Candidates, Please Do Not Write Anything on the Question Paper **ROLL NO._____**

GOVT. WOMEN ENGINEERING COLLEGE AJMER

FIRST MID TERM TEST – 2018

Class	**:**	**B.TECH. 3 RD YEAR**	**Semester**		**:**	**VI**
Branch	**:**		**MECHANICAL ENGINEERING**			
Subject	**:**		**STEAM ENGINEERING**			

Time : 1 HOUR **Max. Marks: 20**

Note: Attempt all the questions.

1. Attempt ***any one*** of the following questions. (6X1=6)
   a) Explain working and construction of Lancashire boiler with neat sketch.
   b) Explain working and construction of Babcock and Wilcox boiler with neat sketch.

2. Attempt ***any one*** of the following questions. (6X1=6)
   a) Explain working of Fluidised Bed boiler with neat sketch.
   b) Explain working of Economizer with neat sketch.

3. Attempt **any one** of the following questions. (6X1=6)
   a) Write down the difference between water tube and fire tube boiler.
   b) Explain working of fusible plug and feed check valve.

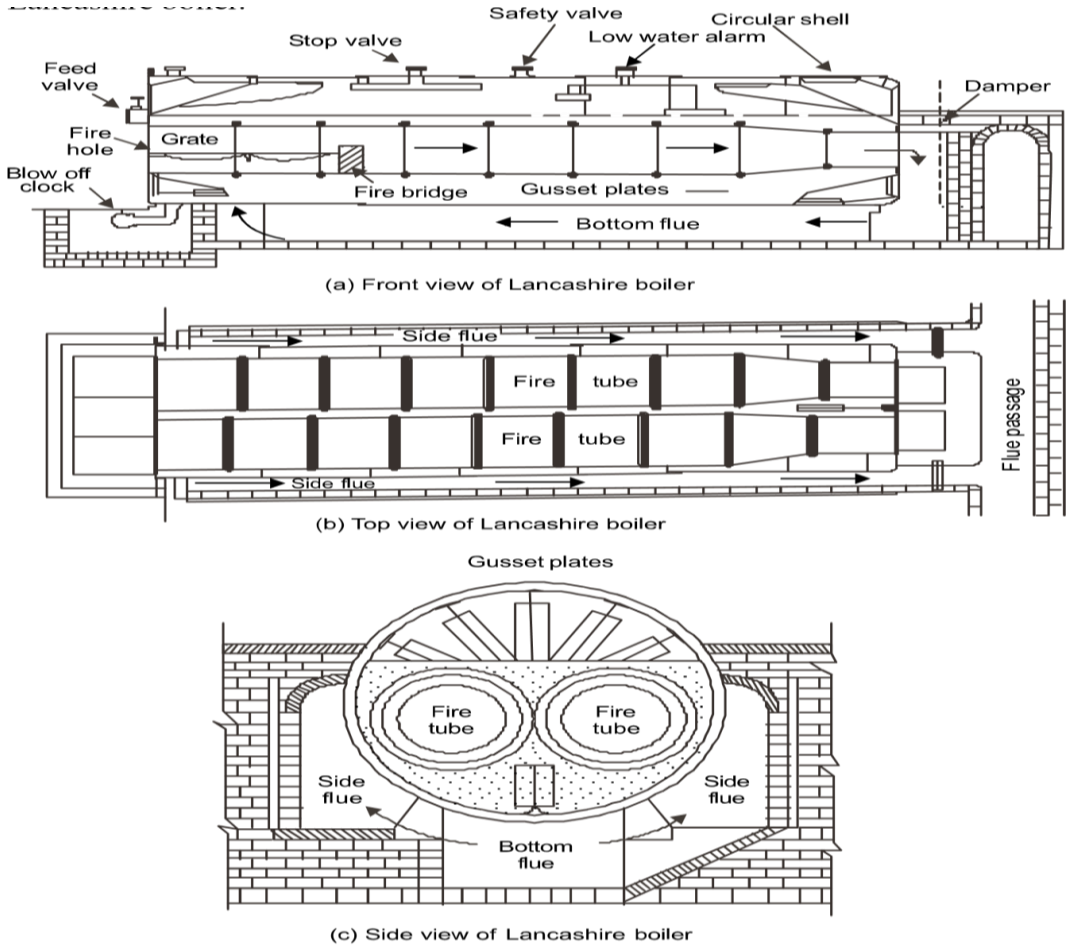
4. Why do we prefer water tube boiler over fire tube boiler? Enlist all the boiler mountings and accessories. (2X1=2)

SOLUTIONS:

1. Attempt ***any one*** of the following questions.
   a) Explain working and construction of Lancashire boiler with neat sketch.

LANCASHIRE BOILER

- It is a horizontal fire tube boiler.
- It has a circular shell connected *to end plates* supported by gusset plates.
- Two *fire tubes* run throughout the length of the boiler.
- Fire tubes are of diameter less than half the diameter of shell and diameter of fire tubes is reduced as shown to have access to lower side of boiler.
- *Fire bridge* is provided to prevent fuel from falling over the end of furnace.
- Fire bridge also helps in producing a better mixture of air and gases for perfect combustion by partly enveloping the combustion space.
- Hot gases start from grate area, enter into fire tubes and come out at back of boiler from where these gases flow towards the front of boiler through *bottom flue*.
- Upon reaching the front these hot gases flow through the *side flues* and enter the *main outlet*.
- Outlet passage may also be used commonly by more than one boilers.
- About 85% of actual heat transferred is transferred through surface of fire tubes while 15% is transferred through bottom and side flues.
- Working pressure in these boilers are in the range of 0.7 MPa to 2 MPa.
- efficiency of the boiler is about 65%–70%.
- Size of these boiler depends upon size of shell which may be 2 m to 3 m in diameter and 6m to 10m in length.



b) Explain working and construction of Babcock and Wilcox boiler with neat sketch.

BABCOCK AND WILCOX BOILER

- It is a water tube boiler suitable for meeting demand of increased pressure and large evaporation capacity or large sized boiler units.
- It has three main parts:

(i) Steam and water drum
(ii) Water tubes
(iii) Furnace.

- *Steam and water drum* is a long drum fabricated using small shells riveted together. End *cover plates* can be opened as and when required. Mountings are mounted on drum as shown. Drum is followed by water tubes which are arranged below drum and connected to one another and drum through headers. Header in which water flows from drum to tubes is called *down take header* while headers in which flow is from tubes to drum is called *uptake header*.
- Soot deposition takes place in mud box which is connected to downtake header. “Blow off cock” for blowing out the sediments settled in *mud box* is shown in figure. Superheater tubes are also shown in the arrangement, which are U-shape

tubes placed horizontally between drum and water tubes. Superheating of steam is realized in superheater tubes.

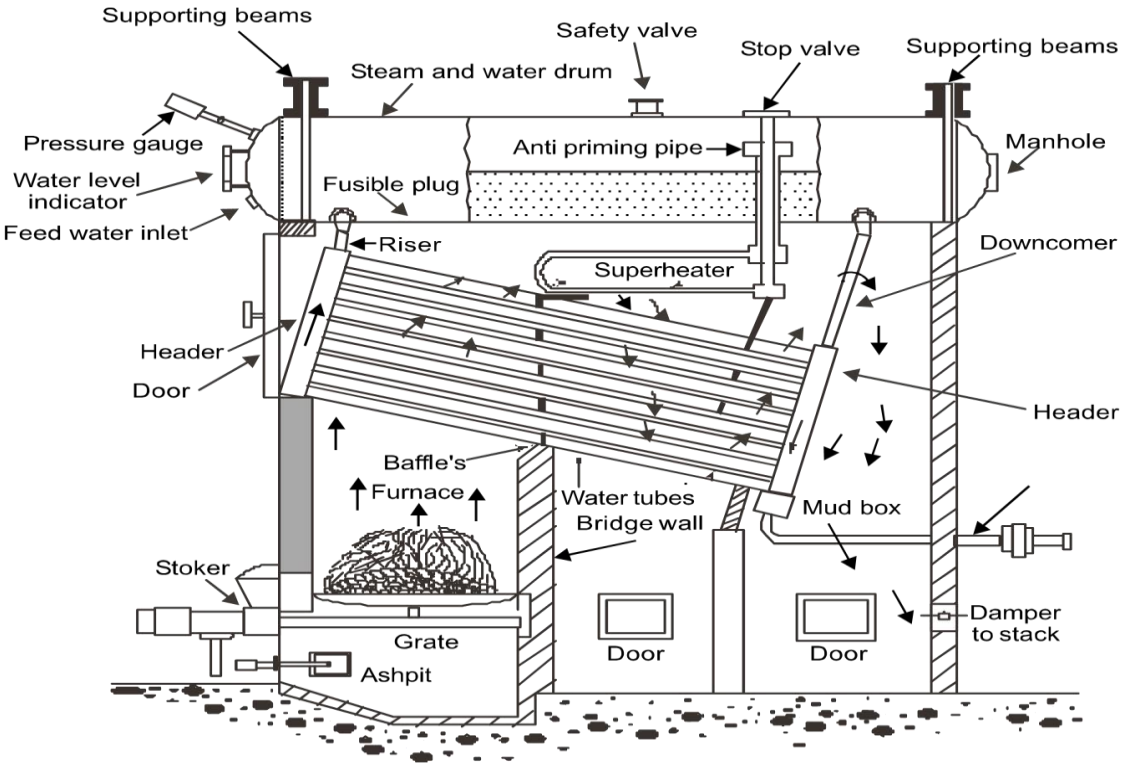


Fig. 11.12 *Babcock and Wilcox boiler*

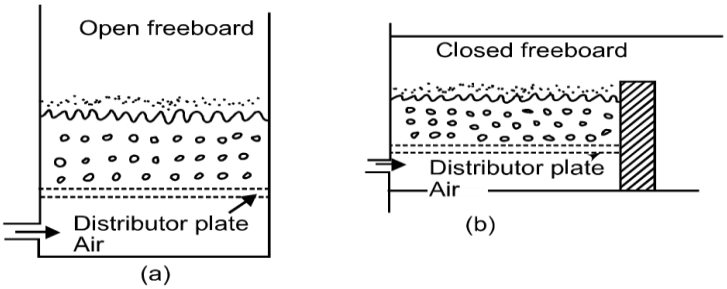
- Below the superheater and water tubes is the *furnace*, at the front of which *fuel feed hopper* is attached. *Mechanical stoker* is arranged below the hopper for feeding fuel.
- Bridge wall and baffles made of fire resistant bricks are constructed to facilitate hot gases moving upward from the *grate* area, then downwards and again upwards before escaping to the chimney.
- A *smoke box* is put at the back of furnace through which smoke goes out via *chimney*.
- A *damper* is used for regulating pressure difference (draught) causing expulsion of hot gases.
- The complete boiler unit with all mountings and accessories is suspended by steel slings from girders resting on steel columns. It is done so as to permit free expansion and contraction of boiler parts with temperature.

2. Attempt ***any one*** of the following questions.
   a) Explain working of Fluidised Bed boiler with neat sketch.

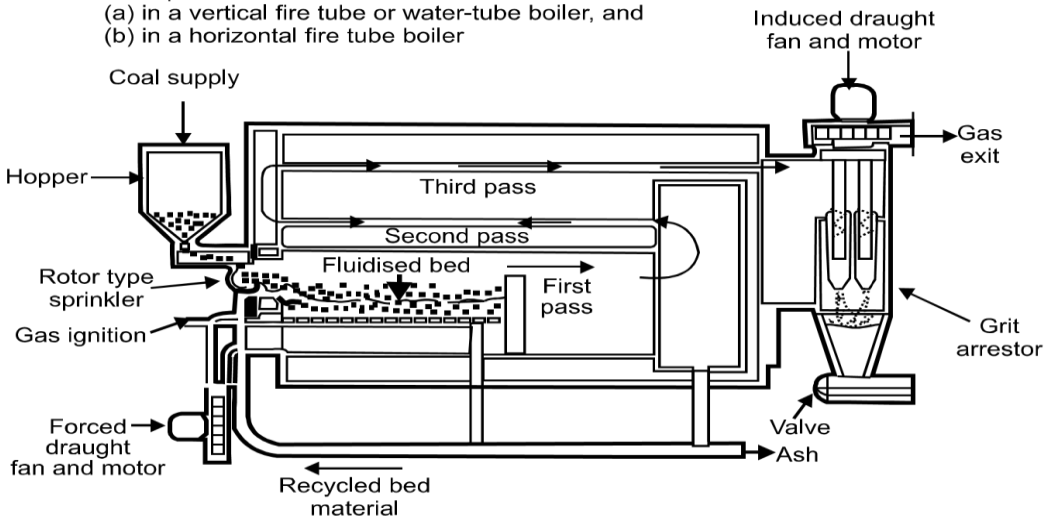
FLUIDIZED BED BOILER

- Schematic of fluidized bed combustion is shown in Fig. for explaining the principle of fluidized combustion.
- Here a bed of inert, refractory sand type material is forced to get fluidized by the air passing through it.
- Air used for fluidization is heated before being sent into the bed.
- Auxiliary fuel which is generally gas gets burnt above or within the bed so as to cause bed temperature to go up to about 650$_\circ$C.

- When suitable temperature level is attained then coal is fed on it or into it for being burnt.
- The burning of auxiliary fuel is stopped at the moment when burning of coal becomes self sustainable.
- The supply of coal and air are governed by the demand on the boiler.
- Maximum bed temperature generally reaches up to 950c as this temperature control avoids clinker formation and emission of undesirable salts.
- For maintaining temperature of bed the arrangement is made for cooling of bed by water tubes and also by supplying excess air for cooling.
- Sometimes the low temperature flue gases leaving boiler are recirculated for bed cooling.
- Fluidized bed combustion offers advantage of using any kind of fuel i.e. solid, liquid or gaseous fuel.
- Also in this type of combustion the use of dolomite or lime stone as bed material helps in retaining sulphur in fuel.
- The clinker formation and emission of undesired substances is also avoided as the combustion can be controlled up to 950$_\circ$C.
- Due to large quantity of both combustible and incombustible material present on the bed there occurs the problems of erosion in bed tubes and surroundings and also large burden on bed etc.
- Fluidized bed combustion is used in both fire tube and water tube boilers but the water tube boiler offers advantage of greater flexibility in design of furnace shape and allowing for greater freeboard in which entrained particles can drop back into bed.
- Air velocity is generally limited to 2.5 m/s as beyond this the possibility of incomplete combustion increases



Principle of fluidized combustion
(a) in a vertical fire tube or water-tube boiler, and
(b) in a horizontal fire tube boiler



b) Explain working of Economizer with neat sketch.

It is also a heat recovery device in which feed water is heated from heat available with exhaust gases. Thus hot feed water available from economizer lowers the fuel requirement in combustion.

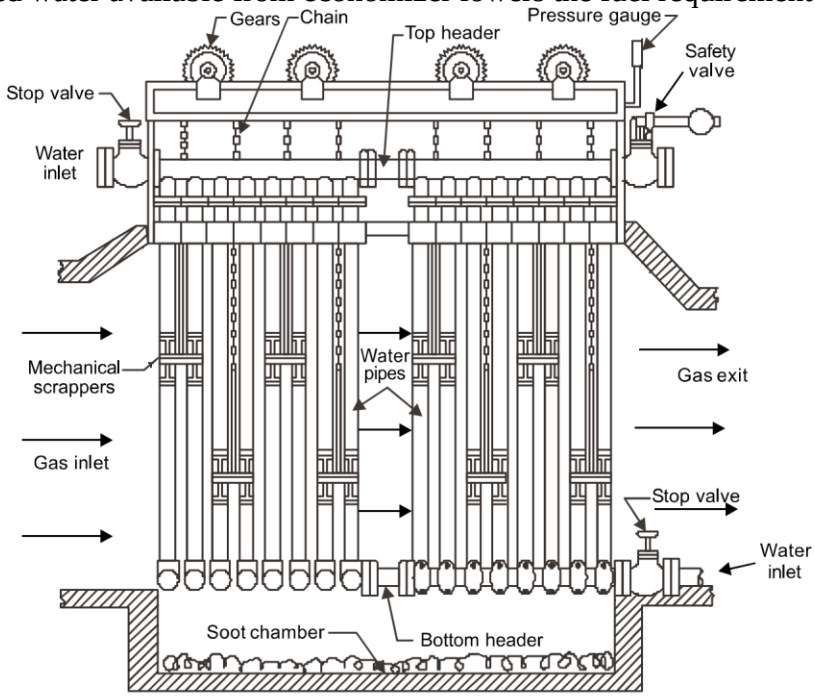


Fig. 11.32 *Economizer*

- It is also a type of heat exchanger having exhaust gas and feed water as two fluids.
- General arrangement in economizer is shown in Fig.
- Economizer also helps in removal of dissolved gases by preheating of water and thus minimizes tendency of corrosion and pitting. Hotter feed water also reduces thermal strain in boiler parts.
- Economizer is located in the boiler structure so as to expose the economizer surface to hot gases.
- Its location varies with the boiler designs.
- Typical economizer called Green's economizer as shown in Fig. has vertical pipes of cast iron fitted with two headers at bottom and top respectively.
- Feed water passes through bottom header, economizer tubes and top header to boiler.
- Thus economizer is simply a heat exchanger where heat is transferred from hot flue gases to water inside the tubes through metal interface.
- Top header is also provided with a safety valve so as to avoid explosion due to excessive pressure of water developing inside economizer tubes.
- Bottom header is also provided with a blow off valve so as to throw out the sediments deposited in feed water.
- Economizer is also provided with scrapers fitted to clean pipes from the deposition of soot carried by the flue gases.
- Continuous scrapping is always desired so as to maximize heat transfer rate.
- Economizer also has a by pass provided so that flue gases can be diverted when economizer is out of full or part operation due to failure or cleaning purpose or feed water temperature control.

3. Attempt **any one** of the following questions.

a) Write down the difference between water tube and fire tube boiler.

FIRE TUBE AND WATER TUBE BOILERS

- Fire tube boilers are those boilers in which hot gases (combustion products) flow inside the tubes and water surrounds them.
- Water extracts heat for its phase transformation from the hot gases flowing inside the tubes, thus heat is indirectly transferred from hot gas to water through a metal interface.
- Fire tube boilers have limitations in terms of steam pressure. Fire tube boilers are used for applications having small steam requirement.

- Water tube boilers are those boilers in which water flows inside the tubes and hot gases surround them.
- This type of boilers came up as a solution to the problem of explosion faced in fire tube boilers when the pressure and steam generation capacity were increased.
- In such boilers the shell behaved as heated pressure vessel subjected to internal pressure which set up tensile stresses (hoop stress) in walls.
- Mathematically, this stress can be given as,
  Hoop stress =PD/(2*t) where *P* is internal working pressure, *D* is diameter of shell and *t* is 2 *t* thickness of shell wall.
- Above expression shows that if '*P*' (pressure) increases then either '*D*' (diameter) should be decreased or '*t*' (thickness) be increased to keep stress within acceptable limits. While increasing thickness the mass of boiler and cost of manufacturing both increase therefore the reduction of '*D*' (diameter) is an attractive option. This became the basis for water tube boilers in which small diameter of tube facilitated quite high-pressure steam generation.

Advantages of fire tube boilers

(a) Fire tube boilers are more flexible and can meet sudden steam demand without much pressure fluctuations. It is because of the large volume of water contained by these boilers and heat energy stored in hot water. It may be noted that energy stored in a definite volume of water at given pressure and temperature shall be more than that stored in same volume of steam at same thermodynamic states.

(b) Fire tube boilers are less sensitive to the failure of feed water supply as they have large capacity of water stored. Such feed water supply failure is very damaging in water tube boilers due to small storage capacity.

(c) Fire tube boilers are rigid and simple in construction, therefore have great reliability and less initial cost. Number of parts in fire tube boilers is less than those in water tube boilers so maintenance cost is also small. Since thickness of boiler shell is large enough so the problems of pitting and erosion are less. Also, the large drum of boiler provides ample water space and desired conditions for dry steam generation.

Advantages of water tube boilers

(a) Steam generation rate is large in water tube boilers as compared to fire tube boilers due to small quantity of water contained, large heating surface, better circulation of water etc. Water tube boilers are made in bigger sizes.

(b) Maximum pressure of steam in water tube boilers is 125 bar and above compared to fire tube boilers (up to 20 bar).

(c) In case of explosion the steam generation may not stop in water tube boilers as the place of explosion in tubes can be plugged easily. While in fire tube boilers the explosion is very dangerous due to large quantity of water flashing into steam.

(d) Water tube boilers are easy to fabricate and transport due to the small size of drum. The shell of fire tube boiler shall be nearly twice or thrice of the shell of water tube boiler for same power.

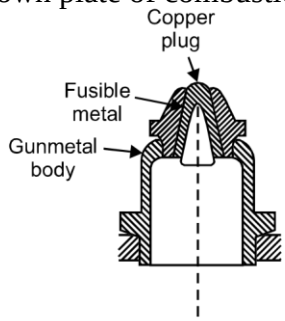
(e) Water tube boilers are generally externally fired and various parts of boiler are more readily accessible for cleaning, inspection and maintenance, compared to fire tube boilers. Characteristics of fire tube and water tube boilers are tabulated as under

Characteristics	*Fire tube boiler*	*Water tube boiler*
(a)Steam Pressure	It is limited to 20–30 bar. In case of waste heat boilers,it can be more.	It is virtually unlimited within metallurgical and design limits.
(b)Unit output	Limited to about 20 MW.within design limits.	It is virtually unlimited
(c)Fuel	All commercial fuels and treated waste can be used.	Any fuel can be used. Also the furnace size is large.
(d)Erection	It is packaged ready for work site.	It is to be shop assembled or erected at site.
(e)Efficiency	Normally 80–85%, gross calorific value, but can be further increased using accessories.	Normally 85–90%,gross calorific but can befurther increased using accessories.
(f)Application	Generally for heat supply.	Generally for power and heat supply together.
(g)Inspection requirement.	Frequent inspection requirement. It is more than in water tube	Inspection requirement is less than in fire tube boiler. boilers.

b) Explain working of fusible plug and feed check valve.

Fusible plug:

- It is a safety device used for preventing the level of water from going down below a critical point and thus avoid overheating.
- Fusible plug is mounted at crown plate of combustion chamber.



○ **Fig. 11.27** *Fusible plug*

- Fusible plug has gun metal body and a copper plug put with fusible metal at interface of copper plug and gun metal body.
- As water level goes down the heat available from furnace could not be completely utilized for steam formation and so the overheating may cause melting of fusible metal.
- Fusible metal is a low melting point metal.

- Thus, upon melting of lining the copper plug falls down and water falls from this opening onto furnace and thus quenches fire.

Feed check valve:

- It is a non return valve at the end of delivery pipe from feed water pump and is placed on boiler shell slightly below normal water level.
- Figure shows the arrangement in a feed check valve.
- It has a check valve whose opening and closing are regulated by the position of spindle.

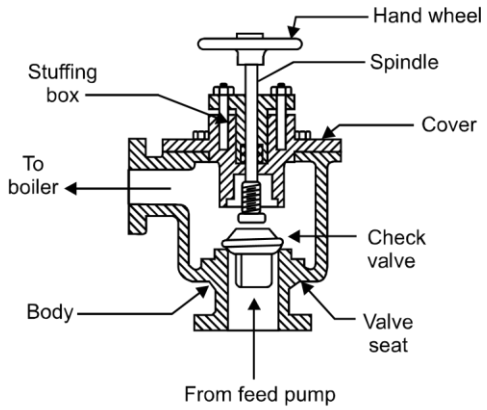


Fig. 11.29 *Feed check valve*

- By hand wheel rotation the position of spindle can be altered suitably.
- Feed check valve permits unidirectional flow of water from feed pump to be boiler shell.
- Under normal running the pressure of feed water coming from pump is more than pressure inside the boiler and so the feed water continues to enter the shell.
- While during the non-working of feed pump the pressure in boiler shell is more and so the check valve gets closed.

4. Why do we prefer water tube boiler over fire tube boiler? Enlist all the boiler mountings and accessories.

    - Steam generation rate is large in water tube boilers as compared to fire tube boilers due to small quantity of water contained, large heating surface, better circulation of water etc. Water tube boilers are made in bigger sizes.
    - Maximum pressure of steam in water tube boilers is 125 bar and above compared to fire tube boilers (up to 20 bar).
    - In case of explosion the steam generation may not stop in water tube boilers as the place of explosion in tubes can be plugged easily. While in fire tube boilers the explosion is very dangerous due to large quantity of water flashing into steam.
    - Water tube boilers are easy to fabricate and transport due to the small size of drum. The shell of fire tube boiler shall be nearly twice or thrice of the shell of water tube boiler for same power.

Different mountings are:

(i) Water level indicator
(ii) Safety valves
(iii) High steam and low water safety valves
(iv) Fusible plug
(v) Pressure gauge
(vi) Stop valve

(vii) Feed check valve
(viii) Blow off cock
(ix) Manhole and mud box

Various boiler accessories are:

(i) Superheater
(ii) Economiser
(iii) Air preheater
(iv) Feed pump