Reduction In Fuel Consumption Using Waste Heat Recovery And Blowdown Control System

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Abstract—

A machine in the present scenario requires energy to operate and more importance is given for energy conservation programs. Every machines in the plant operates continuously and uses large amount of energy. Proper management of process system can lead to energy savings, improved process efficiency, lesser operating and maintenance cost, and greater environmental safety.Many industrial heating processes generate waste energy. Use of waste-heat recovery systems decreases energy consumption. One of the most effective ways of improving the efficiency of a steam boiler is to install an economizer on the boiler. The main idea is to extract maximum amount of heat from exhaust flue gas to heat the feed water of the boiler. The feed water can also be treated in order to reduce the formation of scales and sludges which reduces the boiler blowdown and fuel consumption.

Keywords : *Economizer, Exhaust Flue Gas, Energy Saving, Waste heat recovery.*

I. INTRODUCTION

A standard boiler burns millions of rupees of fuel per year and therefore even small change in efficiency can lead to huge savings of money. The preheating of feed water in boilers is one of the most effective methods for increasing the efficiency of steam boilers. If the temperature of feed water increase to about certain level, then less firing rate is needed for reaching to a specific requirement therefore, a significant saving in fuel consumption is achieved and the efficiency be improved . The preheating of feed water inboilers is one of the most effective methods for increasing the efficiency of steam boilers. The pre heating of water can be done using waste heat recovery system.Economizer in fire tube boilers allows the recycle usage of excess heat from exhaust. Thus excess heat from the exhaust gas can be recovered using economizers.

II. METHODOLOGY

A. Boiler

A boiler is a closed vessel which is used to convert the water into high pressure steam. The high pressure steam so generated is used to generate power.Boilers are widely used in domestic and industrial applications such as:

- Thermal power plants
- Industrial processes
- Heating
- Sanitation
- Sterilizing equipment

The two primary types of boiler are:

- Fire Tube Boiler
- Water Tube Boiler

Water Tube Boiler

A water tube boiler is a type of boiler in which water circulates in tubes heated externally by the fire. Fuel is burned inside the furnace, creating hot gas which heats water in the steam-generating tubes.

Fire Tube Boiler

A fire-tube boileris a type of boiler in which hot gases from a fire pass through one or more tubes running through a sealed container of water. The heat of the gases is transferred through the walls of the tubes by thermal conduction, heating the water and ultimately creating steam.

B. Boiler Efficiency

Boiler Efficiency*is the "relationship between energy* supplied *to the* boiler *and* energy output *received from the boiler."* Boiler Efficiency usually expressed in(%) percentage.
There are two methods to measure the boiler efficiency:

1. Direct method(Input-Output method)
2. Indirect method (Heat loss Method)

The Direct Method is assumed by measuring through instrumentation and the calculated data obtained will be utilized to calculate the fuel-to-steam efficiency. The Indirect Method can be measured by considering the temporal losses totally. Therefore, the values obtained can be used to calculate the heat balance efficiency. The main benefit of this method is that the errors in measurement do not make a major change in efficiency.

1) Direct Method

Direct method of boiler efficiency test is more usable or more common.

Boiler efficiency = power out / power in

$$= (Q * (Hg - Hf)) / (q * GCV) * 100\%$$

Q = rate of steam flow in kg/h

Hg = enthalpy of saturated steam in kcal/kg

Hf = enthalpy of feed water in kcal/kg

q = rate of fuel use in kg/h

GCV = gross calorific value in kcal/kg

2) Indirect Method

To measure the boiler efficiency in indirect method, we need a following parameter like:

- Ultimate analysis of fuel (H2,S2,S,C moisture constraint, ash constraint)
- Percentage of O_2 or CO_2 at flue gas
- Flue gas temperature at outlet
- Ambient temperature in deg c and humidity of air in kg/kg
- GCV of fuel in kcal/kg
- Ash percentage in combustible fuel
- GCV of ash in kcal/kg

C. Furnace Oil

Furnace oil is also known as fuel oil is a fraction obtained from petroleum distillation, either as a distillate or a residue. In general term furnace oil is any liquid fuel that is burnt in a furnace orboiler for the generation of heat or used in engine for the generation of power.

III. EFFECT OF ECONOMIZER

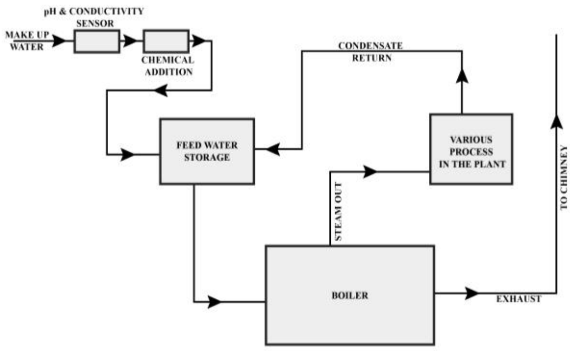
Economizers may be fabricated from common heat exchanger materials, and the tubes may be finned to increase the effective heat-transfer area. The Economizer is mounted at the chimney and the feed water is passed through it, here the economizer uses the waste heat from the boiler exhaust to pre heat the feed water before entering the boiler. It reduce the heat load of the boiler to a greater extend. Boiler efficiency improvement with a conventional economizer is dependent upon the type of fuel burned and the stack gas temperature. It is, however, independent of the quantity of makeup water. Boiler condensate return and makeup feed water are both heated first in the deaerator. This warm feed water is then fed to the economizer where it is further heated by the stack gas. The temperature of the stack gas leaving the economizer and that of the feed water entering the economizer are limited to certain levels to protect equipment from corrosive conditions.

Economizer

IV. FEED WATER MONITORING SYSTEM

Boiler water treatment is used to control alkalinity, prevent scaling, correct pH, and to control conductivity. The boiler water needs to be alkaline and not acidic, so that it does not ruin the tubes. There can be too much conductivity in the feed water when there are too many dissolved solids. These correct treatments can be controlled by efficient operator and use of treatment chemicals. The main objectives to treat and condition boiler water is to exchange heat without scaling, protect against scaling, and produce high quality steam. The treatment of boiler water can be put into two parts. These are internal treatment and external treatment. The internal treatment is for boiler feed water and external treatment is for make-up feed water and the condensate part of the system. Internal treatment protects against feed water hardness by preventing precipitating of scale on the boiler tubes. This treatment also protects against concentrations of dissolved and suspended solids in the feed water without priming or foaming. These treatment chemicals also help with the alkalinity of the feed water making it more of a base to help protect against boiler corrosion. The correct alkalinity is protected by adding phosphates. These phosphates precipitate the solids to the bottom of the boiler drum. At the bottom of the boiler drum there is a bottom blow to remove these solids. These chemicals also include anti-scaling agents, oxygen scavengers, and anti-foaming agents. Sludge can also be treated by two approaches. These are by coagulation and dispersion. When there is a high amount of sludge content it is better to coagulate the sludge to form large particles in order to just use the bottom blow to remove them from the feed water. When there is a low amount of sludge content it is better to use dispersants because it disperses the sludge throughout the feed water so sludge does not form.

Impurities are substance inside a confined amount of liquid, gas or solid which differ from the chemical composition of the material or compound. Impurities are either naturally occurring or added during synthesis of a chemical product. During production impurities may be purposely, accidently or incidentally added into the substance.



Feed Water Monitoring System

The following impurities are present in the boiler water are discussing in below:

A. Calcium (Ca) Scale

Calcium forms with sulfates and other compounds to form calcium sulfate, calcium bicarbonate, calcium carbonate, calcium chloride, and calcium nitrate. During evaporation, these chemicals adhere to boiler tube walls forming scale. Its formation increases with the rate of evaporation so these deposits will be heaviest where the gas temperatures are highest. Scale is a non-conductor of heat which leads to a decreased heat transfer of the boiler tubes, and can result in tube failure due to higher tube metal temperatures.

B. Iron (Fe)

High iron is not found in raw water but high concentrations can come from rusted piping and exfoliation of boiler tubes. Iron is found in condensate return in a particle form as it does not dissolve in water. The detrimental aspect of iron is called steam turbine solid particle erosion, which causes significant erosion of steam turbine steam path components.

C. Oil

Oil is an excellent heat insulator, and adherence of oil on tube surfaces exposed to high temperatures can cause overheating and tube damage.

D. Carbon Dioxide (Co2)

Carbon dioxide can react with water to form carbonic acid (H_2CO_3). Carbonic acid will cause corrosion in team and return lines. Carbon dioxide can originate from condenser air leakage or bicarbonate (HCO_3) alkalinity in the feed water. The feed water must be specially treated to avoid problems in the boiler and downstream systems. Untreated boiler feed water can cause corrosion and fouling.

E. Boiler Corrosion

Corrosive compounds, especially O_2 and CO_2 must be removed, usually by use of a deaerator. Residual amounts can be removed chemically, by use of oxygen scavengers. Additionally, feed water is typically alkalized to a pH of 9.0 or higher, to reduce oxidation and to support the formation of a stable layer of magnetite on the water-side surface of the boiler, protecting the material underneath from further corrosion. This is usually done by dosing alkaline agents into the feed water, such as sodium hydroxide (caustic soda) or ammonia. Corrosion in boilers is due to the presence of dissolved oxygen, dissolved carbon dioxide, or dissolved salts.

F. Fouling

Deposits reduce the heat transfer in the boiler, reduce the flow rate and eventually block boiler tubes. Any non-volatile salts and minerals that will remain when the feed water is evaporated must be removed, because they will become concentrated in the liquid phase and require excessive "blow-down" (draining) to prevent the formation of solid precipitates. Even worse are minerals that form scale. Therefore, the make-up water added to replace any losses of feed water must be demineralized/deionized water, unless a purge valve is used to remove dissolved minerals.

G. Oxygen Scavengers

Oxygen-related metallic corrosion is a significant issue in the operation and maintenance of industrial boiler systems and steam raising plant. To ensure that such boiler systems are well maintained and operate at optimum efficiency it is essential that the correct water conditions are maintained at all times. This can be achieved using carefully selected oxygen scavengers designed specifically for steam boiler corrosion control and feed water corrosion control in steam raising plants. Boiler water oxygen scavengers are scientifically formulated to combat the detrimental effects of oxygen-related corrosion in industrial boiler systems, hot water systems, and steam raising plant and so help reduce maintenance costs, maintain boiler efficiency and extend plant and equipment life.

V. RESULTS AND DISCUSSION

A. Annual Savings

Boiler Efficiency =	75%	
Exhaust gas Temperature	=	$237^{O}C$
Operating Hours =	4380 hours/Year	
Heat Recovered =	0.46 Kg/hour	
Operating Pressure	=	15.8 bar

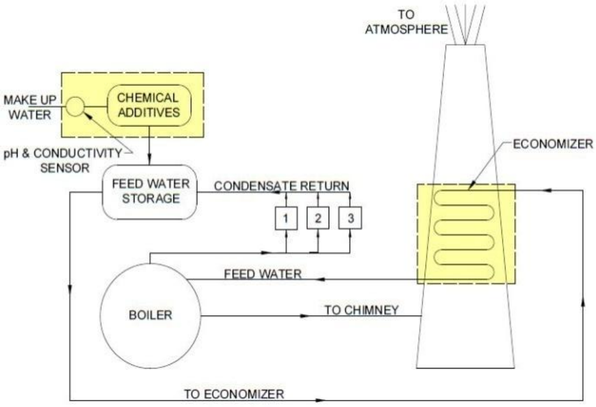
Fuel Cost = 40 rupees/Kg

Annual Savings = [Heat Recovered(Kg/Hr) XOperatingHours(Hr/Yr) X Fuel Cost (Rs/Kg)] / Boiler Efficiency

Annual Savings = [.46 (Kg/Hr) X 4380(Hr/Yr) X 40 (Rs/Kg)] / 0.75

Annual Savings = Rs 1,07,456 per Year

FINAL PLANT LAYOUT



Where,

1 = Steam supplied to Powder Plant

2 = Steam supplied to Butter & Ghee Section

3 = Steam supplied to other sections of the Plant

B. Advantages

- Fuel consumption is reduced.
- Annual saving of the industry is increased.
- Overall efficiency of the plant is increased
- Temperature of the gas leaving in to the atmosphere is reduced.
- Maximum utilization of the exhaust gas temperature.

VI. CONCLUSION

It has been proven that the initial cost of a boiler is a small part of total cost of boiler during its lifetime. The major costs resulting from the fuel costs. Therefore it is important to use a high efficient steam boiler that consume lower rate of fuel, for this purpose some equipment can be used in steam boilers that one of them used in this project that is economizer. The highest heat losses in boilers is related to dry flue gas that is around 12% of the total heat lost through the exhaust . It is found that the method of heat recovery from flue gas by economizer is one of the effective ways to save energy in fire tube boilers.

Water treatment process for thermal power plants have been examined and improved as a counter measure against equipment damage due to factors such as corrosion and scale deposition. Abnormalities in water quality can be a precursor of problems and therefore serious problems can be prevented by analyzing the data and taking necessary measures. The water treatment in modem Western plants, namely, pretreatment in clarifiers, Demineralization and condensate polishing. Also by treating the make-up water the formation of scale and sludge is also reduced (formation of scale and sludge reduce the heat transfer rate and increases the fuel consumption). So when formation of scale and sludge is prevented the consumption of fuel is reduced which in turn increases the efficiency of the boiler.

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