Boiler-Definition, Fuel used, Types or Classification in details, Parts, Boiler Mounting, Accessories, Function, Application, PDF

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Boiler:

The history of boilers began with steam boilers that were used to power transportation, such as those seen in early trains and ships.

Early models like the “Scotch Marine” and similar early fire tube boilers were made from a steel shell with rounded tube sheets that were welded at both ends.

The boiler is like a closed vessel from which steam is used produced from the several methods like in

Fire tube: Water surrounded by a tube and Hot gas flowing in the tube and

Water tube: Hot gases surrounded by tube and Water flowing in the tube.

Definition:

This is a closed vessel in which fluid (generally water) is heated up to high-pressure steam.

The boilers are used in power plants, for the generation of steam.

They are mostly used in the power plants where steam turbines are used for the generation of electricity.

Fuel Used :

1. Solid fuels:

Wood, Coal, Briquettes (a block of compressed coal dust), Pet Coke, Rice Husk.

2. Liquid Fuels:

LDO (Light Diesel Oil), Furnace oil.

3. Gaseous Fuels:

LPG (Liquified Petroleum Gas), LNG (Liquified Natural Gas), PNG (Piped Natural Gas) can be used to carry out the combustion for a specific purpose.

Types or Classification:

According to several Purpose Like:

1. The Position of water and hot gasses:

- Fire Tube and
- Water Tube

2. Axis of Shell:

- Horizontal and
- Vertical

3. The position of the boiler:

- External Fired
- Internally Fired

4. Pressure:

- Low-Pressure
- High-Pressure

5. Use of boilers:

- Mobile
- Stationary

6. Method of circulation:

- Natural Circulation
- forced Circulation

7. Drums:

- Single drum
- Multi drum

8. Nature of drought:

- Forced drought

- Natural drought

9. Fuel firing:

- Solid fuel fired
- Liquid fuel-fired
- Gaseous fuel-fired

10. According to furnace

- Single furnace
- Dual furnace

Fire tube boiler:

Fire tube boiler is those boiler in which the fire or hot gas is present inside the tubes and water surrounds these fire tubes.

Since fire is inside the tubes and hence it is named as fire tube boiler. The heat from the hot gases is conducted through the walls of the tube to the water.

The examples of the fire tube boiler are the **simple vertical, Cochran, Lancashire, Cornish, Locomotive, Scotch marine, and Velcon boiler.**

1. Cochran Boiler:

This system was produced by Cochran & Co. of Annan.

It is a multi-tubular vertical fire tube boiler having a number of horizontal fire tubes.

It is the modification of a simple vertical boiler where the heating surface has been increased by means of a number of fire tubes.

In this, the fire tubes are placed horizontally.

The efficiency is much better than the simple vertical boiler.

Construction or Main parts of Cochran boiler:

Shell:

The main body of the boiler is known as a shell.

It is hemispherical on the top, where space is provided for steam.

This hemispherical top gives a higher volume to area ratio which increases the steam capacity.

Grate:

The area where the fire is placed known as a grate.

It is placed at the bottom of the furnace where coal is burnt.

Combustion Chamber:

It is lined with fire bricks on the side of the shell to prevent overheating of the boiler.

Hot gases enter the fire tubes from the flue pipe through the combustion chamber.

The combustion chamber is connected to the furnace.

Fire Tubes:

There are various fire tubes whose one end is connected to the furnace and other to the chimney.

A number of horizontal fire tubes are provided, thereby the heating surface is increased.

Fire Hole:

The small hole is provided at the bottom of the combustion chamber to place fuel is known as the fire hole.

Fir Box(Furnace):

It works as a mediator of fire tubes and combustion chamber.

It is also dome-shaped like the shell so that the gases can be deflected back till they are passed out through the flue pipe to the combustion chamber.

Chimney:

It is provided for the exit of flue gases to the atmosphere from the smoke box.

Man Hole:
It is provided for the inspection and repair of the interior of the boiler shell.

Flue Pipe:
It is a short passage connecting the firebox with the combustion chamber.

Working of Cochran Boiler:

Step by Step:

First, The coal is placed at the grate through the fire hole.

Then air is entering into the combustion chamber through the atmosphere and fuel is sparked through fire hole.

Then flue gases start flowing into the hemispherical dome-shaped combustion chamber. This flue gases further moves into the fire pipes. And then

Heat is exchanged from flue gases to the water into the fire tubes.

The steam produce collected into the upper side of the shell and taken out by when the required pressure generated and then

The flue gases now send to the chimney through firebox where it leaves to the atmosphere.

Now, this process repeats and run continuously. The steam generates used into the small industrial processed.

Various boiler mounting and accessories are attached to the boiler for its efficient working:

1. Pressure Gauge: It measures the pressure of steam inside the boiler.

2. Safety Valve: It blows off the extra steam when the steam pressure inside the boiler reaches above safety level.

3. Water level Indicator: The position of the water level in the Cochran boiler is indicated by the water level indicator.

4. Stop Valve: Stop valve is used to transfer steam to the desired location when it is required. Otherwise, it stops the steam in the boiler.

5. Blow off Valve: It is used to blow off the settle down impurities, mud, and sediments present in the boiler water.

Application:

Variety of process applications in industries

Chemical processing divisions

Pulp and Paper manufacturing plants

Refining units

Besides, they are frequently employed in power generation plants where large quantities of steam (ranging up to 500 kg/s) having high pressures i.e. approximately 16 megapascals (160 bar) and high temperatures reaching up to 550 °C are generally required.

Features:

In Cochran, any type of fuel can be used.

It is best suitable for small capacity requirements.

It gives about 70% thermal efficiency with coal firing and about 75% thermal efficiency with oil firing.

The ratio of grate area to the heating surface area varies from 10: 1 to 25: 1.

Advantages:

Low floor area required.

Low initialization cost.

It is easy to operate.

Transport from one place to another is very easy.

It has a higher volume to area ratio.

Disadvantages:

Low steam generation rate.

Limited pressure handles capacity.

It is difficult to inspect and maintain.

2. Locomotive Boiler:

This is a fire tube. This is a device which is used to create steam from water by using heat energy.

This is a horizontal drum axis, multi-tubular, natural circulation, artificial draft, forced circulation, medium pressure, solid fuel fired fire tube boiler that has an internal fire furnace.

It is capable of producing high steam rate and hence it is used for railway locomotive engines and in marines.

Using of grate we insert the fuel into the boiler and then providing the fire to ignite the fuel.

When fuel starts burning the hot flue gases is produced. And these hot flue gases are passed through the pipe continuously until the surrounding water gets heated.

So the water changes there phase into saturated steam.

This saturated steam can also be used or else further using of the superheated process we superheat the saturated steam into the steam. This steam is further used in the steam engine.

3. Lancashire Boiler:

Lancashire Boiler is a horizontal type and stationary fire tube boiler. This boiler was invented in the year 1844, by William Fairbairn.

This is an internally fired boiler because the furnace uses to present inside the boiler.

This boiler generates low-pressure steam and it is a natural circulation boiler.

It has high thermal efficiency of about 80 to 90 percent.

The size is approximately from 7-9 meters in length and 2-3 meters in diameter.

It is mostly used in locomotive engines and marines etc.

Working Principle of Lancashire Boiler:

This Lancashire boiler works on the basic principle of the heat exchanger. It is basically a shell and tube type heat exchanger in which the flue gases flow through the tubes and the water flows through a shell.

The heat is transfer from flue gases to the water through convection.

It is a natural circulation boiler which uses the natural current to flow the water inside the boiler.

Water tube boiler:

Water tube boiler is those boiler in which the water is present inside the tubes and fire or hot gases surrounds these fire tubes.

The examples of water tube boilers are a **La-Mont, Benson, Stirling, Yarrow and Loeffler boiler.**

1. La-Mont Boiler:

It works on the principle of forced circulation of water within the boiler with the help of the centrifugal pump.

It's working totally depends upon the pump. The centrifugal pump circulates the mixture of steam and water through the small diameter tubes of the boiler.

A feed pump forces the water into the economizer where the temperature of water increases.

This water forced into the evaporator tube by using a centrifugal pump driven by the steam turbine. Water passes 10 – 15 times into the evaporator tube.

The mixture of saturated steam and water is formed inside the tube. This mixture sends to the steam separator drum which is outside the boiler.

Steam from the separator sends to the superheater, where the saturated steam converts into superheated steam.

The water again sends to the economizer where it again passes by the evaporator tubes.

The air from the air preheater enters into the furnace where fuel burn.

The flue gases first heat the evaporator tube then passes by the superheater.

These gases from the superheater again use to preheat the air into air preheater before exhausting into the atmosphere.

This working pressure of this boiler is above 170 bar and have the steam generation capacity of about 50000 kg/hour at temperature 773 K.

Advantages:

- This boiler can generate a high amount of steam.
- The main advantages easy to start its operation.
- Construction design of Lamont boiler is very simple and easy to understand.
- This boiler can reassemble with the natural circulation boiler and
- It has a high heat transfer rate.
- It is flexible in design.

Disadvantages:

> Bubble formation on a surface of the tube reduces the heat transfer rate. For this reason a little problem with the total amount of steam generation.

2. Benson Boiler:

It works on the pressure of the water which is increased to the supercritical pressure (i.e. above the critical pressure of 225 bar).

When the pressure of water is increased to the supercritical level, the latent heat of water becomes zero and due to this, it directly changes into steam without boiling. And this prevents the formation of bubbles at tube surface.

In Benson Boiler, the feed pump increases the pressure of the water to the supercritical pressure and then it enters into the economizer.

From economizer, the water passes to the radiant heater.

Here the water receives the heat through radiation and partly gets converted into steam.

The temperature raises almost to the supercritical temperature.

After that mixture of steam and water enters into the convective evaporator where it is completely converted into steam and may superheat to some degree.

Finally, it is passed through the superheater to obtained the desired superheated steam.

This superheated steam is then used by turbines or engine to produce the electricity.

3. Babcock and Wilcox boiler:

This was discovered by George Herman Babcock and Stephen Wilcox in the year 1967.

This is a water tube, used in steam power plants. In this type of boiler, water is circulated inside the tubes and hot gases flow over the tubes.

This is a Horizontal drum axis, natural draft, natural circulation, multitubular, stationary, high pressure, solid fuel fired, externally fired Water tube.

These fuel gases are uniformly heated the water tube with the help of baffle plate which works deflect the flues gas uniform throughout the tubes which absorbed the heating maximum from the flue gases.

As the hot flue gases come in contact with water tubes, It exchanges the heat with heater and converts into the steam.

Continuous circulation of water from the drum to the water tubes and water tubes to the drum is thus maintained.

The circulation of water is maintained by convective current and it’s known as Natural Circulation.

The Steam generated is moved upward, due to density difference and through the up-take header, it gets collected at the upper side in the boiler drum. Anti-priming pipe inside the drum which works, separate the moisture from the steam and sends it’s to the superheater.

The superheater receives the water free steam from an anti-priming pipe.

It increases the temperature of the steam to the desired level and transfers it to the main steam stop valve of the boiler.

The superheated steam stop valve is either collected in a steam drum or send it’s inside the steam turbine for electricity generation.

Application:

The main application is to produce high-pressure steam in power generation industries.

Advantages:

The overall efficiency of this boiler is high.

The steam generation rate is higher about 20 ton per hour at pressure 10 to 20 bars.

The tubes can be replaced easily.

The boiler can expand and contract freely.

It is easy to repair maintenance and cleaning.

Disadvantages:

It is less suitable for impure and sedimentary water, as a small deposit of scale may cause the overheating and bursting of tubes. Hence,

water treatment is very essential for water tube boilers.

Failure in feed water supply even for a short period is liable to make the boiler overheated. Hence the water level must be watched very carefully during the operation of a water tube boiler.

Maintenance cost is high.

Mounting:

There are several mounting which is having several works inside or outside the boiler like:

- Water level indicator (Water level gauge)
- Safety valves
- Stop valve
- Pressure gauge
- Feed check valve
- Blow off Valve

Accessories:

There are multiple Accessories. Boiler accessories are used to increase efficiency. The accessories may be installed either inside or outside the Boiler.

1. Feed Pump
2. Economizer
3. Air Preheater
4. Superheater

Function:

The function is to generate the Steam from the Water supplied in the boiler.

The fuels like furnace oil, baggage, coal, etc are generally used in the boiler to generate and supply the required heat.

After that the steams produced which can be used directly in process application or

That steam will be used to run steam turbines for producing electricity.

Application:

Basically, we have studied that Boiler is used for producing Steam but In the various sectors this is used like:

1. Power Sector
2. Food processing industry
3. FMCG
4. Thermal Power plants
5. Sugar Plants
6. Plywood
7. Textiles and many more.

Difference Between Water Tube and Fire Tube Boiler:

SL NO	FIRE TUBE	WATER TUBE
1.	Hot flue gases flow inside the tube and the water outsides the tubes.	Water flow inside the turbine and hot flue gases outside the tube.
2.	These boilers are generally internally fired.	This is externally fired.
3.	Pressure limited to 20 bar.	The pressure is limited up to 100 bar.
4.	This is having a lower rate of steam production.	A higher rate of steam production.
5.	Not suitable for larger power plants.	Suitable for larger power plants.
6.	Involves lesser risk of explosion due to low pressure.	Risk of the explosion is higher due to high boiler pressure.
7.	For a given power, it occupies large floor space.	For a given power, it occupies small floor space.
8.	Robust in construction.	Simple in construction.

9.	Difficult in transportation.	Simple in transportation.
10.	They require less skill to operate, as compare to the water tube boiler.	They required a skilled operator.
11.	They are difficult to repair and cleaning as they are internally fired.	They are easy to repair and clean as they are externally fired.
12.	They required a large shell diameter. Because the firetube situated inside the shell.	They required a small shell diameter.
13.	The efficiency is less as compared to the water tube boiler.	The efficiency is more.
14.	The maintenance is costly. It requires regular inspection.	They are easy to maintain as they are externally fired.
15.	Ex: Cornish, Lancashire Boiler.	Ex: Babcock and Wilcox Boiler.