POWER

STATION

ENGINEERING

TH.3 POWER STATION ENGINEERING

Name of the Course: Diploma in MECHANICAL ENGINEERING			
Course code:		Semester	6th
Total Period:	60	Examination	3 hrs
Theory periods:	4 P/W	Internal assessment	20
Maximum marks:	100	End Semester Examination:	80

A. RATIONALE:

Bulk powers used in industries and for domestic purposes are generated in power stations. A large number of diverse and specialized equipment and system are used in a power plant should have this important subject in mechanical engineering.

B. COURSE OBJECTIVES:

At the end of the course the students will be able to:

- Understand the generation of power by utilizing various energy sources.
- Understand the use of steam, its operation in thermal power stations.
- Understand the nuclear energy sources and power developed in nuclear power station.
- Understand the basics of diesel electric power station and hydroelectric power station.
- Understand the basics of gas turbine power station
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C.TOPIC WISE DISTRIBUTION OF PERIODS

Sl No.	Topic	Periods
1	**INTRODUCTION**	05
2	**THERMAL POWER STATIONS**	20
3	**NUCLEAR POWER STATIONS**	10
4	**DIESEL ELECTRIC POWER STATIONS**	10
5	HYDEL POWER STATIONS	10
6	GAS TURBINE POWER STATIONS	05

D.COURSE CONTENTS:

1.0 INTRODUCTION:

1.1 Describe sources of energy.
1.2 Explain concept of Central and Captive power station.
1.3 Classify power plants.
1.4 Importance of electrical power in day today life.
1.5 Overview of method of electrical power generation.

2.0 THERMAL POWER STATIONS:

2.1 Layout of steam power stations.
2.2 Steam power cycle. Explain Carnot vapour power cycle with P-V, T-s diagram and determine thermal efficiency.
2.3 Explain Rankine cycle with P-V, T-S & H-s diagram and determine thermal efficiency, Work done, work ratio, and specific steam Consumption.
2.4 Solve Simple Problems.
2.5. List of thermal power stations in the state with their capacities.
2.6 Boiler Accessories: Operation of Air pre heater, Operation of Economiser, Operation Electrostatic precipitator and Operation of super heater. Need of boiler mountings and operation of boiler

2.7 Draught systems (Natural draught, Forced draught & balanced draught) with their advantages & disadvantages.
2.8 Steam prime movers: Advantages & disadvantages of steam turbine, Elements of steam turbine, governing of steam turbine. Performance of steam turbine: Explain Thermal efficiency, Stage efficiency and Gross efficiency.
2.9 Steam condenser: Function of condenser, Classification of condenser. function of condenser auxiliaries such as hot well, condenser extraction pump, air extraction pump, and circulating pump.
2.10 Cooling Tower: Function and types of cooling tower, and spray ponds
2.11 Selection of site for thermal power stations.

3.0 NUCLEAR POWER STATIONS:

3.1 Classify nuclear fuel (Fissile & fertile material)
3.2 Explain fusion and fission reaction.
3.3 Explain working of nuclear power plants with block diagram .
3.4 Explain the working and construction of nuclear reactor .
3.5 Compare the nuclear and thermal plants.
3.6 Explain the disposal of nuclear waste.
3.7 Selection of site for nuclear power stations.
3.8 List of nuclear power stations.

4.0 DIESEL ELECTRIC POWER STATIONS:

4.1 State the advantages and disadvantages of diesel electric power stations.
4.2 Explain briefly different systems of diesel electric power stations: Fuel storage and fuel supply system, Fuel injection system, Air supply system, Exhaust system, cooling system, Lubrication system, starting system, governing system.
4.3 Selection of site for diesel electric power stations.
4.4 Performance and thermal efficiency of diesel electric power stations.

5.0 HYDEL POWER STATIONS:

5.1 State advantages and disadvantages of hydroelectric power plant.
5.2 Classify and explain the general arrangement of storage type hydroelectric project and explain its operation.
5.3 Selection of site of hydel power plant.
5.4 List of hydro power stations with their capacities and number of units in the state.
5.5 Types of turbines and generation used.
5.6 Simple problems.
6.0 GAS TURBINE POWER STATIONS
6.1 Selection of site for gas turbine stations.
6.2 Fuels for gas turbine
6.3 Elements of simple gas turbine power plants
6.4 Merits, demerits and application of gas turbine power plants.

Syllabus covered up to I.A-Chapters 1,2 &3

E.LEARNING RESOURCES:			
Sl. No.	***Name of Authors***	***Title of the Book***	***Name of the Publisher***
1	R.K Rajput	Power Plant Engineering	Laxmi Publication
2	P.K.NAG	Power Plant Engineering	TMH
3	Nag pal G,R	Power plant Engineering	Khanna Publisher
4	P.C.SHARMA	Power Plant Engineering	S.K KATARIA &SONS

PPE

(Power Plant Engineering)

Sources of Energy :-

① **Fuels :**

Solid fuels :- Various solid fuels are wood, coal (bituminous coal, anthracite, lignite) peat.

wood (3000 - 4000 Cal/kg).

Liquid fuels :-

Petroleum & its derivatives (petrol, diesel, kerosene etc).

Gaseous fuels :-

Natural gas, producer gas, blast furnace gas, coal gas etc.

② **Energy stored in water :-**

The potential energy of water at higher level is utilized for generation of electrical energy.

Capital Cost

Capital cost of hydroelectric power plant is higher but running cost is low.

③ ~~Nuclear Energy~~ :-

Wind Power

Wind is a renuable source of energy. Velocity of wind can be utilized to generate small amount of electrical energy.

Eg :- Water pump from deep wells.

Wind turbine.

But wind energy is noisy & large area is required.

In india avg wind speed 10 - 16 km/h.

Modern wind mill have cut in low speed 3 - 7 km/h more efficient at 10 - 12 "

④ Solar Energy :-

The heat energy contained in the rays of sun can be utilised.

- Electric power generation
- Solar water pumps. is used for pumping water

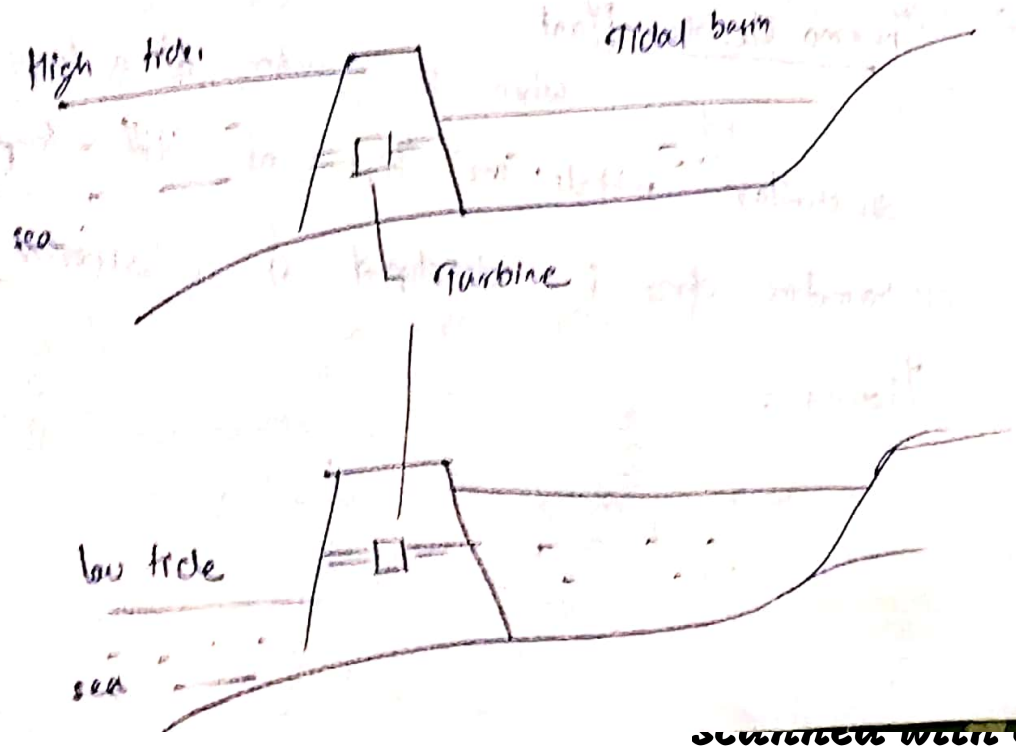
- Solar water heaters used for water heating.
- Solar cabinet type dryers for drying of fruits and food grains.
- Solar kilns for drying wood etc.

Solar energy is available in the day time & can be stored in storage battery.
- It is free from pollution & noise.

(5) Tidal power :-

Ocean waves & tides contains large amount of energy.

In tidal power plant tidal basin is there & turbine generator is used for generating power.



Advantages :-

- There is ~~no~~ cost.
- Does not depends upon rain.
- Free from pollution.
- Less space is required.

Disadvantages :-

- Capital cost is high.
- Supply of power is not continuous
- Away from load centres.

(6) Geo thermal Energy

The earth has a molten core. Due to volcanic action steam vents & hot springs are formed. These natural steam vent is used for generation of plant.

(7) Thermo electric Plant :-

When 2 junctions of a loops of 2 dissimilar metals are kept at diff. temp., an electromotive force is developed. & current starts flowing.

⑧ Nuclear Energy

Heavier unstable atoms such as U^{235}, Th^{232} and Pu^{239} (Plutonium) liberate large amount of heat energy.

1 kg U^{235} = 4500 tonnes of high grade coal.

Captive Power plant

It is used to provide a localised source of power to an energy user.

The plant may operate in grid parallel mode with the ability to exports surplus power to the local electricity distribution network.

Central Power plant :-

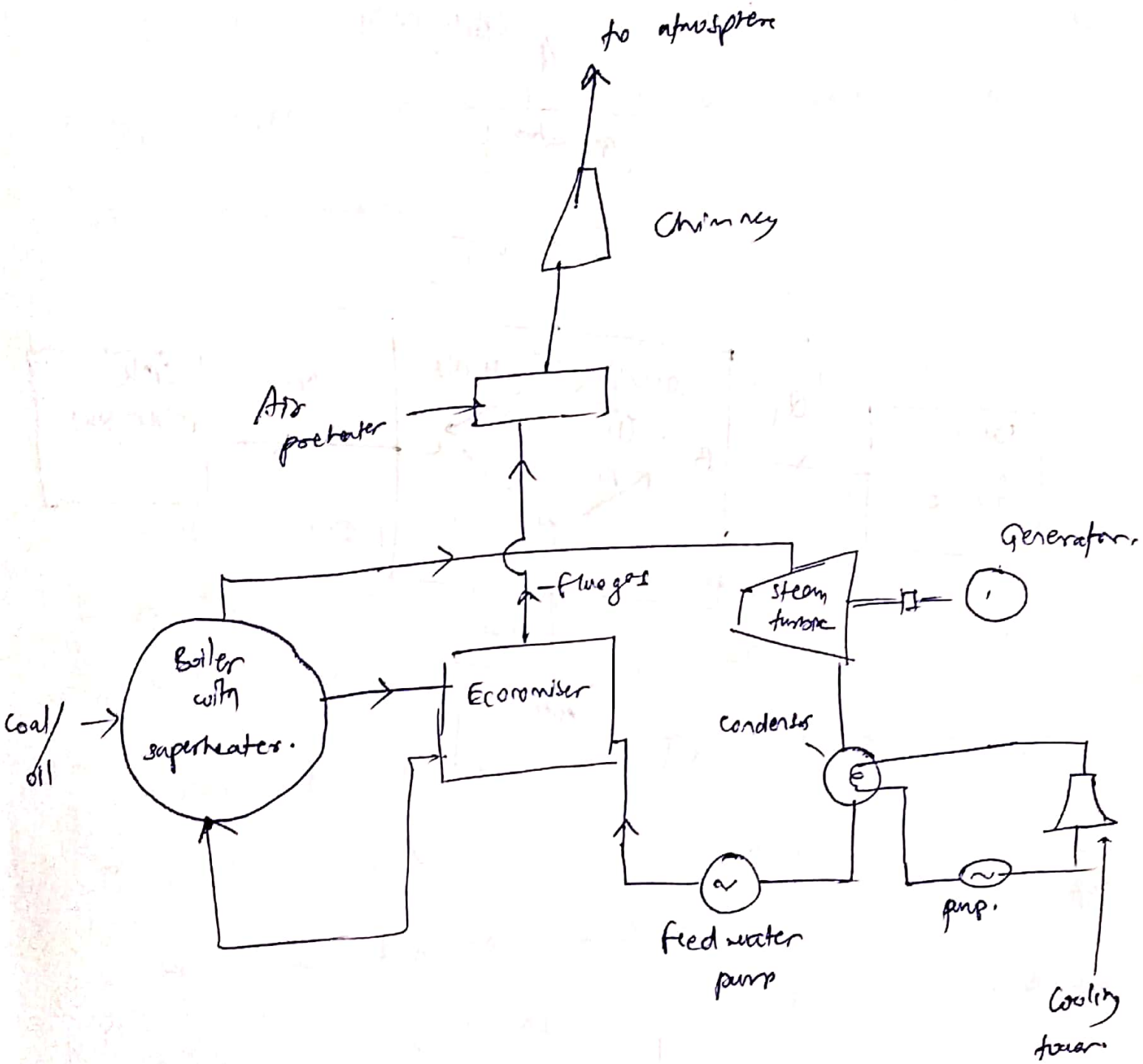
It is the distribution point for campus utilities, including electricity, heat, cooling, natural gas.

It has co generation capacity.

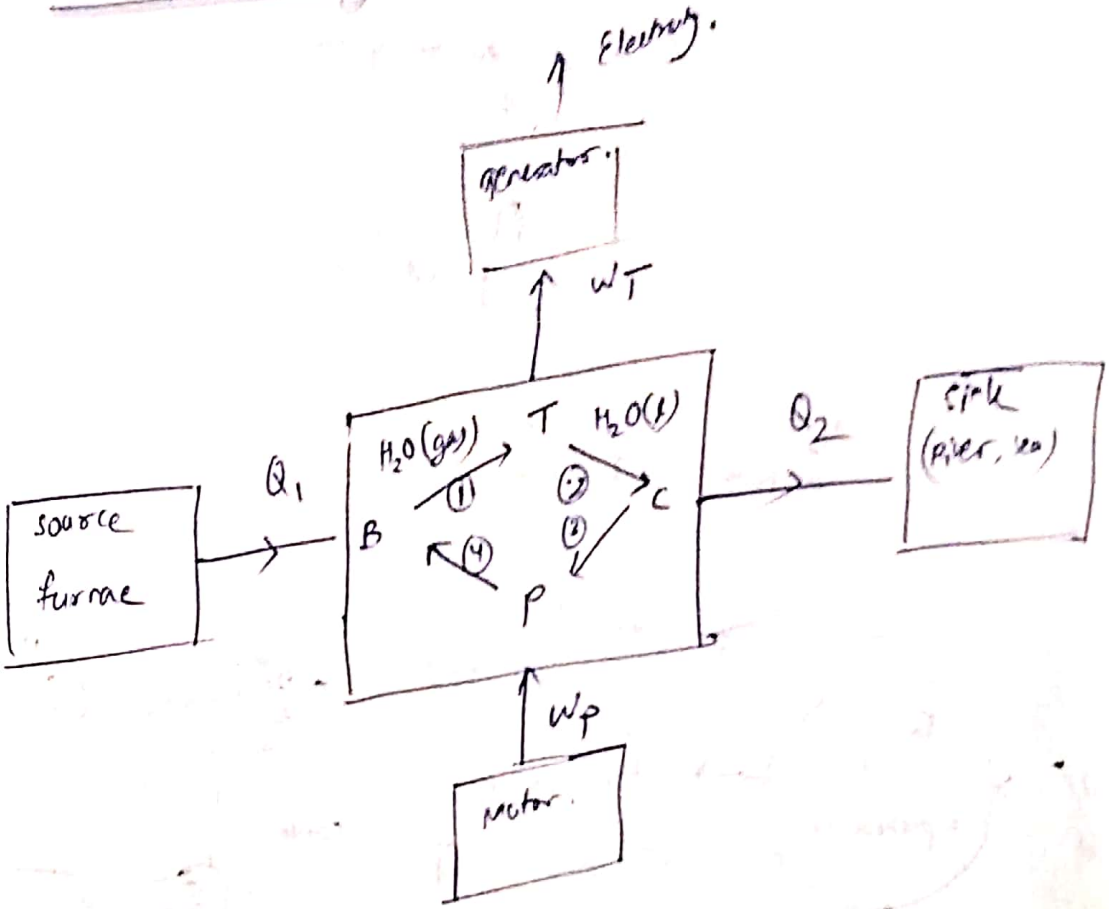
It can produce 30% of campus electricity as a by product of steam production.

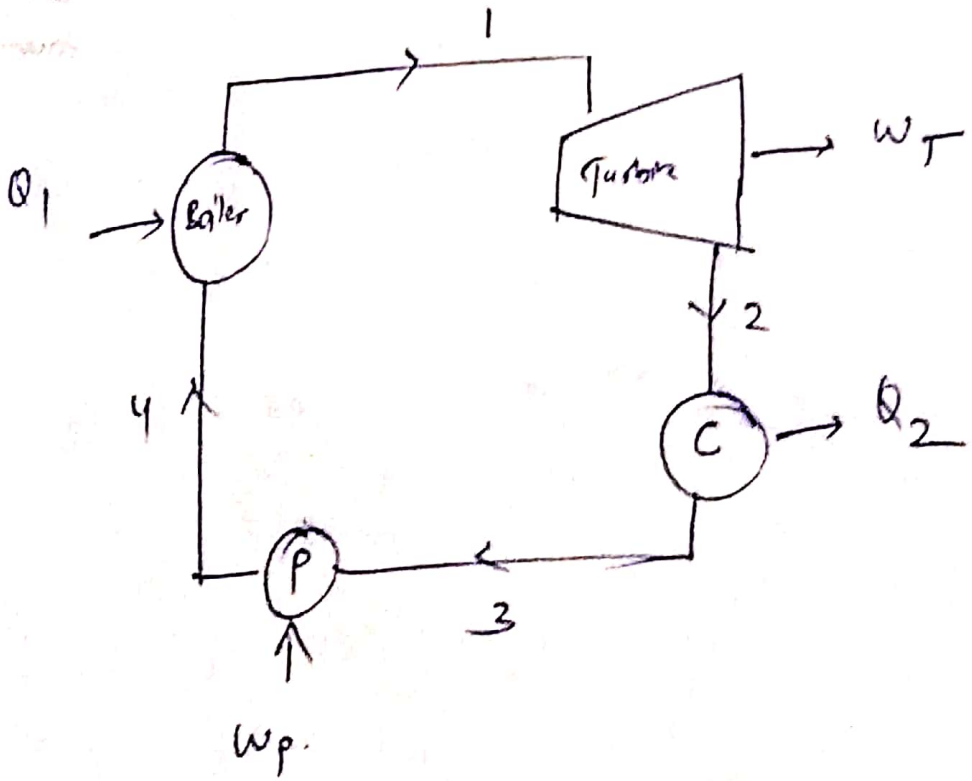
Classification of Power plants

1. On the basis of fuel.
   - i) Steam power plant
     - (a) Condensing P.P.
     - (b) non- " "
   - ii) Diesel P.P.
   - iii) Nuclear P.P.
   - iv) Hydro-electric P.P.
   - v) Gas turbine "
2. On the basis of nature of load.
   - i) Base load. P.P.
   - ii) Peak " "
3. On the basis of location.
   - i) Central power station
   - ii) Isolated " "
4. On the basis of service
   - i) Stationary
   - ii) Locomotive.



Steam Power Cycle :-





A steam power plant continuously converts the energy stored in fuel (coal, oil, gas) into work. & ultimately into electricity.

The working fluid is water, which is in the form of liquid or gaseous state (operation).

The energy released by burning the fuel is transferred to water in boiler (B) to generate steam at a high pr. & temp.

It expands in turbine (T) to a low pr. to produce work.

The steam leaving turbine is condensed into water in condenser (C). Heat is released to sink or river.

Then the water fed back to the boiler by pump (P).

This cycle goes on repeating.

The water flows through B - T - C - P.

Internal energy is constant.

so $\oint dE = 0$.

$$\sum Q_{net} = \sum W_{net}$$

$$Q_1 - Q_2 = W_T - W_p.$$

Q_1 = heat transferred to the working fluid (KJ/kg)

Q_2 = " rejected from " "

W_T = work transferred from the working fluid

W_p = work " into the " "

Efficiency of steam power cycle

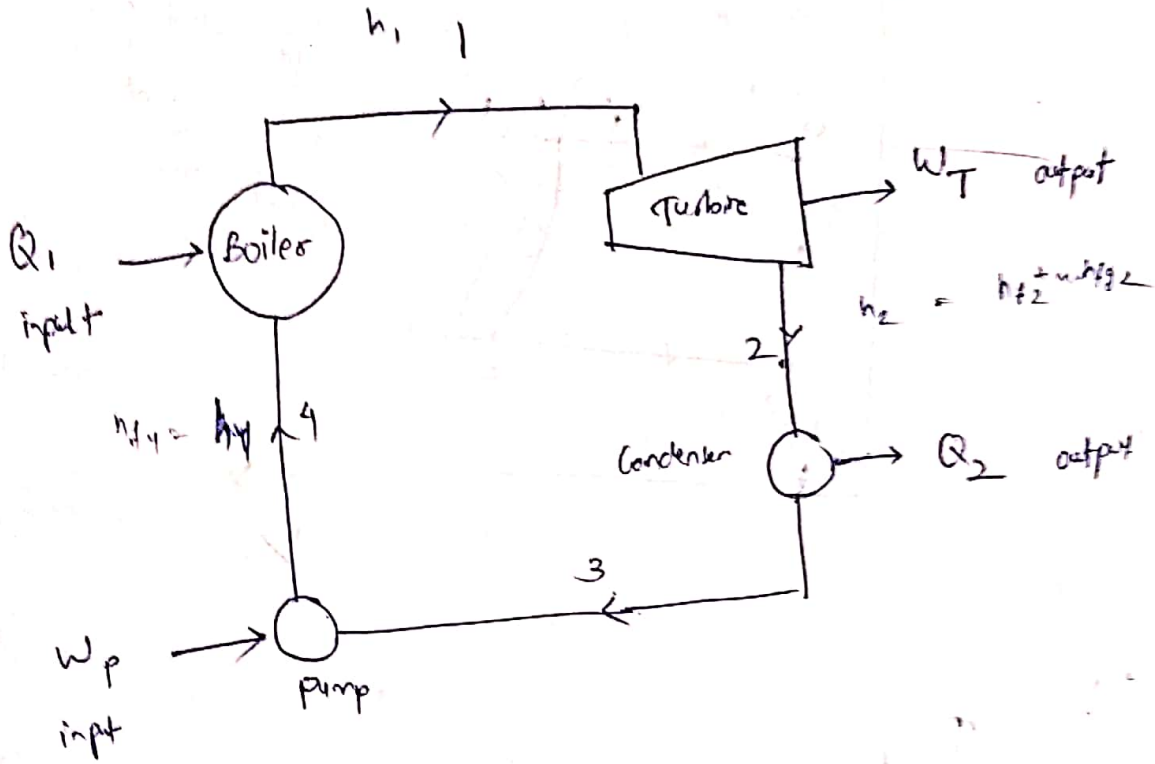
$$\eta_{cycle} = \frac{W_{net}}{Q_1}$$

$$= \frac{W_T - W_p}{Q_1}$$

$$= \frac{Q_1 - Q_2}{Q_1}$$

$$\boxed{\eta = 1 - \frac{Q_2}{Q_1}}$$

Rankine Cycle :-



for the steam boiler it would be a reversible constant heating process. of water to form steam.

(control vol.)

for turbine reversible adiabatic. expansion.

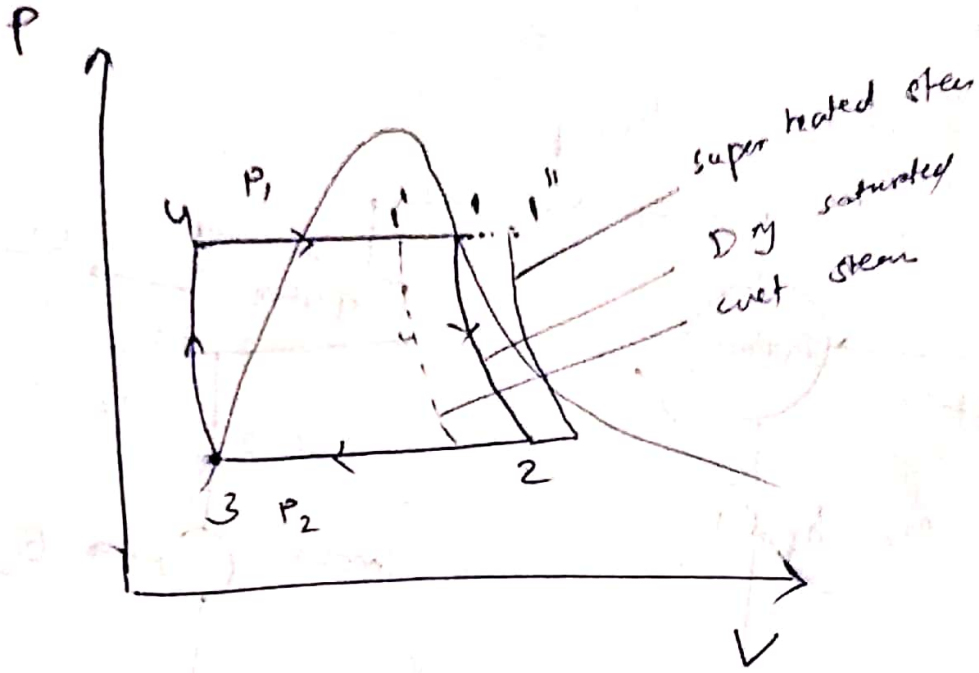
Entropy - temp. is const

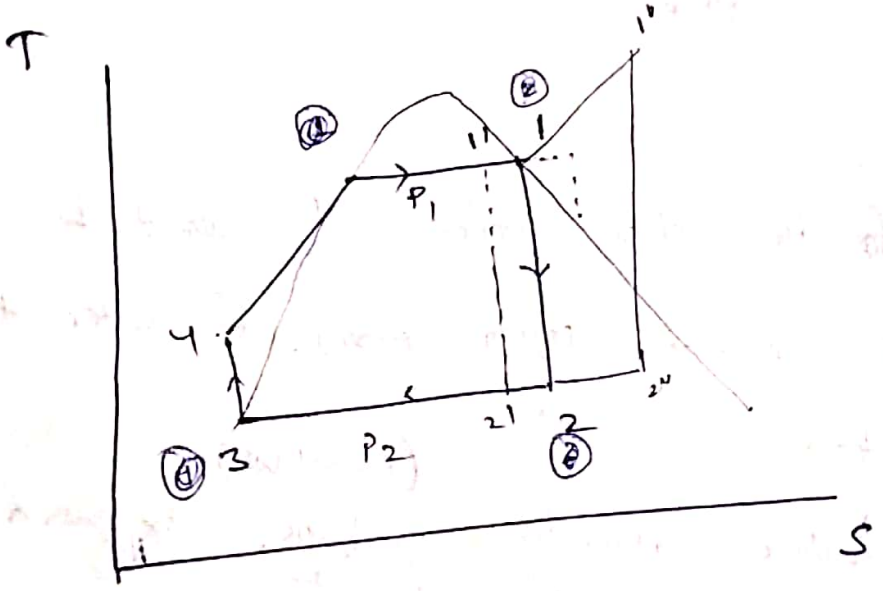
for condenser reversible const pressure heat rejection process.

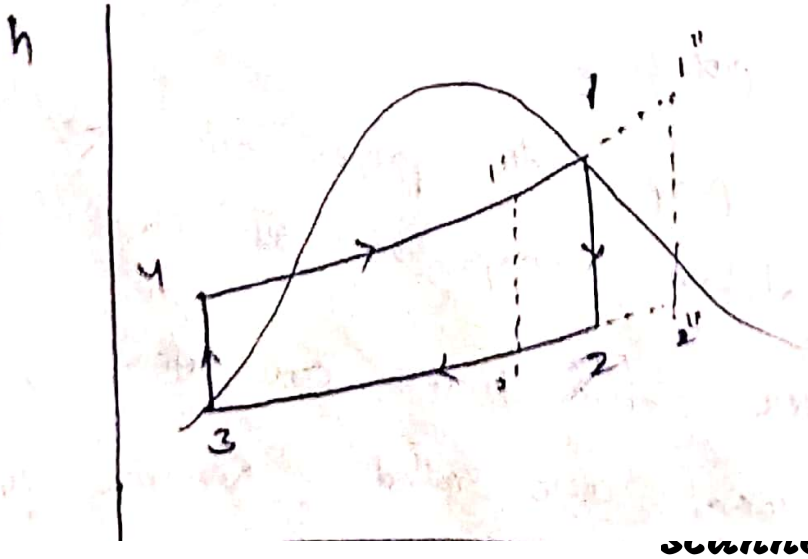
for the pump the process will be reversible adiabatic compression of the liquid.

When all these four process are ideal, the cycle is an ideal cycle called Rankine cycle.

This is a reversible cycle.







Process 1-2 - Reversible adiabatic expansion (Turbine)

" 2-3 - constant pr. heat transfer (condenser)

" 3-4 - Reversible adiabatic pumping process (pump)

" 4-1 - constant pr. transfer of heat (boiler)

[Enthalpy $h = u + pv$; Entropy $S = \frac{dQ}{T}$] u = internal energy.

Applying steady flow energy eqn.

For Boiler

$$h_4 + Q_1 = h_1$$

$$Q_1 = h_1 - h_4$$

Turbine

$$h_1 = W_T + h_2$$

$$W_T = h_1 - h_2$$

Condenser

$$h_2 = Q_2 + h_3$$

$$Q_2 = h_2 - h_3$$

Pump

$$h_3 + W_p = h_4$$

$$W_p = h_4 - h_3$$

Thermal efficiency of Rankine cycle

$$\eta = \frac{W_{net}}{Q_1} = \frac{W_T - W_p}{Q_1} = \frac{(h_1 - h_2) - (h_4 - h_3)}{h_1 - h_4}$$

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

As compare to turbine, the pump work is small.

so it can be neglected.

$$\eta = \frac{h_1 - h_2}{h_1 - h_4}$$

$$\eta = \frac{h_1 - h_2}{h_1 - h_{f2}}$$

$$\text{work Ratio} = \frac{W_{net}}{W_T}$$

$$= \frac{W_T - W_p}{W_T}$$

$$= 1 - \frac{W_p}{W_T}$$

$$= 1 - \left(\frac{h_4 - h_3}{h_1 - h_2}\right)$$

Specific steam consumption or

$$\text{the steam rate (S.R)} = \frac{1}{W_{net}} \left(\frac{kg}{kW_s}\right)$$

$$\text{H.R Heat Rate} = \frac{Q_1}{W_T - W_p} = \frac{1}{\eta} \left(\frac{kJ}{kW_s}\right)$$

Reheat cycle

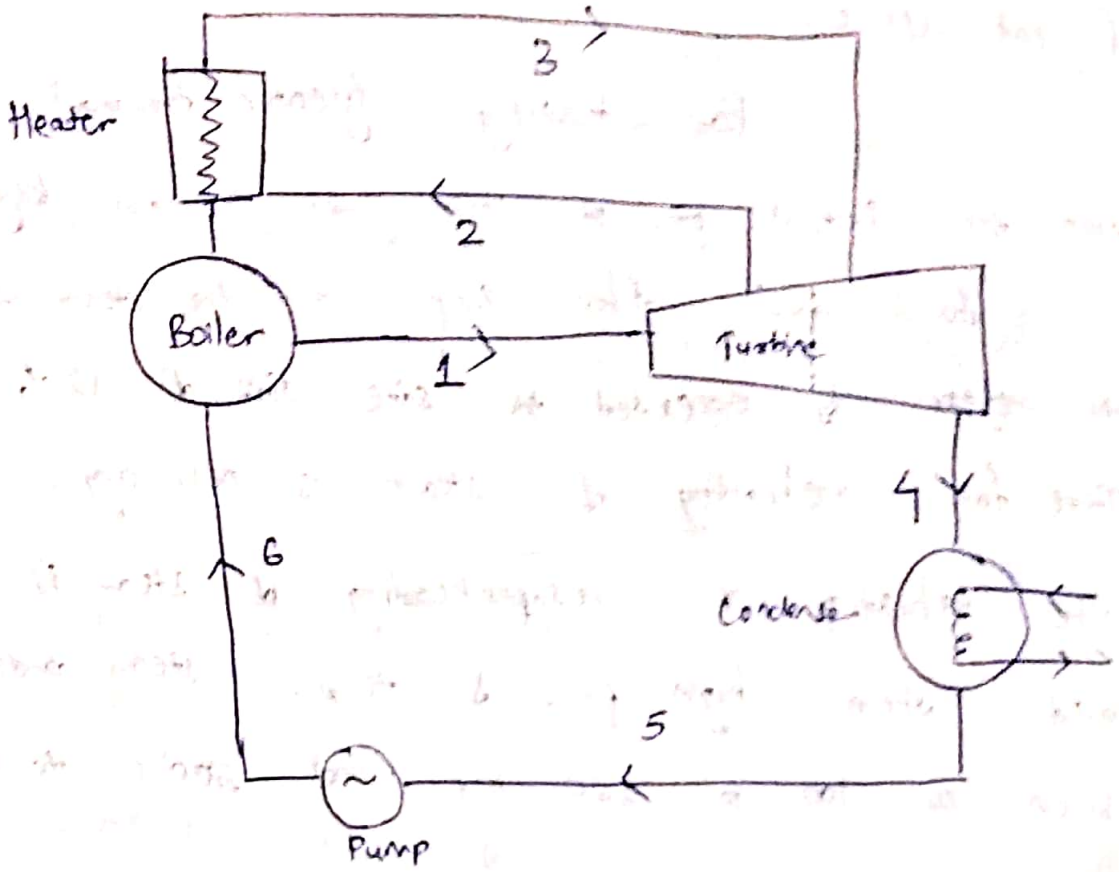
for attaining greater thermal efficiency when the initial pr. of steam was raised beyond 42 bar it is found that, after expansion the steam condition was wetter & exceeded the safe limit of 12%. Therefore reheating of steam is necessary.

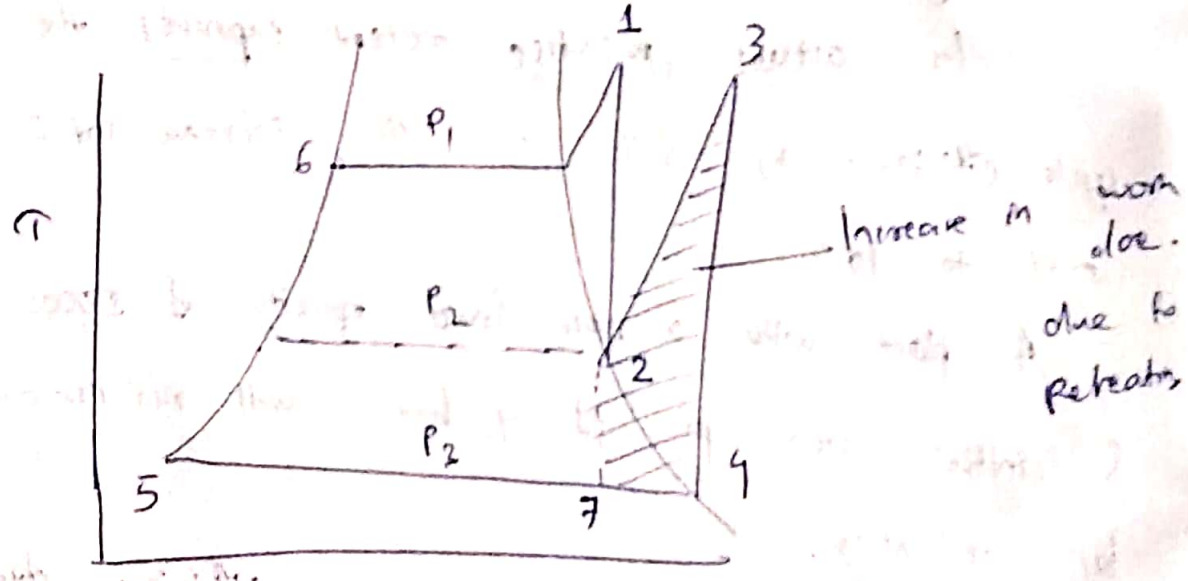
The reheating or resuperheating of steam is now used when high pr. & temp. steam condition such as 100 to 250 bar and 500°C to 600°C. are employed.

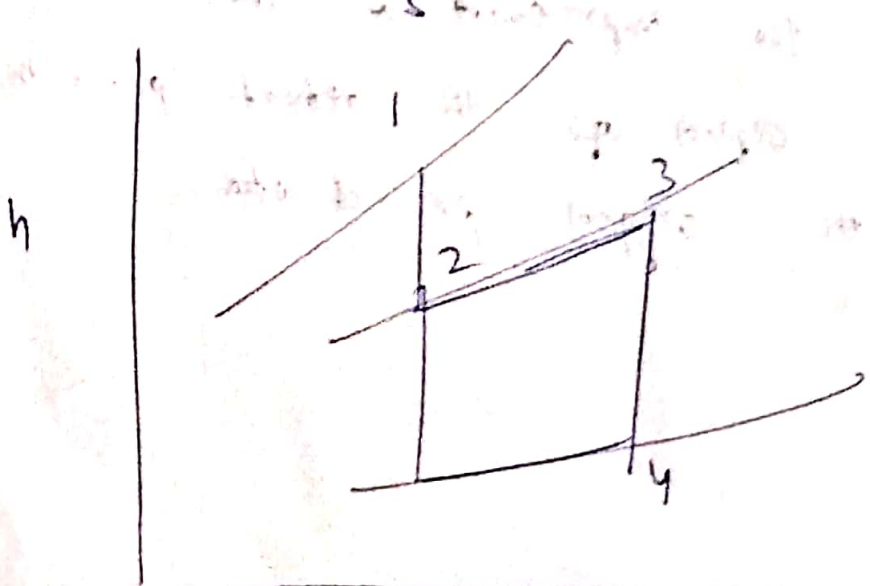
In actual practice reheat improves the cycle efficiency by 5%. The increase set is 5% to 10%.

A plant with a base load capacity of 50,000 kw & initial steam pr. of 42 bar will run economically by reheating.

The improvement of thermal efficiency due to reheat depends upon the reheat pr. with respect to the original pr. of steam.







Heat supplied $= (h_1 - h_{f4}) + (h_3 - h_2)$

Heat rejected $= h_4 - h_{f4}$

Work done by turbine = Heat supplied − Heat rejected

$= (h_1 - h_{f4}) + (h_3 - h_2) - (h_4 - h_{f4})$

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

$$\eta_{thermal} = \frac{(h_1 - h_2) + (h_3 - h_4)}{(h_1 - h_{f4}) + (h_3 - h_2)}$$

$$w_p = \frac{v_f (P_1 - P_2)}{1000} \quad kJ/kg.$$

$$\eta = \frac{(h_1 - h_2) + (h_3 - h_4) - w_p}{(h_1 - h_{f4}) + (h_3 - h_2) - w_p}$$

Efficiency without reheat

$$\left(\eta = \frac{h_1 - h_7}{h_1 - h_{f4}}\right) \quad (\because h_{f4} - h_{f7})$$

Regenerative cycle

In Rankine cycle, the condensate (liquid) is at a low temperature, which mixed with hot boiler water, irreversibly. It results in decrease in efficiency. So the condensate water is heated before feeding to the boiler. This heating method is called regenerative feed heating & the cycle is called regenerative cycle.

Steam is extracted from turbine at several locations & it is supplied to the regenerative heaters.

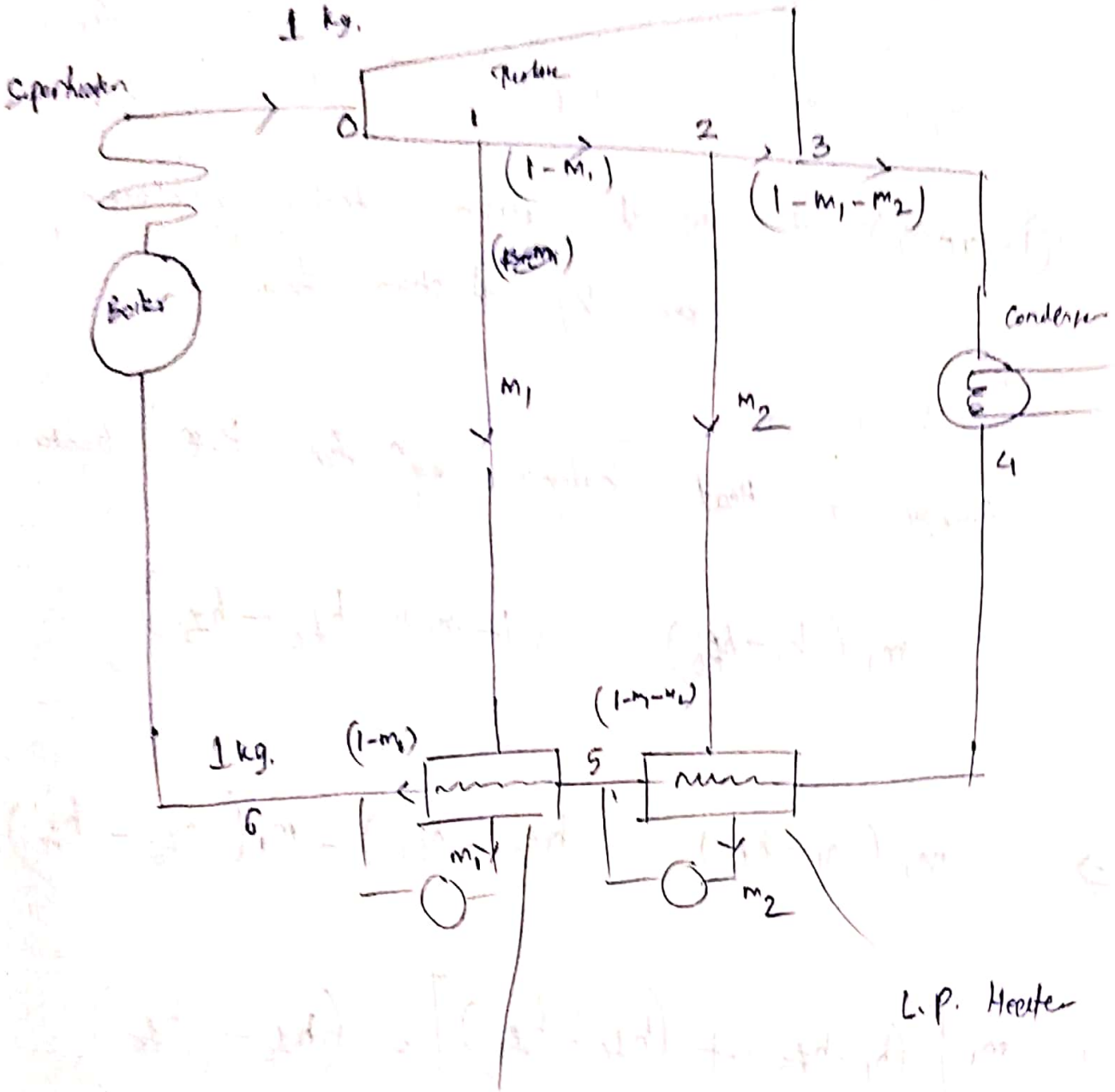
Heating arrangement

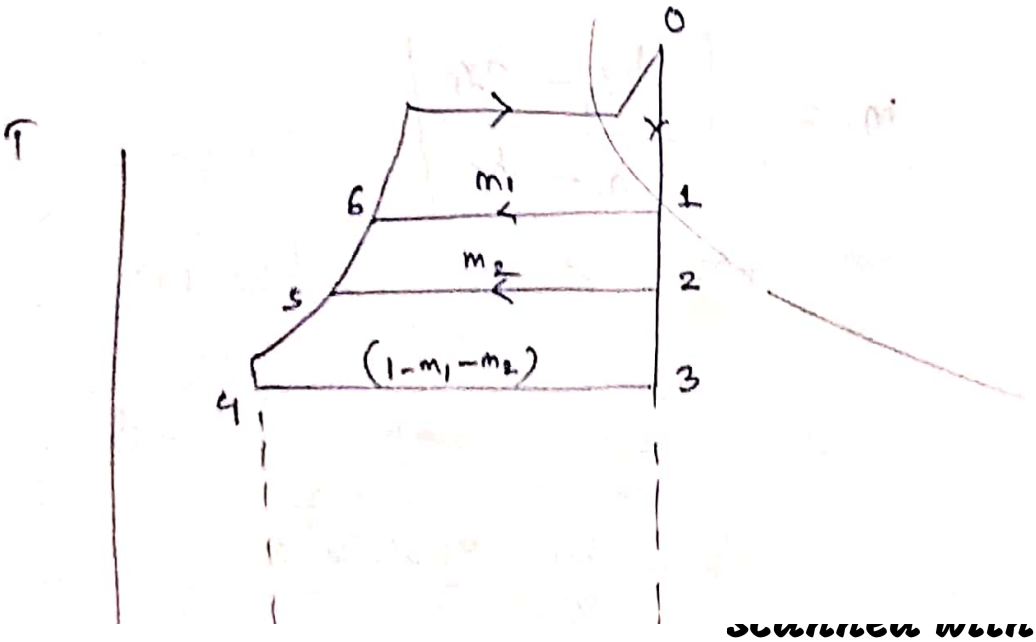
Medium capacity turbines – 3 heaters.

High pr. " – 5-7 "

Supercritical " – 8-9 "

The temp is kept 50° to 60° below the boiler steam.





m_1 = kg of H.P. steam per kg of steam flow

m_2 = " " L.P. "

$(1 - m_1 - m_2)$ = kg of steam entering condenser per kg of steam flow.

Energy or Heat balance eqn for H.P. heater

$$m_1 (h_1 - h_{f6}) = (1 - m_1)(h_{f6} - h_{f5})$$

$$\Rightarrow m_1 (h_1 - h_{f6}) = (h_{f6} - h_{f5}) - m_1 (h_{f6} - h_{f7})$$

$$\Rightarrow m_1 \left[(h_1 - h_{f6}) + (h_{f6} - h_{f5}) \right] = (h_{f6} - h_{f5})$$

$$\Rightarrow m_1 = \left[\frac{h_{f6} - h_{f5}}{h_1 - h_6} \right]$$

For L.P heater.

$$m_2(h_2 - h_{f_7}) = (1 - m_1 - m_2)(h_{f_7} - h_{f_3})$$

$$\Rightarrow m_2(h_2 - h_{f_7}) = (1 - m_1)(h_{f_7} - h_{f_3}) - m_2(h_{f_7} - h_{f_3})$$

$$\Rightarrow m_2\left[(h_2 - h_{f_7}) + (h_{f_7} - h_{f_3})\right] = (1 - m_1)(h_{f_7} - h_{f_3})$$

$$m_2 = \left[\frac{(1 - m_1)(h_{f_7} - h_{f_3})}{(h_2 - h_{f_3})}\right]$$

Here pump work is neglected.

Heat supplied = $(h_0 - h_{f_6})$

Isentropic work done =

$$m_1(h_0 - h_1) + m_2(h_0 - h_2) + (1 - m_1 - m_2)(h_0 - h_3)$$

Thermal efficiency of regenerative cycle

$$\eta = \frac{\text{Work done}}{\text{Heat supplied}}$$

work done by turbine

$$= (h_0 - h_1) + (1 - m_1)(h_1 - h_2) + (1 - m_1 - m_2)(h_3 - h_3$$

Advantages of regenerative cycle :-

1. Heating process becomes reversible
2. thermal stress set up in boiler is minimised.
3. Thermal efficiency improved.
4. Heat rate reduced.
5. Erosion & corrosion in turbine reduces
6. Small size condenser is required.

Disadvantages :-

1. Plant becomes more complicated.
2. Maintenance is req.
3. large boiler is req.
4. Heaters are costly.

Boiler Accessories :-

~~Air preheater~~

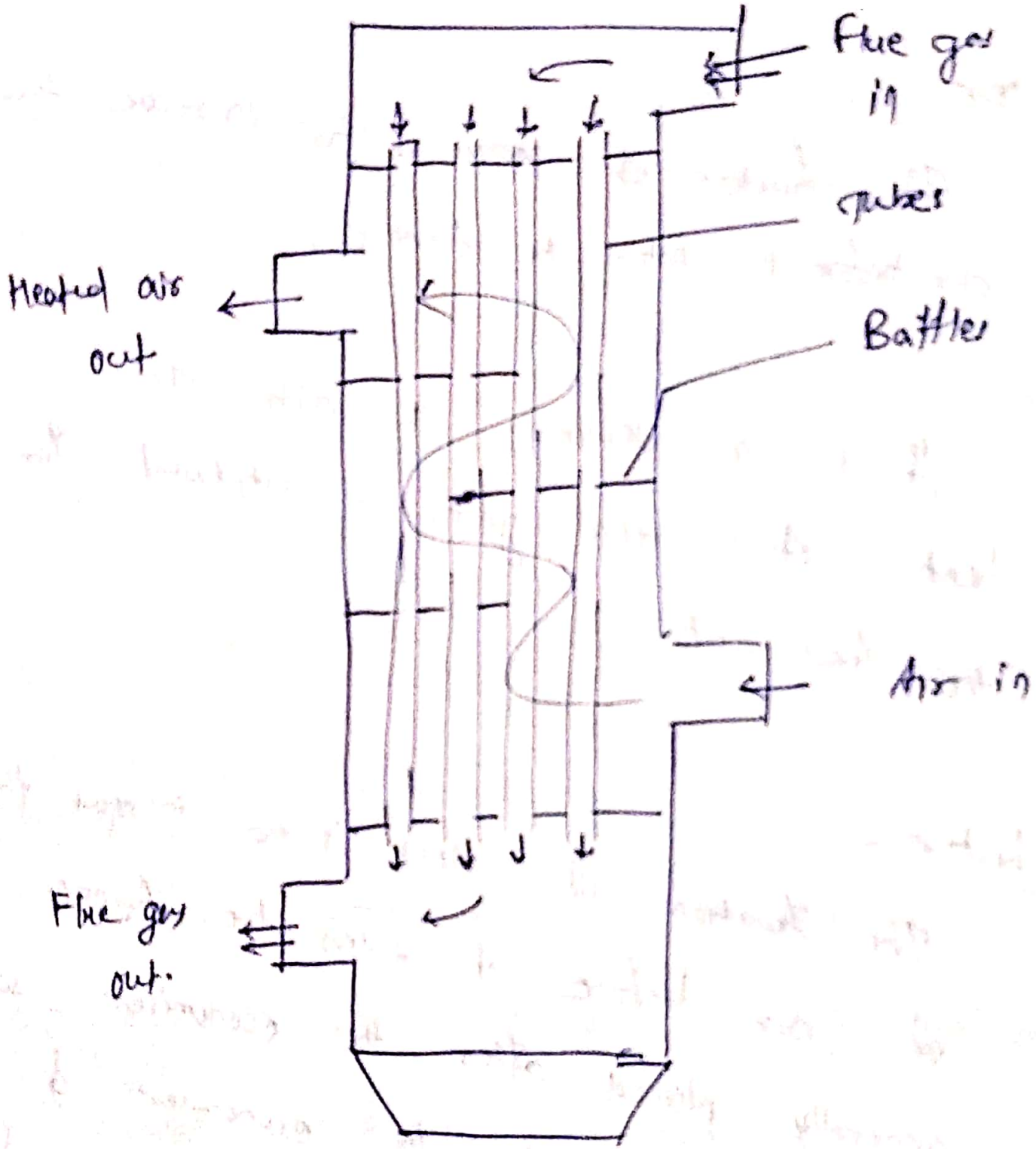
The function of APH is to increase the temp of air before it enters the furnace.

Economiser

It is a device in which the waste heat of flue gases is utilised for heating the feed water.

Air pre heater :

The function of APH is to increase the temp. of air before it enters the furnace, it is generally placed after the economiser, so the flue gases pass through the economiser & then to the air preheater.



APH (Tubular type)

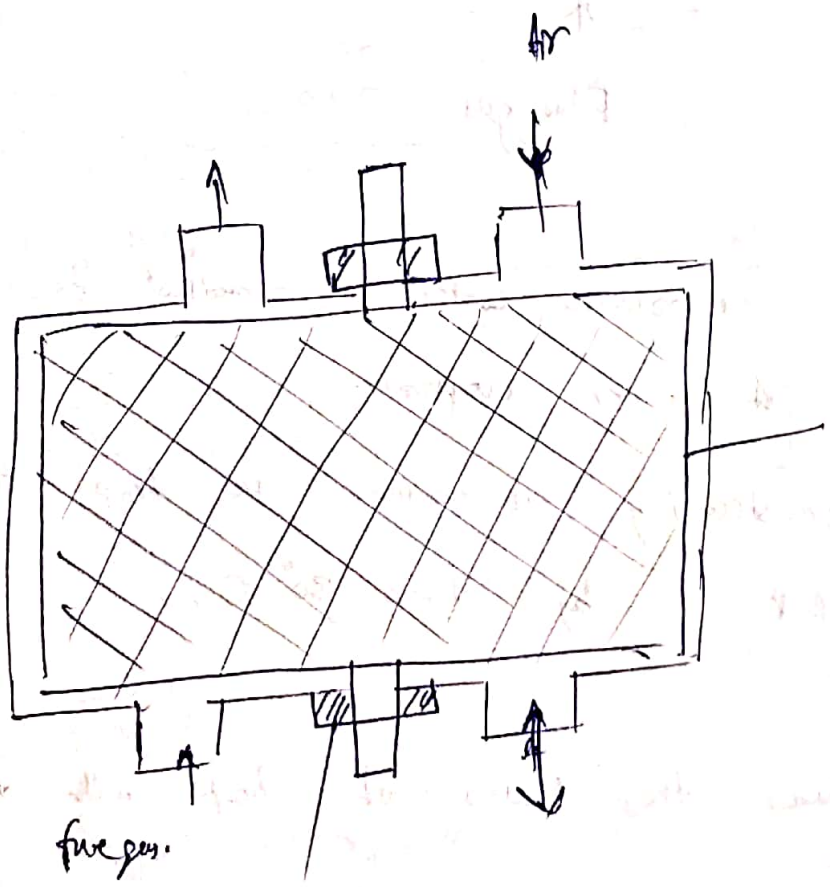
An APH consists of plates or tubes with hot gases on one side & air on another side. It preheats the air. Preheated air accelerate the combustion & facilitate the burning of coal.

The pre heating depends on

- Type of fuel.
- Type of fuel burning equipment

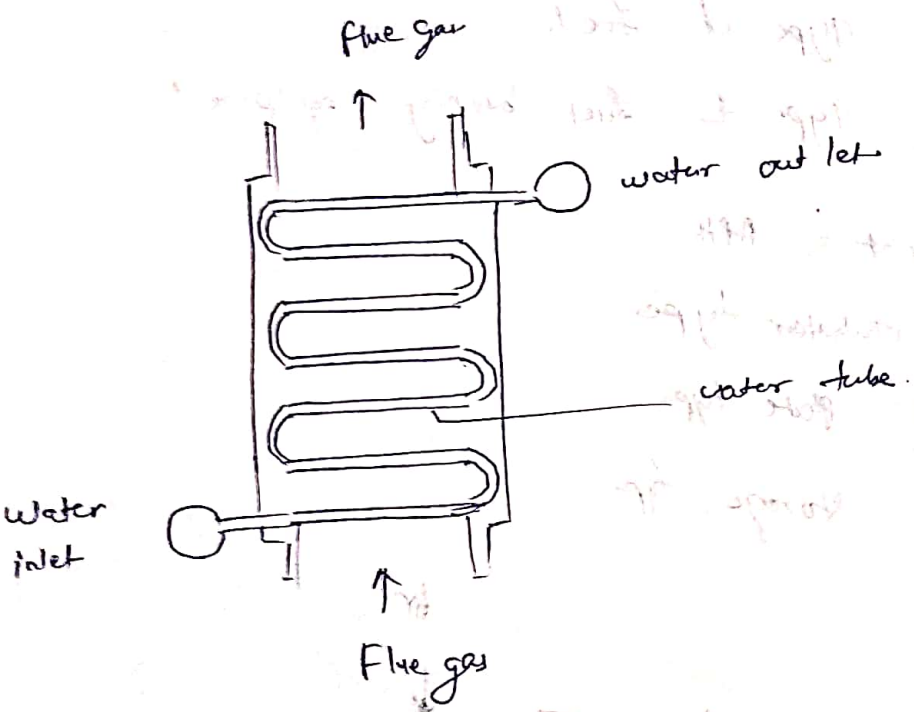
3 types of APH

1) Tubular type
2) Plate type
3) Storage type.



Economiser

It is a device in which the waste heat of flue gas is utilised for heating the feed water.



In steaming economiser water is raised to B.P. 10 - 12 % of water evaporates

In non-steaming economiser the temp. is kept below B.P by 20 - 30° C.

Advt.

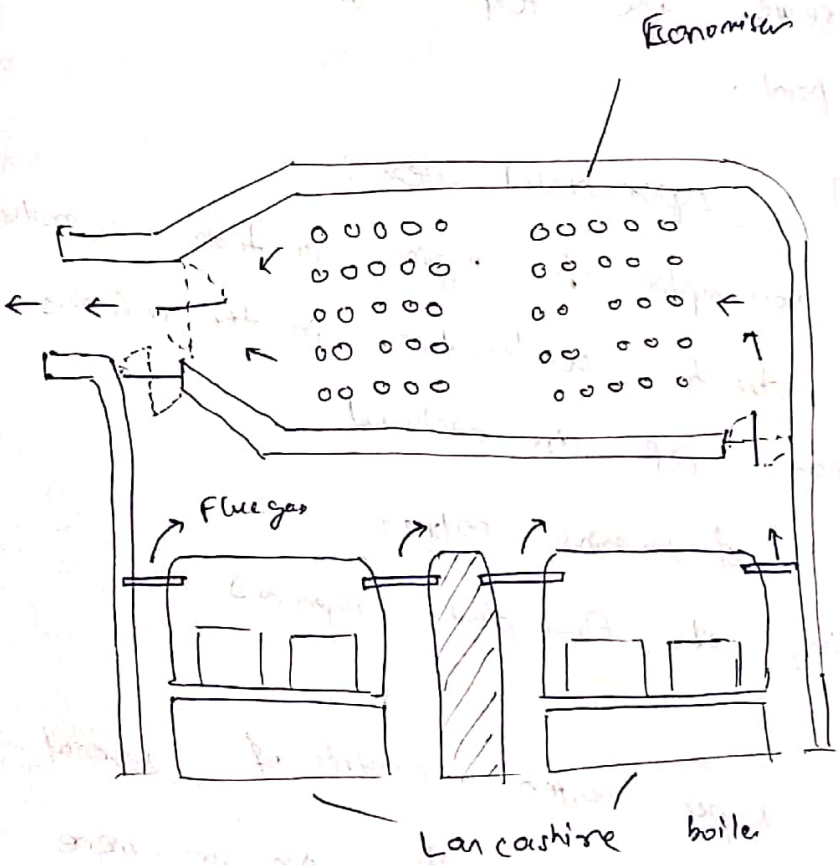
i) Reduces the losses of heat with the flue gases

ii) Reduces consumption of fuel

iii) Improves efficiency of Boiler.

Economiser consists of series of steel tubes through which the feed water flow. The combustion gases pass over the tube & transfer some of their heat to the feed water. The boiler efficiency rises by 1% for each 10°F rise in water.

Economiser may be parallel flow or counter flow.



(By pass arrangement of flue gas)

The by pass arrangement enables to isolate or include the economiser in the path of flue gas.

Super Heater :-

The steam produced in the boiler is nearly saturated. This steam as such should not be used in the turbine because the dryness fraction of the steam leaving boiler will be low. This results in the presence of moisture which causes corrosion of turbine blades. The function of super heater is to increase the temp. of steam above its saturation point.

Advantages of superheated steam :-

i) Steam consumption of engine or turbine is reduced.

ii) Losses due to condensation in the cylinders & the steam pipe are reduced.

iii) Erosion of turbine reduces.

iv) Efficiency of Power plant improved.

The super heater consists of several tubes circuits in parallel with one or more bends connected between headers. Super heater tubes ranges from 1 to 2 inches. in dia.

Super heater supplies steam at constant temp. at diff. loads.

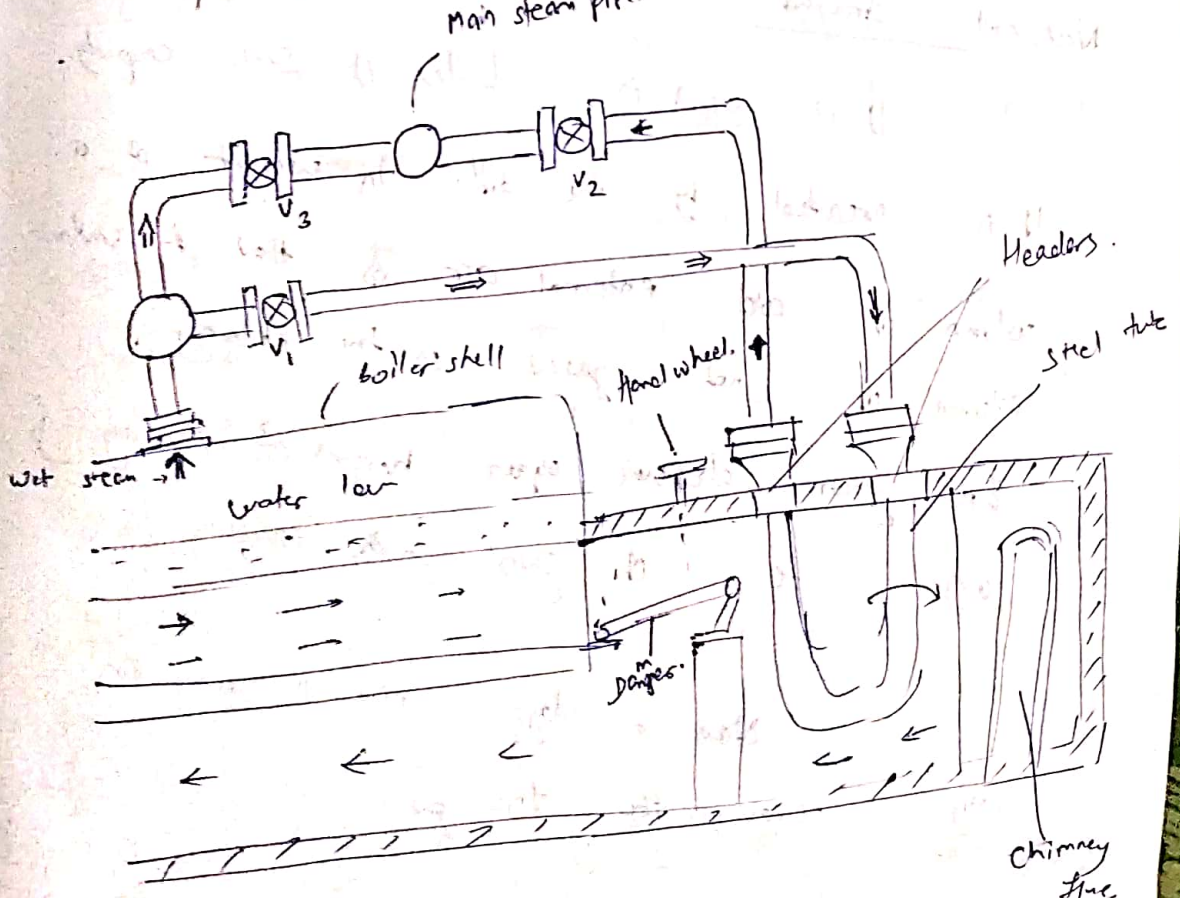
There are 2 types of superheater

1. Convective superheater.
2. Radiant superheater.

Convective superheater makes use of heat in flue gases ~~others~~.

Radiant superheater is placed in the furnace & wall tubes receive heat from the burning fuel through radiant process.

The radiant type of superheater is generally used where a high amount of superheat temp. is required.



→ flue gas
⇒ wet steam.
⇒ superheated steam

(Sugden's superheater)

Draught

The small pr. difference which causes a flow of gas to take place is termed as draught.

purpose

i) to supply req. amount of air to the furnace for the combustion of fuel.

ii) To remove the gaseous products of combustion.

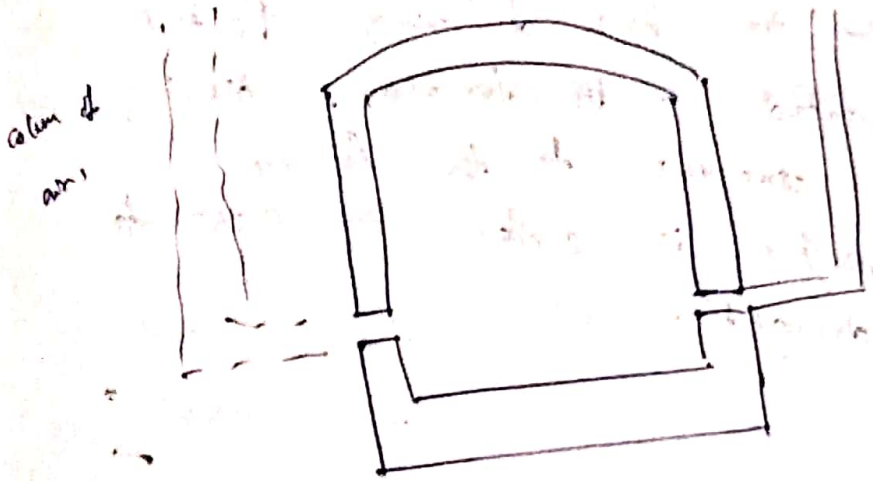
Natural draught

It is used in boiler of small capacity.

It is created by the diff. in weight of a column of cold external air & that of similar column of hot gases in the chimney.

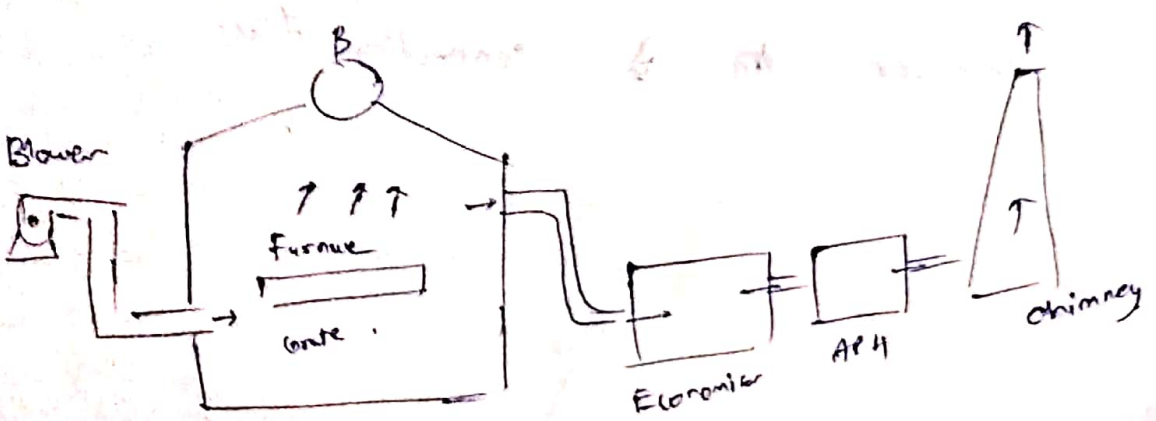
The system depends upon height of chimney & avg. temp. of gases in the chimney.

Now a days chimney is used for only removing the flue gas.



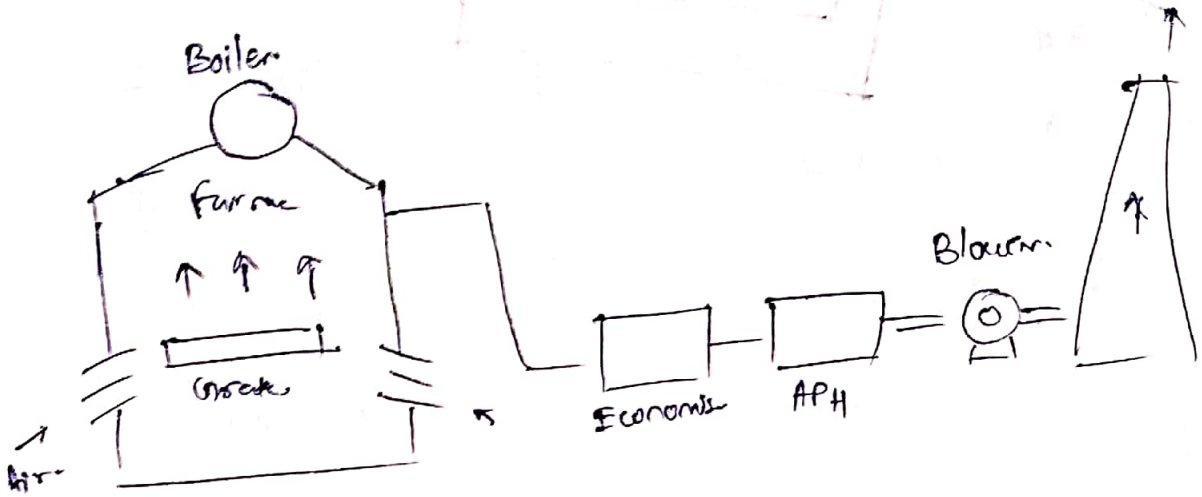
Forced draft :-

In a mechanical draught system the draught is produced by a fan. In a forced draught system, a blower or a fan is installed near or at the base of boiler to force the air through the cold bed of the passage through the furnace.



Induced draft

In this system a fan or blower is located, near the base of chimney. Partial vacuum is created in the furnace. Air is drawn from atmosphere to the furnace. The draft draught is similar in action to the natural draught.



Balanced draft

It is a combination of forced & induced draft system. The forced draft FD Fan overcomes the resistance in the APH and the induced draft ID Fan overcomes draft losses through boiler, economiser, APH & connecting flues.

Advantages of Mechanical Draft

i) Easy control of combustion & evaporation.
ii) Increase the evaporative power of boiler
iii) Improve efficiency
iv) Reduce chimney height.
v) Prevention of smoke.
vi) Capability of consuming low grade fuel.
vii) High draft.

Advantages of forced draft over induced draft

i) FD fan does not require water cooled bearings.
ii) Tendency to air leak into the boiler furnace is reduced.
iii) No loss due to inrush of cold air through the furnace door.
iv) FD fan handles cold air so fan size is 1/5 to 1/2 of ID fan.

Steam Turbines

The steam turbine is a prime-mover in which the P.E of steam is transformed into K.E. and its force is transferred in to mechanical energy (rotation of turbine shaft)

The main parts are :-

1) Rotor . The rotor is fitted with a series of blades on its circumference
2) Bearing to support the shaft.
3) Metallic casing which surrounds blades, nozzles, rotor.
4) Governer to control speed
5) Lubricating oil system

Advantages :-

i) The thermal efficiency is heighten
ii) Power generation is uniform. (absence of shock)
iii) Much heigher speed is possible.
iv) Large thermal stations can be installed,
v) Balancing problem is minimized because of no reciprocating parts

vi) Internal lubricating is not required because there is no rubbing parts

vii) No loss due to condensation.

viii) It can carry higher overload.

Hydel Power Plant

Hydro-electric Power Plant

The energy of water is utilized to move the turbines which runs the electric generator. The kinetic & Potential energy of water is utilized to generate power.

Eg Hirakud dam

Catchment area - 83 400 km^2 (32201^2 $mile^2$)

Turbines - kaplan type

Power = Total 347.5 MW

Burla : P.H I = 2×49.5, 3×37.5, 2×32 MW

Chipling : P.H II = 3×24 MW

Started 1957.

Cost = 1.01 billion Rs.

Type of dam = Composite dam & reservoir.

Height = 60.96 m

Length = 4.8 Km (main section)

25.8 km entire dam.

Spill ways = 64 Sluice-gates, 34 - Crest-gates

Spill way capacity = 42450 m^3/second.

Advantages of Hydro-electric Plants

1) No fuel charges.
2) It is highly reliable.
3) Maintenance & operation charges are very low.
4) Running cost is low.
5) The plant has no stand by losses.
6) The plant efficiency does not change with age.
7) It takes a few minutes to run & synchronise the plant.
8) Less supervising staff is required.
9) No fuel transportation problem.
10) There is no pollution.
11) Used for flood control & irrigation purposes.
12) Long life (100 - 125 years) but Thermal plants 20-45 yr
13) No. of operations required is small as compared to thermal plants.
14) The m/c runs at low speed so there is no mechanical problems.
15) No special alloys are required.
16) It is away from developed area so land cost is low.

Dis-advantages :-

1) Initial cost of plant is high.
2) It takes long time to construct.
3) Such plants are away from load centre so transmission line cost & losses is high.
4) The power developed is dependent on the quantity of water (weather).

Classification

A. According to availability of head.
   1) High head power plant
   2) Medium head " "
   3) Low head " "

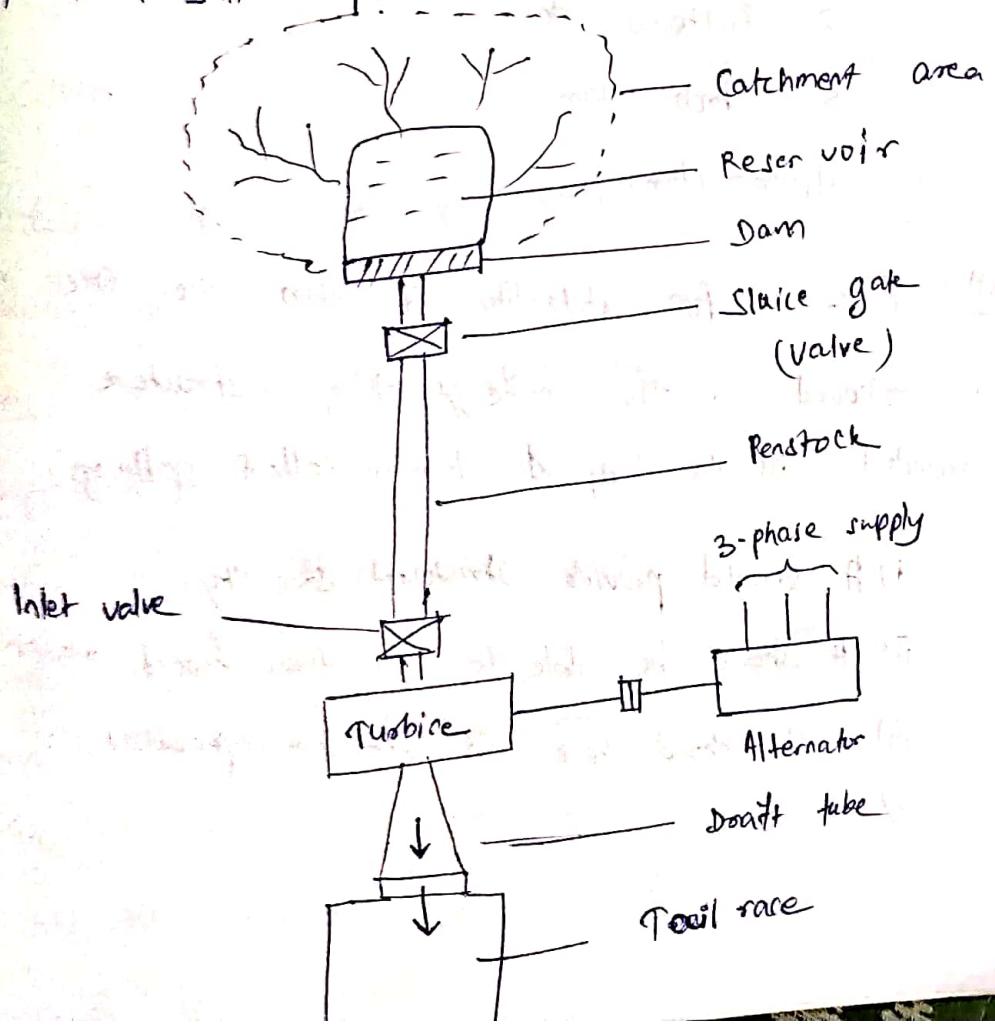
B. According to the nature of load.
   1) Base load plant
   2) Peak load "

C. According to the quantity of water available.
   1) Run-of-river plant without pondage
   2) Run-of river plant with pondage
   3) Storage type plants.
   4) Pump storage plants
   5) Mini & micro-hydel plants.

Essential features of Hydro-electric power plant

1. Catchment area
2. Reservoir
3. Dam
4. Spill ways
5. Conduits
6. Surge tanks
7. Prime movers
8. Draft tubes
9. Power house & equipments.

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.



Reservoir — It is employed to store water.

1. Natural Reservoir (lake)
2. Artificial " (It is built by dam)

Dam — It is a barrier to confine or retain water for storage or diversion to create a hydraulic head.

A. Fill dams
   1. Earthen dams
   2. Rock-fill dams

B. Masonry dams
   1. Solid gravity dam
   2. Buttress dam
   3. Arch dam

C. Timber dam.

Spill ways :- For stability of dam the excess water is relieved. This safe guarding structure is provided in the body of dam is called spillways.

i) It should provide structural stability
ii) It should be able to pass the flood water.
iii) It should have an efficient operation.
iv) Economic.

Type of spillways

1. Overfall / solid gravity spillway.
2. Chute / through spillway.
3. Side channel "
4. Saddle spillway.
5. Emergency "
6. Shaft spillway.
7. Siphon spillway.

Conduits :- It is a channel which leads water to a turbine and a tailrace.

1) Open conduits → Canals, flumes
2) Close " → Tunnels, pipelines & penstock.

Canal :- It is a open waterway excavated in natural ground.

Flume :- It is an open channel erected on the surface supported above ground on a trestle. (frame)

Tunnel :- It is a closed channel excavated through a natural obstruction such as ridge of higher land between the dam & power house.

Pipeline :- It is a closed channel usually supported above the surface above the land.

Penstock :- It is a closed conduit for supplying water under pressure to a turbine.

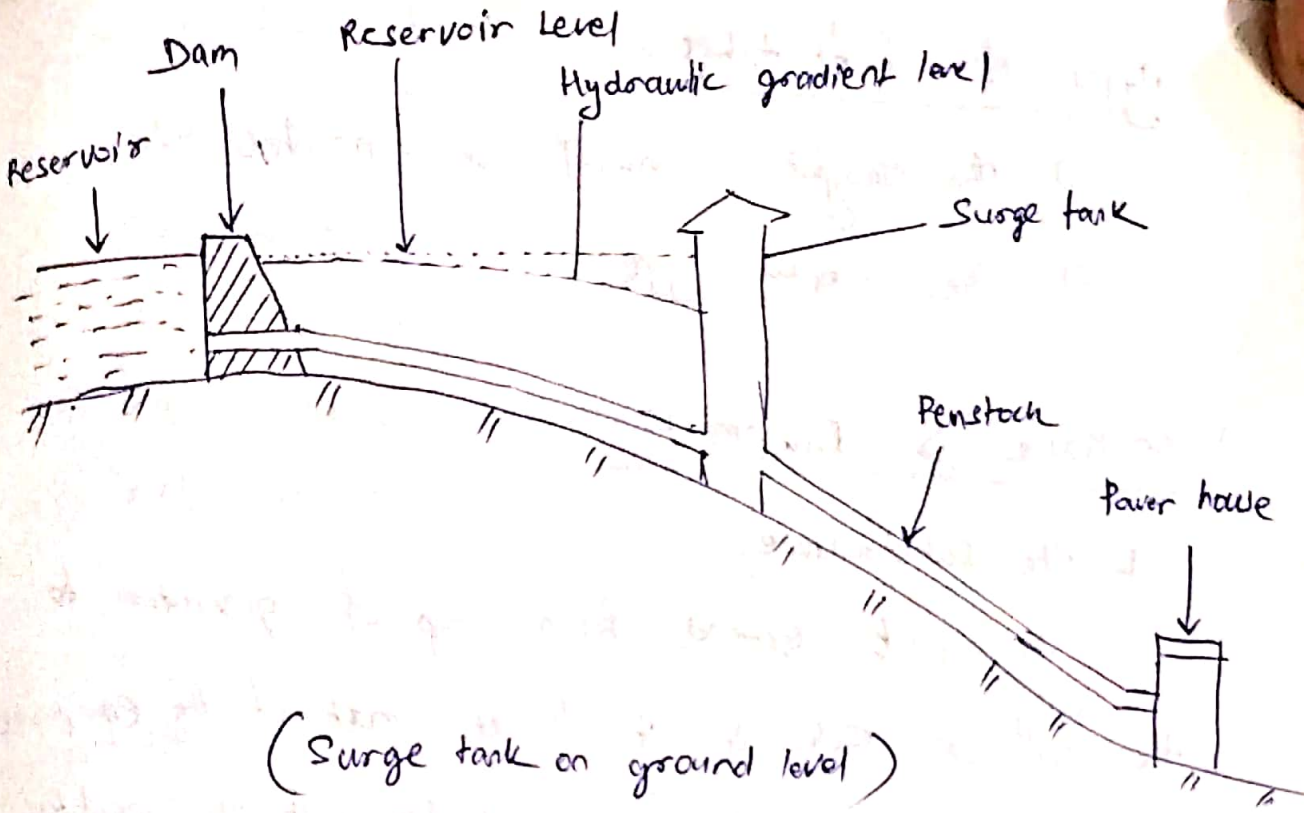
Surge tank :-

It is a small reservoir or tank in which the water level rises or falls to reduce the pressure.

- It reduces the distance between the free water surface & turbine.
- It serves as a supply tank to the turbine & also a storage tank.

Types of surge tanks

1. Simple surge tank.
2. Inclined " "
3. The expansion chamber & gallery type "
4. Restricted orifice surge tank
5. Differential " "



(Surge tank on ground level)

Prime movers :-

In an hydraulic power plant the prime mover converts the energy of water in to mechanical energy & further into electrical energy.

1. Impulse turbine.
2. Reaction turbine.

Draft tubes :-

- It allows the turbine to be set above tail-water level with out loss of head to facilitate inspection & maintenance.
- It regains by diffuser action, the major portion of the K.E. delivered to it from the runner.

Types of draft tubes :

1) The straight conical or concentric tube
2) The elbow type.

Power House & Equipment

1. The substructure :-

This part extends from top of generator to the soil or rock & it houses most of the equipments In case of francis & Kaplan turbine it accomodates the draft tube also.

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

3. Super structure :- It is above the generator level. It houses mostly cranes which handles heavy equipments

i) Hydraulic turbines
ii) Electric generator.
iii) Governers
iv) Gate valves
v) Relief valve
vi) Water circulating pump
vii) Flow measuring equipments
viii) Air duct.

ix) Switch board equipments & instrument.

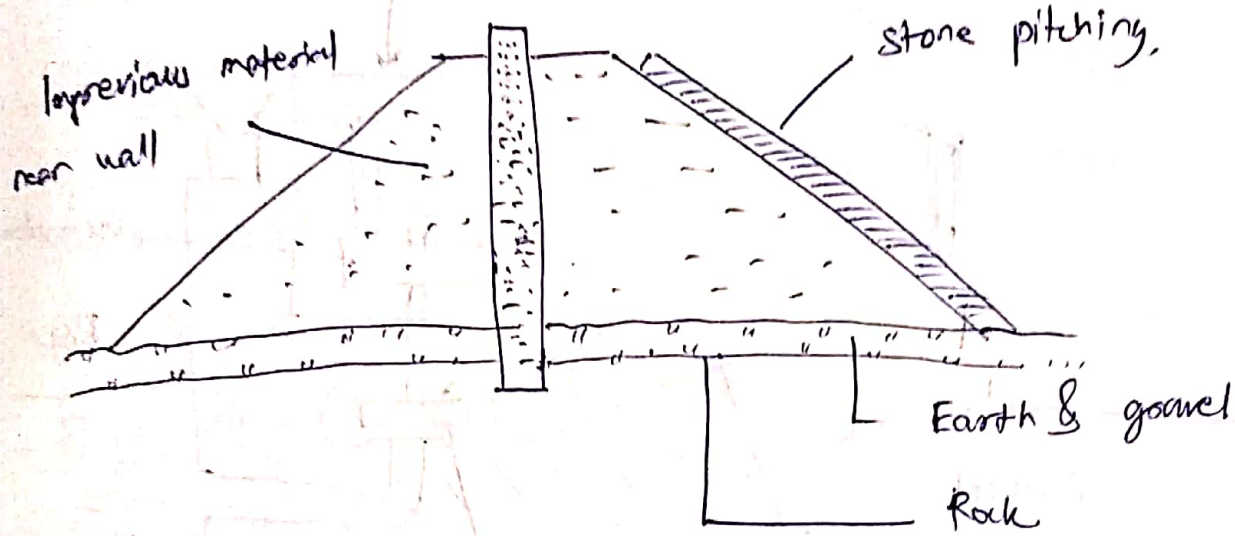
x) Oil circuit break

xi) Reactors

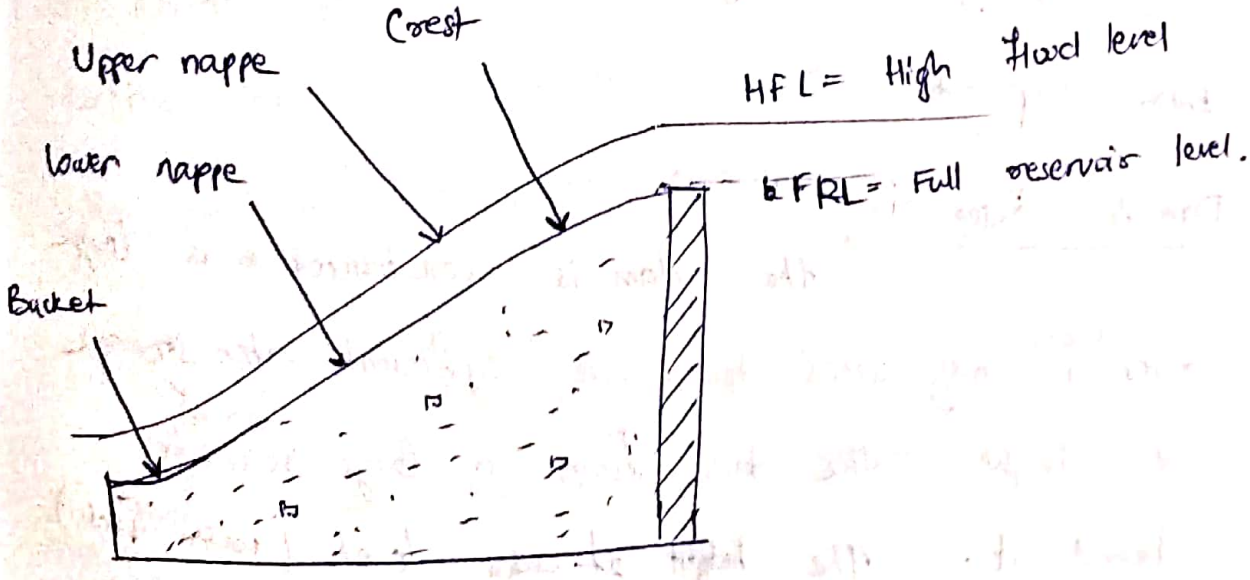
xii) Low tension & high tension bar.

xiii) Storage batteries

xiv) Cranes.

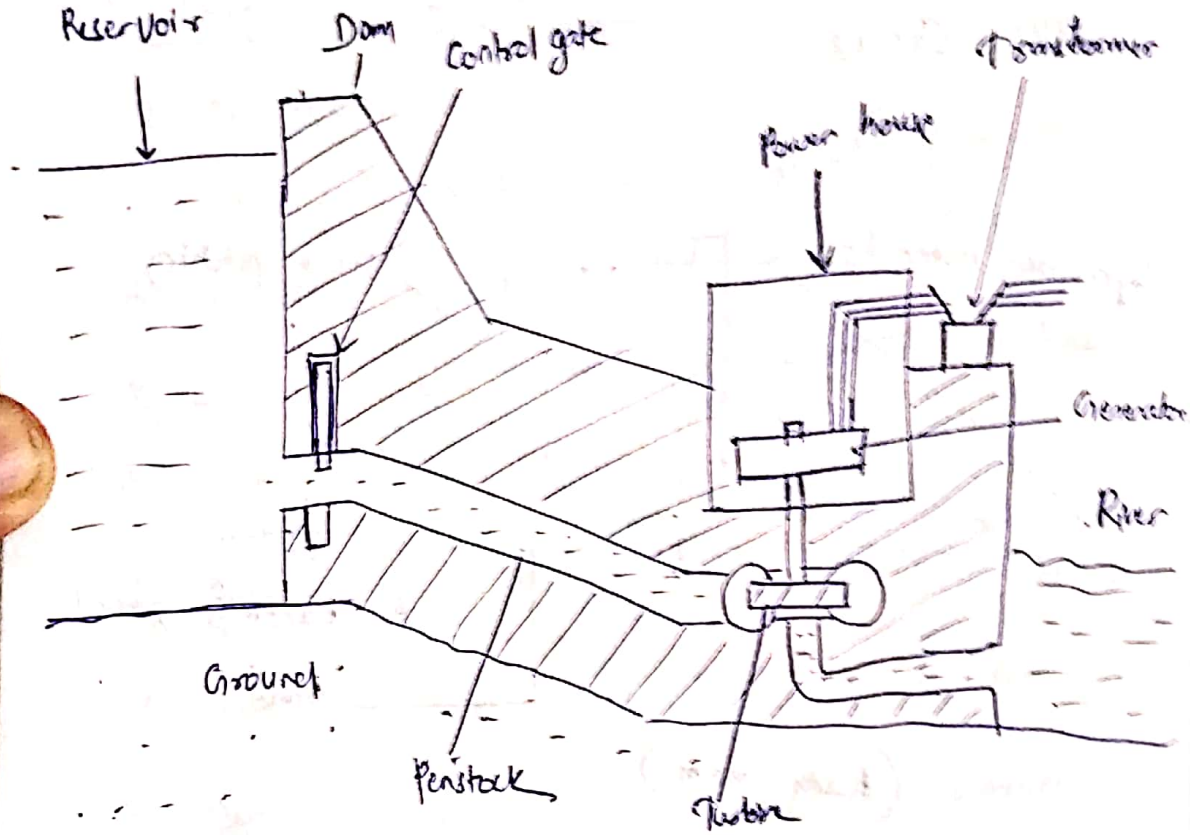


(Earth dam)



(over fall spill way)

General arrangement of storage type hydro electric power plant & its operation :-



(Lay out of Hydro electric plant)

Basic Components

Dam & Reservoir

The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height. The dam forms a large reservoir behind it. The height of water level (water head) determines the amount of P.E. stored in water

Control Gate

Water from the reservoir is allowed to flow through the penstock to the turbine. The amount of water ~~that can be~~ is to be released in the penstock can be controlled by a control gate. when the control gate is fully open, maximum amount of water is released through the penstock.

Penstock

A penstock is a huge steel pipe which carries waters from the reservoir to the turbine. P.E. of water is converted in to K.E. as it flows down through the penstock due to gravity.

Water Turbine :-

Water from the penstock is taken into the turbine. Turbine is mechanically coupled to an electric generator. K.E. of water drives the turbine and consequently the generator gets driven. there are 2 main types turbine 1) Impulse turbine, 2) Reaction "

Impulse turbines are used for large heads.
Reaction turbines are used for low & medium head.

Generator :-

A generator is mounted in the power house and it is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of a transformer for transmission purpose.

Generation of electricity by hydro power is one of the cleanest method of producing electricity. It is the most widely used form of renewable energy.

DIESEL ENGINE POWER PLANT

A generating station in which diesel engine is used as the prime mover for the generation of electrical energy is known as Diesel engine power plant.

These are installed where supply of coal & water is not available in sufficient quantity, or where power is required in small quantity and stand by sets are required like hospitals, telephone exchanges, petrol pumps, radio stations etc.

Range = 2 to 50 MW.

~~Advantages~~ :-

Applications :-

- Peak load plant
- Mobile plant
- Stand-by unit
- Emergency plant
- Nursery station
- Starting station
- Central station
- Industrial use.

Advantages :-

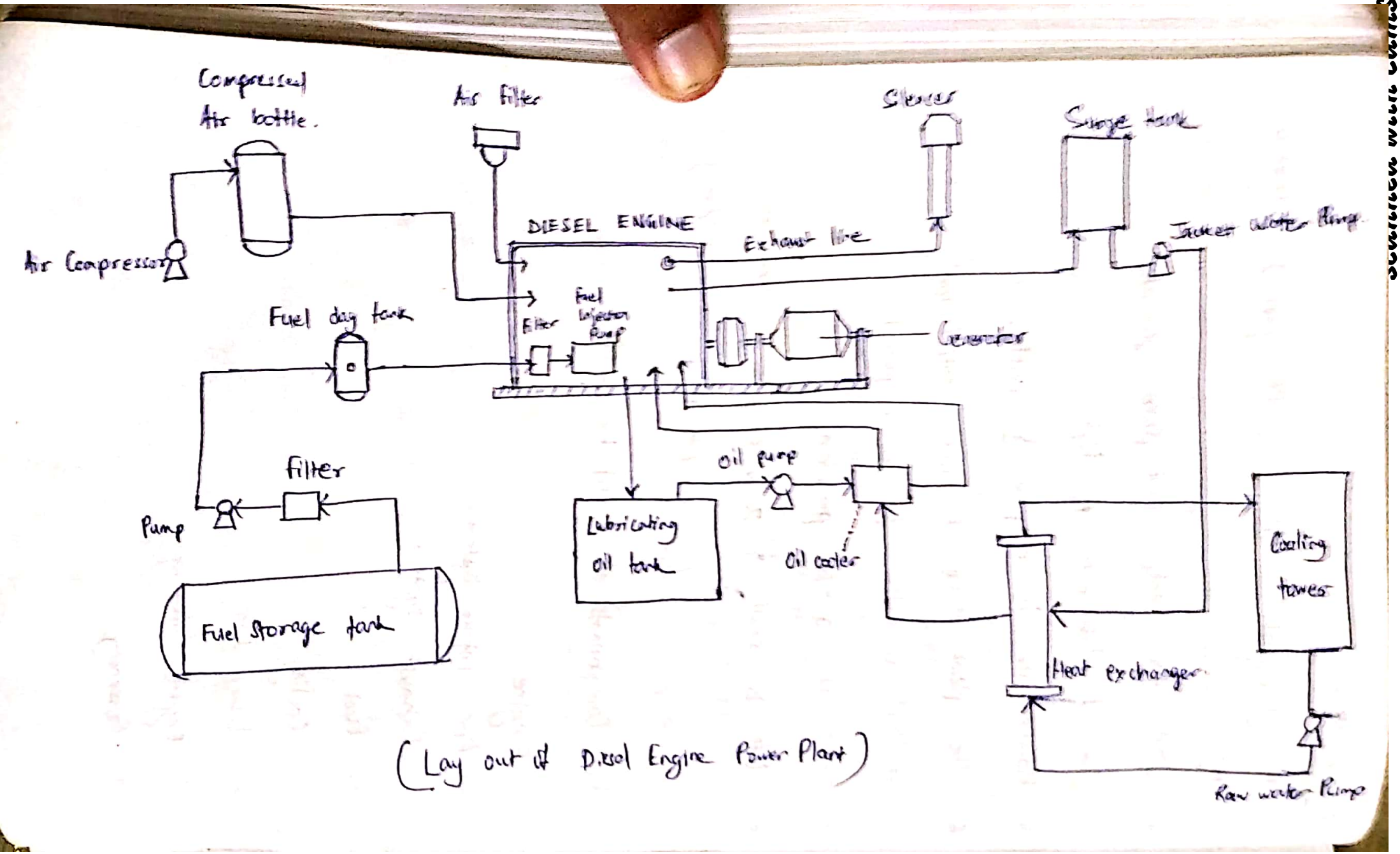
1. Design & installation are very simple.
2. It can respond to varying loads with out any difficulties.
3. Stand by losses are less.
4. Less space is required.
5. Can be started & put on load quickly.
6. It can also be designed for portable use
7. It can be stopped quickly & easily.
8. Cooling system is easy & require less water.
9. Initial cost is less than other power station.
10. Thermal efficiency of diesel is higher than coal.
11. It requires less operating staff.
12. Over all cost is less
13. It can use wide range of fuels
14. These plants can be located very near to the load centre.
15. No need of ash handling.
16. Lubrication system is more economic.

Dis. advantages

1. Running cost is high as the price of diesel is high.
2. Used for only small power generation.
3. Cost of lubricants is high.
4. Maintenance is complex & costly.
5. The plant does not work satisfactorily under overload condition for longer period.
6. Noise is a big problem.
7. Life is small (2 to 5 year). where as (steam power plant 20 - 30 year)

Essential Components of Diesel Power Plant

1. Engine
2. Air Intake System
3. Exhaust system
4. Fuel 4
5. Cooling 4
6. Lubricating 4
7. Engine starting 4
8. Governing 4



(Lay out of Diesel Engine Power Plant)

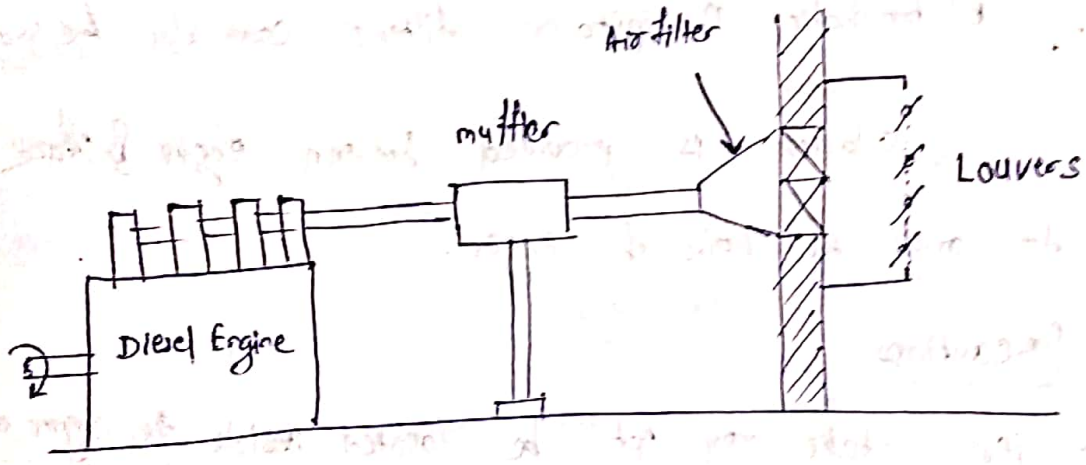
Engine :- It is the main component of the plant which develops power. It is directly coupled with the generator.

2 type :- i) four stroke diesel engine
ii) 2 " " "

Air Intake system :-

It conveys fresh air to the

i) Air intake manifold of 4-stroke engines
ii) Scavanging pump inlet of a 2-stroke engine.
iii) supercharger inlet of a supercharged engine.



(Air Intake system)

The intake located out side the building provided with a filter to catch dirt which would cause excessive wear in the engine.

Light weight steel pipe is used as inlet duct.

Many types of filters can be used.

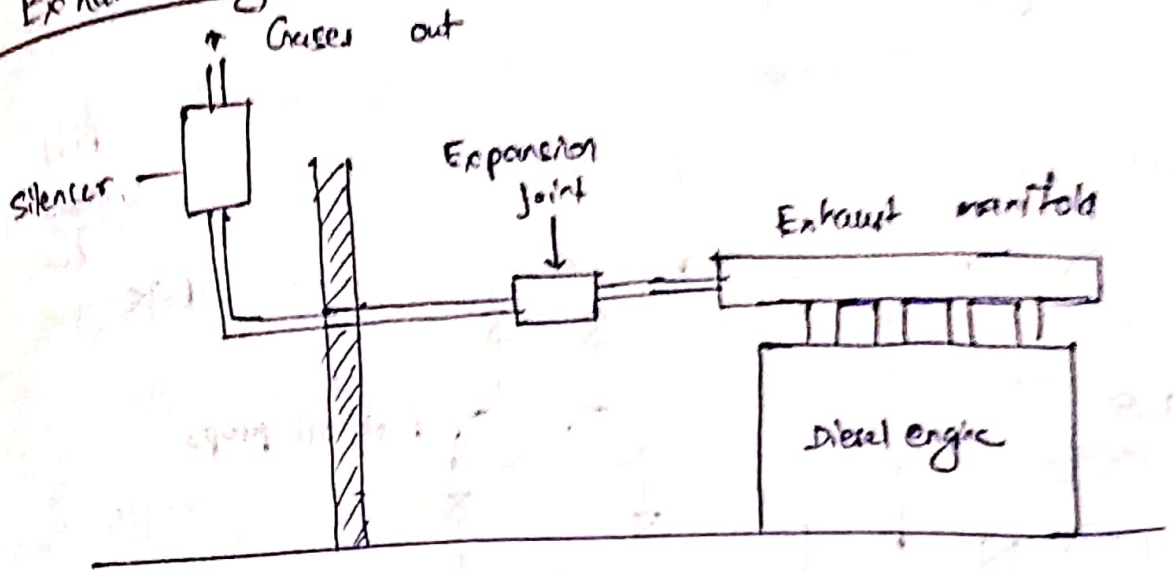
- Oil impingement type of filter consists of a frame filled with metal shavings which are coated with oil so that the air passing through the frame can seize & hold the dust particles.
- The dry type filters are made of cloth, felt, glass wool etc.
- In oil bath type of filter the air is swept over through a pool of oil so that the particles of dust becomes coated.
- Electrostatic Precipitator filters can also be used.

Silencer is provided between engine & intake to arrest the noise of engine.

Precautions

- Air intake may not be located inside the engine room.
- Air should not be taken from a confined space.
- The air intake pipe should neither have small diameter nor large diameter.
- Air intake filter may not be located close to the engine room roof.
- Air intake filter should not be located in an inaccessible location.

Exhaust system :-

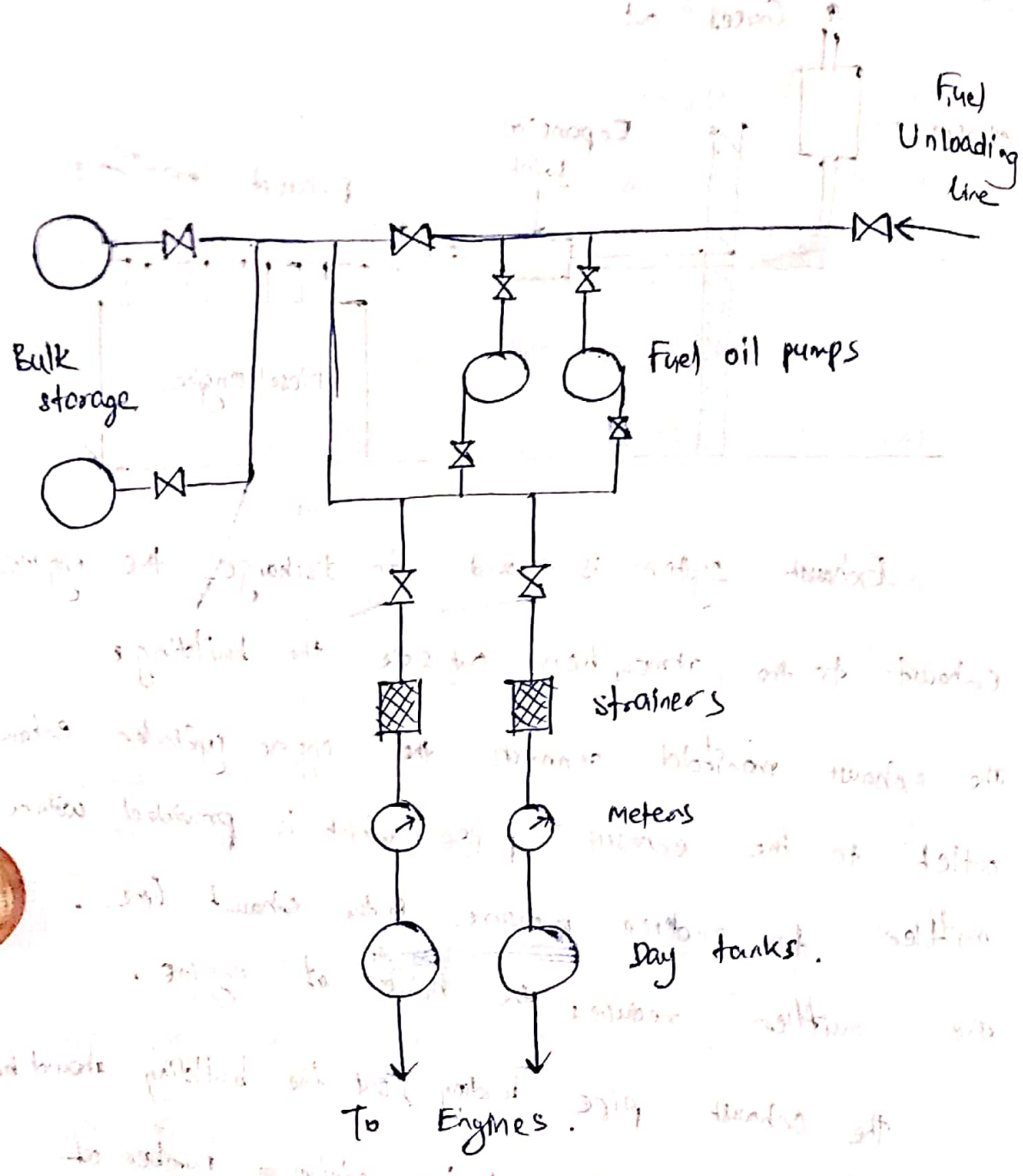


Exhaust system is used to discharge the engine exhaust to the atmosphere out side the building. The exhaust manifold connects the engine cylinder exhaust outlet to the exhaust pipe which is provided with a muffler to reduce pressure in the exhaust line. The muffler reduces the noise of engine.

The exhaust pipe leading out the building should be short in length. with having minimum number of bends. It should have one or 2 flexible tubing sections which take up the effects of expansions. & isolate the system from engine vibration.

Every engine should have it's independent exhaust system.

Fuel System



The fuel oil may be delivered at the plant site by tanks, railroad tank. to the main storage tanks. Then it is transferred to the small storage tank called day tank.

The main flow line is arranged with necessary heaters, by passes, shut-off, drain lines, relief valve, strainers & filters, flow meters, & temperature indicators.

The tank shall contain man-hole for internal access & repair, fill line to receive oil, vent lines to discharge vapours & over flow line.

At least one months requirement amount of oil should be kept in the storage tank. The day tank provide daily need of oil to the engine. The day tanks are placed high so that oil may flow to engine under gravity.

- There should be clean lines provided for pipe lines.
- Changing over of lines during emergencies.
- In all suction lines the pipe joints shall be made tight.
- Before covering the pipe lines should be tested through air pressure & joints should be tested by soap solutions.
- Piping between filter & engine shall be oil flushed.
- High grade filters should be used.

Fuel Injection System :-

A very small quantity of fuel is measured, injected, atomised and mixed with combustion air. In diesel engine atomised fuel is sprayed in the cylinder under pressure usually ranging from approximately 100 to 120 kg/cm².

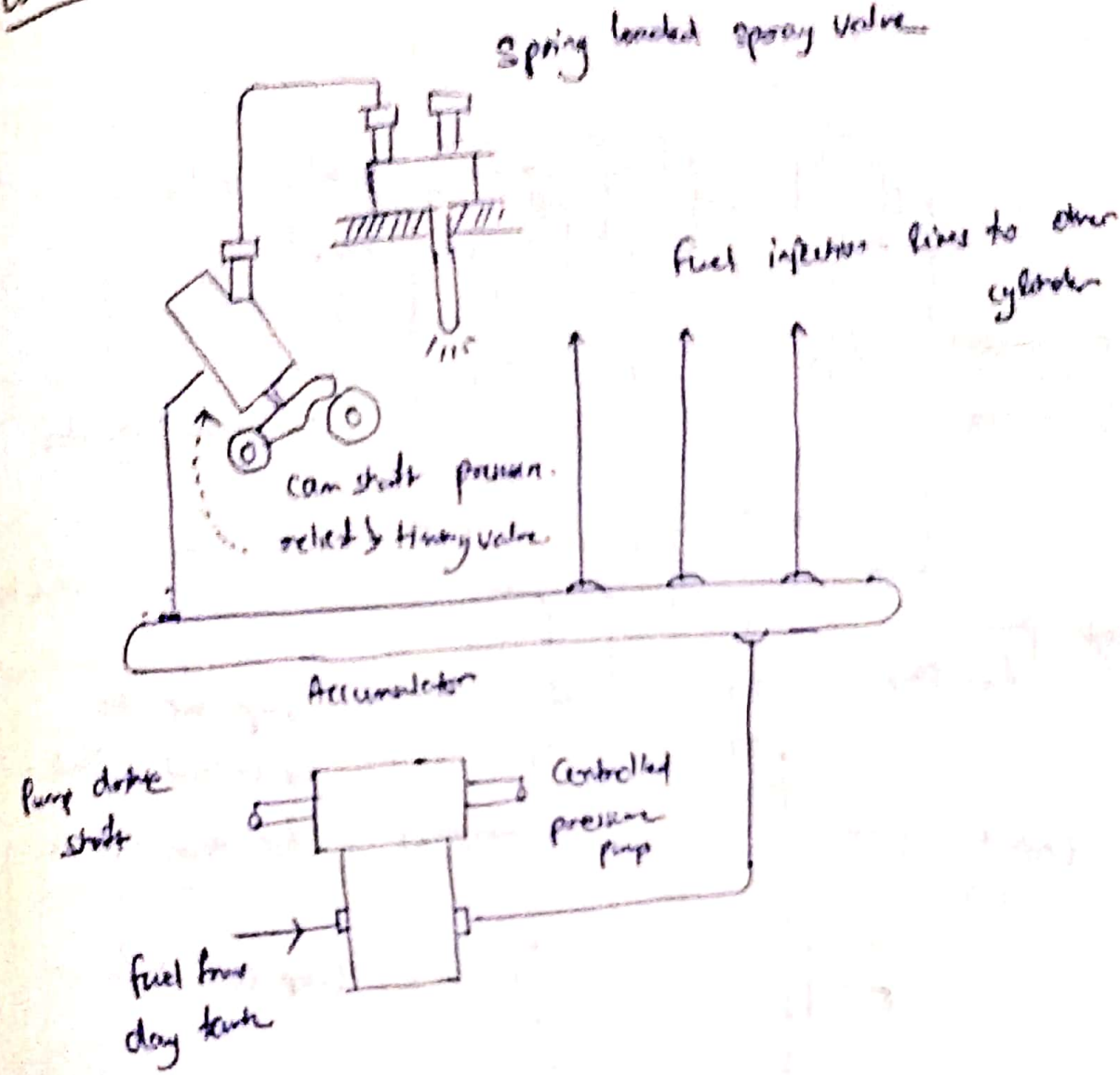
functions of fuel injection system :-

- Filter the fuel.
- Meter or measure the correct quantity of fuel.
- Time the fuel injection
- Control the rate of fuel injection.
- Atomise the fuel
- Properly distribute the fuel in the combustion chamber

Types of fuel injection system

1. Common rail injection system
2. Individual pump
3. Distributor.

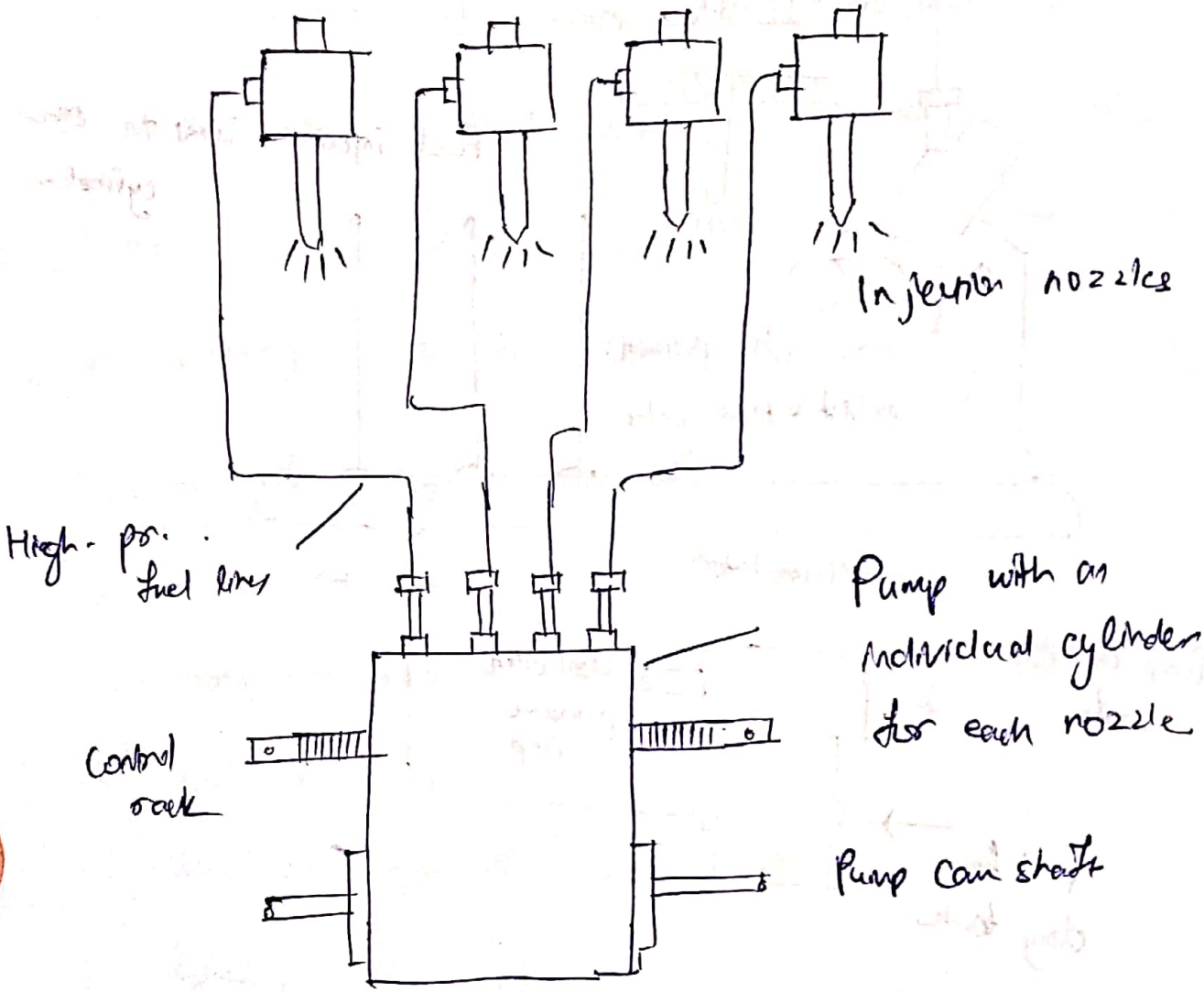
Common rail injection



A single pump supplies high pressure fuel to header, a relief valve holds pressure constant.

Controlled pressure system has pump which maintains set head pressure. pressure relief & timing valves regulate injection time & amount.

Individual pump injection

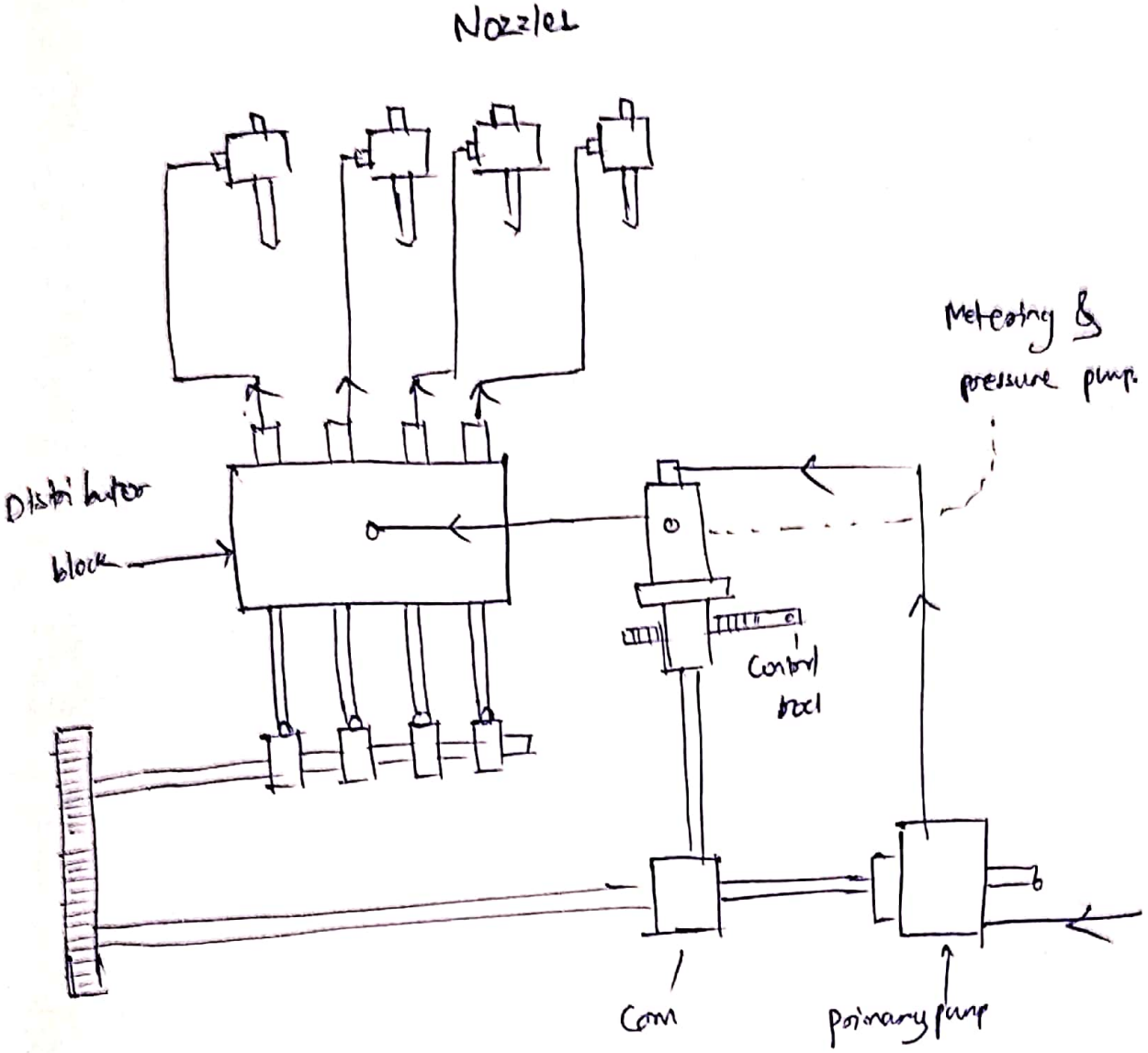


An individual pump or pump cylinder connects directly to each fuel nozzle.

Pump meter charge & control injection timing.

Nozzle contain a delivery valve actuated by the fuel-oil pressure.

Distributor injection



The fuel is metered at a central point, a pump pressurises meters the fuel & times the injection. from here; the fuel is distributed to cylinders. in correct firing order by cam operated poppet valves which open to admit fuel to the nozzles.