High Pressure Boilers

Steam Generators

- Generates steam at desired rate, desired pressure, and temperature by burning fuel
- It is a complex integration of furnace, super-heater, reheater, evaporator, economizer, air pre-heater, along with various auxiliaries such as pulverizes, burners, stokers, dust collectors, ash-handling equipment, chimney or stack
- Boiler is part of steam generator where phase change occurs from liquid to vapor at constant pressure and temperature

Types of steam generators

Application point of view

- Utility steam generators (steam130-1300 kg/s, Pulverized coal)
 - Sub critical (Pr <221.2 bar)
 - Water tube drum type (130-180 bar, 540-560 °C)
 - supercritical boilers (Pr >221.2 bar)
 - Once through drum-less (240 bar or higher,)
- Industrial steam generators (5-105 bar, 125 kg/s, stoker, pulverized, fluidized bed)
 - No super heated steam only wet or saturated steam
 - Sugar, paper
 - They can also be heat recovery type boilers
- Marine steam generators (60-65 bar, 540°C)
 - Ships, ocean cruiser
 - Oil fired, Produce super heated steam

- According to relative flows
 - Fire tube boilers
 - Products of combustion pass through its tubes which are surrounded by water
 - Internal fired (Ex: Scotch marine boiler)
 - -External fired (Ex: Lancashire boiler)
 - Used in industrial plants
 - •To give saturated steam at 18 bar and 6.2 kg/s steaming capacity
 - Low first cost
 - Reliability in operation
 - Less draught required
 - Quick response to load changes

- Water tube boilers
 - Water flows through the tubes surrounding it flue gases are flowing
 - Small diameter drums

boilers

- Method of water circulation
 - Natural circulation
 - Forced circulation
- Type of tubing
 - Friction is there in large length tubes
 - Sets of tubes parallel to each other are used
 - Give better control over steam quality
- Improved methods of heating
 - Heating water by using super-heated steam
 - Evaporating water above critical pressure(saves latent heat)
 - Change the velocity to improve heat transfer rate thorough tube walls
 - Recovering waste heat by using economizer and air preheaters

Natural circulation



fig 1.27 natural circulation of water

Forced circulation



Modern High Pressure boilers Once through Boilers

- Suitable for Supercritical pressure operation as there is no latent heat of evaporation is required
- Water flashes to vapor in case of super critical boilers directly
- Flashed high pressure steam is heated to desired super heated temperatures in super heaters
- Water enters the boilers at one end of a number of parallel paths and emerges at the outlet as superheated steam
- Movement of the water is forced by the boiler feed pump
- The design is well suited to quick starts and

ADVANTAGES

- The tendency of scale formation is eliminated
- Light weight tubes with better heating surface arrangement can be used & less space
- Use of forced circulation, there is more freedom in the arrangement of furnace, tubes and boiler components
- All the parts are uniformly heated reducing the thermal stress problems
- The steam can be raised quickly to meet the variable load
- The efficiency of plant is increased upto 40 to 42%
- A very rapid start from cold is possible

LA MONT BOILER



- Introduced in 1925 by La Mont
- The feed water from hot well is supplied to a storage and separating drum (boiler) through the economizer
- The most of the sensible heat is supplied to the feed water passing through the economizer
- A centrifugal pump circulates the water equal to 8 to 10 times the weight of steam evaporated
- The distribution headers distribute the water through the nozzles into the evaporator
- The steam separated in the boiler is further passed through the super-heater
- These boilers have been built to generate 45 to 50 tons of superheated steam at a pressure of

Draw backs

- Formation and attachment of bubbles on the inner surfaces of the heating tubes
- Attached bubbles to the tube surfaces reduced the heat flow and steam generation as it offers high thermal resistance than water
- Sediment layer formation in the evaporators
- Scaling of super heaters

BENSON BOILER



- Benson in 1922 raised boiler pressure to critical pressure (225 bar)
- The steam and water have the same density and therefore the danger of bubble formation can be easily eliminated
- The water as passed through the economizer into the radiant evaporator (Majority of water converted into steam)
- The remaining water is evaporated in the final evaporator absorbing the heat from hot gases by convection
- The saturated high-pressure steam (at 225 bar) is further passed through the super-heater
- The maximum working pressure obtained in Benson boiler is 500 bar
- The Benson boilers of 150 tones/hr generating capacity are in use

Advantages

- 1.The total weight of Benson boiler is 20% less than other boilers (No Drum), reduces the cost of boiler
- 2.The erection of Benson boiler is easier and quicker and in smaller floor area
- 3.The furnace walls of the boiler can be more efficiently protected by using smaller diameter and closed pitched tubes
- 4.The super-heater in the Benson boiler is an integral part of forced circulation system
- 5.The Benson boiler can be started very quickly

- 8. The Benson boiler can be operated most economically by varying the temperature and pressure at partial loads and over loads
- Insensitiveness to load fluctuations makes it more suitable for grid power station as it has better adaptive capacity to meet sudden load fluctuations

10.The blow-down losses of Benson boiler are hardly 4% of natural circulation boilers of same capacity.

11.Explosion hazards are not that severe as it consists of only tubes of small diameter

Schmidt Hartman Boiler



- Consists of two circuits
 - Primary (Closed)
 - Secondary
- Primary circuit is closed one and having high pressure with distilled water
- High pressure steam of distilled water heats evaporator or steam generator content which is to be supplied to the prime mover via super heater
- High pressure condensate on its way back heats the low pressure feed heater
- Natural circulation is used in primary circuit

Advantages

- There is a rare chance of overheating
- Wide fluctuations of load can be catered
- Cleaning or maintenance is easy



- Deposited of solt in inner surface of water tube in the lamount boiler which reduced the heat transfer rate
- Because of that
 - Over heating
 - Increase thermal resistance
 - Decrease efficiency
 - Heat and energy loss

Velox boiler



- When gas velocity exceeds the sound velocity the heat is transferred from the gas at a much higher rate than rates achieved with sub sonic flow
- Air has to be compressed to 2.5 bar to get supersonic velocity in burners
- Burnt gases pass through the initially in the annulus of the tubes as shown in diagram
- The mixture of water and steam formed sent to separator where the steam is separated from water
- Separated steam is further sent to super-heater where the flue gas coming out of the annulus tubes heat it to higher temperatures
- The flue gas coming out of the super heater are used to run the gas turbine which operates compressor
- Again flue gas of the gas turbine are used to

Advantages

- High heat release rate 8-10 million Kcal / m3 of combustion chamber
- Low excess air and draught
- Compact and flexible unit
- Can be started quickly

Supercharged boiler

- Combustion is carried out under pressure in the combustion chamber
- Supplying the compressed air (Minimum of 5 bar)
- The exhaust gasses from the combustion chamber are used to run the gas turbine
- The gas turbine runs the air compressor to supply the compressed air to the combustion chamber



Boiler accessories

- Accessories of the boiler units are used for improving the efficiency of boilers and also operational capability of units
- The most important boiler accessories are
 - Feed pump
 - Economizer
 - Super heater
 - Desuperheater
 - Air preheated
 - Steam separator
 - Induced draught fan & forced draught fan
 - Chimney

FBC Boiler

 Principle of FBC



Atmospheric FBC boiler a) classical FBC boiler





Pressurized FBC boiler



Adoption of these equipments

- Depends on economic justification
- Maintenance capability of the equipments
- Depends on the capacity of plant
- Corrosion inside and outside of the equipments used is avoided by using proper material and maintaing flue gas temperature

Air preheater

- Flue gas coming out of economizer is further utilized for pre-heating air before supplying to the combustion chamber
- Air pre-heater is mainly used for supply air to burners in pulverized coal burning system and hot air to dry coal for crushing and pulverizing
- Its economical when used with pulverized coal burning unit as the flue gas having 250-350°C
- Air preheater normally used in solid fuel boilers not in liquid and gaseous fuel

the air

- Flame temperature is raised, resulting in increased heat transfer from the hot gases to the heating surface of the boiler
- Speed of combustion is increased; this further raises the flame temperature
- Amount of excess air necessary for complete combustion can be reduced. This will reduce heat losses
- Possible to burn low-grade fuels
- Heat abstracted from the flue gases by the air is returned to the furnace by way of combustion
- Increased thermal efficiency, fuel consumption saving
- Increased steam generation capacity of

Air preheater must provide

- Reliability of operation
- Should occupy small space
- Capital investment should be low
- Easy maintainable and accessible

heater



Types of air-preheater

- Regenerative- It alternately gets heated and cooled by the hot flue gas and air (intermittent in operation)
- Recuperative –transfer heat continuously to air from fuel (Continuous in operation)
 - Tubular air heater (Gilled)
 - Plate air heater

Tubular type air pre-heater



Tubular air heater (Gilled)

- In the tubular air pre heater, air is passed through tubes and the flue gases flow over the tubes or vise versa
- Cleaning the tubes is easier when the gases pass through them
- The rate of heat transfer is low and the space occupied is generally prohibitive with plain tubes
- Using gilled tubes overcomes these problems to some extent.
- Aluminum alloy tubes have also been used in some installations to overcome these problems
- In plate air heater, hollow leaves have been welded electrically and counter flow principle is being used. The gases flow along the outside of the leaves and air to be heated is forced through the leaves. In this unit, difficulty was experienced due to chocking and

Types of Super heater

Base on mode of heat transfer :

- 1. Convective superheater
- 2. Radiant superheater
- 3. Combined convective and radiant

Types of Super heater Based on their position in the furnace W.R.T water tubes • Innerdack superheater.



Over deck superheater superheater

Inner Tube



• Inner Bank superheater



Radiant and convective superheater



Superheat temp control

a) Bypassing the furnace gas around the super heater



c) Tilting burners in the furnaced) Auxiliary Burners



e) Desuperheater using water spray



f) Pre-condensing control



g) Twin furnace arrangement



h) Coil Immersion in the Boiler Drum



in Fig. 14.21 (c).



Fig. 14.21. Different arrangements of superheat control.

Corrosion in boilers and its prevention

- 1. Corrosion at inner surface(water/steam side)
 - 1. Due to an acid or low pH value in water
 - 2. The presence of O_2 , CO_2 or chlorides dissolved in feed water.

2. Corrosion at external surface(flue gases side)