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ENGINEERS ACADEMY

RPSC - A.En.

Assistant Engineering

MECHANICAL

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Volume - 11

Power Plant

SIERRA INNOVATIONS

STEAM GENERATORS/BOILERS

THEORY

1.1 INTRODUCTION

Steam is mainly required for power generation, process heating and space heating purposes. The capacity of the boilers used for power generation is considerably large compared with other boilers.

Due to the requirements of high efficiency, the steam for power generation is produced at high pressures and in very large quantities.

The boilers generating steam for process heating are generally smaller in size and generate steam at a much lower pressure. A steam generator popularly known as boiler is a closed vessel made of high quality steel in which steam is generated from water by the application of heat. The water receives heat from the hot gases through the heating surfaces of the boiler. The hot gases are formed by burning fuel, may be coal, oil or gas.

In simple, a boiler may be degined as a closed vessel in which steam is produced from water by combustion of fuel.

The main requirements of steam generators or boiler are:

(i) Water must be contained safely

(ii) Steam must be safely delivered in desired condition (as required its pressure, temperature, quality).

1.2 CLASSIFICATION OF BOILERS

1.2.1 According to the relative position of water and hot gases

Fire tube or smoke tube boilers and water tube boilers:

(i) In fire tube boilers, hot gases pass through tubes which are surrounded with water. The Cochran, Lancashire and Locomotive are examples of this type of boilers. Due to their simplicity and because of the small capacity requirements of these boilers are used for producing process steam.

(ii) In water tube boilers, the water circulates through the tubes and hot gases around them. Steam is generated inside the tubes and collected in a cylindrical vessel known as boiler drum found suitable for different capacity and pressure requirements, from process steam to power generation.

2.2.2 According to the axis of shell

The boilers are classified as vertical boilers and horizontal boilers. In vertical steam boilers, the axis of the shell is vertical whereas it is horizontal in case of horizontal steam boilers.

1.2.3 According to the method of the furnace

(i) In externally fired boilers, the furnace is placed outside the boiler shell. The advantage of this type is that the fire place is simple and may be enlarged easily. Water tube boilers are always externally fired.

(ii) In internally fired boilers, the furance is placed inside the boiler shell. Most of the fire tube boilers are of this type.

1.2.4 According to the method of water circulation

Boilers are also classified as natural circulation and forced circulation boilers:

(i) In natural circulation boilers, the water is circulated by natural convection currents which are set up due to the temperature difference.

(ii) In forced circulation boilers, water is circulated with the help of a pump driven by motor. Forced circulation is used mainly in high pressure high capacity boilers.

1.3 BOILER TERMS

The details of the boilers are listed below :

- **Shell :** The shell of the boilers is the main container usually of cylindrical shape, which contains water and steam.
- **Furnace :**A furnace is another important part of the boiler. This may be a grate to burn coal or a burner to atomize and burn liquified fuel. Suitable area and volume should be provided for efficient combustion.
- **Water Flow Path :** Water flow path is the path followed by the water in the boiler (particularly in water tube boiler) during the process of absorption of heat from hot gases and conversion into steam.
- **Gas Flow Path :** The hot gas flow path either in fire tube or in water tube should be arranged in such a way that maximum heat of hot gases should be transferred to the water for steam generation. The boiler efficiency mainly depends upon the gas flow path.
- **Steam Path :** In most of the boilers, the steam is taken out preferably at the top of the shell to avoid water particles being carried with the steam. To reduce the water particles carried by the steam, it is generally taken out through steam separators, in the case of large boilers.
- **Fittings :** The valves and gauges which are necessary for the safety of the boiler, are known as mountings. Water level indicator, safety valve, blow-off cock and fusible plug are some of the mountings.
- **Accessories :** Some equipments like economiser, air preheater and superheater are attached to the boiler to improve its overall efficiency. The economiser and air preheater are used to extract maximum heat from the flue gases and superheater is used to increase the temperature of steam above saturation temperature.

1.4. SELECTION OF A BOILER

While selecting a boiler the following factors should be considered :

1. The working pressure and quality of steam required (i.e., whether wet or dry or super-heated).
2. Steam generation rate.
3. Floor area available.
4. Accessibility for repair and inspection.
5. Comparative intial cost.
6. Erection facilities.

7. The portable load factor.
8. The fuel and water available.
9. Operating and maintenance cost.

1.5. FIRE TUBE BOILERS

Hot flue gases flow through turbines surrounded by water in a shell.

Advantages :

(i) Low initial cost

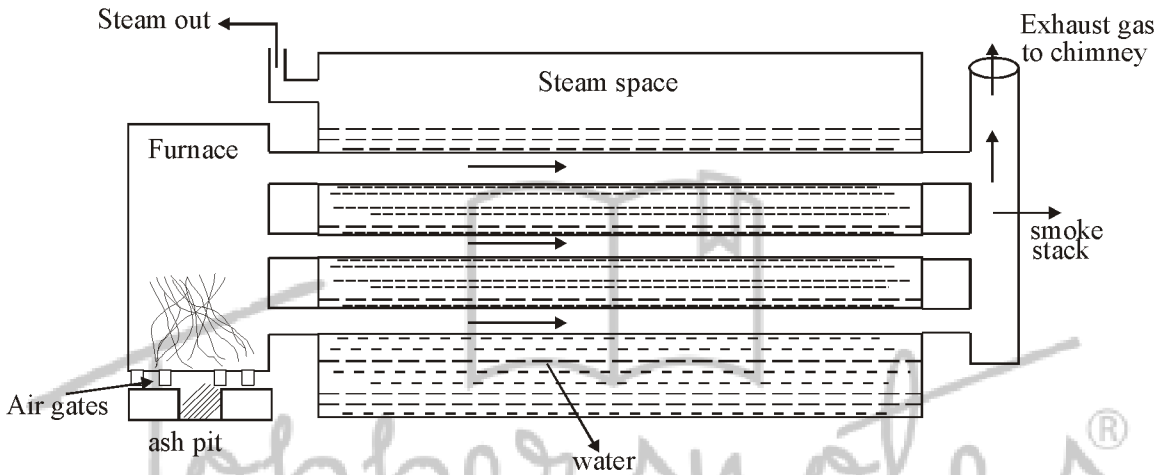
(ii) Reliability in operation.

(iii) Less draught required.

(iv) Quick response to load changes.

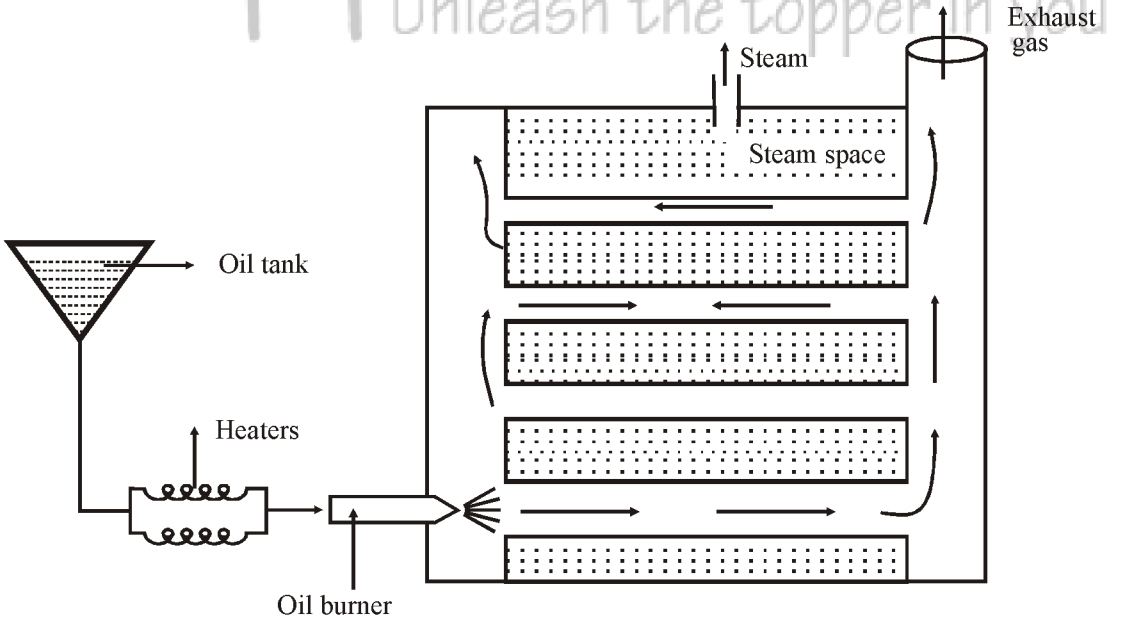
These boilers may be :

(i) Externally fired (Furnace outside the boiler shell)



Fire Tube Boiler

(ii) Internally fired (Furnace intside the boiler shell)



1.6 DIFFERENT TYPE OF FIRE TUBE BOILER

- Simple vertical boiler
- Cochran boiler
- Cronish boiler
- Lancashire boiler
- Locomotive boiler
- Scotch boiler.

1.6.1 Simple vertical boiler

It consists of a cylinderical shell, the greater portion of which is full of water (which surrounds the fire box also) and remaining is the steam space. At the bottom of the fire box is greate on which fuel is burnt and the ah from it falls in the ash pit.

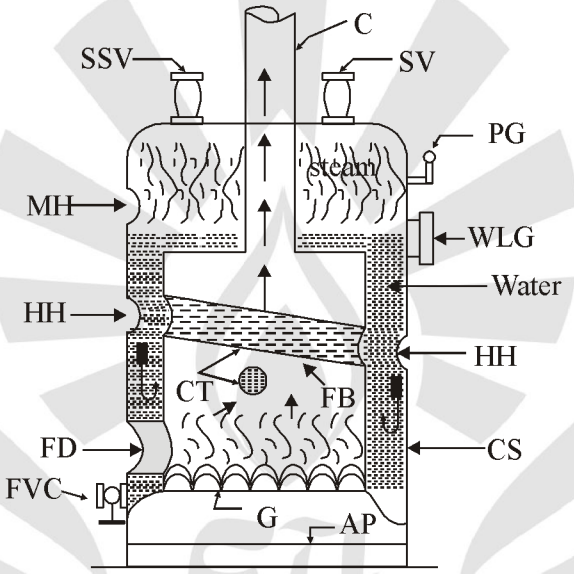


Fig. : Simple vertical boiler

CS	=	Cylindrical shell	C	=	Chimeny	MH	=	Man hole
HH	=	Hand hole	CT	=	Cross tubes	FD	=	Fire door
G	=	Grate	FB	=	Fire box	PG	=	Pressure gauge
AP	=	Ash pit	SV	=	Safety valve	SSV	=	Steam stop valve
WLG	=	Water level gauge	FCV	=	Feed check valve			

The fire box is provided with two cross tubes. This increases the heating surface and the circulation of water. The corrss tubes are fitted inclined. This ensures efficient circulation of water. At the ends of each cross tube are provided hand holes to give access for cleaning these tubes. The combustion gases after heating the water and thus converting it into steam escape to the atmosphere through the chimney. Man hole, is provided to clean the interior of the boiler and exterior of the combustion chamber and chimney.

1.6.2 Cochran boiler

- Multi-tubular vertical fire tube boiler having horizontal fire tubes.
- The heating surface has been increased by means of a number of fire tubes.
- Occupies comparatively less floor area and is very compact.
- Well suited for small capacity requirements.

- Dome shaped furnace causes hot gases to deflect back & unburnt fuel also gets deflected back.
- The spherical top and spherical shape of fire-box are the special features of this boiler. These shapes require least material for the volume. The hemi spherical crown of the boiler shell gives maximum strength to withstand the pressure of the steam inside the boiler. The hemispherical crown of the fire box is advantageous for resisting intense heat. This shape is also advantageous for the absorption of the radiant heat from the furnace.
- Coal or oil can be used as fuel in this boiler. If oil is used as fuel, no grate is provided but the bottom of the furnace is lined with the fire bricks. Oil burners are fitted at a suitable location below the fire door.
- The outstanding freatures of this boiler are listed below.

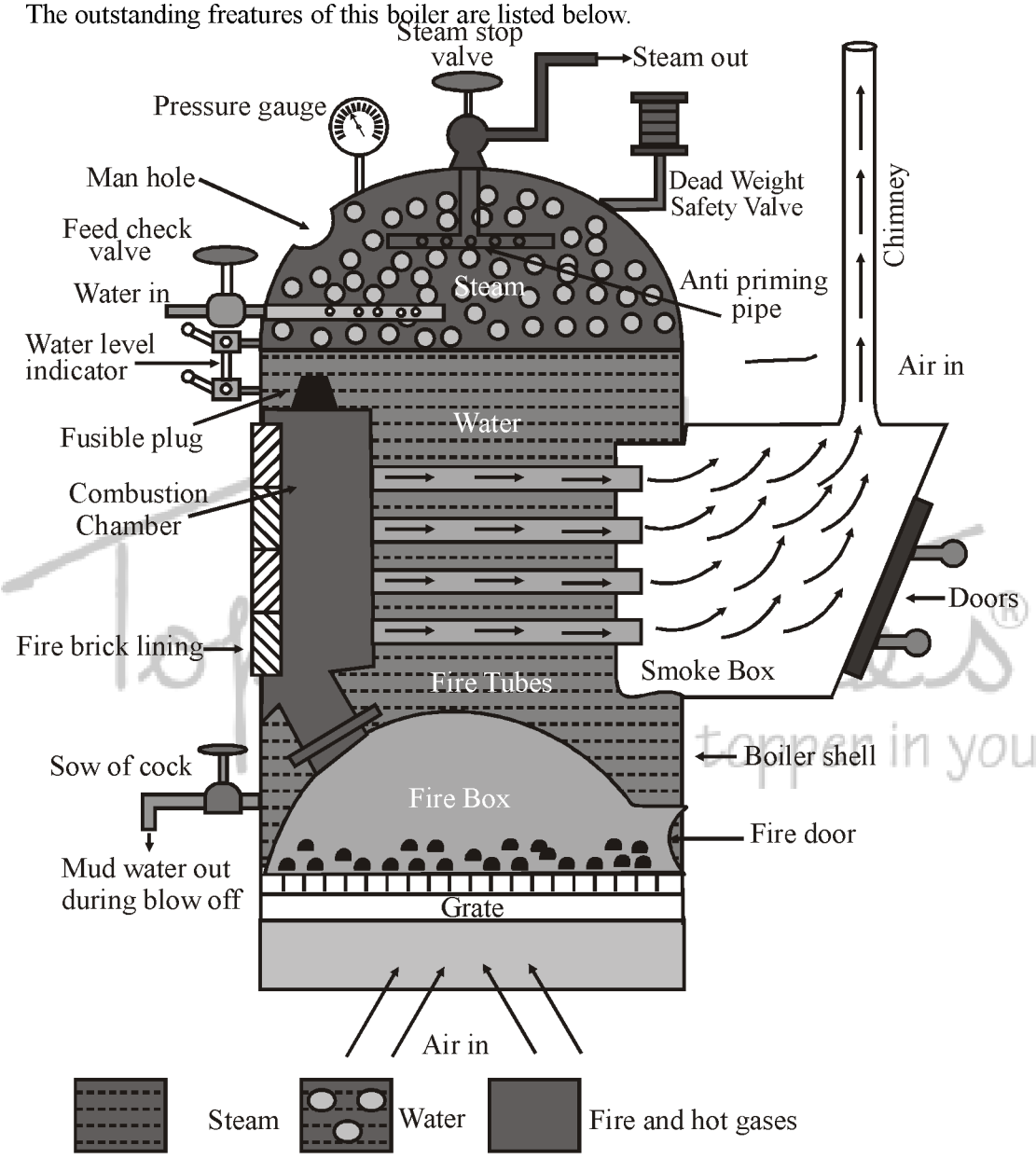


Fig. : Cochran boiler

Advantages :

1. It is very compact and requires minimum floor area.
2. Any type of fuel can be used with this boiler.

3. It is well suited for small capacity requirements.
4. It gives about 70% thermal efficiency with coal firing and about 75% with oil firing.
5. The ratio of grate area to the heating surface area varies from 10 : 1 to 25 : 1.

1.6.3 Cronish boiler

This from of boiler was first adopted by Trevithick, the Cornish engineer, at the time of introduction of high-pressure steam to the early Cronish engine, and is still used.

The specifications of Cornish boiler are given below :

No. of flue tube	—	One
Diameter of the shell	—	1.25 to 1.75 m
Length of the shell	—	4 to 7 m
Pressure of the steam	—	10.5 bar
Steam capacity	—	6500 kg/h.

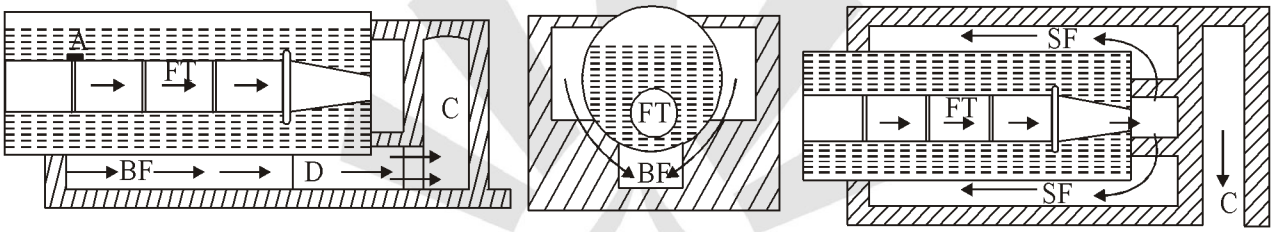


Fig. : Cronish Boiler

It consists of a cylinderical shell with flat ends through which passes a smaller flue tube containing the furnace. the products of combustion pass from the fire grate forward over the brickwork bridge to the end of the furnace tube; they then return by the two side flues to the front end of the boiler, and again pass to the back end of a flue along the bottom of the boiler to the chimney.

The advantage possessed by this type of boiler is that the sediment contained in the water falls to the bottom, where the plates are not brought into contact with the hottest portion of the furnace gases.

1.6.4 Lancashire Bioler

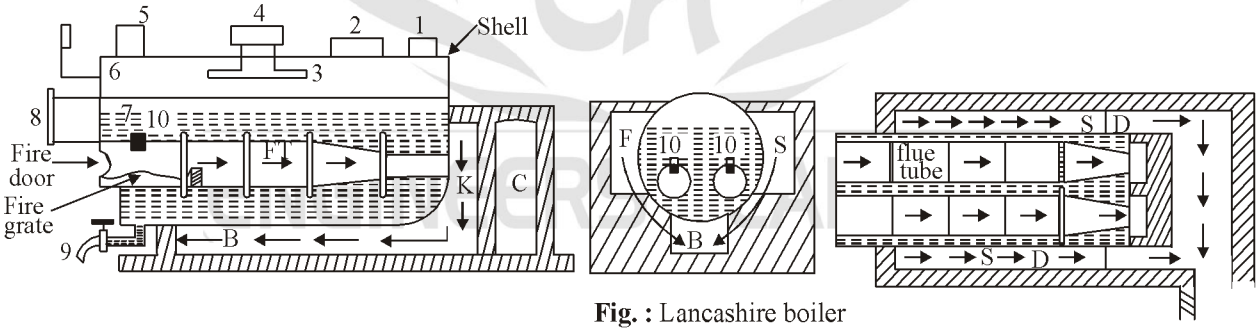


Fig. : Lancashire boiler

It is stationary fire tube, internally fired, horizontal, natural circulation boiler. This is a widely used boiler because of its good steaming quality and its ability to burn coal of inferior quality. These boilers have a cylindrical shell 2 m in diameters and its length varies from 8 m to 10. It has two large internal flue tubes having diamter between 80 cm to 100 cm in which situated. This boiler is set in a brick work forming external flue so that the external part of the shell forms part of the heating surface.

The boiler consist of a cylindrical shell and two big furnace tubes pass right through this. One bottom flue and two side flues are formed by the brick setting. Both the flue tubes which carry hot gases lay below the water level.

The outstanding features of this boiler are listed below :

(i) Its heating surface area per unit volume of the boiler is considerable large.

(ii) Its maintenance is easy.

(iii) It is suitable where a large reserve of hot water is needed. Load fluctuations can be easily met by this boiler due to the large reserve capacity.

(iv) Superheater and economiser can be easily incorporated into the system, therefore, overall efficiency of the boiler can be considerably increased (80–85%).

1.6.5 Scotch boiler

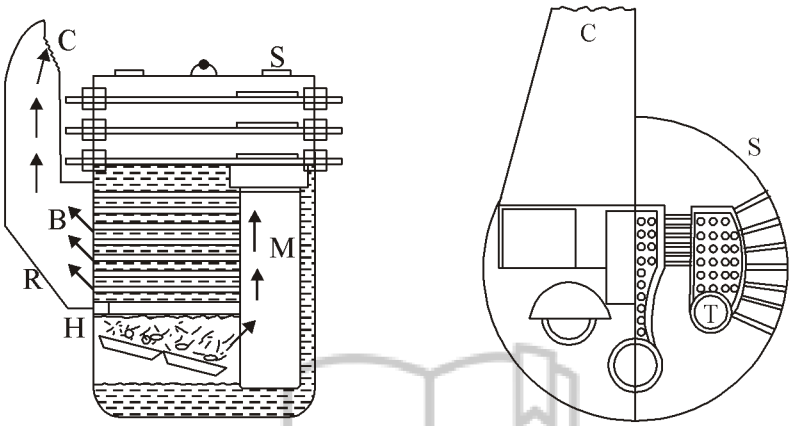


Fig. : Scotch Boiler

The scotch type marine boiler is probabily the most popular boiler for steaming capacities upto about 1000 kg/hr and pressure of about 17 bar. It is of compact size and occupies small floor space. From figure shows that a single ended scotch type marine boiler. It consists of a cylinderical shell in which are incorporated one to four cylinderical, corrugated steel furnaces. The furnaces are internally fired and surrounded by water. A comubstion chamber is located at the back end of the furnace and is also surrounded by water. Usually each furnace has tis own combustion chamber. a nest of fire tubes run from the forn tube plate to the back tube plate.

The hot gases produced due to burning of fuel move to the combustion chambers (by means of the draught). Then they travel to the smoke box through the fire tubes and finally leave the boiler via uptake and the chimney.

1.6.6 Locomotive boiler

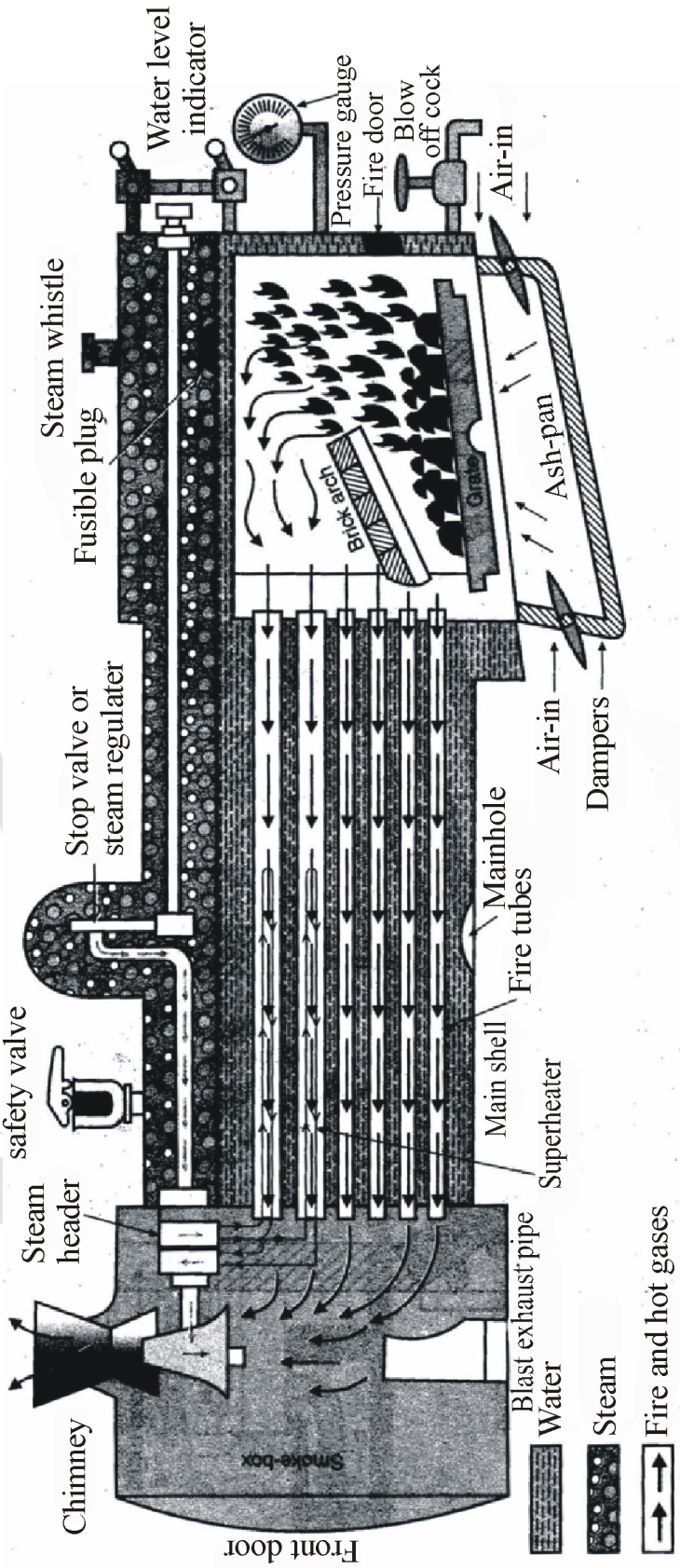
Locomotive boiler is a horizontal fire tube type mobile boiler. The main requirement of this boiler is that it should produce steam at a very high rate. Therefore, this boiler requires a large amount of heating surface and large grate area to burn coal at a rapid rate. The large heating surface area is provided by providing a large number of fire tubes and heat transfer rate is increases by creating strong draught by means of steam jet.

The outstanding features of this boiler are listed below :

(i) Large rate of steam generation per square meter of heating surface. To some extent this is due to the vibration caused by the motion.

(ii) It is free from brickwork, special foundation and chimney. This reduces the cost of installation.

(iii) It is very compact.



LOCOMOTIVE-BOILER

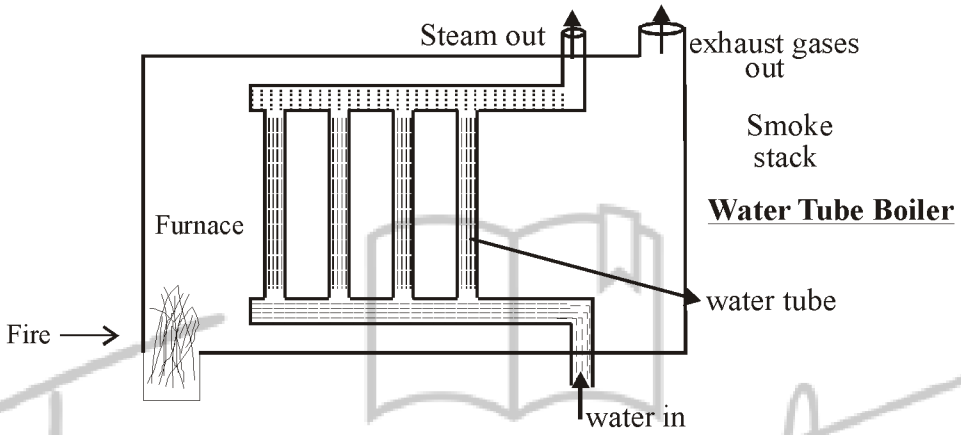
Demerits of locomotive boiler

1. There are practical constructional lomits for pressure and capacity which do not meet requirements.
2. It cannot carry high overloads without being damaged by overheating.
3. Large flat surfaces nned bracing.
4. It is difficult to clean some water spaces.
5. There changes to corrosion and scale formation in the water legs due to the accumulation of sediments and the mud particles.

1.7 WATER TUBE BOILER

Water from a drum flows through the tubes and hot gases flow over them.

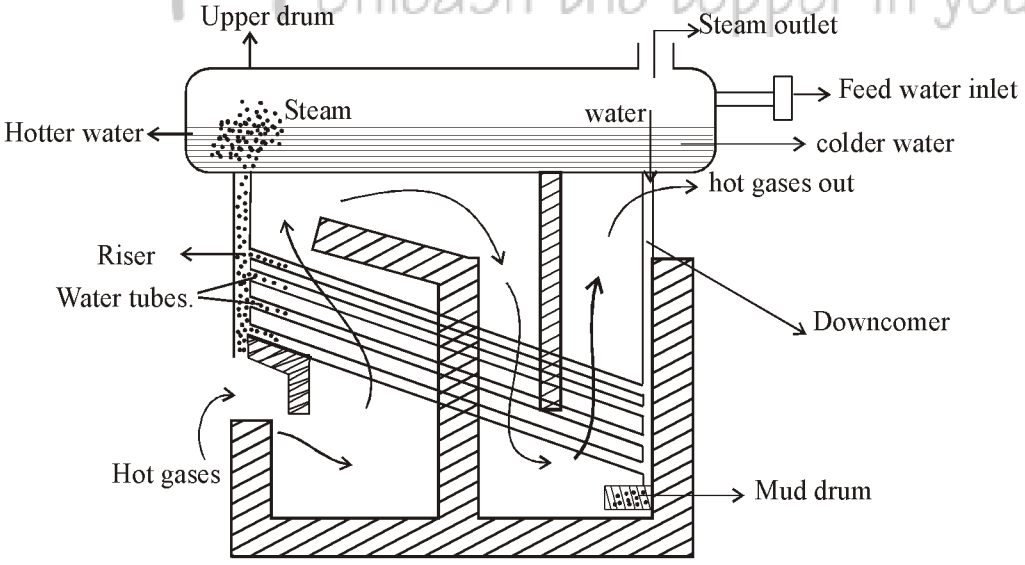
- Developed to permit increases in boiler pressure
- Water flows through tubes & flue gas outside, this puts the pressure in the tubes and have relatively small diameter drums



1.8 TYPE OF WATER TUBE

- Bobcock and Wilcox water-tube boiler
- Stirling boiler

1.8.1 Babcock and Wilcox water-tube boiler



Longitudinal drum boiler

- Nearly saturated water leaving the drum flowed through down comer into tubes.
- Some of this water heated by flue gases gets transferred into steam and the two phase water steam mixture goes back to the drum through riser.
- Density of water in downcomer is greater than density of water steam in riser.
- To increase capacity more than one drum could be installed in parallel.

The outstanding features of this boiler are listed below :

(i) The evaporative capacity of this boiler is high compared with other boilers (20,000 to 40,000 kg/hr). The operating pressure varies between 11.5 to 17.5 bar.

(ii) The draught loss is minimum compared with other boilers.

(iii) The defective tubes can be replaced easily.

(iv) The entire boiler rests over an iron structure, independent of brick work, so that the boiler may expands or contract freely. The brickwalls which form the surroundings of the boiler are only to enclose the furnace and the hot gases.

1.8.2 Stirling boiler

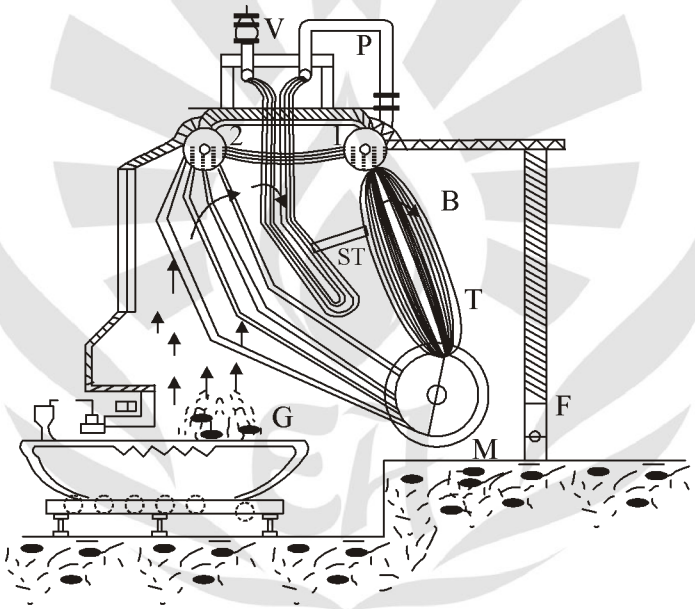


Fig. : Stirling boiler

V	=	Stop valve	ST	=	Superheater tubes	P	=	Steam pipe
T	=	Water tubes	b	=	Water baffle	G	=	Grate
B	=	Baffle wall	M	=	Mud drum			

Stirling water tube boiler is an example of bent tube boiler. The main elements of a bent type water tube boiler are essentially drum or drums and headers conected by bent tubes. For large central power stations these boilers are very popular. They have steaming capacities as high as 5000 kg/h and pressure as high as 60 ber. It consists of two upper drums known as team drums and a lower drum known as mud or water drum. The steam drums are connected to mud drum by banks of bent tubes. As this drum is not subjected to high temperature, so the impurities may not cause harm to the drum. The blow-off cock blows off the impurities.

The combustion products ensuing from the grate move in the upward and downward directions due to the brickwall baffles and are finally discharged through the chimney into the atmosphere. Fire brick arch gets

incandescent hot and helps in combustion and preventing the chilling of the furnace when fire door is opened and cold air rushes in the steam drums and mud drum are supported on steel beams independent of the bricka-work.

Note : It is lighter an more flexible than the straight tube boilers. But it is comparatively more difficult to clean and inspect the bent tubes.

1.9 HIGH PRESSURE BOILER

- Lamont boiler
- Loeffler boiler
- Benson boiler
- Velox boiler
- Super-critical boiler
- Super-charged boiler

1.9.1 Lamont boiler

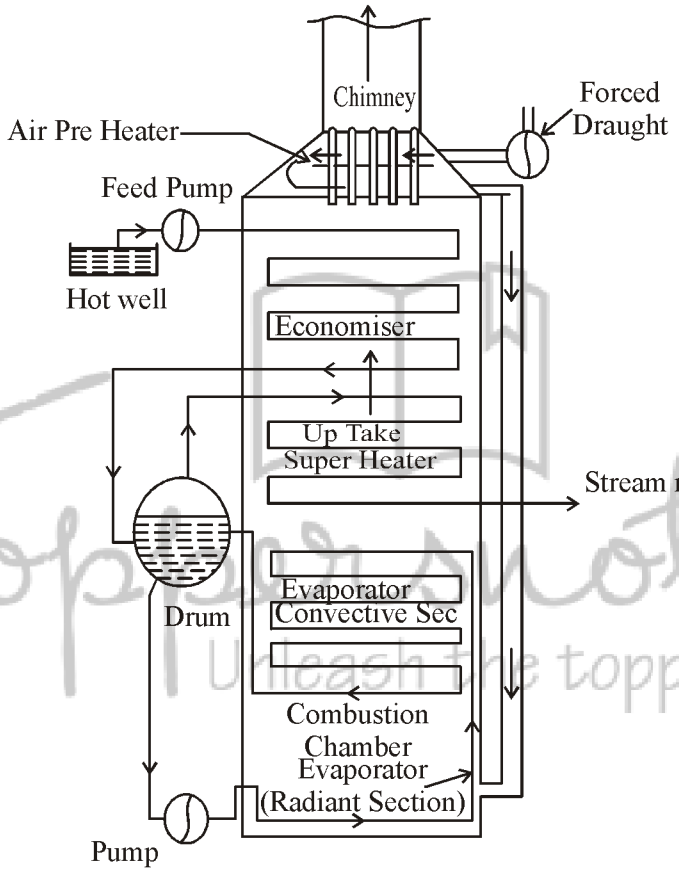


Fig. : Lamont boiler

This boiler works on a forced circulation and the circulation is maintained by a centrifugal pump, driven by a steam tubine using steam from the boiler. for emergency an electrically driven pump is also fitted.

The ffed water passes through the econnomiser to the drum from which it is drawn to the circulation pump. The pump delivers the ffed water to the tube evaporating section which in turn sends a mixture of steam and water to the drum. The steam in the drum is then drawn through the superheater. The superheated steam so obtained is then supplied to the prime mover.

Note : These boilers have been built to generate of 45 to 50 tonnes of superheated steam at a pressure of 130 bar and at a tempeature of 500°C

1.9.2 Loeffler boiler

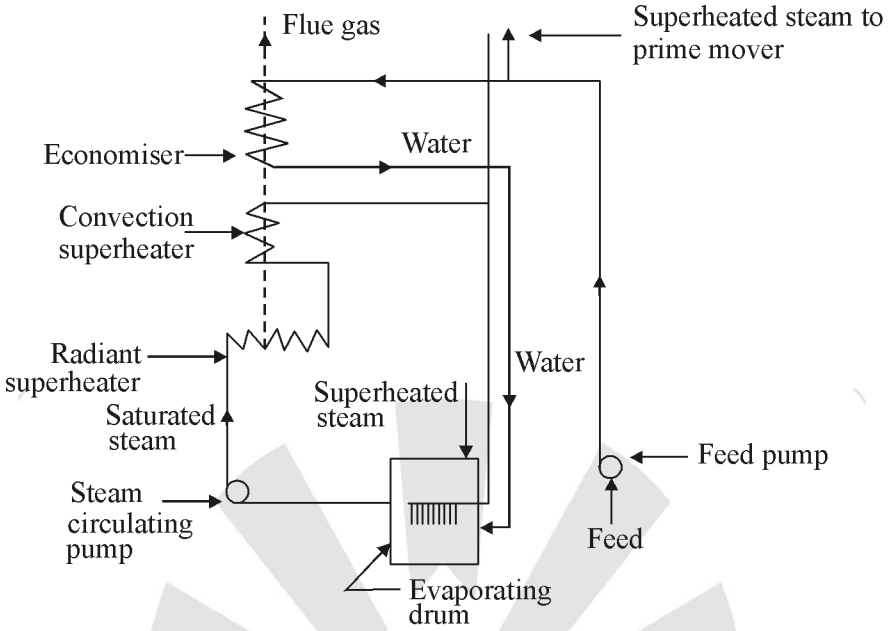


Fig. : Loeffler boiler

In a Lamont boiler the major dificulty experienced is the desposition of salt and sediment on the inner surfaces of the water tubes. The deposition reduces the heat transfer and ultimately the generating capacity. This further increases the danger of overheating the tubes due to salt deposition as it has high thermal resistance. This difficulty was solved in Loeffler boiler by preventing the flow of water into the boiler tubes.

Note :

1. This boier also makes use of forced circulation. Its novel prionciple is the evaporating of the feed water bymeans of superheated steam from the superheater, the hot gases from the furnace being primarily used for superheating purposes.
2. This boiler can carry higher salt concentrations than any other type and is more compact than indirectly heated boilers having natural circulation. These qualities fit it for land or sea transport power generations.

1.9.3 Benson boiler

This boiler too makes use of foced circulation and uses oil as fuel. It chief novel principle is that it eliminates the latent heat of water by first compressing the ffed to a pressure of 235 bar, it is then above the critical pressure and its latent heat is zero. This boiler does not use any drum. The feed water after circulation through the economic tubes flows through the radiant parallel tube section to evaporate partly. The steam water mixture produced then moves to the transit section whee this mixture is converted into steam. The steam is now passed through the convection superheater and finally supplied to the prime mover.

Advantages of Benson boiler

1. It can be erected in a comparatively smaller floor area.
2. The total weight of a Benson boiler is 20% less than other boilers, since there are no drums. This alos reduces the cost of the boiler.
3. It can be started very quickly because of welded joints.
4. natural convection boilers require expansion joints but these are not required for Benson boiloer as the pipes are welded.
5. The furnace walls of the boierl can be more efficiently protected by using smaller diameter and closed pitched tubes.

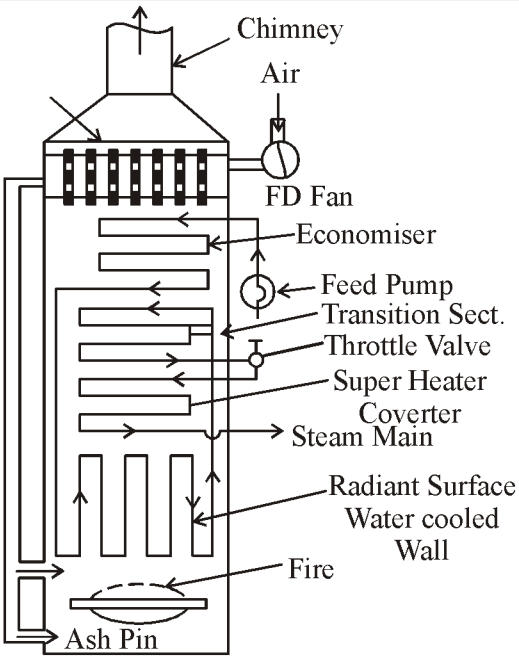


Fig. : Benson boiler

6. The transfer of parts of the boier is easy as no drums are required and majority of the parts are carried to the site without pre-assembly.
7. It can be operated most economically buy varying the temperature and pressure at part5ial loads and overloads. The desired temperature can also be maintained constant at any pressure.
8. The blow down losses of the boiler are hardly 4% of natural circulation boielr of the same capacity.
9. Explosion hazards are not severe as it consists of only tubes of small diameter and has very little storage capacity.
10. The superheater in a Benson boiler is an integral part of forced circulation system, there fore no special starting arrangement for superheater is required.

1.9.4 Velox boiler

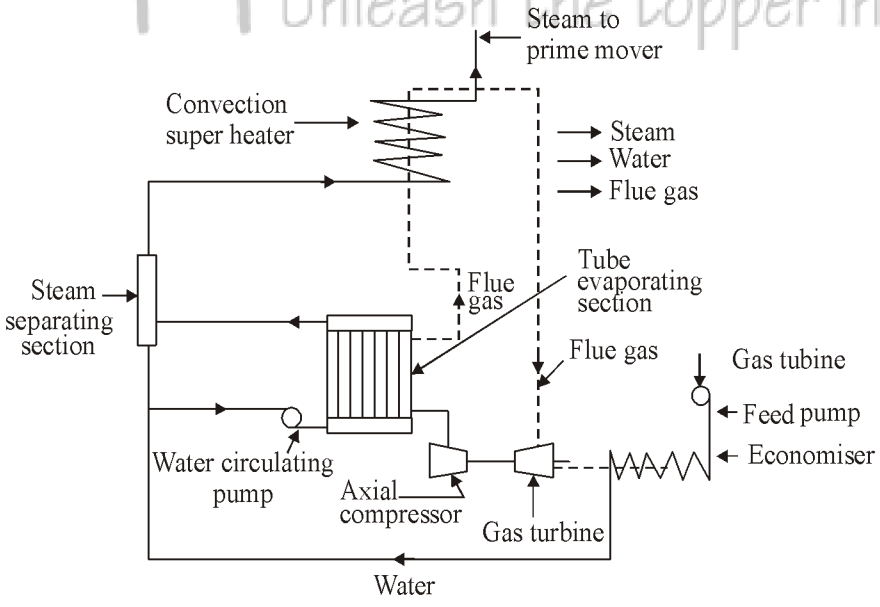


Fig. : Velox boiler

This boiler makes use of pressurised combustion. The gas turbine drives the axial flow compressor which raises the incoming air from atmosphere pressure to furnace pressure. The combustion gases after heating the water and steam flow through the gas turbine to the atmosphere. the feed water after passing through the economiser is pumped by a water circulating pump to the tube evaporating section. Steam sepearted in steam separating section flows to the superheater, from there it moves to the prime mover.

Advantages :

1. The boiler is very compact and has greater flexibility.
2. It can be quickly started.
3. Low excess air si required as the pressurised air is used and the problem of draught is simplified.
4. Very high combustion rates are possible.

1.9.5 Super critical boilers

A large number os team generating plants are designed between working ranges of 125 at,/ amd 510°C to 300 atm. and 660°C; these are basically characterised as sub-critical and super-critical. A super critical boiler requires only preheater and superheater.

Advantages :

1. The turbo-generators connected to super critical boilers can generate peak loads by changing the pressure of operation.
2. Owing to less heat capacity of the generator the pressure level is more stable and there fore gives better response.
3. Large heat transfer rates.
4. Because of absence of two phase mixture the problems of erosion and corosion ar minimused.
5. More adaptable to load fluctuations (because of great ease of operation, simplicity and flexibiltiy).
6. Higher thermal efficiency.

1.9.6 Super charge boiler

In a superhcarged boiler, the combustion is carried out under pressure in the combustion chamber by supplyin the compressed air. the exhaust gases from the combustion chamber are used to run the gas turbine as they are exhusted to high pressure. The gas turbine runs the air compressor to supply the compressed air to the combustion chamber.

Advantages :

1. Comparatively less number of operators are required
2. Rapid start of the boiler is possible.
3. Small heat storage capacity of the boiler plant gives better response to control.
4. The part of the gas turbine output can be used to drive other auxilliaries.

1.10 BURNING OF COIL

- Stoker firing
- Pulverised fuel firing

1.10.1 Stoker firing

A stoker is a power operated fuel feeding mechanism and grate. stoker firing (as compared to hand firing) entails the following advantages and disadvantages.

Advantages :

1. Reduction in axuxiliary plant.
2. Practically immune from explosions.
3. Very reliable, and maintenance charges are reasonably low.
4. Can be used for small or large boiler units.
5. A cheaper grade of fuel can be used.
6. A hihger efficiency attained.
7. less smoke produced.

Disadvantages :

1. Construction is complicated.
2. In case of very large units the intial cost may be rather higher than with pulverised fuel.
3. There is always a certain amount of loss of coal in the form of riddlings through the grates.
4. Sudden variation in the steam demand cannot be met to the same degree.

1.10.2 Pulversied fuel firing

Ina pulverised fuel firing system the coal is reduced to a fine power with the help of grinding mill and then projected into the combustion chamber with the help of hot air current. The amount of air required (known as secondary air) to complete the comubstion is supplied separately to the combustion chamber.

The amount f air which is used to carry the coal and to dry it before entering into the combustion chamber is known as 'primary air' and the amount of air which is supplied separately for completing the combuwstion is known as 'secondary air'.

Advantages :

1. This system works successfully with or in combinatin with gas and oil.
2. No moving parts inthe furnace subjected to high temperatures.
3. The external-heating surfaces are free from corrosion.
4. The system is practically free from sagging and clinkering troubles.
5. Practically no ash handling troubles.
6. Greater capacity to meet peak loads.
7. Since there is almost complete combustion of the fuel there is increased rate of evaporation and higher boiler efficiency

Disadvantage :

1. The skilled operators are required.
2. High capital cost.
3. The possibilities of explosion are more as coal burns like a gas.
4. The maintenance of furnace brick work is costly.
5. Special equipment is needed to start this system.

1.11 COMPARISON BETWEEN FIRE TUBE AND WATER TUBE BOILER

Comparison between Fire - Tube and Water - Tube			
	Particulars	**Fire Tube**	**Water tube**
1.	Position of H_2O & hot gases.	Gases inside tubes water out side tubes	Water inside tubes. Gases outside tubes.
2.	Mode of firing	Generally internally fired	Externally fired.
3.	Operating pressure	Limited to 16 bar	Can go as high as 100 bar
4.	Rate of steam production	Lower	Higher
5.	Suitability	Not suitable for large power plant	Suitable for large power plant
6.	Floor area	Given power occupies more floor area	Given power occupies less floor area.
7.	Construction	Difficult	Simple
8.	Treatment of water	Not so necessary	More necessary
9.	Risk of bursting	Less	More
10.	Requirement of skill	Less	More + careful attention

1.12 MERITS AND DEMERITS OF FIRE TUBE BOILERS OVER WATER TUBE BOILERS

1.12.1 Merits :

1. The fire tube boilers have greater reliability and low first cost because of simple and rigid construction.
2. Due to large cylindrical drums of fire tube boilers, there is ample water surface from which the system can be quickly raised. Simple antipriming devices serve the purpose very well.
3. Fire tube boilers are excellent for engines operating with rapid changes in load like locomotive boiler.
4. Fire tube boilers are very compact and space occupied per kg of steam generation by fire tube boilers is considerably less than the water tube boilers.
5. Failure in feed water supply for some time does not cause damage to boiler as it contains large quantity of water.

1.12.2 Demerits :

1. Fire tube boilers have large ratio of water to steam and therefore makes the boiler slow in reaching the operating pressure.
2. Larger diameter of shell 2.4 m and limit of maximum thickness 3 cm and stress consideration limit the generation pressure to 30 bar.
3. The maximum generating capacity of these boilers is about 900 kg/hr.
4. The explosion of the fire tube boilers becomes very serious because of its large water capacity.
5. The transportation of fire tube boilers is very inconvenient because of large size of the shell.
6. Slow rate of steam generation renders the fire tube boilers unsuitable for use in steam power plants.

1.13 MERITS AND DEMERITS OF WATER TUBE BOILERS OVER FIRE TUBE BOILERS

1.13.1 Merits :

1. Generation of steam is much quicker due to small ratio of water content of steam content. This also helps in reaching the steaming temperature in short time.

2. Its evaporative capacity is considerably larger and the steam pressure range is also high-200 bar.
3. Heating surfaces are more effective as the hot gases travel at right angles to the direction water flow.
4. The combustion efficiency is higher because complete combustion of fuel is possible as the combustion space is much larger.
5. The thermal stresses in the boiler parts are less as diffrent parts of the boiler remain at uniform temperature due to quick circulation of water.
6. The boiler can be easily transported and erected as its different parts can be separated.
7. Damage due to the bursting of water tube is less serious. Therefore, water tube boilers are sometimes called safety boilers.
8. All parts of the water tube boilers are easily accessible for cleaning, inspecting and repairing.
9. The water tube boiler's furnaces area can be easily altered to meet the fuel requirements.

1.13.2 Demerits :

1. It is less suitable for impure and sedimentary water, as a small deposit of scale may cause the overheating and bursting of tube. Therefore, use of pure feed water is essential.
2. They require careful attention. The maintenance costs are higher.
3. Failure in feed water supply even for short period is liable to make the boiler over-heated.

1.14 REQUIREMENTS OF A GOOD BOILER

A good boiler must possess the following qualities :

1. The boiler should be capable to generate steam at the required pressure and quantity as quickly as possible with minimum fuel consumption.
2. The initial cost, installation cost and the maintenance cost should be as low as possible.
3. The boiler should be light in weight, and should occupy small floor area.
4. The boiler must be able to meet the fluctuating demands without pressure fluctuation.
5. All the parts of the boiler should be easily approachable for cleaning and inspection.
6. The boiler should have a minimum of joints to avoid leaks which may occur due to expansion and contraction.
7. The boiler should be erected at site within a reasonable time and with minimum labour.
8. The water and flue gas velocities should be high for high heat transfer rates with minimum pressure drop through the system.
9. There should be no deposition of mud and foreign materials on the inside surface and soot deposition on the outer surface of the heat transferring parts.
10. The boiler should confirm to the safety regulations as laid down in the Boiler Act.

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PRACTICE SHEET

OBJECTIVE QUESTIONS

1. Match **List-I** (Type of boiler) and **List-II** (Classification of boiler) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Babcock and Wilcox	**1.** Forced circulation
B. Lancashire	**2.** Fire tube
C. La-mont	**3.** Water tube
D. Cochran	**4.** Vertical

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	3	4	1
(c)	3	2	1	4
(d)	2	4	1	3

2. In forced circulation boilers, about 90% of water is recirculated without evaporation. The circulation ratio is

(a) 0.1 (b) 0.9

(c) 9 (d) 10

3. Consider the following

1. Increasing evaporation rate using convection heat transfer from hot gases.

2. Increasing evaporation rate using radiation.

3. Protecting the refractory walls of the furnace.

4. Increasing water circulation rate.

The main reasons for providing water wall enclosure in high pressure boiler furances would include

(a) 2 and 3 (b) 1 and 3

(c) 1, 2 and 4 (d) 2 and 3

4. Consider the following components:

1. Radiation evaporator.

2. Economizers.

3. Radiation superheater.

4. Convection superheater.

In the case of Benson boiler, the correct sequence of the entry of water through these components is:

(a) 1, 2, 3, 4 (b) 1, 2, 4, 3

(c) 2, 1, 3, 4 (d) 2, 1, 4, 3

5. Coal fired power plant boilers manufactured in India generally use:

(a) pulverized fuel combustion

(b) fluidized bed combustion

(c) circulating fluidized bed combustion

(d) moving stoker firing system

6. Once-through boilers will not have

(a) Drums, headers and pumps

(b) Drums, steam separators and pumps

(c) Drums, headers and steam separators

(d) Drums, headers and pumps

7. Match **List-I** (Name of boiler) with **List-II** (Special features) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Lancashire	**1.** High pressure water tube
B. Cornish	**2.** Horizontal double fire tube
C. La-Mont	**3.** Vertical multiple fire tube
D. Cochran	**4.** Low pressure inclined water tube
	5. Horizontal single fire tube

Codes:

	A	B	C	D
(a)	2	5	1	3
(b)	2	4	3	1
(c)	1	5	2	3
(d)	5	4	1	3

8. Benson boiler is one of the high pressure boilers having

(a) One drum

(b) One water drum and one steam drum

(c) Three drums

(d) No drum

9. Consider the following statements:

1. Forced circulation is always used in high pressure power boilers.
2. Soot blowers are used for cleaning tube surfaces at regular intervals.
3. Electrostatic precipitator is used to remove fly and form flue gases.

Which of these statements are correct?

(a) 1, 2 and 3 (b) 2 and 3

(c) 1 and 3 (d) 1 and 2

10. Boilers operate at

(a) subcritical pressure

(b) supercritical pressure

(c) subcritical as well supercritical pressures

(d) critical pressure only

11. In a boiler, feed water supplied per hour is 205 kg while coal fired per hour is 23 kg. Net enthalpy rise per kg of water is 145 kJ for conversion to steam. If the calorific value of coal is 2050 kJ/kg then the boiler efficiency will be

(a) 78% (b) 74%

(c) 62% (d) 59%

12. In steam generators, a stoker acts as one of the following devices. What is this device?

(a) Air preheating device

(b) Steam superheating device

(c) Air superheating device

(d) Fuel feeding device

13. Scale deposits in Benson Boiler are prevented because

(a) boiler is flushed out after every 4000 working hour

(b) forced circulation is used

(c) bore of tubing is small.

(d) steam and water have same density

14. In a boiler 25kg of fuel is burnt per hour 150kJ of enthalpy rise is required for conversion of 1kg steam from water. The feed water supplied per hour's 220kg. Calculate the boiler efficiency if calorific values of fuel is 5150 kJ /kg.

(a) 61% (b) 62%

(c) 63% (d) 65%

15. Match List I with List II and select the correct answer

List I

A. Lancashier Boiler

B. La-mont Boiler

C. Babcock & Wilcox Boiler

D. Cochran Boiler

List II

1. Forced circulation
2. Fire tube
3. Water tube
4. Vertical

Codes:

	A	B	C	D
(a)	2	3	1	4
(b)	1	2	3	4
(c)	2	1	3	4
(d)	4	1	3	2

16. Which of the following is a water tube boiler?

(a) Locomoative boiler

(b) Cocharan boiler

(c) Babcock & Wilcox

(d) Lancasher boiler

17. The water tubes in Babcox & Wilcox boiler are inclined to

(a) improve convective heat transfer

(b) improve radiative heat transfer

(c) shorter the size of the boiler

(d) promote natural circulation of water

18. Which of the following is a forced circulation boiler ?

(a) Babcock and Wilcox

(b) Locomotive Boiler

(c) Simon Carres Boiler

(d) Benson Boiler

19. Feed water is heated by superheated steam in

(a) Benson Boiler

(b) Velox Boiler

(c) Leoffler Boiler

(d) Babcock and Wilox Boiler

20. Steam from a high pressure boiler

(a) is first superheated and then throttled

(b) is first throttled and then superheated

(c) is first superheated and cooled

(d) is fed into turbine without throttling

21. In water tube boilers parallel sets of tubing are used

(a) to reduce the friction loss in flow

(b) to reduce the length of tubing

(c) to increase the exposed surface area

(d) to improve heat transfer

22. With the use of condensate instead of using the feed water, the deposition of salt in the boiler is

(a) increased

(b) prevented

(c) dependent of other factors

(d) None of the above

23. A good condensing plant should have

(a) maximum cooling surface per kW capacity

(b) minimum cooling surface area per kW capacity

(c) average cooling surface area per kW capacity

(d) None of the above

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ANSWERS AND EXPLANATIONS

1. *Ans. (c)*

Fire tube boilers:

(i) Locomotive boiler (Horizontal boiler)

(ii) lancashire boiler

(iii) Scotch marine boiler

(iv) Cochran boiler (verticale boiler)

Water tube boilers:

(i) Babcox-wilcox boiler

(ii) Lamont boiler (high pressure boiler)

(iii) Benson boiler (High pressure boiler)

2. *Ans. (d)*

3. *Ans. (a)*

Heat transfer to water wall is predominately by radiation.

$$\boxed{E = \varepsilon\sigma AT^4}$$

4. *Ans. (d)*

5. *Ans. (a)*

Coal fired power plant boilers manufactured in india generally use pulverized fuel combustion.

6. *Ans. (c)*

7. *Ans. (a)*

8. *Ans. (d)*

Benson Boiler is a typical high pressure, water tube, forced circulated once through boiler. This boiler does not have any drum.

9. *Ans. (a)*

Forced circulation is required because at high pressure the density difference between steam and water is very less.

10. *Ans. (c)*

NTPC-Talcher (Orissa) plant has sub-critical once-through boiler.

11. *Ans. (c)*

Mass of feed water = 205 kg/hr

Mass of coal = 23 kg/hr

Calorific value of coal = 2050 kJ/kg

Net enthalpy rise = 145 kJ/kg of water

Total enthalpy rise = 145 × 205

Net heat supplied by the coal = 23 × 2050

Boiler efficiency $\boxed{\frac{145\times205}{23\times2050} = 60\%}$

12. *Ans. (d)*

13. *Ans. (a)*

14. *Ans. (a)*

Heat utilized = 220 × 150 = 33000kJ/hr.

Heat supplied by fuel

= 25 × 2150 = 53750 kJ /hr.

Boiler efficiency

$$= \frac{\text{heat utilized}}{\text{heat supplied by fuel}} = \frac{33000}{53750} = 0.61$$

= 61%

15. *Ans. (c)*

16. *Ans. (c)*

17. *Ans. (d)*

18. *Ans. (d)*

19. *Ans. (c)*

20. *Ans. (c)*

21. *Ans. (a)*

22. *Ans. (b)*

23. *Ans. (b)*

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