CHAPTER-1

<INTRODUCTION>

Power plant Engg. is the branch of science in which we understand the generation of power by utilizing various energy sources.

or

A power plant or power generating station is basically an industrial location that is utilised for generation and distribution of electric power in mass scale usually in order of several 1000 watt.

Energy

- Energy is the capacity of a physical system to do work, or capacity to do work.
- Energy exist in various forms e.g mechanical, thermal, electrical etc.
- One form of energy can be converted into other forms of energy by using suitable arrangements.

Sources of Energy

It can be classified in to 3 categories

1) Primary & secondary
2) Commercial & Non commercial
3) Renewable & Non renewable.

1) Primary & Secondary

Energy which comes directly from nature like coal, oil, natural gas, wood, nuclear energy geothermal energy etc are called as primary energy.

Energy which is derived from primary energy sources is called secondary energy eg electricity.

2) Commercial & Non commercial

Sources of energy which are available in the market at a price are called commercial energy.
for eg electricity, coal, petroleum products etc.

Energy sources which are not available in the commercial market for a price are called non commercial energy eg solar energy, wind energy etc.

3) Renewable & Non renewable

Renewable energy refers to permenent source of energy which cannot be finished eg wind, solar geothermal, tidal & hydroelectric energy. they don't harmful pollution.

Non renewable energy refers to conventional fossil fuels like coal, oil, gas etc, which are likely to deplete with time.

Classification of steam power plant

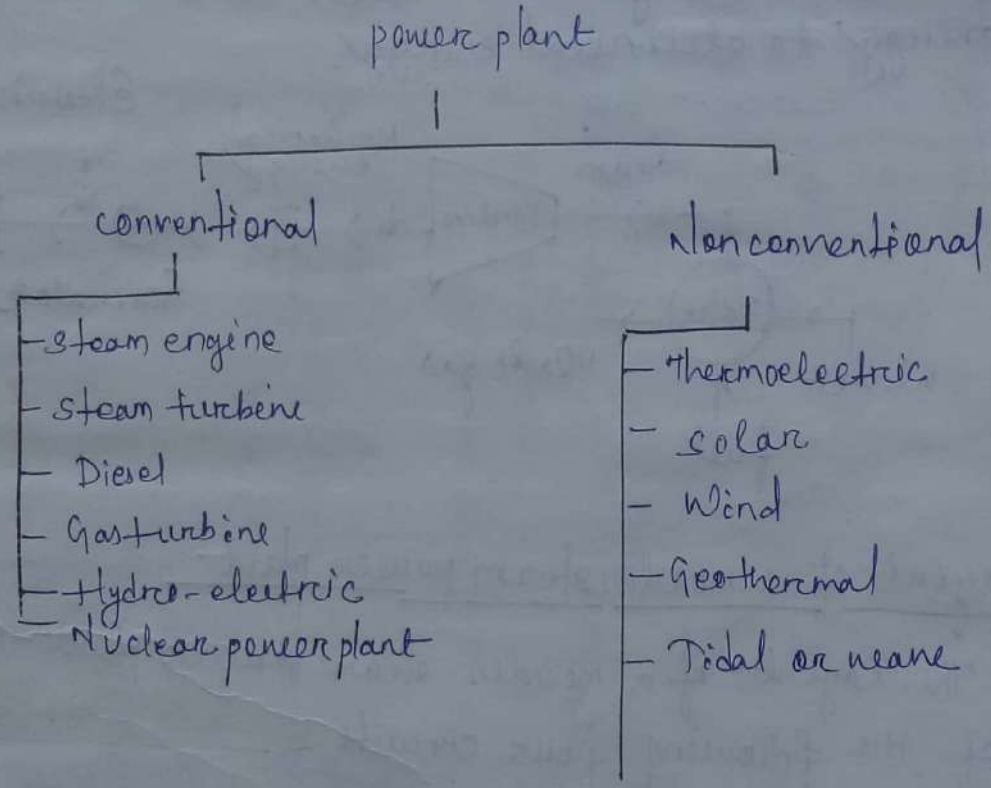
Captive power plant

Captive power plant is a power plant set up by any person to generate electricity primarily for his/her own use. It is also called autoproducer and power generation managed by an industrial or commercial energy users for their own energy consumption. Normally these plants are non-condensing because a large quantity of steam is required for different manufacturing operations.

Central power plant

Central power generation, refers to the large scale generation of electricity at centralized facilities. These facilities are usually located away from end-users and connected to a network of high voltage transmission lines. There are condensing type, where the exhaust-steam is discharged to condenser instead of atmosphere.

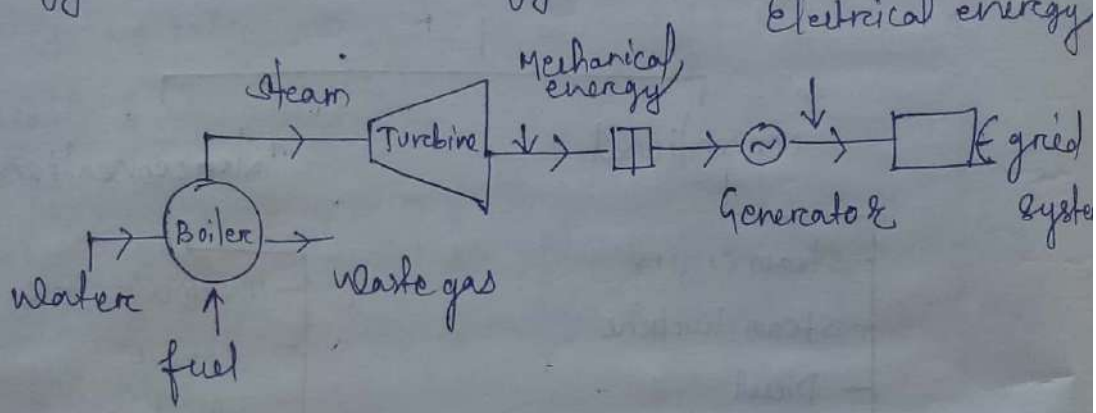
Types of powerplant



CHAPTER-2

<STEAM POWER PLANT>

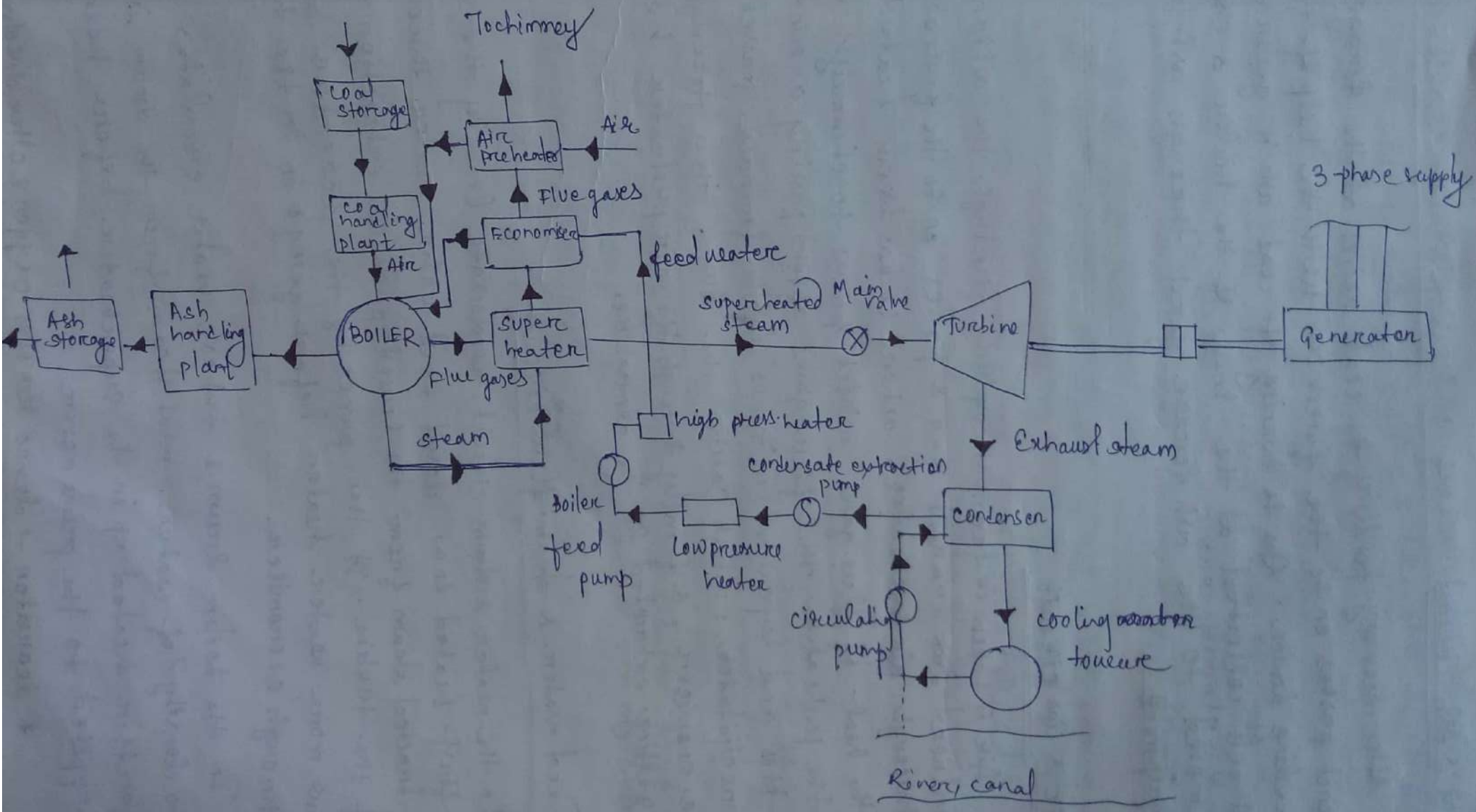
- A steam power plant converts the chemical energy of the fossil fuels (coal, oil, gas) into mechanical/ electrical energy.
- This is achived by raising the steam in the boilers, expanding it through the turbines and coupling the turbines to the generators which convert mechanical energy to electrical energy.



Layout of a morden steam power plant

The layout of a morden steam power plant comprises of the following four circuits.

1. Coal & ash circuit
2. Air & gas circuit
3. Feed water & steam flow circuit.
4. Cooling water circuit.



LAYOUT OF STEAM POWER PLANT

1. Coal & Ash circuit

After necessary handling the coal arrives at the storage yard then it passes on to the furnace with the help of fuel feeding device. Due to burning of coal ash is generated at gets collected at the bottom of the boiler & can be removed to the ash storage yard through ash handling equipment.

2. Air & Gas circuit

Air is taken in from atmosphere through the action of induced draught fan & passes on to the furnace through air preheater, where it has been heated by the heat of flue gases which passes to chimney via the preheater. The flue gases after passing around boiler tubes and superheater tubes in the furnace passes to a precipitator, which catches the dust, then through the economiser, & finally through the air preheater before getting exhausted to the atmosphere.

3. Feed water & steam flow circuit

- In the water & steam circuit, condensate leaving the condenser is first heated in a closed feed water heater through extracted steam from the lowest pressure extraction point of the turbine. It then passes by the deaerator and a few more water heaters before going * in to the boiler through economiser.

- In the boilers drum & tubes, water circulates due to density of water. wet steam from the drum is further heated up in the superheaters before being supplied to the prime mover.

* deaerator → device removes oxygen & other dissolved from

- After expanding in high pressure turbine steam is taken to the reheat- boiler & brought to its original dryness or superheat before being passed on to the low pressure turbine.

- From the low pressure turbine it is exhausted through the condenser is to hot well. The condensate is heated in the feed heaters using the steam trapped from different points of turbine.

- A part of steam & water is lost while passing through different components & this is compensated by supplying additional feed water. This feed water should be purified before hand, to avoid the scaling of the tubes of the boiler.

4. Cooling water circuit

The cooling water supply to the condenser helps in maintaining a low pressure in it. The water may be taken from a natural source such as river, lake or sea or the same water may be cooled & circulated over again. In the later case the cooling arrangement is made through Spary pond or cooling towere.

STEAM POWER CYCLES / VAPOUR POWER CYCLE

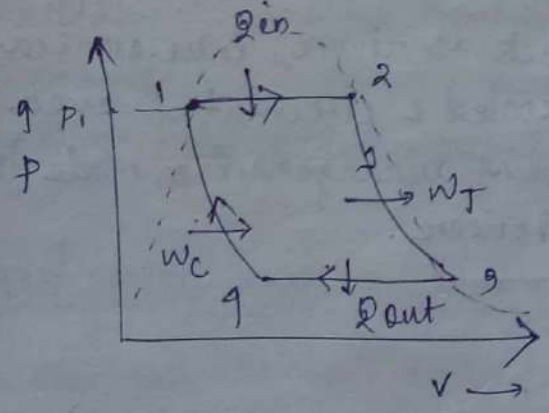
In thermal power plants working fluid goes through a repetative cyclic change & this cyclic change involves heat & work, i.e known as thermodynamic cycle. Here the working fluid is alternatively vaporised & condensed.

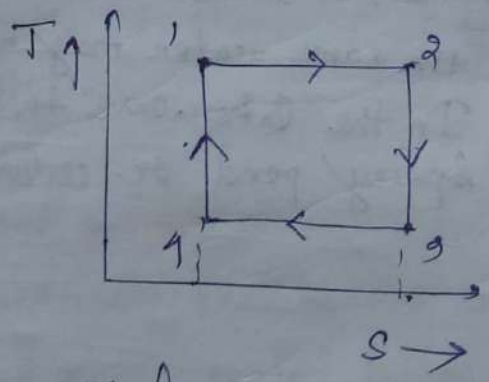
1. CARNOT CYCLE

Carnot cycle is used as an ideal power cycle for steam power plant. It consist of 4 process.

1. isothermal heat addition (1-2)
2. isentropic expansion (2-3)
3. isothermal heat rejection (3-4)
4. isentropic compression (4-1)

~~- operation (opp) - 1 kg of boiling water at temp~~





→ In the above cycle heat supplied at const. temp. T_1

$= T_1(S_2 - S_1)$ or $T_1(S_3 - S_1)$

→ Heat rejected at const temp. T_2.

$= T_2(S_3 - S_4)$

$S_1 = S_4$
$S_2 = S_3$

Net work done = Heat supplied − heat rejected.

$= T_1(S_3 - S_4) - T_2(S_3 - S_4)$

$= (T_1 - T_2)(S_3 - S_4)$

→ Carnot efficiency $\eta_{th} = \frac{\text{work done}}{\text{heat supplied}}$

$$= \frac{(T_1 - T_2)(S_2 - S_3)}{T_1 (S_2 - S_3)}$$

$$\boxed{\eta_{th} = \frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1}}$$

→ Work ratio = $\frac{\text{Network}}{\text{Turbine Work}}$

→ heat rate - It is the rate of heat input to produce a unit power.

→ Specific steam consumption (SSC) → Defined as the steam consumed in a power plant to produce one unit of power.

$$SSC = \frac{\text{steam consumption / hour}}{\text{net power o/p.}}$$

Limitations of carnot cycle

Carnot vapour cycle is the most efficient cycle and has the highest thermal efficiency, but it is extreamly difficult to operate because of the following reasons.

→ It is difficult to compress a wet vapour i.e 2 phase mixture isentropally to the saturated state. (process 4-1)

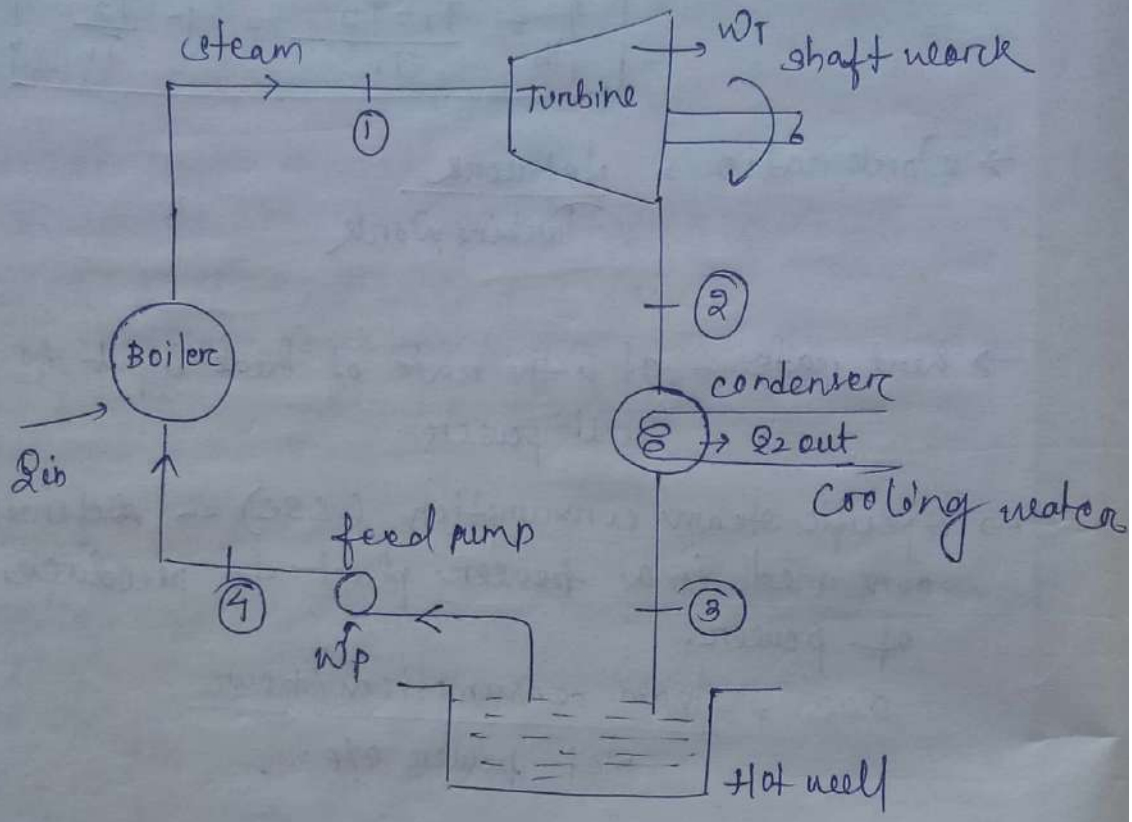
→ It is difficult to control the quality of the condensate coming out of condenser.

→ Vapour has large specific volume so to accomodate it requires large size compressor.

→ Isentropic compression of vapour requires more work due to high sp. vol^m reducing the work ratio.

→ This cycle is more difficult to operate in practice with Superheated steam due to necessity of supplying the Superheat at const. temp. instead of const. pressure.

2. RANKINE CYCLE



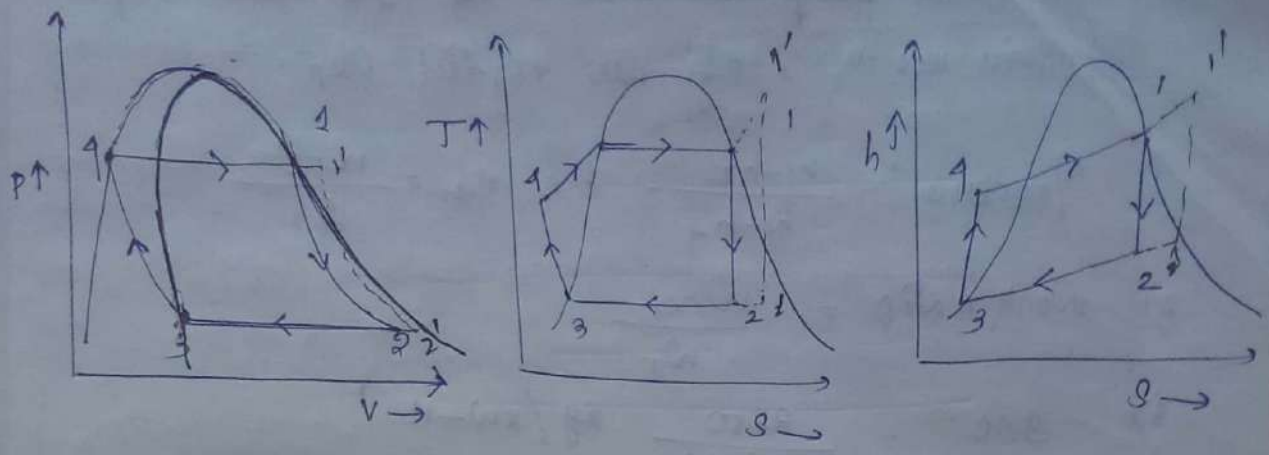
Various component

→ Boiler → generates steam at const p & desired T.

→ Turbine → Expands steam isentropically to generate work o/p.

→ Condenser → Maintained at lower atmospheric p & removes heat from steam & convert steam into water. so can be further used in boiler.

→ pump → Raises the p of water to the boiler pressure



The rankine cycle consist of 4 cycle process.

- process 1-2 → Reversible adiabatic expansion in the turbine. $w_T = h_1 - h_2$

process 2-3 → constant pressure heat rejection in the condensere.

$$Q_2 = h_2 - h_3 = h_2 - h_{f3}$$

process 3-4 → Reversible adiabetic pumping process in the feed pump

$$w_p = h_4 - h_3$$
$$= h_{f4} - h_{f3}$$

Process 4-1 → const. pressure heat addition in boiler.

$$Q_1 = h_1 - h_4 = h_1 - h_{f4}$$

for isentropic process

$Tds = dh - vdp$ { $ds = \frac{dQ}{T}$ ⇒ $dQ = TdS$

$ds = 0$

$dh = vdp$

$\Rightarrow \Delta h = v\Delta p$

$\Rightarrow h_4 - h_3 = v_3(P_1 - P_2)$

$\Rightarrow w_p = h_4 - h_3$ ✓

$$w_{net} = w_T - w_p$$
$$= (h_1 - h_2) - (h_4 - h_3)$$

$$\eta_{rankine} = \frac{w_{net}}{Q_1} = \frac{w_T - w_p}{Q_1} = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_4)}$$

$$\boxed{\eta_{rankine} = \frac{Q_1 - Q_2}{Q_1}}$$

$$= \frac{(h_1 - h_4) - (h_2 - h_3)}{h_1 - h_4}$$

* The feed pump work done $h_4 - h_3$ is small compared to turbine work, so we neglect wp.

1) $\eta_{rankine} = \frac{h_1 - h_2}{h_1 - h_4}$ i.e $\eta_{th} = \frac{w_{net}}{q_1}$

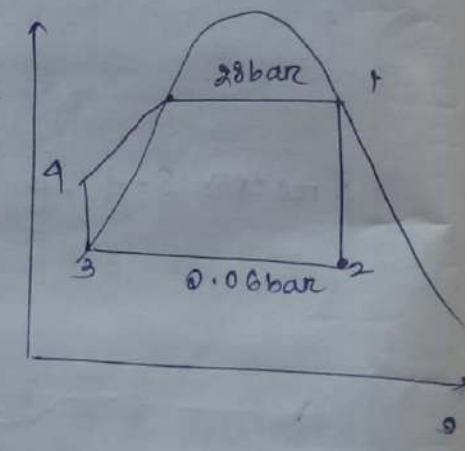
2) Work ratio $= \frac{w_{net}}{w_T}$

3) $SSC = \frac{3600}{w_{net}}$ kg/kW-H

19) A simple Rankine cycle works between pressure 28 bar & 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio & SSC.

Soln

From steam table.



At 28 bar $t_{sat} = 230°$

$h_g = h_1 = 2802$ kJ/kg

$s_g = s_1 = 6.2104$ kJ/kgK

At 0.06 bar $t_{sat} = 36.2°$

$h_{fg_2} = 2415.9$ kg/kg

$h_{f_2} = 151.5 = h_{f_3}$

$s_{fg_2} = 7.809$ kg/kgK

$s_{f_2} = .521$ kg/kgK

$v_f = 0.001\ m^3/kg$

for process 1-2 we have $s_1 = s_2$ (isentropic process)

$s_1 = s_{f_2} + x\, s_{fg_2}$

$\Rightarrow 6.2104 = 0.521 + x_2 \times 7.809$

$\Rightarrow x_2 = 0.728$

$h_2 = h_{f2} + x_2 \times h_{fg2}$

$= 151.5 + .7,28 \times 2415.9$

$= 1910.27$ kJ/kg.

(Turbine work) $W_T = h_1 - h_2$

$= 2802 - 1910.27$

$= 891.73$ kJ/kg.

(Pump work) $W_P = h_{f4} - h_{f3}$

$= v_f (P_1 - P_2)$

$= 0.01 (28 - 0.06) \times 10^5$

$= 2794$ J/kg

$= 2.794$ kJ/kg.

Net work $W_{net} = W_T - W_P$

$= 891.73 - 2.79$

$= 888.94$ kJ/kg.

cycle efficiency $= \frac{W_{net}}{Q_1}$

$= \frac{888.94}{h_1 - h_{f4}}$

$= \frac{888.94}{2802 - 154.29}$

$= 33.57\%$.

Work ratio $= \frac{W_{net}}{W_T} = \frac{888.94}{891.73}$

$= .997$ Ans

SSC $= \frac{3600}{W_{net}} = \frac{3600}{888.94}$

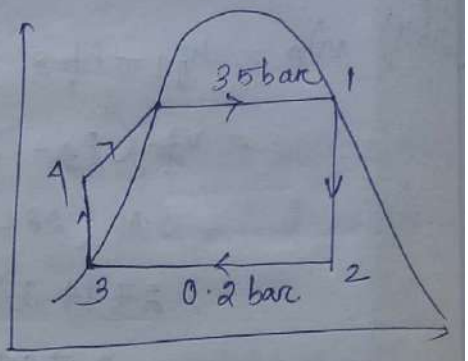
$= 4.049$ kg/kWH. Ans

Q2) In a rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar & the exhaust pressure is 0.2 bar. Determine

1) pump work
2) The turbine work
3) η rankine
4) the condenser heat flow
5) Dryness fraction at the end of expansion

Assume flow rate of 9.5 kg/s.

Soln



$P_1 = 35$ bar, $x = 1$

$P_2 = 0.26$ bar

$\dot{m} = 9.5$ kg/s

At 35 bar. $h_1 = h_{g_1} = 2802$ kJ/kg

$s_1 = s_{g_1} = 6.1228$ kJ/kg K

At 0.2

$h_{f_3} = h_{f_2} = 251.5$ kJ/kg

$h_{fg_2} = 2358.4$ kJ/kg

$v_f = 0.001017$ m³/kg

$s_f = 0.8321$ kJ/kg K

$s_{fg} = 7.0773$ kJ/kg K.

c) pump work, $W_p = h_{f4} - h_{f3}$

$= (P_4 - P_3) v_f$

$= (35 - 0.2) \times 10^5 \times 0.001017$

$= 3.54$ kJ/kg.

Now power required to drive the pump

$= 9.5 \times 3.54$

$= 33.63$ kW

$W_p = h_{f4} - h_{f3}$

$\Rightarrow h_{f4} = W_p + h_{f3} = 3.54 + 251.5 = 255.04$ kJ/kg

ii) Turbine work.

$W_T = h_1 - h_2$

$s_1 = s_2 = s_{f2} + x_2 \times s_{fg2}$

$\Rightarrow 6.1228 = .8321 + x_2 \times 7.0773$

$\Rightarrow x_2 = 0.747$

$h_2 = h_{f2} + x_2 h_{fg2}$

$= 251.5 + 0.747 \times 2358.4$

$= 2013$ kJ/kg.

$W_T = 2802 - 2013$

$= 789$ kJ/kg.

Net power $= m \times W_T = 9.5 \times 789$

$= 7495.5$ kW

It may be noted that W_p very small as compared to W_T.

iii) Rankine efficiency.

$$\eta_{rankine} = \frac{h_1 - h_2}{h_1 - h_{f4}} = \frac{2802 - 2013}{2802 - 255.04}$$

$$= \frac{789}{2546.98} = 30.93\%.$$

iv) condenser heat flow

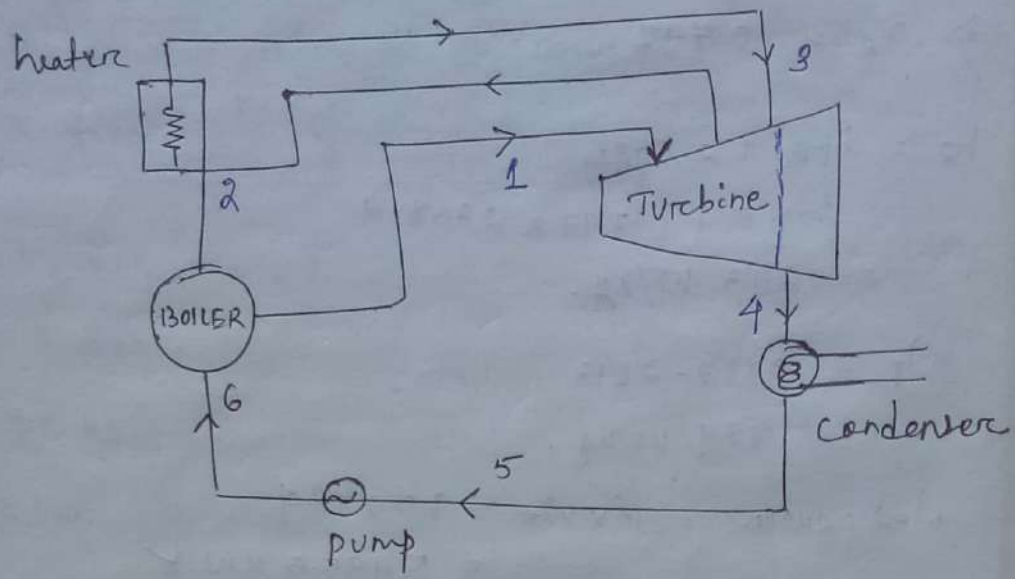
$= m' (h_2 - h_{f4})$

$= 9.5 (2013 - 251.5) = 16734.25$ kW

v) The dryness at the end of expansion

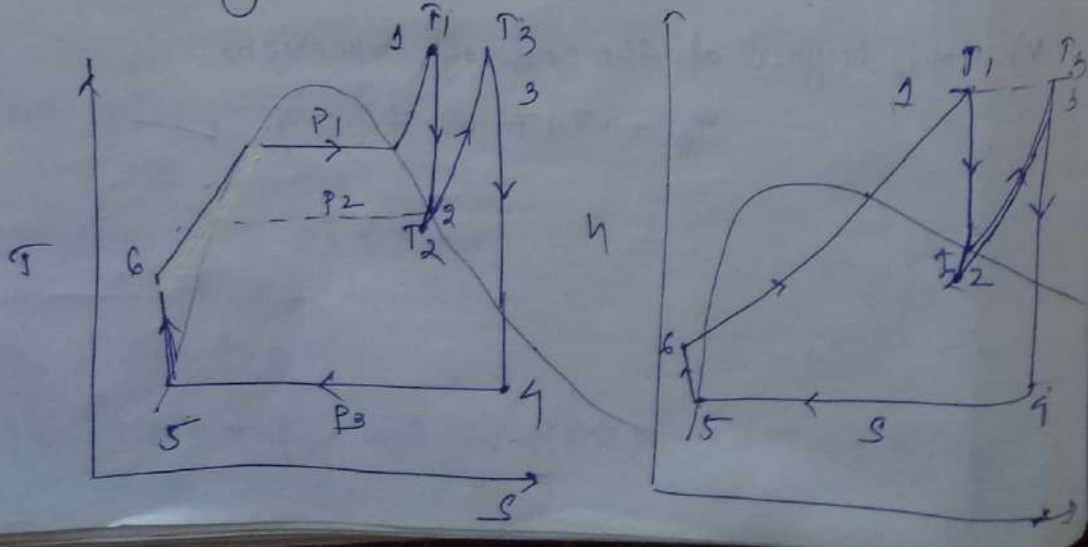
$x_2 = .747 = 74.7\%$.

3. REHEAT CYCLE



— In actual practice reheat improves the cycle efficiency by about 5%. In the above fig, the steam as at state point 1 (i.e. press. p_1 & Temp T_1) enters the turbine & expa isentropically to a certain pressure p_2 & temp T_2. Fro this state point 2 the whole of steam is drawn out of the turbine & is reheated in a heater at temp

— This reheated steam is then re admitted to the turbine where it is expanded to condenser pressure isentropically.



Thermal efficiency with Reheating (neglecting pump work)

heat supplied = $(h_1 - h_6) + (h_3 - h_2)$

heat rejected = $h_4 - h_5$

Work done by the turbine = Heat supplied − Heat rejected

$= (h_1 - h_6) + (h_3 - h_2) - (h_4 - h_5)$

$= (h_1 - h_2)$

Work done by the turbine $W_T = (h_1 - h_2) + (h_3 - h_4)$

$$\eta_{reheat} = \frac{W_{net}}{q_{in}} = \frac{(h_1 - h_2) + (h_3 - h_4)}{}$$

$$W_p = h_6 - h_5 \quad \left(-\int_{P_2}^{P_1} v\,dp\right)$$

$$W_{net} = W_T - W_p = (h_1 - h_2) + (h_3 - h_4) - (h_6 - h_5)$$

$$\eta_{reheat} = \frac{(h_1 - h_2) + (h_3 - h_4) - (h_6 - h_5)}{(h_1 - h_6) + (h_3 - h_2)}$$

or

$$\eta_{reheat} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{h_4 - h_5}{(h_1 - h_6) + (h_3 - h_2)}$$

Advantages

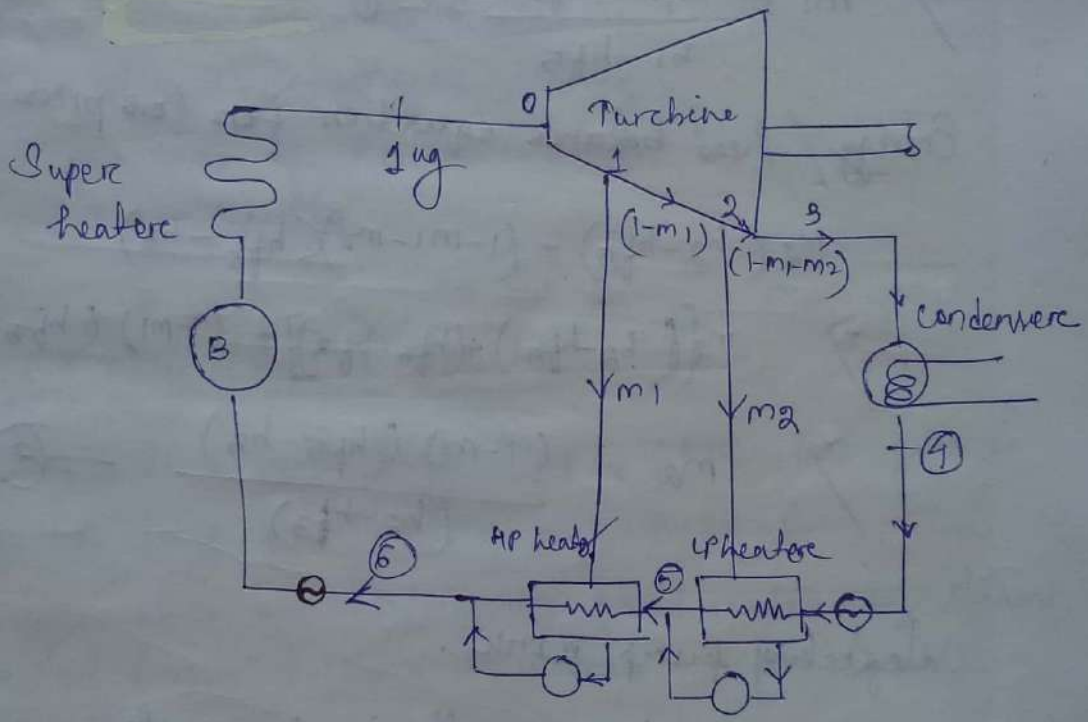
- There is an increased o/p of the turbine.
- corrosion problems can be eliminated.
- There is an improvement in the thermal efficiency.
- Final dryness fraction of steam is improved.

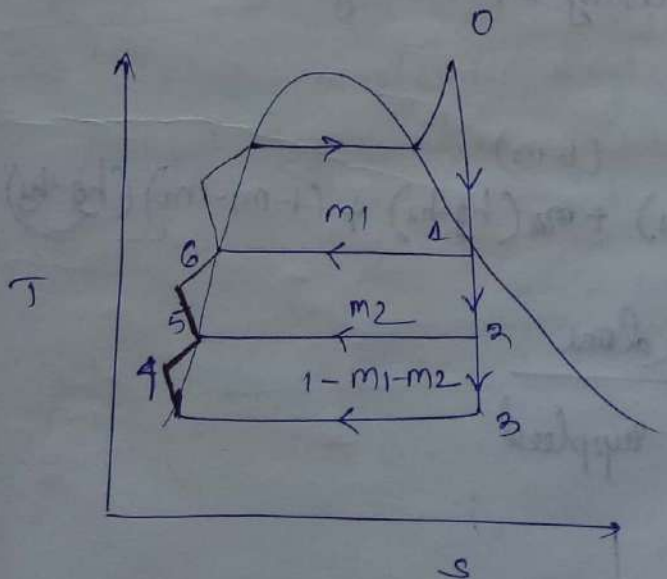
Disadvantages

- Reheating requires more maintainance.
-

REGENERATIVE CYCLE

The principle of regeneration can be practically utilised by extracting steam from the turbine at several locations and supplying it to regerative heaters. The resulting cycle is known as Regerative or bleeding cycle. By using these heaters the temperature of the saturated steam will be 4 to 10°c higher than the final condensate temperature.





Advantages

- The thermal efficiency is improved because the avg. temp. of heat addition to the cycle is increased.
- Heat rate is reduced.
- Due to many extractions there is an improvement in the turbine drainage & its reduce erosion due to moisture.
- A small size condenser is required.

Disadvantage

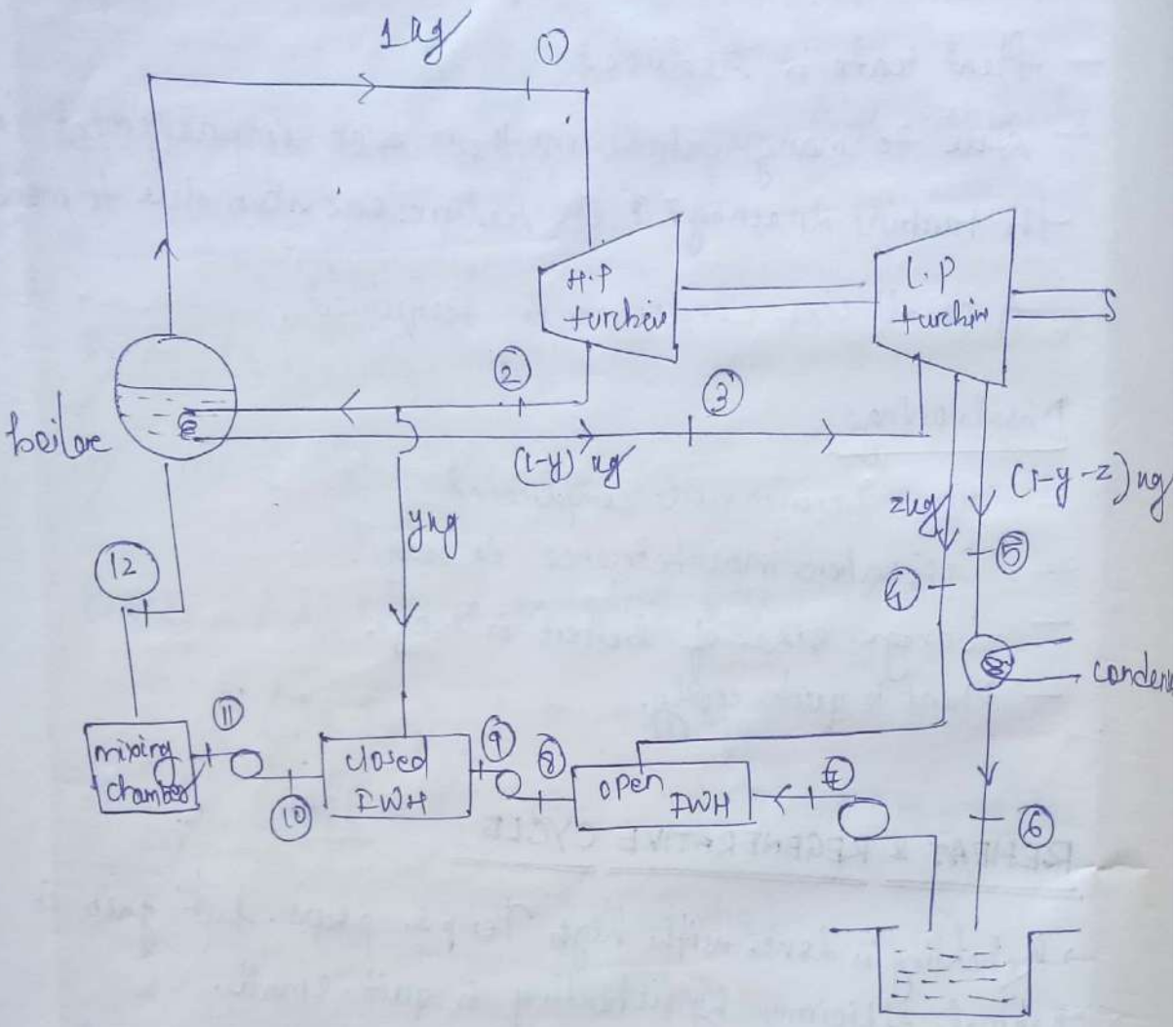
- Plant becomes more complicated.
- Greater maintainance is req.
- Large size of boiler is req.
- Plant is quite costly.

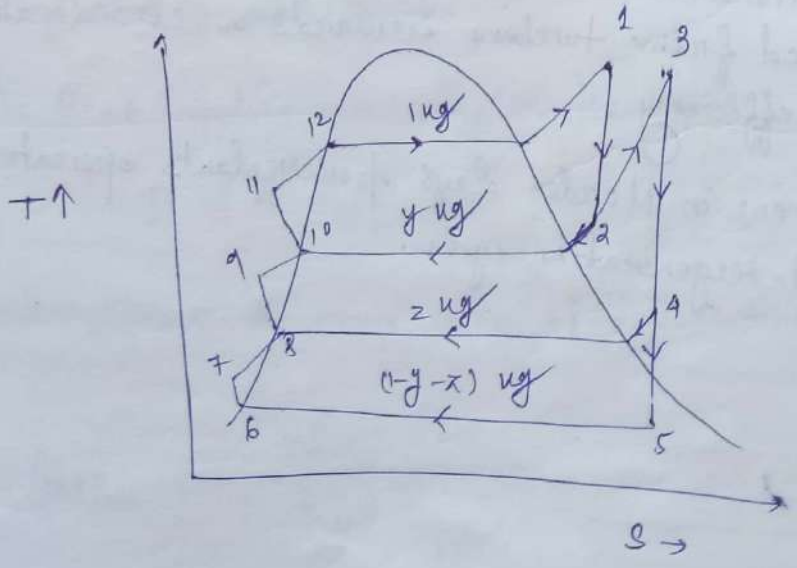
REHEAT & REGENERATIVE CYCLE

→ Reheating is done with high Temp & press. but gain in thermal efficiency by reheating is quite small.

→ In regeneration are heating up feed water by steam extracted from turbine towards a considerable gain in efficiency.

→ So now in Modern days powerplants operates on reheat-regeneration cycle.





considering unit mass of steam

$Q_{add} = Q_1 = 1(h_1 - h_{11}) + (1-y)(h_3 - h_2)$

$Q_{out} = Q_2 = (1-y-z)(h_5 - h_6)$

$W_T = W_{T1} + W_{T2}$

$= 1(h_1 - h_2) + (1-y)(h_3 - h_4) + (1-y-z)(h_4 - h_5)$

$W_P = W_{P1} + W_{P2} + W_{P3}$

$= (1-y-z)(h_6 - h_7) + (1-y)(h_9 - h_8) + 1(h_{11} - h_{10})$

Advantages

- It improves the thermal efficiency.
- It increases the net work o/p of the turbine.
- It reduces the steam rate / kWh.

Disadvantages

- The cost & size of the plant increases due to addition of reheating reheater, feed water heater and its long piping.
- Large size condenser is required.

BOILER'S ACCESSORIES

Boilers accessories are the auxillary parts required to increase the overall efficiency of the boiler & to improve the operating conditions.

Difference between Mountings & Accessories

Boilers mountings is an essential apparatus without which a boiler cannot be operated, but boiler accessories is not an essential part.

→ Mountings are mounted on the boiler but accessories are not generally mounted on the boiler but installed with in or near the boilers.

→ Mountings occupy less floor space but accessory occupy more floor space.

eg Economiser, Air preheaters, Electrostatic precipitator Super heaters etc.

Air Preheater

→ Air preheater, recovers some portion of the waste heat of the flue gases, and the air supplied to the combustion chambers is preheated by using the heat of flue gases.

→ It is placed after economisers and before the gases enters the chimney.

→ Due to the preheating of Air, the following advantages are obtained.

* Waste heat from the flue gases is recovered for heating air & reduces the fuel consumption by about 1.5% for each 100°C drop in gas temperature.
* Inferior grades of coal can be burnt efficiently with preheated air.
* Combustion can be more efficient & the intense flame can be achived in the furnace. This increases the evapercation rate of boiler.

→ Air preheater can be clasified as

- tubular type
- plate type
- regenerative type / storage type

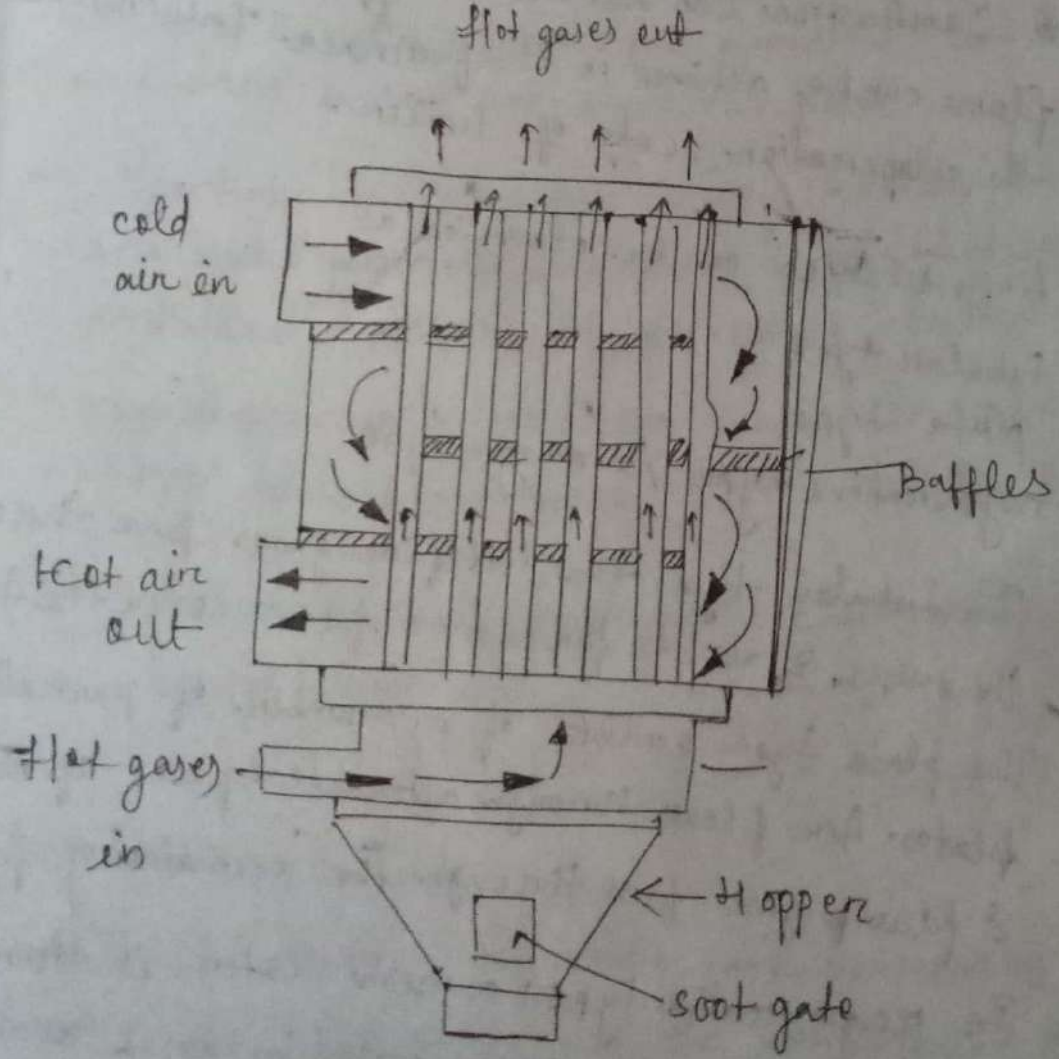
- In tubular type, the hot flue gases pass through the tubes & air is forced to flow over the tubes.
- The plate type consists of a number of parrallel plates. Air flows through alternate spaces of the plates & flue gases pass through the remaining passages.
- In regenerative type, a mesh rotor is alternately heated by flue gases, & then cooled by air & as a result the air is heated.

→ Degree of pre-heating depends on

- Types of fuel
- Type of burning equipment
- Rating at which boiler & furnace are operated.

→ After leaving the boiler, flue gases preheats the the air i.e supplied to the furnace. And finally the gas escapes to the atmosphere through chimney.

* Temp. of gases leaving the chimney should be kept as low as possible to minimize losses.

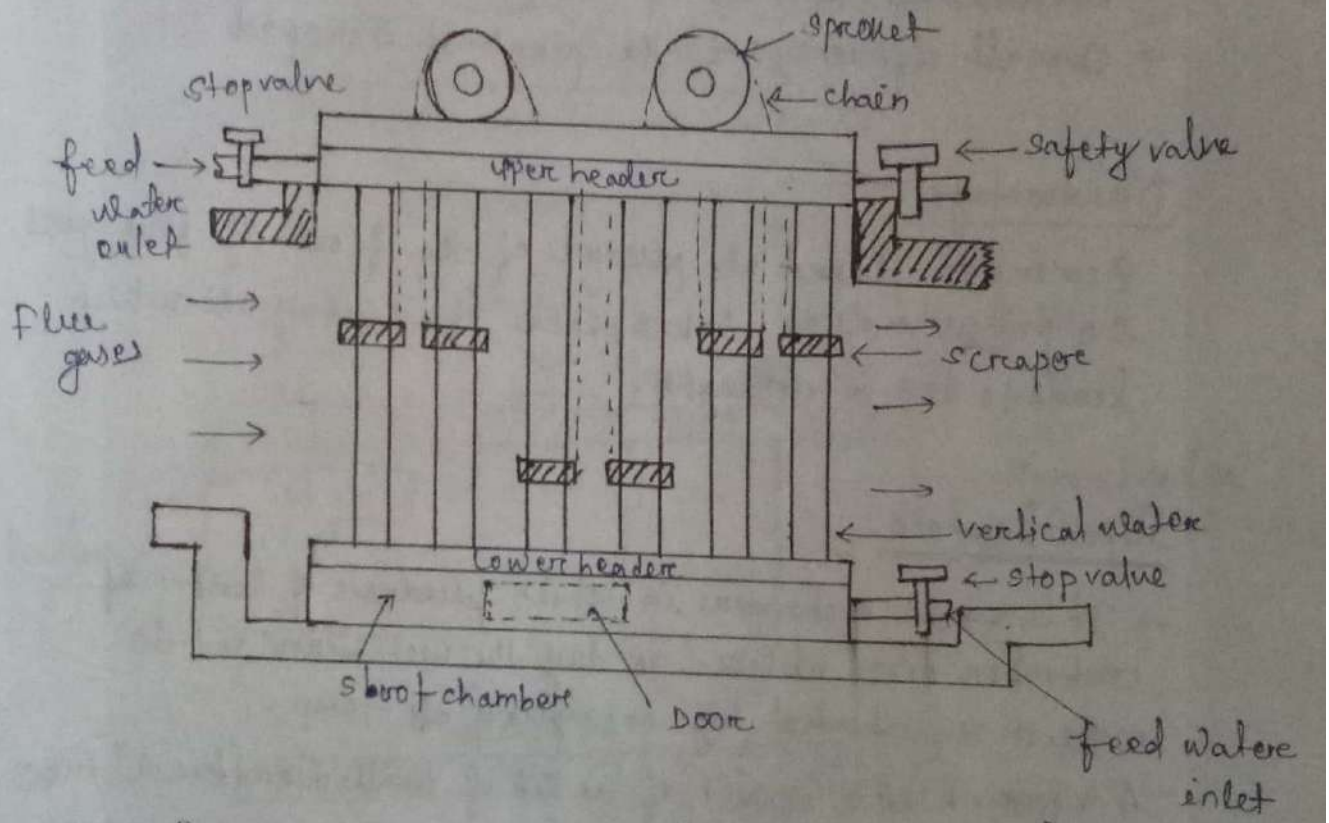


Tubular type Air preheater

Economiser

An economiser is a heat exchanger used for heating the feed water before it enters to the boiler. It utilised the waste heat of flue gases for heating the feed water.

- It is placed in the path of the flue gases at the rear end of the boiler just before the airpreheater.
- The most popular economiser is Green's economiser, as shown in the fig.



→ Green economiser consist of a set of vertical cast-iron pipes joined with horizontal lower & upper headers. The cold feed water flows through the vertical pipes via the lower header.

→ The hot flue gases pass over them transferring heat to the water. The heated water is supplied to the boiler through the upper header.

→ The soot of the flue gases which gets deposited on the pipes reduces the efficiency of economiser. To prevent the soot deposition, the scrapers are move up and down to

keep the external surface of the pipes for better heat transfer.

→ The soot collected in the soot chamber can be removed from the door.

→ For proper functioning each economiser is equiped with a safety valve, a drain valve, release valve, pressure gauge & thermometers.

Advantages

→ Evaporative capacity of the boiler is increased.

→ Overall efficiency of the plant is increased.

Disadvantage

Economiser placed at passage of the flow of flue gases, so pressure drop takes place of flue gases which leads to loss in draught.

Superheaters

→ It is a heat exchanger in which products of heat of combustion are utilized to dry the wet steam and to make it superheated by increasing its temp.

– A superheater consist of a set of small diameter U tubes in which steam flows & takes up the heat from hot flue gases.

– A superheater consist of two headers and a set of superheater tubes made of high quality steel in the form of U tube. Superheater is located in the path of furnace gases where the temperature of gases is not less than 500°C.

keep the external surface of the pipes for better heat transfer.

→ The soot collected in the soot chamber can be removed from the door.

→ For proper functioning each economiser is equiped with a safety valve, a drain valve, release valve, pressure gauge & thermometers.

Advantages

→ Evaporative capacity of the boiler is increased.

→ Overall efficiency of the plant is increased.

Disadvantage

Economiser placed at passage of the flow of flue gases so pressure drop takes place of flue gases which leads to loss in draught.

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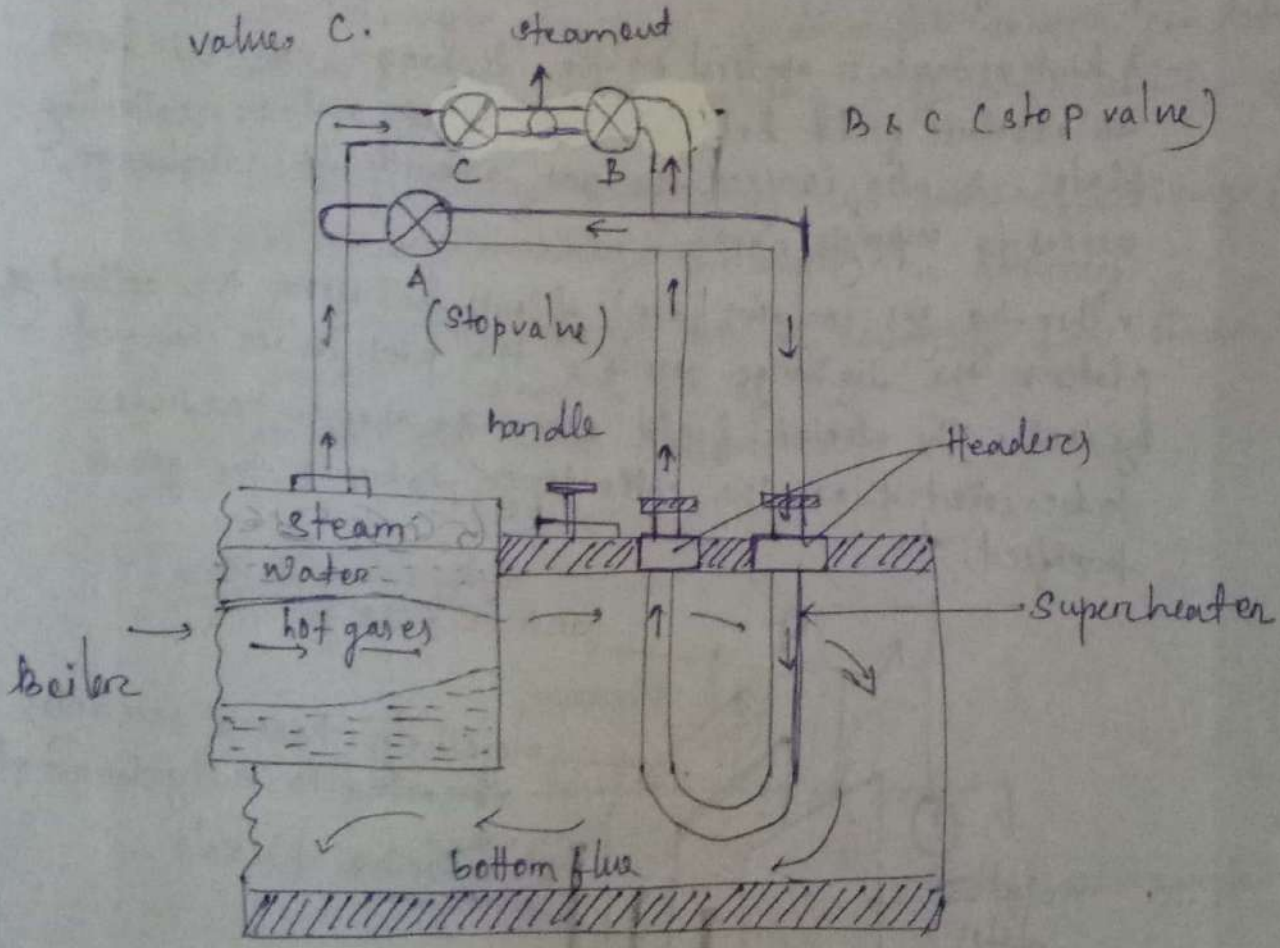
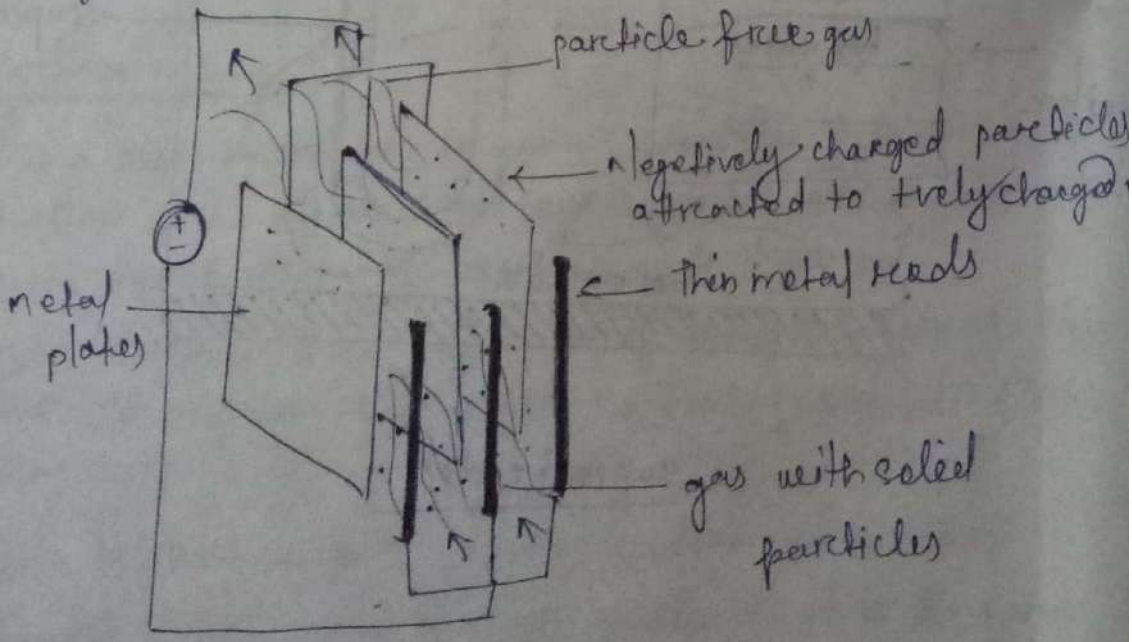
- The arrangement for getting superheated or wet steam is shown in the fig. For getting superheated steam, the valves A & B are opened and valve C is closed. The steam from the boiler enters into superheater through valve A. and withdrawn through valve B.
- If wet steam is required, the valve A & B kept closed, and steam directly comes out of the boiler, through the valve C.



Super heater.

Electrostatic Precipitator (ESP)

- Electrostatic precipitator is used for removal of dust & ash particle carried with exhaust gases of thermal power plant.
- It is a filtration device that removes fine particles, like dust & smoke, from a flowing gas using the force of an induced electrostatic charge.
- If high voltage is applied to the discharge wires to form an electric field between the wires and the collecting plates, & also ionizes the gas around the discharge wires to supply ions.
- When the gas contains dust flows between the collect plates & the discharge wires, the particles are charged by ions. The electric field causes the charge particles to be collected on the collecting plates & the gas is purified.



Adv

- Removes very small particles
- η 99.5%

Dis

- running cost is high
- Large Area required.

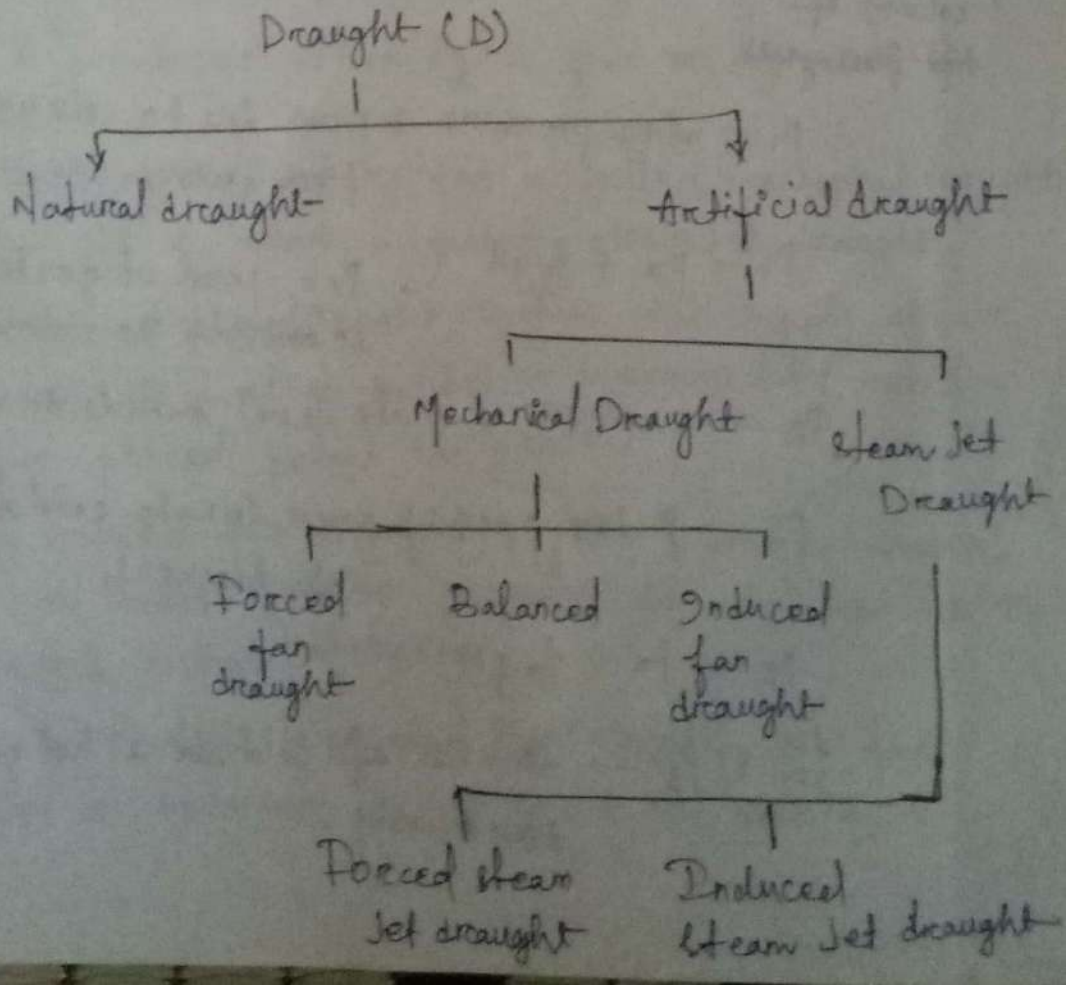
DRAUGHT

Draught is the difference of pressure which causes a flow of air to take place from outside atmosphere into the boiler furnace for complete combustion of fuel.

Necessity for producing draught

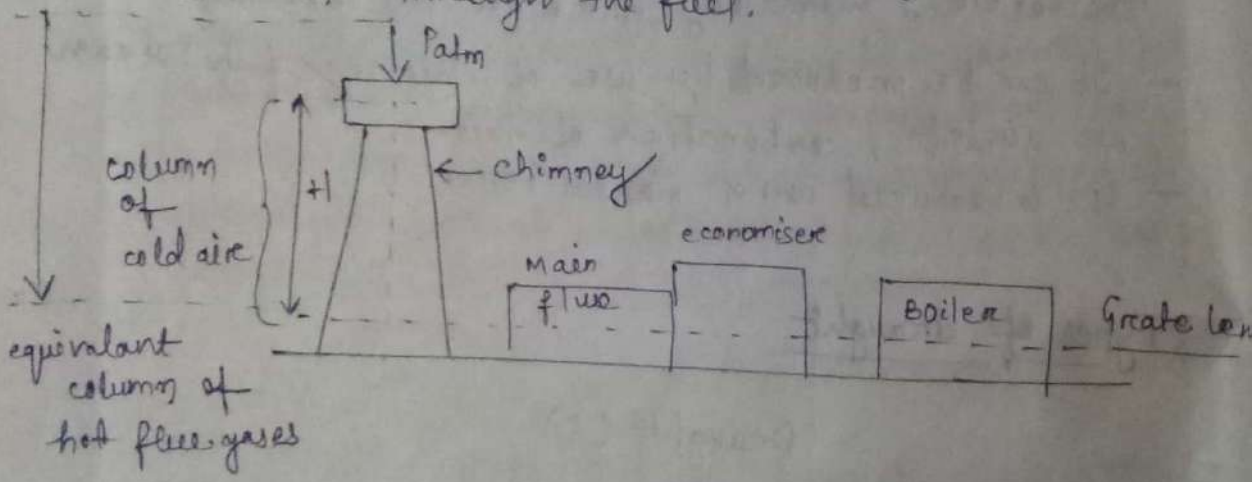
- Complete combustion of fuel require sufficient supply of air through the fuel, so draught ensure complete combustion of fuel by supplying sufficient quantity of air.
- It helps to carry away the flue gases effectively in the boiler & ultimately through the chimney.
- It can be produced by use of chimney, fan, steam or air jet, combination of this.
- It is measured using manometers.

Types of draught



Natural Draught

- The draught produced by a chimney is called natural draught.
- It is due to the difference in weight between the column of hot gas within the chimney & an equal column (i.e. of same height & cross section) of cold air outside the chimney.
- The chimney gas, being much lighter than outside cold air tends to rise up so the outside cold air flows in through the fuel to take its place with the chimney, so a continuous supply of air is ensured through the fuel.



P_1 = atmo. pressure + press. due to column of hot flue gases in the chimney.

$P_1 = P_a + \rho_g g H$ (P_1 = press. at grate level in outside the chimney)

P_2 → pressure at grate level outside the chimney

P_2 = atmo. press + press due to cold air column of height H

$P_2 = P_a + \rho_a g H$

ρ_a & ρ_g → densities of cold air & hot gases respectively.

The net pressure difference $\Delta p = P_2 - P_1$

$$\Delta p = (\rho_a - \rho_g) g H$$

Advantages

- Easy to construct.
- No power is required for producing the draught.
- Long life to chimney.
- No maintainance is required.

Disadvantages

- Tall chimney is required
- poor efficiency.
- Effi. decreases with increases in outside temperature.
-

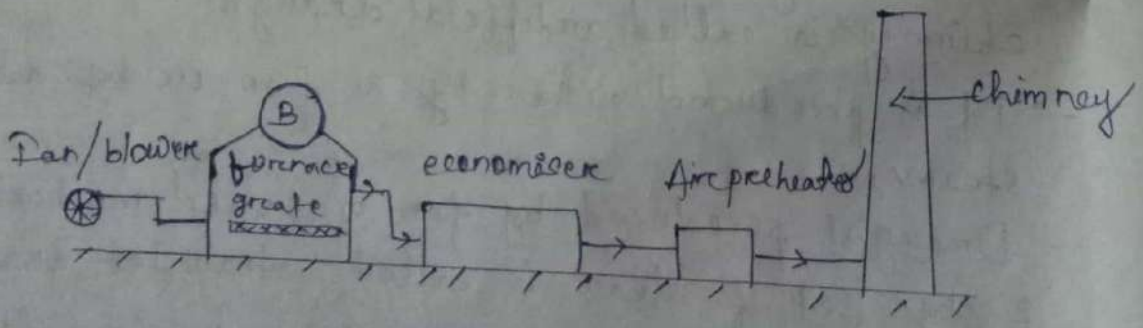
Artificial Draught

- The draught produced by any other means than by chimney is called artificial draught.
- It is produced either by a fan or by a jet of steam.
- Draught produced by fan is called mechanical draught & by jet of steam is called steam jet draught.
- In forced fan draught system, the supply of air through the fuel in the boiler is ensured by means of fan placed below the grate.
- In induced fan draught system, air is drawn into the boiler due to pressure diff between boiler furnace & outside atmosphere.
- This press. diff is created by means of a fan placed in between the boiler & the chimney.

- The fan continuously & rapidly draws in the flue gases from the boiler furnace through the flue gas path & discharges them into the chim Thus it creats a zone of partial vaccum in boiler furnace. As a result, the atmosphere air rush in to the boiler furnace through the opening of the greate.

Forced draught

- The fan or blower is installed near the base of the boiler & air is forced to pass through the furn flues, economiser, air pre heater & to chimney.
- It is called the as forced draught because the pressure of air throughout the system is above atmospheric and air is forced to flow through the system.

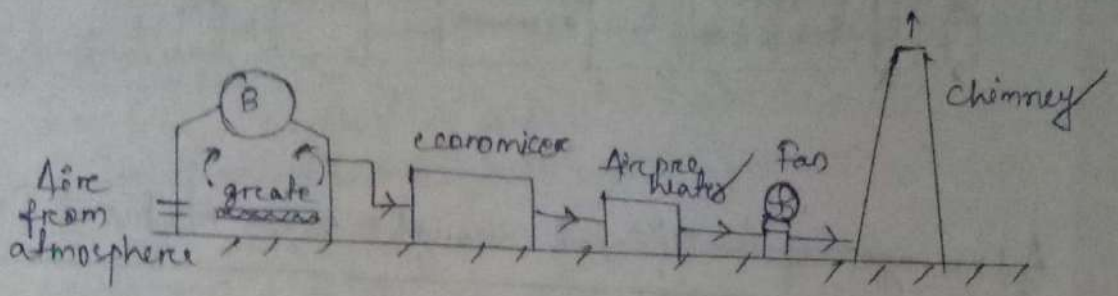


Forced draught

Induced draught

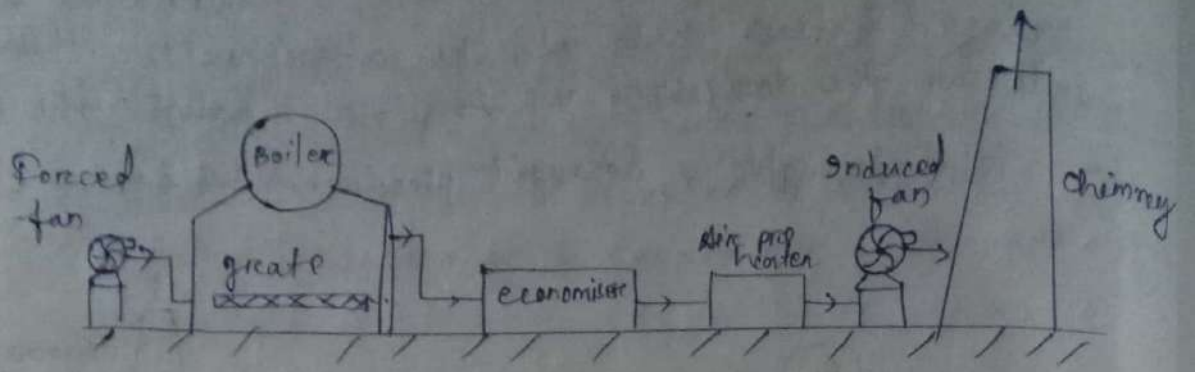
- The fan is located near the base of chimney, as shown in fig.
- The air is sucked into the system by reducing the pressure through the system below the atmospheric pressure.

- The induced draught fan sucks the gas from the furnace & the pressure inside the furnace is reduced below that of the atmospheric, thus inducing the atmosphere air to flow through the furnace.
- Total draught = draught produced by fan + chimney



Balanced Draught

- It is always preferable to use a combination of forced & induced draught instead of using separately.
- If only forced draught is used, the furnace can not be opened either for firing or inspection as high press air inside the furnace will blow out suddenly.
- If only induced draught is used the furnace can't be opened either for firing or inspection as the cold air will try to rush into the furnace as press is below atmosphere. So reduces effective draught & dilutes the combustion gases.
- Balanced draught overcomes the resistance of the fuel bed so sufficient air is supplied to the fuel bed for complete combustion.
- The induced draught fan removes the gases from the furnace maintaining P in the furnace just below atm press. This helps to prevent the blow out of flames & leakage of air inwards when furnace doors are opened.



Advantages of Artificial draught over Natural Draught

- Forced draught puts better control on combustion
- Low grade fuel can be efficiently burnt.
- Overall efficiency of a thermal power plant is higher due to better heat recovery from the exhaust flue gases in economisers & preheaters.
- The height of the chimney can be reduced than that required in natural draught.
- Higher the rate of fuel burning capacity on the grate, higher the heat-supply rate at higher effective temperature.
- Smoke formation is less.
- Tendency for air leakage in the furnace is less.

Forced draught

Advantages

- more efficient then induced draught
- more safe
- vibration & noise are minim.
- No problem of blade erosion.

Disadvantage

- Fan size is limited to 4 m.
- power requirement high.
- In cold weather, ice is formed on nearby equipments & in the fan housing.

Induced draught

Advantage

- less space required.
- lower initial cost.
- capable of cooling through a wide range
- recirculation is not a problem.

Disadvantage

- Air velocity through packing are uneven.
- ~~movement~~
- High HP motor is required to drive the fan comparatively.

Balanced draught

Advantage

-

Steam Jet draught

Steam Jet draught is a simple and easy method producing artificial draught. It may be of forced induced type depending upon where the steam jet to produced draught is located. If the steam jet is directed in to the smoke box, the air is induced through the flues, the grate & ash pit to the smoke box. If the jet is located before the grate, air is forced through the fuel bed, furnace & flues to the chimney.

Advantages

- very simple & economical
- occupies minimum space
- Requires very little attention.
- Low grade fules can be used with this system

STEAM CONDENSER

A condenseer is a device in which vapour / steam is condensed by abstracting heat to liquid phase at saturation temperature & const. pressure.

- In steam condenseer the cooling of steam is accomplished by circulating water as cooling agent in the condenseer.

Components of steam condenseer

1) condenseer — used to condense steam.
2) condenseer cooling water pump & make up pump
3) Condensate extraction pump
4) Hot well
5) Boiler feed pump
6) Air extraction pump
7) cooling towere

2) condenseer cooling water pump & make up water pump

It maintains the circulation of water through the condenseer. some cooling water is lost (1-2%) during the process which is supplied by make up pump.

3) condensate extraction pump

Its function is to extract the condensate from the condenseer where the pressure is below atmosphere & feed it to the hot well, where p is atmospheric.

4) Hot well

It is a sump between the condenseer & boiler, where condensed comming from condenseer is collected

5) Boiler feed pump

It's function is to pump the condensate from well in to the boiler by ↑ the pressure of the condensate above boiler pressure.

6) Air extraction Pump

It's function is to extract the air which has leaked into the condenser by various paths & to maintain the required vacuum inside.

7) Cooling Tower

- The hot water coming from the condenser is cooled by forcing it trough the cooling tow instead of discharging it to the downward side of the river.

COOLING TOWER

When cooling water supply is limited, there is a need to recycle the water through the condenser. Cooling tower is an artificial device used to cool the hot cooling water coming out of the condenser effectively.

- cooling towers are desired when positive control on temp is required and space occupied by cooling system is an important factor.
- It reduces the cooling water demand.

Types

1) Wet type
2) Dry type

- Mechanical draught C.T
- Natural draught C.T

Factors affecting cooling Tower

→ Temp. of air
→ humidity of air
→ Temp. of hot air
→ Size & height of tower
→ Velocity of air entering to tower.
→ Accessibility of air to all parts of tower.
→ Arrangement of plates in tower.

1) According to material, it is classified in 3 types.

a) Timber

b) Concrete

c) Steel duct

a) Timber C.T

- These towers are rarely used due to the following disadvantages
  - → Due to environmental conditions it rots easily.
  - → Short life.
  - → High maintenance charges.
  - → Limited cooling capacity.

b) Concrete ~~to~~ C.T

- These concrete C.T poxess the following advantages
  - → Large capacity
  - → Improved ~~creat~~ air circulation.
  - → Increased stability
  - → Low maintainance.

c) Steel duct C.T

It is the most modern type of C.T but rarely used due to the small capacity.

2) According to the type of draught

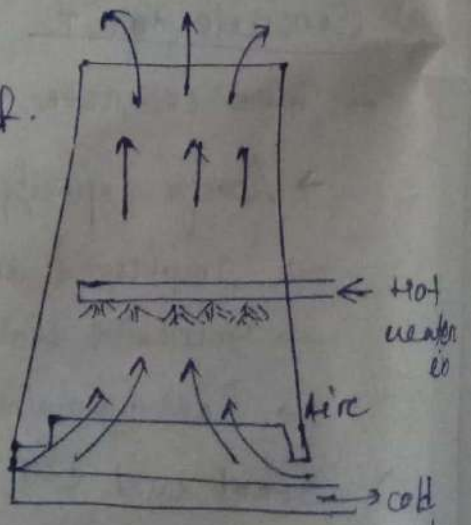
a) Natural draught C.T

b) Mechanical " " — Forced, Induced

a) Natural draught C.T

In this type of towers, the hot waters from the condensers is pumped to the nozzel & troughs situated near the bottom.

- Troughs spray the waters falls in the form of droplets into a pond situated at the bottom of the towers.
- The air enters the cooling towers from the air openings provided near the base rises upward & takes up the heat of falling waters.



Advantages

- Less operating & maintainance cost.
- Trouble free operation.
- It is made up of concrete can withstand very high speed wind flow.

Drawback

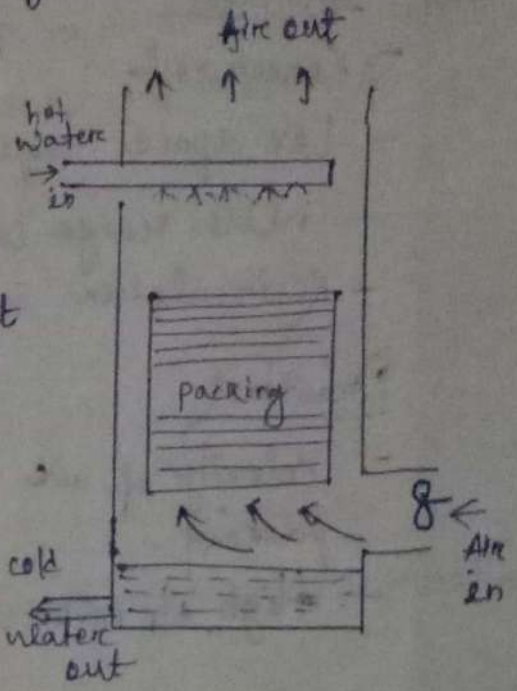
- high initial cost
- The performance varies according to seasons.

b) Mechanical draught C.T

In these towers the draught of air for cooling the tower is produced mechanically by means of propeller fans

2) Forced Draught C.T

It is similar to natural draught tower as far as interior construction is concerned, but the sides of the tower are closed and form an air & water tight structure, except for fan opening at the base for the inlet of fresh air, and the outlet at the top for the exit of air & vapour.



Advantages

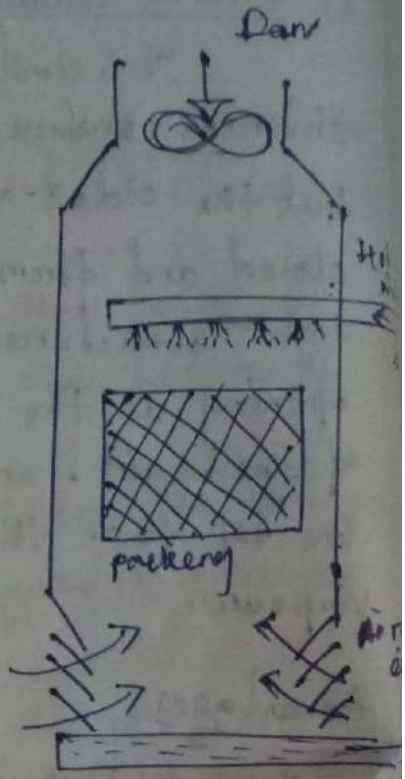
- More efficient
- No problem of blade erosion
- More safe
- The vibration & noise are minimum

Drawback

- Fan size limited to 4m.
- More power requirement.
- In cold weather ice is formed on nearby equipments.

ii) Induced draught C.T

In induced draught C.T the fans are placed at the top of the towers and they draw the air in through louvers extending all around the towers at its base.



Advantages

- Lower cost.
- Less space required.
- Wide range cooling is possible
- Recirculation is not a problem.

Drawback

- Velocity of air is uneven in packing.
- High hp motor is required.

STEAM PRIME MOVERS

Steam prime movers are steam turbine are the device in which potential energy of the steam is transformed in to kinetic energy and later it is transformed to mechanical energy of rotation of turbine shaft.

- The high velocity steam strikes on the curved blades which change the direction causes the movement of the rotor & power is developed.

Advantages of steam turbine.

- η is higher than steam engine.
- Maintainance cost is less.
- Vibration & noise is reduced due to absence of reciprocating parts.
- higher speed is possible.
- Uniform torque is generated.
- No need of internal lubrication.
- There is no loss due to initial condensation of steam.

Classification

a) Acc to mode of steam action
   - impulse
   - Reaction

b) Acc to direction of steam flow
   - Axial
   - Radial.

c) Acc to exhaust condition of steam
   a) condensing
   b) noncondensing

d) Acc to number of pressure stages
   a) single stage
   b) multistate

e) Acc to steam pressure at inlet
   a) high
   b) medium
   c) low

COMPOUNDING OF STEAM TURBINE (REDUCING ROTOR SPEED)

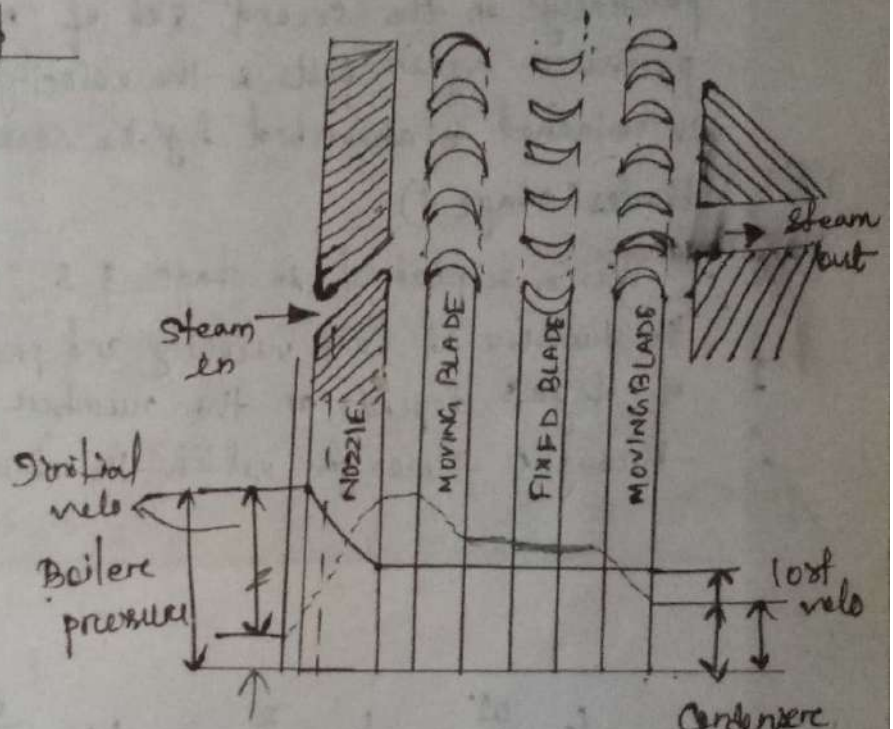
High pressure & high temp steam is used to increase the η_{th} of power plant. But if the steam is expanded from the boiler pressure to condenser pressure (from 140 bar to below 1 bar) in one stage the speed of the rotor becomes very high i.e about 30,000 rpm). Such high speed will cause many disadvantages from practical point of view.

— Thus to reduce such high rotor speed, a no. of rotor keyed to a common shaft and the steam pressure or jet velocity is absorbed in many stages as it flows over the rotor blades. This method is called as compounding.

Types of compounding

1) velocity
2) pressure
3) pressure - velocity.

1) Velocity compounding.



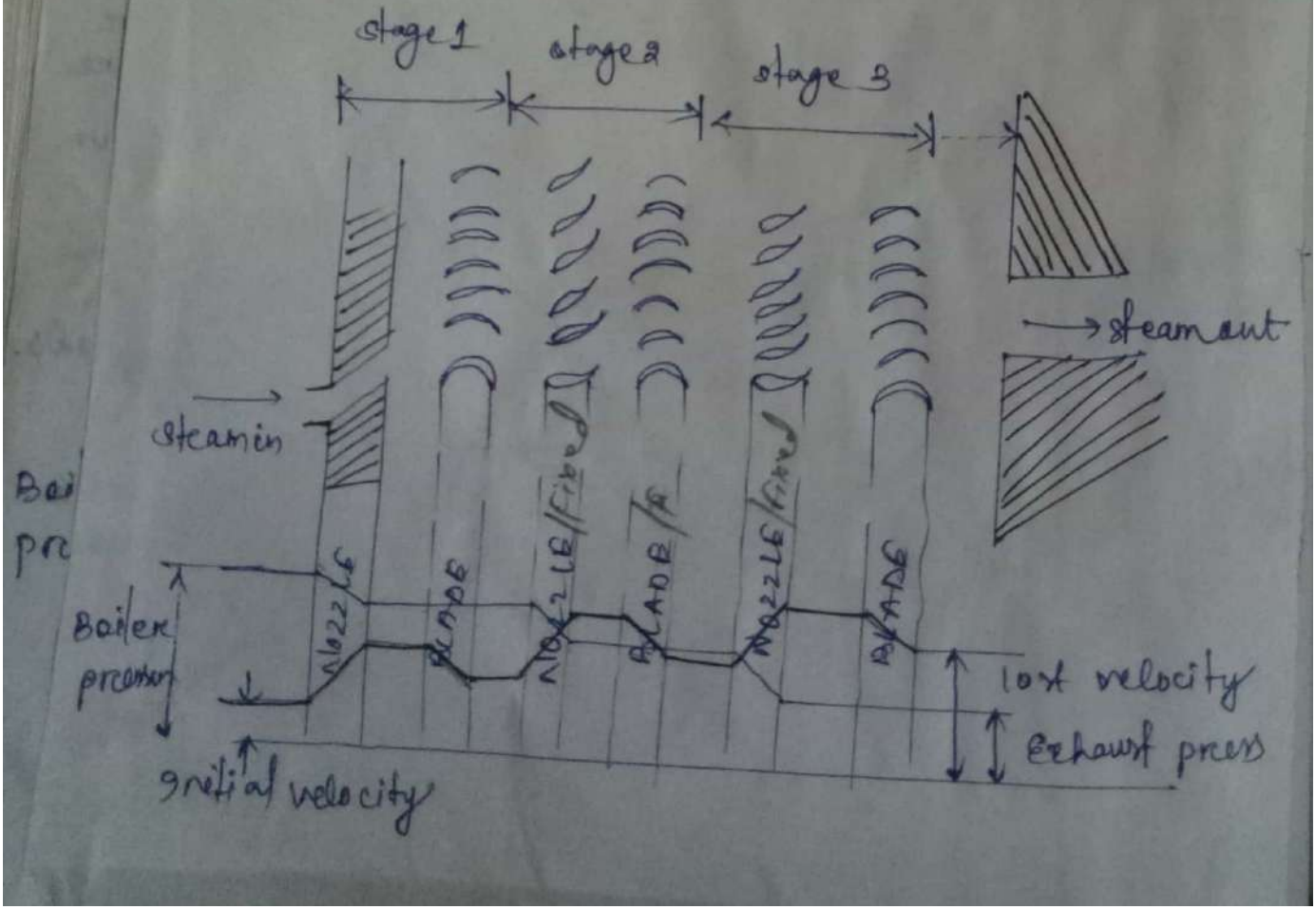
- Expansion of steam takes place in a nozzel or set of nozzeles from boiler press to condenser pressure. The wheel has 2 or 3 rows of moving blades. There is a row of fixed blade is only to direct the steam coming from 1st moving row to next moving rows.
- The enthalpy drop occurs only in nozzel at first stage & converted in to K.E. Thus gained K.E is successively absorbed in stages by rows of moving blades & finally the steam is exhausted from last row of blades.
- Efficiency is low due to less no. of stages.

2) Pressure Compounding

As shown in the fig, fixed nozzels incorporated between the rings of moving blades. The steam at boiler pressure enters the first set of nozzels and expands partially.

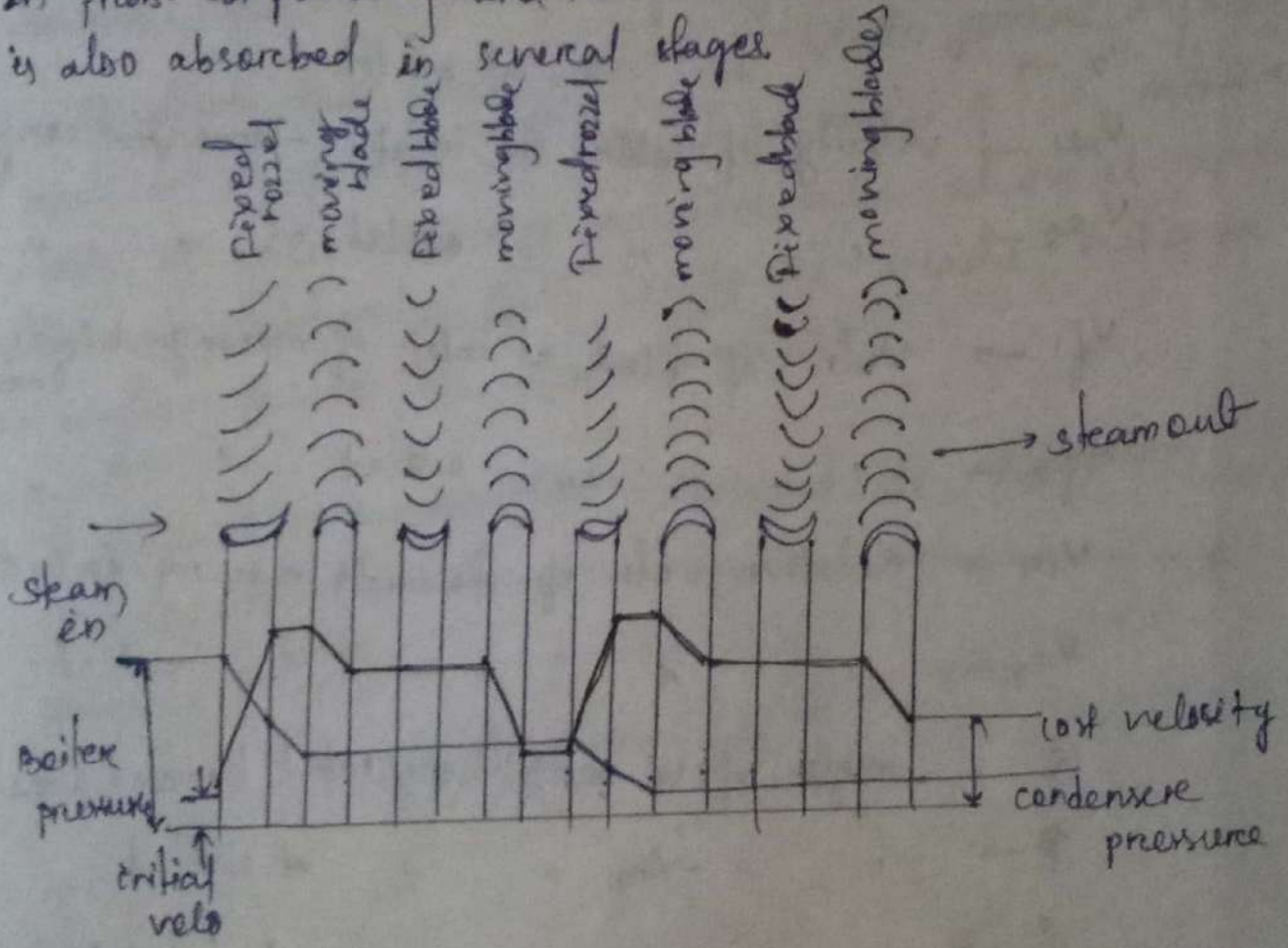
- The K.E of the steam thus obtained is absorbed by the moving blades (stage 1). The steam then expands partially in the second set of nozzels where as it's pressure again falls & the velocity increases, the K.E so obtained is absorbed by the second ring of moving blades (stage 2).

- This is repeated in stage 3 & steam finally leaves the turbine at low velocity and pressure. The number of stages depends on the number of rows of nozzels & troughs through which the steam must pass.



3) Pressure - Velocity compounding

- This is a combination of pressure and velocity compounding. Here the total press. drop of the steam from boiler to condenser press is divided into a no. of stages as done in press. compounding and the velo. obtained in each stage is also absorbed in several stages.



NUCLEAR POWER PLANT

A nuclear power plant is a thermal power station. heat is used to generate steam that drives a steam turbine connected to a generator that produces electricity

Nuclear Fuel

- Nuclear fuel is any material that can be used to drive nuclear energy. It is broadly classified into two types

i) Fissile material
ii) Fertile "

i) Fissile material

This type of fuels under goes nuclear fission chain reactions. eg. ^{235}U, ^{233}U, ^{239}Pu

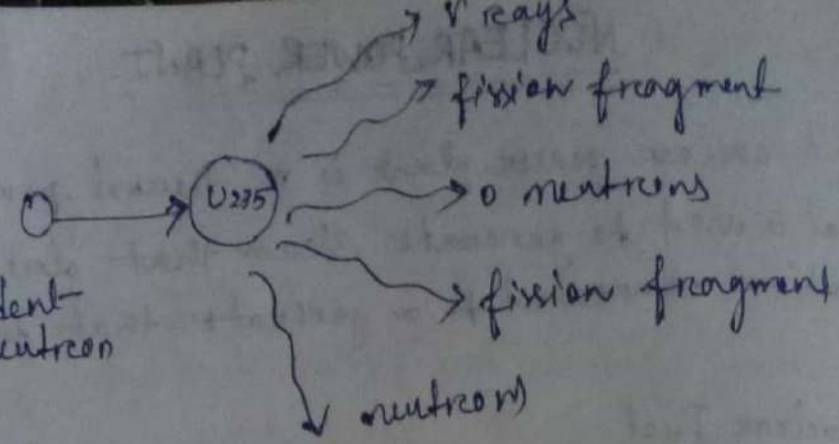
ii) Fertile material

Some materials are not fissionable by themselves but they can be converted to fissionable materials. these are known as fertile materials. eg ^{238}U, ^{232}Th

Nuclear Fission

← Fission is the process that occurs when a neutron collides with the nucleus of certain heavy atoms, causing the original nucleus to split into two or more unequal fragments which carry off most of the energy of fission as kinetic energy. This process is accompanied by the emission of neutrons & gamma rays.

— The fission fragments that results from the fission process are radioactive & decay by emission of beta particles, gama rays, alpha particles & neutrons.



Nuclear Fusion

Nuclear fusion is the process of combining one or more two lighter nuclei into a stable & heaviere nuclei. Here a large amount of energy is released.

Fission	Fusion
→ spliting of large atom in to 2 or more.	→ It is the fusing of 2 or more atoms to form a larger one.
→ It does not normally occurs in nature	→ It occurs in stars such as sun.
→ produces high radioactive particles as by product.	→ Few radioactive particles are produced.
→ Takes little energy to split atoms.	→ High energy is requi
→ Energy released is million times higher than chemical reac^n but less than fusion reac^n.	→ Extreamly high ener than fission reac^n.
→ Health hazard is more due to more radioactive material	→ less hazardous
→ Temp is managable	→ Extreamly high temp difficult to handle.

→ used in nuclear power plants →

→ fuel - U → deuterium, isotopes of hydrogen

Nuclear Reactors

A nuclear reactor is an apparatus in which nuclear fission is produced in the form of a controlled self-sustaining chain reaction. In other words, it is a controlled chain-reacting system supplying nuclear energy.

- It is a nuclear furnace which burns fuels like U^{235}, U^{233} and in results produces many products like heat, neutrons & radioactive isotopes.

Classification

1) Acc to neutron energies
   - fast reactors
   - intermidiate "
   - slow "

2) Acc to fuel moderator assembly
   - Homogeneous
   - Heterogeneous

3) Acc to fuel state
   - solid
   - liquid
   - Gas

Componets of nuclear Reactor :→

1) Reactore core
2) Reflector
3) control mechanisms
4) Moderator
5) coolant
6) ~~Measuring instrument~~
7) Shidding

1) Reactore core :—

- The reaction core is that part of a nuclear powe plant where fision chain reaction takes place : an the fision energy liberated in the form heat.
- The core of the reaction consist of fuel elements control rods, coolant & moderator.
- The fuel elements are made of plates or rods of uran metal. These fuel plates or rods are usually covere in a thin sheath of stainless steel, zirconium or aluminium to provide corrosion resistance, retentio of radioactivity & structural support. Enough space is provided betn individual plates or rods to allow free passage of coolant.

2) Reflector :—

A reflector is usually placed arround the core to reflect back some of the neutrons that leak out

from the surface of the core. It is generally made of the same material as the moderator. The req. properties of good reflector are low neutrons absorption & high capacity to reflect

3) Control Mechanism :—

It is the essential part of a reactor & do the following functions

i) For starting the reactors - to bring it normal operating level

ii) For maintaining at that level

iii) For shutting the reactor down under normal or emergency condition.

- The control system is also necessary to prevent the chain reaction from becoming violent & damaging the reaction
- It allow only one neutron evolved in each fission to take part in further reaction to maintain the chain. eg. Cd, boron etc.

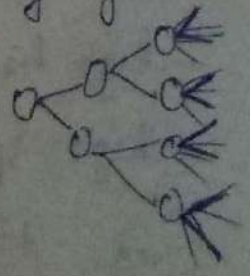
* chain rea^n

- The chain rea^n is a process in which the no. of neutrons keeps on multiplying rapidly (geometric progression) during fission till whole of the fissionable material is disintegrated.
- This cond^n can be conveniently expressed in the form the multiplication factor or reproduction factor.

$$K = \frac{\text{No. of neutrons in any particular generation}}{\text{No of " " preceding gener}^n.}$$

If $K > 1$ → rea^n continue

$K < 1$ → " not "



4) Moderator :-

A moderator fun is to absorbs the part of th K.E of the neutrons. The neutrons colide directly wi moderator & then slow down. Th Here the moder slow down the neutrons but not absorbs.

A moderator should have

- high slowing down power
- low non corrosive.
- chemical & radiation stability
- High thermal conductivity.
- Abundance in pure form.

eg water, heavy water, graphite, hydrocarbon

5) coolant :-

It's fun is to transfer the heat generated in the reacto core & use it for steam generation. The coolant circulated in the reaction keeps the temperature of fuel below safe level by continuous removal of heat from the core.

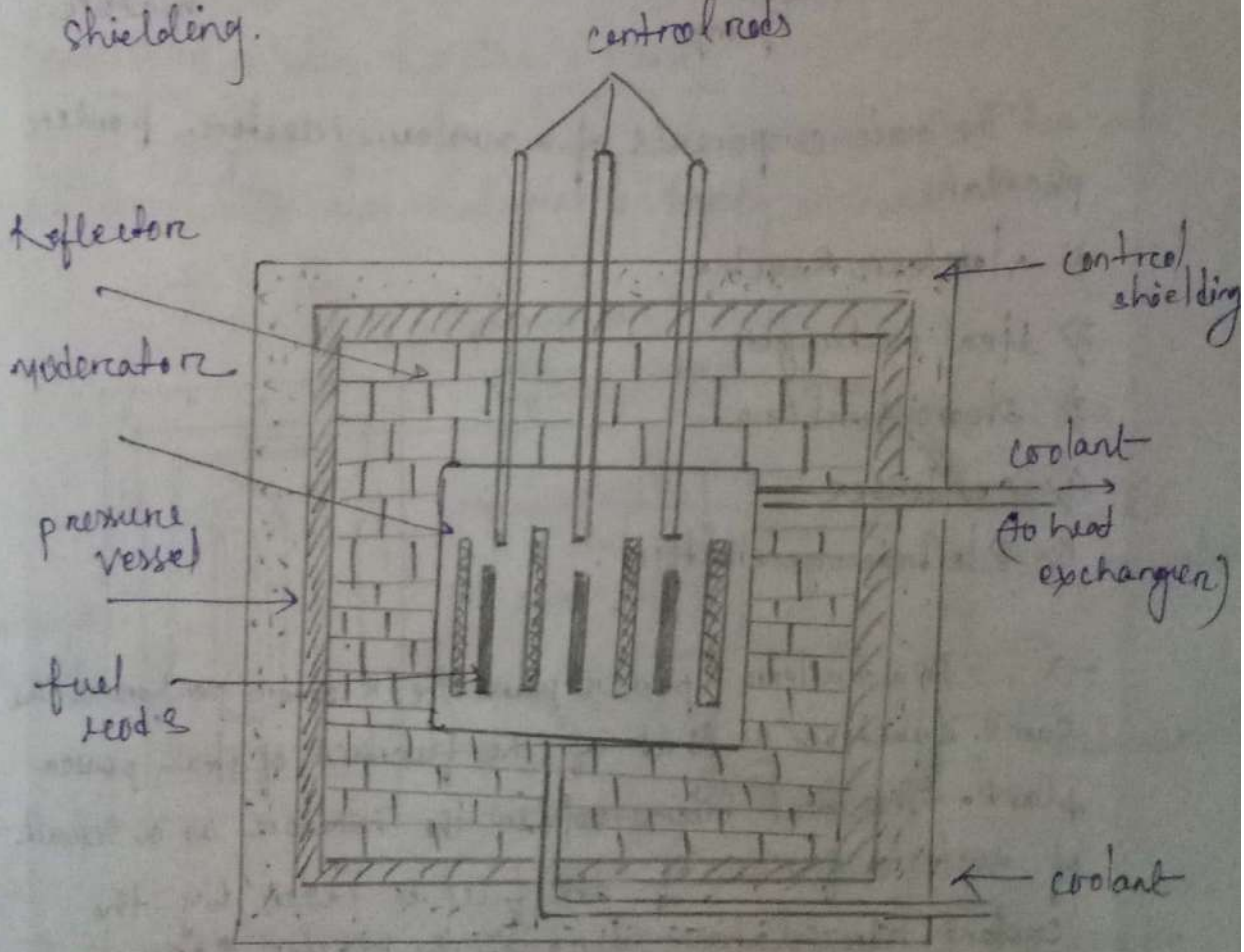
- It must be
- non corrosive
- Non toxic
- Low melting pt.
- high boiling pt
- high specific heat

eg. H_2O, Heavy water, CO_2.

6) Measuring instruments :-

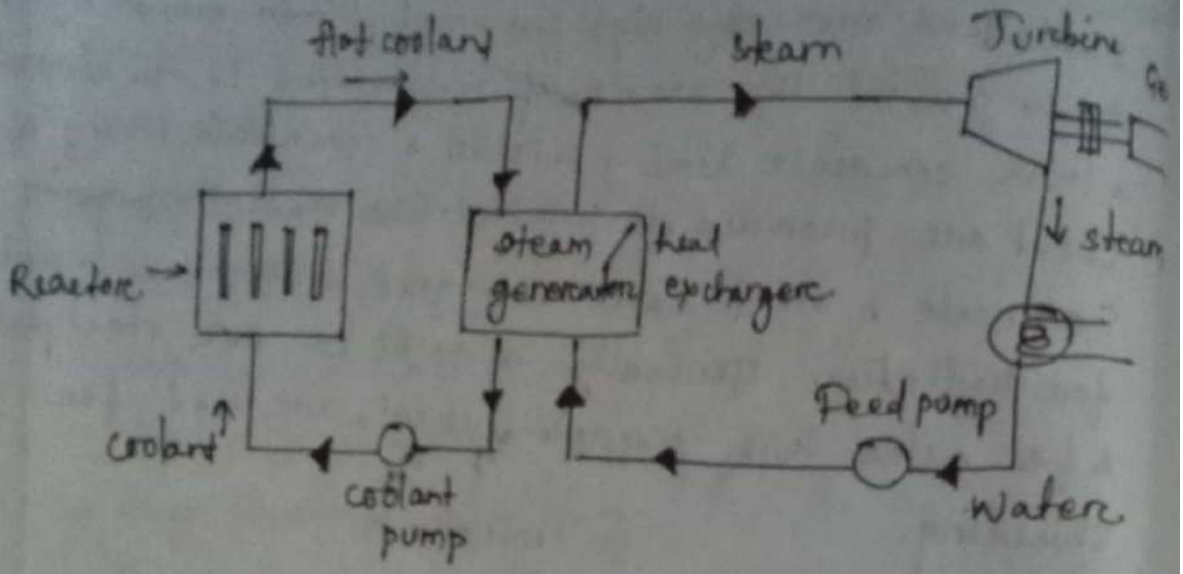
6) Shielding :-

A reactor is a source of intense radioactivity, these radiations are very high & harmful for human life, so to prevent the escape of radiactions to the atmosphe a thick concreate lining outside & inner thin lining of steel are provided to prevent the radiations going. Concreate & steel have very good absorption capacity for radiation. Generally 50 to 60 cm thick steel plate & few meter thick concrete out side are used for shielding.



Nuclear Reactor

Main Components of a nuclear power plant



The main components of a nuclear reactor power plant are

1) Nuclear Reactor
2) Heat exchanger
3) steam turbine
4) Condenser
5) Electric generator.

→ In a nuclear power plant the Reactor performs the same function as that of the furnace of steam power plant. The heat liberated in the reactor as a result of nuclear fission of the fuel is taken by the coolant circulating through the reactor core.

→ Hot coolant leaves the reactor at the top & then flows through the tubes of the steam generator & passes on it heat to the feed water.

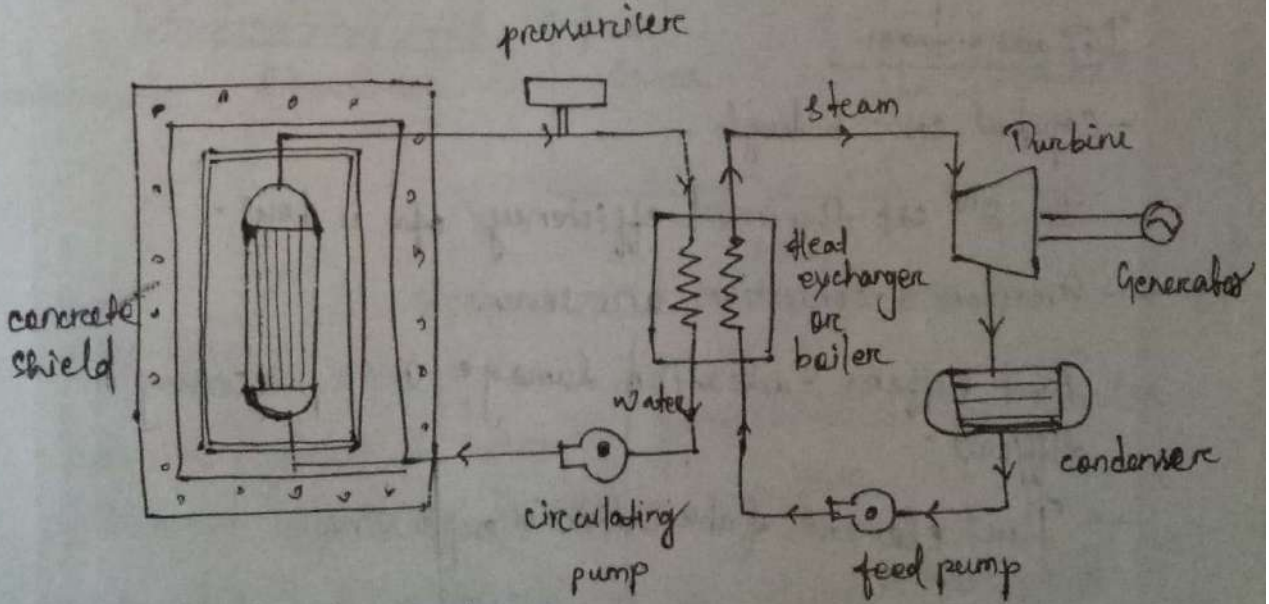
→ The steam so produced expands in the steam turbine producing work & thereafter is condensed in the condenser.
→ The steam turbine in turn runs an electric generator thereby producing electrical energy.

Nuclear Reactors

There are two types water cooled reactor
- Pressurised Water Reactor (PWR)
- Boiling water Reactor (BWR)

Pressurised Water Reactor (PWR)

It is a simplest form of water cooled & moderated thermal reactor. It uses natural & highly enriched fuel.



→ It uses ordinary water as coolant & moderator. It can produce only saturated steam.
→ It uses two circuits of H_2O.
→ H_2O in the primary circuit gets heated by absorbing the fission energy in the reactor & the same energy transferred to water to generate steam in the heat exchanger.

→ To prevent boiling of water & to maintain it in liquid state when it passes through reactore core, the pressure of H_2O in the 1st ckt is maint at a high level (about 150 bar)

→ Secondary ckt consist of heat exchanger, turbine condenser & feed pump.

Advantages

→ Ordinary H_2O is used as coolant & moderator, so cheap & easily available.

→ The reactore is compact & have high energy density 65 KW/litre.

→ No. of control rods required are considerably le

→ Steam is not contaminated by radiation.

Disadvantages

- Capital cost is high.
- In 2nd ckt thermal efficiency of is low.
- Erosion & corrosion are severe.
- Fuel suffers radiation damage so reprocessing is difficult.
- Fuel element fabrication is expensive.

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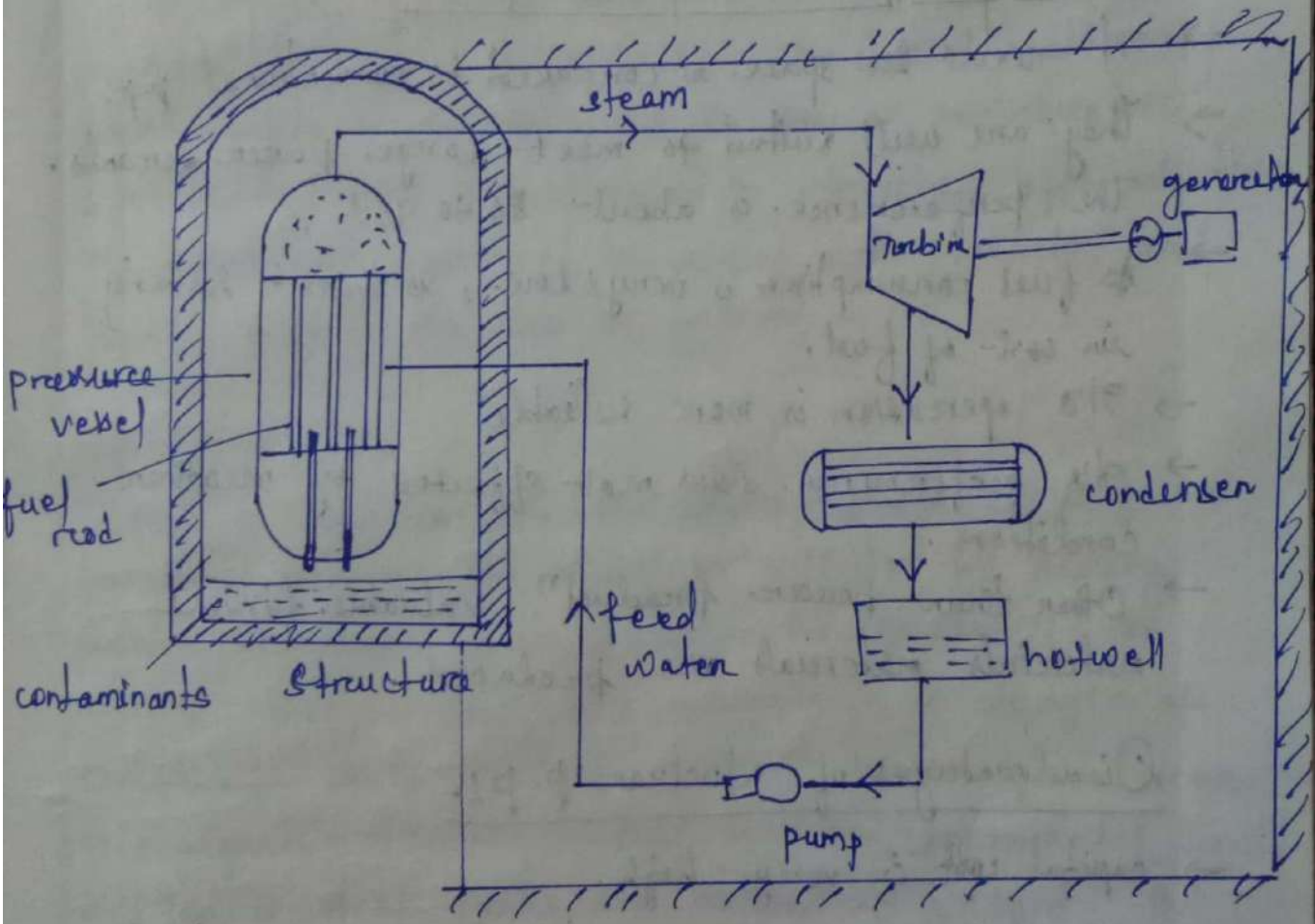
Boiling Water Reactor (BWR)

Here enriched fuel is used, Arrangement of BWR plant is simple than PWR. Here the steam is allowed to generate directly in the reactor.



Advantages

- As the steam is directly generated in the reactor thermal efficiency is higher than PWR.
- Capital cost is lower as the reactor vessel is designed to take low stress.
- The no. of equipment req is less.
- It is more stable than any reactor and rate of steam generation is also high.

disadvantages

- Shielding of turbine & other components is necessary as radioactive steam enters in to the turbine.
- The vessel should be largeer.

Advantages of nuclear power plant:-

→ It needs less space as compared to conventional p.p.
→ They are well suited to meet large power demands. The perfarmence is about 80 to 90%.
→ Its fuel consumption is very low, so there is saveing in cost of fuel.
→ It's operation is more reliable.
→ It's perfarmence does not effected by weather conditions.
→ Other than power product, valuable fissible materials materials are produced.

Disadvantages of Nuclear p. p:-

→ capital cost is very high.
→ The dangere of radioactivity always persist in the nuclear stations.
→ These plants can not be operated on varying load efficiently.
→ Maintenance cost is high.
→ Disposal of fission produces is a big problem.
→ Working conditions in nuclear power station are always dangerous for health of workers

DIESEL ENGINE POWER PLANT

A Diesel engine is the prime mover in diesel power plants. The combustion products generated by burning of diesel in the cylinder, act as the working medium. The crankshaft converts reciprocating motion of piston in to rotary motion of the shaft which drives the alternator. For maintaining continuous supply of electricity such as hospital, telephone, exchanges, radio stations etc. diesel power plant work as stand by unit. They also act as mobile power plant. The capacity is 2 to 50 MW.

Advantages

- They have simple design & layout.
- Can respond to varying loads without any difficulty.
- Occupy less space.
- They can be taken to & installed at any place.
- Diesel sets are readily available in various capacities.
- Starting time is less.
- Require less quantity of water for cooling.
- The overall cost is much less than that of steam power station of the same capacity.
- Thermal efficiency of diesel powerplant is higher than that of a steam power plant.
- It require less operating staff.
- Lubrication system is more economical than steam power station.

Disadvantages

- High running cost as diesel is a costly fuel.
- High maintainance & lubrication cost.
- Noise is a serious problem.
- Not economical where fuel to be imported.
- Life of these plants is quite small as compared to steam power plant.

Application

- Mobile plant
- Stand by units
- Emergency plants
- Starting stations
- central stations
- Industrial purpose.

Site selection Factors

- Availability of water
- Distance from @ load centers → Reduces the cost of transmission.
- Fuel transportation → nearer to fuel source
- Foundation on soil →
- Access to the site.

Main components of Diesel power plant

- Engine
- Air intake system
- Exhaust "
- fuel "
- cooling "
- Lubrication "
- Engine starting system
- Governing system.

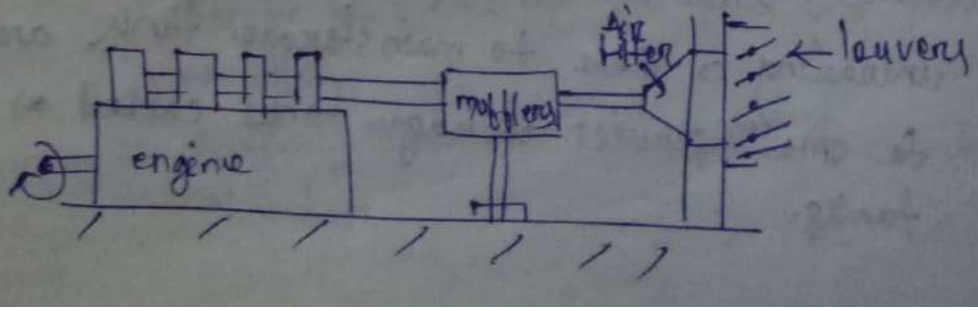
1) Engine

It is the main component of the plant which developes the required power. It is coupled directly with the generator.

2) Air intake system

Air is necessary for combustion of fuel is supplied by the air intake system. It consist of pipes or ducts for supply of fresh air to the engine intake manifold.

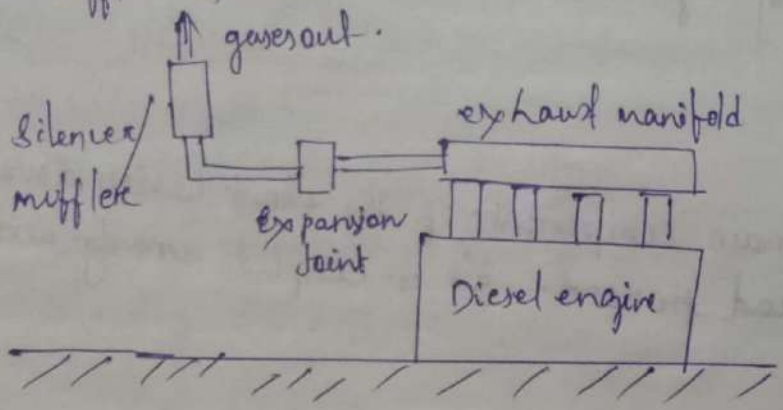
- The air system begins with an intake located outside the building provided with filters to catch dirt particles from air, which would otherwise causes excessive wear in the engine. Some time electrostatic precipitators are also used.



Air intake system should be located inside the engine room.

3) Exhaust system

The purpose of the exhaust system is to discharge the engine exhaust to the atmosphere outside the building. The exhaust manifold connects the engine cylinders exhaust outlets to the exhaust pipe which is provided with a muffler to reduce noise.



The exhaust pipe leading out of the building should be short in length with minimum no. of bends. & should have flexible tubing. The waste heat is utilised further in different applications like water heating, Air preheating etc.

4) Fuel system

The fuel oil may be delivered at the plant side by trucks, railroads tank cars or tankers. From here unloading is done to main storage tanks and then to small service storage tanks called as engine day tanks.

→ The tank should contain manhole for internal access & repair. Here fill lines are used to receive oil, vent lines to discharge vapours, overflow return lines for controlling oil flow and a suction line to withdrawn oil.

→ Day tank supply the daily fuel need of engine & may contain minⁿ of about 8 hrs of oil requirement to the engine. These tanks are usually placed high so that oil may flow to the engines under gravity. minⁿ storage capacity of atleast 1 month requirement is kept in bulk.

→ It consist of a storage tank, strainers & injectors. The fuel is passes through strainers to remove suspended impurities to avoid blockages of the injector. Clean oil is injected into the engine with the help of fuel injector.

5) Fuel Injection System

The heart of a diesel engine is the fuel injⁿ system. A very small quantity of fuel must be measured, injected, atomised and mixed with air.

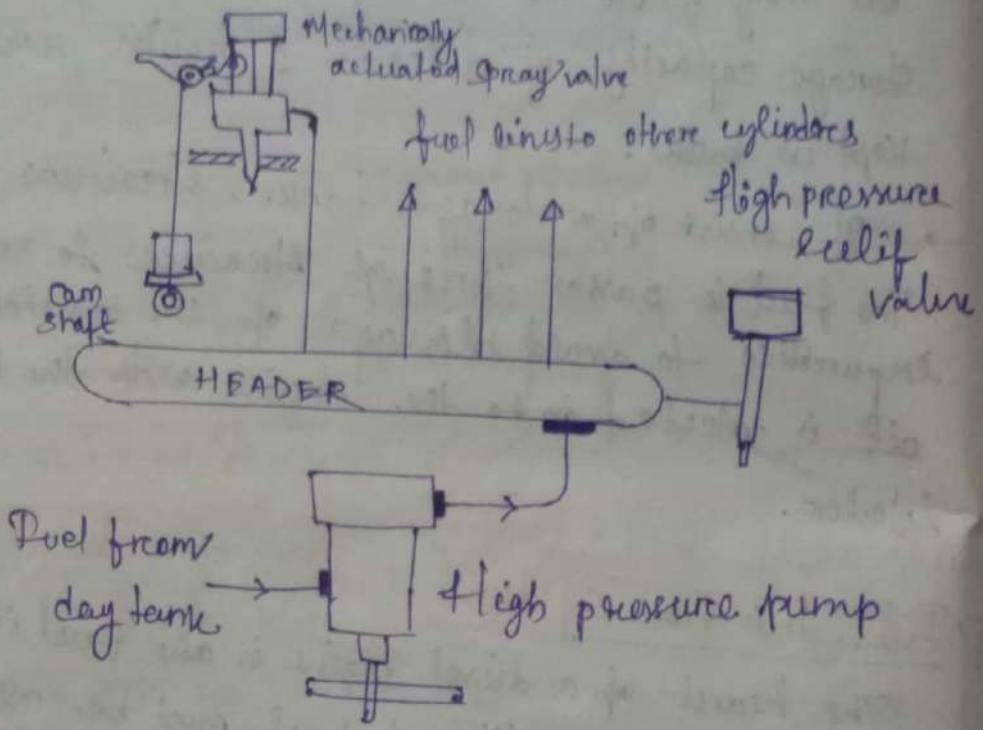
Functions

- filter the fuel
- Measure the correct quantity of fuel to be injected.
- Control the rate of fuel injection.
- Atomise or break up the fuel into fine particles
- properly distribute the fuel in combustion chamber.

Types

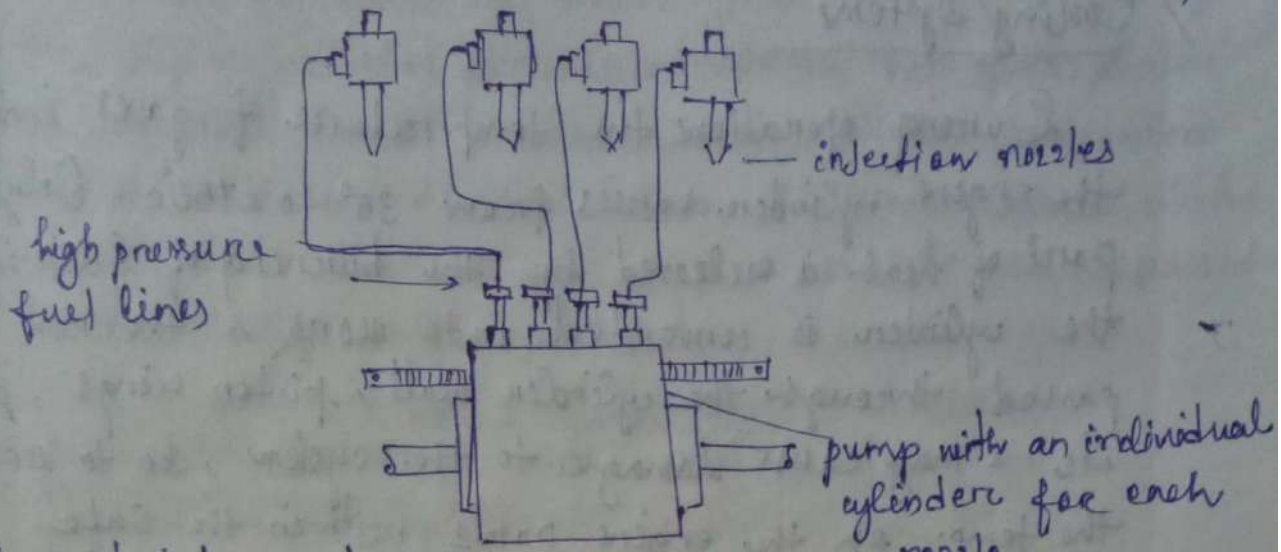
a) common rail injection system

A single pump supplies high pressure fuel to header a relief valve holds pressure constant. The control needge adjust the lift of the mechanical operated valve to set amount & time of injection.



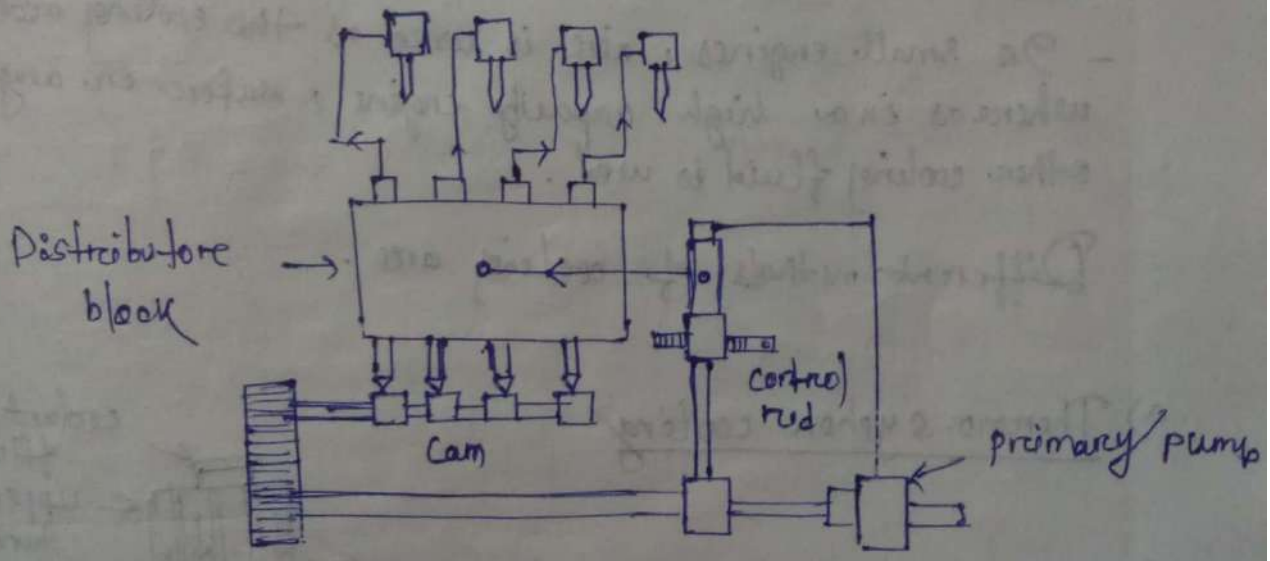
b) Individual pump injection system

In this system an individual pump are cylinder connects directly to each fuel nozzle. Pump meter charge and control injection timing. Nozzle contain a delivery valve controlled by fuel oil pressure.



9 Distributor System

In this system, the fuel is metered at a central point a pump pressurises, meters the fuel & times the injection. From there, the fuel is distributed to cylinders in correct firing order by cam operated valves which open to admit fuel to the nozzles.



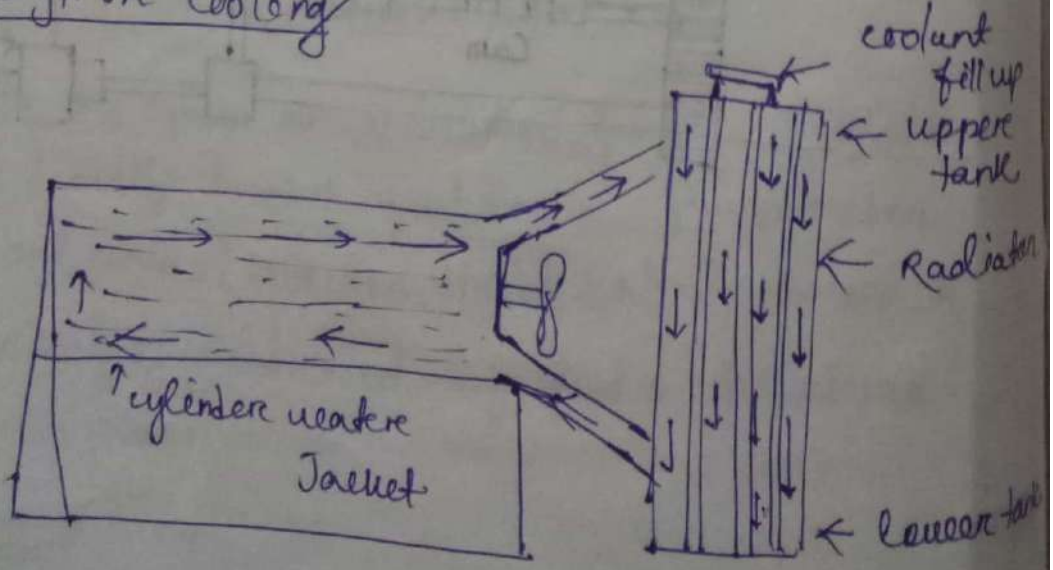
6) Cooling system

During operation the temperature of gases inside the engine cylinder varies from 35° to 2750°c. Only a part of heat is released by the burning of fuel in the cylinder is converted into work & the rest is passed through the cylinder wall, piston rings, etc & may cause damage to the system, so to keep the temp. of the engine parts with in the safe operating limits cooling is provided.

- Thus cold water is circulated through the cylinder & heat Jacket. The water takes away heat from engine & becomes hot. To re-circulate the same water again for cooling, it is sent to the cooling towers / ~~radiations~~ radiators.
- In small engines, air is used as the cooling medium whereas in a high capacity engine, water or any other cooling fluid is used.

Different methods of cooling are.

a) Thermo-syphon cooling



The above fig shows the thermosyphon cooling arrangement. The top of radiator is connected to the top of radiator is connected to the top water jacket. and bottom of the radiator to the bottom of water jacket. while travels down the radiator across which air is passed to cool it, by the fan provided.

- This system is simple & automatic.

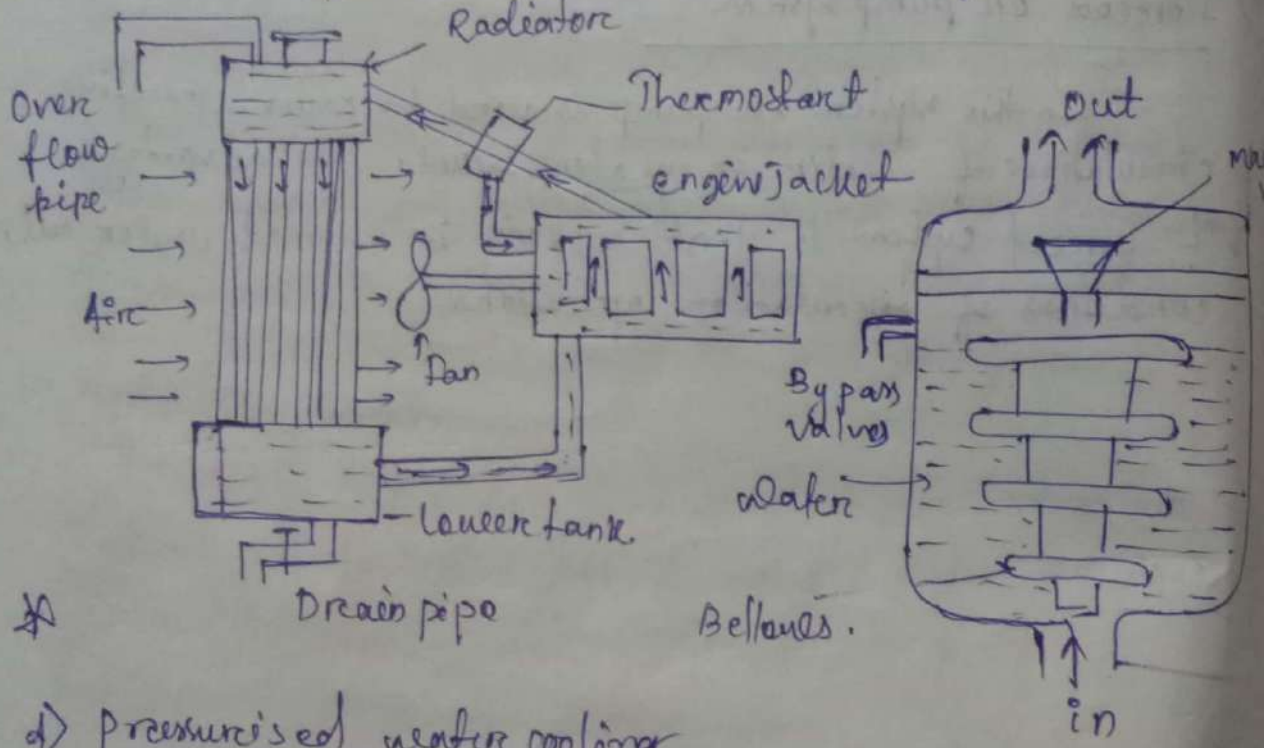
b) Forced or pump system

In this system, a pump is used to cause positive circulation of water in water jacket. The advantage of forced system is that cooling is ensured under all conditions of circulation operation.

c) Thermo-stant cooling

Most modern cooling system employ a thermo-static device which prevents the water in the engine jacket from circulating through the radiator for cooling until its temperature has reached to a value suitable for efficient engine operation.

A typical thermostart consists of bellows which are m
of thin copper tubes, partially filled with volatile liqu
like methyl alcohol. These liquid changes into vapo
at the correct working temp, thus creating enou
pressure to expand the bellows. The movement of t
bellows opens the main valve ~~in~~ with respect to
temp rise, maintaining the flow of water from en
to the radiator. Hence when the normal temp has be
reached the valve opens & circulation of water commen



d) Pressurised water cooling

The boiling of the coolant can be increased by increasing its pressure. Here pressurised water is used for cooling whose pressure is about (1.5 bar to 2bar)

7) Lubrication System

- This system minimises the wear & tear of the rubbing surface of the engine. It consist of lubricating oil tank, pump, filter & oil cooler. The lub. oil is drawn from the oil tank by the pump & is passed through a filter to remove impurities. Clean lub. oil is delivered to the points which req. lubrn. To keep the temp. of the oil low, oil coolers are used.

- The components of engine which req. lubrication are crankshaft bearings, gudgeon pin, piston rings, cylinder walls, cam shaft, valve mechanism etc.

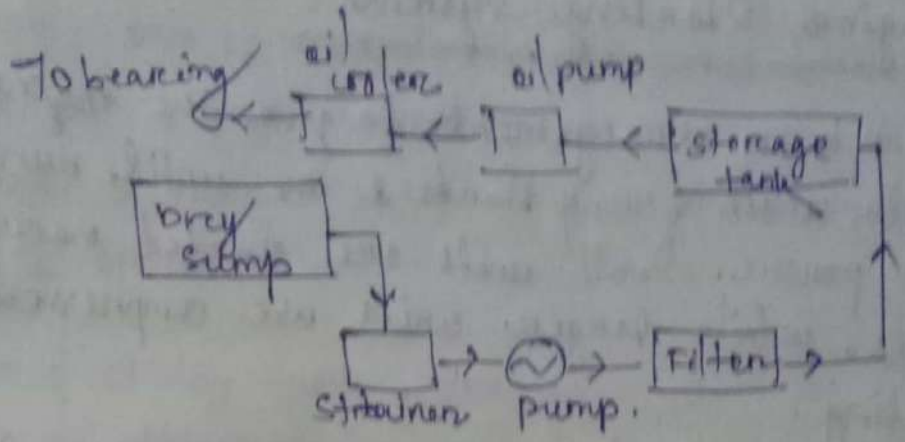
Some imp. lubrn system are.

a) Mist lubrication

This system is used for 2-stroke engine. These engines are lubricated by adding 2 to 3% of lub. oil in the fuel tank. The oil & the fuel mixture is inducted through the carburettor. The gasolin is vaporised, & the oil in the form of mist goes into the cylinder. The oil which penetrates in the crankcase walls lubricates the main & connecting rod bearing. & rest of oil passes to the cylinder during charging, lubricates the piston, piston rings & the cylinder

b) Dry Sump lubrication system

In this system, the oil from the sump is carried to a separate storage tank outside the engine cylinder block. The oil from the sump is pumped by means of pump through filters to storage tank, From storage tank pumped to engine cylinder. used in high capacity engine

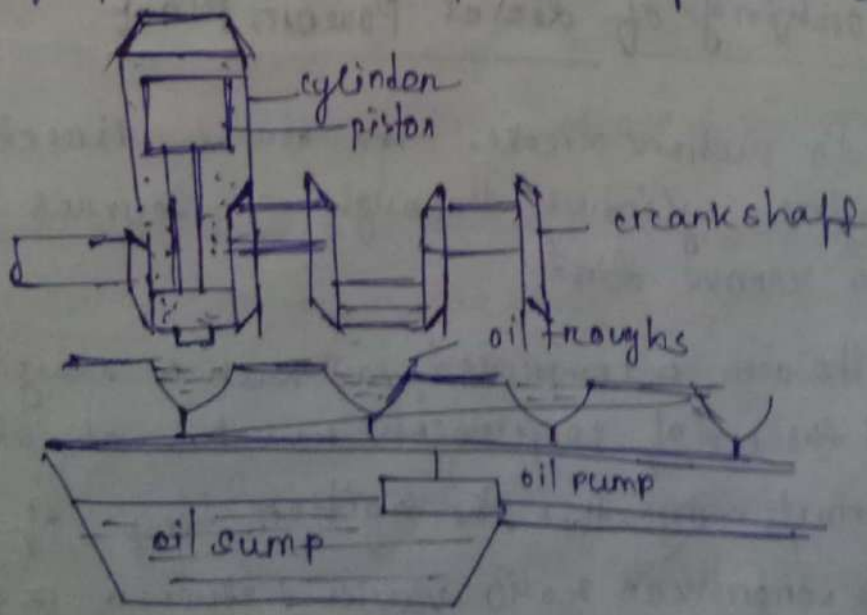


c) wet sump lubrication

This system uses a large oil sump at the base of crank chamber, from where oil is drawn by a low pressure pump & delivers it to various parts.

a) splash lubrication system

It is used in small 4-s engine. It is suitable for low & medium speed engines having moderate bearing load pressure. When the connecting rod is at lowest position, it get dipped into the oil troughs & thus direct oil goes to the big end bearing. Due to splash of oil it reaches the upper portion of the cylinder walls & other req. position. Then extra oil flows back to the oil sump.



8) Engine Starting System

- This is an arrangement to give the engine an initial start, until firing starts & the until runs with its own power. Small units are started manually by hands, while largers units use compressed air for starting.
- Commonly used engine starting system are

a) starting by an auxilary engine
b) By use of electric motor or self starter.
c) By compressed air system.

9) Governing System

The function of governing system is to maintain the speed of the engine constant irrespective of load on the plant. This is done generally by varying the fuel supply to the engine according to the load.

Working of diesel Power Plant

- In suction stroke, the air is directed into the engine cylinder through a louvres & air filters to remove dirt.
- The air is compressed in such a way that the temp at the end of compression reaches about 500°C which is much more then the ingition temp. of diesel (350°C). The compression ratio varies between 15 to 22 & results in 40 bar pressure.

- Fuel is delivered at the plant site by trucks, railways. ~~oooo~~ is unloaded to the main fuel tank or storage tank, from where it is pumped to engine day tank & here it is stored for approximately 8 hours of operation.
- From fuel day tank, the oil is sent to the fuel filter which removes unwanted particles & dirts.
- Now the fuel injection pump, atomizer, vaporizes & pump at high pressure to the combustion chamber. The fuel injection ensures to break down of fuel in to small droplets i.e it is atomized properly & distributed evenly in the cylinders.
- The heat of the compressed air vaporises the fuel from the surface of the droplets. The vapours are then ignited by heat of compressed air in to combustion chamber.
- The combustion gases push the piston downward & the crankshaft connected with piston rotates the shaft. The generator converts the shaft power into electrical power.
- Lubricating oil from the oil tank passes through oil filter before it is sent to the engine bearings. After filtration, the oil pases through an oil cooler & then pumped to main bearings for lubrication.
- The cylinder & its head are enclosed in water jackets, which are connected to a radiator for cooling. The water flowing in the jacket carries away heat from the engine & becomes heated. the hot water then flows to the radiator & gets cooled ~~oooooo~~ by releasing heat to air from radiator walls cooled water is again circulated in water jacket.

HYDEL POWER PLANT

A hydel power plant utilises the energy of water to drive the turbine which runs the generator to produce electricity. About 20% of total power need of world is met by this renewable & naturally available source.

Advantages

- No fuel charges.
- As hydro-electric plant is highly reliable.
- Maintainance & operation charges are very low.
- Running cost of plant is low.
- The plant has no stand by losses.
- The plant efficiency does not change with age.
- It takes few minutes to run & synchronise the plant.
- Less supervising staff required.
- No fuel transportation problem.
- No ash problem & atmosphere is not polluted since no smoke is produced.
- These plants are also used for flood control & irrigation.
- Long life like 100-125 years.
- The m/c used in hydro-electric plants are more robust and generally run at low speed at 300 to 400 rpm.
- The cost of land is not major problem since these plants are located away from developed areas.

Dis advantage

- The initial cost of plant is very high.
- It takes a long time to set up such plant.
- As they are situated away from locality so cost on transmission is more as well as ~~load~~ losses is also more.
- It completely depends upon the water availability (or) natural phenomenon of Rain.

Selection of site

The following factors should be considered while selecting a site for hydro-electric plant.

- Availablity of water
- Water storage
- Water head - should be high
- Accessibility of the site
- Distance from the load centre
- Type of the land of the site → should be cheaper rocky

Classification of Hydroelectric plants

1) Acc to availability of head
   - High head (100 m or above) - pelton
   - Medium " (30m - 100m) - Francis
   - Low " (less than < 30m) - Francis & kaplan

2) Acc to the nature of load

i) Base load plant → These are req to supply const. power to the grid. They run continuously without any interruption & are mostly remote control.

ii) Peak load plant → Only work during peak load demand. ~~Thermal stations work with hydel plants~~ Such plants supply the power during average as well as peak load. The run of river plants may be made for the peak load.

3) Acc to discharge quality

i) pumped storage plant — Water is stored in tail race reservoir, when demand is low, water is pumped to head reservoir of when demand is high the stored water is used to produce shaft work by turbine.

ii) Run-off river plant — They store a few hour's supply of water so that when river flow exceeds the amount req. by plant, the stored water can be utilised during peak demand.

iii) Storage reservoir - During rainy season, water is stored in the reservoir. It is used during other seasons when flow in river is low.

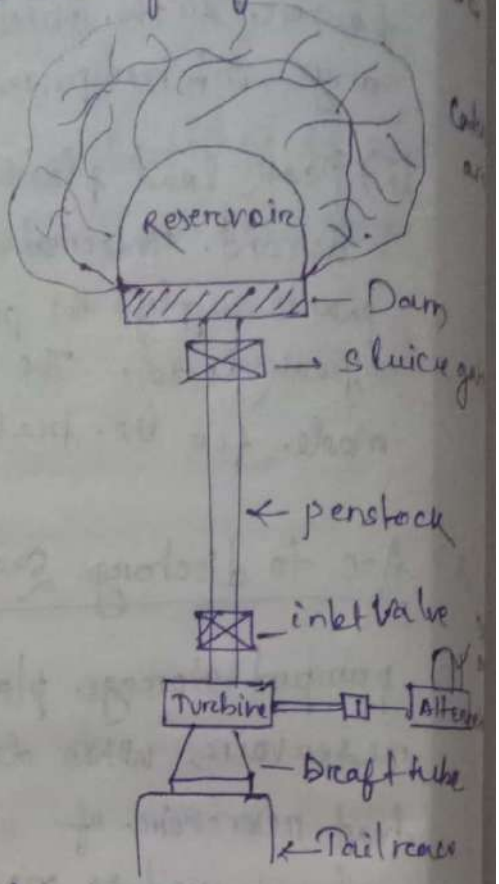
iv) Mini^{m} & micro hydro power -

Mini plant operates with 5m-20m head producing above 1 MW - 5MW of power & micro plant work under head of less than 5m & generates (.1MW to 1MW)

Essential elements of hydroelectric power plant

The following essential elements of hydro-electric power plant.

1. catchment area
2. Reservoir
3. Dam
4. Spillways
5. conduits
6. Surge tanks
7. prime movers
8. Draft tubes
9. power house & equipment.



1. catchment area

The whole area behind the dam draining into a stream or river across which the dam has been built at a suitable place, is called catchment area.

2. Reservoir

The water reservoir is the primary requirement of hydro-electric plant. A reservoir is employed to store water which is further utilised to generate power by running the hydraulic turbines.

- Natural
- Artificial

Water held in upstream reservoir is called storage whereas waters behind the dam is called as pondage.

3. Dam

It is constructed to restrict the water flow from the reservoir and create a water head to increase the energy present in it. It is consist of gates to control the water level. Dam can be of different types like rockfill, masonary, solid gravity, buttress type arc type etc. It develops a reservoir of the desired capacity to store water, It also build up a head for power generation.

4. Spill ways

When water enters to the reservoir, the water level rises. This rise is temporary in nature but excess accumulation of water ~~attracts~~ is a threat to the Sability of the dam structure. To relive the reservoire from excess of water a structure is provided near the dam called as spill ways.

- It should provide structural stability under all conditions.
- It should be able to pass any flood situation.
- It should have effivent operation.

5) Conduits

A headrace is a channel which leads water to a turbine and tailrace is a chanel which conducts water from the wheels. It is of two type

- open conduits
- close "

6) Surge Tanks

A surge tank is a small reservoir or tank in which the water level rises or falls to reduce the pressure. It serves the following purpose.

- To reduce the distance between the free water surface & turbine.
- To reduce the water hammer (variation in pressure rapidly above & below the normal pressure) on penstock.
- Protect the upstream tunnel from high pressure
- Serve as supply tank to turbine.

types → Simple surge tank
Lined " "
Restricted orifice "
Differential "

7) Prime movers

In an hydraulic power plant the prime movers convert the energy of water into mechanical energy & further into electrical energy. These m/c are classified on the basis of the action of water on moving blade. Acc to action of water. there are 2 types

1. Impulse turbine - Here the pressure energy of water is converted in to K.E & passed through the nozzle & forms the high velo jet of water. The water jet is used for driving the wheel.

2. Reaction turbine - In this case the water pressure combined with the velocity works on the runner. The power in this turbine is developed from the combined action of pressure & velo. of water that completly fills the runner & water passage.

8) Draft tube

The draft tube serves the following two purpose.

- It allows the turbine to be set above tail water level without loss of head, to help inspection & maintainance.
- It regains, the maker portion of K.E delivered to it from the runner.
- There are two types of draft tube.
  - The straight conical
  - The elbow type.

9) Power House & Equipments

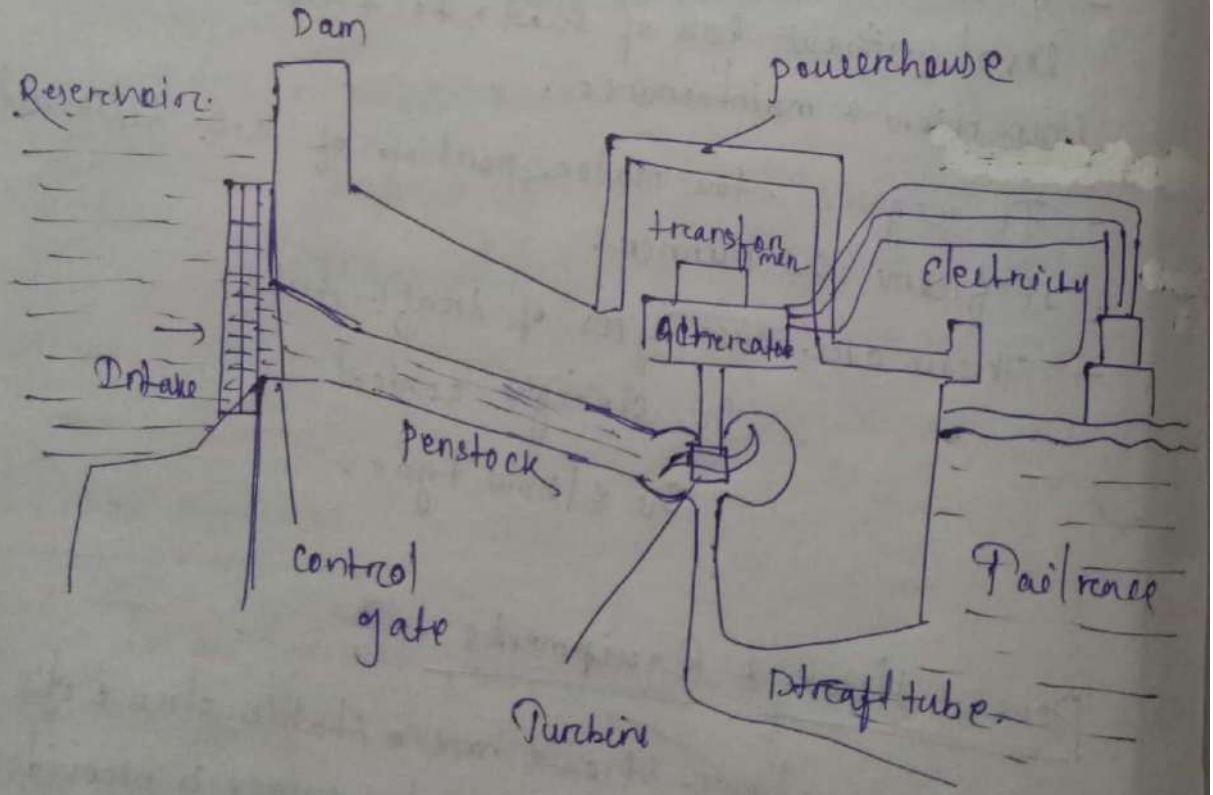
A powerhouse should have a stable structure it's layout should be such that adequate space is provided arround the equipment (such as turbine, generater valves, pumps etc) so that repairing can be easy.

A power house mostly, consist of following subdiv

1. The sub structure - This part of the powerhouse extend from top of generator to bedrock & houses most of the generating equipment.

2. Intermediate structure - It is the part of structure which extends from the top of the draft tube to the top of generator foundation.

3. Super structure - It lies above the generator level It houses mostly the cranes which handle the heavy equipment in the substructure.



layout of Hydraulic power plant

Site selection in detail

Availability of water - It is the most imp criterion. At first the runoff data should be collected. The rain fall pattern is taken into consideration. Estimate should be made about the ava. quantity of water available throughout the year.

Water storage - Since there is a wide variation in rainfall during the year, therefore, it is always necessary to store the water for continuous generation of power. Maxim storage should justify the expenditure on the project.

Water head - In order to generate a requisite quantity of power it is necessary that a large quantity of water at a sufficient head could be available.

Accessibility to the site - The site should be easily accessible. This is important if the electric power generated is to be utilised at or near the plant site. It should have the transportation facilities of rail or road.

Distance from load center. - The powerplant should be set up near the load centre, this will reduce the cost of erection and maintenance of transmission line.

Type of the land on the site - The land to be selected for site should be cheap & rocky. The ideal site [illegible] where the dam will have largest-