proficiency even somewhat can drop down the fuel charges fundamentally [4]. Enhancement in boiler effectiveness can be accomplished if certain means are pursued. This Article characterizes a basic advance arrangement which will guarantee enhanced boiler effectiveness.

Monitor Feedwater Quality [6]
The nature of boiler feedwater influences the general boiler execution and henceforth the boiler productivity. Poor feedwater quality builds the TDS levels in the boiler drum. Expanded TDS calls for more blowdown which results in expanded blowdown losses and lower boiler proficiency. On the off chance that the TDS level isn't brought down in as far as possible, it prompts water remainder which results in poor operational productivity of the steam framework.

Blowdown Control and Heat Recovery from Blowdown [6]
To control the TDS level when limits are specified; we have to empty out water out of boiler drum with higher salt focus and supplant it with fresh water. Emptying out the water out of boilerr drum results in loss of energy as the water inside will be hot and pressurized. Manual blowdown is once in a while precise and results in either under or over blowdown. Over blowdown cuts down the boiler effectiveness. Rather than relying upon manual blowdown, executing a blowdown control framework will surely help.

Furnace Draft Tuning [6]
Pressure inside the boiler furnace to be tuned appropriately (-2 to - 5 mm of water section for little boilers) to get a decent boiler effectiveness. On the off chance when pressure falls below - 5, it will result in expanded un-burnt damage and will bring the boiler effectiveness. This makes furnace pressure draft tuning a basic acclimation to enhance the boiler proficiency.

Excess Air [6]

Abundance air builds the enthalpy damage and accordingly, the boiler effectiveness decreased. For appropriate combustion of fuel inside the furnace, certain measure of air (oxygen) is needed. In the event that adequate amount of air isn't provided, the carbon present in the fuel is deficiently oxidized to carbon monoxide and less amount of heat is discharged which cuts down the general productivity of the fuel. Then again, if the abundance air is more than needs, this air absorbs the energy by retaining the heat from burning and this energy is lost alongside the flue gases which again cut down the boiler proficiency. Observing stack oxygen levels and controlling them inside the required band is fundamental for high boiler productivity.

Fuel Quality [6]
Nature of fuel is of prime significance to the extent boiler productivity is concerned. Similarly for instance, if fuel has high dampness content, the enthalpy losses occurring will be significantly higher and therefore, the boiler productivity will descend. In the event of strong fuel terminated boilers, drying the fuel before ignition can stay away from enthalpy losses and consequently enhance the boiler productivity.

Heat Recovery from Exhaust [6]
Flue gases turning out from the boiler contain impressive amount of heat energy because of their hot temperature. This energy from the hot flue gases can be recuperated and used to warm feedwater. This framework enhances the boiler proficiency. In the event that the sulfur substance of the fuel is high, there might a danger of dew point consumption and consequently, the warmth ought to be recuperated to a specific degree as it were.

VIII. COMBUSTION REQUIREMENTS

The consuming of any hydrocarbon fuel requires oxygen from the climate in adequate Quantity to guarantee appropriate burning. Since barometrical air is a blend of oxygen and nitrogen, a lot of nitrogen must be taken care of to give adequate oxygen. Moreover, abundance air is typically given to guarantee finish burning of the fuel under defective blending conditions. The net outcome is that, in extensive steam-creating units, tremendous measures of burning air must be given to the heater and significantly more noteworthy measures of fumes gases evacuated.

For coal, an air– fuel proportion of 11:1 to 12:1 is needed. For oil this is to some degree higher. A run of the mill coal let go control plant with an electrical yield of 500 MW requires around 50 kg s– 1 of coal and around 550 kg s– 1 of air to deliver around 600 kg s– 1 of exhaust gas. This, converted into volumetric air and gas volume stream rates at the inlet and outlet, gives around 500 m3 s– 1 and 675 m3 s– 1 separately. To deal with these streams substantial ducts and fans are needed and a lot of energy is used in keeping up these streams.

Air and fuel are provided to the furnace and hot exhaust gases expelled from it. The furnace itself must work at a pressure marginally beneath barometrical pressure with the goal that exhaust gases don't blow out through different assessment and access openings when they are not shut. Be that as it may, it ought not work at too low a pressure generally excessive cold air will be absorbed into the furnace.

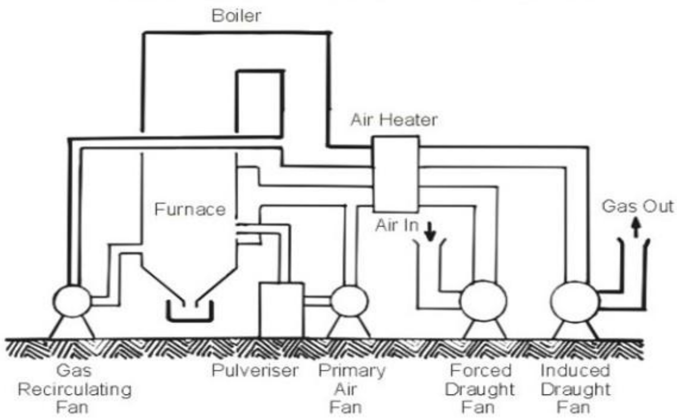

Figure 5-Air and gas path in a coal-fired boiler plant

IX. FAN CHARACTERISTICS

A. FORCED DRAUGHT FAN

The constrained draft fans normally supply all the burning air required by the furnace. They are more often medium-speed centrifugal type. They should be designed in the manner to take into consideration extra wind stream emerging from four conceivable sources. if the air heater has a hot air recirculating framework back to the constrained draft fan , it must have the capacity to deal with the additional stream at that temperature.

B. PRIMARY AIR FAN

The essential air fans give the air required to transporting pummeled fuel to the burners. Since higher pressures are needed they are as a rule of the rapid radiating compose.

C. INDUCED DRAUGHT FAN

The incited draft fans are the biggest in the plant since they need to deal with the aggregate gaseous items leaving the boiler. They might be of the medium-speed diffusive compose or the pivotal stream compose.

D. GAS RECIRCULATING FAN

The gas recycling fans work under the most burdensome conditions. They need to deal with hot gas from upstream of the air warmer on an irregular and fluctuating premise contingent on the boiler heat exchange prerequisites.

X. IMPROVING ENERGY EFFICIENCY OF BOILER SYSTEM [3]

when we talk about boiler energy saving, constantly it include the include boiler effectiveness. The boiler providers and deals individual will regularly refer to different numbers, similar to the boiler has a thermal effectiveness of 85 %, combustion efficiency 87 %, a boiler efficiency of 80 %, and a fuel to steam efficiency of 83 %.

Typically,

- Thermal productivity reflects how well the boiler vessel exchange heat. The figure more often than not bars radiation and convection damages.

- Combustion proficiency ordinarily shows the capacity of the burner to utilize fuel totally without producing carbon monoxide or leaving hydrocarbons unburned. Some burning proficiency counts represent different damages.

- Boiler proficiency could mean nearly anything. Any fuel-utilize figure must contrast energy put into the boiler and energ turning out.

- Fuel to steam productivity is acknowledged as a genuine input/output value.

The least demanding and most financially savvy strategy is to survey the fundamental boiler structure criteria and providers information used to ascertain the efficiency esteem on 5 – wide components.

1. Boiler Stack Temperature [12]:

Fuel gas or boiler stack temperature is the temperature of the combustion gases as they leave the boiler.

This temperature shows the real part of the energy not changed over to usable output. When temperature is higher than energy transferred to output is decrease and the boiler efficiency will reduce. At the point when stack temperature is calculated, it is vital to decide whether the value is proven. For instance, if an boiler keeps running on natural's gas with a stack temperature of 350 F, the most extreme hypothetical proficiency of unit is 83.5 %. For the boiler to work at 84 % effectiveness, the stack temperature must be under 350F.

2. Fuel Specification:

The fuel determined dramatically affects effectiveness. With gaseous fuels, when the hydrogen content will high, then more water vapor is created amid of combustion. The outcome is come in the form of energy loss as the vapor retains energy in the boiler and brings down the productivity of the equipment.

As a rule, common natural gas a hydrogen/-carbon (H/C) ratio of 0.31. If an H/C ratio of 0.25 is utilized for measuring efficiency, the value increases from 82.5% to 83.8%. However, if this higher efficiency fuel is not accessible, the boiler will never conduct at the higher efficiency level.

3. Heat Content of Fuel:

The efficiency calculation requires knowledge of the calorific value of the fuel (heat content), its carbon to hydrogen ratio, and whether the water product is lost as steam, or this is condensed and the latent heat (heat require to turn water into steam) is recovered.

4. Excess Air Levels:

Abundance air is provided to the boiler beyond what is needed for finish burning basically to guarantee finish ignition and to consider typical varieties in burning. A specific amount of overabundance air is given to the burner as a safety factor for adequate ignition air.

5. Ambient Air Temperature and Relative Humidity:

Surrounding conditions affect the boiler ability of boiler. Most productivity measurement utilize a surrounding temperature of 80 F and a relative humidity of 30 %. Proficiency changes more than 0.5 % for each 20 F change in surrounding temperature. Changes in air humidity would have comparable impacts, the more the humidity; the lower will be the proficiency.

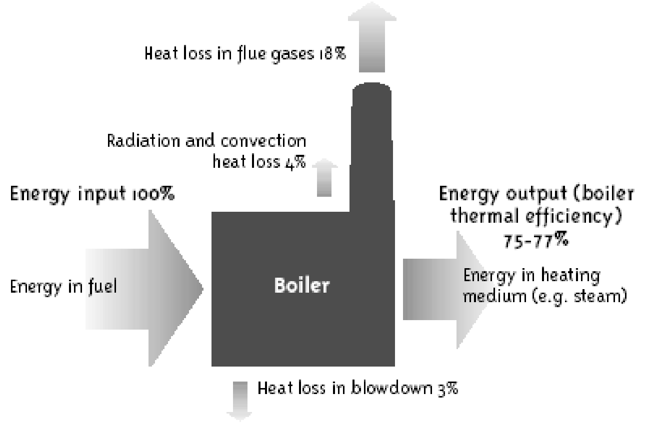

Figure 6 -Typical Energy Balance of a Boiler/Heater

XI. CONCLUSION

In this paper we have studied about Air heater, air preheater, steam air heater, primary and secondry air, steps to improve boiler efficiency, economizer, combustion requirements, fan characteristics and steps to improve energy efficiency of boiler system topics.

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