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Analysis And Improving Of 10TPH Briquette Boiler Efficiency

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Abstract:
Boiler is one of the important applications of the engineering without which there may not be many of the industrial sectors. And most of the engineering applications would be in vain without. Imagining a power plant, steel plants, manufacturing units, beverages industries, chemical plants, pharmaceutical industries and many more without a boiler would not be reasonable and appreciable. To maintain high efficiency and profitable products without boiler would highly impossible. This shows the role of a boiler is vital in the engineering society and is to be given an effort to study it leads to its further developments.
The research in this field would be beneficial and economic to the developing country like India. In this piece of article we made an effort to analysis and improving of 10tph briquette boiler efficiency. The efficiency improvement requires many inputs and outputs to be considered. We tried to put all the required inputs to get the desired input.

1.Analysis And Improving Of 10TPH Briquette Boiler Efficiency

1.1.Introduction To Boiler

Definition: A boiler is a closed vessel in which water is heated until the water is converted into steam at required pressure. This can then be used to provide space heating and/or service water heating to a building. In most commercial building heating applications, the heating source in the boiler is a natural gas fired burner. Oil fired burners and electric resistance heaters can be used as well. Steam is preferred over hot water in some applications, including absorption cooling, kitchens, laundries, sterilizers, and steam driven equipment.

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. The process of heating a liquid until it reaches its gaseous state is called evaporation.

Heat is transferred from one body to another by means of :

- Radiation, which is the transfer of heat from a hot body to a cold body without a conveying medium,
- Convection, the transfer of heat by a conveying medium, such as air or water and
- Conduction, transfer of heat by actual physical contact, molecule to molecule.

1.2.Types Of Boiler

Boiler systems are classified in a variety of ways. They can be classified according to the end use, such as foe heating, power generation or process requirements. Or they can be classified according to pressure, materials of construction, size tube contents (for example, waterside or fireside), firing, heat source or circulation. Boilers are also distinguished by their method of fabrication. Accordingly, a boiler can be pack aged or field erected. Sometimes boilers are classified by their heat source. For example, they are often referred to as oil-fired, gas-fired, coal-fired, or solid fuel –fired boilers.

Let us take a look at some typical types of boilers,

1.2.1.<u>Fire Tube Boiler</u>

Fire tube boilers consist of a series of straight tubes that are housed inside a water-filled outer shell. The tubes are arranged so that hot combustion gases flow through the tubes. As the hot gases flow through the tubes, they heat the water surrounding the tubes. The water is confined by the outer shell of boiler. To avoid the need for a thick outer shell fire tube boilers are used for lower pressure applications. Generally, the heat input capacities for fire tube boilers are limited to 50 MMbtu per hour or less, but in recent years the size of fire tube boilers has increased.

Fire tube boilers are subdivided into three groups. Horizontal return tubular (HRT) boilers typically have horizontal, self-contained fire tubes with a separate combustion chamber. Scotch, Scotch marine, or shell boilers have the fire tubes and combustion chamber housed within the same shell. Firebox boilers have a water-jacketed firebox and employ at most three passes of combustion gases.

Most modern fire tube boilers have cylindrical outer shells with a small round combustion chamber located inside the bottom of the shell. Depending on the construction details, these boilers have tubes configured in one, two, three, or four pass arrangements. Because the design of fire tube boilers is simple, they are easy to construct in a shop and can be shipped fully assembled as a package unit.
These boilers contain long steel tubes through which the hot gases from the furnace pass and around which the hot gases from the furnace pass and around which the water circulates. Fire tube boilers typically have a lower initial cost, are more fuel efficient and are easier to operate, but they are limited generally to capacities of 25 tons per hour and low pressures about 17.5 kg per cm^2.
As a guideline, fire tube boilers are competitive for steam rates up to 12,000 kg/hour. Fire tube boilers are available for operation with oil, gas or solid fuels. For economic reasons, most fire tube boilers are nowadays of “packaged” construction (i.e. manufacturers shop erected) for all fuels.

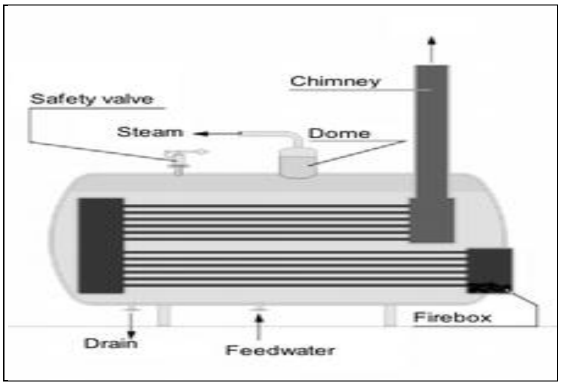

Figure 1: Fire Tube Boiler

1.2.1.1.Advantages Of Fire Tube Boiler

- The water is supplied in shell and outside tubes while hot gas is supplied inside tubes so the water volume cannot be shaken easily when the fire tube boiler is running.
- Fire tube boiler is so easy to use, operate, clean and maintain
- Fire tube boiler can be used in small scale industries.
- Fire tube boiler is relatively cheaper than water tube boiler.

1.2.1.2.Disadvantages Of Fire Tube Boiler

1.From the furnace combustion side, required time to fill water is longer than to increase temperature and pressure.
2. The efficiency of heat transfer (heat transfer efficiency) is bad enough because of the heat exchanger does not use thermal radiation.
3. In case of bombers fire tube boiler would be very dangerous if a large amount of hot water and steam have been accumulated inside (leakage occur).
4. The fire tube boiler cannot produce steam at a pressure higher than 250 pounds per square inch.
5. Capacity of generated steam is limited.

1.2.2.Water Tube Boiler

Water tube boilers are designed to circulate hot combustion gases around the outside of a large number of water filled tubes. The tubes extend between an upper header, called a steam drum, and one or lower headers or drums. In the older designs, the tubes were either straight or bent into simple shapes. Newer boilers have tubes with complex and diverse bends. Because the pressure is confined inside the tubes, water tube boilers can be fabricated in larger sizes and used for higher-pressure applications.
Small water tube boilers, which have one and sometimes two burners, are generally fabricated and supplied as packaged units. Because of their size and weight, large water tube boilers are often fabricated in pieces and assembled in the field. In water tube or “water in tube” boilers, the conditions are reversed with the water passing through the tubes and the hot gases passing outside the tubes. These boilers can be of a single- or multiple-drum type. They can be built to any steam capacity and pressures, and have higher efficiencies than fire tube boilers.
Almost any solid, liquid or gaseous fuel can be burnt in a water tube boiler. The common fuels are coal, oil, natural gas, biomass and solid fuels such as municipal solid waste (MSW), tire-derived fuel (TDF) and RDF. Designs of water tube boilers that burn these fuels can be significantly different.
Coal-fired water tube boilers are classified into three major categories: stoker fired units, PC fired units and FBC boilers.
Package water tube boilers come in three basic designs: A, D and O type. The names are derived from the general shapes of the tube and drum arrangements. All have steam drums for the separation of the steam from the water, and one or more mud drums for the removal of sludge. Fuel oil-fired and natural gas-fired water tube package boilers are subdivided into three classes based on the geometry of the tubes.
The “A” design has two small lower drums and a larger upper drum for steam-water separation. In the “D” design, which is the most common, the unit has two drums and a large-volume combustion chamber. The orientation of the tubes in a “D” boiler creates either a left or right-handed configuration. For the “O” design, the boiler tube configuration exposes the least amount of tube surface to radiant heat. Rental units are often “O” boilers because their symmetry is a benefit in transportation.

Most modern water boiler tube designs are within the capacity range 4,500 – 120,000 kg/hour of steam, at very high pressures
The features of water tube boilers are:

- Forced, induced and balanced draft provisions help to improve combustion efficiency.
- Less tolerance for water quality calls for water treatment plant.
- Higher thermal efficiency shifts are possible.

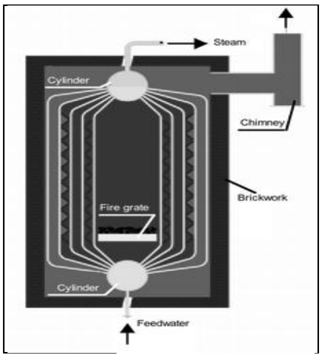

Figure 2: Water Tube Boiler

1.2.2.1.Advantages Of Water Tube Boilers

- Easier to have a super heater if necessary.
- Rapid warming due to a much larger heating surface per pound of water in the boiler.
- Virtually unlimited Maximum Allowable Working Pressure (within reason).
- Smaller footprint than a fire-tube boiler of the same rating.
- Less working volume of water contained in the pressure parts.
- More water volume exposed to the heating surface than a fire tube boiler (more efficient).
- Faster load change response due to less water.
- Less chance of a pressure part explosion due to less volume of water exposed to a rupture situation, plus, the rupture is usually into the furnace area which is safer.

1.2.2.2.Disadvantages Of A Water Tube Boiler

- Must be more careful of feed-water quality
- More complex control systems for drum level necessary due to smaller water spaces, (although I have worked in plants with old marine three drum boilers with huge steam drums which only had thermo-hydraulic regulators for drum level)
- Operators must be quicker on the draw when there is an upset because everything happens faster with a water tube boiler

1.2.3.Packaged Boiler
The packaged boiler is so called because it comes as a complete package. Once delivered to site, it requires only the steam, water pipe work, fuel supply and electrical connections to be made for it to become operational. Package boilers are generally of shell type with fire tube design so as to achieve high heat transfer rates by both radiation and convection.
The features of package boilers are:

- Small combustion space and high heat release rate resulting in faster evaporation.
- Large number of small diameter tubes leading to good convective heat transfer.
- Forced or induced draft systems resulting in good combustion efficiency.
- Number of passes resulting in better overall heat transfer.
- Higher thermal efficiency levels compared with other boilers.

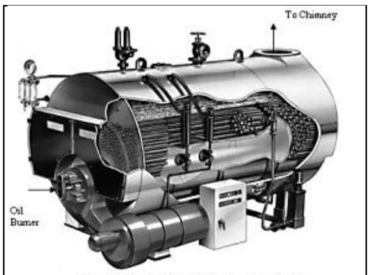

Fig: A typical 3 Pass, Oil fired package boiler
Reference: http://www.spiraxsarco.com/learn/default.asp?redirect=html/3_2_01.htm

Figure 3: Oil Fired Package Boiler

1.2.4.Electric Steam Boiler
An electric steam boiler is a type of boiler where the steam is generated using electricity, rather than through the combustion of a fuel source. They are used to generate steam for process purposes in many locations, for example laundries, food

processing factories and hospitals. Although they are more expensive to run than gas-fired or oil-fired boilers they are popular because of their simplicity and ease of use. Because of the large currents required, they are normally run from a three-phase electricity supply. They convert electrical energy into thermal energy with almost 100% efficiency but the overall thermal efficiency is variable, depending on the efficiency with which the electricity is generated.

An electric boiler can replace any other small to medium size boiler in the home, and are known to be light, small and compact, often completely silent and, of course, boasting the main benefit of a low running cost due to the price of electricity in comparison to oil or gas. It is most common to need an electric powered boiler in rural areas where oil or gas access may not be available, but also some new housing projects or flats are being fitted with electric boilers by choice due to its environmental and cost benefits.

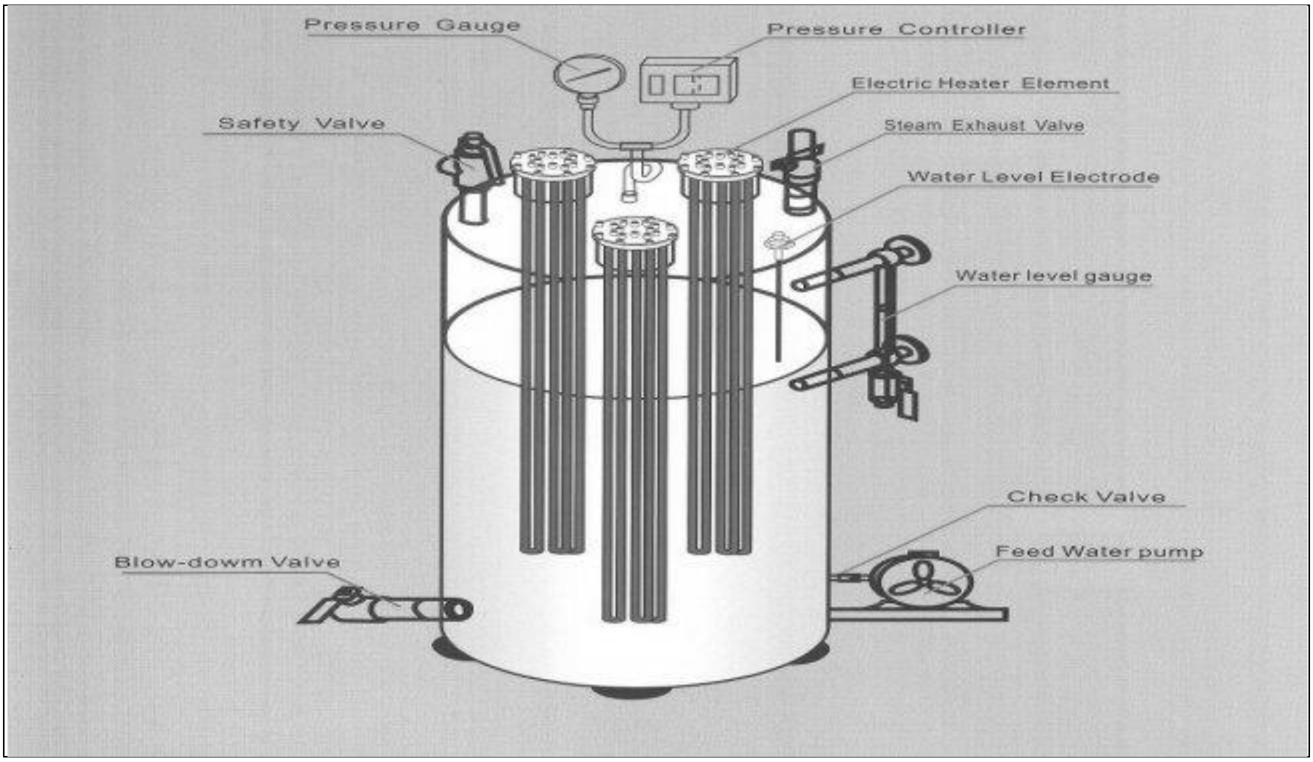

Figure 4: Electric Boiler

1.2.4.1.Advantages Of An Electric Boiler

Increaseefficiency

A traditional gas boiler system normally disposes of waste gases by taking it out of the property via a flue or chimney. As the flue is not required in an electric boiler system setup, this means that useful heat does not escape, helping the electric boiler to run at around 99% efficiency.

No Need For A Mains Gas Supply

Over 2 million homes in the UK don’t have access to a mains gas supply, making electric boilers an essential (and cheap) means of providing central heating and hot water.

Reduced Installation Costs

If you do not currently have a gas pipe supply into your property it can cost a lot of money to get this setup. An electric boiler is a cheaper solution. It is also beneficial as you do not need to purchase a separate Flue or chimney as there is no requirement to take waste emissions from the boiler to outside of the property, as with a gas boiler. This will obviously save you money in the initial installation stage.

Space Efficient

The fact that a flue is not required benefits smaller properties where space is an issue. There is also a lot more flexibility in where the electric boiler can be installed, as it doesn’t necessarily need to be close to an outside wall. Unlike other types of boiler, there is also no requirement for an additional fuel storage tank.

Quiet

Electric boilers are not reliant on elements within the boiler moving to generate heat. This means that electric boilers are renowned as being very quiet systems when in use.

Maintenance

Electric boilers generally don’t need to be serviced as regularly as gas and oil boilers as they are considered to be like any other electrical appliance. Generally they only need maintaining if there is a problem with the boiler itself.

Good For Environment

Electric boilers rely on electricity rather than the burning of fossil fuels to generate heat. The electric boilers themselves are therefore considered more environmentally friendly than other types of boiler as there isn’t a requirement to take the waste gas emissions produced by the boiler out into the atmosphere. However, the full environmental picture does cast doubt over the claim that electric boilers are fully environmentally friendly.

1.2.4.2.Disadvantages Of An Electric Boiler

Not Always Suitable For Larger Properties:

Electric boilers can only heat a certain amount of water at any one time, therefore a more conventional boiler system may be more suitable to heat larger properties where hot water usage levels may be higher.

Environmental Benefits Myth:

Although the electric boiler units themselves are considered fairly environmentally friendly heating systems, there are concerns that the actual process of creating electricity itself in power stations generates the same amount of pollution as gas and oil boiler systems, therefore negating this benefit.

Cost Of Electricity:

Due to the higher cost of electricity over gas, electric boilers are considered a slightly more expensive way to provide heat to a property.

Potential Power Cuts:

By choosing an electric boiler you will be relying on an electricity source to provide hot water to your home. This means that in the event of a power cut you could be without central heating or hot water for hours or (depending on where you live) even days.

1.3.Properties Of Boiler

- Safety. The boiler should be safe under operating conditions.
- Accessibility. The various parts of the boiler should be accessible for repair and maintenance.
- Capacity. Should be capable of supplying steam according to the requirements.
- Efficiency. Should be able to absorb a maximum amount of heat produced due to burning of fuel in the furnace.
- It should be simple in construction.
- Its initial cost and maintenance cost should be low.
- The boiler should have no joints exposed to flames.
- Should be capable of quick starting and loading.

1.4.Factors To Be Considered For Selection Of A Boiler

- The working pressure and quality of steam required
- Steam generation rate
- Floor area available
- Accessibility for repair and inspection
- Comparative initial cost
- Erection facilities
- The portable load factor
- The fuel and water available
- Operating and maintenance costs

1.5.Requirements Of An Efficient Boiler

- The boiler should generate maximum amount of steam at a required pressure and temperature and quality with minimum fuel consumption and expenses
- Steam production rate should be as per requirements
- It should be absolutely reliable
- It should be light in weight
- It should not occupy large space
- It should be capable of quick starting
- It should conform to safety regulations
- The boiler components should be transportable without difficulty
- The installation of the boiler should be simple
- It should have low initial cost, installation cost and maintenance cost
- It should be able to cope with fluctuating demands of steam supply
- All parts and components should be easily accessible for inspection, repair and replacement
- The tubes of the boiler should not accumulate soot or water deposits and should be sufficiently strong to allow for wear and corrosion
- The water and gas circuits should be such as to allow minimum fluid velocity (for low frictional losses)

1.6.Boiler Mountings And Accessories

Boilers are equipped with two categories of components:

- Boiler mountings.
- Boiler accessories.

1.6.1.Boiler Mountings

Are the machine components that are mounted over the body of the boiler itself for the safety of the boiler and for complete control of the process of steam generation.

Various boiler mountings are as under:

- Pressure gauge.
- Fusible plug.
- Steam stop valve
- Feed check valve
- Blow off cock
- Man and mud holes.

1.6.1.1.Pressure Gauge

Function: To record the steam pressure at which the steam is generated in the boiler.

- A bourdon pressure gauge in its simplest form consists of elliptical elastic tube ABC bent into an arc of a circle as shown in figure.
- This bent up tube is called as BOURDEN'S tube.
- One end of tube gauge is fixed and connected to the steam space in the boiler.
- The other end is connected to a sector through a link.

1.6.1.2.Fusible Plug

Function: To extinguish fire in the event of water level in the boiler shell falling below a certain specified limit.

It protects fire tubes from burning when the level of the water in the water shell falls abnormally low and the fire tube or crown plate which is normally submerged in the water, gets exposed to steam space which may not be able to keep it cool.

- It is installed below boiler's water level.
- When the water level in the shell falls below the top of the plug, the steam cannot keep it cool and the fusible metal melts due to overheating. Thus the copper plug drops down and is held within the gunmetal body by the ribs. Thus the steam space gets communicated to the firebox and extinguishes the fire. Thus damage to fire box which could burn up is avoided. By removing the gun metal plug and copper plug the fusible plug can be put in position again by interposing the fusible metal usually lead or a metal alloy.

1.6.1.3.Steam Stop Valve

A valve is a device that regulates the flow of a fluid (gases, fluidized solids, slurries, or liquids) by opening, closing, or partially obstructing various passageways

Function: to shut off or regulate the flow of steam from the boiler to the steam pipe or steam from the steam pipe to the engine. When the hand wheel is turned, the spindle which is screwed through the nut is raised or lowered depending upon the sense of rotation of wheel. The passage for flow of steam is set on opening of the valve.

1.6.1.4.Feed Check Valve

- To allow the feed water to pass into the boiler.
- To prevent the back flow of water from the boiler in the event of the failure of the feed pump.

1.6.1.5.Blow Off Cock

Function: To drain out the water from the boiler for internal cleaning, inspection or other purposes.

1.6.1.6. Man And Mud Holes

Function: To allow men to enter inside the boiler for inspection and repair.

1.6.2.Boiler Accessories

Are those components which are installed either inside or outside the boiler to increase the efficiency of the plant and to help in the proper working of the plant.

Various boiler accessories are:

- Air Preheater
- Economizer
- Superheater

1.6.2.1.Air Preheater

Function: Waste heat recovery device in which the air to on its way to the furnace is heated utilizing the heat of exhaust gases

1.6.2.2.Economiser

Function: To recover some of the heat being carried over by exhausts gases

- This heat is used to raise the temperature of feed water supplied to the boiler.

1.6.2.3.Superheater

Function: To superheat the steam generated by boiler

- Super heaters are heat exchangers in which heat is transferred to the saturated steam to increase its temperature.

1.7.Comprehensive Study On 10tph Briquette Boiler

- 10TPH Briquette boiler means it produces 10 tons of steam per hour by using briquettes as fuel.
- Here we are using the FBC boilers

1.7.1.Advantages Of Fluidized Bed Combustion Boilers

1.7.1.1.High Efficiency

FBC boilers can burn fuel with a combustion efficiency of over 95% irrespective of ash content. FBC boilers can operate with overall efficiency of 84% (plus or minus 2%).

1.7.1.2.Reduction In Boiler Size

High heat transfer rate over a small heat transfer area immersed in the bed result in overall size reduction of the boiler.

1.7.1.3.Fuel Flexibility

FBC boilers can be operated efficiently with a variety of fuels. Even fuels like flotation slimes, washer rejects, agro waste can be burnt efficiently. These can be fed either independently or in combination with coal into the same furnace.

1.7.1.4.Ability To Burn Low Grade Fuel

FBC boilers would give the rated output even with inferior quality fuel. The boilers can fire coals with ash content as high as 62% and having calorific value as low as 2,500 kcal/kg. Even carbon content of only 1% by weight can sustain the fluidized bed combustion.

1.7.1.5.Ability To Burn Fines

Coal containing fines below 6 mm can be burnt efficiently in FBC boiler, which is very difficult to achieve in conventional firing system.

1.7.1.6.Pollution Control

SO_2 formation can be greatly minimized by addition of limestone or dolomite for high sulphur coals. 3% limestone is required for every1% sulphur in the coal feed. Low combustion temperature eliminates NO_x formation.

1.7.1.7.Low Corrosion And Erosion

The corrosion and erosion effects are less due to lower combustion temperature, softness of ash and low particle velocity (of the order of 1 m/sec).

1.7.1.8.Easier Ash Removal-No Clinker Formation

Since the temperature of the furnace is in the range of 750 – 900 ^{o}C in FBC boilers, even coal of low ash fusion temperature can be burnt without clinker formation. Ash removal is easier as the ash flows like liquid from the combustion chamber. Hence less manpower is required for ash handling.

1.7.1.9.Less Excess Air – Higher Co_2 In Flue Gas

The CO_2 in the flue gases will be of the order of 14 – 15% at full load. Hence, the FBC boiler can operate at low excess air - only 20 – 25%.

1.7.1.10.Simple Operation, Quick Start-Up

High turbulence of the bed facilitates quick start up and shut down. Full automation of start up and operation using reliable equipment is possible.

1.7.1.11.Fast Response To Load Fluctuations

Inherent high thermal storage characteristics can easily absorb fluctuation in fuel feed rates. Response to changing load is comparable to that of oil fired boilers.

1.7.1.12.No Slagging In The Furnace-No Soot Blowing

In FBC boilers, volatilization of alkali components in ash does not take place and the ash is non sticky. This means that there is no slagging or soot blowing.

1.7.1.13.Provisions Of Automatic Coal And Ash Handling System

Automatic systems for coal and ash handling can be incorporated, making the plant easy to operate comparable to oil or gas fired installation.

1.7.1.14.Provision Of Automatic Ignition System

Control systems using micro-processors and automatic ignition equipment give excellent control with minimum manual supervision.

1.7.1.15.High Reliability
The absence of moving parts in the combustion zone results in a high degree of reliability and low maintenance costs.

1.7.1.16.Reduced Maintenance
Routine overhauls are infrequent and high efficiency is maintained for long periods.

1.7.1.17.Quick Responses To Changing Demand
A fluidized bed combustor can respond to changing heat demands more easily than stoker fired systems. This makes it very suitable for applications such as thermal fluid heaters, which require rapid responses.

1.7.1.18.High Efficiency Of Power Generation
By operating the fluidized bed at elevated pressure, it can be used to generate hot pressurized gases to power a gas turbine**.** This can be combined with a conventional steam turbine to improve the efficiency of electricity generation and give a potential fuel savings of at least 4%.

1.7.2.Briquette
- A briquette is a block of flammable matter used as a fuel to start and maintain the fire.
- Commonly there is available in three types
  - Charcoal briquettes
  - Piet briquettes
  - Biomass briquettes
- Here we are using biomass briquettes

1.7.2.1.Biomass Briquettes
These are made from agricultural waste and are a replacement for fossil fuels such as oil or coal, and can be used to heat boilers in manufacturing plants, and also have applications in developing countries. Biomass briquettes are a renewable source of energy and avoid adding fossil carbon to the atmosphere. The machine to produced briquettes and the briquettes is shown in the following figures 1 and 2 respectively.

Figure 5: (Machinery)


Figure 6: (Biomass Briquettes)

1.7.2.2.Composition And Production
Biomass briquettes, mostly made of green waste and other organic materials, are commonly used for electricity generation, heat, and cooking fuel. These compressed compounds contain various organic materials, including rice hush, bagasse, ground nut shells, municipal solid waste,, agricultural waste, or anything that contains a high nitrogen content. The composition of the briquettes varies by area due to the availability of raw materials. The raw materials are gathered and compressed into briquette in order to burn longer and make transportation of the goods easier. These briquettes are very different from charcoal because they do not have large concentrations of carbonaceous substances and added materials. Compared to fossil fuels, the briquettes produce low net total greenhouse gas emissions because the materials used are already a part of the carbon cycle.
One of the most common variables of the biomass briquette production process is the way the biomass is dried out. Manufacturers can use torrefaction, carbonization, or varying degrees of pyrolysis. Researchers concluded that torrefaction and carbonization are the most efficient forms of drying out biomass, but the use of the briquette determines which method should be used.

Figure 7: Cyclic Process Of Briquette Usages

1.7.3.<u>Various Parts Of Boiler And Their Purpose</u>

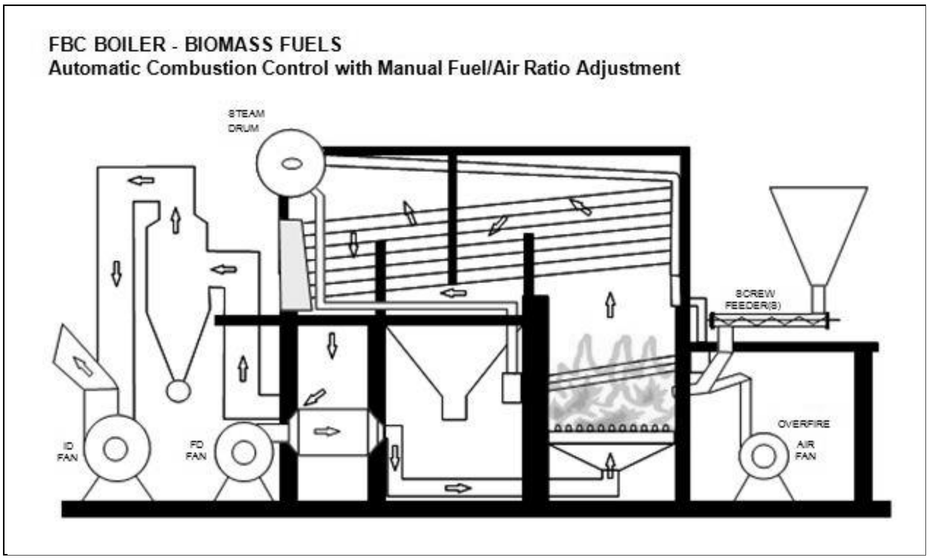

Figure 8: Overview Of Boiler

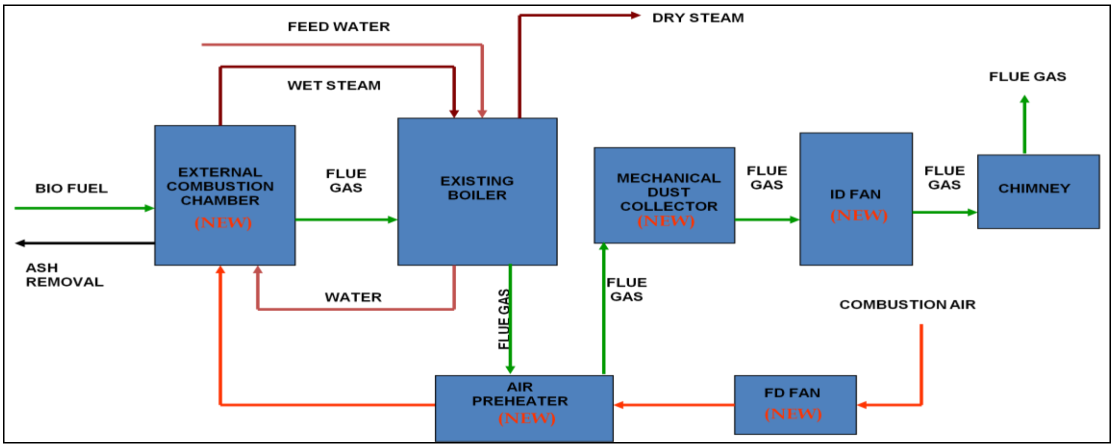

Figure 9: Working Process Of Boiler

1.7.3.1.<u>Feeder</u>

Here we are using belt type rotary feeders.

The purpose of this feeder is to transfer briquettes to crushers continuously.

In most of the applications the types of feeders used for transporting fuel from RC bunker to the mills are:

- Volumetric type feeders
  - Chain feeders
  - Belt feeders
  - Belt type rotary feeders
- Gravitimetric type feeders

Figure 10: Fuel Feeder *Figure 11: Fuel To Bunker*

1.7.3.2.<u>CRUSHER</u>
The main purpose is to crushed the briquette into the finesse powder and it also sieve the powder the finesse powder is sent into the bunker and the remaining uncrushed powder again send to feeder until it change into the finesse powder.
1.7.3.3.<u>Bunker</u>
The main purpose is it stores the finesse powder and, is carried forward by air through pipes directly to burners or storage bins from where it is passed to burners. When discharged into combustion chamber, the mixture of air and briquette finesse powder ignites and burns in suspension.

1.7.3.4.<u>Furnace</u>
Here we are using water tube type furnace.
The first thing that you need to understand is that the burner is literally the most important part of the boiler. The burner is heated through fuel, and there are a number of different types of fuel that can supply the boiler burner. For instance you could use biomass briquettes. When the burner is finished heating up, the gasses are sent to the boiler. The water within the boiler will be heated up, and will then be ready for use throughout the entire establishment. The heat is constant, and there is no storage tank for hot water. This means you will have hot water on demand the moment you turn the tap on. Without the burner none of this would be possible. The following figure shows how the burning is done inside the boiler.

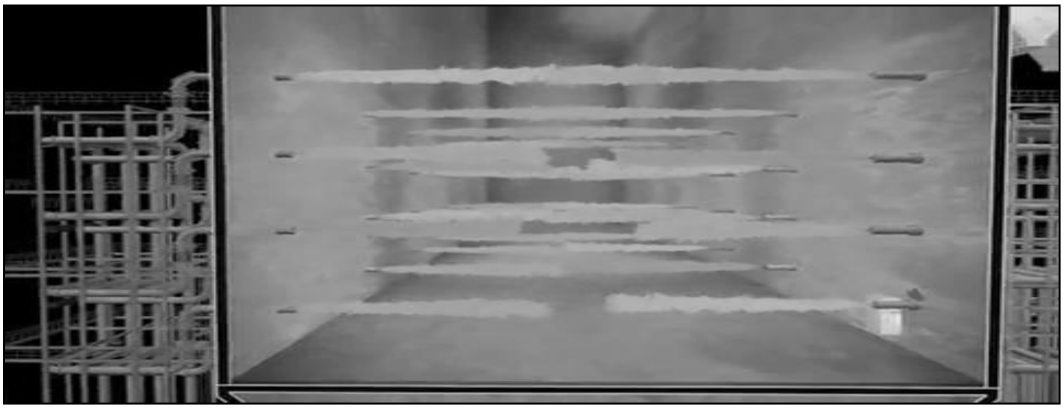

Figure 12: Firing Chamber

1.7.3.5.<u>Boiler Drum</u>
Here we are using fire tube type boiler.
The primary function of a utility boiler is to convert water into steam which is used in various purposes in the plant. A steam/water interface exists within the boiler drum. An objective for safe and efficient boiler operation is to maintain a constant level in the boiler drum. This can be accomplished by maintaining a balance between the amounts of steam leaving and water entering the boiler drum. Unfortunately, boiler drum level control is complicated by changes in electrical load requirements or variations in the fuel and air supply.

1.7.3.6.<u>Moberly System</u>
The purpose of this Moberly system to maintain the water level in the boiler drum. If water level in decreases the pump is on. To avoid the dangerous we are using this system. These are the most important for the boilers.

1.7.3.7.<u>Induced Draft Fan</u>
The main purpose of ID Fan is to suck flue gas from the furnace and send it out to atmosphere through Chimney and maintain Furnace Draft. The ash particles in the flue gas are precipitated in the ESP before entering ID fan. ID Fan rotates in Anti clockwise direction when viewed from motor end.

1.7.3.8.Forced Draft Fan
The main purpose of FD Fan is to supply adequate amount of air to furnace for combustion. It sucks air from the atmosphere. FD Fan rotates in Anti clockwise direction when viewed from motor end.

1.7.3.9.Air Preheater
Air preheater is a general term to describe any device designed for heating air before any other process (here combustion in the boiler).
The purpose of air preheater is to recover the heat from the flue gas exiting the boiler and transferring it to air being supplied for combustion of fuel in the boiler, thus increasing the efficiency of the boiler, and reducing useful heat loss from flue gas in the form of radiation. Thus the gases are sent to chimney at a lower temperature, hence meeting the emission regulations.
Advantages of Air heater:
- Increased boiler efficiency.
- More stable combustion in the furnace.
- Fuel can be effectively dried for combustion.

1.7.3.10.Water Prehaeter
The purpose of the water preheater is to recovery the heat from the boiler flue gases which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gases. It also allows the control over the temperature of gases leaving the stack (to meet emissions regulations).

1.7.3.11.Dust Collectors
A dust collector is a system used to enhance the quality of air released from industrial and commercial processes by collecting dust and other impurities from air or gas. Designed to handle high-volume dust loads, a dust collector system consists of a blower, dust filter, a filter-cleaning system, and a dust receptacle or dust removal system. It is distinguished from air cleaners, which use disposable filters to remove dust. The father of the dust collector was Wilhelm Beth from Lubeck.

1.7.3.12.Chimney
A chimney performs 3 functions:
- Means of escape from the boiler for combustion products.
- Provides the natural draught required for some boilers.
- Provides a means of reducing atmospheric pollution to ‘acceptable limits’.

This requirement fixes the height of the chimney.

1.7.4.Principles Of Combustion
The primary function of oil and coal burning systems in the process of steam generation is to provide controlled efficient conversation of the chemical energy of the fuel into heat energy which is then transferred to the heat absorbing surfaces of the steam generator. The combustion elements of a fuel consist of carbon, hydrogen and usually a small amount of sulphur. When combustion is properly completed the exhaust gases will contain, carbon dioxide, water vapor, sulphur dioxide and a large volume of Nitrogen, Combustion is brought about by combining carbon and hydrogen or hydrocarbons with the oxygen in air. When carbon burns completely, it results in the formation of a gas known as carbon dioxide. When carbon bums incompletely it forms carbon monoxide.
- Composition of air: The supply of oxygen for combustion is obtained from air. This is as important as the supply of fuel. The average composition of air is
  - 79% nitrogen and 21% oxygen by volume
  - 77% nitrogen and 23% oxygen by weight
- Nitrogen does not burn but passes through the combustion chamber to the chimney unchanged excepting its temperature.
- Ignition: Fuel must be ignited before it can burn. Combustion is brought about by raising the temperature of the fuel to its ignition temperature. This temperature varies with different fuels.
- Excess air: The amount of air required to burn any fuel can be calculated if the amount of the elements present in the fuel are known. This amount of air is known as the theoretical air. In practice this quantity is not sufficient to ensure complete combustion and extra air has to be supplied. This extra air is known as excess air.

The loss of combustibles and un-burnt gas loss reduces as excess air is added reaches maximum and any further additions of excess air beyond this stage, the boiler losses increase. Thus there is one and only one quantity of excess air, which will give the lowest combustion loss. The value of excess air needed depends upon the fuel used, the type of firing etc.
The following factors in efficient combustion are usually referred to as “The three T’s.

1.7.4.1.Time
It will take a definite time to heat the fuel to its ignition temperature and having ignited, it will also take time to burn. Consequently sufficient time must be allowed for complete combustion of the fuel to take place in the chamber.

1.7.4.2.Temperature
A fuel will not burn until it has reached its ignition temperature. The speed at which this Temperature will be reached is increased by preheating the combustion air. The temperature of the flame of the burning fuel may vary with the quantity of air used. Too much combustion air will lower the flame temperature and may cause unstable ignition.

1.7.4.3.Turbulence

Turbulence is introduced to achieve a rapid relative motion between the air and the fuel particles. It is found that this produces a quick propagation of the flame and its rapid spread throughout the fuel/air mixture in the combustion chamber.

1.8.Evaluating Boiler Efficiency

The most basic efficiency norm which everybody agrees is the "input/output" ratio:

$$\text{Efficiency}\ (\eta) = \frac{E_{out}}{E_{in}}$$

Where

- E_{out} is the energy needed to convert feed water entering the boiler at a specific pressure and temperature to steam leaving the boiler at a specific pressure and temperature. (This includes the energy picked up by the blow down and not converted into steam).
- E_{in} is the input energy into the boiler. The heat input is based on the high heat (gross calorific) value of fuel for efficiency calculations in US, UK and many other countries. Germany uses low heat (net calorific) value basis, implying that for an identical boiler, the stated efficiency will be higher.

There are two methods of assessing boiler efficiency;

- Input – output or direct method, and
- Heat loss or indirect method.

1.8.1.Direct Method For Calculating Boiler Efficiency

Direct method compares the energy gain of the working fluid (water and steam) to the energy content of the fuel. This is also known as 'input-output method' due to the fact that it needs only the useful output (steam) and the heat input (i.e. fuel) for evaluating the efficiency. The efficiency is than estimated using equation below:

$$\textit{Boiler Efficiency} = \frac{\text{Steam flow rate x (steam enthalpy} - \text{feed water enthalpy)}}{\text{Fuel firing rate x Gross calorific value}}\ x\,100$$

1.8.1.1.Procedure

- Measure quantity of steam flow kg (or lb.) over a set period, e.g. one hour period. Use steam integrator readings, if available, and correct for orifice calibration pressure. Alternatively, use the feed water integrator, if available, which will in most cases not require a correction for pressure.
- Measure the quantity of fuel used over the same period. Use the gas or oil integrator, or determine the mass of solid fuel used.
- Determine the working pressure in Kg/cm^2 (psi) and superheat temperature, °C (°F), if any.
- Determine the temperature of feed water °C (°F)
- Convert steam flow, feed water flow and fuel flow to identical energy units, e.g. kJ/kg or Btu/lb.
- Determine the type of fuel and gross calorific value of the fuel (GCV or HHV) in kJ/kg or Btu/lb.
- Calculate the efficiency using the above mention formula.

Direct method is simple in a way that it requires few parameters for computations and needs few instruments for monitoring. However this method may not be as accurate due to errors in metering fuel flow and steam flow. In practice, only very large industrial set ups and electric utility companies are instrumented well enough to obtain the required data.

1.8.2.Indirect Method Or Heat Loss Method For Calculating Boiler Efficiency

Here the efficiency is estimated by summing the losses and comparing with the heat input. The major heat losses from boiler are due to:

- High temperature flue gas leaving the stack
- Moisture in fuel and combustion air
- Combustion of hydrogen (leaves boiler stack as water vapor)
- Heat in un-burnt combustibles in refuse
- Radiation from the boiler surfaces
- Unaccounted for un-measured losses

Sum up the losses and calculate the efficiency using equation:

Efficiency (% E) = 100 – Σ Losses

- Evaluating Heat Losses From Boiler

The procedure for calculating boiler efficiency by indirect method is illustrated below.

1.8.2.1.Dry Flue Gas Loss (LDG)

Heat is lost in the "dry" products of combustion, which carry only sensible heat since no change of state was involved. These products are carbon-dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), nitrogen (N_2) and sulfur dioxide (SO_2). Concentrations of SO_2 and CO are normally in the parts-per-million (ppm) range so, from the viewpoint of heat loss, they can be ignored. Calculate the dry flue gas loss (LDG) using the following formula:

LDG, % = [DG x Cp x (FGT - CAT)] x 100 / HHV

Where:

- DG is the weight of dry flue gas, lb/lb of fuel,
- Cp is the specific heat of flue gas, usually assumed to be 0.24
- FGT is the flue gas temperature, °F
- CAT is the combustion air temperature, °F
- HHV is the higher heating value of the fuel, Btu/lb.

The formula can be simplified to LDG, % = [24 x DG x (FGT - CAT)] / HHV

If temperatures are measured in °C, other units remaining unchanged, the formula becomes

LDG = [43.2 x DG x (FGT - CAT)] ÷ HHV

The weight of dry gas (DG), varies with fuel composition and the amount of excess air used for combustion. For the normal case of zero CO or unburned hydrocarbons, it can be calculated as:

$DG = (11CO_2 + 8O_2 + 7N_2) \times (C + 0.375S) / 3CO_2$

Where

- CO_2 and O_2 are % by volume in the flue gas
- N_2 is % by volume in the flue gas = $100 - CO_2 - O_2$
- C and S are weight fractions from the fuel analysis (lb/lb fuel)

1.8.2.2.Loss Due To Moisture From The Combustion Of Hydrogen (LH)

The hydrogen component of fuel leaves the boiler as water vapor, taking with it the enthalpy (or heat content) corresponding to its conditions of temperature and pressure. The vapor is a steam at very low pressure, but with a high stack temperature. Most of its enthalpy is in the heat of vaporization. The significant loss is about 11 percent for natural gas and 7 percent for fuel oil.

The ASME formula for calculating the loss due to moisture from the combustion of hydrogen is:

LH, % = [900 x H_2 x (hg – hf)] / HHV

Where:

- H_2 is the weight fraction of hydrogen in the ultimate analysis of the fuel
- HHV is the higher heating value
- hg is the enthalpy of water vapor at 1 psi and the flue gas temperature (FGT) in °F
- hf is the enthalpy of water at the combustion air temperature (CAT) in °F

hg can be determined from steam tables or from the equation:

hg (Btu/lb) = 1055 + (0.467 x FGT)

hf can also be determined from steam tables, or from the simple relationship:

hf (Btu/lb) = CAT - 32

1.8.2.3.Loss Due To Radiation And Convection (LR)

This loss occurs from the external surfaces of an operating boiler. For any boiler at operating temperature, the loss is constant. Expressed as a percentage of the boiler's heat output, the loss increases as boiler output is reduced; hence, operating the boiler at full load lowers the percentage of loss. Since the boiler's surface area relates to its bulk, the relative loss is lower for a larger boiler and higher for a smaller boiler. Instead of making complex calculations, determine the radiation and convection loss using a standard chart available from the American Boiler Manufacturers Association (ABMA). Refer to the figure below for illustration:

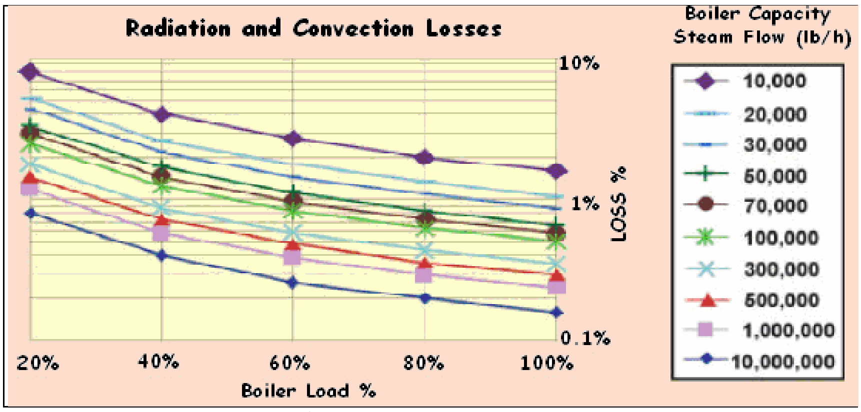

Figure 13: Graph Of Radiation And Convection Losses

1.8.2.4.Losses Those Are Unaccounted For (LUA)
Reasonable assumptions concerning these losses are 0.1 percent for natural-gas-fired boiler systems and 0.2 percent for light oil-fired systems. For heavy oil, a value between 0.3 and 0.5% may be appropriate, to account for fuel heating and, perhaps, atomizing steam.

1.8.2.5.How To Use Heat Loss Data
Once the 4 losses have been estimated, the operator can make use of this data to compute the boiler efficiency as follows:
Efficiency (E) % = 100 – (LDG + LH + LR + LUA)
Where:

- LDG = Dry flue gas loss
- LH = Moisture from hydrogen loss
- LR = Radiation and convection loss
- LUA = Unaccounted for losses

In general, the combustion efficiency of boiler falls in range of 75 to 85%.
The above analysis only highlights the part of thermal losses. Majority of energy efficiency improvements are typically found after the generation of steam. There are a lot of other controllable losses, for instance:

- Boiler blow down rate
- Unreturned condensate
- Deaerator steam vent losses
- Steam use in end use equipment
- Identifiable losses in the distribution and use of process steam etc.

1.8.3.Calculated The Present Efficiency
By using the direct method I have calculated the present efficiency
Formula

$$Boiler\ Efficiency = \frac{\text{Steam flow rate x (steam enthalpy} - \text{feed water enthalpy)}}{\text{Fuel firing rate x Gross calorific value}}\ x\,100$$

Where

- Steam flow rate is in kg/hr
- Steam enthalpy is in kcal/kg
- Enthalpy of feed water is in kcal/kg
- Fuel firing rate is in kg/hr
- Gross calorific value of fuel is in kcal/kg

S.no	Water consumption (liters)	Briquette consumption (kg's)	Feed water temperature (°C)	Revolution per minute	Steam generated (kg/hr)	Efficiency
1	86800	17850	85	150	80500	68.24
2	81000	19200	90	140	81000	65.28
3	70300	16050	85	140	70300	66.27
4	81700	17100	90	130	77000	67.54
5	46000	13500	85	140	65000	72.85
6	66000	14400	85	130	62000	65.14
Average	71966.6	16350	86.66	138.33	72633.33	67.55

Table 1: Efficiency Calculations Table

Therefore the present average efficiency of the 10TPH briquette boiler is 68%
But according to the conditions the boiler should developed the efficiency of about 75 to80% .

1.9.Defects For The Boiler Efficiency

1.9.1.Calorific Value Of Fuel
In the briquettes if the moisture content is high then steam production is reduced. So we have to maintain the good calorific value for briquettes means moisture content should be minimized.

1.9.2.Scaling
As water is heated and converted into steam, contaminants brought into a boiler with makeup water are left behind. The boiler functions as a distillation unit, taking pure water out as steam, and leaving behind concentrated minerals and other contaminants in the boiler Scale forms as a result of the precipitation of normally soluble solids that become insoluble as temperature increases. Some examples of boiler scale are calcium carbonate, calcium sulfate, and calcium silicate.

1.9.3.Corrosion
is a general term that indicates the conversion of a metal into a soluble compound. In the case of boiler metal, corrosion is the conversion of steel into rust In a boiler, two types of corrosion are prevalent: 1.) Oxygen pitting corrosion, seen on the tubes and in the pre-boiler section. 2.) Low pH corrosion, seen in the condensate return system. Corrosion of either type can lead to failure of critical parts of the boiler system, deposition of corrosion products in critical heat exchange areas, and overall efficiency loss.

1.9.4.Priming
is the sudden violent eruption of boiler water, which is carried along with steam out of the boiler, usually caused by mechanical conditions. Priming can cause deposits and around the main steam header valve in a short period of time.

1.9.5.Foaming
Causes carryover by forming a stable froth on the boiler water, which is then carded out with the steam. Over a period of time, deposits due to foaming can completely plug a steam or condensate line.

1.9.6.Carryover
is caused by either priming or foaming.

1.10.Methods To Improve Efficiency
Controlling the boiler is of utmost importance in any steam generation energy saving program.
Below are some ways to improve boiler efficiencies:

- Reducing excess air
- Installing economizer
- Reducing scale and deposits
- Reducing blow down
- Recovering waste heat from blow down
- Stopping dynamic operation
- Reducing boiler pressure
- Operating at peak efficiency
- Preheating combustion air
- Switching from steam to air atomization

1.10.1.Reducing Excess Air
By far the most common reason for energy inefficiencies in a boiler can be attributed to the use of excess air during combustion at the burners. When there is more air than is required for combustion, the extra air becomes heated up and is finally discharged out to the atmosphere. However, there are reasons for putting in some extra air for combustion to compensate for imperfect burner fuel-air mixing conditions, air density changes, control system "slop", burner maintenance, fuel composition and viscosity variation, and imperfect atomizing steam or air controls for burners.
Adjusting the fuel-air ratio for combustion can be quite tricky. If the fuel is too much as compared to the air, incomplete combustion occurs. This will give rise to carbon soot deposits inside the combustion chamber or even over the boiler tubes. The consequences of having soot deposits over the heat transfer surfaces and the potential of having explosive flue gases inside the boiler are much worst than losing a slight amount of energy through the exhaust stack. Therefore, many boiler operators choose to adjust their burners to be slightly on excess air.

1.10.2.Installing Economizer
This is only appropriate if there are insufficient heat transfer surfaces in the boiler. The economizer tubes may contain either circulating boiler water or circulating feed water. Because the temperature of the exhaust gases can be quite high, the economizer tubes may be fitted with safety valves to avoid over-pressure damage. Also temperature control of feed water is required to prevent pump airlock. To avoid corrosion, careful design is needed to ensure that the exhaust flue gas temperature does not drop below the dew point.

1.10.3.Reducing Scale And Deposits
For any boiler operation, this is a must. The safety of the boiler is at stake. Any scale or deposits will lead to reduced heat transfer that will eventually lead to overheating, reduction of mechanical strength of the steel and finally to bursting. This should already be in the normal daily procedure of boiler operation.

1.10.4.Reducing Blow Down
Blow down of boiler water is discharging hot water into the drains. However, blow down is necessary to maintain the boiler water concentration of dissolved solids that are necessary for conditioning the boiler water. The dissolved solids are necessary for preventing boiler corrosion and scaling. As steam is generated from the evaporation of water, the remaining water in the boiler becomes more and more concentrated. This must be drained away during blow down. The challenge is to control the draining to the minimum.

1.10.5.Recovering Waste Heat From Blow Down
Since it is necessary to blow down to control the total dissolved solids in the boiler water, methods can be adopted to recover back some of the heat from the drained hot water. Blow down tanks, heat exchanger tubes and pumping arrangements can be fabricated to recover some of the heat back into the boiler.

1.10.6.Stopping Dynamic Operation
Whenever a boiler starts or stops, a few minutes are spent running the forced draft fan for purging the combustion chamber of unborn gases. This is a necessary step for the safe operation of a boiler. During this time the heat from the boiler water in the shell or tubes will be lost to the purging air. To avoid this type of losses, it is better to maintain a steady firing condition in the boilers.

1.10.7.Reducing Boiler Pressure
By reducing the boiler pressure, some of the heat losses through leakages or transmission may be reduced slightly. However there can be problems with the boiler with reduced pressure. The boiler circulation may be upset and the steam lines may have insufficient capacity and flow to transport the low pressure steam.

1.10.8.Operating At Peak Efficiency
When operating two or more boilers, improved efficiency can sometimes be obtained by unequal sharing of the load so that the combined load operates at peak efficiency.

1.10.9.Preheating Combustion Air
Any heat loss from the skin of the boiler to the boiler room can be utilized back for combustion. By preheating the intake air the combustion in the furnace becomes more efficient.

1.10.10.Switching From Steam To Air Atomization
For burners with steam atomization, switching to air atomization will naturally result in less steam consumption overall and better boiler efficiencies. This is only applicable for heavy fuel oil burners.

2.Problems And Remedies

2.1.Problems Identified
As the plant is maintained regularly there are very less problems identifies regularly the main problems are listed below:

- If water is not treated properly there will be accumulation of the bacteria in the beverage
- If the syrup is not manufactured with care then beverage will get fungus
- If any person with enters the syrup without cleaning himself before entry the syrup then manufactured will get spoiled
- The filler machine sometimes will not fill the bottle it leaves the bottles empty
- The crowner will not crown the bottles sometimes
- Pumps and motors will breakdown
- Printing machine sometimes will not print the dates and batch number

2.2.Remedies

- To maintain the plant regularly without fail
- Water to be treated properly
- Syrup manufacturing to be done properly
- Person should be clean without bacteria when entering the syrup room
- Counter pressure should be maintained and monitored and lubrication to be done properly
- Crowns are to be filled regularly and the machined should have proper r.p.m
- Pumps should be monitored and lubricated
- Motors are to checked properly and fitted
- Ink should be checked time to time

2.3.For Boilers

- Lines should be insulated
- Certain pressure should be maintained in the line
- Hot surface should be insulated for e.g. boiler drum, furnace
- Bends should not be there in the lines
- Steam traps used to remove condensed water from the lines
- It reused and collected in the feed water tanks
- Use of expansion bends

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