UTKAL GOURAV MADHUSUDAN INSTITUTE OF TECHNOLOGY

POWER STATION ENGINEERING LAB

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1. To study the modern steam power plant with model.
2. To determine the various efficiencies of steam turbine.
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6. To study the spring loaded safety valve.
7. To study the following steam generators (boilers) models.
    a) Lancashire boiler.
    b) Cornish boiler.
    c) Babcock & Wilcox Boiler.
    d) d) Vertical water tube boiler.

EXPERIMENT 1

AIM:

To study the modern steam power plant with model.

OBJECTIVE:

1. Study about the layout of the steam power plant.
2. Study about the Rankin cycle and different components of the steam power plant.

APPARATUS / EQUIPMENTS REQUIRED :

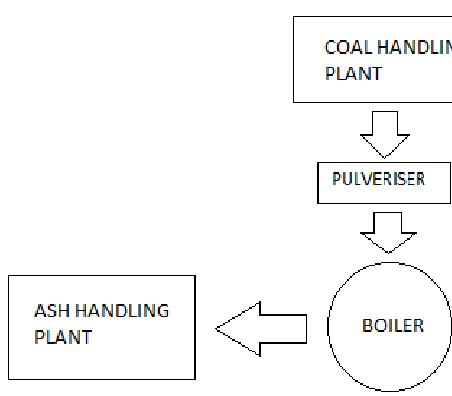
1. Modern steam power plant model.
2. Modern steam power plant schematic chart (Diagram or Layout).

THEORY:

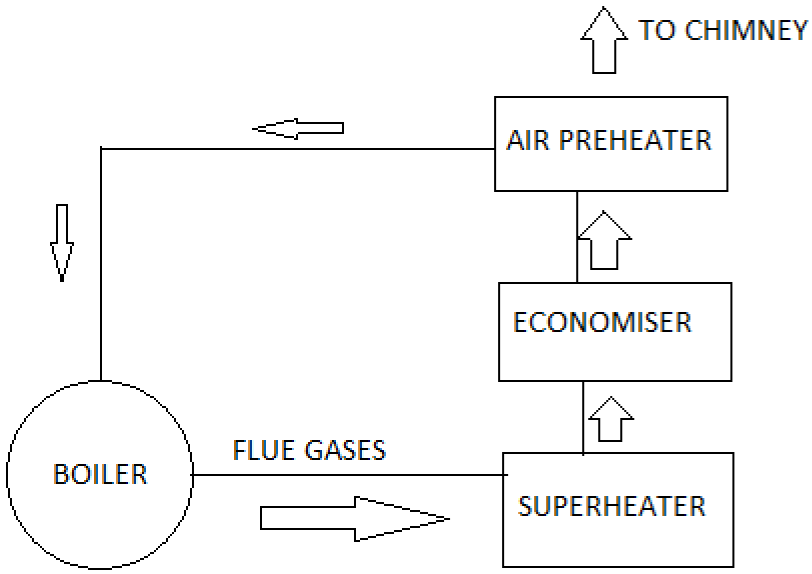
Introduction: A steam power plant / thermal power plant is using steam as working fluid. A thermal power station is a power plant in which the prime mover is steam & spins a steam turbine which drives an electrical generator. After steam passes through the turbine, it's condensed in a condenser & recycled to where it was heated. In the steam turbine, heat energy is converted into mechanical energy which is used for generating electric power. Generator is an electro-magnetic device which makes the power available in the form of electrical energy.

The general layout of the modern steam power plant consists of mainly four circuits which are:
1. Coal and Ash Circuit.
2. Air and Gas Circuit.
3. Feed water and Steam flow Circuit.
4. Cooling water Circuit.

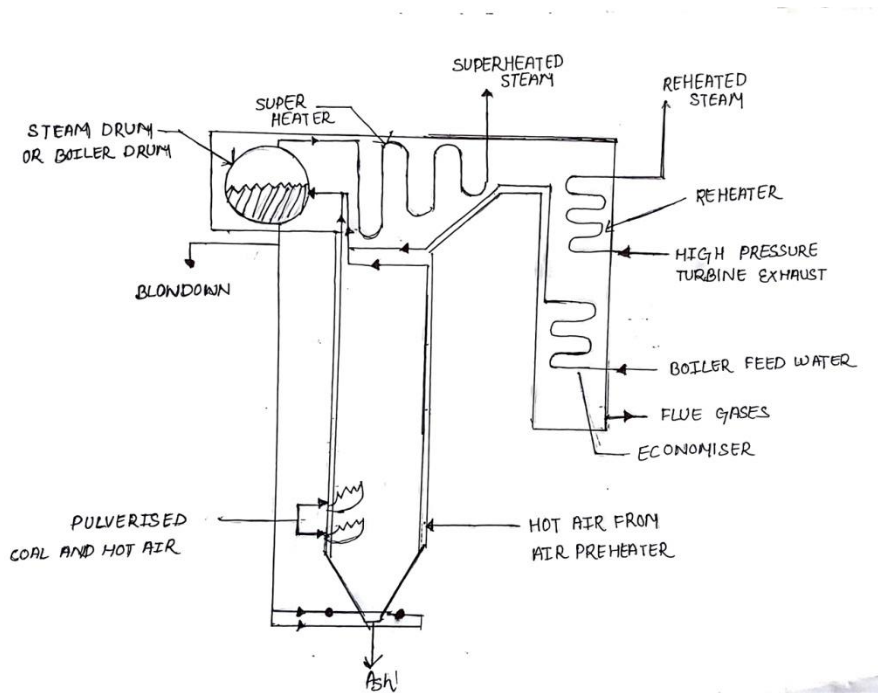
1. **Coal and Ash Circuit :** coal arrives at the coal handling plant after necessary handling process, passes through pulveriser & fuel feeding device. Ash resulting from combustion of coal collects at the back of the boiler and is removed to the ash storage.



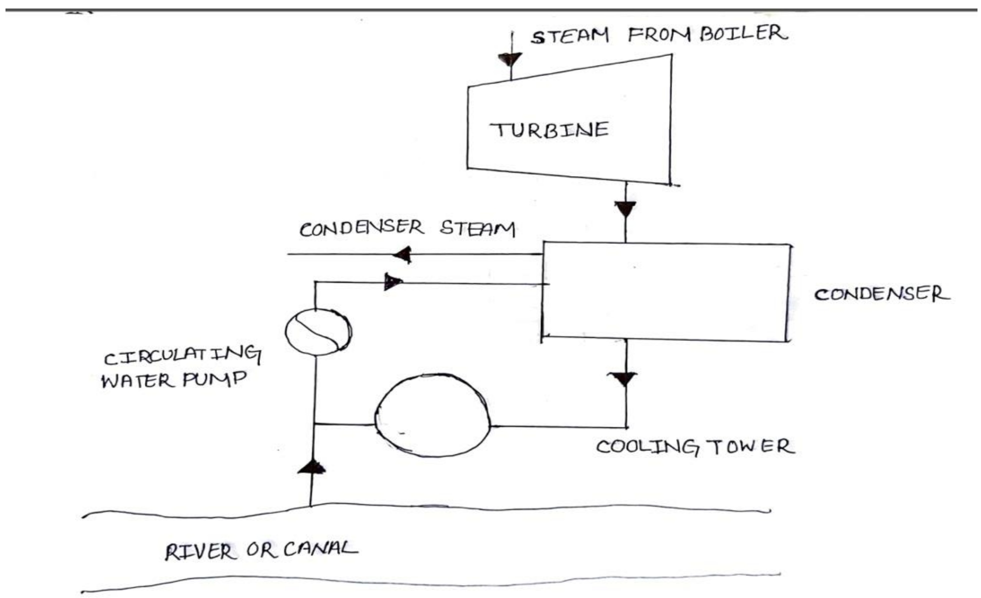
2. **Air and Gas Circuit :**Air is taken from the atmosphere through the action of forced drought (FD) fan and passes on the furnace through air preheater. Flue gases are produced when coal is combusted in the boiler. The flue gases after passing around the boiler tube and superheater tubes in the furnace passes through an economiser and finally passes through preheater before being exhausted to the atmosphere via electrostatic precipitator & chimney.

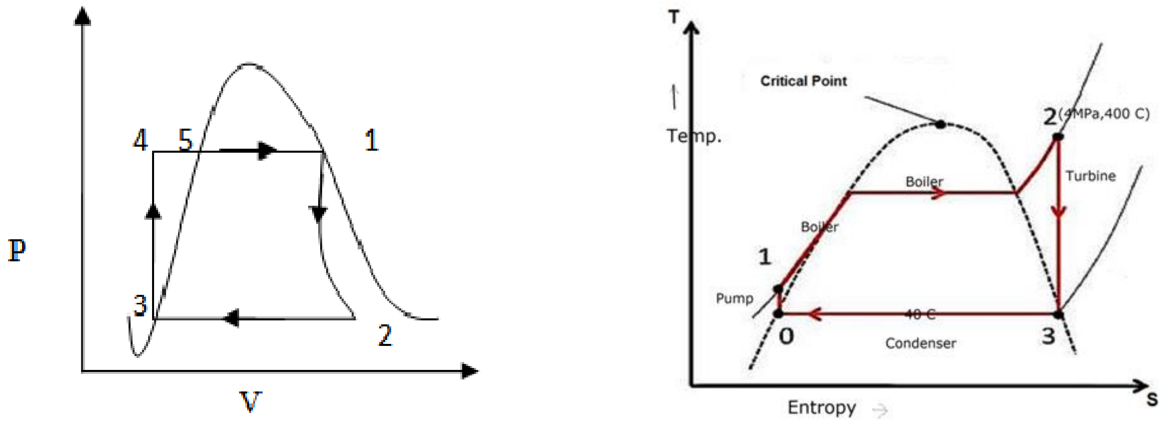


3. **Feed Water and Steam Flow Circuit :** In the water and steam circuit condensate leaving the condenser is passes through the deaerator and water heaters before going the boiler through economiser. In the boiler drum and tubes , water circulates due to the difference between the density of water in the lower temperature and higher section of the boiler. Wet steam from the drum is further heated up in superheater before being supplied to the turbine. After expanding in turbine, steam is condensed in condenser. The condensate leaving the condenser is circulated to the boiler. A part of steam and water is lost while passing through different components and this compensated by suppling additional feed water. This feed water is purified & softened before going to the boiler , to avoid the scaling of the tubes off the boiler. The purification and softening of the water are done in the water treatment plant.

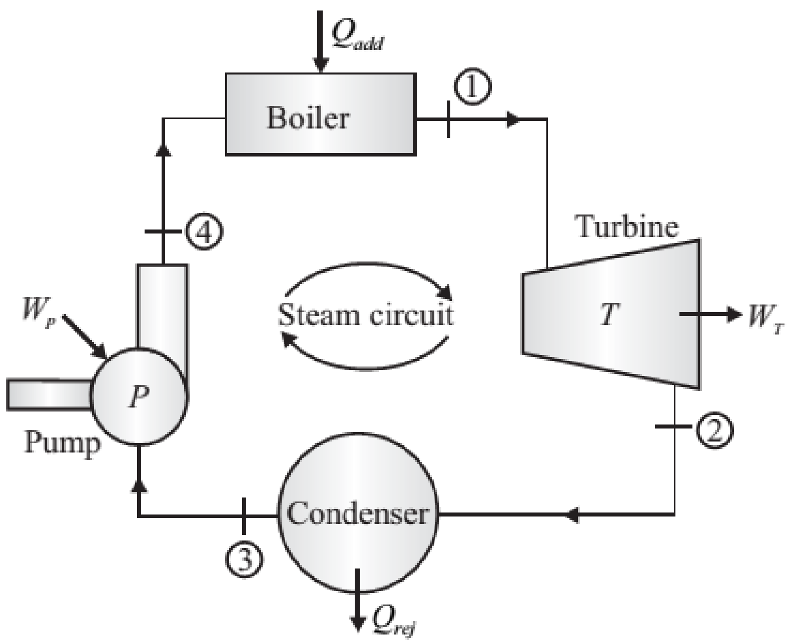


4. **Cooling Water Circuit:** The cooling water supply to the condenser helps in the maintaining a low pressure in it. The cooled water extract heats from turbine exhaust steam in the condenser and became hot. The hot water gets cooled after passing through cooling tower and again circulated to condenser through circulating water pump. A part of water is lost in the cooling tower and this compensated by supplying the water from a natural source as river , lake or sea.





P-V, T-S and H-S Diagram of Simple Rankine Cycle :



Simple Rankine Cycle:

Nomenclature :

1.**SATURATED TEMPERATURE :** Its is the temperature for a corresponding saturation pressure at which a liquid boil into its vapour phase.

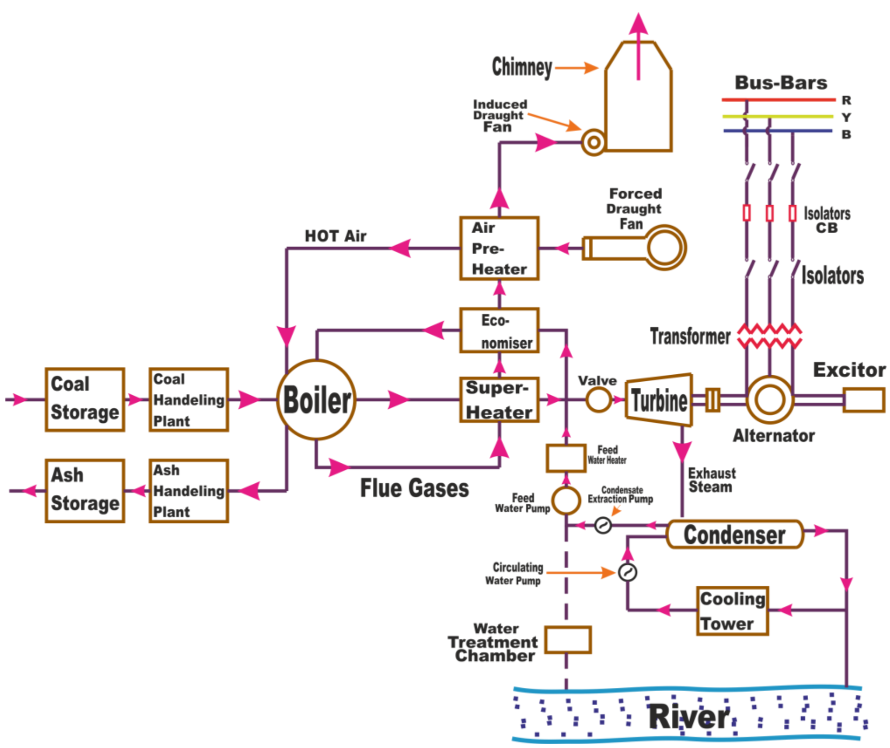
2.**WET STEAM OR UNSATURATED STEAM :** Its a mixture which contains both water vapour and liquid droplets. Most of the boiler discharge steam containing 3% to 5%wetness. If the mass of the steam contains 5% water its said to be 5% wet and 95% dry.

3.**SUPERHEATED STEAM :** It's an extremely high temperature vapour generated by heating the saturated steam or wet steam beyond saturation point.

4. **DRY STEAM OR SATURATED STEAM :** Dry steam is steam that is at the temperature of the saturation, but does not contains water particles in suspension.

5. **CONDENSATE :** A liquid phase produced by condensation of the steam.

Schematic Diagram of steam power plant :



CONCLUSION :

In the above experiment we studied about Modern steam power plant and its Layout.

EXPERIMENT 2

AIM:

To determine the various efficiencies of the steam turbine.

APPARATUS / EQUIPMENTS REQUIRED:

- Steam turbine test rig.
- Tachometer.

THEORY:

INTRODUCTION: A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency from the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible expansion process. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator--about 85% of all electricity generation.

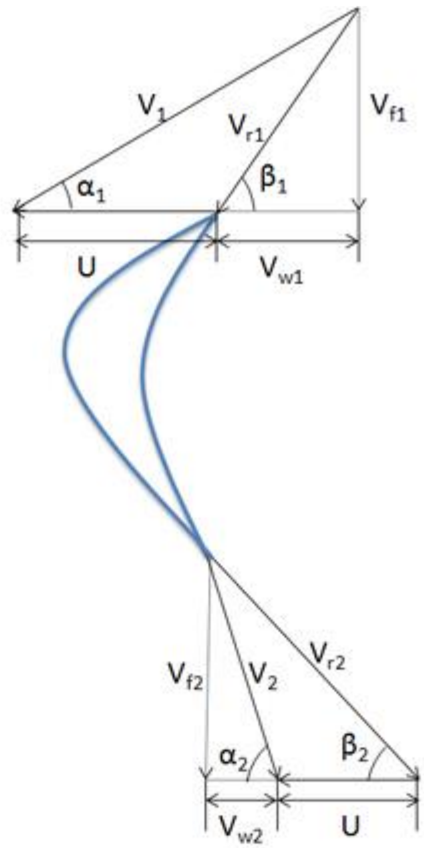
There are mainly two types of steam turbine:

- IMPULSE TURBINE.
- REACTION TURBINE.

1. **Impulse Turbine:** An impulse turbine has fixed nozzles that orient the steam flow into high speed jets. These jets contain significant kinetic energy, which is converted into shaft rotation by the bucket-like shaped rotor blades, as the steam jet changes direction. A pressure drop occurs across only the stationary blades, with a net increase in steam velocity across the stage. As the steam flows through the nozzle its pressure falls from inlet pressure to the exit pressure (atmospheric pressure). Due to this high ratio of expansion of steam, the steam leaves the nozzle with a very high velocity. The steam leaving the moving blades has a large portion of the maximum velocity of the steam when leaving the nozzle. The loss of energy due to this higher exit velocity is commonly called the carry over velocity or leaving loss.
The law of moment of momentum states that the sum of the moments of external forces acting on a fluid which is temporarily occupying the control volume is equal to the net time change of angular momentum flux through the control volume.

The swirling fluid enters the control volume at radius r_2 with tangential velocity Vw_1 and leaves at radius r_2 with tangential velocity Vw_2.

A velocity triangle paves the way for a better understanding of the relationship between the various velocities. In the adjacent figure we have:



V_1 and V_2 are the absolute velocities at the inlet and outlet respectively.
V_{f1} and V_{f2} are the flow velocities at the inlet and outlet respectively.
V_{w1} and V_{w2} are the swirl velocities at the inlet and outlet respectively, in the moving reference.
V_{r1} and V_{r2} are the relative velocities at the inlet and outlet respectively.
U_2 and U_2 are the velocities of the blade at the inlet and outlet respectively.
α is the guide vane angle and β is the blade angle.

Then by the law of moment of momentum, the torque on the fluid is given by:

$$T=\dot{m}(r_2V_{w2}-r_1V_{w1})$$

For an impulse steam turbine: $r_1=r_2=r$. Therefore, the tangential force on the blades is

$F_c = \dot{m}(V_{w1}-V_{w2})$. The work done per unit time or power developed: $W=T\omega$.

When ω is the angular velocity of the turbine, then the blade speed is $U=\omega r$. The power developed is then $W= \dot{m}U(\Delta V_w)$.

Blade Efficiency: It can be defined as the ratio of the work done on the blades to kinetic energy supplied to the fluid, and is given by

$$\eta_b = \frac{workdone}{Kinitic\ Energy\ supplied} = \frac{U\Delta V_w}{V_1^2}$$

Stage Efficiency: A stage of an impulse turbine consists of a nozzle set and a moving wheel. The stage efficiency defines a relationship between enthalpy drop in the nozzle and work done in the stage.

$$\eta_{stage} = \frac{work\ done\ on\ stage}{Energy\ supplied\ per\ stage} = \frac{U\Delta V_w}{\Delta h}$$

Where $\Delta h = h_2 - h_1$ is the specific enthalpy drop of steam in the nozzle.

By the first law of thermodynamics:

$$h_1 + \frac{1}{2}V_1^2 = h_2 + \frac{1}{2}V_2^2$$

Assuming V_1 is appreciably less than V_2, We get $\Delta h \approx \frac{1}{2}V_2^2$. Furthermore stage efficiency is the product of blade efficiency and nozzle efficiency, or$\eta_{stage} = \eta_b \eta_N$.

Nozzle efficiency is given by $\eta N = \frac{V_2^2}{2(h_1 - h_2)}$, where the enthalpy (in J/Kg) of steam at the entrance of the nozzle is h_1 and the enthalpy of steam at the exit of the nozzle is h_2.

$$\Delta V_w = V_{w1} — V_{w2}$$

$$= V_{w1} + V_{w2}$$

$$= V_{r1}\cos\beta_1 + V_{r2}\cos\beta_2$$

$$= V_{r1}\cos\beta_1\left(1 + \frac{V_{r2}\cos\beta_2}{V_{r1}\cos\beta_1}\right)$$

The ratio of the cosines of the blade angles at the outlet and inlet can be taken and denoted $= \frac{\cos\beta_2}{\cos\beta_1}$. The ratio of steam velocities relative to the rotor speed at the outlet to the inlet of the blade is defined by the friction coefficient$k = \frac{V_{r2}}{V_{r1}}$.

$k < 1$ and depicts the loss in the relative velocity due to friction as the steam flows around the blades.

$$\eta_b = \frac{2U\Delta V_w}{V_1^2} = \frac{2U}{V_1}\left(\cos\alpha_1 - \frac{U}{V_1}\right)(1 + kc)$$

The ratio of the blade speed to the absolute steam velocity at the inlet is termed the blade speed ratio $\rho = \frac{U}{V_1}$.

η_b is maximum when $\frac{d\eta_b}{d_\rho}$ or $\frac{d}{d\rho}(2\cos\alpha_1 - \rho^2(1 + kc)) = 0$. That implies $\rho = \frac{1}{2}\cos\alpha_1$ and therefore $\frac{U}{V_1} = \frac{1}{2}\cos\alpha_1$. Now $\rho_{opt} = \frac{U}{V_1} = \frac{1}{2}\cos\alpha_1$.

Therefore, the maximum value of stage efficiency obtained is

$$\eta b_{max} = 2(\rho\cos\alpha_1 - \rho^2)(1 + kc) = \frac{1}{2}\cos^2 a_1\,(1 + kc).$$

So, The maximum Efficiency is $\eta b_{max} = cos^2 a_1$.

2. Reaction turbines: In the reaction turbine, the rotor blades themselves are arranged to form convergent nozzles. This type of turbine makes use of the reaction force produced as the steam accelerates through the nozzles formed by the rotor. Steam is directed onto the rotor by the fixed vanes of the stator. It leaves the stator as a jet that fills the entire circumference of the rotor. The steam then changes direction and increases its speed relative to the speed of the blades. A pressure drop occurs across both the stator and the rotor, with steam accelerating through the stator and decelerating through the rotor, with no net change in steam velocity across the stage but with a decrease in both pressure and temperature, reflecting the work performed in the driving of the rotor.

BLADE EFFICIENCY:

Energy input to the blades in a stage: $E = \Delta h$ is equal to the kinetic energy supplied to the fixed blades (f) + the kinetic energy supplied to the moving blades (m). Or *E*= enthalpy drop over the fixed blades, Δh_f + enthalpy drop over the moving blades, Δh_m.

The effect of expansion of steam over the moving blades is to increase the relative velocity at the exit. Therefore, the relative velocity at the exit Vr_2 is always greater than the relative velocity at the inlet Vr_1.

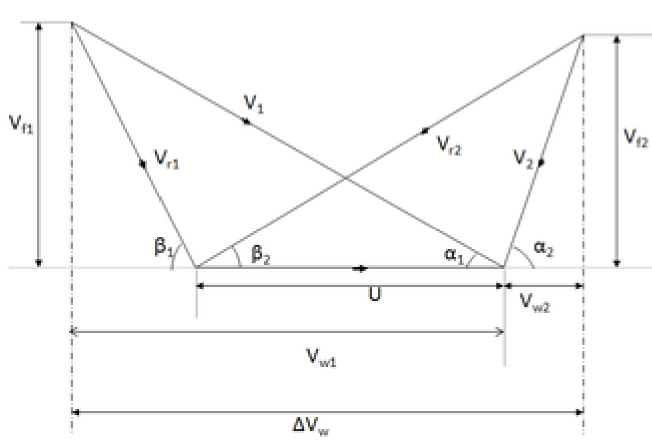
In terms of velocities, the enthalpy drop over the moving blades is given by:

$$\Delta h_m = \frac{V_{r2}^2 - V_{r1}^2}{2}$$

The enthalpy drop in the fixed blades, with the assumption that the velocity of steam entering the fixed blades is equal to the velocity of steam leaving the previously moving blades is given by:

$$\Delta h_f = \frac{V_1^2 - V_0^2}{2}$$

where V_0 is the inlet velocity of steam in the nozzle



V_0 is very small and hence can be neglected. Therefore, $\Delta h_f = \frac{V_1^2}{2}$

$$E = \Delta h_f + h_m$$

$$= \frac{V_1^2}{2} + \frac{V_{r2}^2 - V_{r1}^2}{2}$$

A very widely used design has half degree of reaction or 50% reaction and this is known as Parson's turbine. This consists of symmetrical rotor and stator blades. For this turbine the velocity triangle is similar and we have:

$$\alpha_1 = \beta_2, \beta_1 = \alpha_2$$

$$V_1 = V_{r2}, V_2 = V_{r1}$$

Assuming *Parson's turbine* and obtaining all the expressions we get

$$E = V_1^2 - \frac{V_{r1}^2}{2}$$

From the inlet velocity triangle we have $V_{r1}^2 = V_1^2 + U^2 - 2UV_1 \cos\alpha_1$.

$$E = V_1^2 - \frac{V_1^2}{2} - \frac{U^2}{2} + \frac{2UV_1 \cos\alpha_1}{2}$$

$$= \frac{V_1^2 - U^2 + 2UV_1 \cos\alpha_1}{2}$$

Work done: $W = U\Delta V_w = U(2V_1 \cos\alpha_1 - U)$

Therefore, the **blade efficiency** is given by

$$\eta_b = \frac{2U(2V_1 \cos\alpha_1 - U)}{V_1^2 - U^2 + 2UV_1 \cos\alpha_1}$$

MAXIMUM BLADE EFFICIENCY:

If $\rho = \frac{U}{V_1}$, then

$$\eta_{bmax} = \frac{2U(2V_1 \cos\alpha_1 - U)}{V_1^2 - U^2 + 2UV_1 \cos\alpha_1}$$

For maximum efficiency $\frac{d\eta_b}{d\rho} = 0$, we get

$$(1 - \rho^2 + 2\rho\cos\alpha_1)(4\cos\alpha_1 - 4\rho) - 2\rho(2\cos\alpha_1 - \rho)(-2\rho + 2\cos\alpha_1) = 0$$

And this finally gives $\rho_{opt} = \frac{U}{V_1} = \cos\alpha_1$.

Therefore, η_{bmax} is found by putting the value of $\rho = \cos\alpha_1$ in the expression of blade efficiency

$$\eta_{b_{reaction}} = \frac{2cos^2\alpha_1}{1 + cos^2\alpha_1}$$

$$\eta_{b_{impulse}} = cos^2\alpha_1$$

PROCEDURE:

Pre-Start:

- Lock caster wheels.
- Assure front and rare boiler doors are closed.
- Open steam admission valve. (Do not attempt to fill the boiler while hot or under pressure.)
- Insert supply fill/drain fitting into filler port located at the rare of the boiler.
- Gill the boiler with clean tap water.
- Remove filler hose.
- Close the steam admission valve.
- Turn the load to off position.
- Turn the burner switch to off position.
- Turn the load to minimum load.

Start:

- Open the fuel for furnace.
- Turn the boiler on. (Combustion starts automatically at the burner wait for 30 to 40 seconds).
- Boiler pressure indication should be observed for 3min of ignition.
- Open the steam admission valve.
- Control the flow of steam by steam admission valve.
- Take steam pressure reading.
- Turn the load to on position.
- Take the reading of load.
- Take RPM reading by Tachometer.

Shut Down:

- Close steam admission valve when water level reaches pre selected lower bezel setting.
- Turn boiler to off position.
- Turn off the load.
- Turn fuel supply off.
- Drain the water after it gets cooled.

OBSERVATION:

Sl no.	P_1	P_2	H_1	H_2	W_1	W_2	RPM	Efficiency
1								
2								
3								

CALCULATION:

We know,

Input energy = $H_1 - H_{2.}$ (Using steam table.)

Output = $2 \times \pi \times D \times (W_1 - W_1) \times N$

Now,

$$\eta = \frac{Output}{Input}$$

$$\eta = \frac{2 \times \pi \times D \times (W_1 - W_1) \times N}{(H_1 - H_2) \times 60}$$

NOMENCLATURE:

P_1 - Inlet pressure.

P_2 - Outlet pressure.

W_1 - Dead weight (Kg).

W_2 - Spring balance reading (Kg).

H_1 - Enthalpy at Inlet.

H_2 - Enthalpy at outlet.

N - RPM of the break drum.

CONCLUSION:

We have successfully derived the efficiencies of turbines.

EXPERIMENT 3

AIM :

To study the Cooling tower.

OBJECTIVE:

- To Study the constructional feature of the Cooling tower.
- To the study the working of Cooling tower.

APPARATUS / EQUIPMENTS REQUIRED :

1. Study model of the cooling tower
2. Schematic Diagram of Cooling tower.

THEORY :

A cooling tower is a heat rejection device that rejects waste heat to the atmosphere through the cooling of a coolant stream, usually a water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of closed circuit cooling towers or dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature using radiators.

Common applications include cooling the circulating water used in oil refineries, petrochemical and other chemical plants, thermal power stations, nuclear power stations and HVAC systems for cooling buildings. The classification is based on the type of air induction into the tower: the main types of cooling towers are natural draught and induced draught cooling towers.

Commonly used Terms for Cooling Towers

- **Dry-Bulb temperature** refers basically to the ambient air temperature. It is called "Dry Bulb" because the sensing tips of the thermometer not affected by the moisture of the air.
- **Wet-Bulb temperature** is the temperature of adiabatic saturation indicated by a moistened thermometer bulb exposed to the airflow.
- **Relative Humidity** is the amount of moisture in the air, as a percentage of the total moisture the air can contain at the current temperature
- **The approach** is the difference in temperature between the cooled-water temperature and the entering air wet-bulb temperature.
- **The range** is the temperature difference between the water inlet and the water exit.
- **Cycles of concentration** represent the accumulation of dissolved minerals in the recalculating cooling water.
- **Blow-down** - The portion of the circulating water flow that is removed in order to maintain the number of dissolved solids and other impurities at an acceptable level.
- **Fills** – Inside the tower, fills are added to increase contact surface as well as contact time between air and water. Thus they provide better heat transfer.
- **Drift** – Water droplets that are carried out of the cooling tower with the exhaust air.
- **Plume** – The stream of saturated exhaust air leaving the cooling tower.
- **Blow-out** – Water droplets are blown out of the cooling tower by wind, generally at the air inlet openings.

MAIN PARTS OF COOLING TOWER

Fills: Cooling Tower Fill is the main heat transfer area available for Heat transfer from Hot water to Cold Air. There are two types of fills available namely Splash fills & Film Fills.

Drift Eliminators: The purpose of Drift eliminator is to reduce the drift loss in cooling tower. Drift eliminators normally kept next to fills in the air flow path thereby reducing the drift loss

Cold Water Basin: Cold Water Basin is normally made up of Reinforced Cement Concrete (RCC). It has got two functions. One is to collect the cold water from tower and acts as storage.

Cooling Tower Fans: Main part of the cooling tower components. Cooling Tower fans are normally made from Aluminum, Fiber Reinforced Plastic (FRP), Glass fiber and hot-dipped galvanized steel are commonly used as fan materials. FRP being light in weight, impellers made up of FRP reduces the power requirements of the fan.

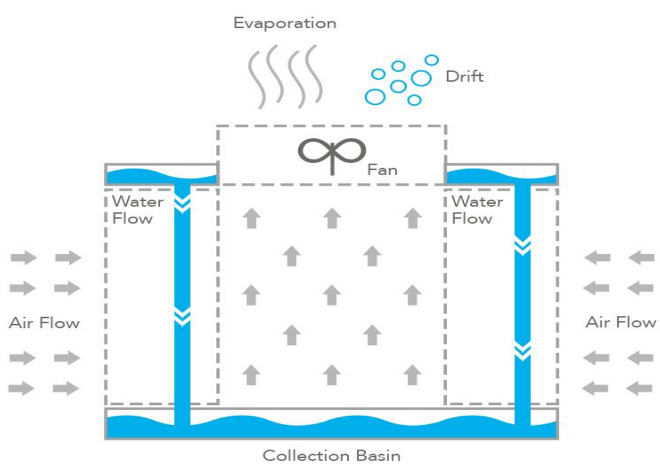
Water Distribution Piping's: Cooling Water Distributing pipes to hot basin must be buried underground or supported in ground to avoid thrust loading of the tower due to self weight and water pressure inside the pipe. Individual cell inlet piping is to be independently supported.

Fan Deck & Fan cylinder: Fan deck provides a platform for the support of the fan cylinders and acts as access way to the fan and water distribution system.

Distribution Valves: Distribution Valves are used to regulate the hot water flow to distribute evenly in cells. The outlet is open to atmosphere. Valve body is designed to withstand the adverse corrosive environment. Valve should pose minimum pressure drop.

Cooling Tower Fan Motor: Explosion proof motors are preferred for use in Petrochemical & Refinery cooling tower applications. As the Hot Cooling water from exchangers may have explosive gas if a heat exchanger is leaky. Motor is to be provided with Protection systems like Earth fault relay and over load relay etc.

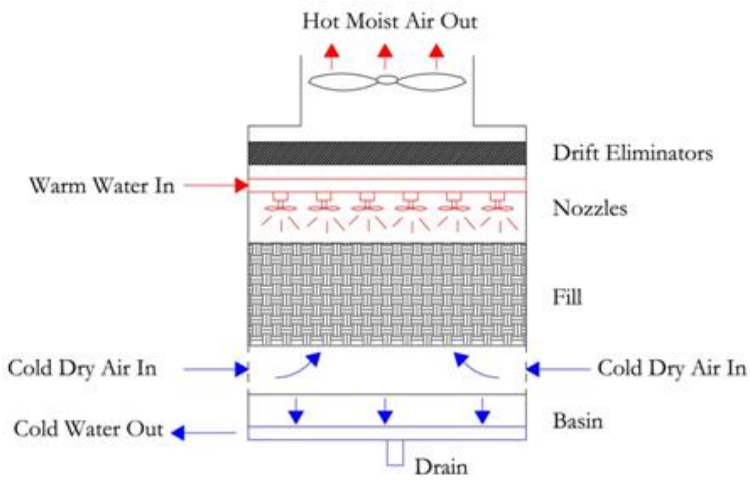
Cooling Tower Instrumentation: Vibration Switches, Low Oil Level Switches, Level Switches for Hot & Cold Water Basin, Thermocouples for Hot & Cold Water Temperature measurement and Flow meters for Cooling water makeup & Blow down rate are normal instrumentation system available in any cooling tower.



Cooling Tower Diagram

<u>Types of Cooling Tower:</u>

1.Mechanical draught cooling tower: mechanical draught cooling towers employ fans or other mechanics to circulate air through the tower. Common fans used in these towers include propeller fans and centrifugal fans. Mechanical draught towers are more effective than natural draught towers, and can even be located inside a building with the proper exhaust system.



Forced Draught Cooling Towers: In this system, fan is located near the bottom and on the side. This fan forces the air from bottom to top. An eliminator is used to prevent loss of water droplets along with the forced air.

Induced Draught Cooling Towers: In this system, a centrally located fan at the top, takes suction from the tower and discharges it to the atmosphere. Air enters the sides of the tower at low velocity through large openings and passes through the fill, whereas the hot humid air is exhausted to the atmosphere through the ventilator.

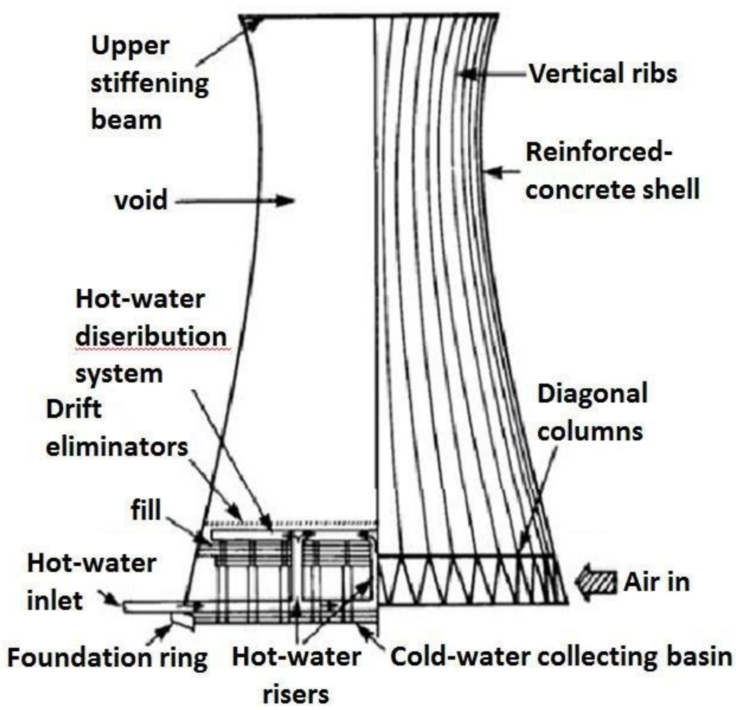
Advantage of Mechanical draught cooling tower:

- For the same capacity used, the mechanical draught cooling towers are much smaller than the natural draught cooling towers. This is because of the increase in cooling capacity due to increase in volume of the air being forced out by fan.
- Capacity control is possible in mechanical draught cooling tower. By controlling the speed of the fan, the volume of air can be controlled, which in turn controls the capacity.
- The natural draught cooling towers can be located only in open space. As they do not depend up the atmospheric air, the mechanical draught cooling towers shall be located even inside the building.

Disadvantages of Mechanical draught cooling tower:

- In Mechanical draught towers more power is required to run the system.
- In this type of towers, running cost is higher due to increase in maintenance of the fans, motors and its associated controls.

2. Natural draught cooling tower: natural draught cooling towers rely on natural convection to circulate air throughout the tower, which then cools the water. Air movement occurs due to differences in density between the entering air and the internal air within the tower.



Advantage of Natural draught cooling tower:

- No energy consumption for fans operation.
- No recirculation.
- Low costs of maintenance and spare parts.
- Low thermal energy waste.

Disadvantage of Natural draught cooling tower:

- Higher investment costs.
- Large overall dimensions that could cause difficulties with area aesthetics and requirement of large areas for tower installation.

CONCLUSION:

We have successfully studied about cooling tower in power plant.

EXPERIMENT 4

AIM:

To study about the jet condenser.

OBJECTIVE :

- To the construction of jet condenser.
- To study working of jet condenser.

APPARATUS / EQUIPMENTS REQUIRED :

- Jet condenser
- Schematic diagram of jet condenser

THEORY:

INTRODUCTION:

A jet condenser is a type of condenser in which steam and cooling water are mixed up in a chamber, where the steam is converted into liquid form and know as condensate. This condensate is then used for many other industrial purposes.

WORKING PRINCIPLE:

A condenser works on the principle of heat transfer (heat energy always flows from higher temperature to lower temperature). It transfers heat from hot steam from the compressor to the coolants and converts it into water.

Types of Jet Condenser:

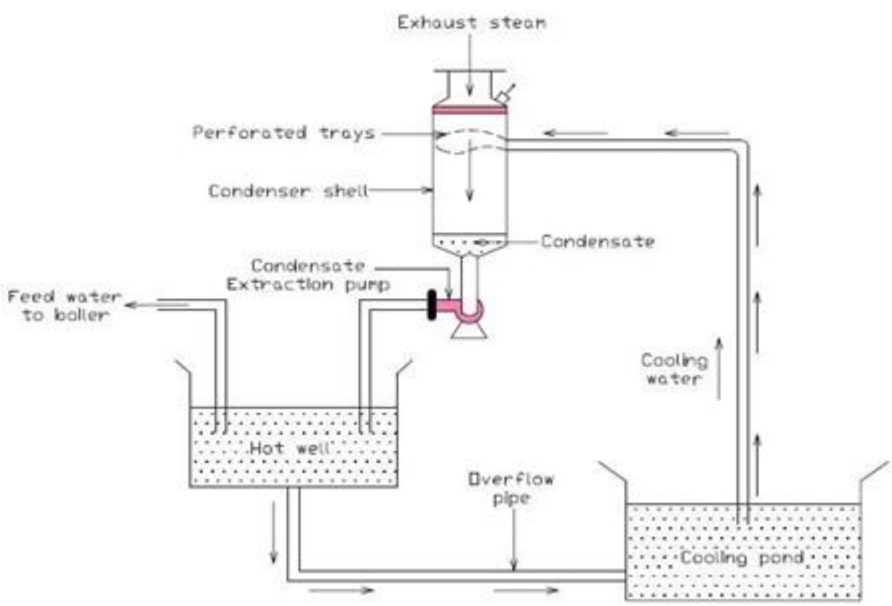
There are 3 basic types of jet condensers:-

1. **Low-level Jet Condenser**
    - **Parallel Flow Jet Condenser**
    - **Counter flow Jet Condenser**
2. **Barometric Jet Condenser or High-level Jet Condenser**
3. **Ejector Condenser**

Parallel Flow Jet Condenser:

As the name suggests in a parallel flow jet condenser the steam and water enters from the top of the condenser and hence flow parallel to each other, this is because the air pump creates a vacuum due to which there is a flow of water and steam. During the flow of water and steam, the heat from the steam gets transferred to the flowing water as we know heat always flows from higher temperature to lower temperature.

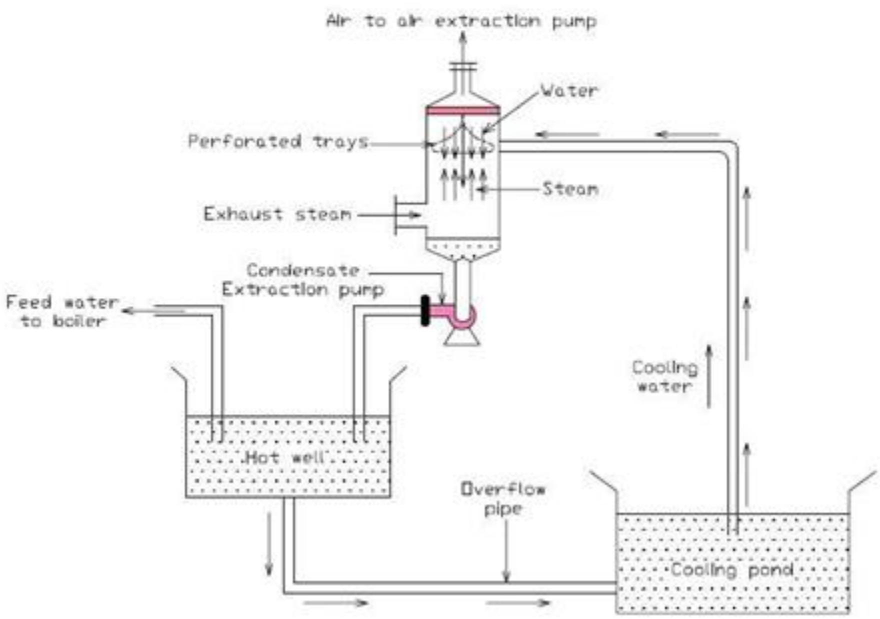
The condensate produced is collected at the bottom of the condenser. The perforated trays and air pump is used to make the process faster. There is an extraction pump located at the bottom which is used to transfer the condensate to the hot well. After passing through the hot well condensate is sent to the boiler. The design of a parallel flow jet condenser is quite simple when compared to other types of the jet condenser.



Counter Flow or Low-Level Jet Condenser:

As we can see the word "counter" itself says that the flow of steam and water are opposite to each other. In counter-flow jet condenser steam comes into the chamber from below and the cooling water comes from the top. The air pump creates a vacuum which forces cooling water into the condenser.

Water being heavy falls down and steam being light rises up through perforated trays. The falling water gets stored in the perforated trays. As soon as cooling water meets steam on its way, the process of heat transfer takes place as the result of which condensate gets accumulated in the bottom.

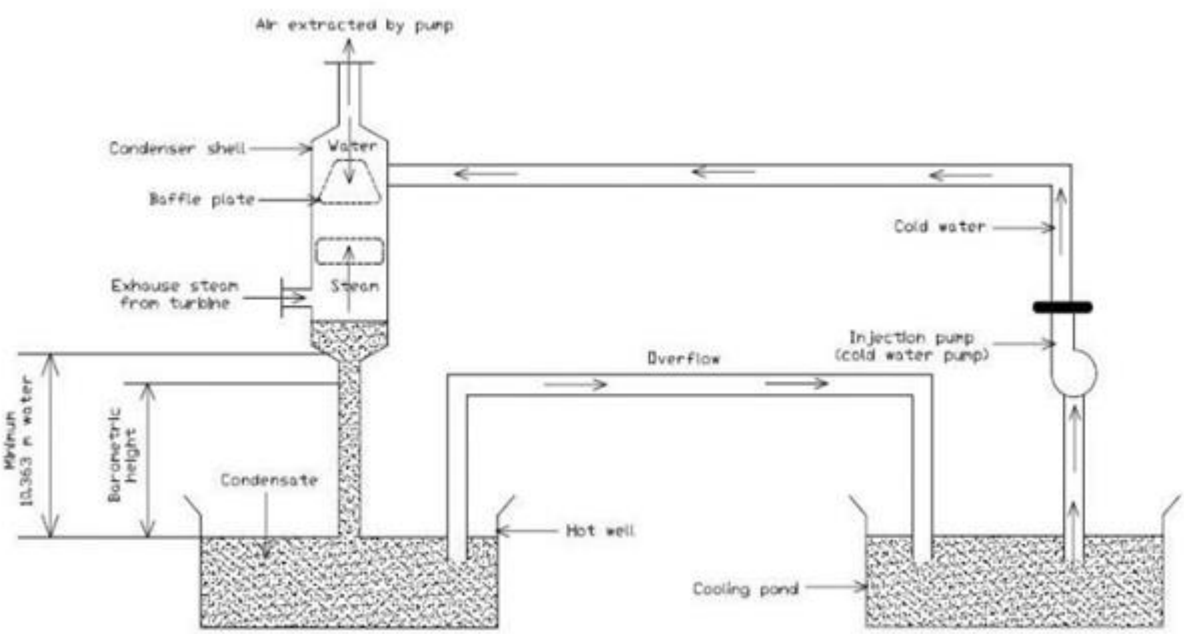


Barometric or High-Level Jet Condenser:

Barometric or high level jet condenser works much similar to counter flow jet condensers. There are a few changes in the basic structure, there is a long discharge pipe from where the condensate passes and accumulates in the hot well.

The air pump and injection pump forces cooling water from the top of the condenser and the steam is forced from below, again steam being light rises up and water being heavy falls down through perforated trays. Heat transfer between water and steam takes place producing condensate which gets settled down.

Unlike other condensers, there's no need for a pump to extract the condensate. The potential energy of condensate is high enough to make it fall this is because of the long discharge pipe.

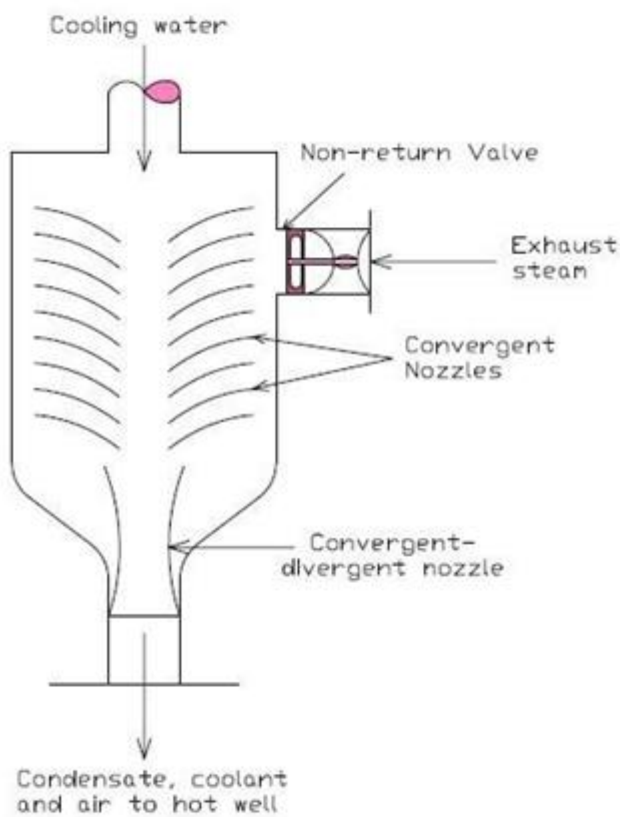


Ejector Condenser:

In the Ejector type jet condenser the steam and cooling water mixes together and pass through few metal cones. These metal cones increase the time taken by the water to come down, thus increasing the time of heat transfer.

The steam enters into the condenser through a non-return valve (the steam can only go in and can't come out of the valve).

Steam and cooling water get mixed together properly while passing through the cone where the heat transfer process takes place. There are no pumps used as the area of cross-section does not get narrow. The condensate gets collected into a hot well.



Applications of Jet Condenser:

These are some of the Applications of Jet Condenser:

- A jet condenser is a direct type of condenser hence used for condensing vapors in evaporators.
- It is also used for condensing vapors in a vapor pans.
- Jet condensers are used in some of the thermal power plants to condense steam or hot air.

Advantages of Jet Condenser:

A Jet Condenser has following Advantages:

- As we can see that the construction of jet condenser is easy to understand and hence do not need many skilful labels.
- Because of the simple design installation cost of the jet condenser is low.
- Less amount of water or coolant is required in jet condensers.
- Jet condensers are quite small in size therefore they acquire less area.
- The maintenance cost of jet condensers is quite low.
- Unlike other condensers, the cooling water and steam mix together physically in jet condensers.

Disadvantages of Jet Condensers:

Disadvantages of Jet Condensers are:

- Condensate waste cannot be reused in jet condensers.
- Air pump used in jet condensers requires high power.
- Vacuum efficiency is quite low therefore there’s a requirement of the pump to circulate water.
- The water pumps used also require high power to operate.
- The efficiency of jet condensers is low. This is because of the compact size of jet condensers.
- The capacity of jet condensers is also low that’s why jet condensers are not used for heavy industrial purposes.

- The cooling water should be free from impurities which is not the case with jet condensers.
- In a situation, if the extraction pump fails in the case of low-level jet condensers the condenser may get flooded.

Conclusion:

We have successfully studied about Jet Condenser.

EXPERIMENT 5

AIM :

To study the De Laval turbine.

OBJECTIVE:

- To Study the constructional feature of the De Laval turbine,
- To the study the working of De Laval turbine using Schematic Diagram.

APPARATUS / EQUIPMENTS REQUIRED :

3. Study model of De Laval turbine.
4. Schematic Diagram of Diagram of De Laval turbine.

THEORY :

INTRODUCTION: De Laval turbine is an impulse turbine, in which steam impinges upon revolving blades from a flared nozzle. The flare of the nozzle causes expansion of the steam, and hence changes its pressure energy into kinetic energy. An enormous velocity (30,000 revolutions per minute in the 5 H. P. size) is requisite for high efficiency, and the machine has therefore to be geared down to be of practical use. Some recent development of this type includes turbines formed of several de Laval elements compounded as in the ordinary expansion engine. The Parsons turbine is an impulse-and-reaction turbine, usually of the axial type. The steam is constrained to pass successively through alternate rows of fixed and moving blades, being expanded down to a condenser pressure of about 1 lb. per square inch absolute. The Curtis turbine is somewhat simpler than the Parsons, and consists of elements each of which has at least two rows of moving blades and one row of stationary. The bucket velocity is lowered by fractional velocity reduction. Both the Parsons and Curtis turbines are suitable for driving dynamos and steamships directly. In efficiency, lightness, and bulk for a given power, they compare favorably with reciprocating engines."

Main parts of De Laval Turbine:

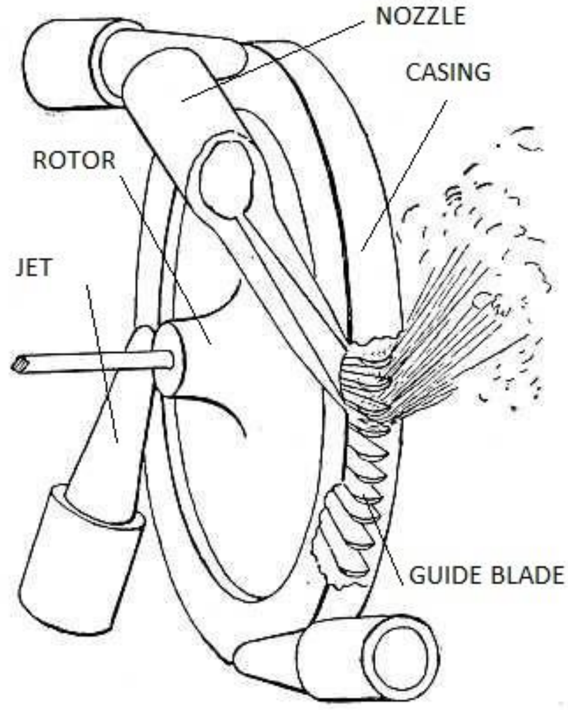
1. Rotor.
2. Guide Blades.
3. Nozzles and jet.
4. Casing.

Rotor- It’s a part of turbine which is enacted to the guide blade, it is responsible for the absorption of kinetic energy and conversion to mechanical energy.

Guide blade-A turbine blade is the individual component which makes up the turbine section of a gas turbine or steam turbine. The blades are responsible for extracting energy.

Nozzles and jet -The nozzle sits downstream of the power turbine and, while the nozzle does no work on the flow, there are some important design features of the nozzle. Jets contain significant kinetic energy, which is converted into shaft rotation by the bucket-like shaped rotor blades, as the steam jet changes direction.

Casing- the casing is used to be the main cover of the parts in the steam turbine. With the casing, the steam turbine component is not directly exposed from the outside so it remains durable.



WORKING PRINCIPLE OF **De Laval** TURBINE:

In these turbines, the static pressure inside the runner is constant, and the turbine runner is at atmospheric pressure. The runner spins in the air, and the fluid is sprayed to the blades through the nozzle to exchange energy with the turbine. A jet nozzle or a series of nozzles directs the high-speed flow to the blades, which are usually in the shape of buckets or cups. Therefore, only pressure changes occur in the nozzles.

This strike causes a change in momentum and based on the law of conversation of energy, a force is applied to the turbine blades.

Thus, in the power generation process in impulse turbines, the following steps are implemented.

- The stored water flows from a source upstream through Penstock to be delivered to the nozzle.
- The potential energy of the water inside the nozzle is converted into kinetic energy and injected into the blades or buckets; thus, the runner spins.
- There is a mechanism to control the flow of water injected into the runner. The spear usually plays an important role in this process.
- The generator attached to the shaft converts mechanical energy into electrical energy.

Impulse turbines have the ability to take all the kinetic energy from the water for high efficiency. Water is discharged into the atmosphere from the bottom of the turbine housing after reaching the runner; therefore, there is no suction at the bottom of the turbine.

CONCLUSION:

We have successfully studied about De Laval Turbine.

EXPERIMENT 6

AIM:

To study the Spring Loaded Safety Valve.

OBJECTIVE:

- To study the construction of spring loaded safety valve.
- To study the features of spring loaded safety valve.

APPARATUS / EQUIPMENT REQUIRED:

1. Spring loaded safety valve model.
2. Spring loaded safety valve constructional diagram.

THEORY:

INTRODUCTION-

Basic function of a spring loaded safety valve

1. *Valve closed*-
   In a direct spring loaded safety valve the closing force or spring force is applied by a helical spring which is compressed by an adjusting screw. The spring force is transferred via the spindle onto the disc. The disc seals against the nozzle as long as the spring force is larger than the force created by the pressure at the inlet of the valve. The figure shows the enlarged nozzle and disc area of a safety valve with the forces acting on the disc.
2. *Valve opening*-
   In an upset situation a safety valve will open at a predetermined set pressure. The spring force F_s is acting in closing direction and Fp, the force created by the pressure at the inlet of the safety valve, is acting in opening direction. At set pressure the forces Fs and Fp are balanced. There is no resulting force to keep the disc down on the seat. The safety valve will visibly or audibly start to leak (initial audible discharge).

   The pressure below the valve must increase above the set pressure before the safety valve reaches a noticeable lift. As a result of the restriction of flow between the disc and the adjusting ring, pressure builds up in the huddling chamber. The pressure now acts on an enlarged disc area. This increases the force Fp so that the additional spring force required to further compress the spring is overcome. The valve will open rapidly with a "pop", in most cases to its full lift. Overpressure is the pressure increase above the set pressure necessary for the safety valve to achieve full lift and capacity. The overpressure is usually expressed as a percentage of the set pressure. Codes and standards provide limits for the maximum overpressure.

3. ***Valve reclosing*-**
   In most applications a properly sized safety valve will decrease the pressure in the vessel when discharging. The pressure in the vessel will decrease at any subsequent point, but not later than the end of the upset situation. A decreasing pressure in the vessel will lower the force F_p. At set pressure however the flow is still acting on the enlarged disc area, which will

keep the valve open. A further reduction in pressure is required until the spring force F_s is again greater than F_p and the safety valve begins to reclose. At the reseating pressure the disc will touch the nozzle again and the safety valve recloses. Blowdown is the difference between set pressure and reseating pressure of a safety valve expressed as a percentage of set pressure.

Constructions:

1. It consists of a cast iron body having two branch pipes.
2. Two separate valves are placed over the valve seat.
3. A lever is placed over the valve by means of two pivots.
4. The lever is held tight at its proper position by means of a spring.
5. One end of spring is connected with the lever while other end with the body of the valve.
6. The valve is kept on it seats with help of spring force.

Parts:

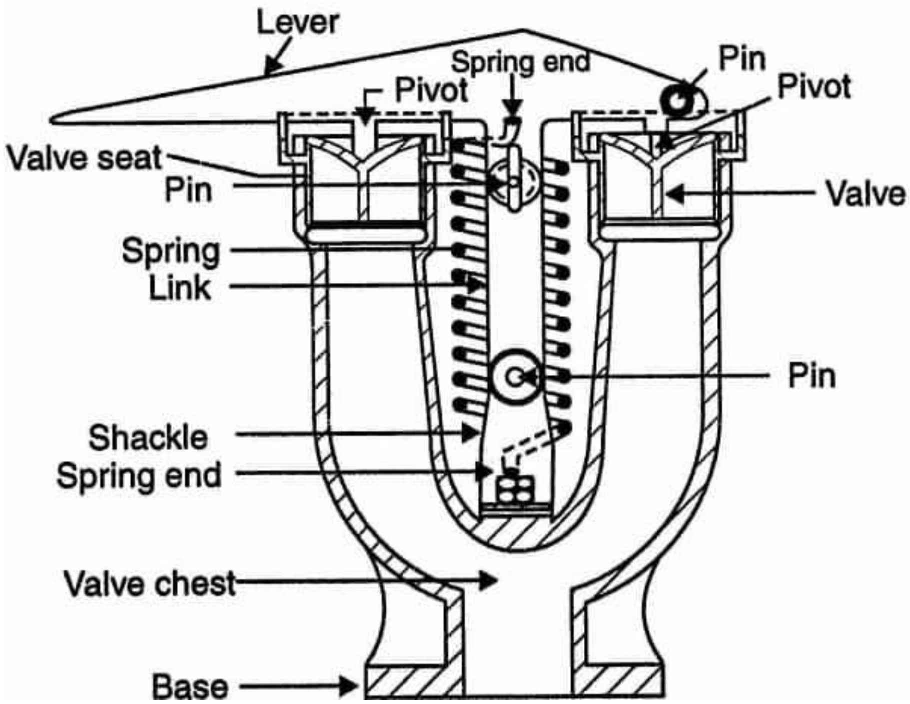
- *Lever:*

Working Principle:

- In the normal condition, the downward force due to spring is higher than upward force applied by steam.
- The valve is closed due to spring force.
- When steam pressure exceeds the normal limit, upward force due to steam pressure is become higher than downward force due to spring.
- Thus the valves are lifted from their seats opening the passages for steam to release out of boiler.

ADVANTAGE:

The spring loaded safety valve is much **lighter and compact** compared with other safety valves. For locomotive or marine service, the safety valve should be such that it is unaffected by jerks and vibration likely to occur in such device. Hence spring loaded safety valve is preferred for locomotive and marine services, in addition to stationary boilers.



CONCLUSION:

We have successfully Studied about SPRING LOADED SAFETY VALVE .

EXPERIMENT 7

AIM: To study the following steam genrators(boiler) models.

a) Lancashire boiler.
b) Cornish boiler.
c) Babcock and Wilcox boiler.
d) Vertical water tube boiler.

OBJECTIVE:

a) To study the construction of the given boiler.
b) To study the working of the given boiler.

APPARATUS / EQUIPMENTS REQUIRED:

a) Lancashire boiler (model).
b) Cornish boiler (model).
c) Babcock & Wilcox boiler (model).
d) Vertical water tube boiler (model).

THEORY:

INTRODUCTION: A boiler is an enclosed pressure vessel in which water is converted into steam by gaining heat from any source (coal,oil, gas etc).

Boiler in Thermal power plant accumulates the steam and build up a pressure to expend it in turbine and convert thermal energy to mechanical energy. The genrator which is connected to turbine converts mechanical energy into electrical energy.

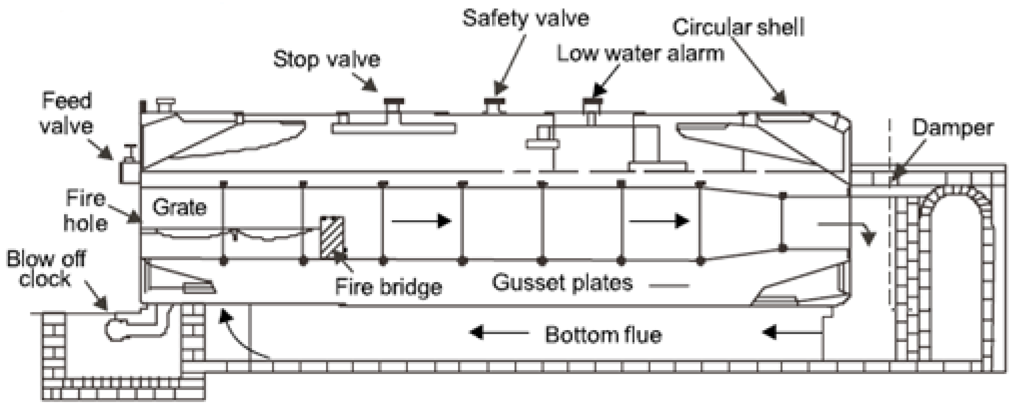
TYPES OF BOILER:

1. Based on tube content
    - Fire Tube boiler.
    - Water Tube Boiler
2. Base on fule used
    - Solid Fuel Fired.
    - Stoker Fired Boilers.
        - Pulverized Fuel Boiler.
        - Fluidized Bed Combustion (FBC) Boiler.
    - Oil Fired.
    - Gas Fired Boiler.
3. Based on draught system
    - Natrual Draught.
    - Mechanical Draught.
        - Forced Draught System.
        - Induced Draught System.
        - Balanced Draught System.
        -

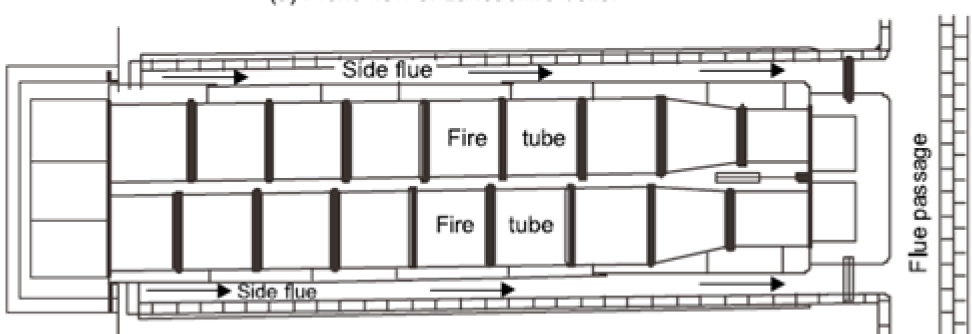
1) **<u>Lancashire Boiler:</u>** The Lancashire boiler is similar to the Cornish, but has two large flues containing the fires instead of one. **Lancashire Boiler** is a horizontal type and stationary fire tube boiler. This boiler was invented in the year 1844, by William Fairbairn.

This is an internally fired boiler because the furnace uses to present inside the boiler. This boiler generates low-pressure steam and it is a natural circulation boiler. It has high thermal efficiency of about 80 to 90 percent. The size is approximately 7-9 meters in length and 2-3 meters in diameter.

Parts of a Lancashire Boiler:



(a) Front view of Lancashire boiler



(b) Top view of Lancashire boiler

A Lancashire Boiler consists of following parts:

- Safety valve
- Pressure Gauge
- Feed check valve
- Water Level Indicator
- Blow off valve
- Steam stop valve
- Manhole
- Fire door

- Fusible Plug
- Ash pit
- Economizer
- Air preheater
- Superheater

Safety valve:

The safety valve is used to blow off the steam when the pressure of the steam inside the boiler exceeds the working pressure.

Pressure gauge:

The function of the pressure gauge is to indicate the pressure of the steam inside the boiler.

Feed check valve:

It stops and allows the flow of water inside the boiler.

Water level indicator:

It indicates the level of water in the boiler. It is placed in front of the boiler. Two water level indicators are used in the boiler.

Blow off Valve:

Its function is to remove the sediments or mud periodically that is collected at the bottom of the boiler.

Steam stop valve:

The function of a steam stop valve is to stop and allows the flow of steam from the boiler to the steam pipe.

Manhole:

The hole is provided on the boiler so that a man can easily enter inside the boiler for the cleaning and repairing purpose.

Fire door:

This is used to ignite the present fuel inside or outside the boiler.

Fusible plug:

It is used to extinguish the fire inside the boiler when the water level inside the boiler falls to an unsafe level and prevent an explosion.

It also prevents the damage that may happen due to the explosion.

Ash pit:

The Ash-pit used to collect the ash of the burnt fuel.

The other various accessories that are also used in Lancashire boiler are:

Economizer:

An economizer is a mechanical device that is used as a heat exchanger in the steam power plant.

It is used to pre-heat the fluid or water by taking the residual heat from the combustion products(flue gases).

It is installed to increase the efficiency of the boiler.

Air pre-heater:

Air preheater is also a mechanical device that abstracts the heat from the flue gases and transfers it to the air(atmosphere).

Superheater:

The main purpose of the superheater is to increase the temperature of the saturated steam without any change in the pressure.

Working Principle of Lancashire Boiler:

This Lancashire boiler works on the basic principle of the heat exchanger.

It is basically a shell and tube type heat exchanger in which the flue gases flow through the tubes and the water flows through a shell.

The heat is transfer from flue gases to the water through convection.

It is a natural circulation boiler that uses the natural current to flow the water inside the boiler.

Applications of Lancashire Boiler:

Lancashire Boiler can be used in several filed like:

- The Lancashire boiler is used to drive steam turbines, locomotives, marines, etc.

- It is used in industries like paper industries, textile industries, sugar industries, tire industries, etc.

Advantages of Lancashire Boiler:

- This has high thermal efficiency. Thermal efficiency is about 80 to 90%.
- This is easy to operate.
- It can easily meet the load requirement.
- Easy to maintain.
- Low consumption of electricity due to natural circulation.

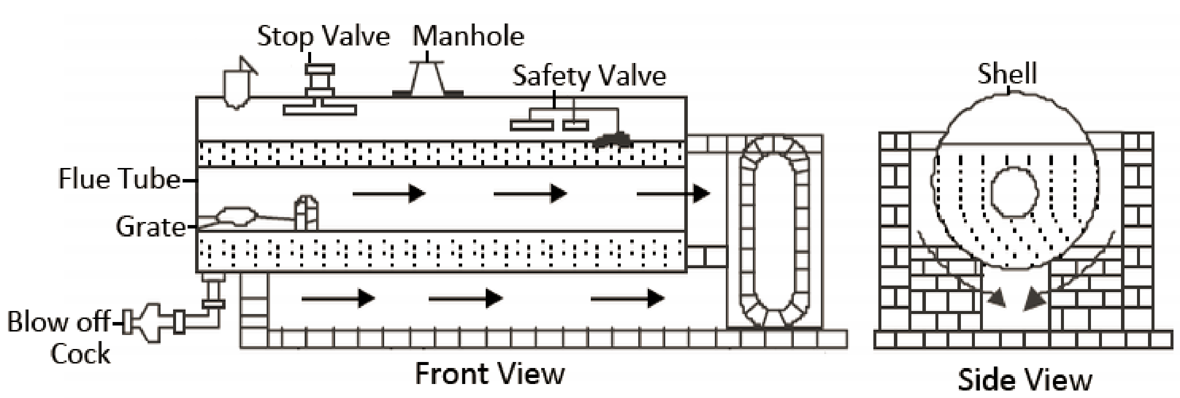
Disadvantages of Lancashire boiler:

- This is a low-pressure type boiler, so high-pressure steam is not produced.
- It has a limited grate area due to the small diameter of the flue tubes.
- The steam production rate is low. It is about 9000 kg/hr.
- Corrosion occurs in the water legs.
- This boiler requires more floor space.

2) **<u>CORNISH BOILER</u>**: Cornish Boiler is a fire tube boiler. After Cochran, Locomotive, Scotch marine boiler, a Cornish boiler is another type of boiler. This type of boiler works on very limited pressure which is up to 20 bars only. It has a long horizontal cylinder with a single large flue containing the fire.

Cornish boiler is a fire tube boiler that works is to produce steam by the burning of fuel (coal) and further used in the steam turbine, textile or sugar mill industry, and so on.

Construction or Parts of Cornish Boiler:



A Cornish Boiler consists of several parts those are:

- Shell
- Grate
- Furnace
- Combustion chamber
- Chimney
- Smokebox
- Water level indicator
- Safety Valve
- Man Hole
- Stop Valve
- Blow off valve

Shell:

A shell contains water inside it as well as a tube. The transfer of heat between water takes place in the shell.

And also the shell is like it covers all the components of the boiler and it is also called the main body.

Grate:

It is a door form which the fuel is provided for burning and generating heat. The grate is located at the bottom of the furnace.

Furnace:

A furnace works like a mediator, because it is connected between the fire tube and the combustion chamber. Here fuel burns and produces Heat.

Combustion chamber:

Here in the combustion chamber the fuel burns and produces heat which is then supplied to the tube here water is surrounded. The combustion chamber is connected to the furnace.

Ash pit:

Here ash of fuel which is completely burned and no use inside the boiler.

Chimney:
The chimney is here for releasing the exhaust gases to the atmosphere.

Smokebox:
The smokebox is provided here to collect the smoke and further sends it to the chimney.

Water level indicator:
This is an instrument which gives the detail of the water level of the boiler. This also works when water exceeds the limit or water down the limit.

Safety Valve:
The safety valve is another type instrument which is used for safety purpose and This also works when no other indicators work.

Man Hole:
It is the main hole from which when any components inside the boiler get damage then an engineer will enter and replace it from here.

Stop Valve:
The stop valve is also used for regulating the control of things.

Blow off valve:
A blow of valve is used to clean the boiler by discharging the water and sediments from the bottom of the boiler.

Working Principle of Cornish Boiler:

The working substance here is COAL. Let’s study working, At the grate, the fuel which is coal is provided and it sends to the furnace. Here we burn the fuel by providing some amount of fire to it. So as we know this is a single large tube boiler. Burning of coal produces the heat which is then sent to the tube and here water is surrounded. Why water is surrounded automatically? Because we supply water here and with the use of an instrument, water level indicator we measure the level of water.

So now tube has as much heat that water gets start heated which means water first converts into saturated steam and then it further heated and converts into superheated steam which is now working steam. The steam can be further used for different purposes.

Meanwhile here the burning coal ash comes to the ash pit and from here it comes to the smokebox and the gas will release to the chimney to the environment. And we extract the ash from the system and clean this.

Advantages of Cornish Boiler:

- The designs are simple and easy.
- The construction is easy and its compactness.

- It is a portable types boiler.
- The maintenance cost is low.
- It can handle load fluctuation to some extent.

Disadvantages of Cornish Boiler:

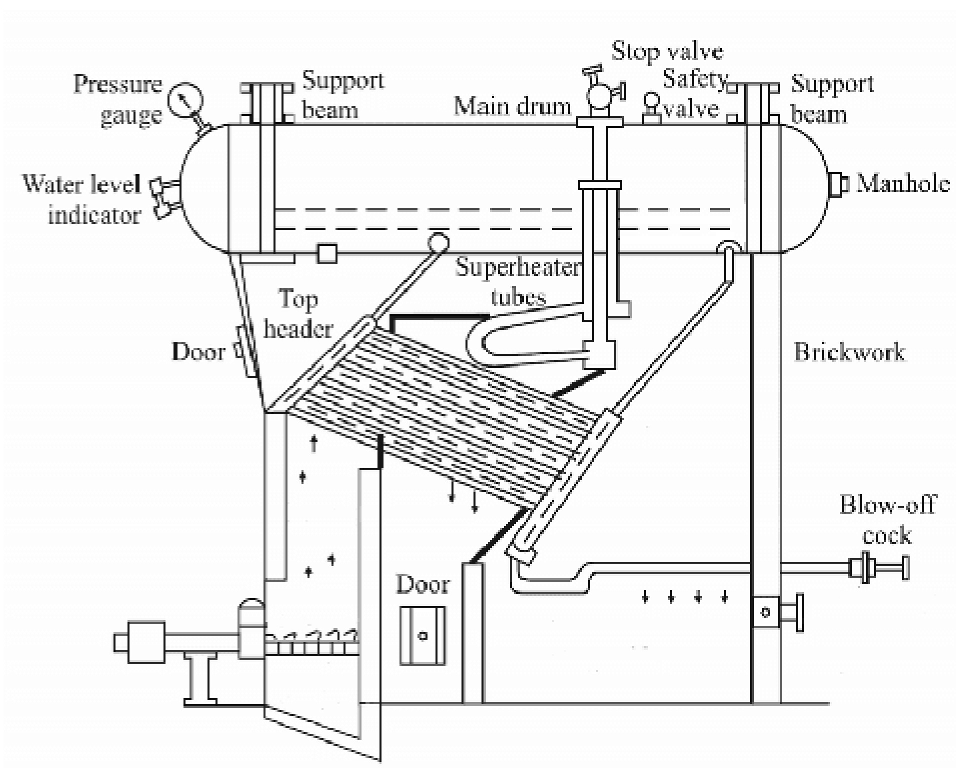
- It is a type of low production steam rate which is around 1350 kg/hour.
- The pressure is low comparatively other boilers which are 12-13 bar.

Applications of the Cornish boiler are:

- It is used in several industries like sugar, mill, chemical, and other more industry.
- It is also used to run the steam turbine.
- Cornish Boiler used in marines.

3) **Babcock & Wilcox Boiler**: Babcock and Wilcox Boiler were discovered by George Herman Babcock **and** Stephen Wilcox **in the year 1967**.This is a water tube boiler, used in steam power plants. In this type of boiler, water is circulated inside the tubes and hot gases flow over the tubes. This is a Horizontal drum axis, natural draught, natural circulation, multitubular, stationary, high pressure, solid fuel fired, externally fired Water tube boiler.

Babcock and Wilcox Boiler Parts:



A Babcock and Wilcox Boiler Parts or Construction consists of:

- Drum

- Water Tubes
- Uptake and Downtake header
- Grate
- furnace
- Baffles
- Superheater
- Mud box
- Inspection Door
- Water Level Indicator
- Pressure Gauge

Drum:

This is a horizontal axis drum which contains water and steam.

Water tubes:

Water tubes are placed between the drum and furnace in an inclined position (at an angle of 10 to 15 degrees) to promote water circulation.

Uptake and Downtake Header:

This is present at the 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. And This is present at the rear end of the boiler and connects the water tubes to the rear end of the drum.It receives water from the drum.

Grate:

Coal is fed to the grate through the fire door.

Furnace:

The furnace is kept below the uptake-header.

Baffles:

The fire-brick baffles, two in number, are provided to deflect the hot flue gases.

Superheater:

It increases the temperature of saturated steam to the required temperature before discharging it from the steam stop valve.

Mud Box:

This is used to collect the mud present in the water.

Mud box is provided at the bottom end of the down-take header.

Inspection Door:

Inspection doors are provided for cleaning and inspection of the boiler.

Water Level Indicator:

The water level indicator shows the level of water within the drum.

Pressure Gauge:

The pressure gauge is used to check the pressure of steam within the boiler drum.

Working Principle of Babcock and Wilcox Boiler:

The working of Babcock and Wilcox boiler is first the water starts to come in the water tubes from the drum through down take header with the help of a boiler feed pump which continues to feed the water against the drum pressure.

The water present in the inclined water tubes gets heated up by the hot flue gases produced by the burning of coal on the fire grate.

These fuel gases are uniformly heated the water tube with the help of a baffle plate which works deflect the flues gas uniform throughout the tubes which absorbed the heating maximum from the flue gases.

As the hot flue gases come in contact with water tubes, It exchanges the heat with heater and converts into the steam.

Continuous circulation of water from the drum to the water tubes and water tubes to the drum is thus maintained.

The circulation of water is maintained by convective current and it's known as Natural Circulation.

The Steam generated is moved upward, due to density difference and through the up-take header; it gets collected at the upper side in the boiler drum.

Anti-priming pipe inside the drum which works separates the moisture from the steam and sends it's to the superheater.

The superheater receives the water-free steam from an anti-priming pipe. It increases the temperature of the steam to the desired level and transfers it to the main stream stop valve of the boiler.

The superheated steam stop valve is either collected in a steam drum or sends it's inside the steam turbine for electricity generation.

Applications Babcock and Wilcox Boiler:

The main application Babcock and Wilcox boiler to produce high-pressure steam in power generation industries**.**

Advantages of Babcock and Wilcox:

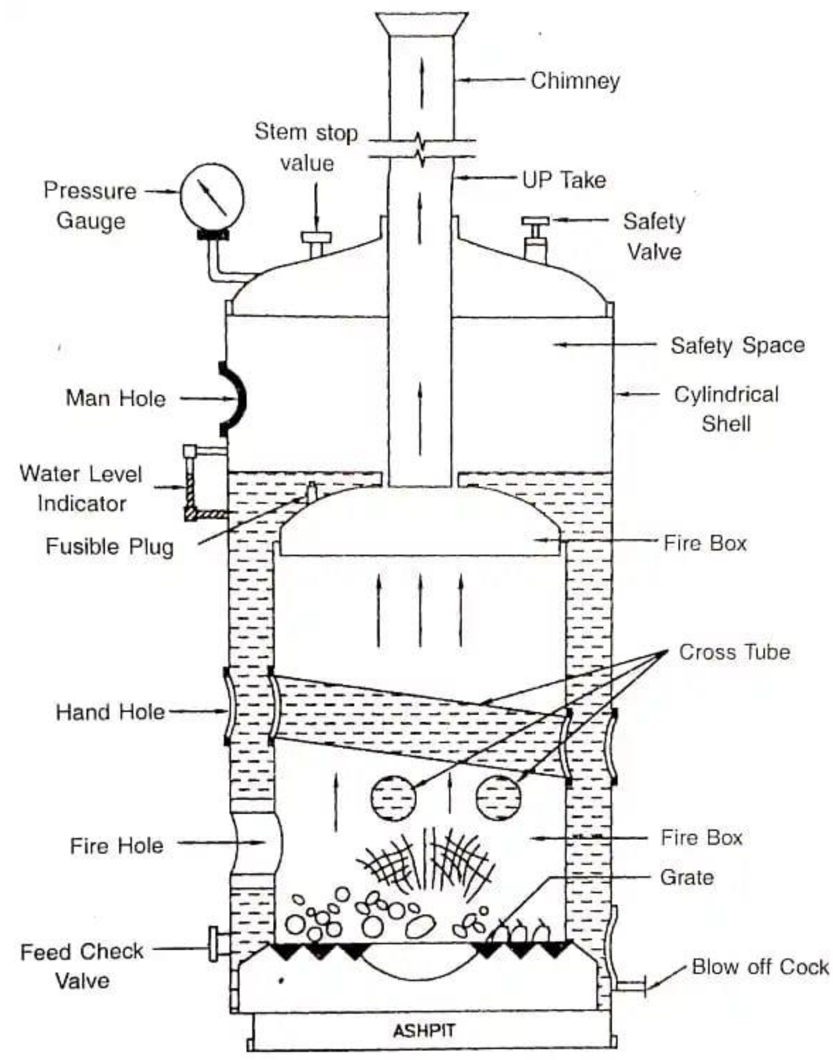
- The overall efficiency of this boiler is high.
- The steam generation rate is higher about 20 ton per hour at pressure 10 to 20 bars.
- The tubes can be replaced easily.
- The boiler can expand and contract freely.
- It is easy to repair maintenance and cleaning.

Disadvantages of Babcock and Wilcox Boiler:

- It is less suitable for impure and sedimentary water, as a small deposit of scale may cause the overheating and bursting of tubes. Hence, water treatment is very essential for water tube boilers.
- Failure in feed water supply even for a short period is liable to make the boiler overheated. Hence the water level must be watched very carefully during the operation of a water tube boiler.
- The maintenance cost is high.

4) **<u>Vertical Water Tube Boiler:</u>** A vertical boiler is a type of fire-tube or water-tube boiler where the boiler barrel is oriented vertically instead of the more common horizontal orientation. Vertical boilers were used for a variety of steam-powered vehicles and other mobile machines, including early steam locomotives.

Parts of Simple Vertical Boiler:



The following are the construction parts of a simple vertical boiler:

1. Ash pit
2. Grate
3. Feed check valve
4. Fire hole

5. Firebox
6. Handhole
7. Cross tubes
8. Fusible plug
9. Water level indicator
10. Cylindrical shell
11. Manhole
12. Pressure gauge
13. Steam stop valve
14. Safety valve
15. Chimney

1.Ash Pit:

The purpose of the ash pit is to collect fuel ash after burning the fuel.

2. Grate

The grate usually consists of cast iron bars which are spaced aside so that the air (required for combustion) can pass through them. It is a platform, in the combustion chamber, upon which the fuel is burnt.

3. Feed Check Valve

The purpose of a feed check valve is to regulate the flow of water from the feed pump to the boiler and to prevent the backflow of the water.

4. Fire Hole

The Fire hole is hole provided at the air rear end of the boiler. The solid fuel is inserted and burned into the furnace through this hole.

5. Fire Box

The firebox is a type of a box in this the burning of the solid fuel takes place.

6. Handhole

The handhole is provided in the shell opposite the ends of each cross tube for cleaning the cross tube.

7. Cross Tubes

One or more cross tubes are either fastened or flanged into the furnace to enhance the heating surface and improve water circulation.

8. Fusible Plug

The function of the fusible plug is to put-off the fire in the furnace of the boiler when the water level falls below an unsafe level and thus avoids the explosion, which may take place due to overheating of the tubes and the shell.

9. Water Level Indicator

It is an important device, which indicates the water level inside the boiler. It is a safety device upon which the safe working of the boiler depends.

10. Cylindrical Shell

The shell is in a vertical position and is attached to the bed of the furnace. The greater part of the shell is filled with water which also surrounds the furnace. The remaining part is the steam space. The shell can be about 1.25 m in diameter and 2.0 m in height.

11. Man Hole

The manhole is provided at the top of the shell to allow a man to enter into it to repair and to inspect the boiler from inside. It is also for cleaning the inner part of the boiler shell and the outer part of the combustion chamber and the chimney.

12. Pressure Gauge

The pressure gauge is used to measure the pressure of the steam inside the boiler. It is arranged in front of the boiler.

13. Steam Stop Valve

The function of a steam stop valve is to regulate the flow of the steam from within the boiler and to stop it completely when required.

14. Safety Valve

The safety valve is an instrument which prevents the boiler pressure from rising above its normal working pressure by automatically opening when the boiler pressure exceeds the normal working pressure, thus allowing excess steam to escape into the atmosphere until the pressure comes down to its normal value.

15. Chimney

The chimney is located on the top portion of the boiler. It is employed to throw out the exhaust smoke and gases to the environment.

Working of Simple Vertical Boiler

It consists of a cylindrical shell surrounding a nearly cylindrical firebox. The firebox is slightly tapered towards the top to allow the ready passage of the steam to the surface. At the bottom of the firebox, is a grate. The firebox is provided with two or more inclined cross tubes F, F.

The inclination of the cross tubes is provided to improve the heating surface as well as to increase the circulation of water. An uptake tube passes from the top of the firebox to the chimney. The handhole is fitted opposite to the end of each water tubes for cleaning the depositions.

A manhole is located at the top portion of the boiler for a man to enter and to clean the boiler. A mud hole is provided at the bottom of the shell to remove the mud, that settles down. The space between the boiler shell and firebox is filled with water to be heated.

Advantages of Simple Vertical Boiler

The following are the advantages of a simple vertical boiler:

1. The initial cost is low because of fewer parts.
2. Maintenance cost is low.
3. Working is simple.
4. It is easy to install and replace.
5. It occupies a small space on the ground.
6. These type of boilers have water level tolerance.

Disadvantages of Simple Vertical Boiler

The following are the disadvantages of simple vertical boiler:

1. The vertical design of this boiler limits its work in many places.
2. Steam production is limited because of the limited great area.
3. The impurities settle at the bottom and thus prevents the water from heating up.
4. The boiler tube should be kept small to reduce height. As a result, most of the available heat is lost through the chimney, as the tubes have very little time to heat.

Application of Simple Vertical Boiler

The following are the application of a simple vertical boiler:

1. Simple vertical boilers may have applications in railway locomotives, for example, a railway steam engine.
2. Simple vertical boilers are employed in road vehicles such as steam wagons or steam lorry.
3. The simple vertical boiler has a very well known application that is a steam tractor.
4. The number of boats is particularly small which uses simple vertical boilers to power the engine.
5. In some parts of the world ordinary vertical boilers are used in the steam donkey.
6. Simple vertical boilers are also worked in steam cranes and steam shovels.

CONCLUSION:

We have successfully studied about the different types of boiler and their function.