Chapter No. 6:- Steam Boiler

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**INTRODUCTION**

- **Boiler**: “It is a closed vessel in which the heat produced by the combustion of the fuel is transferred to water for its conversion into steam at the desired temperature and pressure.

- A boiler is a device used for generating:–

  (a) Steam for power generation
  (b) Hot water for heating purpose
According to the Indian Boiler Regulation (I.B.R) a boiler is a closed pressure vessel with capacity exceeding 22.75 liters used for generating steam under pressure.
What is the difference between steam boiler and steam generator?

- Technically speaking a steam boiler consists only of the containing vessel and convection heating surfaces.

- While steam generator covers the whole unit of water wall tubes, superheaters, air heaters and economizers.
Classification of boilers

- Horizontal, Vertical and Inclined boiler
  (a) If the axis of the boiler is horizontal, it is called the horizontal boiler.
  
  (b) If the axis of the boiler is vertical, it is called the vertical boiler.
  
  (c) If the axis of the boiler is inclined, it is called the inclined boiler.
Fire tube and Water tube boilers:

(a) The boilers in which the hot gases are inside the tubes and water is surrounding them is called fire tube boiler.

(b) The boilers in which the water is inside the tubes and the hot gases surrounding them is called water tube boiler.
Externally fired and internally fired boilers

(a) In the boiler if the fire is outside the shell, that boiler is known as externally fired boiler.

(b) The boiler in which the furnace is located inside the boiler shell it is known as internally fired boiler.
Forced Circulation and Natural circulation boiler:

(a) In the boilers if the circulation of water is done by a pump then they are known as **forced circulation** boilers.

(b) In the boilers of the circulation of water takes place due to difference in density resulting from difference in temperature, it is known as **natural circulation** boilers.
High, medium, and low pressure boilers:

(a) It is one in which the working pressure of the boiler is more than 25 bar, it is known as high pressure boilers.

(b) It is one in which the working pressure of the boiler is between 10 to 25 bar, it is known as medium pressure boilers.

(c) It is one in which the working pressure of the boiler is between 3.5 to 10 bar, it is known as low pressure boilers.
Stationary and portable boilers:

(a) The boilers which can not be transported easily from one place to another are called **stationary boilers**.

(b) The boilers which can be transported easily from one place to another are called **portable boilers**.
Single tube and multi tube boilers:

(a) The Boiler having only one fire tube or water tube in the boiler then it is known as **single tube boiler**.

(b) The Boiler having two or more fire tube or water tube in the boiler then it is known as **multi tube boiler**.
Simple Vertical Boiler:

- It is vertical.
- It is portable with very small floor area.
- It is a water tube boiler.
- It is internally fired.
- It is a multi tube boiler with two cross tubes.
- It is naturally circulated.
- It is low a low pressure boiler.
Simple vertical boiler

Fig. 5.14: Simple vertical boiler
5.7.2 Vertical multitubular boiler (Cochran boiler):

- Steam stop valve
- Pressure gauge
- Manhole
- Feed check valve
- Water inlet
- Water level indicator
- Fusible plug
- Combustion chamber
- Fire brick lining
- Flue pipe
- Blow-off cock
- Mud and water off during blow-off
- Ash-pit
- Fire box
- Fire door
- Grate
- Smoke box
- Boiler shell
- Door
- Chimney
- Anti-priming pipe
- Dead weight safety valve
- Steam out

Fig. 5.15: Cochran boiler
CHARACTERISTIC OF COCHRAN BOILER

- Vertical
- Fire tube
- Multi tube
- Internally fired
- Natural circulated boiler
- Portable
- Low pressure boiler
Specifications of Cochran boiler

- Shell diameter = 2.75 m
- Height = 5.75 m
- Working pressure = 6.5 bar
- Steam capacity = 3500 kg/hr
- Heating surface area = 120 m²
- Efficiency = 70% to 75%
Advantage – disadvantage of cochran boiler

**Advantage**

1. Compact
2. Portable
3. Low initial cost
4. Easy installation
5. Any types of fuel can be used

**Disadvantage**

- Steam raising capacity is low due to vertical design
- Poor efficiency
Fig. 5.16: Lancashire boiler
Characteristic of Lancashire boiler

- horizontal
- stationary
- fire tube
- internally fired
- multi tube
- natural circulation of hot gases
- medium pressure
Specification of Lancashire boiler

- Shell diameter: 2 to 3 metre
- Length of shell: 7 to 9 m
- Max pressure: 16 bar
- Steam capacity: 9000 kg/hr
- Efficiency: 50 to 70%
Advantage–disadvantage of lancashire boiler

**Advantage**
- Heating surface per unit volume is high
- Fluctuation in the load can be easily met.
- Easy operation
- Low maintenance
- Easy to clean

**Disadvantage**
- Maximum working pressure limited to 16 bar
- Due to brick work more floor area is required
- Furnace placement is inside the flue tube, so grate area is restricted
Babcock and Wilcox boiler
Specification of babcock and wilcox boiler

- Drum diameter = 1.22 to 1.83 m
- Length of drum = 6.096 to 9.144 m
- Size of water tubes = 7.62 to 10.16 cm
- Size of superheated tubes = 3.84 to 5.71 cm
- Maximum working pressure = 40 bar
- Maximum steam capacity = 40000 kg/hr
- Efficiency = 60 to 80%
Characteristics of babcock and wilcox boiler

- Horizontal
- Multitube
- Water tube
- Externally fired
- Natural circulation of water
- Forced circulation of air and hot gases
- Solid as well as liquid fuel used
- Stationary
- High pressure boiler
Advantage of babcock and wilcox boiler

- Higher steam generation capacity
- 2000 to 40000 kg/hr steam generation capacity
- Maintainance is easy
- Used in power station for producing large quantity of steam
- Less floor area required
- Greater operation safety
Boiler mounting and accessories

- **Boiler mounting**: mounting are devices, which are necessary for the operation and safety of a boiler.

- **Accessories**: accessories are required for proper operation of the boiler and to increased efficiency of the boiler.
According to IBR (Indian Boiler Regulation) following mounting should be fitted to the boiler:

- Two safety valve
- Two water level indicator
- Pressure gauge
- Steam stop valve
- Feed check valve
- Blow off cock
- An attachment for inspector’s test gauge
- Man hole
- Mud holes
Commonly used boiler accessories are

- Feed pump
- Injector
- Economizer
- Air preheater
- Super heater
- Steam separator
- Steam trap
Bourden tube pressure gauge:
Function: it is used for measurement of pressure in the boiler.
Fig. 8.19  Bourdon tube pressure transducer
Water level indicator

Function: Used to indicate water level inside boiler vessel

Fig. 5.5: Water level indicator (Water gauge)
Steam stop valve

**function:** To regulate flow of steam from boiler to steam pipe
Feed check valve: To control the supply of water to the boiler and prevent back flow.

Feed check valve:

![Diagram of feed check valve]

Fig. 6.18 Feed check valve
Blow off cock function:
1. remove water impurities
2. to empty the boiler for cleaning, inspection and repair

Fig. 6.19 Blow-off valve
Fusible plug

Function: To protect boiler against over heating
Safety valve

**function**: to release the excess steam when pressure of the steam inside the boiler increase higher than safe pressure. Safety valve may be classified as,

1. dead weight safety valve
2. lever safety valve
3. spring loaded safety valve
4. high steam low water safety valve
Dead weight safety valve
Lever safety valve

Fig. 6.22 lever safety valve
Spring loaded safety valve

Fig. 6.23 Ramsbottom safety valve
High steam and low water safety valve

Fig. 6.24 High steam and low water safety valve
Feed pump:

To feed water into the boiler through feed check valve pumps are classified as
1. reciprocating pump
2. rotary pump
3. centrifugal pump
**Injector**: To feed water into the boiler, it is commonly used for vertical and locomotive boiler. It is also used where space for feed pump is not available.

![Diagram of an Injector](image)

**Fig. 6.26 Injector**

- **Spindle**
- **Steam pipe**
- **Steam inlet**
- **Steam cone**
- **Combining cone**
- **Overflow pipe**
- **Overflow**
- **Delivery cone**
- **Water in**
- **Water pipe**
- **Water out** (High pressure water to boiler)
Feed water heater

to increase the temperature of feed water, before it enters into the boiler

Feed water heater may be classified as

- 1. economiser
- 2. exhaust steam feed water heater
Economizer:

**function:** To increase the temp of feed water by using waste heat of fuel Gases

8.3 Economiser:

![Diagram of Economiser]

- A, B – Headers
- S – Scraper
- P – Pipes
- C – Soot Chamber
- SV – Safety valve
- V – Stop valve

**Fig. 5.28:** Economiser

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[Note: The diagram and text provide a detailed explanation of the components and function of an economizer. The text and diagram together illustrate how the economizer increases the temperature of feed water using the waste heat from fuel gases.]
Advantages and disadvantages of economiser

Advantage

- Higher feed water temp., reduce boiler thermal stresses, so boiler life increased.
- Economiser utilised waste heat from fuel gases, so fuel consumption reduce.
- Increased evaporative capacity.

Disadvantages

- Economiser placed at the passage of flow of flue gases, so pressure drop takes place of flue gases (loss of draught).
Exhaust steam feed water heater:
To increase temperature of feed water using heat from exhaust steam of steam turbine or steam from boiler

![Diagram of Exhaust steam feed water heater](image)

*Fig. 6.28 Exhaust steam feed water heater*
Super heater
to increase the stem temperature of steam above saturation point

Fig. 6.29 Superheater
Thank you