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Department of Mechanical Engineering

SUBJECT-Thermal Engineering-II (TH-4)

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BOILERS

Boiler is defined as a closed vessel in which steam is produced from water by combustion of fuel.

Classification of Boilers

① According to the contents in the tube:-

- (i) Fire Tube or smoke tube Boiler
- (ii) Water Tube Boiler

② According to the position of the furnace:-

- (i) Internally fired Boiler
- (ii) Externally fired Boiler

③ According to the axis of shell:-

- (i) Vertical Boiler
- (ii) Horizontal Boiler

④ According to the number of tubes:-

- (i) Single Tube Boiler
- (ii) Multi Tube Boiler

⑤ According to method of circulation of water and steam

- (i) Natural circulation Boiler
- (ii) Forced circulation Boiler

⑥ According to the use:-

- (i) Stationary Boiler
- (ii) Mobile Boiler

⑦ According to the source of heat:-

Sources are solid fuel, liquid fuel, gaseous fuel, hot waste gases etc.

Important Terms of Boiler :-

Shell → It consists of one or more steel plates bent into a cylindrical form and riveted or welded together. The shell ends are closed with end plates.

Setting → It is made up of brickwork and forms the wall of the furnace and combustion chamber whose function is to confine heat to the boiler.

Grate → It is the platform in the furnace upon which fuel is burnt and is made of cast iron bars.

Furnace → It is a chamber formed by space between above the grate and below the boiler shell in which combustion takes place.

Water space & Steam space → The volume of shell occupied by the water is called 'water space' while the entire shell volume other than water is called 'steamspace'.

Mounting → These are the fittings which are mounted on the boiler for its proper functioning. Boilers can not work safely without them.
ex - Water level indicator, pressure gauge, safety valve

Accessories → These are the devices which form an integral part of a boiler but are not mounted on it. They help the boiler to increase the efficiency.
ex - Super heater, economiser, feed pump etc.

Water level → The level at which water stands in the Boiler is called water level.

Foaming → Formation of steam bubbles on the surface of boiler water due to high surface tension of water.

Scale → A deposit of medium to extreme hardness occurring on water heating surfaces of a boiler because of an undesirable condition in the boiler water.

Blowing off → The removal of the mud & other impurities of water from the lowest part of the boiler is called blowing off.

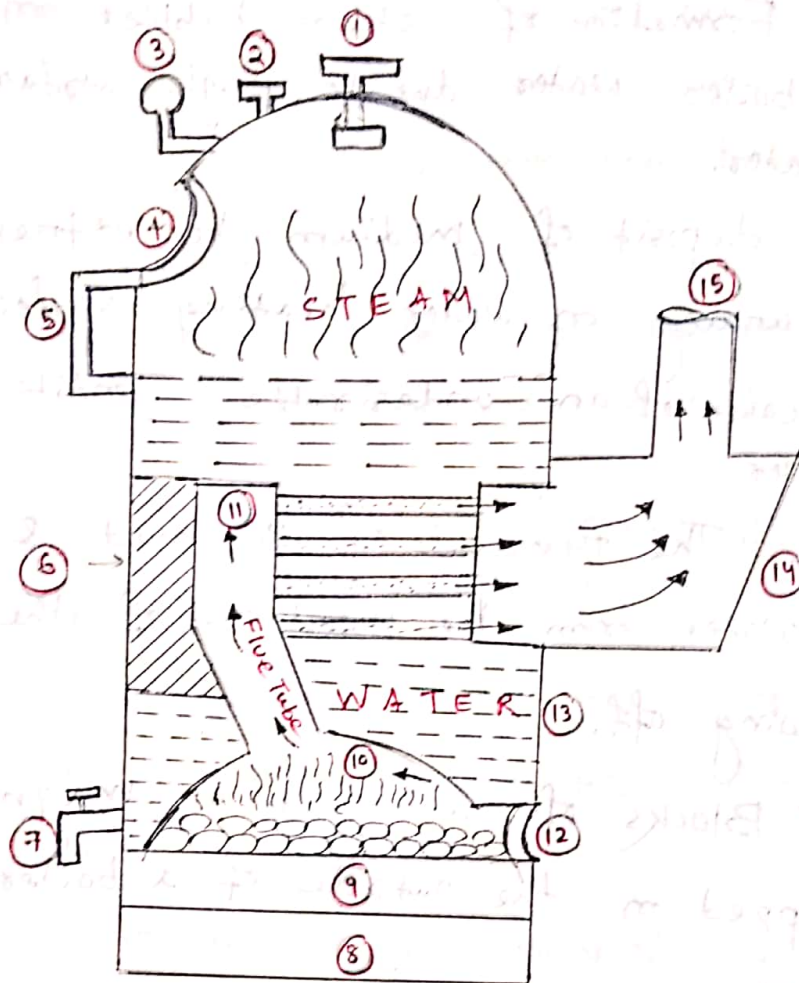
Lagging → Blocks of asbestos or magnesia insulation wrapped on the outside of a boiler shell or steam piping.

Refractory → A heat insulation material such as fire brick or plastic fire clay used for lining combustion chambers.

Fire Tube Boiler → In fire tube steam boilers the flames and hot gases produced by combustion of the fuel pass through the tubes which are surrounded by water. The heat is conducted through the walls of the tubes from the hot gases to the surrounding water.

Ex:- Simple Vertical Boiler, Cochran Boiler, Lancashire Boiler, Cornish Boiler.

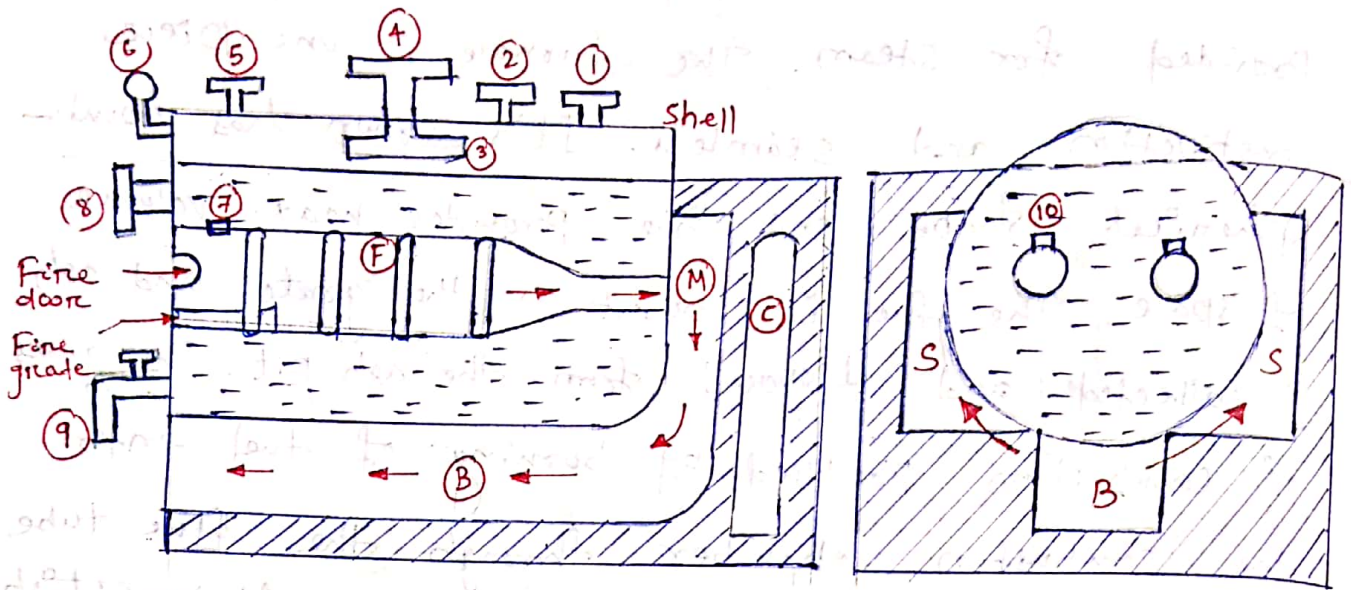
Cochran Boiler →



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|-----------------------|------------------------|
| ① → Steam stop valve | ⑨ → Grate |
| ② → Safety valve | ⑩ → Furnace |
| ③ → Pressure gauge | ⑪ → Combustion chamber |
| ④ → Man hole | ⑫ → Fire hole |
| ⑤ → Water level gauge | ⑬ → cylindrical shell |
| ⑥ → Fire brick lining | ⑭ → smoke Box |
| ⑦ → Blow off cock | ⑮ → chimney |
| ⑧ → Ash pit | |

Working → Cochran boiler consists of a cylindrical shell with a dome shaped top where the space is provided for steam. The furnace is one piece construction and seamless. It's crown has hemi-spherical shape and this provides max. volume of space. The fuel is burnt on the grate and ash is collected and disposed from the ash pit. The gases of combustion produced by burning of fuel enter the combustion chamber through the flue tube and strike against the fire brick lining which directs them to pass through no. of horizontal tubes being surrounded by water. Then the gases escape to the atmosphere through the smoke box & chimney. A number of hand holes are provided for cleaning of the shell.

Lancashire Boiler



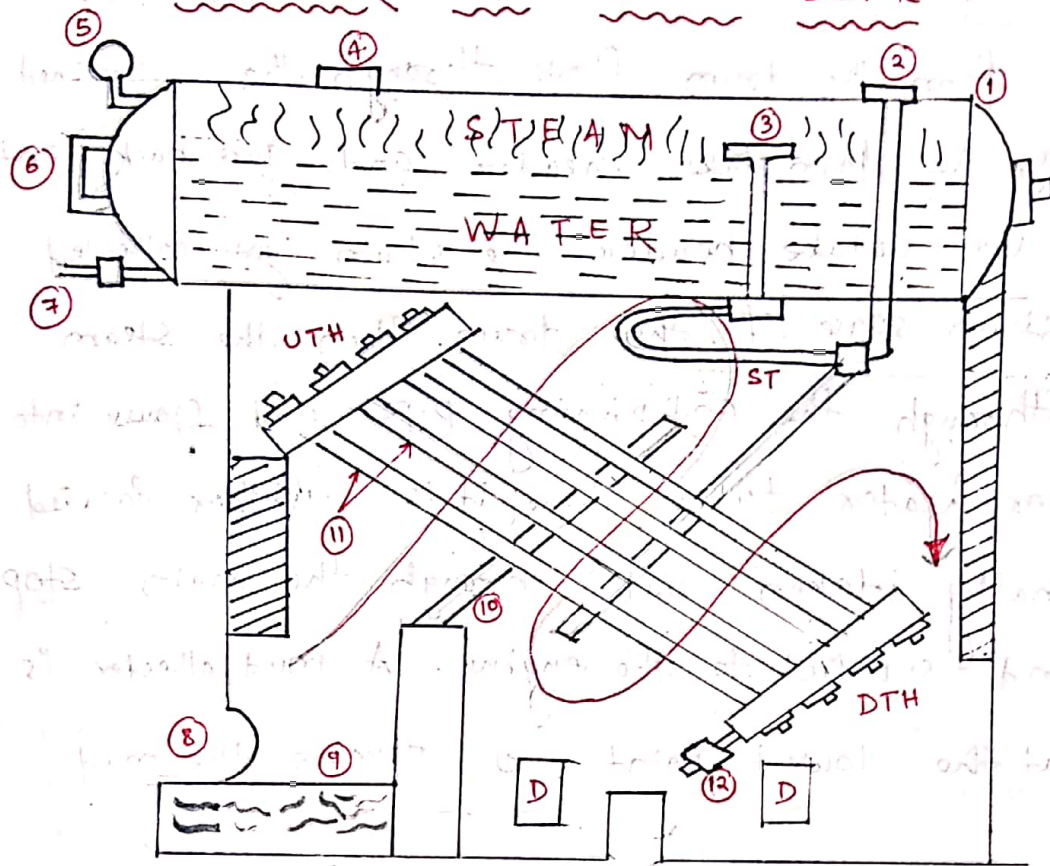
(SIDE VIEW)

(FRONT SIDE VIEW)

- ① → High steam low water safety valve
 - ② → Man hole
 - ③ → Anti Priming pipe
 - ④ → Steam stop valve
 - ⑤ → Safety valve
 - ⑥ → Pressure gauge
 - ⑦ → Feed check valve
 - ⑧ → Water gauge
 - ⑨ → Blow down cock
 - ⑩ → Fusible Plug
- B → Bottom flue
 - C → Chimney
 - F → Flue tube
 - M → Main flue
 - S → side flue

Working → Lancashire Boiler consists of a cylindrical shell inside which two large tubes are placed. The shell is constructed with several rings of cylindrical form and it is placed horizontally over a brickwork. These two tubes are also constructed with several rings of cylindrical form. They pass from one end of the shell to the other and are covered with water. The furnace is placed at the front end of each tube and they are known as furnace tubes. The coal is introduced through the fire hole into the grate. The combustion products from the grate pass up to the back of the furnace tubes and then down ward direction. Then they move through the bottom channel or bottom flue up to the front end of the boiler where they are divided and pass up to the side flues. Now they move along the two side flues and come to the chimney flue from where they lead to the chimney. To control the flow of hot gas dampers are provided.

Babcock and Wilcox Boiler



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|-----------------------|-------------------------|--------------------------|
| ① → Drum | ⑥ Water level indicator | ⑪ Water tubes |
| ② → Main stop Valve | ⑦ Feed Valve | ⑫ Mud collector |
| ③ → Anti Priming Pipe | ⑧ Fire Door | D → Doors |
| ④ → Safety valve | ⑨ Grate | DTH → Down Take Header |
| ⑤ → Pressure gauge | ⑩ Baffle plate | UTH → Upper Take Header |
| | | ST → Super heater tubes. |

Working → It is a stationary type Water Tube Boiler.

It consist of a drum connected to a series of front end and rear end headers by short riser tubes. These headers are connected to series of inclined water tubes. The angle of inclination of the water tubes to the horizontal is about 15° . A hand hole is provided in the header for cleaning & inspection of tubes. A feed valve is provided to fill the drum and inclined tubes with water. Through the fire door the fuel is supplied to the grate where it is burnt. The hot gases are forced to move upward

between the tubes provided with baffle plates. The water from the down flows through the inclined tubes via the down take header and goes back into the shell via uptake header. The steam get collected in the steam space of the drum. Then the steam enters through the anti priming pipe and flows into the super heater tubes where it is further heated and finally taken out through the main stop valve and supplied to the engine. A mud collector is provided at the lowest point to remove the mud particles.

• Comparison between Water Tube Boilers & Fire Tube Boilers.

Water Tube Boiler

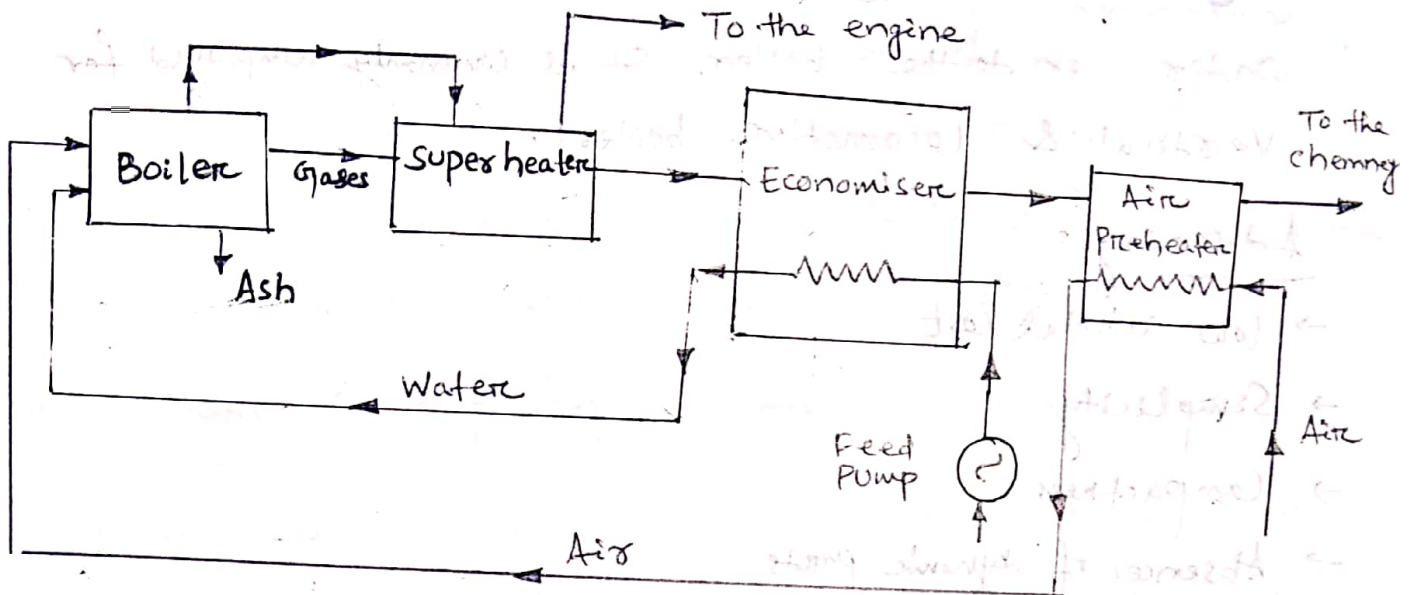
- ① The water circulates inside the tubes which are surrounded by hot gases from the furnace.
- ② It can generate steam at a higher pressure upto 165 bar.
- ③ The rate of generation of steam is high upto 450 tonnes per hr.
- ④ The floor area required for the generation of steam is less.
- ⑤ Overall efficiency with economiser is upto 90%.
- ⑥ It can be transported & erected easily.
- ⑦ It is preferred for widely fluctuating load.
- ⑧ High operating cost.
- ⑨ Bursting chances are more.
- ⑩ Used for large power plants.

Fire Tube Boiler

- The hot gases pass through the tubes which are surrounded by water.
- It can generate steam upto 24.5 bar.
- The rate of generation of steam is upto 9 tonnes per hr.
- The floor area required is more.
- It's overall efficiency is only 75%.
- Transportation & erection is difficult.
- It can cope reasonably with suddenly increased load for a shorter time.
- Less operating cost.
- Bursting chances are less.
- Not suitable for large power plants.

Boiler Accessories

Accessories are the auxiliary parts required for steam boilers for their proper operation and for the increase of their efficiency.



① Feed Pump → It is a pump which is used to deliver feed water to the boiler. Two types of commonly used feed pumps are

- (1) Reciprocating pump
(ii) Rotary pump

Reciprocating pump may be of two types.

- (a) Single acting
(b) Double acting.

→ In single acting pump the water is displaced by one side of the piston only and so water is discharged in alternate strokes.

→ In double acting pump water is discharged on each stroke of the piston & displaced by both side of the piston.

Rotary feed pumps are of centrifugal type and are commonly run either by small steam turbine or by an electric motor.

② Injector → - The function of an injector is to feed water into the boiler. It is commonly employed for Vertical & Locomotive boilers.

Advantages

- Low initial cost
- Simplicity
- Compactness
- Absence of dynamic parts
- Thermal efficiency is very high (90%)
- Ease of operation

Disadvantages

- Low pumping efficiency
- It can not force very hot temp. water.
- Irregularity of operation under extreme variation in steam pressure.
- Not applicable for large capacity high pressure boiler.

③ Economiser → An economiser is a device in which the waste heat of the flue gases is utilised for heating the feed water. Economiser is of two types.

(a) Independent type → It is installed in the chamber which is situated at the passage of the flow of the flue gas from the boiler or boiler to the chimney.

(b) Integral type → It is a part of the boiler heating surface and is installed within the boiler setting.

Advantages of using an Economiser

- The temperature range between various parts of the boiler is reduced which results in reduction of stress due to the unequal expansion.
- Evaporative capacity of the boiler is increased.
- Overall efficiency of the plant increases.

④ Air preheater →

The function of the air preheater is to increase the temperature of air before it enters the furnace. It is generally placed after the economiser. It preheats the air to be supplied to the furnace which accelerates the combustion and facilitates the burning of coal.

Degree of Pre heating depends on

- Type of fuel
- Type of fuel burning equipment
- Rating at which the boiler and furnace are operated.

Air Preheaters are of 3 types

- (i) Tubular type
- (ii) Plate type
- (iii) Storage type.

5) Superheater. → The function of a superheater is to increase the temperature of the steam above its saturation point.

Advantages →

- Steam consumption of the engine or turbine is reduced.
- Losses due to condensation in cylinders & steam pipes are reduced.
- Erosion of turbine blades is eliminated.
- Efficiency of the plant increases.

There are two types of superheaters

- (1) Convective superheater
- (2) Radiant superheater.