DEPARTMENT OF MECHANICAL ENGINEERING

Greater Noida institute of technology

(2015-16)

SEMINAR REPORT

ON

BOILER
(BABCOCK & WILCOX BOILER)

Submitted To:

Mr. Vikram Chauhan

Department of Mechanical Engineering

Submitted By:

Prashant Chaudhary

1313240119 3rdys.

Certificate

This to certify that Mr. **Prashant Chaudhary** student of 3rd year mechanical engineering in **Greater Noida Institute of Technology** has submitted a seminar report on **"Boiler (BABCOCK & WILCOX BOILER)"** as a partial fulfilment of degree of bachelor in technology from **UPTU.**

(Mr. Vikram Chauhan)

CONTENT

<u>**LIST OF FIGURES**</u>

Abstract

A boiler is a closed vessel in which water or other fluid is heated. The fluid does not necessarily boil. (The term "furnace" is normally used if the purpose is not actually to boil the fluid.) The heated or vaporized fluid exits the boiler for use in various processes or heating applications, including central heating, boiler-based power generation, cooking, and sanitation.

Boiler is an apparatus use to produce steam. It is a device in which thermal energy released by combustion of fuel is used to make steam at the desired temperature and pressure.

A boiler or steam generator is used wherever a source of steam is required. The form and size depends on the application: mobile steam engines such as steam locomotives, portable engines and steam-powered road vehicles typically use a smaller boiler that forms an integral part of the vehicle; stationary steam engines, industrial installations and power stations will usually have a larger separate steam generating facility connected to the point-of-use by piping. A notable exception is the steam-powered fireless locomotive, where separately generated steam is transferred to a receiver (tank) on the locomotive.

Introduction

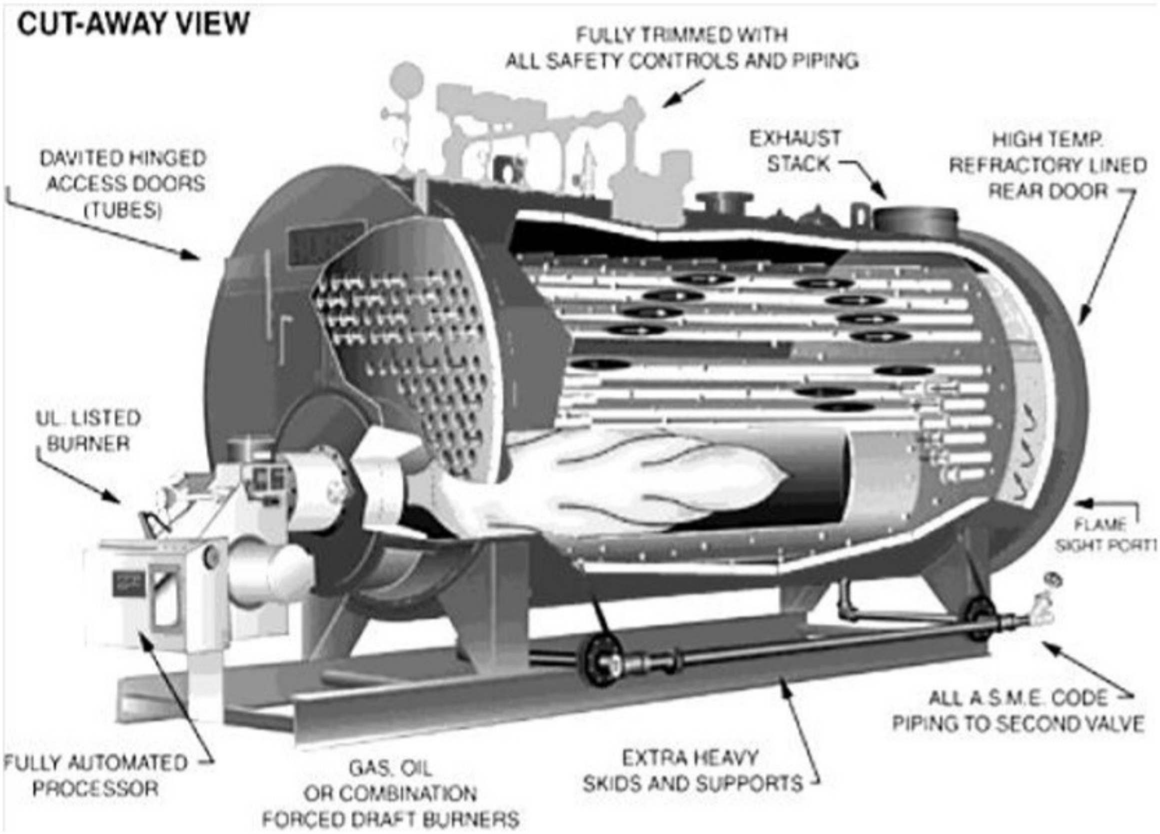
The steam generator or boiler is an integral component of a steam engine when considered as a prime mover. However it needs be treated separately, as to some extent a variety of generator types can be combined with a variety of engine units. A boiler incorporates a firebox or furnace in order to burn the fuel and generate heat. The generated heat is transferred to water to make steam, the process of boiling. This produces saturated steam at a rate which can vary according to the pressure above the boiling water. The higher the furnace temperature, the faster the steam production. The saturated steam thus produced can then either be used immediately to produce power via a turbine and alternator, or else may be further superheated to a higher temperature; this notably reduces suspended water content making a given volume of steam produce more work and creates a greater temperature gradient, which helps reduce the potential to form condensation. Any remaining heat in the combustion gases can then either be evacuated or made to pass through an economiser, the role of which is to warm the feed water before it reaches the boiler.

Boilers have several strengths that have made them a common feature of buildings. They have a long life, can achieve efficiencies up to 95% or greater, provide an effective method of heating a building, and in the case of steam systems, require little or no pumping energy. However, fuel costs can be considerable, regular maintenance is required, and if maintenance is delayed, repair can be costly. Guidance for the construction, operation, and maintenance of boilers is provided primarily by the ASME (American Society of Mechanical Engineers), which produces the following resources:

Rules for construction of heating boilers, Boiler and Pressure Vessel Code, Section IV-2007 Recommended rules for the care and operation of heating boilers, Boiler and Pressure Vessel Code, Section VII-2007 Boilers are often one of the largest energy users in a building. For every year a boiler system goes unattended, boiler costs can increase approximately 10%.

Working principle

Both gas and oil fired boilers use controlled combustion of the fuel to heat water. The key boiler components involved in this process are the burner, combustion chamber, heat exchanger, and controls.

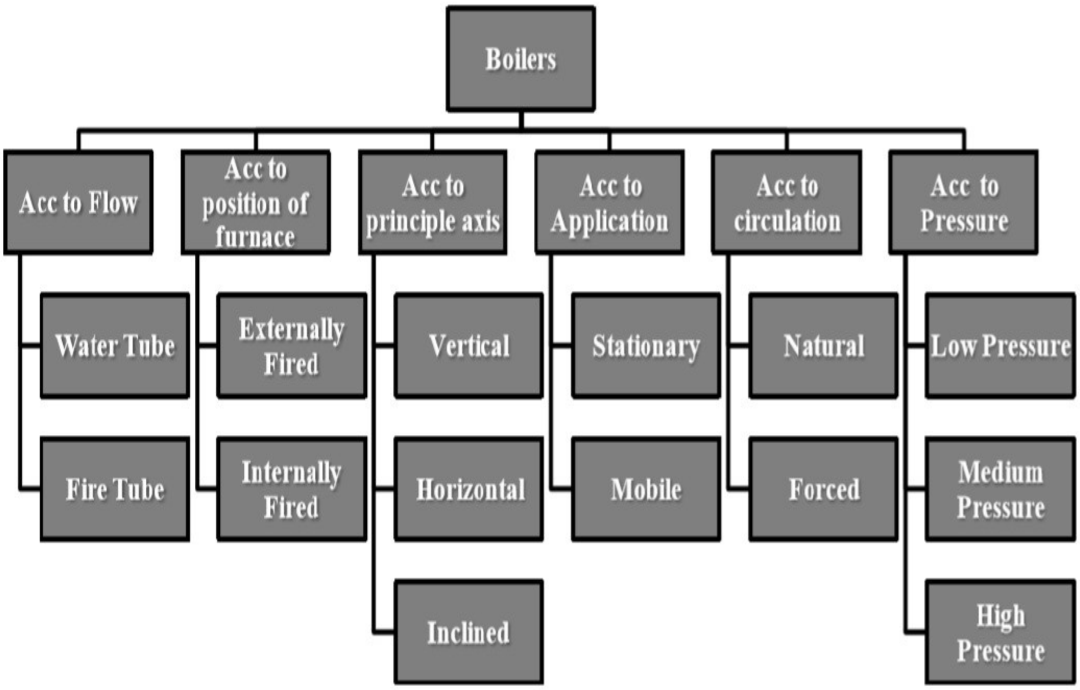


Firetube Boiler

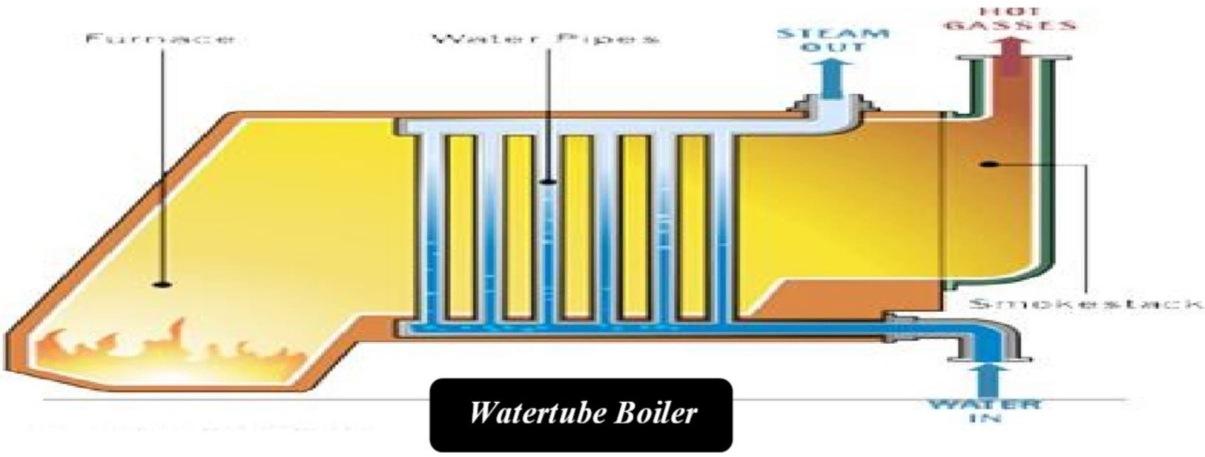
The burner mixes the fuel and oxygen together and, with the assistance of an ignition device, provides a platform for combustion. This combustion takes place in the combustion chamber, and the heat that it generates is transferred to the water through the heat exchanger. Controls regulate the ignition, burner firing rate, fuel supply, air supply, exhaust draft, water temperature, steam pressure, and boiler pressure. Hot water produced by a boiler is pumped through pipes and delivered to equipment throughout the building, which can include hot water coils in air handling units, service hot water heating equipment, and terminal units. Steam boilers produce steam that flows through Fire tube Boiler pipes from areas of high pressure to areas of low pressure, unaided by an external energy source such as a pump. Steam utilized for heating can be directly utilized by steam using equipment or can provide heat through a heat exchanger that supplies hot water to the equipment. The discussion of different types of boilers, below, provides more detail on the designs of specific boiler systems.

Classification of boilers

Boilers are classified according certain condition. Following figure shows classification of boiler.



Two primary types of boilers include Fire tube and Water tube boilers. In a Fire tube boiler, hot gases of combustion flow through a series of tubes surrounded by water. Alternatively, in Water tube boiler, Water flows in the inside of the tubes and the hot gases from combustion flow around the outside of the tubes.



Watertube Boiler

Fire tube boilers are more commonly available for low pressure steam or hot water applications, and are available in sizes ranging from 500,000 to 75,000,000 BTU input. Water tube boilers are primarily used in higher pressure steam applications and are used extensively for comfort heating applications. They typically range in size from 500,000 to more than 20,000,000 BTU input. Cast iron sectional boilers are another type of boiler commonly used in commercial space heating applications. These types of boilers don't use tubes. Instead, they're built up from cast iron sections that have water and combustion gas passages. The iron castings are bolted together, similar to an old steam radiator. The sections are sealed together by gaskets. They're available for producing steam or hot water, and are available in sizes ranging from 35,000 to 14,000,000 BTU input. Cast iron sectional boilers are advantageous because they can be assembled on site, allowing them to be transported through doors and smaller openings. Their main disadvantage is that because the sections are sealed together with gaskets, they are prone to leakage as the gaskets age and are attacked by boiler treatment chemicals.

Working Pressure and Temperature Boilers are classified as either low pressure or high pressure and are constructed to meet ASME Boiler and Pressure Vessel Code requirements. Low-pressure boilers are limited to a maximum working pressure of 15 psig (pound-force per square inch gauge) for steam and 160 psig for hot water (2). Most boilers used in HVAC applications are low-pressure boilers. High-pressure boilers are constructed to operate above the limits set for low-pressure boilers, and are typically used for power generation. Operating water temperatures for hot water boilers are limited to 250o F (2).

Fuel Type In commercial buildings, natural gas is the most common boiler fuel, because it is usually readily available, burns cleanly, and is typically less expensive than oil or electricity. Some boilers are designed to burn more than one fuel (typically natural gas and fuel oil).

Dual fuel boilers provide the operator with fuel redundancy in the event of a fuel supply interruption. They also allow the customer to utilize the fuel oil during “peak time” rates for natural gas. In times when the rates for natural gas are greater than the alternate fuel, this can reduce fuel costs by using the cheaper alternate fuel and limiting natural gas use to occur only during “off peak” times. Electric boilers are used in facilities with requirements for a small amount of steam or where natural gas is not available. Electric boilers are known for being clean, quiet, and easy to install, and compact. The lack of combustion results in reduced complexity in design and operation and less maintenance. Heating elements are easily replaced if they fail. These types of boilers can be used to produce low or high pressure steam or water, and may be good alternatives for customers who are restricted by emissions regulations. Sizes range from 30,000 to 11,000,000 BTU input with overall efficiency generally in the range of 92% to 96%.

Draft Methods The pressure difference between the boiler combustion chamber and the flue (also called the exhaust stack) produces a draft which carries the combustion products through the boiler and up the flue. Natural draft boilers rely on the natural buoyancy of hot gasses to exhaust combustion products up the boiler flue and draw fresh air into the combustion chamber. Mechanical draft boilers include: Forced Draft, where air is forced into the combustion chamber by a fan or blower to maintain a positive pressure; and Induced Draft, where air is drawn through the combustion chamber by a fan or blower to maintain a negative pressure.

Size and Capacity Modular Boilers are small in size and capacity and are often intended to replace a large single boiler with several small boilers. These modular boilers can easily fit through a standard doorway, and be transported in elevators and stairways. The units can be arranged in a variety of configurations to utilize limited space or to accommodate new equipment. Modular boilers can be staged to efficiently meet the demand of the heating load.

Condensing Method Traditional hot water boilers operate without condensing out water vapour from the flue gas. This is critical to prevent corrosion of the boiler components. Condensing Boilers operate at a lower return water temperature than traditional boilers, which causes water vapour to condense out of the exhaust gasses. This allows the condensing boiler to extract additional heat from the phase change from water vapour to liquid and increases boiler efficiency. Some carbon dioxide dissolves in the condensate and forms carbonic acid. While some condensing boilers are made to handle the corrosive condensation, others require some means of neutralizing the condensate. Traditional non-condensing boilers typically operate in the range of 75% – 86% combustion efficiency, while condensing boilers generally operate in the range of 88% to 95% combustion efficiency.

Important boilers

- **COCHRAN BOILER**

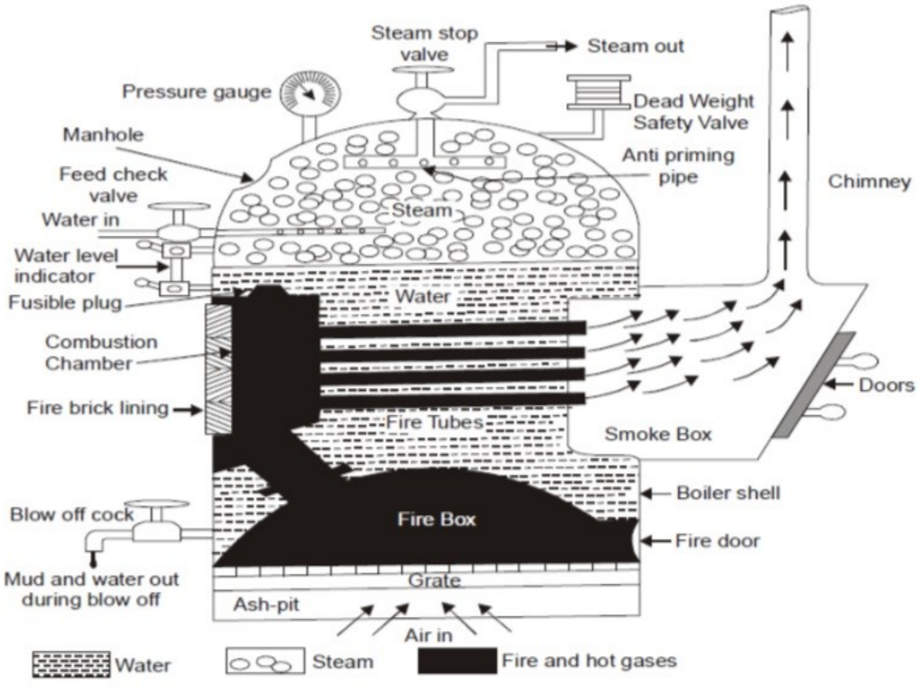
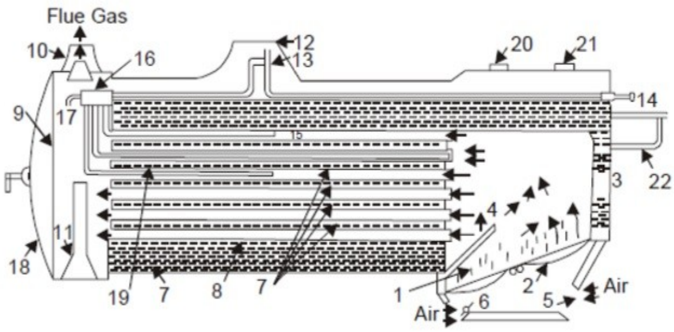


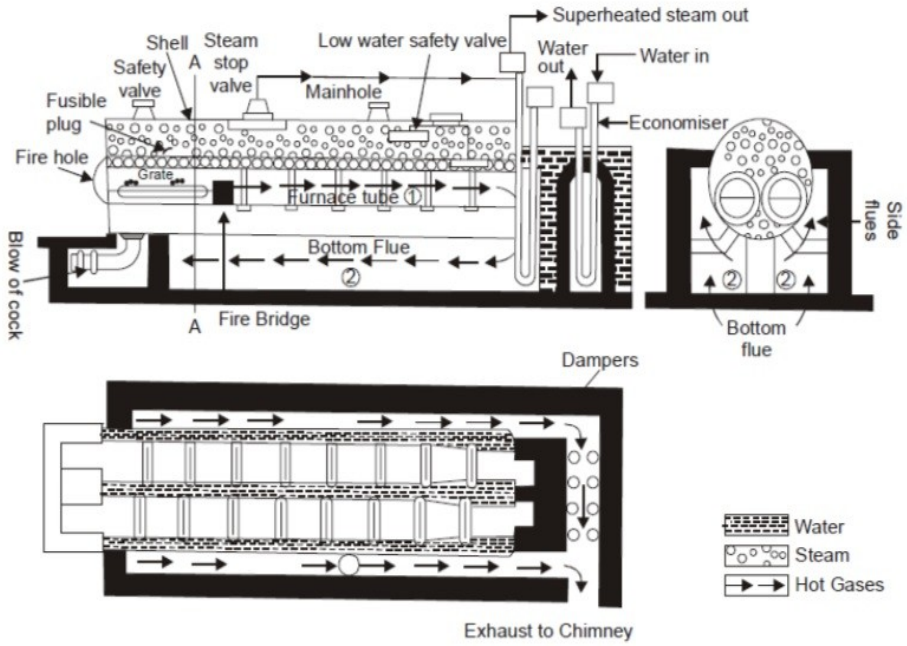
Fig. 5.1. Cochran Boiler.

➢ LOCOMOTIVE BOILERS

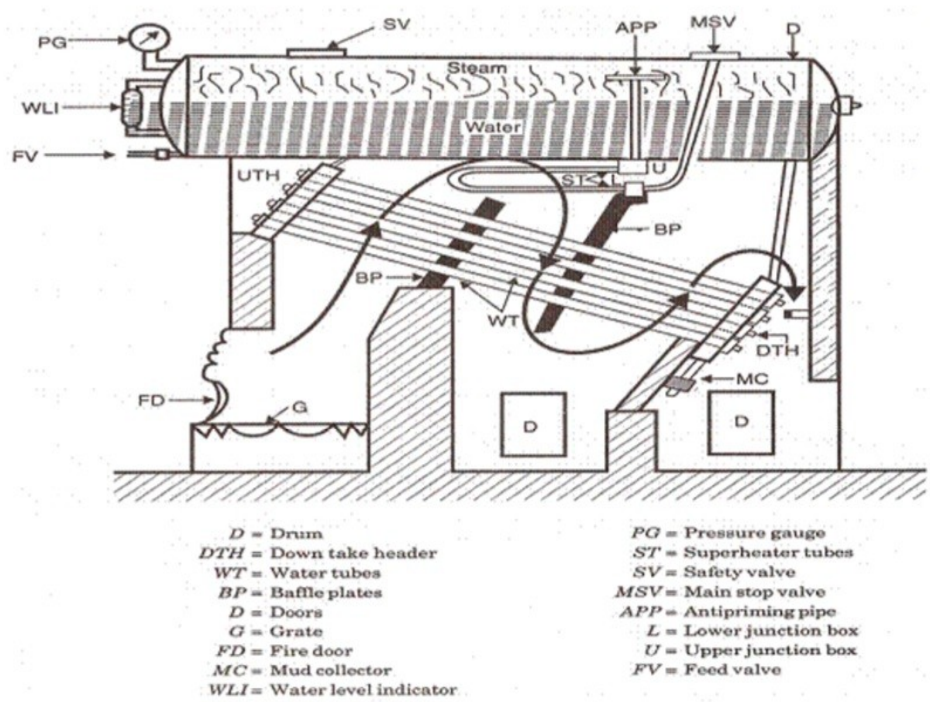


1. Fire box
2. Grate
3. Fire hole
4. Fire bride arch
5. Ash pit
6. Damper
7. Fine tubes
8. Barrel or shell
9. Smoke box
10. Chimney (short)
11. Exhaust steam pipe
12. Steam dome
13. Regulator
14. Lever
15. Superheater tubes
16. Superheater header
17. Superheater exist pipe
18. Smoke box door
19. Feed check valve
20. Safety valve
21. Whistle
22. Water gauge

➢ LANCSHIRE BOILER

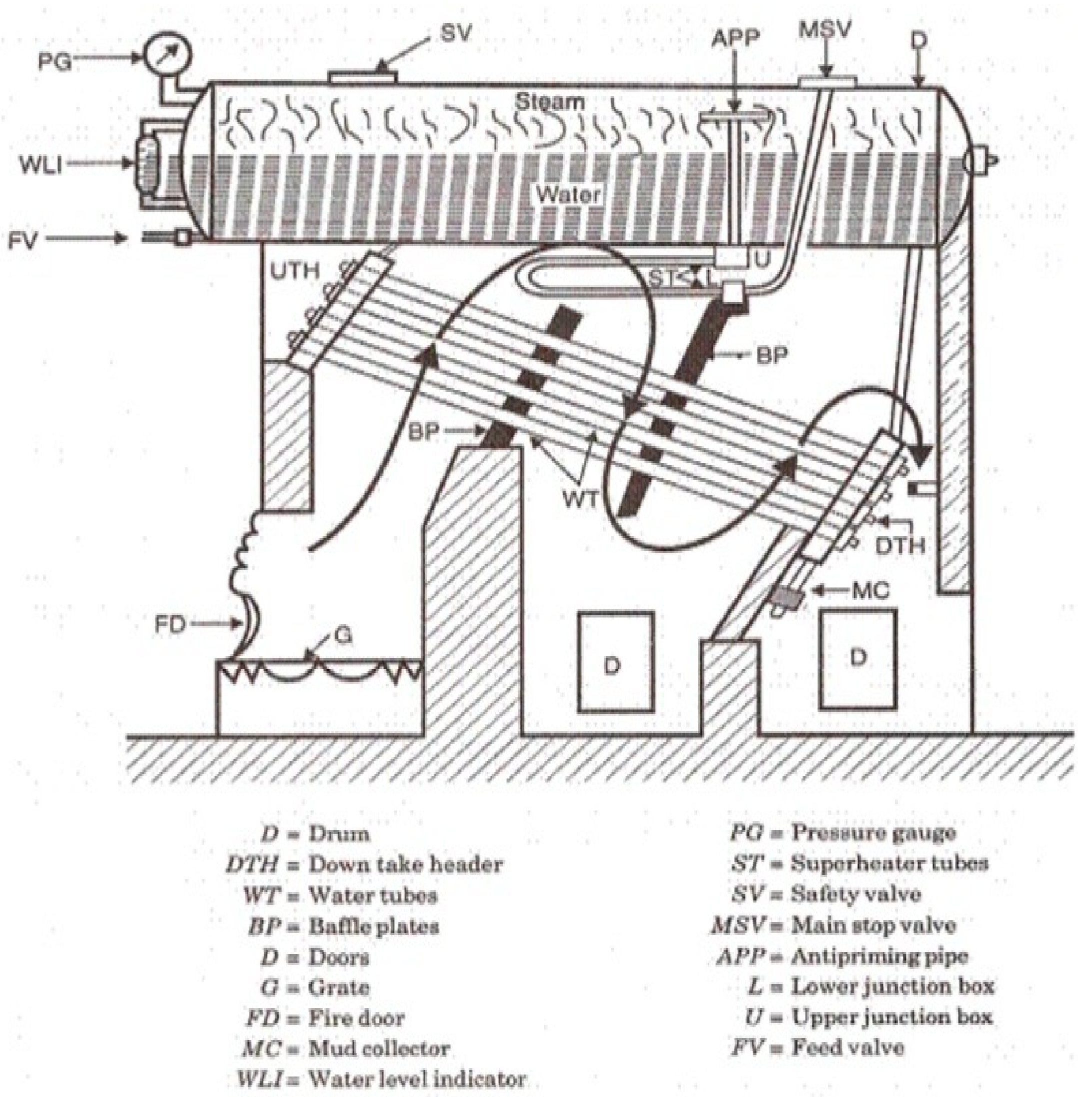


- **BABCOCK WILCOX BOILER**



- **HYDRONIC BOILERS**

Babcock Wilcox boiler



- The evaporative capacity of this boiler is high compared with other boilers (20,000 to 40,000 kg/hr). The operating pressure lies between 11.5 to 17.5 bars.
- The draught loss is minimum compared with other boilers.
- The defective tubes can be replaced easily.
- The entire boiler rests over an iron structure, independent of brick work, so that the boiler may expand or contract freely. The brick walls which form the surroundings of the boiler are only to enclose the furnace and the hot gases.

Construction of Babcock and Wilcox boiler

The Babcock and Wilcox Boiler consists of

1. Steam and water drum (boiler shell)
2. Water tubes
3. Uptake-header and down corner
4. Grate
5. Furnace
6. Baffles
7. Super heater
8. Mud box
9. Inspection door
10. Damper

Steam and water drum (boiler shell):

One half of the drum which is horizontal is filled up with water and steam remains on the other half. It is about 8 meters in length and 2 meter in diameter.

Water tubes:

Water tubes are placed between the drum and furnace in an inclined position (at an angle of 10 to 15 degree) to promote water circulation. These tubes are connected to the uptake-header and the down-comer as shown.

Uptake-header and down-corner (or down take-header)

the drum is connected at one end to the uptake-header by short tubes and at the other end to the down-corner by long tubes.

Grate: Coal is fed to the grate through the fire door.

Furnace: Furnace is kept below the uptake-header.

Baffles: The fire-brick baffles, two in number, are provided to deflect the hot flue gases.

Super heater: The boiler is fitted with a super heater tube which is placed just under the drum and above the water tubes

Mud box: Mud box is provided at the bottom end of the down comer. The mud or sediments in the water are collected in the mud box and it is blown-off time to time by means of a blow –off cock.

Inspection doors: Inspection doors are provided for cleaning and inspection of the boiler.

Working of Babcock and Wilcox Boiler

Coal is fed to the grate through the fire door and is burnt.

Flow of flue gases:

The hot flue gases rise upward and pass across the left-side portion of the water tubes. The baffles deflect the flue gases and hence the flue gases travel in the zig-zag manner (i.e., the hot gases are deflected by the baffles to move in the upward direction, then downward and again in the upward direction) over the water tubes and along the super heater. The flue gases finally escape to atmosphere through chimney.

Water circulation:

That portion of water tubes which is just above the furnace is heated comparatively at a higher temperature than the rest of it. Water, its density being decreased, rises into the drum through the uptake-header. Here the steam and water are separated in the drum. Steam being lighter is collected in the upper part of the drum. The water from the drum comes down through the down –comer into the water tubes.

A 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 currents and is known as **"natural circulation**".

A damper is fitted as shown to regulate the flue gas outlet and hence the draught.

The boiler is fitted with necessary mountings. Pressure gauge and water level indicator are mounted on the boiler at its left end. Steam safety valve and stop valve are mounted on the top of the drum. Blow-off cock is provided for the periodical removed of mud and sediments collected in the mud box.

Salient features of Babcock and Wilcox Boiler:

1. Its overall efficiency is higher than a fire tube boiler.
2. The defective tubes can be replaced easily.
3. All the components are accessible for inspection even during the operation.
4. The draught loss is minimum compared with other boiler.
5. Steam generation capacity and operating pressure are high compared with other boilers.
6. The boiler rests over a steel structure independent of brick work so that the boiler may expand or contract freely.
7. The water tubes are kept inclined at an angle of 10 to 15 degree to promote water circulation.

Boiler fittings and accessories

- **Safety valve**: It is used to relieve pressure and prevent possible explosion of a boiler.
- **Water level indicators**: They show the operator the level of fluid in the boiler, also known as a sight glass, water gauge or water column is provided.
- **Bottom blowdown valves**: They provide a means for removing solid particulates that condense and lie on the bottom of a boiler. As the name implies, this valve is usually located directly on the bottom of the boiler, and is occasionally opened to use the pressure in the boiler to push these particulates out.

- **Continuous blowdown valve**: This allows a small quantity of water to escape continuously. Its purpose is to prevent the water in the boiler becoming saturated with dissolved salts. Saturation would lead to foaming and cause water droplets to be carried over with the steam - a condition known as priming. Blowdown is also often used to monitor the chemistry of the boiler water.
- **Flash Tank**: High pressure blowdown enters this vessel where the steam can 'flash' safely and be used in a low-pressure system or be vented to atmosphere while the ambient pressure blowdown flows to drain.
- **Automatic Blowdown/Continuous Heat Recovery System**: This system allows the boiler to blowdown only when makeup water is flowing to the boiler, thereby transferring the maximum amount of heat possible from the blowdown to the makeup water. No flash tank is generally needed as the blowdown discharged is close to the temperature of the makeup water.
- **Hand holes**: They are steel plates installed in openings in "header" to allow for inspections & installation of tubes and inspection of internal surfaces.
- **Steam drum internals**: A series of screen, scrubber & cans (cyclone separators).
- **Low- water cut-off**: It is a mechanical means (usually a float switch) that is used to turn off the burner or shut off fuel to the boiler to prevent it from running once the water goes below a certain point. If a boiler is "dry-fired" (burned without water in it) it can cause rupture or catastrophic failure.
- **Surface blowdown line:** It provides a means for removing foam or other lightweight non-condensable substances that tend to float on top of the water inside the boiler.
- **Circulating pump**: It is designed to circulate water back to the boiler after it has expelled some of its heat.
- **Feed water check valve or clack valve**: A non-return stop valve in the feed water line. This may be fitted to the side of the boiler, just below the water level, or to the top of the boiler.
- **Top feed**: In this design for feed water injection, the water is fed to the top of the boiler. This can reduce boiler fatigue caused by thermal stress. By spraying the feed water over a series of trays the water is quickly heated and this can reduce lime scale.
- **Desuperheater tubes or bundles**: A series of tubes or bundles of tubes in the water drum or the steam drum designed to cool superheated steam. Thus is to

supply auxiliary equipment that does not need, or may be damaged by, dry steam.

- **Chemical injection line**: A connection to add chemicals for controlling feed water ph.

Steam accessories

- **Main steam stop valve**: It is use to regulate supply of steam.
- **Steam traps**
- **Main steam stop/Check valv**e: It is used on multiple boiler installations.

Combustion accessories

- Fuel oil system or fuel oil heaters
- Gas system
- Coal system
- Soot blower

Other essential items

- Pressure gauges
- Feed pumps
- Fusible plug
- Inspectors test pressure gauge attachment
- Name plate

Advantages and disadvantages of water tube boilers over fire tube boilers

Advantages water tube boilers:

- Steam can be generated at very high pressures.
- Heating surface is more in comparison with the space occupied, in the case of water tube boilers.

- Steam can be raised more quickly than is possible with a fire tube boiler of large water capacity. Hence, it can be more easily used for variation of load.
- The hot gases flow almost at right angles to the direction of water flow. Hence maximum amount of heat is transferred to water.
- A good and rapid circulation of water can be made.
- Bursting of one or two tubes does not affect the boiler very much with regard to its working. Hence water tube boilers are sometimes called as safety boilers.
- The different parts of a water tube boiler can be separated. Hence it is easier to transport.
- It is suitable for use in steam power plants (because of the various advantages listed above).

Disadvantages of water tube boilers

- 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.
- Maintenance cost is high.
- 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 operation of a water tube boiler.

Applications

"The ability of water tube boilers to generate superheated steam makes these boilers particularly attractive in applications that require dry, high-pressure, high-energy steam, including steam turbine power generation".

Owing to their superb working properties, the use of water tube boilers is highly preferred in the following major areas:

- 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 mega pascals (160 bar) and high temperatures reaching up to 550°C are generally required. For example, the Ivanpah solar-power station uses two Rentech Type-D water tube boilers.

Stationary

Modern boilers for power generation are almost entirely water-tube designs, owing to their ability to operate at higher pressures. Where process steam is required for heating or as a chemical component, then there is still a small niche for fire-tube boilers.

Marine

Their ability to work at higher pressures has led to marine boilers being almost entirely water-tube. This change began around 1900, and traced the adoption of turbines for propulsion rather than reciprocating (i.e. piston) engines – although water tube boilers were also used with reciprocating engines.

Railway

There has been no significant adoption of water-tube boilers for railway locomotives. A handful of experimental designs were produced, but none of these were successful or led to their widespread use.[4] Most water-tube railway locomotives, especially in Europe, used the Schmidt system. Most were compounds, and a few inflows. The Norfolk and Western Railway's *Jawn Henry* was an exception, as it used a steam turbine combined with an electric transmission.