Unit 1 Syllabus: MARINE BOILERS

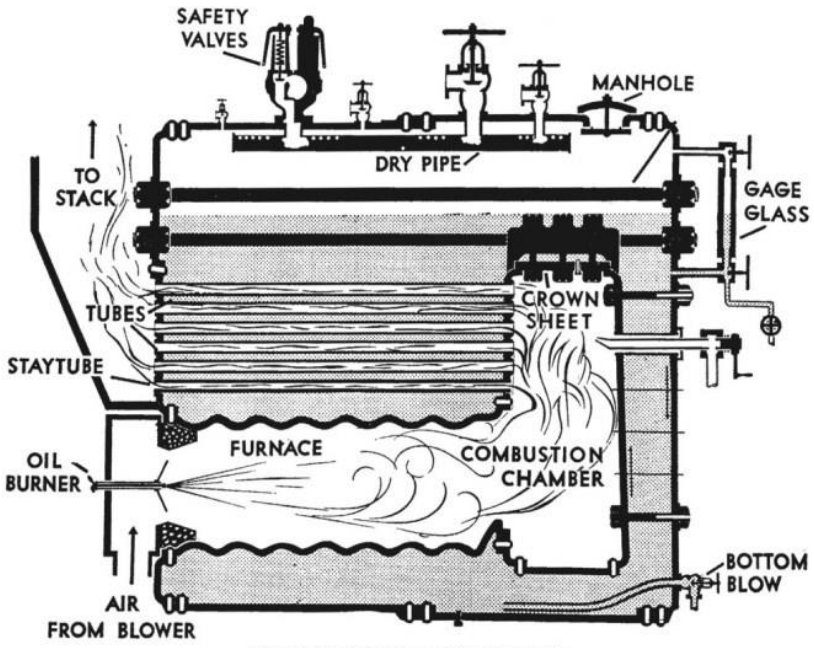
Construction & Working of Scotch boiler, Cochran boiler. Water tube boiler: - Babcock Wilcox boiler, foster wheeler, Thimble tube boiler, Double evaporation boilers, composite boilers, Lamont exhaust gas boiler. Advantages of water tube boilers. Stresses in boilers and corrosion in steam system.

Session No *	MAIN TOPICS	COVERED
1	**CONSTRUCTION AND WORKING OF SCOTCH BOILER**	✓
2	**CONSTRUCTION AND WORKING OF COCHRAN BOILER**	✓
3	**CONSTRUCTION AND WORKING OF BABCOCK AND WILCOX BOILER**	✓
4	**CONSTRUCTION AND WORKING OF FOSTER WHEELER**	✓
5	**CONSTRUCTION AND WORKING OF THIMBLE TUBE BOILER**	✓
6	**CONSTRUCTION AND WORKING OF DOUBLE EVAPORATION BOILER/ COMPOSITE BOILER**	✓
7	**CONSTRUCTION AND WORKING OF LAMONT EXHAUST GAS BOILER**	✓
8	**ADVANTAGES OF WATER TUBE BOILERS**	✓
9	**STRESSES IN BOILERS AND CORROSION IN STEAM SYSTEM**	✓

REFERED VARIOUS BOOKS & VARIOUS INTERNET SOURCES **
FOR RASY UNDERSTANDING ONLY/ THIS IS NOT A NOTES**

TOPIC NO 1: CONSTRUCTION AND WORKING OF SCOTCH BOILER

Scotch marine boiler is one of the most common boilers which are used on ships. In this post, we will learn about the scotch marine boiler construction, working principle with its advantage.



SIDE VIEW SCOTCH MARINE BOILER

Scotch Marine Boiler:

- First of all Scotch Marine Boiler is a **Fire Tube Boiler**.
- It is also a scotch or tank type boiler.
- It is a common boiler in the marine industry.
- This boiler has some special advantage like its compactness and operation efficiency.
- Scotch Marine Boiler can use any type of water.

- The general layout of the Scotch Marine Boiler is that of a squat horizontal cylinder.
- At the lower part of the boiler shell, one or more large cylindrical furnaces are present.
- Burned gases and smoke from the boiler furnace pass through the back side of this boiler.
- After that gases and smoke return through the small tubes and up and out through the boiler chimney.

Types of Scotch Marine Boiler:

Single Ended: Generally the single-ended steam boiler contains one to four furnaces. All these furnaces enter from the front part of the boiler. Normally the length of the single-ended steam boiler can be 3.5 meters.

Double Ended: Furnaces are present at both ends of this type of boiler. But a number of furnaces with the boiler varies from 2 to 4 in each end. Normally the length of the double-ended steam boiler can be 6.5 meters.

Construction of Scotch Marine Boiler:

- This **boiler** consists of some basic component like another boiler.
- First of all, it's Furnace, and like other boilers, it used to burn the fuel inside the boiler. We already know that a single-ended scotch marine boiler is fired with four furnaces.
- But each of the furnaces has its own combustion chamber with it. Now come to another component which is a combustion chamber.

- It is one of the parts of the boiler where the fuel combustion normally takes place. You will also find plates in the combustion chamber.
- It requires staying the top plate, back plate, two side plate, and the tube plate.
- There are some smokes tubes placed horizontally. All those smoked tubes connect the combustion chamber to the chimney.

Smoke box.

- This boiler has numbers of smoke tubes.
- We know that all are tubes placed horizontally and connects each other from the combustion chamber to the chimney.
- After fuel combustion, burned smoke passes through smokes tubes and then it enters the chimney.
- Like others, boiler Chimney is used to exhaust the burned gases and smoke out of the boiler during operation. Exhaust gases release into the environment by the chimney.
- Another important component is the Boiler shell.
- It will be better you know how boiler shell made.
- It protects the internal parts of the boiler.
- Boiler shell size and its thickness depending on the amount of pressurized steam required for the purpose.

Working of Scotch Marine Boiler:

Working on the boiler is very simple.

- It will take the fuel, burn it in the combustion chamber and water will be heated. After then heated water becomes steam.
- For this reason at first fuel is inserted into the furnace. Fuel passes through the furnace by fire hole. When there is fuel in the furnace then it ignites through the fire hole.
- After that burnt fuel enters the combustion chamber and this is the place where combustion of the fuel takes place.

Now come to the heat transfer procedure.

- When heat generated into the combustion chamber then it is used to heat the water surrounding the combustion chamber.
- Again it is the basic heat transfer procedure for regular fire tube boiler.
- When water becomes steam, then it supplies to the steam turbine.
- Here we have some burnt flue gases and smoke that created at the fuel combustion procedure and it needs to release in the environment.
- For this step the exhaust gases pass through the smoke tubes and reaches to the boiler chimney.
- Then the chimney releases all smoke and exhaust gases into the atmosphere. In this boiler, the water uses to surround with the furnace, combustion chamber and the smoke tubes.
- For this reason, it provides the greater heating surface to the water during **boiler operation**.

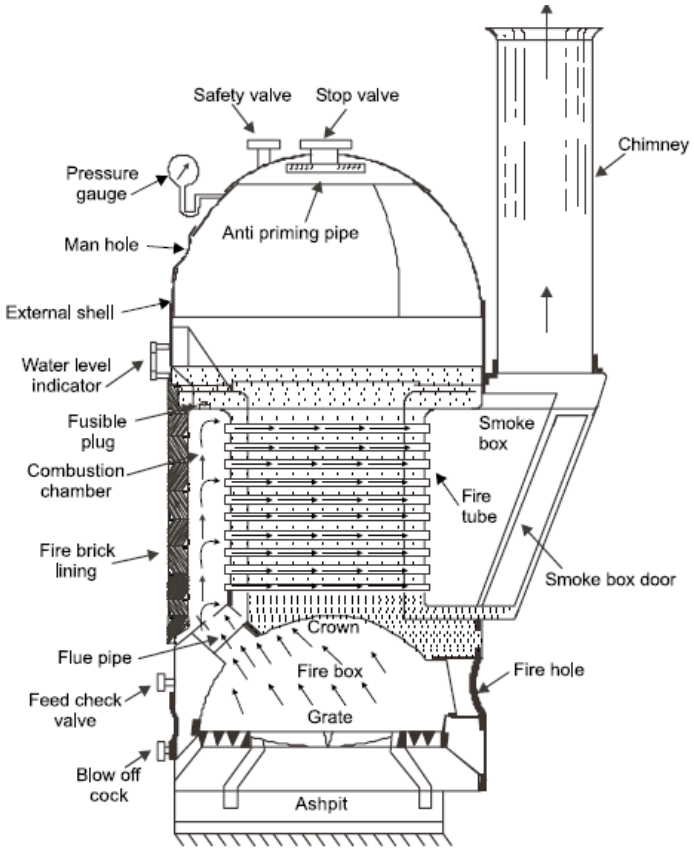
Advantages of Scotch Marine Boiler:

- This boiler has a great advantage and for this reason, this boiler is generally used in marine works and on ships.
- It is a compact size boiler and it has great efficiency in operation
- This boiler can generate steam by any type of water.
- Brick work setting like Locomotive Boiler and external flues are not required in this boiler.

TOPIC NO 2: CONSTRUCTION AND WORKING OF COCHRAN BOILER

What is Cochran Boiler?

Cochran Boiler is a vertical drum axis, natural circulation, natural draft, low pressure, multi-tubular, solid fuel fired, fire tube boiler with internally fired furnace. It is the modified form of a simple vertical boiler. In this boiler, the fire tubes are placed horizontally. The efficiency of this boiler is much better than the simple vertical boiler.



Main Parts and Construction

1. Shell: It has a vertical axis cylindrical drum with a hemispherical dome-type shell at the top.
2. Grate: It is the platform on which the solid fuel is burnt.
3. Combustion Chamber: The burning of fuel takes place in the combustion chamber.
4. Fire Tubes: Cochran boiler has multi-tubular fire tubes. The hot flue gases from the combustion chamber travels to the smokebox through these fire tubes. The fire tubes helps in the exchange of heat from the hot flue gases to the water.
5. Fire Hole: It is the hole provided to fire the fuel inside the furnace.
6. Furnace: It lies at the bottom of the boiler. Furnace is the place where all the fuel is burnt. Without furnace, the working of this boiler is not possible.
7. Chimney: The chimney is attached to the smokebox. It transfer smoke to the environment. The size of the chimney is small as compared with other boiler.
8. Fire Brick Lining. The fire brick lining is present in the combustion chamber and helps in the combustion of the fuel.
9. Manhole: A manhole is provided for the cleaning and inspecting of the boiler from inside.
10. Flue Pipe: It is a small passage connecting the firebox and combustion chamber. The hot gases enter into the combustion chamber through the flue pipe.

OTHER MOUNTINGS

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.

Working

- In Cochran boiler first the fuel is inserted into the firebox and placed on the grate. The fuel is ignited through the fire hole provided at the right bottom of the boiler.
- The fuel is burnt in the firebox, and due to the burning of the fuel, smoke and hot flue gases emerge out. The hot flue gases enter into the combustion chamber through flue pipes.
- From the combustion chamber, hot gases enter into the fire tubes. The fire tubes are surrounded by water.
- The hot flue gases inside the tubes exchange the heat from the hot gases to the water. Due to the exchange of heat, the temperature of the water starts increasing and it gets converted into steam.
- The steam produced rises upward and collected at top of the boiler in the hemispherical dome. An anti-priming pipe is installed at top of the boiler which separates the water from the steam and makes it dry steam.
- This dry steam is then transferred to the turbines through the steam stop valve.
- The hot flue gases and smoke after exchanging heat moves to the smokebox. From the smokebox, the burnt gases and smoke is discharged to the atmosphere through the chimney.
- Burnt fuel is transferred to the ash pit. Blow off Valve is pre-set at left bottom of the boiler and is used to blow off the impurities, mud, and sediment from the boiler water.
- A fusible plug is also provided at the top of the combustion chamber.
- When the temperature of the combustion chamber crosses the permissible level, the fusible plug melts and the water through the combustion chamber enters into the furnace of the boiler and stops the fire.
- In this way, a big fire accident can be prevented to take place and also protects the boiler from damage.
- Various boiler mounting and accessories are attached to the boiler for its efficient working.

Advantages

(i) Low initial installation cost.
(ii) It requires less floor area.
(iii) Easy to operate and handle.
(iv) Transportation of Cochran boiler is easy.
(V) It can use all types of fuel.

Disadvantages

(i) Low rate of steam generation.
(ii) Inspection and maintenance is difficult.
(iii) High room head is required for its installation due to the vertical design.
(iv) It has limited pressure range.

TOPIC NO 3: CONSTRUCTION AND WORKING OF BABCOCK AND WILCOX BOILER

What is Babcock and Wilcox Boiler?

It is a Horizontal drum axis, natural draft, natural circulation, multi-tubular, stationary, high pressure, solid fuel fired, externally fired water tube boiler.

It was discovered by George Herman Babcock and Stephen Wilcox in the year 1967. And if was named after its discoverer as Babcock and Wilcox boiler.

Construction

The various main parts of Babcock and Wilcox Boiler are as follows

1. **Drum:** It is horizontal axis drum which contains water and steam.

2. **Down Take Header:** It is present at rear end of the boiler and connects the water tubes to the rear end of the drum. It receives water from the drum.
3. **Up Take Header:** it is present at front end of the boiler and connected to the front end of the drum. It transports the steam from the water tubes to the drum.
4. **Water Tubes:** They are the tubes in which water flows and gets converted into steam. It exchanges the heat from the hot flue gases to the water. It is inclined at angle of 10-15 degree with the horizontal direction. Due to its inclination the water tubes do not completely filled with water and the water and steam separated out easily.
5. **Baffle Plates**: Baffle plates are present in between water tubes and it allows the zigzag motion of hot flue gases from the furnace.
6. **Fire Door:** It is used to ignite the solid fuel in the furnace.
7. **Grate:** It is a base on which the burning of the solid fuel takes place.
8. **Mud Collector:** It is present at the bottom of down take header and used to collect the mud present in the water.
9. **Feed Check Valve:** it is used to fill water into the drum.**10. Damper**: It regulates the flow of air in the boiler.

The various boiler mounting and accessories used in this type of boiler are:

1. **Super heater:** It increases the temperature of saturated steam to the required temperature before discharging it from steam stop valve.
2. **Pressure Gauge:** It is used to check the pressure of steam within the boiler drum.
3. **Water Level Indicator:** It shows the level of water within the drum.
4. **Safety Valve:**
   - It is a valve which acts when the pressure of steam within the boiler drum increase above the safety level.
   - It opens and releases the extra steam in the environment to maintain the desired pressure within the boiler.

Working:

Now let's discuss the working of Babcock and Wilcox boiler step by step.

- ✓ First the water starts to come in the water tubes from drum through down take header.
- ✓ The water present in the inclined water tubes gets heated up by the hot flue gases. The coal burning on the grate produces hot flue gases and it is forced to move in zigzag way with the help of baffle plates.
- ✓ As the hot flue gases come in contact with water tubes, it exchanges the heat with water and converts it into steam.

- ✓ The steam generated is moved upward and through up take header it gets collected at upper side in the boiler drum.
- ✓ An anti-priming pipe is provided in the drum. This anti-priming pipe filters the water content from the steam and allows only dry steam to enter into super heater.
- ✓ The super heater receives the water free steam from the anti-priming pipe. It increases the temperature of steam to desired level and transfers it to the steam stop valve.

1. The superheated steam from the steam stop valve is either collected in a steam drum or made to strike on the steam turbine for electricity generation.

Application

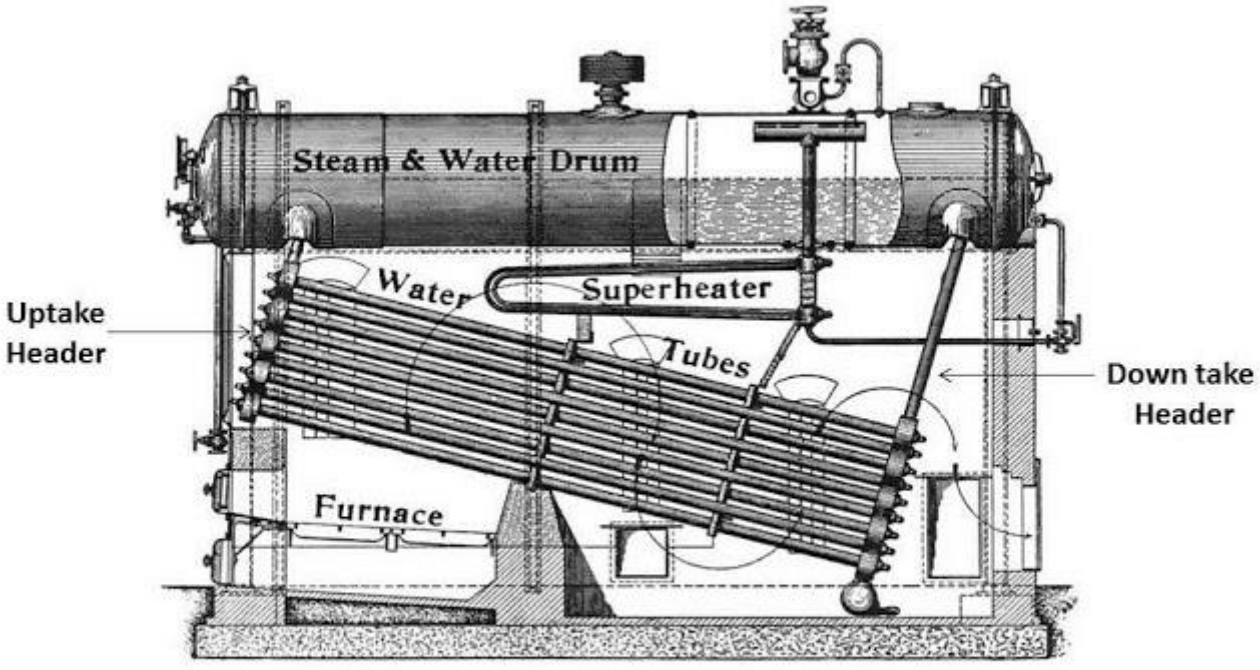
The Babcock and Wilcox boiler are generally used to produce high pressure steam in power generation industries. The high pressure steam so generated is used to produce electricity.

Advantages

- Steam generation capacity is high. It is about 2000 to 40000 kg/hr.
- It occupies less space.
- Replacement of defective tubes is easy.
- It is the only boiler that is used to generate large quantity of heat in power stations.
- The draught loss is minimum.
- Inspection of this types of boiler can be done anytime during its working.

Disadvantages

- High maintenance cost.
- It is not much suitable for impure and sedimentary water. In case of impure and sedimentary water, scale may deposit in the tubes and this leads to overheating and bursting of tubes. That's why water treatment is must before feeding into the boiler.
- Continuously supply of feed water is required for the working. In the case if feed water is not continuously supplied even for a short period of time, the boiler gets overheated. Water level must be carefully watched during the operation of the Babcock and Wilcox boiler.



Babcock and Wilcox Boiler

TOPIC NO 4: CONSTRUCTION AND WORKING OF FOSTER WHEELER

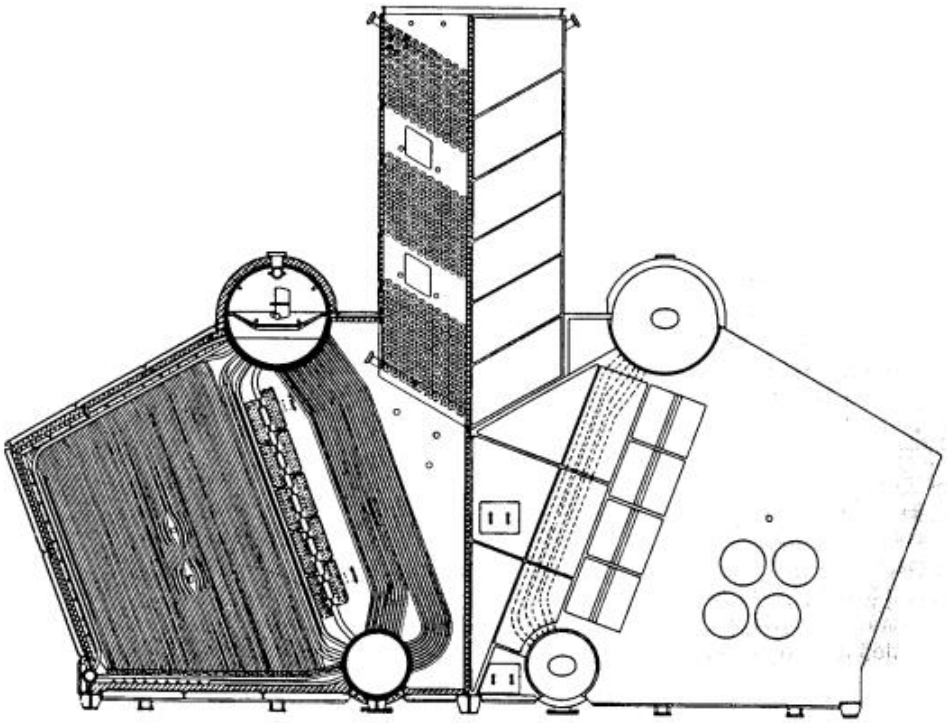
- ✓ Foster Wheeler D-Type boiler with it's largely water cooled furnace is suitable for high operating conditions. The long bent tubes however, due to difficulty of cleaning and tube replacement, demand good quality feed water in order to avoid the formation of scale. The basic design consist of two drums; the larger steam drum is placed above a smaller water drum and the two are connected by numerous 32mm diameter generating tubes.
- ✓ The furnace is placed to one side, the hot gases passing over two rows of 50 mm diameter screen tubes to a super heater placed between the drums in front of the generating tube bank.
- ✓ After leaving these tubes, the gases enter the economiser section in the lower part of the uptakes. Baffles are placed to direct this gas flow as required.
- ✓ In the Foster Wheeler D-Type boiler, 82 mm diameter underfloor tubes are used to supply the lower headers for the water walls with water from the water drum. External down comers are only fitted between the steam and water drums. Feed water entering the steam drum flows through the down comers to the water drum to replace the water rising up through the water wall and generating tubes, as its density decreases upon receiving heat from the hot gases, thus providing the positive circulation of water required in all types of water tube boilers. From the top headers. Risers return the mixture to the steam drum.
- ✓ In the Babcock and Wilcox version, The Integral furnace boilers, external down comers are used not only to supply the water drum, but also the water wall headers; the underfloor tubes in this case are omitted.
- ✓ In both types of boiler, the external down comers consist of tubes about 100 mm in diameter fitted in the double casing of the boiler.
- ✓ Refractory material is used on the furnace floor and font burner wall in the both types of boiler. It's also used behind the water walls, etc. In addition the Babcock and Wilcox boiler also uses studded tube walls.
- ✓ The combustion air passes through ducting arranged in the double casing of the boiler, and it then passes through air registers into the furnace where combustion takes place.
- ✓ Internal access to tubes, etc. is obtained by manhole in the steam and water drums, and by handholes in the water wall headers.
- ✓ In the later versions of these boilers the double casing is all welded. All the tubes, including the down comers, are expanded and bell-mouthed into drums and headers.
- ✓ The drums are of all-welded construction, the water wall headers are solid forged, with welded ends. All the tubes are solid-drawn mild steel.

'D' Type Boiler:

Foster Wheeler 'D' Type Boiler:

- ✓ This is an early bi-drum design in which the two drums are connected by a multi-row bank of small bore generating tubes, and three rows of larger bore screen tubes in front of a U-loop super heater.
- ✓ The furnace sidewall tubes extend upwards from a header at floor level, turn over to form the furnace roof and are connected to the steam drum.
- ✓ The furnace rear wall is water-cooled and the lower headers of this and the sidewall are fed with water from the lower drum.
- ✓ Unheated down-comer tubes connect the two drums.
- ✓ The front wall and floor of the furnace are refractory lined.
- ✓ The horizontal U- tubes of the super heater are connected to vertical inlet and outlet headers. Baffles are fitted inside the headers, requiring the steam to make several passes through the tubes, thus achieving the high steam velocity necessary to ensure safe tube metal temperature in service. Oil burners are fitted in the refractory front wall of the furnace and on leaving the boiler, combustion gases pass over further heat recovery surfaces such as economiser (heating feed-water) or air heater (heating combustion air).

- ✓ Steam soot blowers are fitted to give means of on load cleaning of boiler, super heater and further heat recovery tubes.



Foster Wheeler 'D' Type Boiler:

TOPIC NO 5: CONSTRUCTION AND WORKING OF THIMBLE TUBE BOILER

Thimble tube

- The boiler was developed to generate steam by causing a prolonged series of spasmodic ebullitions to take place in a series of horizontal tapered thimble tubes heated externally, without any special means being provided for circulation within the tube.
- It enhances the heat transfer between the tubes and feed water to produce steam.
- It consists of an outer shell enclosing a cylindrical furnace surmounted by the combustion chamber into which the thimble tubes project.
- These are expanded and bell-mouthed into a cylindrical tube plate forming the combustion chamber.
- These boilers will operate for long periods without internal cleaning although, if an undue amount of scale forms inside the thimble tubes, it is very difficult to remove.
- Thus reasonable quality of feed water should be provided. The formation of scale will subject the thimble tubes to a certain amount of overheating.
- The tubes have a diameter of about 100mm.
  (DIAGRAM AVAILABLE IN BOOK)

TOPIC NO 6: CONSTRUCTION AND WORKING OF DOUBLE EVAPORATION BOILER

TOPIC NO 7: CONSTRUCTION AND WORKING OF SCOTCH BOILER