ANNAMACHARYA INSTITUTE OF TECHNOLOGY AND SCIENCES::
RAJAMPET
(An Autonomous Institution)

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURE NOTES

POWER PLANT ENGINEERING
[20A37IT]

Title of the Course Power Plant Engineering

Category PEC

Course Code 20A37IT

Year IV B. Tech **Semester** I Semester **Branch** ME

Lecture Hours	Tutorial Hours	Practice Hours	Credits
3	0	0	3

Course Objectives:

- To understand the student present day energy demand.
- To understand the working and combustion phenomenon in steam power plant.
- To gain knowledge on the concept and the working of diesel power plants and gas turbines.
- To understand the function and operation of the basic components of a hydro-electric power plant & nuclear power station.
- To learn the concept of non-conventional sources and factors affecting the site selection for a power plant and concept of base load plant and peak load plant.

Unit 1 Introduction **9**

Introduction to the Sources of Energy - Resources and Development of Power in India.
Steam Power Plant: Plant Layout, Working of different Circuits, Fuel and handling equipment's, types of coals,
coal handling, choice of handling equipment, coal storage, Ash handling systems.
Learning Outcomes: At the end of the unit, the student will be able to

- Discuss the various sources of energy and functions of the components of power plant. (L2)
- Identify and explains the coal handling and ash handling units. (L2)

Unit 2 Steam Power Plant -Combustion Process **9**

Properties of coal - overfeed and underfeed fuel beds, travelling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components, combustion needs and draught system, cyclone furnace, design and construction, Dust collectors, cooling towers and heat rejection. Corrosion and feed water treatment.
Learning Outcomes: At the end of the unit, the student will be able to

- Explain the various combustion processes. (L2)
- Identify the components of water treatment process. (L2)

Unit 3 Internal Combustion Engine Plant-Diesel Power Plant **9**

Introduction - IC Engines, types, construction- Plant layout with auxiliaries - fuel supply system, air starting equipment, super charging.
Gas Turbine Plant: Introduction - classification - construction - Layout with auxiliaries - Principles of working of closed and open cycle gas turbines. Combined Cycle Power Plants and comparison.
Learning Outcomes: At the end of the unit, the student will be able to

- Describe the functions of the components of diesel power plant and concepts of fuel supply system. (L2)
- Classify and explain the functions of various gas turbine power plants. (L2)

Unit 4 Hydro Electric Power

Plant **10**

Hydro Electric Power Plant: Water power - Hydrological cycle / flow measurement - drainage area characteristics - Hydrographs - storage and Pondage - classification of dams and spill ways.

Hydro Projects And Plant: Classification – Typical layouts – plant auxiliaries – plant operation pumped storage plants.

Nuclear Power Station: Nuclear fuel - breeding and fertile materials - Nuclear reactor - reactor operation- radioactive waste disposal.

Boiling water reactor - Pressurized water reactor - Gas cooled reactor - Fast breeder reactor - Liquid metal cooled reactor-reactor materials - Radiation shielding

Learning Outcomes: At the end of the unit, the student will be able to

- Demonstrate the functioning of Hydro-electric power plants and concepts of hydro projects. (L3)
- Describe the working principles of various nuclear reactors. (L2)

Unit 5 Power From Non-Conventional Sources **6**

Power From Non-Conventional Sources: Utilization of Solar Collectors- Principle of Working, Wind Energy – types - HAWT, VAWT - Tidal Energy.

Power Plant Economics And Environmental Considerations: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, Load curves, and load duration curve. Definitions of connected load, Maximum demand, demand factor, average load, load factor, diversity factor - related exercises. Effluents from power plants and Impact on environment - pollutants and pollution standards - Methods of Pollution control.

Learning Outcomes: At the end of the unit, the student will be able to

- Describe the concept of non-conventional sources of Solar, wind and tidal energy. (L2)
- Examine about power plant economics and the concept of pollutants and pollution standards. (L4)

Prescribed Text Books:

1. P.K.Nag, Power Plant Engineering. TMH, 4 th Ed.2014.ISBN 10: 9339204042ISBN 13: 9789339204044.
2. P.C.Sharma, Power Plant Engineering. S.K.Kataria&sons, 2014. ISBN-10 : 9350143844, ISBN-13 : 978-9350143841.

Reference Books:

1. Rajput. R.K., A Text Book of Power Plant Engineering. Laxmi Publications;, 2016, 5th Ed. ISBN-10 : 8131802558ISBN-13 : 978-8131802557.
2. Hegde R.K. Power Plant Engineering. Pearson Education India, 2015. ISBN-10 : 9332534101ISBN-13 : 978-9332534100
3. Arora and S. Domkundwar.A Course in Power Plant Engineering Dhanpat Rai& Co. (P) Limited, 6th Ed. 2016. ISBN-10 : 8177001957, ISBN-13 : 978-8177001952.

Course Outcomes:

A student will be able to	Blooms Level of Learning
1. Summarize the different energy sources, fuel and ash handling systems in steam power plant.	L2
2. Summarize the combustion process, Dust collectors, cooling towers and feed water treatment in steam power plant.	L2
3. Summarize the working of diesel engine, gas turbine power plants and its auxiliaries.	L2
4. Summarize the working of hydroelectric power plant and nuclear power plants.	L2
5. Calculate the operating costs of steam power and highlight the power production from various non-conventional sources.	L

CO-PO-PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
20A37IT.1	2	2	1	2	-	-	-	-	-	-	-	-	2	2
20A37IT.2	2	2	1	2	-	-	-	-	-	-	-	-	2	2
20A37IT.3	2	2	1	2	-	-	-	-	-	-	-	-	2	2
20A37IT.4	2	2	1	2	-	-	-	-	-	-	-	-	2	2
20A37IT.5	3	3	1	2	-	-	-	-	-	-	-	-	2	2

UNIT-I

Power plant :-

It is an industrial facility that generates electricity from primary energy.

most power plants use one or more generators that convert mechanical energy into electrical energy in order to supply power to the electrical grid for society's electrical needs.

power plant engineering :-

The branch of engineering where in the various machines, machinery & space of power plant is discussed is called PPE.

PPE is one of the techniques of art that we can study, use, repair, preserve, operate & place in the machines & equipment of the power plant.

PPE also discusses power generation, transmission, distribution & its use.

In addition to protecting the balance of the environment & making more profit at a lower cost is also a matter of PPE.

What is the power plant?

It refers to a center or organization where electricity is produced by use of mechanical energy.

i.e where the power is generated by the conversion of energy through a no of instruments & this power is transmitted to the nearest or far distances following the necessary steps is called PP.

It is also known as PP, power station, generating station or power house.

power plant Types :-

It can be divided into the following categories based on conversion of energy from different energy into power.

→ steam power plant
hydro electric " "
diesel "
nuclear "
Gas "
Solar "
wind Turbine "

→ steam power plants, diesel power plants, gas turbine power plants & nuclear power plants are called thermal power plants because they convert heat into electrical energy.

→ Also based on nature & location of the load, the PP is also divided into following sections.

→ for example, depending on the nature of load, the PP is divided into two parts.

1) base load power plant
2) peak " "

the PP is divided into two parts based on location, namely 1) central power plant
2) Isolated " "

→ In addition to the above types, there are several obsolete power plants in the world.

→ For example; Thermo electric generator
Thermionic "
fuel cells power plants
photo voltaic solar cells power system
MHD PP
Fusion Reactor power system
Biogas / biomass energy power system.
Geothermal energy.
wind energy power system
Ocean Thermal energy Conversation
wave & Tidal wave
energy plantation scheme.

Power plant procedures :-

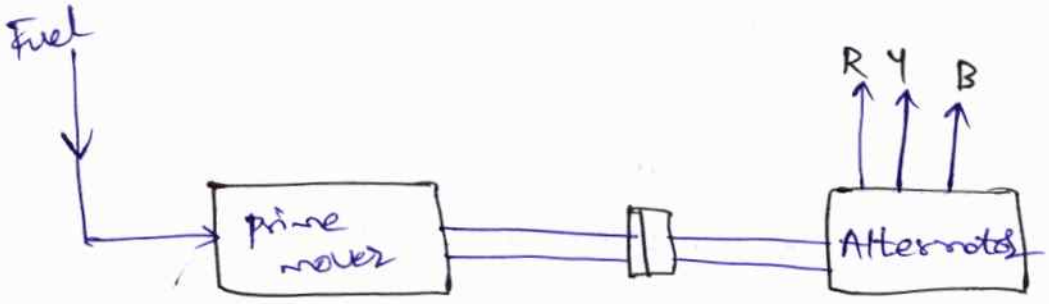
At the core of the power plant, there is a generator that converts mechanical energy into electrical energy by creating an interplay between the conductor & the magnetic field.

→ In most power plants, one or more generators are used to convert mechanical energy into electrical power.

→ The power generated at a power plant is conveniently sent to the nearest or far off for doing the necessary work by step up & step down.

→ In addition to generators at power stations, transformers, switch gears, starting motors, controlling units etc are used.

→ The following figure shows the power generation method of a typical power plant.



→ who turns the prime mover into a power station, first with an energy source or fuel?

The prime mover then turns on the alternator or the AC generator.

Since the shaft of the prime mover coupling to the shaft of the generator, the generator also rotates when the prime mover rotates.

And this rotation generates electricity from the generator.

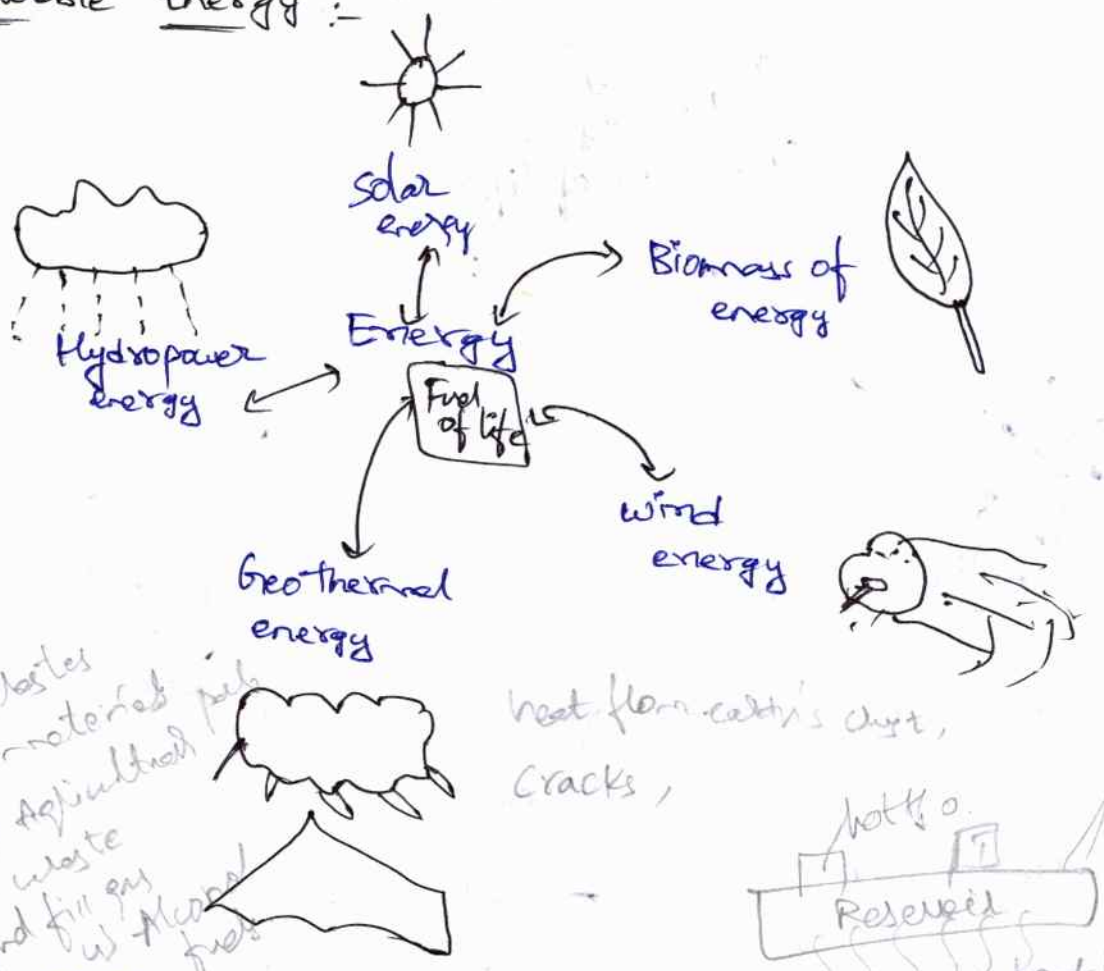
→ At a power station, a generator is rotated to a specific rpm for a fixed frequency.

This generates a certain amount of voltage at the output of the generator & this voltage is provided to the national grid by step up & step down with the transformer.

Energy

Renewable | Non Renewable

Renewable Energy :-



It is the energy derived from natural sources that are replenished at a higher rate than they are consumed.

→ Sunlight & wind.

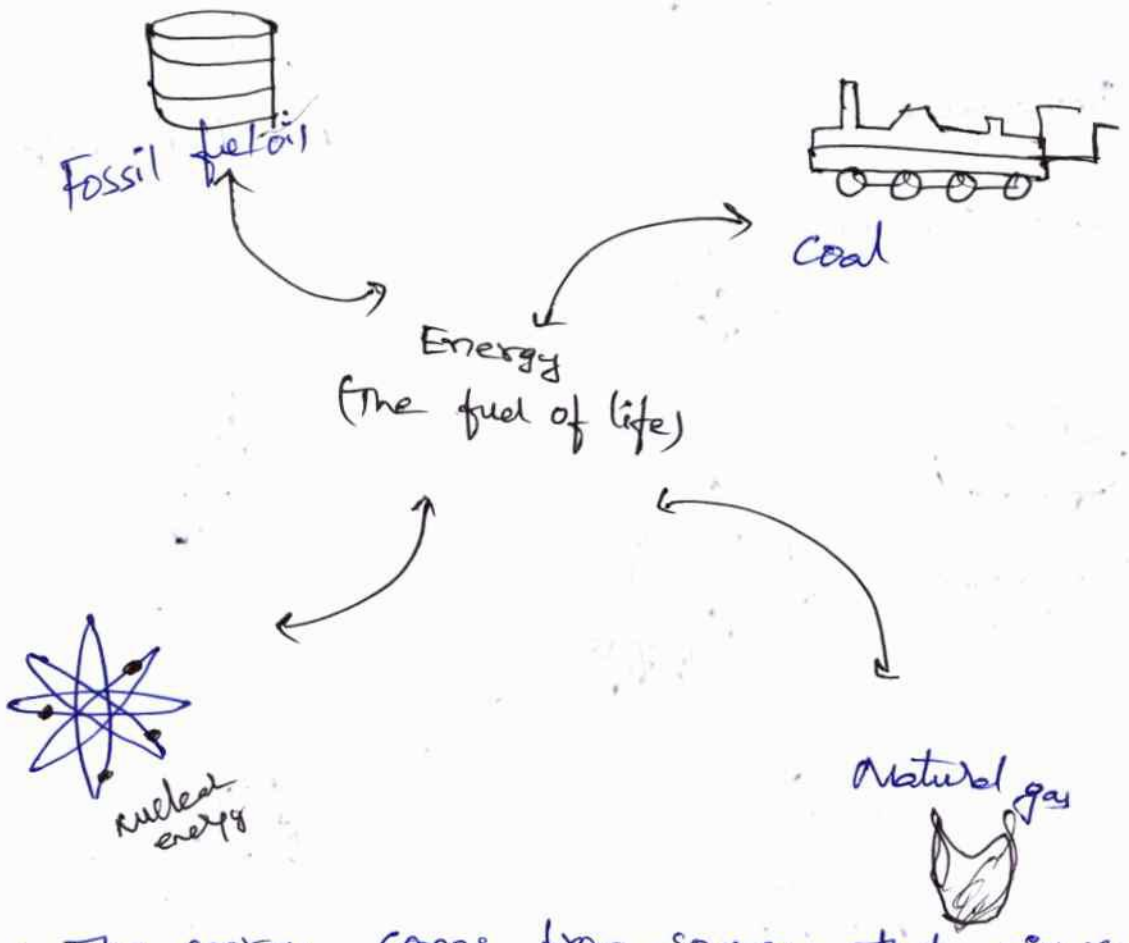
for example, are such sources that are constantly being replenished.

→ Renewable energy sources are plentiful & all around us.

⇒ Solar, wind, Hydro, Tidal, Geothermal & biomass energy.

⇒ A resource that can be used repeatedly & does not run out because it is naturally replaced.

Non Renewable Energy :-



→ The energy comes from sources that will run out or will not be replenished (or replaced) in our life-times.

examples :- Fossil Fuels :- Coal, petroleum & Natural gas.

→ Carbon is the main element in Fossil fuels.

→ examples → Ores, Rocks as resources.

Earth's Resources :-

Resources come from the earth, either in the raw form or as material used to make new products.

→ earth's resources include organisms, air, water & soil as well as materials such as oil, gas, & ores that are removed from the ground for processing.

→ Two main classification of Resources :-

1) Renewable resources
2) Non " "

Criteria	Non-renewable energy resources	Renewable energy Resources
1) Repetitively used energy Sources	one time use	Can use again & again.
2) Perpetual sources	Varish one day	available for Perpetal use.
3) Eco friendly Sources	emits gasses & pollute the environment	do not emit gases & does not pollute the environment
4) Availability	limited quantity	unlimited quantity
5) production cost	high	low
6) maintenance cost	low	high
7) production quantity	large	less
Space Area	→ Large land area is required for its power plant.	→ less land area is required for its power plant installation.

Commercial & Non commercial energy sources :-

Energy sources like Coal, oil, gas, uranium & hydel power are known as commercial energy sources, because they are directly used to produce electricity.

→ Energy sources like wood, dung, waste etc are known as non commercial energy sources.

→ These are mainly used as fuel for cooking & are also used in cottage industries. (eg smithy)

→ In sugar mills also non commercial energy sources are utilised.

→ The energy sources available can also be classified into 3 major types based on yield of net energy.

They are :- 1) primary energy sources
2) secondary "
3) supplementary "

1) primary energy sources :-

The energy source which provides a net supply of energy is called primary energy source.

ex:- Coal, natural gas, uranium, oil etc.

→ The energy to be expended to obtain these fuels is very much less than the energy that can be obtained from them by combustion or nuclear reaction.

2) secondary energy sources :-

from the " " ", the yield of energy is less than the input.

ex:- solar energy, wind energy, tidal energy, water energy etc.

(3) Supplementary energy sources :-

If the net energy yield provided by the energy source is zero, it is called Supplementary energy source.

ex:- Thermal insulation.

Non-renewable energy sources :-

The different non-renewable sources of energy are :-

1) Fossil Fuels 2) Nuclear energy.

(1) Fossil Fuels :-

The Fossil Fuels are classified into 3 major types.

1) solid fuels — Coal including anthracite, bituminous, brown coal, lignites & peats.

2) liquid fuels — petroleum products.

3) Gaseous " — Coal gas, natural gas.

(1) solid Fuels :-

Coal is obtained as the result of decomposition of vegetable matter buried under earth for thousands of years, in absence of oxygen.

→ About 33% of world's energy need is met by Coal.

→ Coal is used in power plants & for producing steam in process & chemical industries.

→ It is used for iron & steel making.

→ Chemical industries such as fertilizers, plastics, paints depend on the by products of Coal.

(2) Liquid Fuels (oil/petrol)

Nearly 40% of world's energy need is met by oil.

→ After refining the oil fuels are used in I.C. engines, diesel power plants & furnaces.

→ The by products are useful in petrochemical industries like Fertilizer, synthetic rubber, synthetic fibre, medicine, lubricants etc.

→ Gaseous Fuels (gas)

The gaseous fuels are classified as natural gas & prepared gas.

(i) Natural gas :-

It is a mixture of various compounds of hydrogen & Carbon & small amount of non hydrocarbons existing in the gaseous phase.

→ Natural gas is again classified into two main types. They are :- (a) Associated gas – It is the gas evolved from fields producing both liquid & gaseous hydrocarbons.

(b) Non Associated gas – It is the gas evolved from fields producing liquid & gaseous hydro Carbons separately.

(ii) Prepared gas :-

The gases are obtained as by products of some processes.

ex:- Coal gas, blast furnace gas, producer gas, water gas.

Renewable Energy sources :-

(1) Hydel power :-

Hydel power is obtained from the water, when it is allowed to fall under the force of gravity.

→ It is mostly used in the generation of electricity.

→ It is an indirect use of solar energy.

→ The potential energy of water is converted into mechanical energy by using hydraulic turbines.

Advantage :- Hydel plants is the low operating cost, since no fuel is necessary.

→ Hydel power accounts for about 20% of total power generated in the country.

Solar energy :-

It is one of the major sources of renewable energy.

→ The part of the heat energy radiated from the sun is collected by means of different types of solar collectors.

→ Then this heat energy is used to generate steam, which is used to run the turbines, & hence the generators to generate electricity.

→ The temp range of around 5000°c.

Applications :-

Solar water heating
Heating & cooling of buildings.
Solar cookers
" furnace
" refrigeration
" ponds
" electric power generation.

→ Solar energy is used for water heating in a no of private sector projects by using available collectors.

→ In small power generating systems, photo voltaic cells are used.

Wind Energy :-

It can be used for the generation of electricity.

It is created by two main factors. They are :-

1) Heating & cooling of the atmosphere which creates convention currents.

2) The rotation of earth, relative to the atmosphere, & its motion around the sun.

→ The energy obtained from the wind is used to rotate the windmill, which in turn drives the generator to produce electricity.

→ Two main types of windmill. They are :-

1) Horizontal axis type – multi blade type windmill, sail type windmill, propeller type windmill.

2) Vertical axis type – Savonius type windmill, darrieus type windmill.

Biomass Energy :-

Biomass means organic matter produced by plants (grown both on land & water) & their derivatives.

There are three types :-

1) Wood & agricultural residue :- Energy is obtained by direct combustion.

Sugarcane, straw, eucalyptus, Casuarina.

2) Biomass converted into liquid fuels :- (Thermochemical Conversion)

ethyl alcohol & methyl alcohol.

These fuels can be used in engines.

(3) Biogas is produced by the fermentation of biomass :-
biomass resources include harvested biomass (wood, agricultural crops, algae, etc). municipal refuse, sewage, industrial waste, animal & human waste.

→ It is used for cooking & lighting.
It is also used for running IC engines.

→ wet cow dung is mainly used to produce biogas.

Ocean Thermal Energy :-

The solar radiation emitted by the sun is absorbed by the sea water & its temperature is raised.

→ The upper layers of sea water act as a storage device for heat.

→ Then this heat is used to generate vapours from any organic fluid that has a low boiling point.

→ Then the vapours are used to run a heat engine.

Tidal Energy :-

Tides occur as result of the gravitational attraction of the sun & moon on the earth.

→ It is defined as the periodic rise & fall of the sea level.

→ Tides are of two different types.

(i) High tide (flood tide)
when the water level in the sea is above the mean sea level, then the tide is called high tide or flood tide.

(ii) low tide (Ebb tide)
when the water level is below the mean sea level, then the tide is called low tide or ebb tide.

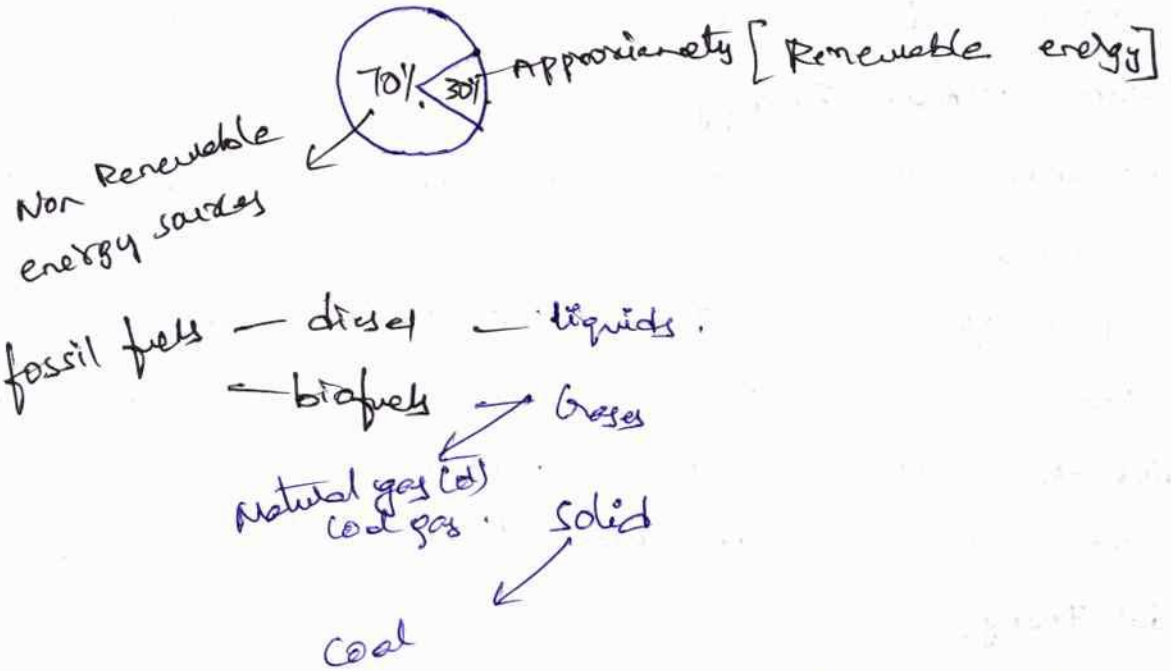
Geo-Thermal Energy :-

The heat energy which is stored inside the earth can be used to generate power.

This heat energy obtained from the earth is called the geo-thermal energy.

This heat is absorbed by working fluid & steam is generated, which in turn is used to produce electricity.

Resources and development of power in India :-



In world wise, India is the 4th largest country.

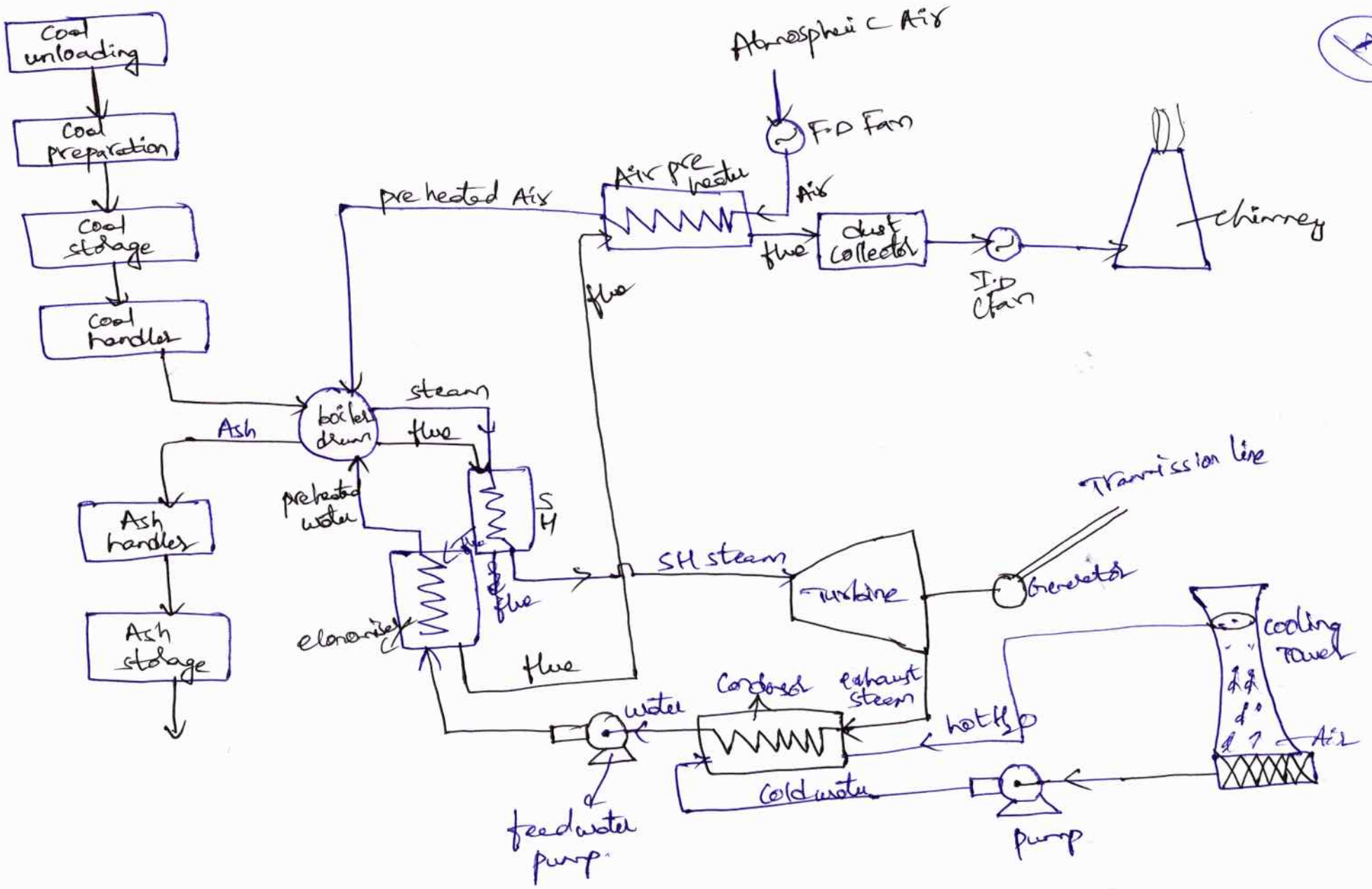
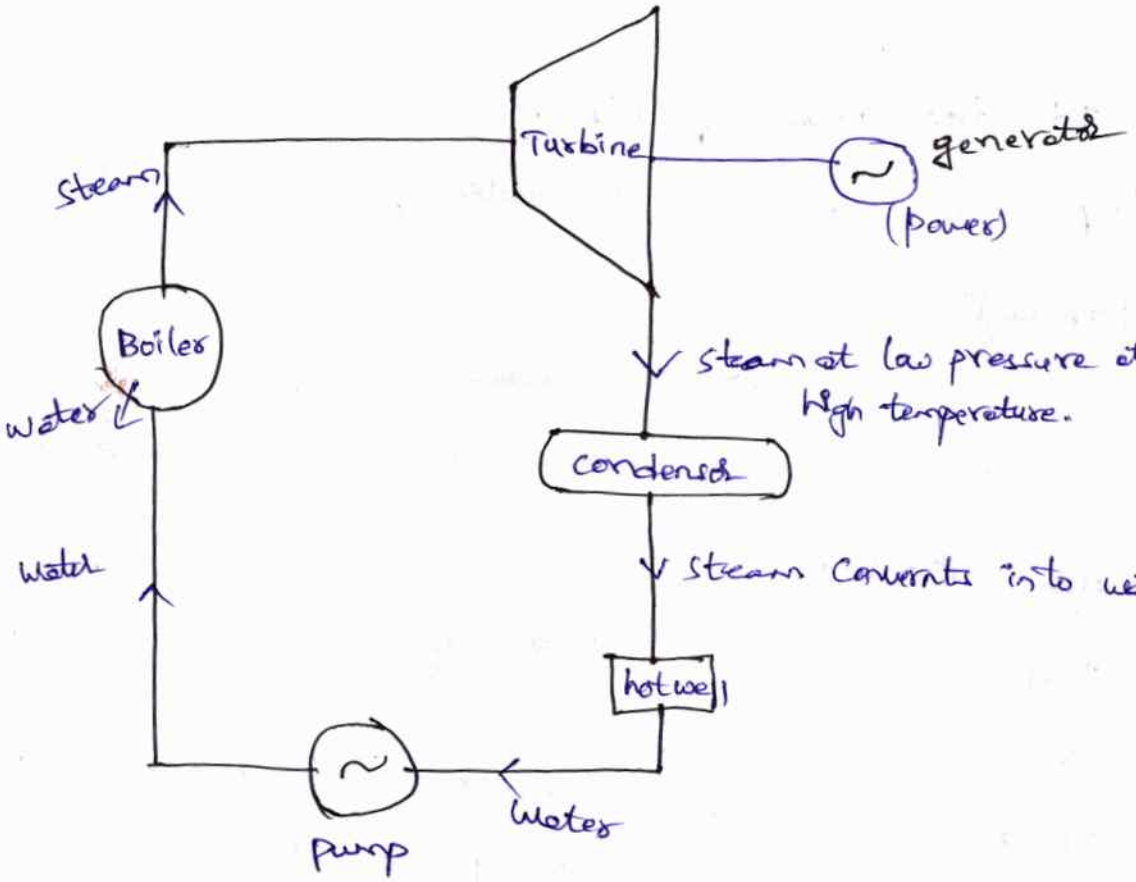


fig:- layout of a steam power plant layout

Steam power plant layout :-



Boiler — burning of fuel will be moved to water & then its converts into steam at required pressure as well as temperature.

→ The steam is then expanded in a turbine to do work.

Turbine — A Turbine is a machine that transforms rotational energy from a fluid that is picked up by a rotor system into usable work & energy.

Turbines achieve this either through mechanical gearing (or) electromagnetic induction to produce electricity.

→ The Turbine drives a generator to produce electric power.

→ The expanded steam is then passed through the condensor.

Condensor → These are heat exchangers which convert steam from its gaseous to its liquid state at a pr below atmospheric pr.

Hot well :- A Tank or reservoir in which hot water is collected before being recirculated.

It store tonnes of water.

Pump - from the pump, water flows in to the boiler.

Introduction :-

Steam is an important medium for producing mechanical energy.

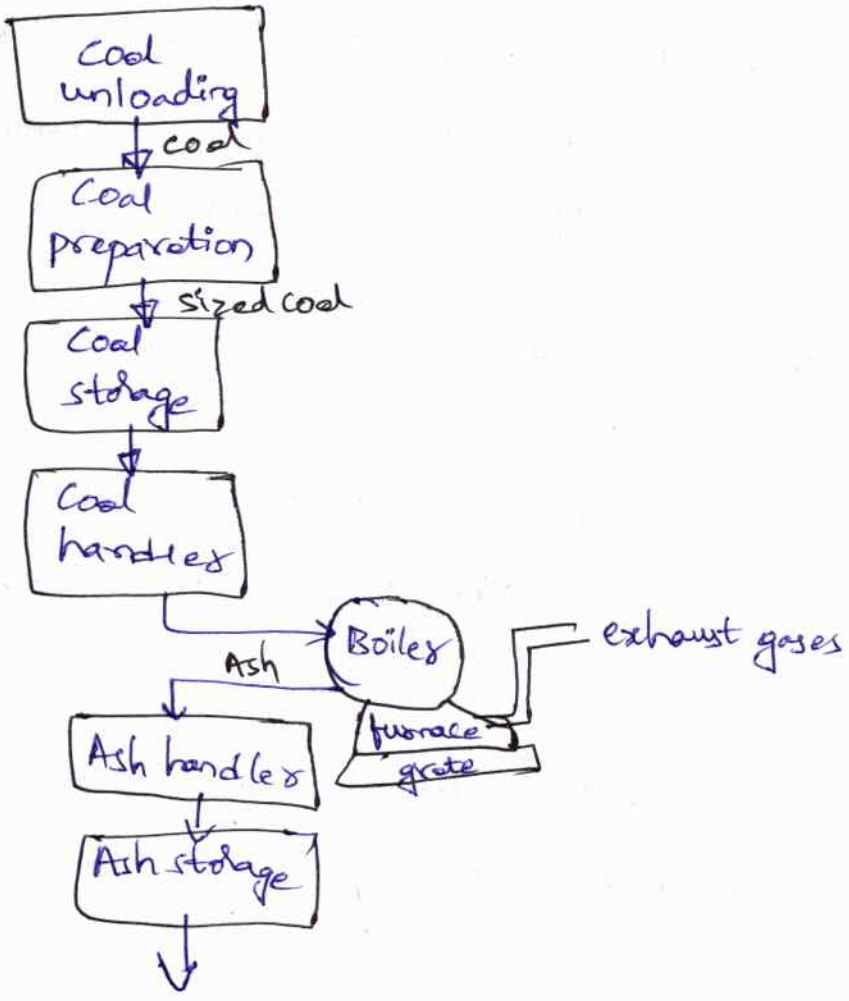
→ It is used to drive steam engines & steam turbines.

Steam advantages :-

1) Steam can be raised quickly from waters which is available in plenty.

2) It does not react much with ~~members~~ materials of the equipment used in power plants.

(3) It is stable at temperatures required in the plant.



Coal unloading → removing foreign (dust) particles.
It prepare permanent stores.

Coal preparation → All coal should be in sized coals.

Coal storage → The coal is sized by crushers, breakers etc.

Coal storage → The sized coal is then stored in coal storage. (Stock yard)

Coal handler → From the stock yard, the coal is transferred to the boiler furnace by means of conveyors, elevators etc.

Boiler furnace → The coal is burnt in the boiler furnace & ash is formed by burning of coal.

Ash handler → Ash coming out of the furnace will be too hot, dusty & accompanied by some poisonous gases.

Ash storage → The ash is transferred to ash storage.
→ The ash is quenched to reduced temp, corrosion & dust content.

Equipment of a steam power plant :-

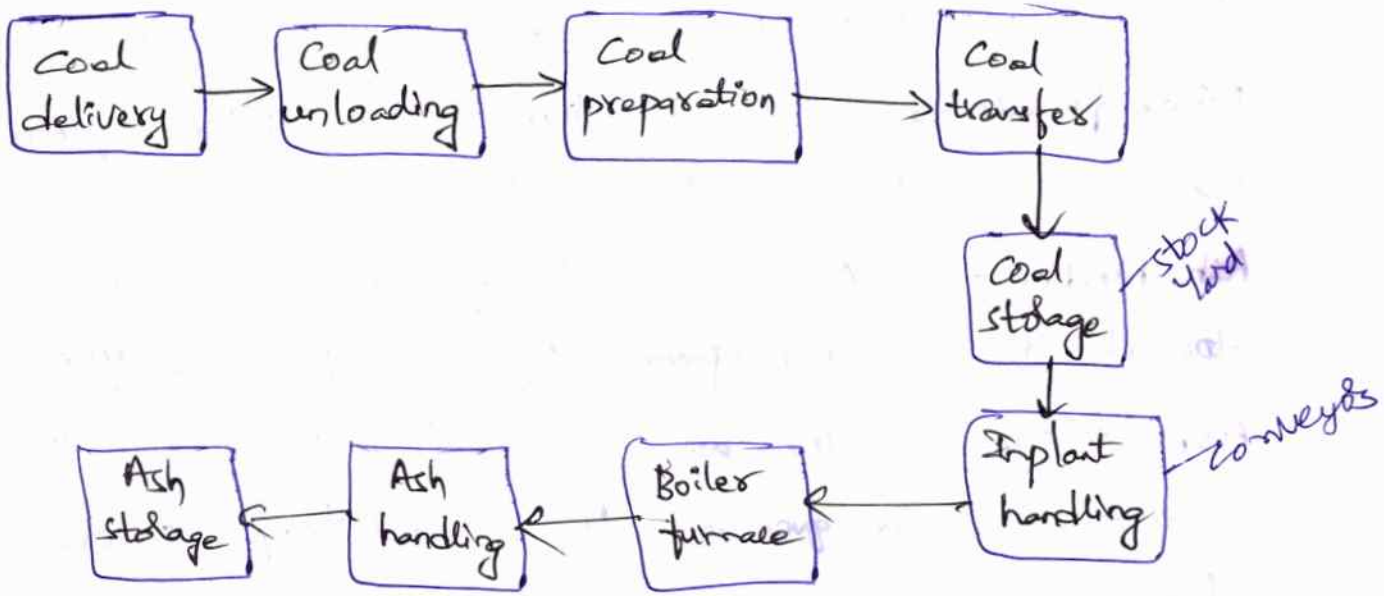
A steam power plant must have the following equipment.

1) A furnace for burning the fuel.
2) A steam generator or boiler for steam generation.
3) A power unit like an engine or turbine to convert heat energy into mechanical energy.
4) A generator to convert mechanical E into electrical E.
5) Piping system to carry steam & water.

→ The working of a steam power plant can be explained in four circuits.

1) Fuel (Coal) & ash circuit
2) water & steam circuit
3) Air & flue gas "
4) Cooling water flow "

1) Fuel (Coal) & ash circuit :-



This includes coal delivery, preparation, coal handling, boiler furnace, ash handling & ash storage.

The coal from coal mines is delieveld by ships, rail & by trucks to the powerstation.

This coal is sized by crushers, breakers etc. The sized coal is then stored in coal storage (stock yard.

From the stock yard, the coal is transferred to the boiler furnace by means of conveyors, elevators etc.

The coal is burnt in the boiler furnace & ash is formed by burning of coal.

Ash coming out of the furnace will be too hot, dusty & accompanied by some poisonous gases.

The ash is transfered to ash storage.

Usually, the ash is quenched to reduced temperature, corrosion & dust content.

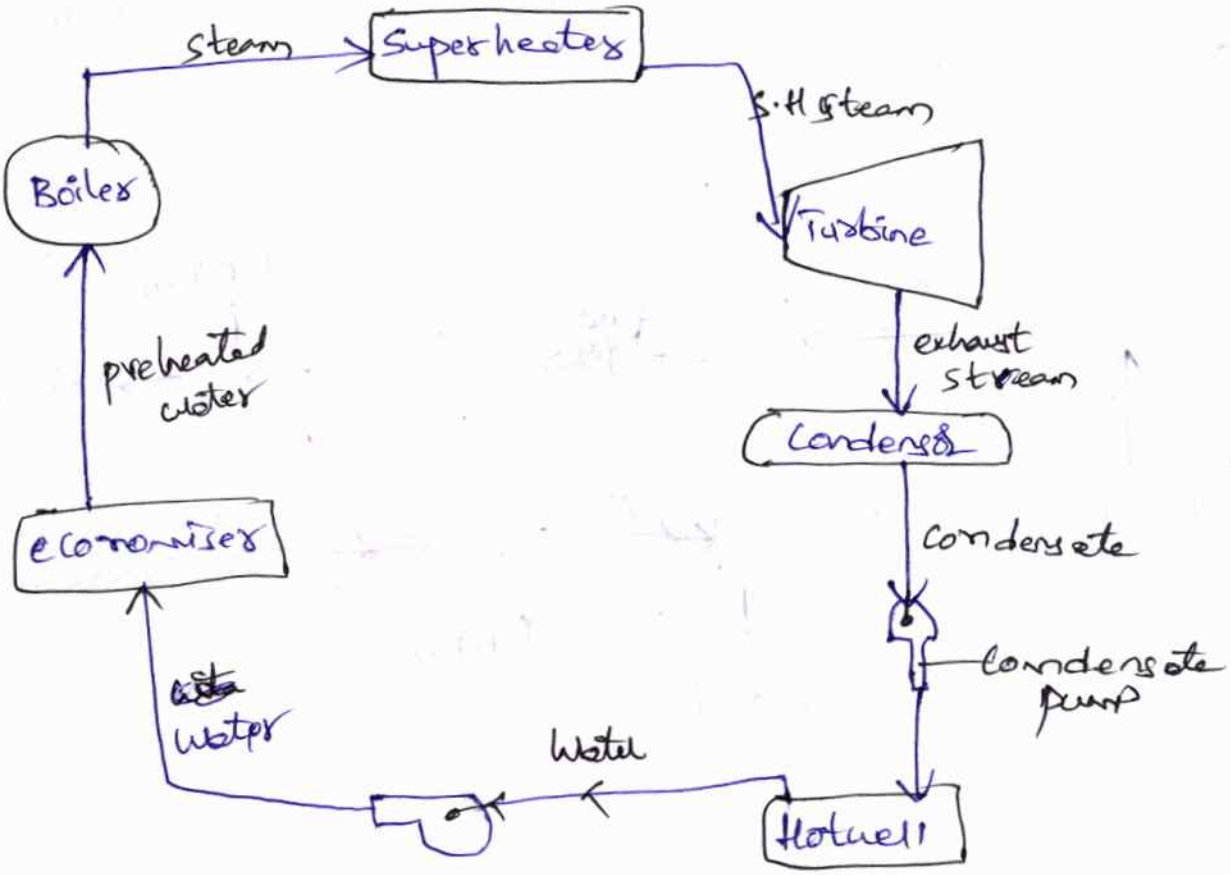
There are different methods employed for the disposal of ash. They are hydraulic system, water jetting, ash sluice ways, pheremotic system etc.

In large power plants hydraulic system is used.

In this system, ash falls from the furnace grate into high velocity water stream.

It is then carried to the slumps.

(2) Water and steam circuit :-



It consists of feed pump, economiser, boiler drum, superheater, turbine, condensor etc.

Feed water is pumped to the economisers from the hot well. This water is preheated by the flue gases in the economiser. This preheated water is then supplied to the boiler drum. Heat is transferred to the water by the burning of coal. Due to this water is converted in to steam.

→ The steam is raised in boiler is passed through a superheater. It is superheated by the flue gases.

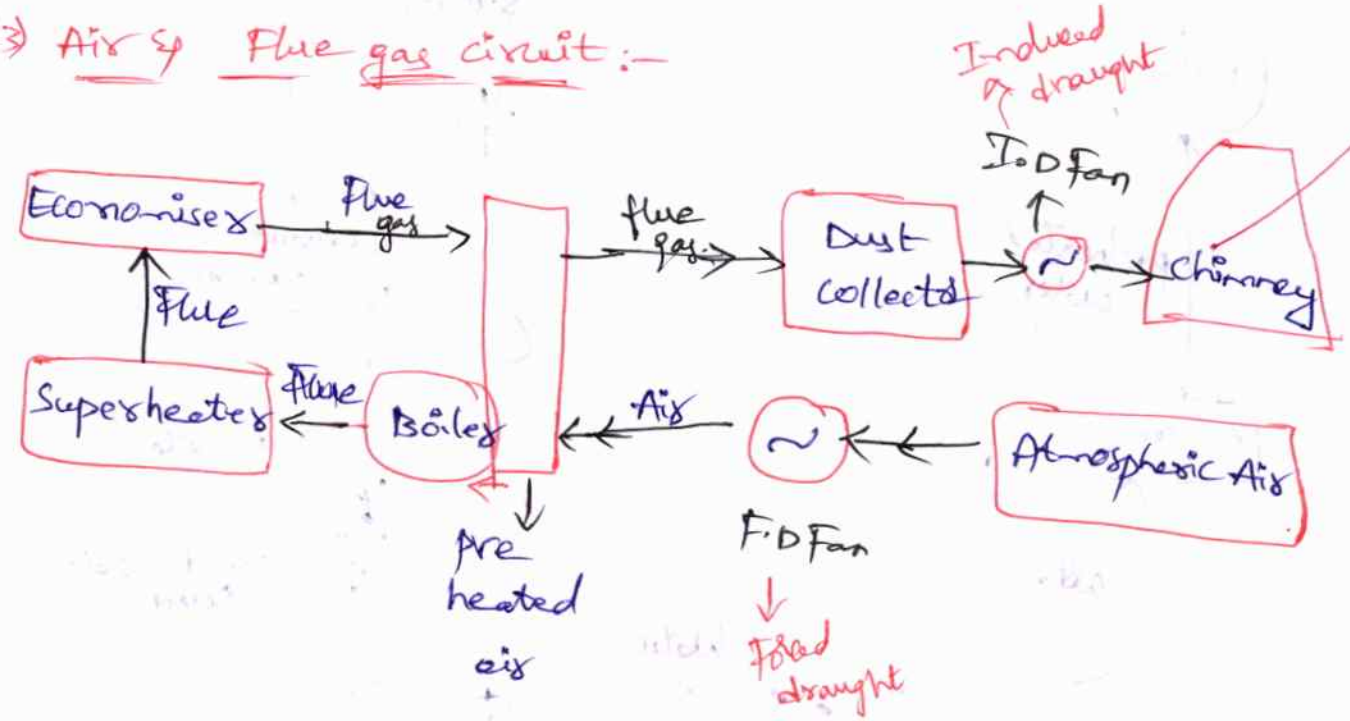
→ The superheated steam is then expanded in a turbine to do work.

→ The turbine drives a generator to produce electric power.

→ The expanded (exhaust) steam is then passed through the condensor.

→ In the condensor, the steam is condensed in to water & recirculated.

(3) Air & Flue gas circuit :-



It consists of forced draught fan, air preheater, boiler furnace, superheaterer, economisers, dust collector, induced draught fan, chimney etc.

Air is taken from the atmosphere by the action of a forced draught fan.

It is passed through an air pre-heater. The air is preheated by the flue gases in the pre heater.

This preheated air is supplied to the furnace to aid the combustion of fuel.

Due to combustion of fuel, hot gases (flue gases) are formed.

→ The flue gases from the furnace pass over boiler tubes & superheater tubes. (In boiler, wet steam is generated & in superheater the wet stream is superheated by the flue gases).

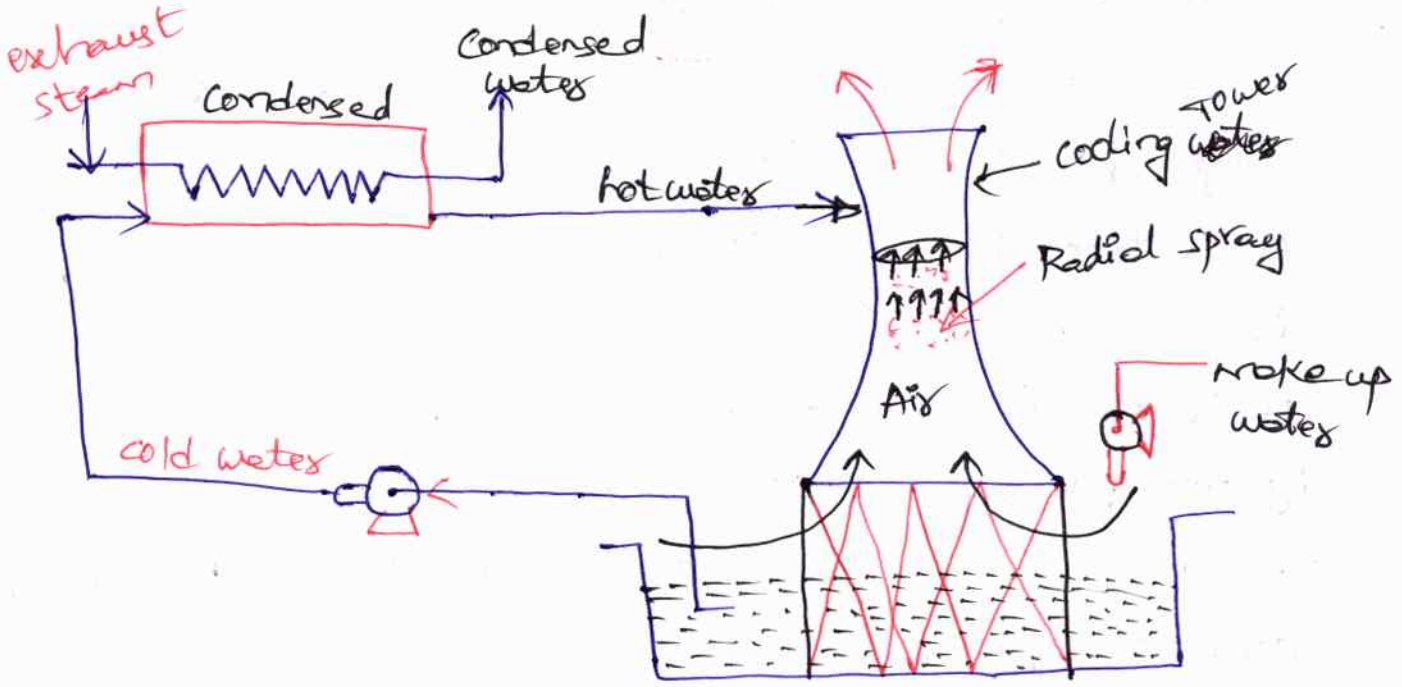
→ Then the flue gases pass through economisers to heat the feed waters.

After that it passes through the air pre-heater to preheat the incoming air.

It is then passed through a dust catching device (dust collector).

Finally it is exhausted to the atmosphere through chimney.

(4) Cooling water circuit :-



This circuit includes a pump, condenser, cooling tower etc. The exhaust steam from the turbine is condensed in a condenser.

In the condenser, cold water is circulated to condense the steam into water.

The steam is condensed by losing its latent heat to the circulating cold water.

heat is absorbed & released during a phase change of a substance

Thus the circulating water is heated. This hot water is then taken to a cooling tower.

In cooling tower, the water is sprayed in the form of droplets through nozzels.

The atmospheric air enters the cooling tower from the openings provided at the bottom of the tower.

This air removes heat from water.

Cooled water is collected in a pond known as a cooling pond.

This cold water is again circulated through the pump, Condenser & cooling tower.

Thus the cycle is repeated again & again.

Some amount of water may be lost during the circulation due to vaporisation etc.

Hence make up water is added to the pond by means of a pump.

This water is obtained from a river or lake.

Types of coals :-

Coal :- Its main constituents are Carbon, hydrogen, oxygen, nitrogen, sulphur, moisture & ash.

Coal passes through different stages during its formation from vegetation.

These stages are enumerated & discussed below :-

Plant debris - peat - Lignite - Brown coal - sub - bituminous coal - bituminous coal - semi - bituminous coal - semi anthracite coal - Anthracite coal - graphite.

Peat :- It is the first stage in the formation of coal from wood.

It contains huge amount of moisture & therefore it is dried for about 1 to 2 months before it is put to use.

→ It is used as a domestic fuel in europe & for power generation in Russia.

In India it does not come in the categories of good fuels.

(2) Lignites & brown coals :-

These are intermediate stages between peat & coal. They have a woody & often a clay like appearance associated with high moisture, high ash & low heat contents.

→ Lignites are usually amorphous (unformed shape) in character & impose transport difficulties as they break easily.

→ They burn with a smoky flame. Some of this type are suitable for local use only.

(3) Bituminous (dl black) coal :- It burns with long yellow & smoky flames & has high percentages of volatile matter. The average Calorific value of bituminous coal is about 31350 KJ/kg. → high heating → used in electricity generation & steel making. It may be of two types, namely Caking & non-Caking.

(4) Semi bituminous coal :-

It is softer than the anthracite. It is a type of coal which when heated in anaerobic conditions leaves a solid residue when heated in air tight conditions leaves a powdery residue.

It burns with a very small amount of smoke.

It contains 15 to 20% of volatile matter & has a tendency to break into small sizes during storage & transportation.

(5) Semi anthracite :-

It has less fixed carbon & less lustre as compared to true anthracite & gives out longer & more luminous flames when burnt.

(6) Anthracite :- It is very hard coal & has a shining black lustre.

It ignites slowly unless the furnace temperature is high.

It is non caking & has high percentage of fixed carbon.
It burns either with very short blue flames & without flames.
→ The calorific value of this fuel is high to the tune of 35500 KJ/kg & as such is very suitable for steam generation.

(7) Wood charcoal :-

It is obtained by destructive distillation of wood.
during the process the volatile matter & water are expelled.
→ The physical properties of the residue (charcoal) however depends upon the rate of heating & temperature.

(8) Coke :- It consists of carbon, mineral matter with 2% sulphur & small quantities of hydrogen, nitrogen & phosphorus.
It is solid residue left after the destructive distillation of certain kinds of coals.
It is smokeless & clear fuel & can be produced by several processes.
It is mainly used in blast furnace to produce heat & at the same time to reduce the iron ore.

Fuel Handling :-

Three types of fuels can be burnt in any type of steam generating plant.

1) Solid Fuel such as coal.
2) liquid " " oil.
3) Gaseous " " gas.

Supply of these fuels to the power plants from various sources is one of the important considerations for a power plant engineer.

The handling of these fuels is an important aspect.

→ The following factors should be considered in selecting the fuel handling system.

1) plant fuel rate.
2) plant location in respect of fuel shipping
3) storage area available.

Fuel handling plant needs extra attention, while designing a thermal power station, as almost 30 to 60% of total operating cost consists of fuel purchasing & handling.

Fuel system is designed in accordance with the type & nature of fuel.

Continuously increasing demand for power at lower cost calls for setting up of higher capacity power stations.

→ Rise in capacity of the plant poses a problem in coal supply system from coal mines to the power stations.

→ The coal from coal mines may be transported by the following means :-

1) Transportation by sea or river.
2) " by rail
3) " " ropeways
4) " road
5) " of coal by pipeline.

The pipeline coal transport system offers the following advantages :-

(1) It provides simplicity in installation & increased safety in operation.

(2) more economical than other modes of transport when dealing with large volume of coal over long distances.

(3) This system is continuous as it remains unaffected by the vagaries of climate & weather.

(4) high degree of reliability.

(5) loss of coal during transport due to theft & pilferage is totally eliminated.

(6) manpower requirement is low.

Requirements of Good coal Handling plant :-

1) It should need minimum maintenance.

2) It should be reliable.

3) It should be simple & sound.

4) It should require a minimum of operatives.

5) It should be able to deliver requisite quantity of coal at the destination during peak periods.

6) There should be minimum wear in running the equipment due to abrasive action of coal particles.

Coal Handling systems :-

Mechanical handling of coal is preferred over manual handling due to following reasons.

1) Higher reliability.

2) less labour required.

3) Economical for medium & large capacity plants.

4) operation is easy & smooth.

5) Can be easily started & can be economically adjusted according to the need.

6) With reduced labour, management & control of plant becomes easy & smooth.

7) minimum labour is put to unhealthy condition.

8) losses in transport are minimised.

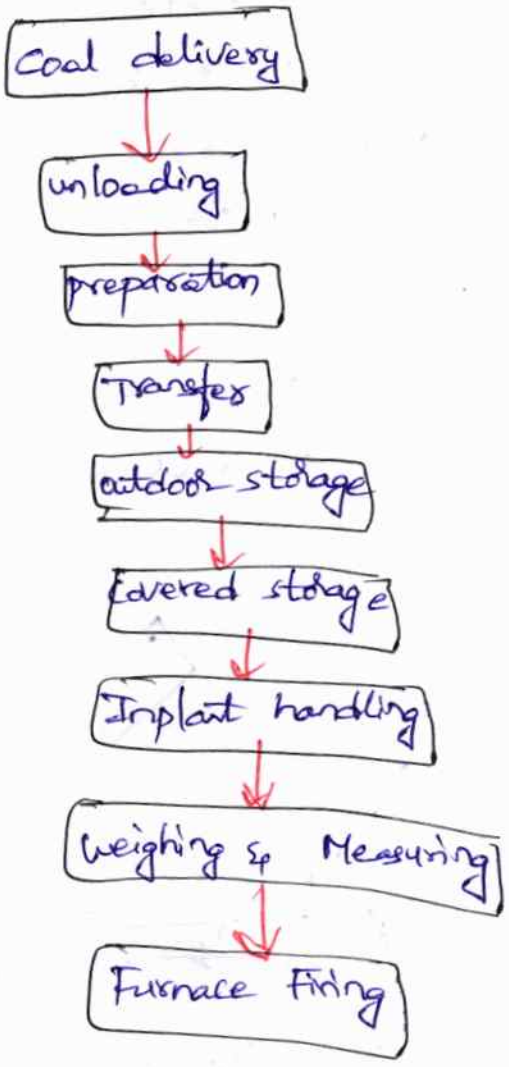
Disadvantages :-

1) Needs continuous maintenance & repair.

2) Capital cost of the plant is increased.

3) In mechanical handling some power generated is usually consumed, resulting in less net power available for supply to consumers.

Coal Handling :-



(1) Coal delivery :-

From the supply points the coal may be delievered to power station through rail, road, river or sea.

→ plants situated near the river or sea may make use of navigation facilities.

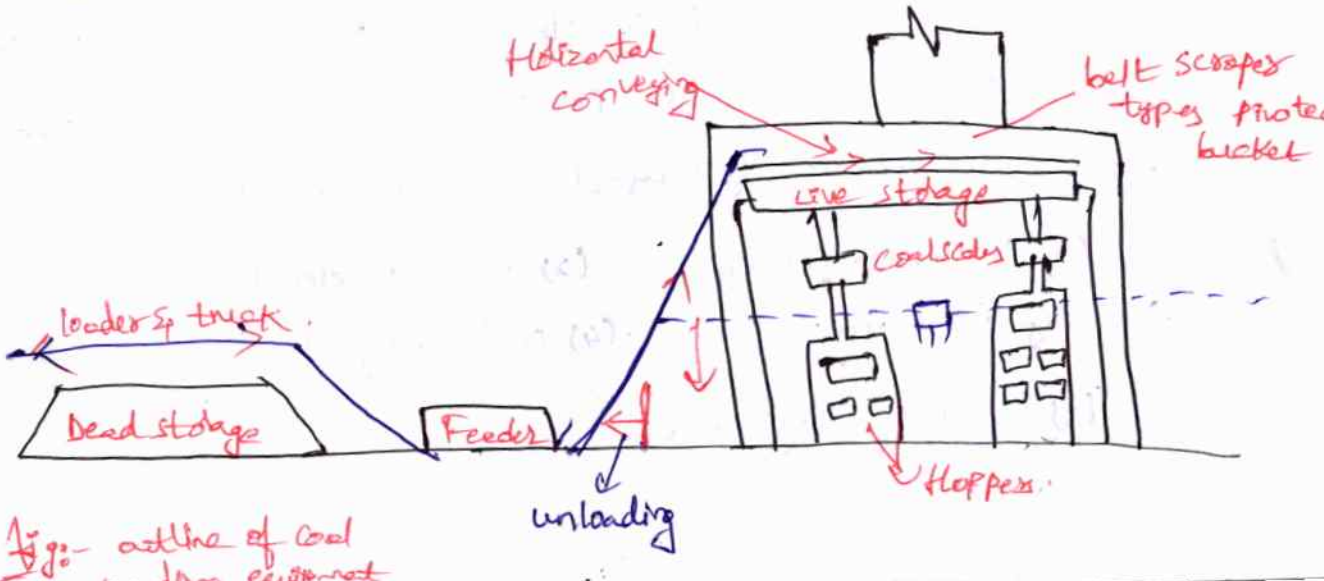


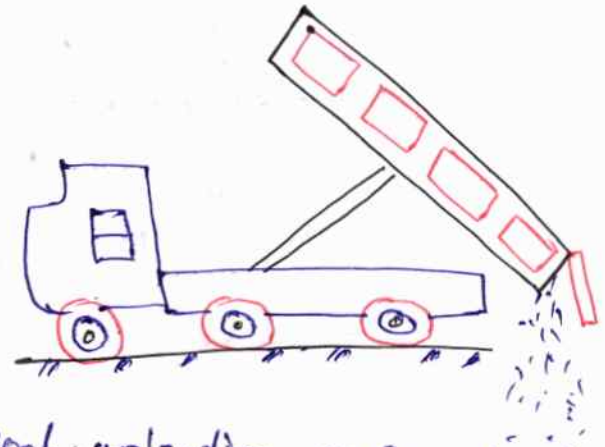
Fig:- outline of Coal handling equipment

→ stations which cannot make use of navigation facilities may be supplied coal either by rail or trucks.

→ Transportation of coal by trucks is usually used in case the mines are not far off or when the necessary railway facilities are not available.

→ In case rail transport is to be adopted, the necessary siding for receiving the coal should be brought as near the station as possible.

(3) unloading :-



The type of coal unloading equipment used in plant depends upon the type of out plant handling mode as road, rail or ship.

If coal is delievered by trucks, there is no need of unloading device as the trucks may dump the coal to the outdoor storage.

Coal is easily handled if the lift trucks with scoop are used.

→ When the coal is transported by sea, the unloading equipment normally used is given below :-

(1). Portable conveyors (2) Coal accelerators

(3) Coal towers (4) Unloading bridges

(5) Self unloading boats

(3) preparation :- If the coal when delivered is in the form of lumps, the coal preparation may be carried out by:

(1) Breakers (2) Crushers (3) Sizers (4) Dryers

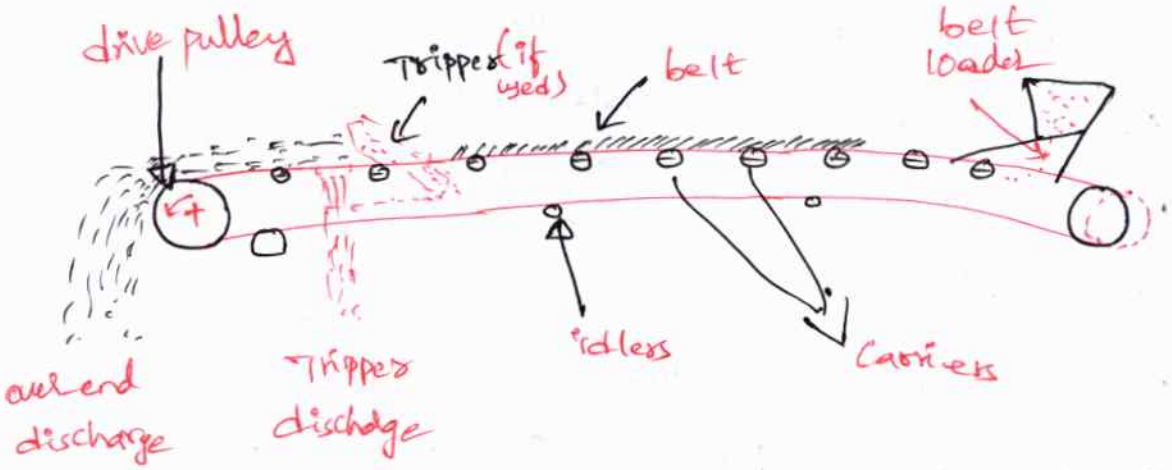
(5) magnetic separators.

(4) Transfers :- Transfers means the handling of coal b/w the unloading point & the final storage point from where it is discharged to the firing equipment.

The following equipment may be used for transfer of coal.

1) Belt conveyors
2) Screw conveyors
3) Vee bucket elevator & conveyor
4) pivoted bucket conveyor
5) Grab bucket
6) Flight conveyors
7) Skip hoists
8) mass flow conveyor
9) Chutes

(i) Belt conveyor :-



It is very suitable means of transporting large quantities of coal over large distances.

It consists of an endless belt (made of rubber, canvas or balata).

running over a pair of end drums or pulleys & supported by a series of rollers (known as idlers) provided at regular intervals.

The return idlers which support the empty belt are plain rollers & are spaced wide apart.

The initial cost of system is not high.

The inclination at which coal can be successfully elevated by belt conveyor is about 20°.

Average speed of belt conveyor is 60 to 100 m per min.

→ The load carrying capacity of the belt may vary from 50 to 100 tonnes/hour & it can easily be transferred through 400m.

It is used in medium & large power plants.

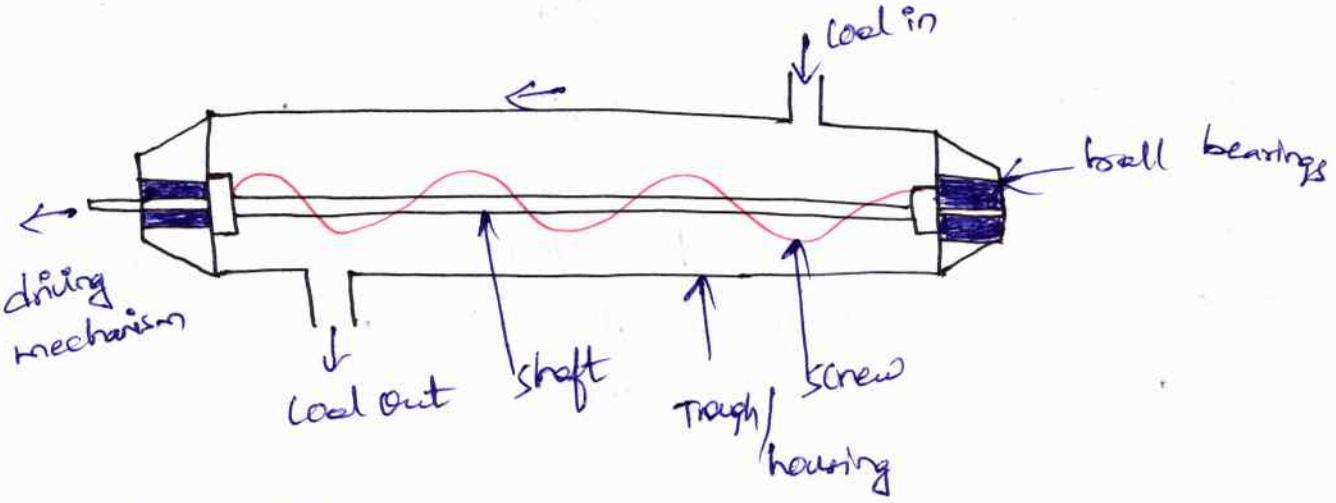
Advantages :-

1) most economical method of coal transport in medium & large capacity plants.
2) Its operation is smooth & clean.
3) Repair & maintenance costs minimum.
4) large quantities of coal can be discharged quickly & continuously.
5) power consumption is minimum.
6) The rate of coal transfer can be easily varied by just varying the belt speed.
7) Coal being transferred is protected

Disadvantages:-

1) Not suitable for greater heights & shaft distances.

(ii) Screw Conveyor:-



It consists of an endless helicoid screw fitted to a shaft.

The driving mechanism is connected to one end of shaft & other end of shaft is supported in an enclosed ball bearings.

The screw while rotating in a trough/ housing transfers Coal from one end to other end.

The following particulars relate to this conveyor.

diameter of screw - 15 to 50 cm.

Speed - 70 to 120 rpm

max Capacity - 125 tonnes/hour

(iii) Vee bucket elevator:-

In this type of elevator, steel V shaped buckets are rigidly fastened to an endless chain going round sprockets.

The buckets are equally spaced on the chain & receive their load by dipping into coal pocket at lower end of the system.

The material elevated in V buckets is discharged either by centrifugal force at top of elevator or by drawing back the buckets on discharged side.

Advantages :-

1) less power is required for operating the equipment.
2) Coal can be discharged at elevated places.
3) less floor area is required.

disadvantages :-

It is not suitable for large capacity stations.

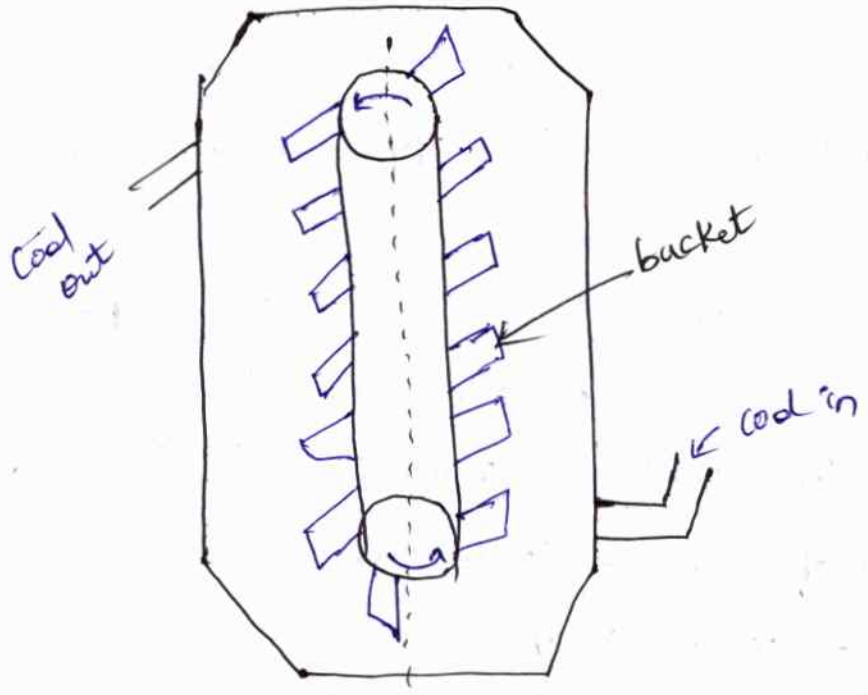


fig shows, which is used for moderate lifts.

The material is continuously handled & can be both hoisted & conveyed.

(iv) Pivoted bucket conveyor :-

This conveyor consists of malleable iron buckets suspended by pivots midway b/w the joints of two endless chains, which are driven by a motor located at some convenient point, usually at the top of a vertical rise.

while travelling horizontally, buckets maintain their position due to gravity & support the joints.

The conveyor is loaded by passing below a crusher.

The coal is charged into buckets by a tipping device.

Advantages :-

low operational cost

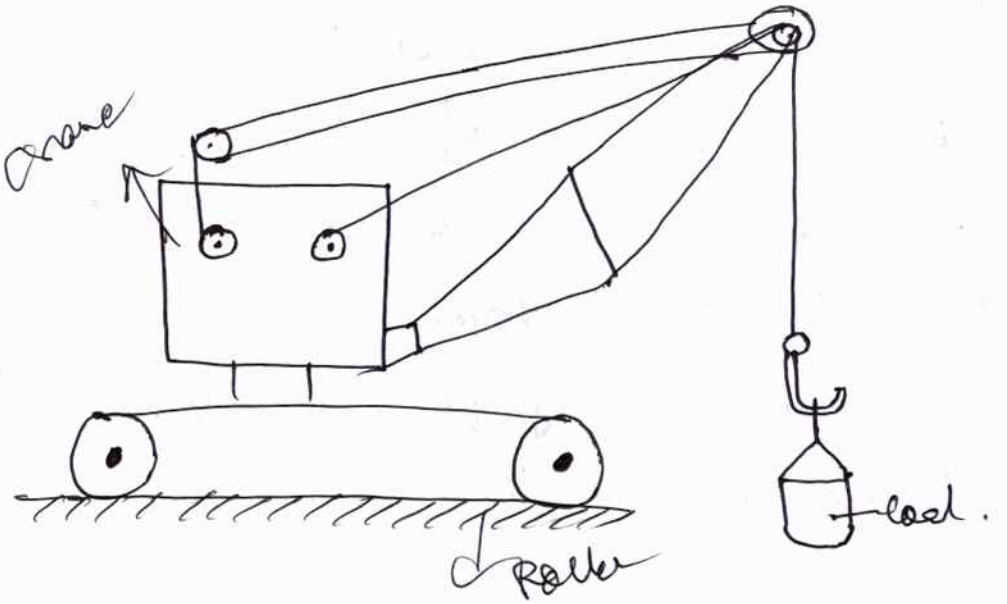
High capacity

Less floor area requirement

disadvantages :-

High initial cost of the equipment.

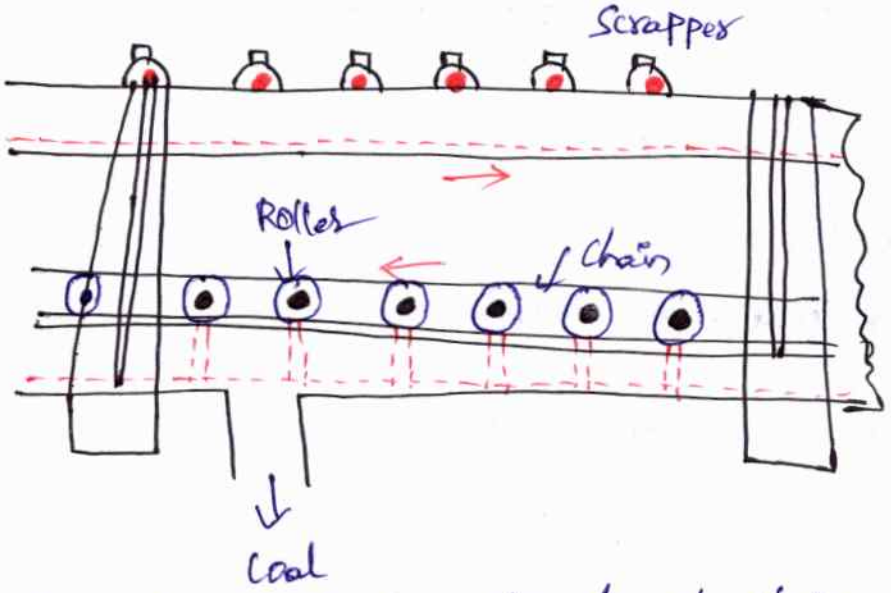
(v) Grab bucket conveyor :- Costly m/c — hr - 50 Tonnes capacity



It is a form of hoist which lifts & transfers the load on a single rail or track from one point to another.
This is a costly machine & is justified only when other arrangements are not possible.
Capacity of a grab bucket may be about 50 Tonnes per hour.

(vi) Flight Conveyor (or) scrapers :-

It is generally used for transfer of coal when filling of No of storage bins situated under conveyor is required.



It consists of one or two strands of chain, to which steel scrapers are attached.
The scraper scraps the coal through a trough & the coal is discharged in bottom of trough as shown in fig.
→ Capacity of a conveyor of the type may range from 10 to 100 tonnes per hour.
It is used extensively for conveying coal horizontally & for inclinations up to 35°.

Advantages :-

It has a rugged construction.

It can be used for transfer of coal as well as ash.

Its speed can be easily regulated.

It needs small headroom.

Disadvantages :-

excessive wear due to dragging action.

high maintenance cost.

The speed is limited to 30m/min to reduce the abrasive action of material handled.

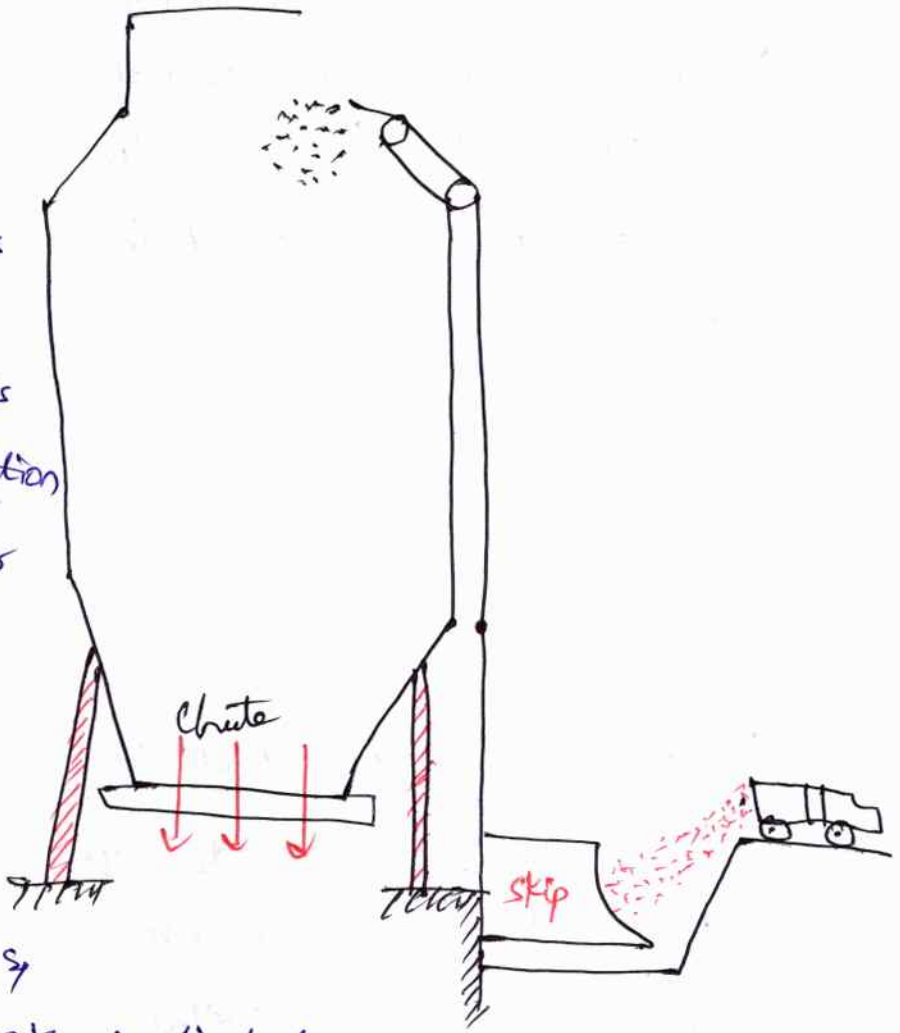
power consumption is more.

(vii) Skip hoist :-

It is used for high lifts & handling is non-continuous.

→ This arrangement is simple & cheap & operation costs including labour & maintenance are low.

→ It is oldest & simplest means of elevating coal & ash & is favourite of engineers particularly in ash handling.



(5) Storage of Coal :-

It is very essential that adequate quantity of coal should be stored.

Storage of coal gives protection against the interruption of coal supplies when there is delay in transportation of coal or due to strikes in coal mines.

1) There should be no standing water near the storage area.
2) Storage area should be solid & not loose & porous.
3) Conical piling should be avoided.

→ Bunkers made of steel & reinforced concrete are used to store the coal, from here the coal is transferred to boiler grates.

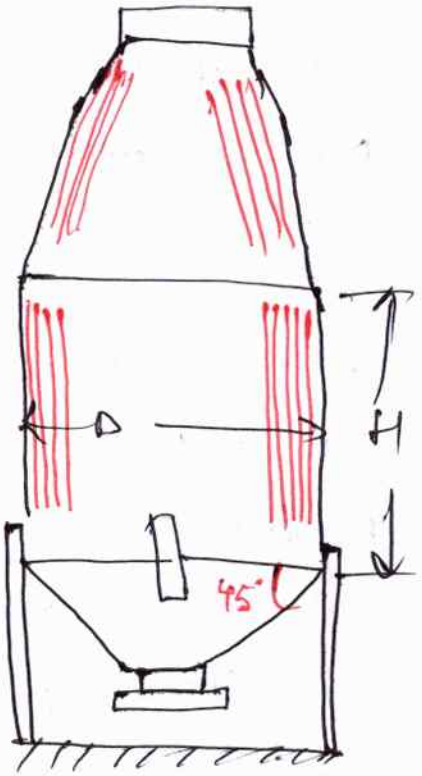


fig: Cylindrical bunker

(6) Inplant Handling :- (moving of coal from one place to another)

1) Coal handling b/w final storage & firing equipment.
2) A conveying system to feed coal from any bunker section to any firing unit & to move coal from one bunker section to another.

Inplant handling may mean no more than chutes to direct flow into individual firing units & gates or Valves to control the flow.

It may include the equipment such as belt conveyors, screw conveyors, bucket elevator etc to transfer the coal.

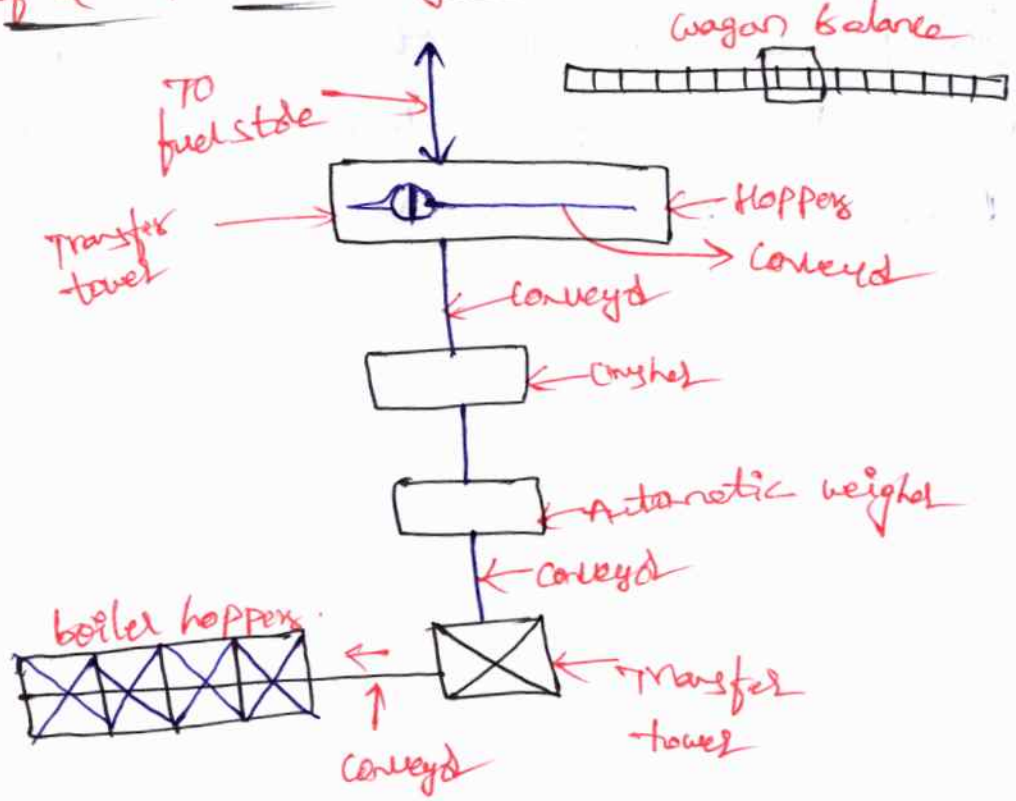
→ weigh lorries, hoppers & automatic scales are used to record the quantity of coal delivered to the furnace.

(7) weighing & Measuring :- To weigh the quantity of coal the following equipment is used

1) weigh bridge 2) belt scale
3) " lorry 4) Automatic scale

(8) Furnace firing :- Refer to coal delivery, unloading.

Layout of a fuel handling equipment :-



Coal is supplied to the power plant in railway wagons.

→ After weighing on wagon balance the coal is then unloaded underground hoppers of bunkers.

→ The wagon can be unloaded either manually & through rotary wagon tipplers.

→ From the bunkers, the coal is lifted by conveyor to transfer to. from where it can be delivered either to the fuel store & by a conveyor to a crusher.

→ The coal is then passed through the magnetic separators & screens & crushed in crushers into pieces 25 to 30 mm in size for stoker firing & 6 to 20 mm when pulverised fuel is fired in boiler furnaces.

→ The crushed coal in letter case is milled to a fine powder & then it is carried through automatic weighers to a transfer tower where fuel is lifted & distributed b/w boiler hoppers by a conveyor.

Ash handling :-

A huge quantity of ash is produced in central stations, sometimes being as much as 10 to 20% of total quantity of coal burnt in a day.

Hundreds of Tonnes of ash may have to be handled every day in large power stations & mechanical device become indispensable.

A station using low grade fuel has to deal with large quantities of ash.

Handling of ash includes :-

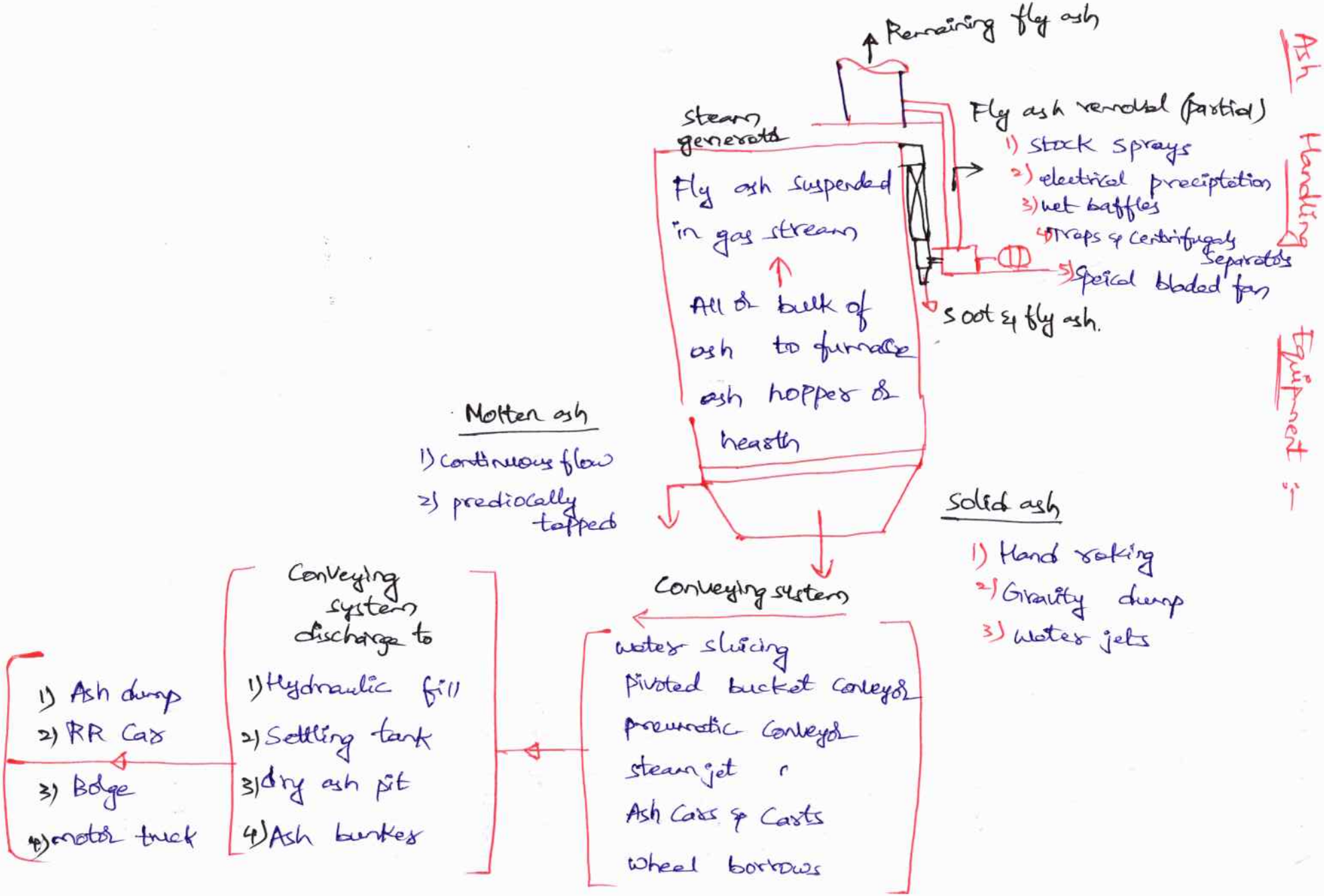
1) Its removal from the furnace.
2) loading on the conveyors & delivery to the fill & dump from where it can be disposed off by sale & otherwise.

Handling of ash is a problem because ash coming out of furnace is too hot, it is dusty & irritating to handle & is accompained by some poisonous gas.

→ Ash needs to be quenched before handling due to following reasons :-

1) quenching reduces corrosion action of ash.
2) It reduces the dust accompanying the ash.
3) " " " temperature of ash.
4) Ash forms clinkers by fusing in large lumps & by quenching clinkers will disintegrate.

Ash Handling Equipment :-



A good ash handling plant should have the following characteristics:-

1) It should have enough capacity to cope with the volume of ash that may be produced in a station.
2) It should be able to handle large clinkers, boiler refuse, soot etc. with little personal attention of the workmen.
3) It should be able to handle hot & wet ash effectively & with good speed.
4) It should be possible to minimise the corrosive & abrasive action of ashes & dust nuisance should not exist.
5) The plant should not cost much.
6) The operation charges should be minimum possible.
7) " " of plant should be noiseless as much as possible.
8) The plant should be able to operate effectively under all variable load conditions.
9) In case of addition of units, it should need minimum changes in original layout of plant.
10) The plant should have high rate of handling.

The commonly used equipment for ash handling in large & medium size plants may comprise of :-

1) Bucket elevator
2) " conveyor
3) belt "
4) Pneumatic "
5) hydraulic sluicing equipment
6) Trollies & rail cars etc.

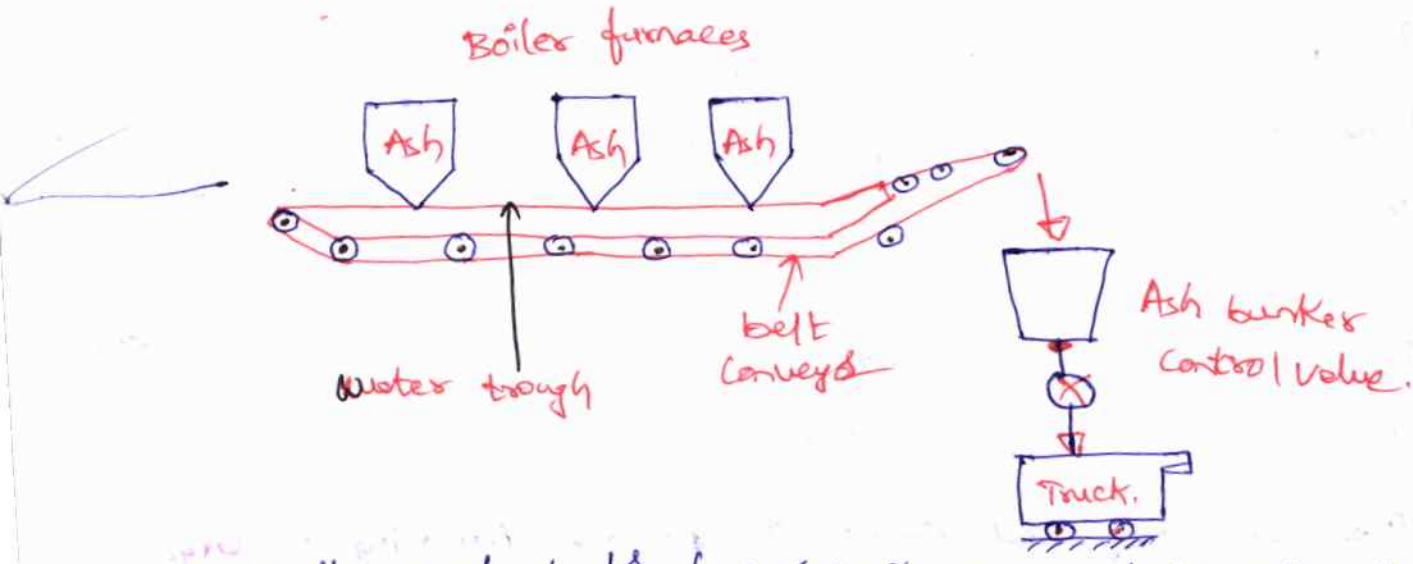
Ash handling systems :-

The modern ash handling systems are mainly classified into 4 groups.

1) Mechanical handling system.
2) Hydraulic system
3) Pneumatic "
4) Steam jet "

1) Mechanical handling system :-

Fig shows a mechanical handling system. This system is



generally employed for low capacity power plants using coal as fuel.

The hot ash released from the boiler furnaces is made to fall over the belt conveyor after cooling it through water sea

→ This cooled ash is transported to an ash bunker through the belt conveyor.

From ash bunker the ash is removed to the dumping site through trucks.

(2) Hydraulic system :-

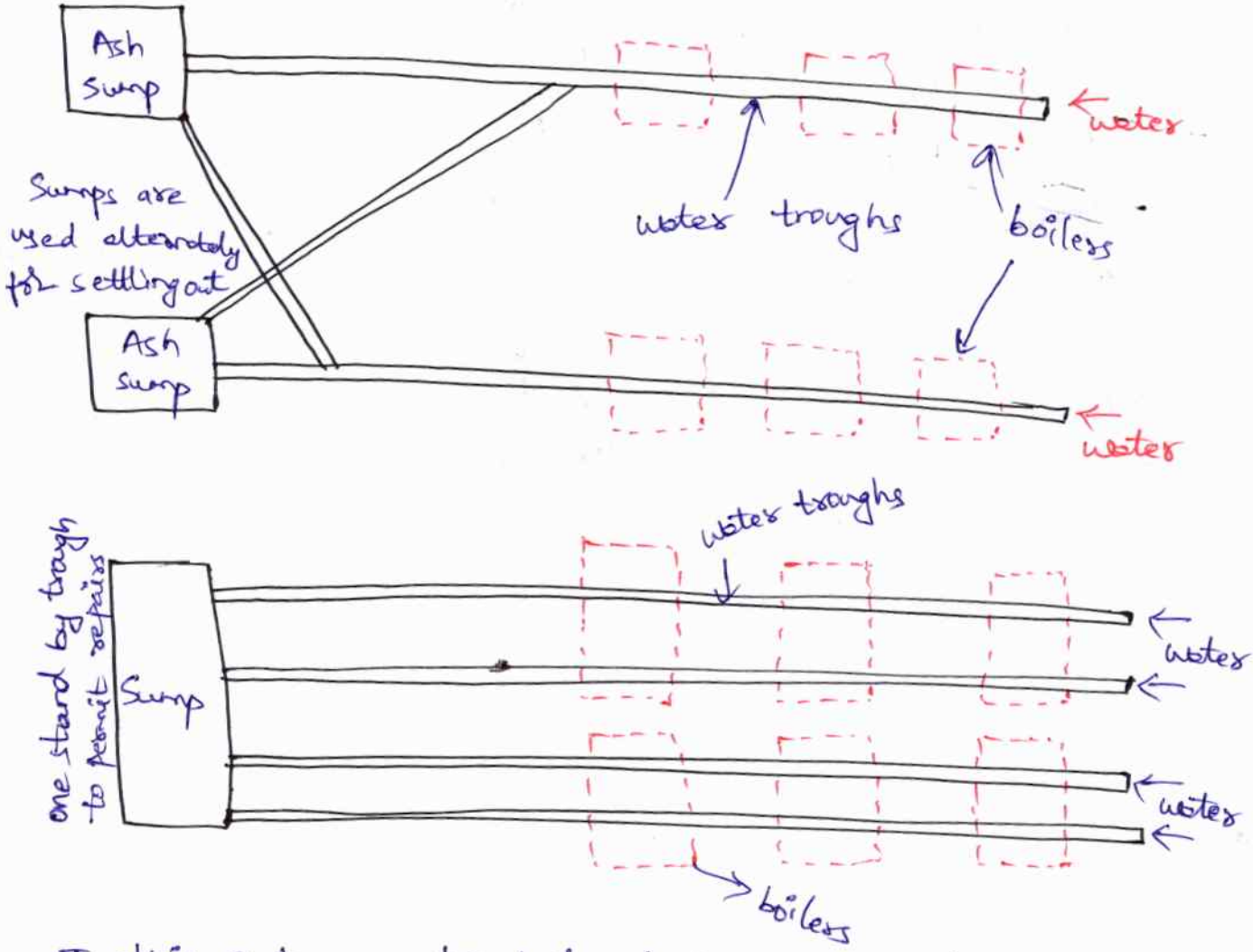
In this system ash is carried with the flow of water with high velocity through a channel & finally dumped in the sump.

This system is subdivided as follows :-

a) low pressure system

b) high " "

(a) Low pressure system :-



In this system, a trough or drain is provided below the boilers & the water is made to flow through the trough.

→ The ash directly falls into the troughs & is carried by water to sumps.

In the sump the ash & water are made to pass through a screen so that water is separated from ash, this water is pumped back to the trough for reuse & ash is removed to the dumping yard.

→ The ash carrying capacity of this system is 50 tonnes/hr & distance covered is 500m.

(b) High pressure system :-

The hoppers below the boilers are fitted with water nozzels at the top & on the sides.

The top nozzels quench the ash while the side ones provide the driving force for the ash.

The cooled ash is carried to the sump through the trough.

The water is again separated from ash & recirculated.

The ash carrying capacity of this system is as large as 120 tonnes per hour & the distance covered is as large as 1000 metres.

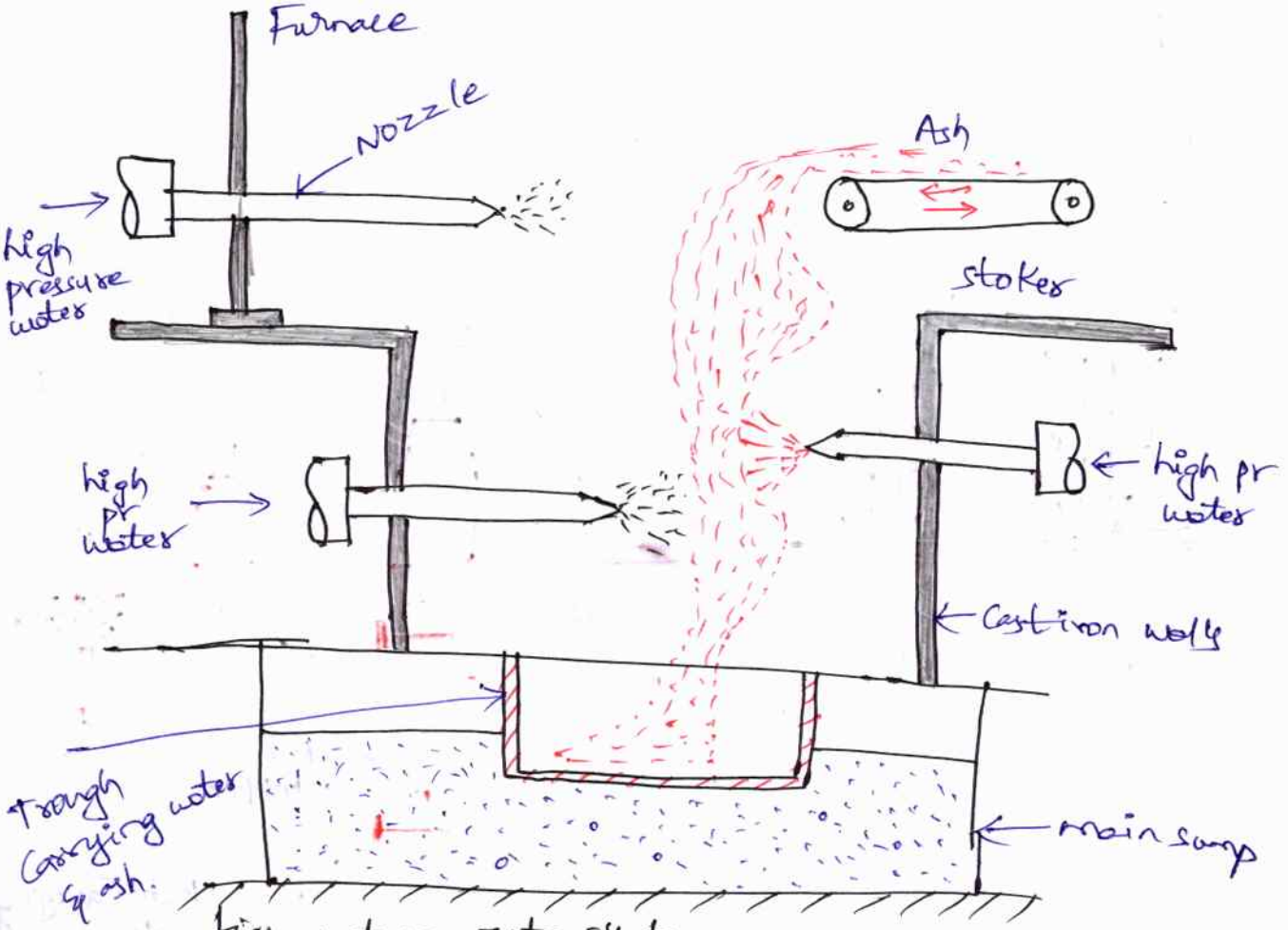


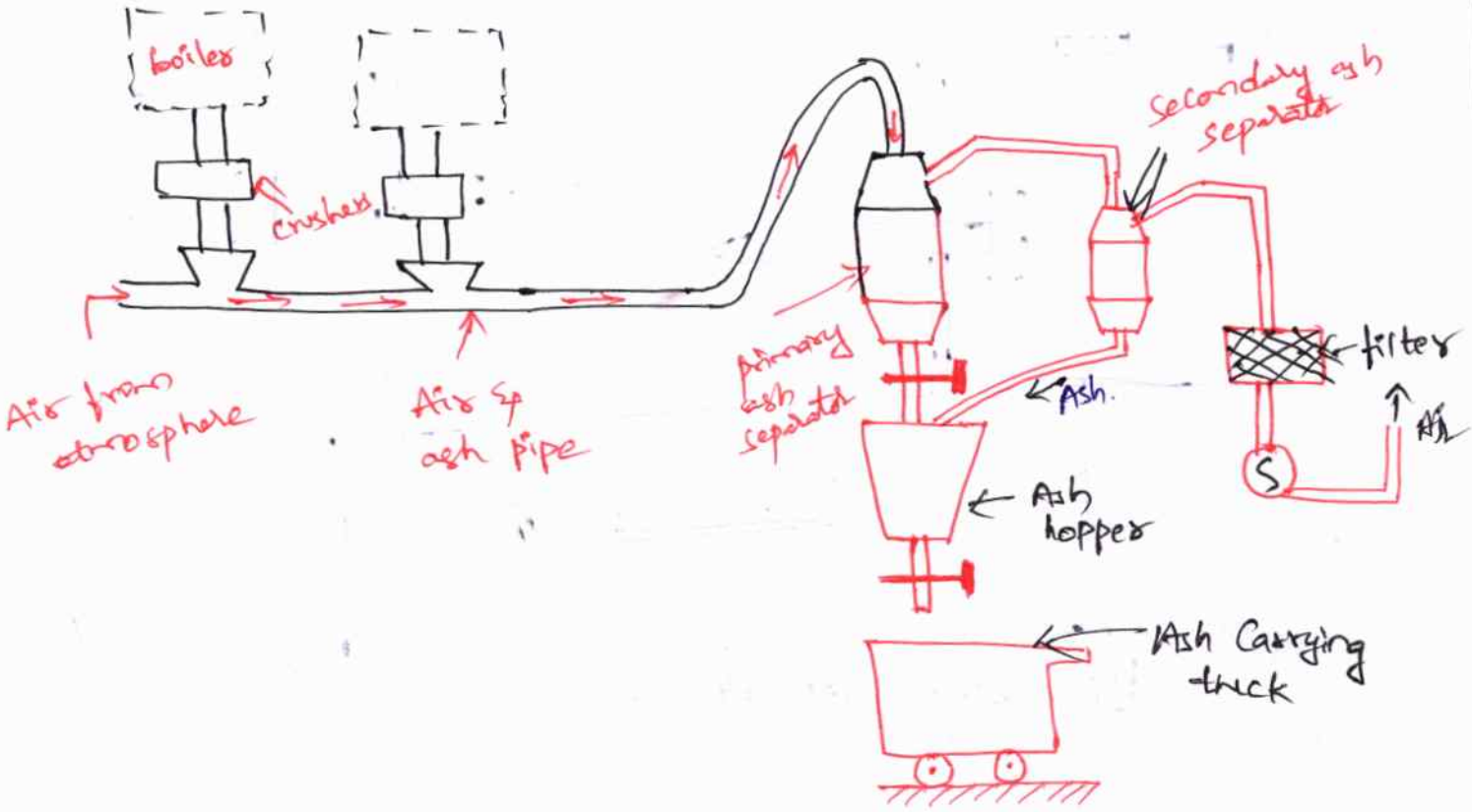
Fig. Water Jet System

Advantages of hydraulic system :-

1) The system is clean & healthy.
2) It can also be used to handle stream of molten ash.
3) working parts do not come into contact with the ash.
4) It is dustless & totally closed.
5) It can discharge the ash at a considerable distance (1000 m) from the power plant.
6) The unhealthy aspects of ordinary ash basement work is eliminated.
7) Its ash carrying capacity is considerably large, hence suitable for large thermal power plants.

(3) pneumatic systems:-

It shows the schematic of a pneumatic ash handling system.



This system can handle abrasive ash as well as fine dusty materials such as fly ash & soot.

It is preferable for the boiler plants from which ash & soot must be transported some far off distance for final disposal.

The exhauster provided at the discharge & creates a high velocity stream which picks up ash & dust from all discharge points & then these are carried in conveyed pipe to the point of delievery.

large ash particles are generally crushed to small sizes through mobile crushing units which are fed from the furnace ash hopper & discharge into the conveyed pipe

to the point of delivery.

Large ash particles are generally crushed to small sizes through mobile crushing units which are fed from furnace ash hopper & discharge into conveyed pipe which terminates into a separator at the delivery end.

The separator working on cyclone principle removes dust & ash which pass out in to the ash hopper at the bottom while clean air is discharged from the top.

The exhauster may be mechanical & it may use steam jet (or) water jet for its operation.

When a mechanical exhauster is used it is usually essential to use a filter & washer to ensure that the exhauster handles clear air.

Such type of exhauster may be used in large station as the power requirements are less.

Steam exhauster may be used in small & medium size stations.

Where large quantities of water are easily & cheaply available water exhauster is preferred.

The ash carrying capacity of system varies from 25 to 15 tonnes per hour.

Advantages :-

1) No spillage & rehandling
2) High flexibility
3) There is no chance of ash freezing or sticking in the storage bin & it can be discharged freely by gravity.

4) The dustless operation is possible as the materials are handled totally in an enclosed conduit.

5) The cost of Plant power per tonne of ash discharged is less in comparsion to other systems.

Disadvantages :-

1) There is a large amount of wear in pipe work at high maintenance charges.

2) more noisy than the other systems.

(4) steam jet system :-

In this case, steam at sufficiently high velocity is passed through a pipe & dry solid materials of considerable size are carried along with it.

In a high pr steam jet system a jet of high pr steam is passed in direction of ash travel through a conveying pipe in which ash from the boiler ash hopper is fed.

The ash is deposited in ash hopper.

This system can remove economically the ash through a horizontal distance of 200m & through a vertical distance of 30m.

Advantages :-

1) less space requirement

2) " capital cost in comparsion to other systems

3) Auxiliary drive is not required

4) It is possible to place the equipment in afavored position too.

Disadvantages :-

1) Noisy operation
2) This system necessitates continuous operation since its capacity is limited to about tonnes per hour.
3) Due to abrasive action of ash the pipes undergo greater wear and to reduce this wearing action the pipes are lined with Ni alloy.

UNIT-II

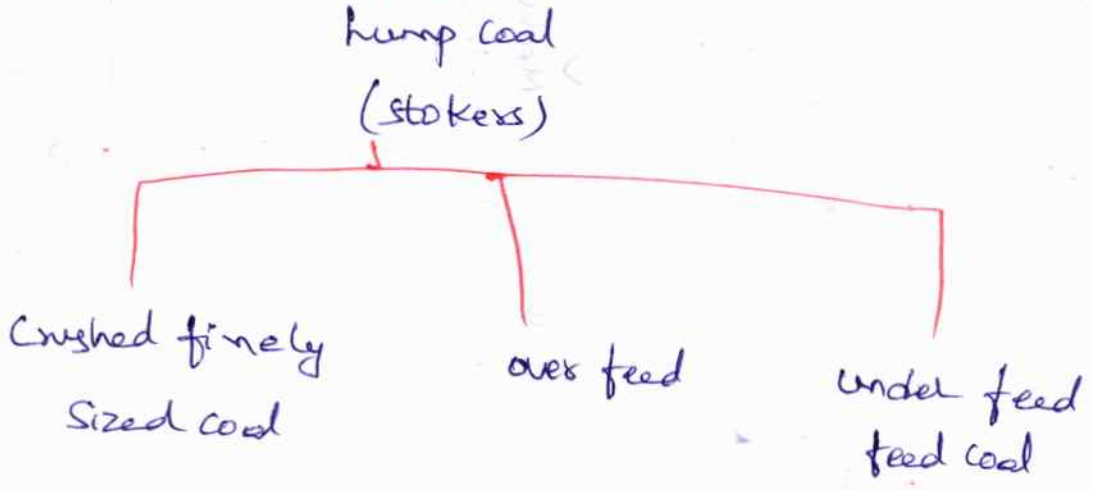
Steam power plant - Combustion process

Since the source of heat is the combustion of a fuel, a working unit must have whatever equipment is necessary to receive the fuel & air, proportioned to each other & to the boiler steam demand, mix, ignite & perform any other special combustion duties such as distillation of Voltaile from coal prid to ignition

→ Fluid Fuels are handled by burners, solid lump fuels, by stokers.

Since so many different principles are used in combustion equipment, it has been prepared to summarize the more important currently manufactured types of stokers used for solid fuels.

Classification of combustion system :-



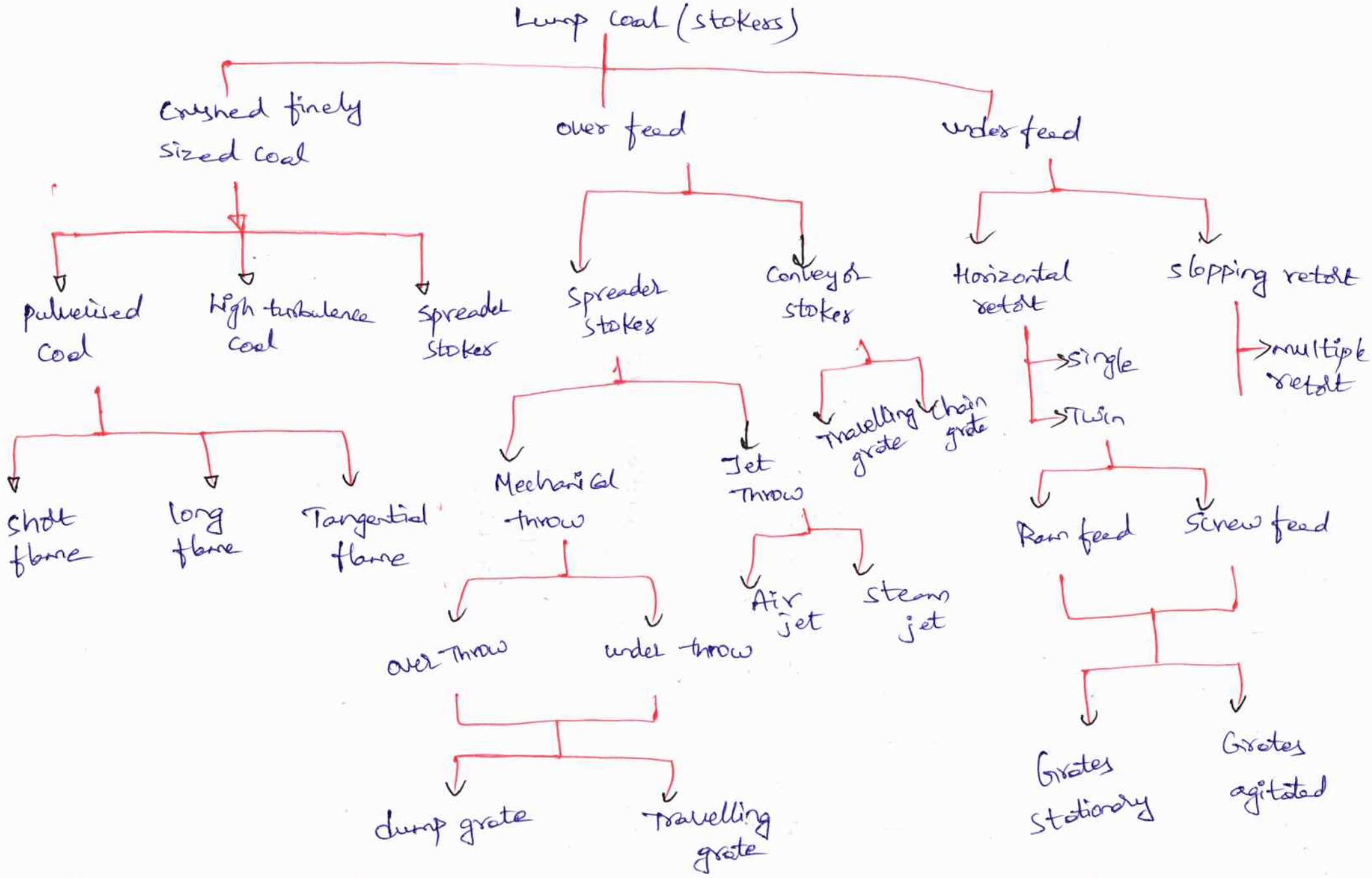
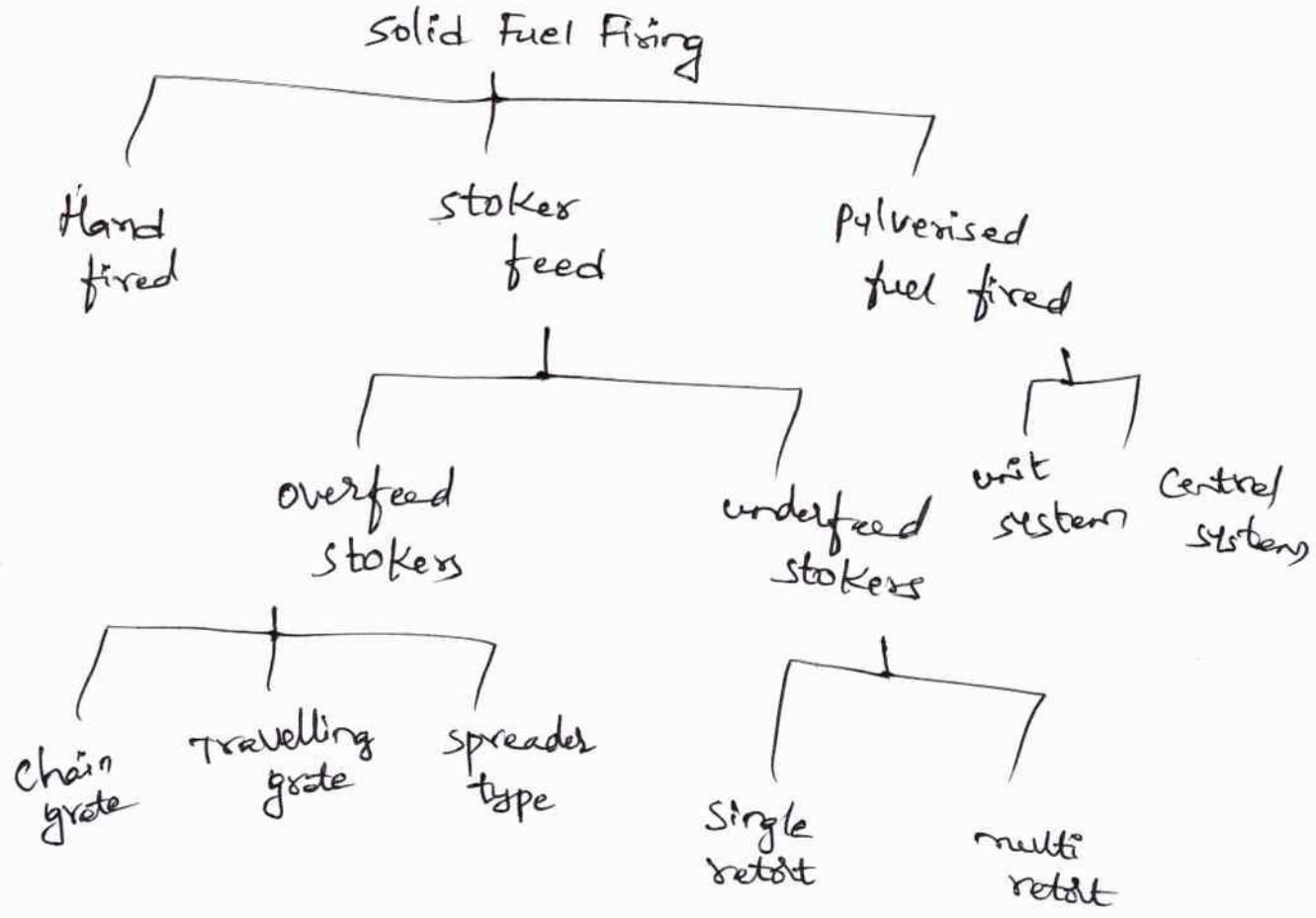


fig:- The detailed classification of combustion system used for coal burning

Combustion equipment for steam Boilers :-



Solid fuel – coal – stokers

liquid fuel – petrol, diesel – bunkers

Combustion process:-

properties of Coal:-

The properties of coal are broadly classified as:-

1) physical properties
2) chemical "

(1) physical properties:-

Proximate Analysis:-

Proximate Analysis indicate the percentage by weight of the fixed carbon, volatiles, ash & moisture content in coal.

→ The amounts of fixed carbon & volatile combustible matter directly contribute to the heating value of coal.

→ Fixed carbon acts as a main heat generator during burning.

→ high volatile matter content indicates easy ignition of fuel.

→ The ash content is important in the design of the furnace grate, combustion volume, pollution control equipment & ash handling systems of a furnace.

Significance of various parameters in proximate Analysis:-

1) Fixed Carbon:- It is the solid fuel left in the furnace after volatile matter is distilled off.
It consists mostly of carbon but also contains some hydrogen, oxygen, sulphur & Nitrogen not driven off with the gases.

→ fixed carbon gives a rough estimate of heating value of coal.

(2) Voltaile matter :- These are the methane, hydrocarbons, hydrogen & Carbon monoxide and incombustible gases like Carbon dioxide & Nitrogen found in coal.

→ Thus the voltaile matter is an index of the gaseous fuels present.

→ Typical range of voltaile matter is 20 to 35% voltaile matter.

→ proportionately increases the flame length & helps in easier ignition of coal.

→ Sets minimum limit on the furnace height & volume.

→ Influences secondary air requirement & distribution aspects.

→ Influences secondary oil support.

(3) Ash content :- Ash is an impurity that will not burn.

Typical range is 5 to 40% of ash.

Reduces handling & burning capacity

Increases handling costs

Affects Combustion efficiency & boiler efficiency.

Causes clinkering & slagging.

(4) Moisture content :-

moisture in coal must be transported, handled & stored.

Since it replaces combustile matter, it decreases the heat content per kg of coal.

Typical range is 0.5 to 10% moisture.

Increases heat loss, due to evaporation & superheating of vapours.

helps to a limit in binding fines.

Aids radiation heat transfer.

(5) Sulphur content :-

Typical range is 0.5 to 0.8% normally.

Sulphur → Affects clinkering & slagging tendencies

Corrodes chimney & other equipment such as air heaters & economisers.

Limits exit flue gas temp.

Chemical properties :-

Ultimate Analysis :-

It indicates the various elemental chemical constituents such as C, H, O, S, etc. It is useful in determining the quantity of air required for the combustion & the volume & composition of the combustion gases.

This information is required for the calculation of flame temp & flue duct design etc.

Classification of Mechanical stokers :-

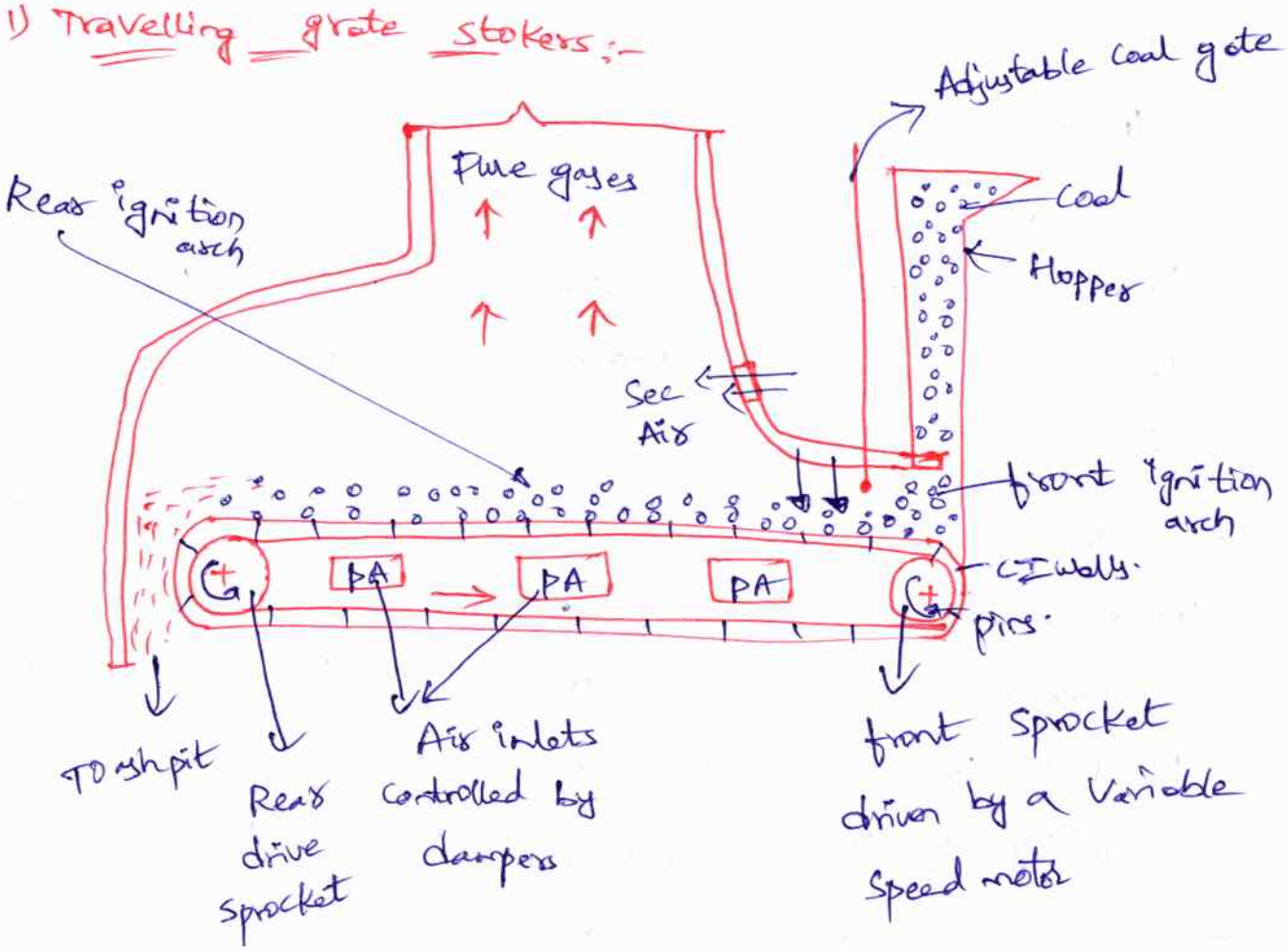
In small boilers, the grate is stationary & coal is fed manually by shovels.

But for more uniform operating condition, higher burning rate & greater efficiency, many grates or stokers are employed.

→ stokers may be of following types :-

1) Travelling grate stoker
2) Chain " "
3) Spreader " "
4) Vibrating " "
5) Underfeed "

1) Travelling grate stokers :-



The grate surface is made up of a series of cast iron bars joined together by links to form an endless belt running over two sets of sprocket wheels with a surface as wide as needed.

→ A coal gate at the rear of the coal hopper regulates the depth of fuel bed.
The gate can be raised or lowered as needed.
Simultaneous adjustment of grate speed, fuel bed thickness and air flow controls the burning rate so that nothing but ash remains on the grate by the time it reaches the furnace rear.
The ash falls into the ash pit as the grate turns on the rear sprocket to make return trip.

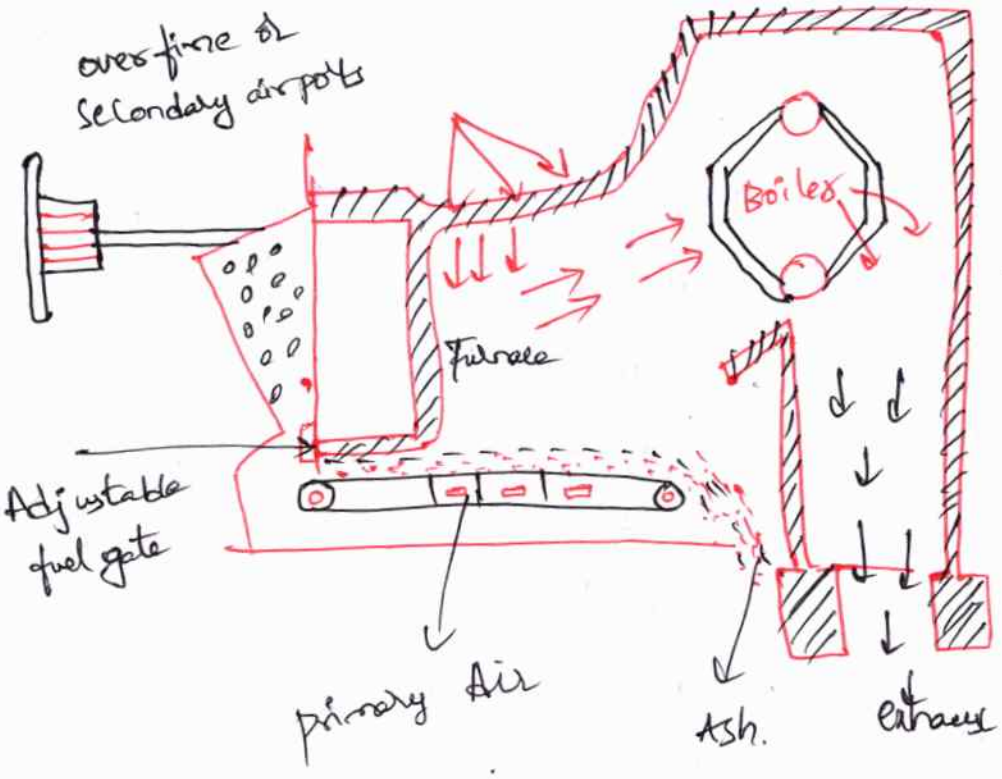
→ As the raw or green coal on the grate enters the furnace, the surface coal gets ignited from heat of the furnace flame & from radiant heat rays reflected by ignition arch.

→ The fuel bed becomes thinner toward the furnace rear as the combustible matter burns off.

→ under grate air pressures are varied by dampers from front to rear of stoker to admit gradually reduced quantity of primary air fed by FD Fan.

→ The secondary air aids in mixing gases & supplies Oxygen to complete combustion.

(2) Chain grate stokers :-



A travelling type chain grate is shown in fig.

It consists of an endless chain which forms a support for the fuel bed.

The chain travels over two sprocket wheels one at the front & other at the rear of furnace as shown in fig.

The front sprocket is connected to a variable speed drive mechanism.

The coal is fed by gravity from a hopper located in front of the stoker.

The depth of fuel on grate is regulated by hand adjusted gate as shown in fig.

The speed of grate varies at rate at which the coal is fed to the furnace.

The combustion control automatically regulates the speed of

grate to maintain the required steam generation rate.

→ The ash containing a small amount of combustile matter is carried over the rear end of the stoker & deposited in the ash pit as shown in fig.

→ The air required for combustion is supplied through the air inlets situated below the grate.

→ The secondary air is supplied through the openings provided in furnace wall above the grate as shown in fig.

→ The combination of primary air & over fire air supplied provide turbulence required for rapid combustion.

→ The primary air is brought in from the sides & then it is forced through the upper grate.

→ The air ducts under the stoker are divided in to sections, so that air supply to different parts of stoker is regulated to meet the changing demand.

→ The air openings in grate depend upon the kind of coal burned & vary from 20 to 40% of total grate area.

→ Air dampers are provided to control the air supply to the various zones.

→ The air dampers enable the operator to control the rate of burning in diff zones. The air dampers enable the operator to control the rate of burning in diff zones & thus by reduce to a minimum the coke carry over into the ash pit.

If the satisfactory operation cannot be accomplished by adjusting these dampers, then the control is achieved by adjusting the fuel bed depth.

The coal supplied to the grate is regulated by two ways, as by varying the depth of coal on grate with the help of grate valve & by varying the rate of grate travel.

→ These grates are suitable for low rating of fuel because the fuel must be burnt before it reaches the rear end of furnace.

→ The rate of burning with this stoker is 200 to 300 kg per m^2 per hour when forced draught is used.

→ Any type of fuel except caking bituminous coal can be used with chain grate stoker.

→ The bituminous coal cannot be used as large % of fines results in increased carbon loss.

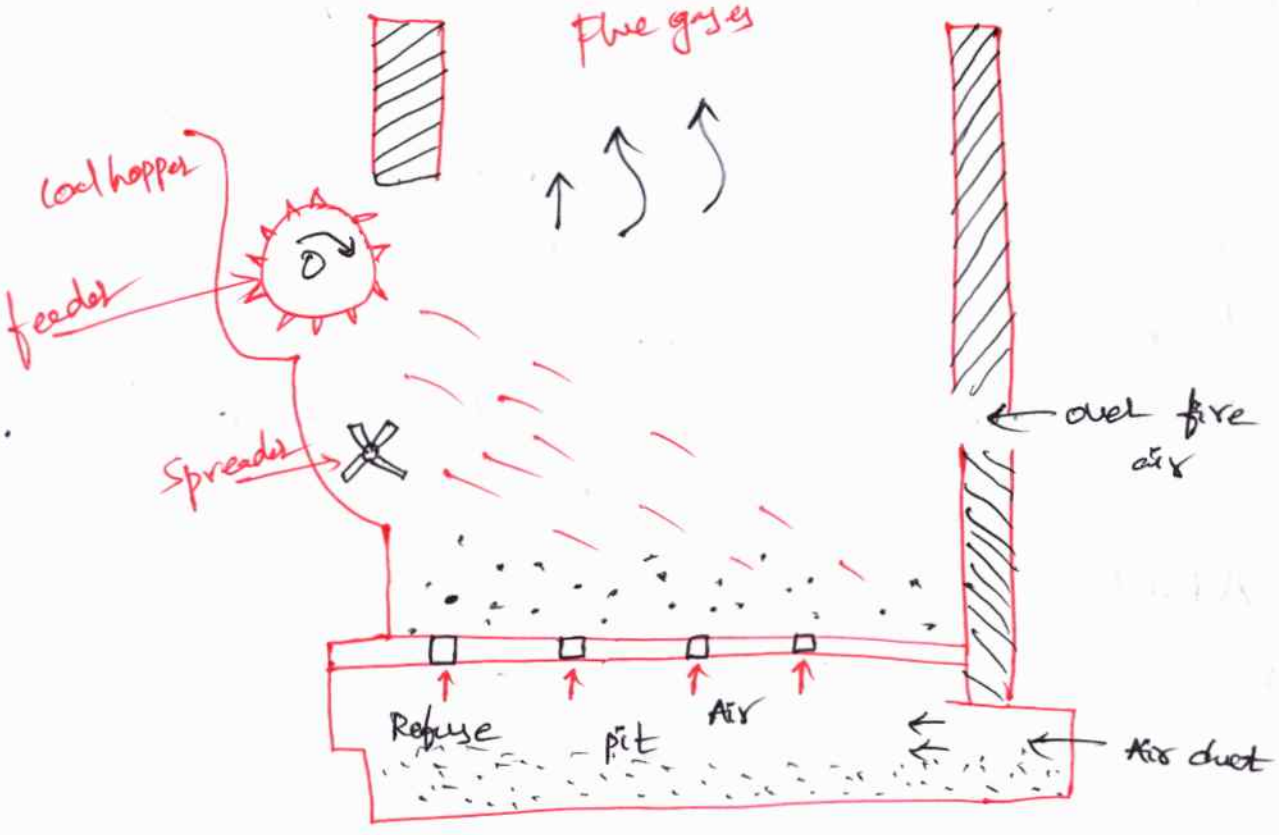
Advantages :-

1) It is simple in construction & its initial cost is low.
2) It is self cleaning stoker.
3) It is more reliable in service
4) maintenance charges are low.
5) The heat release rates can be controlled just by the controlling of speed of chain
6) It gives high heat release rates per unit volume of the furnace.

Disadvantages

1) The amount of coal carried on grate is small as the increase in grate size creates additional problems.
2) This cannot be used for High Capacity boilers (200 tons/hr)
3) The temp of preheated air is limited to 180°C
4) The clinker troubles are very common.
5) Ignition arches are required.

(3) Spreader stoker :-



A spreader stoker is shown in fig, In this stoker the coal from the hopper is fed on to a feeder which measures the coal in accordance to the requirements.

Feeder is a rotating drum fitted with blades.

It can be reciprocating rams, endless belts, spiral worms etc.

From the feeder the coal drops on the spreader distributor which spread the coal over the furnace.

The spreader system should distribute the coal evenly over the entire grate area.

The spreader speed depends on size of coal.

Advantages :-

→ Its operation cost is low.

→ A wide variety of coal can be burnt easily by this stoker.

→ A thin fuel bed on grate is helpful in meeting the fluctuating loads.

(4) Vibrating grate stoker :-

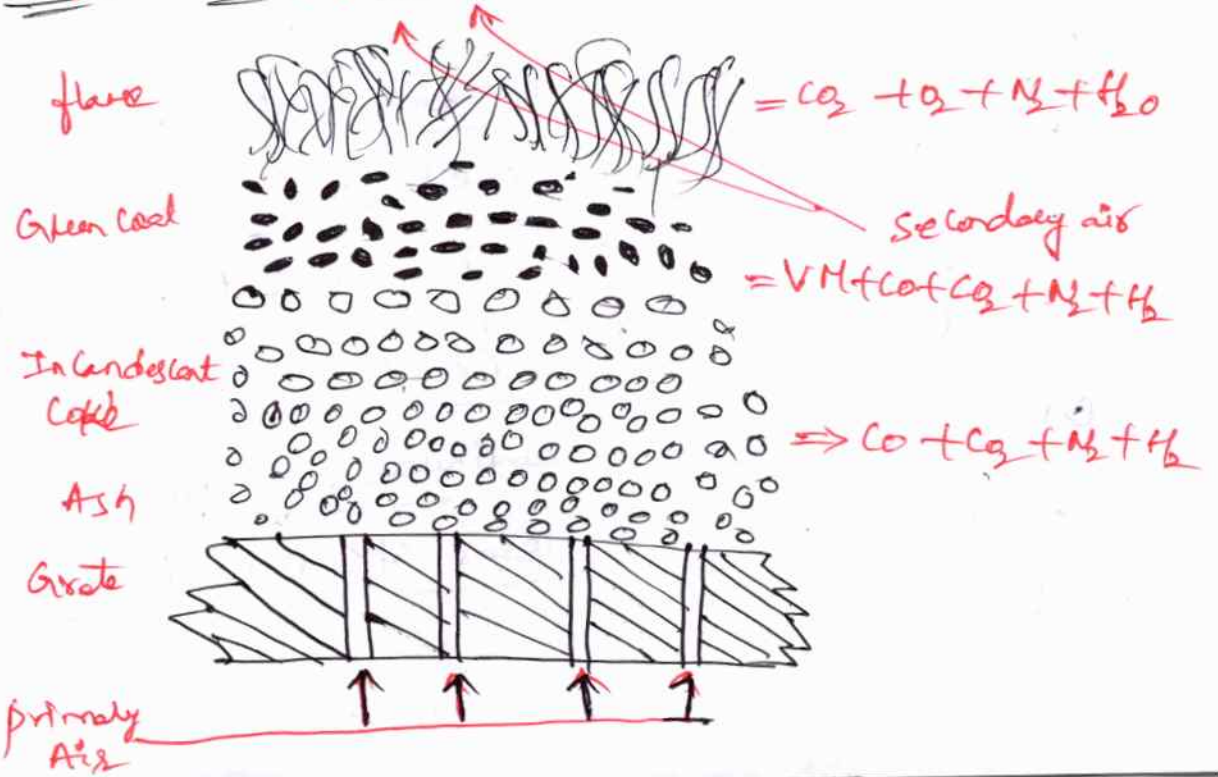
The stoker shakes the fuel bed intermittently, the frequency & amplitude of vibration depending on boiler load.

→ The fuel bed is inclined so that the fuel moves towards the rear of the boiler by gravity with the progress of combustion & then falls into the ash pit.

The grate is water cooled to prevent slagging.

Method of Feeding coal to Combustion chamber :-

(1) over feed supply of coal :-



In case of overfeed stoker the coal is fed on to the grate above the point of air admissions as shown in fig.

→ The Mechanics of combustion in overfeed stoker is given below :-

1) The pressurised air coming from F.D fan enters under the bottom of the grate.
The air passing through the grate is heated by absorbing the heat from the ash & grate itself, where as the ash & grate are cooled.
The hot air then passes through a bed of incandescent coke.
As the hot air passes through incandescent coke, the O_2 reacts with C to form CO_2.
The rate of carbon oxidation in this part of fuel bed depends entirely on rate of air supply.
Generally for a fuel of 8cm deep, all the O_2 in the air disappears in the incandescent region.
The water vapour carried with air also reacts with C in incandescent zone & forms CO, CO_2 & H_2.
Part of CO_2 formed reacts with C passing through incandescent zone & converts into CO.
The gases leaving the incandescent region of fuel bed consists of N_2 CO_2 CO H_2 & H_2O.

2) The raw coal is continuously supplied on the surface of the bed. here it loses its volatile matter by distillation.

The heat required for the distillation of coal is given by incandescent coke below the fresh fuel, hot gases diffusing through the surface of bed & hot gases & flame in the furnace above.

The ignition zone lies directly below the raw fuel undergoing distillation.

(3) The gases leaving the upper surface of fuel bed contain combustible voltaile matter formed from the raw fuel, N_2 CO_2, H_2 & H_2O.

Additional secondary air is supplied at a very high speed to create turbulence which is required for complete combustion of unburned gases.

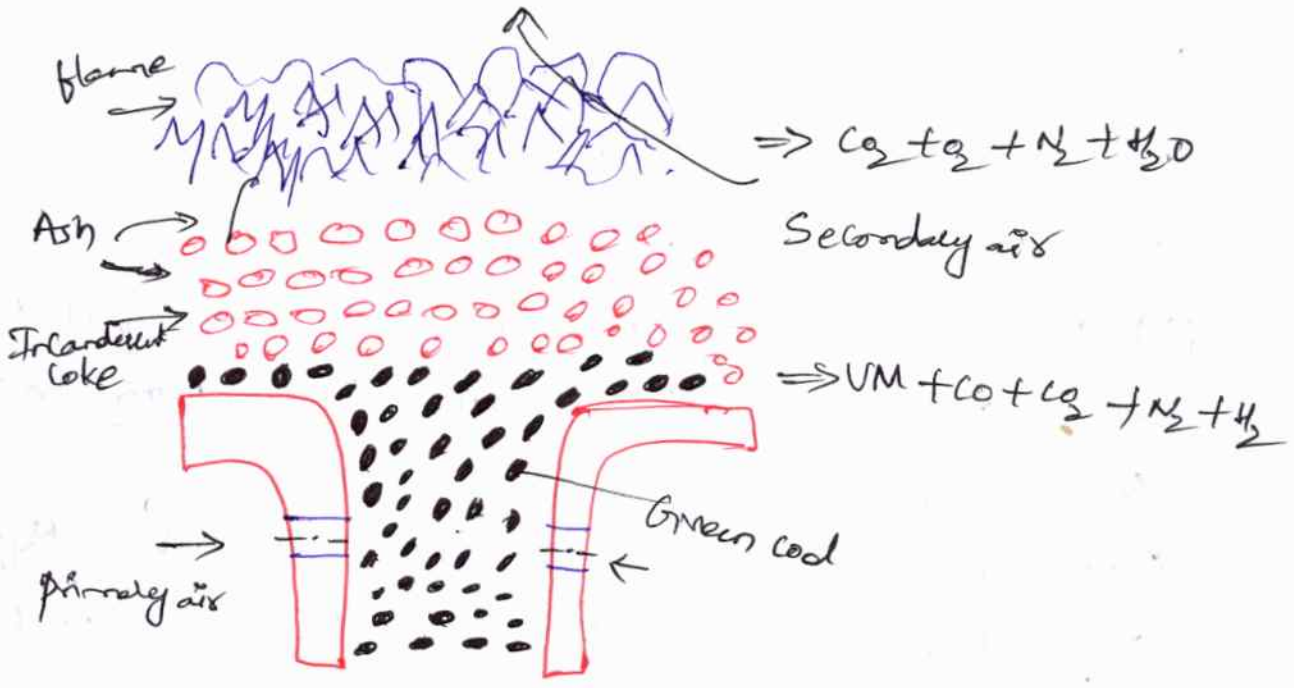
The combustion of the remaining combustible gases is completed in the combustion chamber.

(4) The burned gases entering the boiler contain N_2 CO_2 & H_2O & some CO if burning is incomplete.

(5) During incandescence, the fuel continuously loses its Carbon by oxidation until only the ash remains. The primary air supplied from the bottom ~~coals~~ cools the ash until it rests on a plane immediately adjacent to the grate.

(2) under feed stoker :-

In this type of stokers, the fuel & air move in the same direction. The mechanism of combustion in under feed stoker is described below :-



(1) Air after passing through the holes in the grate as shown in fig. meets the coal.

As it diffuses through the bed of raw coal, it meets with the volatile matter generated by the raw-coal.

The heat for distillation comes by conduction from the mass of incandescent fuel bed which exists above the raw coal.

The air mixes with the formed voltaile matter & passes through the ignition zone & then enters into the region of incandescent coke.

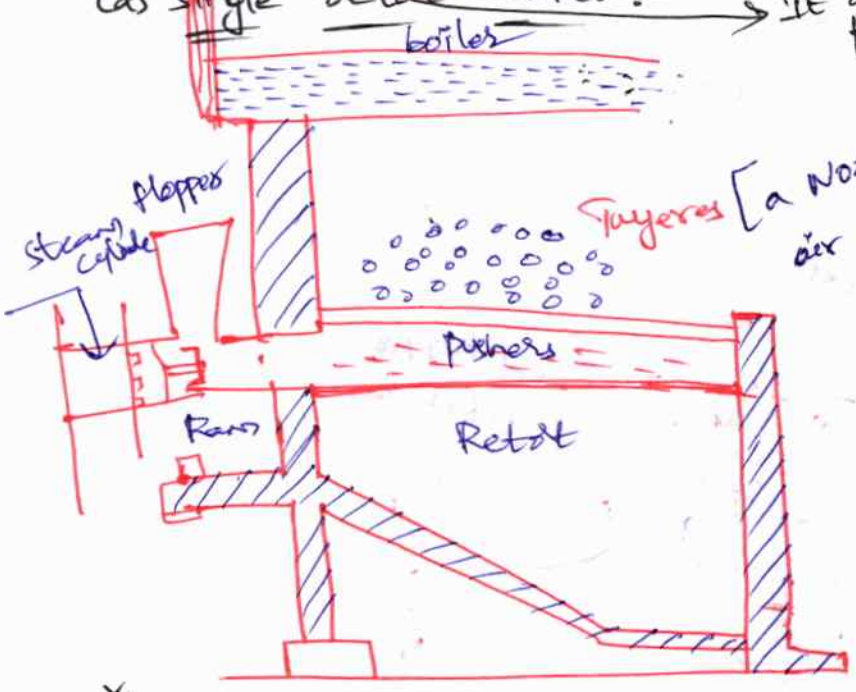
(2) The reactions which take place in the incandescent zone of under feed stokes are exactly the same as in the incandescent zone of over feed stoker except some breaking of the molecular structure of voltaile matter takes place & part of the broken volatile matter reacts with the oxygen of air.

(3) The gases coming out of raw fuel bed pass through a region of incandescent ash on the surface of the fuel & finally discharged to the furnace with the constituents like coal feed stoker.

(4) The supply of secondary air is required in this case as the gases coming out of fuel bed also contain combustile matter.

(5) The ash left at the bottom of the stoker is at a higher temp than over feed stoker.

(a) single retort stoker :- → It act as a stationary part part as a fuel bed.



front view fig single retort stoker

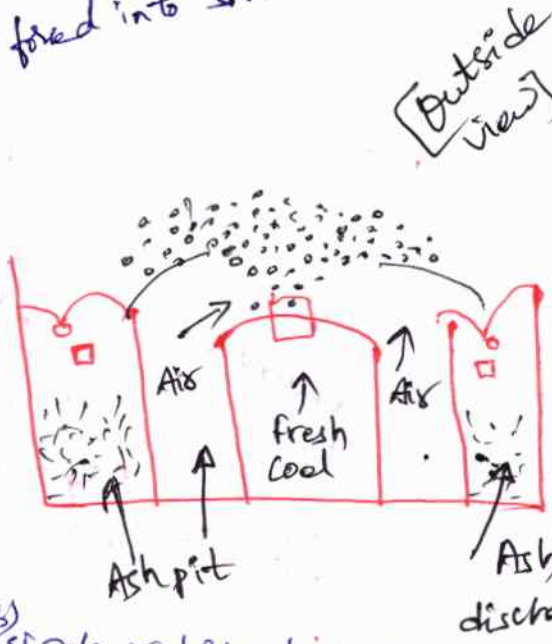


fig (b) single retort type stoker

The arrangement of single retort stoker is shown in figs in form of two views.

The fuel is placed in large hopper on the front of the furnace, & then it is further fed by reciprocating ram & screw conveyor into the bottom of horizontal trough.

The air is supplied through the tuyeres provided along the upper edge of grate as shown in fig (b)

The ash & clinkers are collected on the ash plate provided with dumping arrangement.

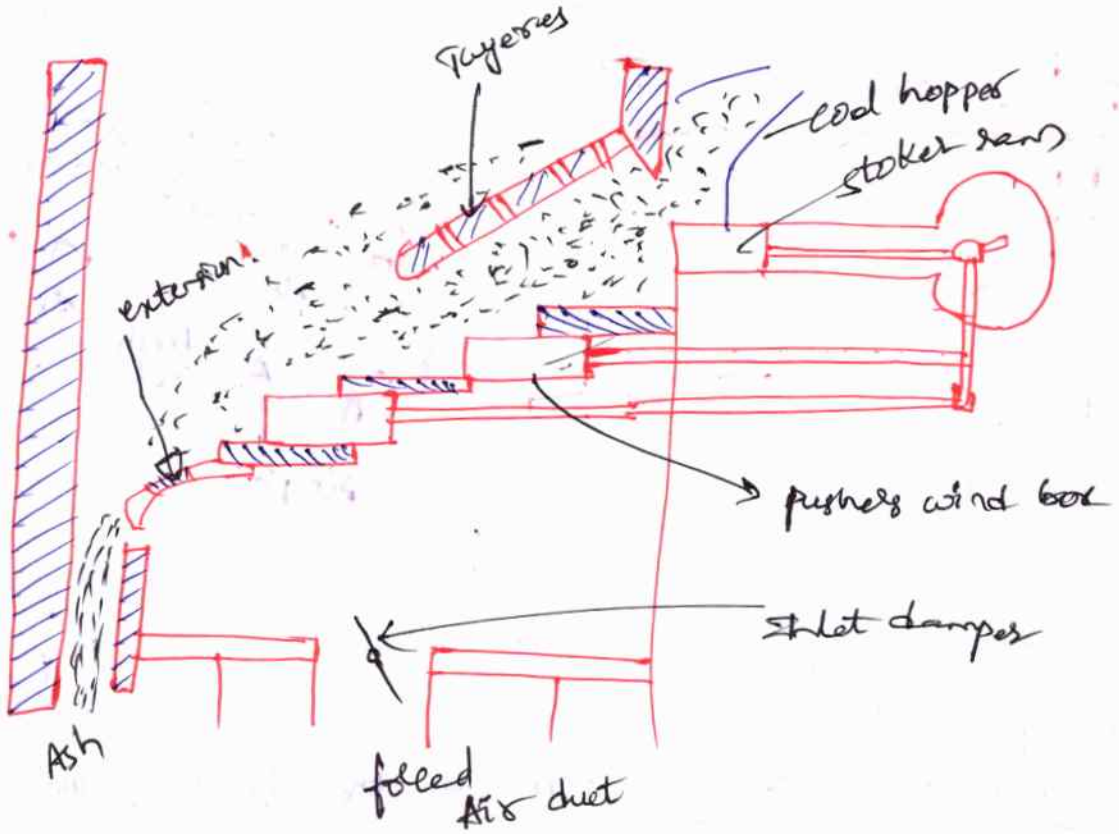
The coal feeding capacity of a single retort stoker varies from 100 to 2000 kg per hour.

The increase of capacity in an underfeed cannot be obtained simply by building larger single retort stoker.

The size of retort for increasing the capacity is limited by virtue of inability of obtaining even air distribution from the sides of retorts.

multi retort stokers are generally used for increasing the burning capacity of the stoker.

(b) Multi retort stoker :-



A multi retort stoker is shown in fig. The coal falling from the hopper is pushed forward during inward stroke of stoker ram.

The distributing rams (pushers) then slowly move the entire coal bed down the length of stoker.

The length of stroke of pushers can be varied as desired.

→ The slope of stroke helps in moving the fuel bed & this fuel bed movement keeps it sightly agitated to breakup clinker formation.

→ The primary air enters the fuel bed from main wind box situated below the stoker.

→ Partly burnt coal moves on to the extension grate. A Thinner fuel bed on extension grate requires lower air pressure under it.

→ The air entering from the main wind box in to the extension grate wind box is regulated by an air damper.

→ As sufficient amount of coal always remains on the grate, this stoker can be used under larger boilers upto (27000 kg/hr capacity) to obtain high rates of combustion.

→ Due to thick fuel bed the air supplied from the main wind box should be at higher pressure.

coal is fired into fine particles

Pulverized fuel Burning system & its Components :-

Coal is pulverized (powdered) to increase its surface exposure thus permitting rapid combustion.

efficient use of coal depends greatly on combustion process employed.

For large scale generation of energy the efficient method of burning of coal is confined still to pulverized coal combustion.

It is obtained by grinding the raw coal in pulverizing mills.

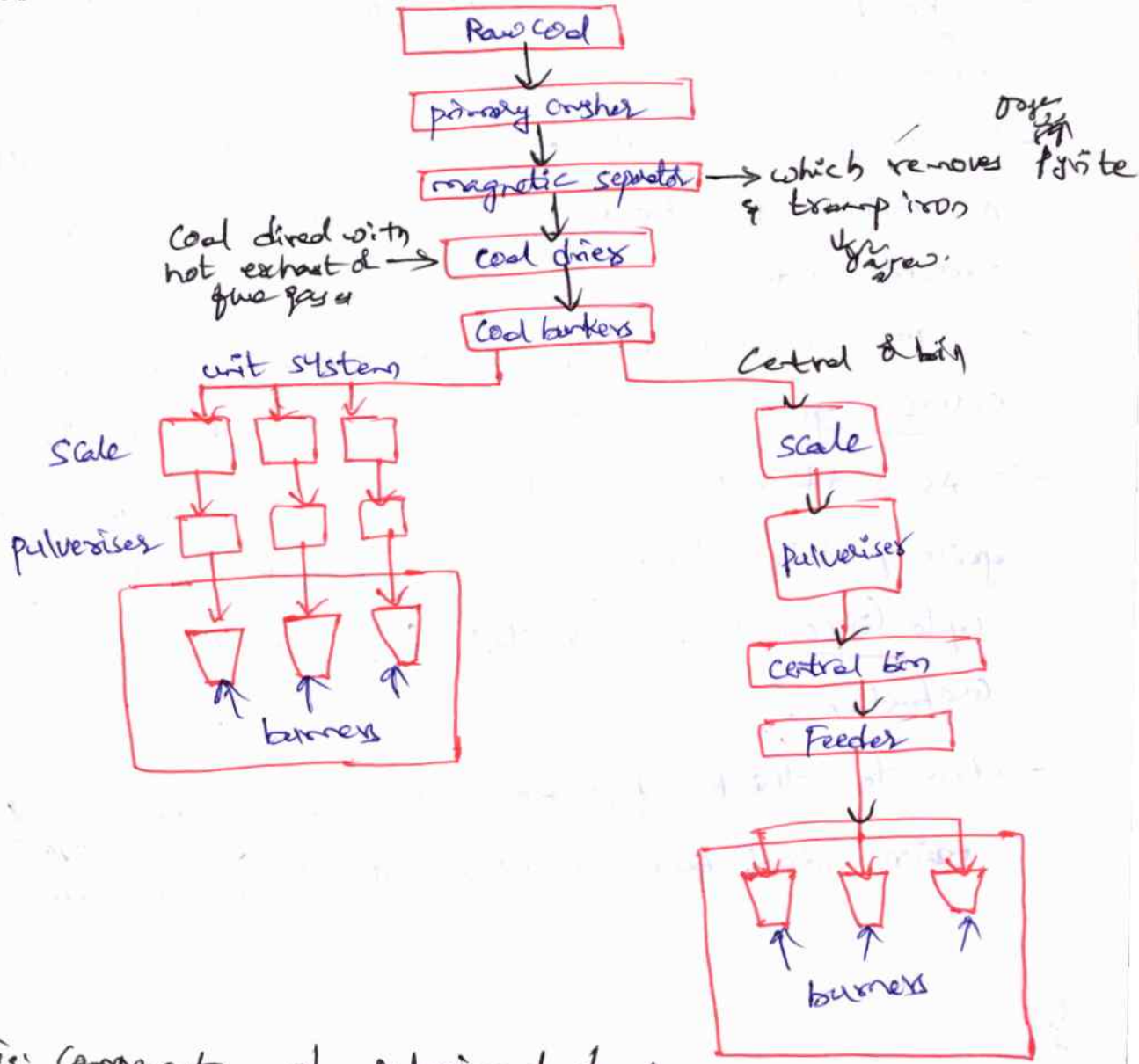
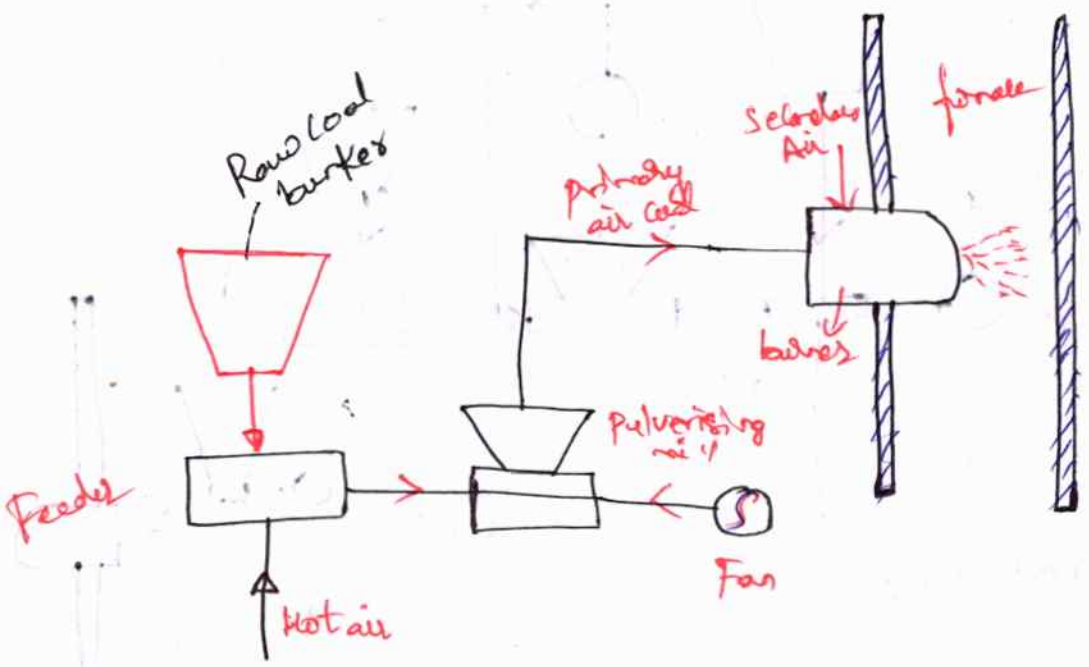


fig: Components of pulverized fuel burning

Pulverized coal firing is done by two systems :- (12)

1) unit system or direct system :-



In this system the raw coal from the coal bunker drops on to the feeder.

Hot air is passed through coal in the feeder to dry the coal.

→ The coal is then transferred to the pulverising mill where it is pulverised.

→ primary air is supplied to the mill, by the fan.

→ The mixture of pulverised coal & primary air then flows to burner where secondary air is added.

→ The unit system is so called from the fact that each burner or a burner group & pulveriser constitute a unit.

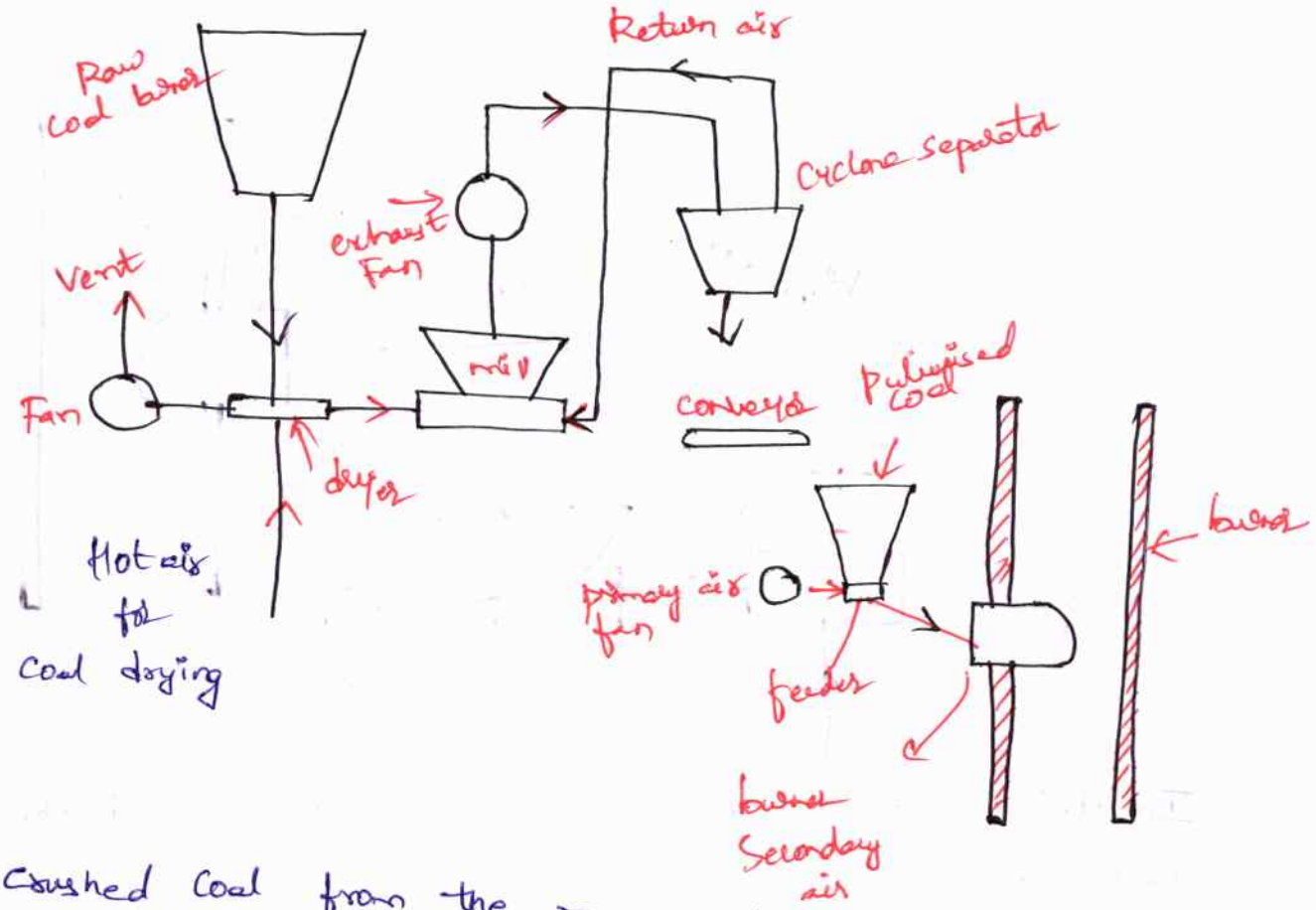
Advantages :-

1) The system is simple & cheaper than the central system.

2) There is direct control of combustion from the pulverising mill

3) Coal transportation system is simple.

(2) Central or Bin system :-



Crushed coal from the raw coal bunker is fed by gravity to a dryer where hot air is passed through the coal to dry it.

The dryer may use waste flue gasses, preheated air or bleeder steam as drying agent.

The dry coal is then transferred to the pulverising mill.

→ The pulverised coal obtained is transferred to the pulverised coal bunker (bin).

→ The transporting air is separated from the coal in the cyclone separator.

→ The primary air is mixed with the coal at the feeder & mixture is supplied to the burner.

Advantages :-

(1) The pulverising mill grinds the coal at a steady rate irrespective of boiler feed.

2) There is always some coal in reserve. Thus any occasional breakdown in the coal supply will not affect the coal feed to the burner.

3) For a given boiler capacity pulverising mill of small capacity will be required as compared to unit system.

Disadvantages :-

1) The initial cost of the system is high

2) Coal Transportation system is quite complicated

3) The system requires more space.

Dust Collectors :-

It is a system used to enhance the quality of air released from industrial & commerical processes by collecting dust & other impurities from air or gas.

→ designed to handle high volume dust loads, a dust collector system consists of a blower, dust filter, a filter-cleaning system & a dust receptacle or dust removal system.

→ It is distinguished from air cleaners, which use disposable filters to remove dust.

→ Five main types of industrial dust collectors are :-

(1) Inertial separators
2) Febric filters
3) wet scrubbers
4) unit collectors
5) electrostatic precipitators

1) Inestial Separators :-

It separate dust from gas streams using a combination of forces such as centrifugal, gravitational & inestial.

→ These forces move the dust to an area where the forces exerted by the gas stream are minimal.

→ The separated dust is moved by gravity into a hopper, where it is temporarily stded.

→ The three primary types of inestial separators are :-

1) settling chambers
2) Baffle "
3) Centrifugal collectors

→ Neither settling chambers nor baffle chambers are commonly used in the minerals processing industry.

→ however their principles of operation are often incdporated into the design of more efficient dust collectors.

2) Fabric Filters :-

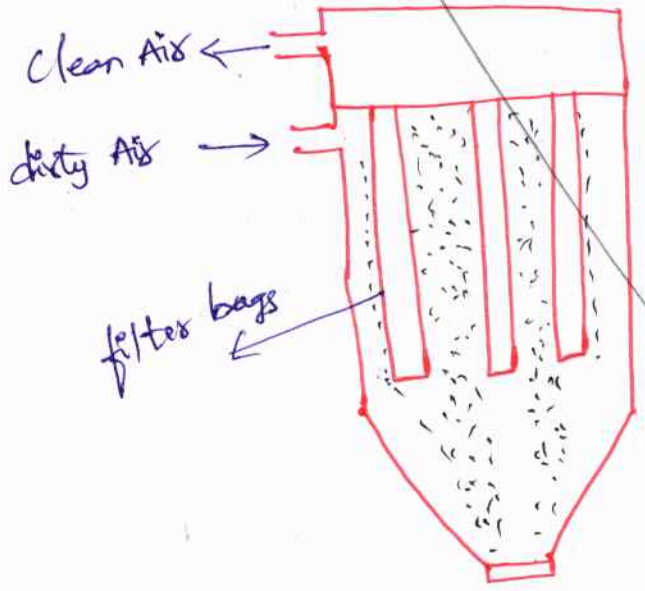


fig:- Bag House

Commonly known as bag house, fabric collectors use filtration to separate dust particulates from dusty gases.

→ They are one of the most efficient & cost effective types of

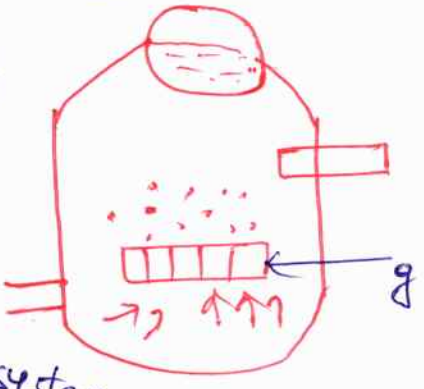
Combustion Needs and Draught System :-

Draught & draft :-

Defintion :- The difference between atmospheric pressure and the pressure existing in the furnace (&) flue gases passage of a boiler is termed as draft & draught.

→ It is measured in mm of water.

→ **Combustion needs & purpose of draught :-**



In a boiler, the Combustion of the fuel requires supply of sufficient quantity of air & removal of exhaust gases & this is achieved by draught system.

→ The draught is one of the most essential systems of the thermal power plant.

→ The purpose of draught is too supply the required quantity of air for combustion & remove the burnt products from the system.

→ The move the air through the fuel bed & to produce a flow of hot gases, through a boiler, economisers, preheater & chimney requires a pressure difference. passage creates compared to atmospheric pressure called draught.

→ draught can be obtained by use of chimney, fan, steam jet or Combination of these.

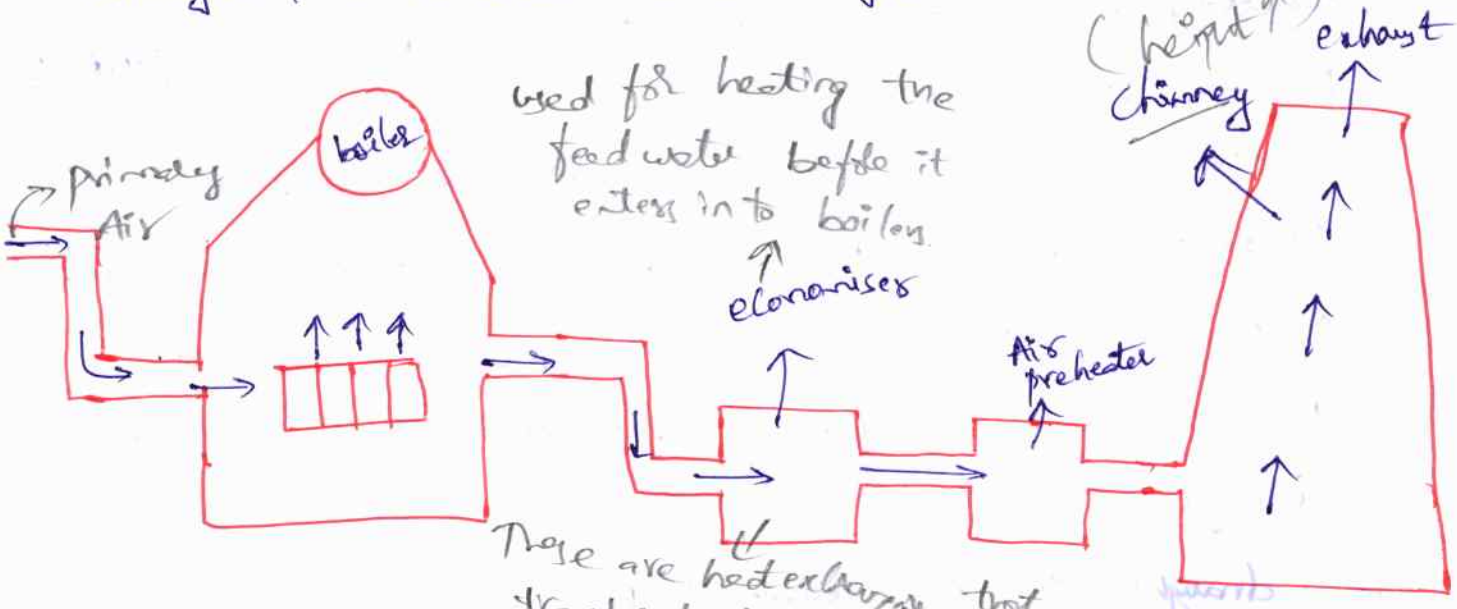
Economizer :- It is also known as feed water heater, in which waste heat of flue gases is utilized for heating the feed H2O.

Air pre heater — It is used to increase the temp of air before it enters into furnace.

classification of draught :-

- draught
  - Natural draught (produced by chimney)
  - Artificial draught (equipment add for airflow & flue gases)
    - Steam jet (produced by steam)
      - Induced
      - forced
    - Mechanical produced by fan / blower
      - Induced
      - forced
      - Balanced

Natural draught :- If only chimney is used to produce the draught, it is called natural draught.



These are heat exchanger that transfer heat into flue gas to another medium.

The system employs a tall chimney as shown in fig.

The chimney is a vertical tubular masonry structure of reinforced concrete.

It is constructed for enclosing a column of exhaust gases to produce the draught.

It discharges the gases high enough to prevent air pollution.

→ The draught is produced by this tall chimney due to the temperature difference of hot gases in the chimney & cold external air outside the chimney.

→ due to this pressure difference (p), the atmospheric air flows through the furnace grate & the flue gases flow through the chimney.

The pressure difference can be increased by increasing the height of the chimney or reducing the density of hot gases.

Merits :-

1) No external power is required for creating the draught.
2) Air pollution is prevented since flue gases are discharged at a higher level.
3) It has longer life.
4) Capital cost is less than that of an artificial draught.
5) maintenance cost is practically nil since there are no mechanical parts.

Demerits :-

1) maximum pressure available for producing draught by the chimney is less.
2) Flue gases have to be discharged at higher temperature since draught increases with increase in temp of flue gases.

3) Heat cannot be extracted from the flue gases for economiser, superheater, Air preheater etc. since effective draught will be reduced if the temp of flue gases is decreased.

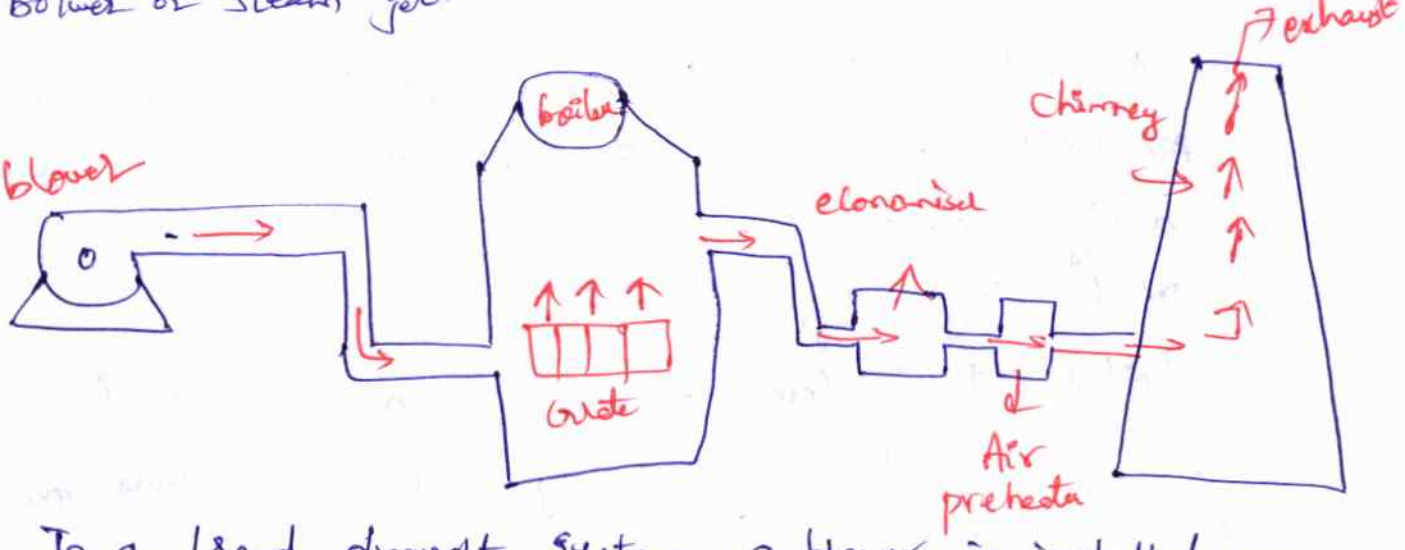
4) overall efficiency of the plant is decreased since the flue gases are discharged at higher temp.

Applications :-

It is used only in small capacity boilers & it is not used in high capacity thermal plants.

Artificial draught :- If the draught is produced by steam jet & fan it is known as Artificial draught

i) Forced draught :- The air is forced into the system by a bolwer or steam jet.



In a forced draught system, a blower is installed near the base of the boiler & air is forced to pass through the furnace, flues, economisers, air-preheater & to the stack.

→ This draught system is known as positive draught system & forced draught system because the pressure & air is forced to flow through the system.

The action of induced draught is similar to the action of the chimney.

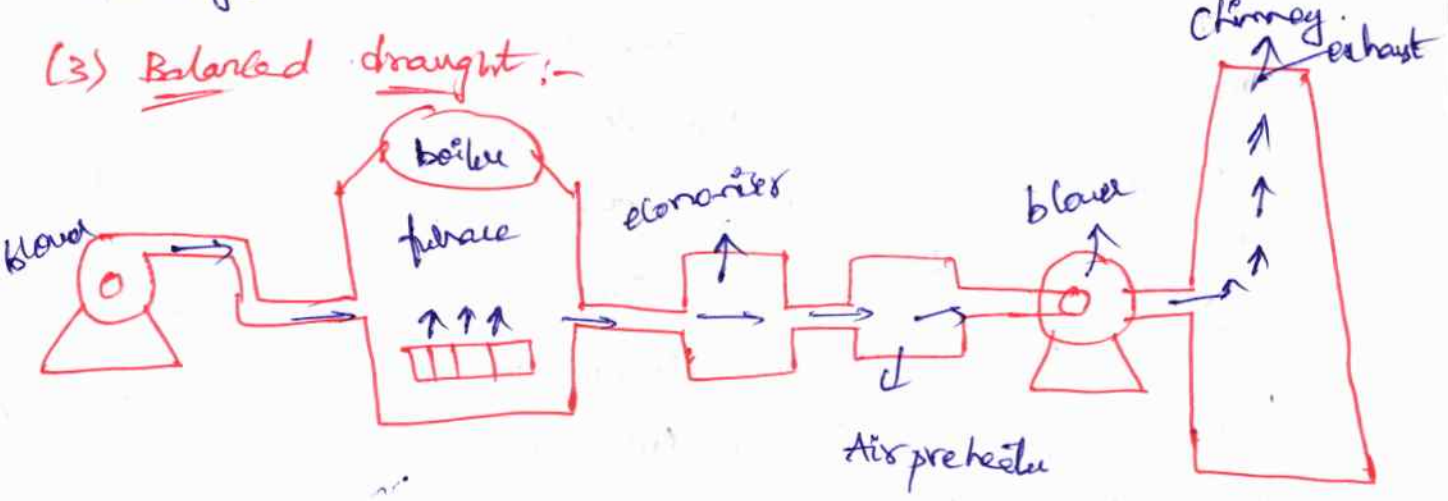
The draught produced is independent of the temperature of hot gases therefore the gases may be discharged as cold as possible after recovering as much heat as possible in air preheater & economiser.

This draught is used generally when economiser & air preheater are incorporated in the system.

The fan should be located at such a place that the temperature of the gas handled by the fan is lowest.

The chimney is also used in the system & its function is similar as mentioned in forced draught but total draught produced in induced draught system is sum of of the draughts produced by the fan & chimney.

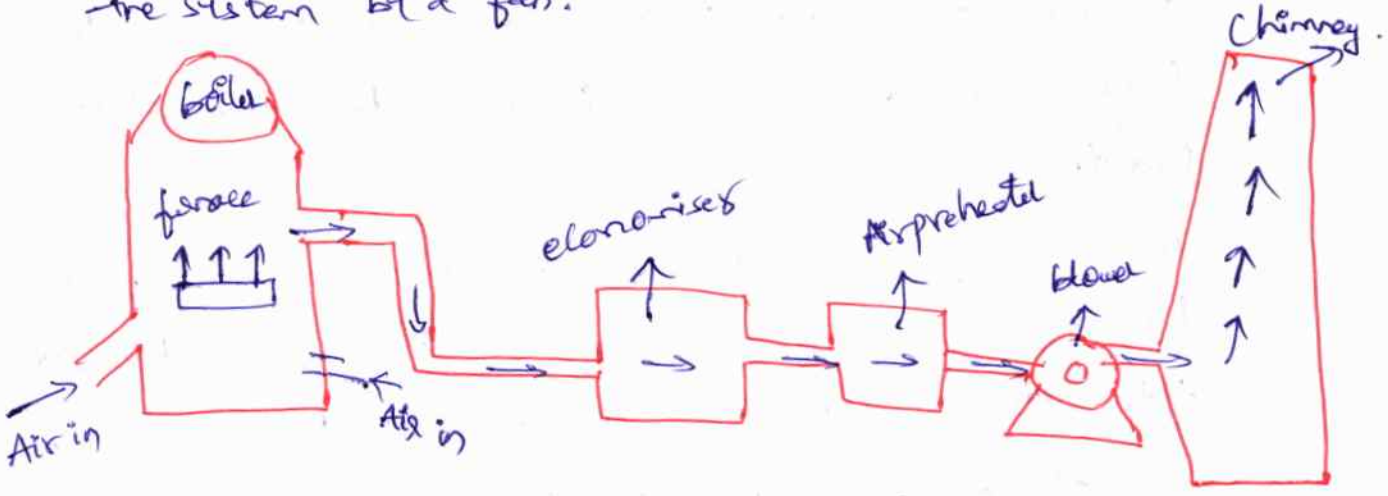
(3) Balanced draught :-



It is always preferable to use a combination of forced draught & induced draught instead of forced or induced draught alone.

The arrangement of system is shown in fig.
A stack or chimney is also used in this system as shown in fig but its function is to discharge gases high in the atmosphere to prevent the contamination.
It is not much significant for producing draught
∴ height of chimney may not be very much

(2) Induced draught :- The flue is drawn (sucked) through the system by a fan.



In this system, the blower is located near the base of the chimney instead of near the grate.
The air is sucked in the system by reducing the pressure through the system below atmosphere.
The induced draught fan sucks the burned gases from the furnace & the pressure inside the furnace is reduced below atmosphere & induces the atmosphere
The induced draught fan sucks the burned gases from the furnace & the pressure inside the furnace is reduced below atmosphere & induces the atmospheric air to flow through the furnace.

If the forced draught is used alone, then the furnace cannot be opened either for firing or inspection because high pressure air inside the furnace will try to blow out suddenly & there is every chance of blowing out the fire completely & furnace stops.

→ If the induced draught is used alone, then also furnace cannot be opened either for firing & inspection because cold air will try to rush into the furnace as the pressure inside the furnace is below atmospheric pressure. This reduces the effective draught & dilutes the combustion.

→ The forced draught overcomes the resistance of fuel bed therefore sufficient air is supplied to the fuel bed for proper & complete combustion.

→ The induced draught fan removes the gases from the furnace maintaining the pressure in furnace just below atmosphere.

This helps to prevent the blow off of flames when doors are opened as the leakage of air is invalids.

Cooling Towers → These are the heat rejection devices used to transfer waste heat to the atmosphere through the cooling of a water stream.

Use of CT

to remove heat absorbed in the circulating cooling water systems.

used in PP, petroleum refineries, petrochemical plants, Natural gas processing plants, food processing plants & other industrial facilities.

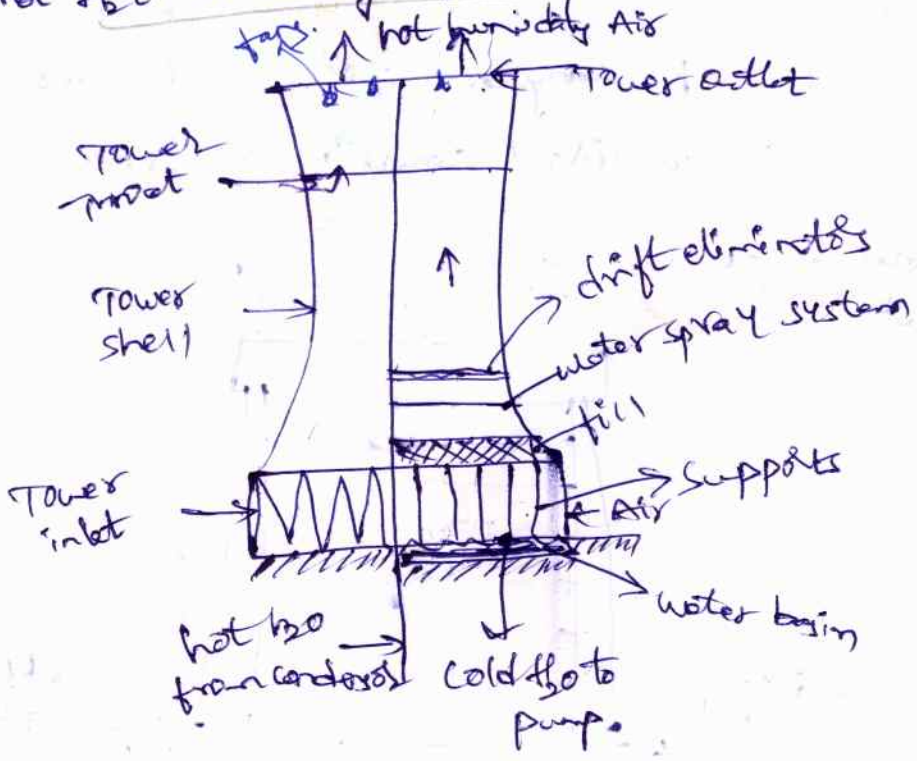
Work (or) principle :- evaporative cooling to cool a continuous flow of water.

→ That are defined by how water & air pass through them.

⇒ purpose of a Cooling Tower

To reduce the temp of circulating hot water to reuse this water again in the boiler.

This hot H_2O is coming from the condenser



Top of CT, fans are used to lift air from bottom to the top.

because of slow speed & more contact area of water, it makes a good connection b/w air & hot H_2O.

The process will reduce the temp of water by evaporation process & cooled water is collected at bottom of cooling tower & this cooled water is used again in the boiler.

⟹ Cooling Towers are of two types :-

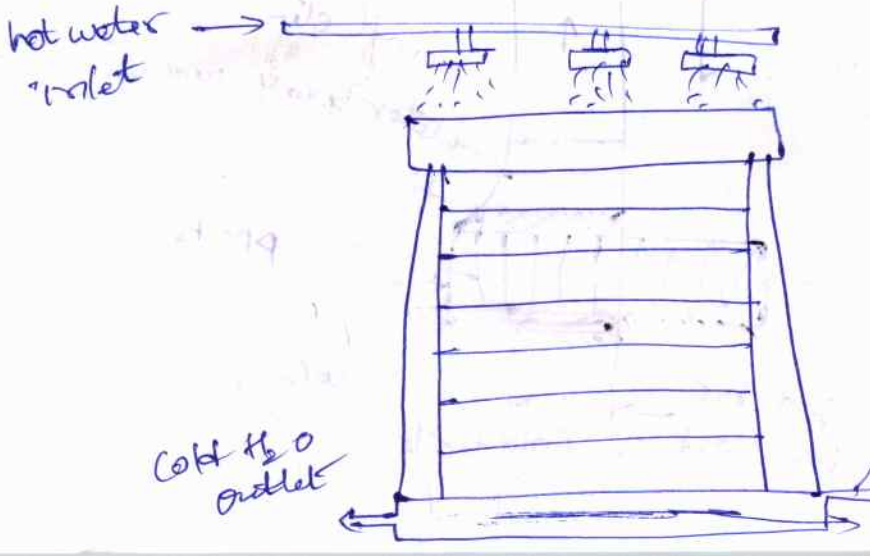
1) Natural draft cooling Tower :-

Fan is not used for circulating air but here, by enclosing the heated air in the chimney & it will create pressure difference b/w heated air & surrounding air.

→ because of this pressure difference air enters in to the Cooling Tower.

It requires large hyperbolic tower, so Capital cost is high but operating cost is low because of absence of electrical fan.

Again → Rectangular Timber Tower
→ reinforced concrete hyberbolic tower.



2) Mechanical (or) forced draught cooling Tower :-

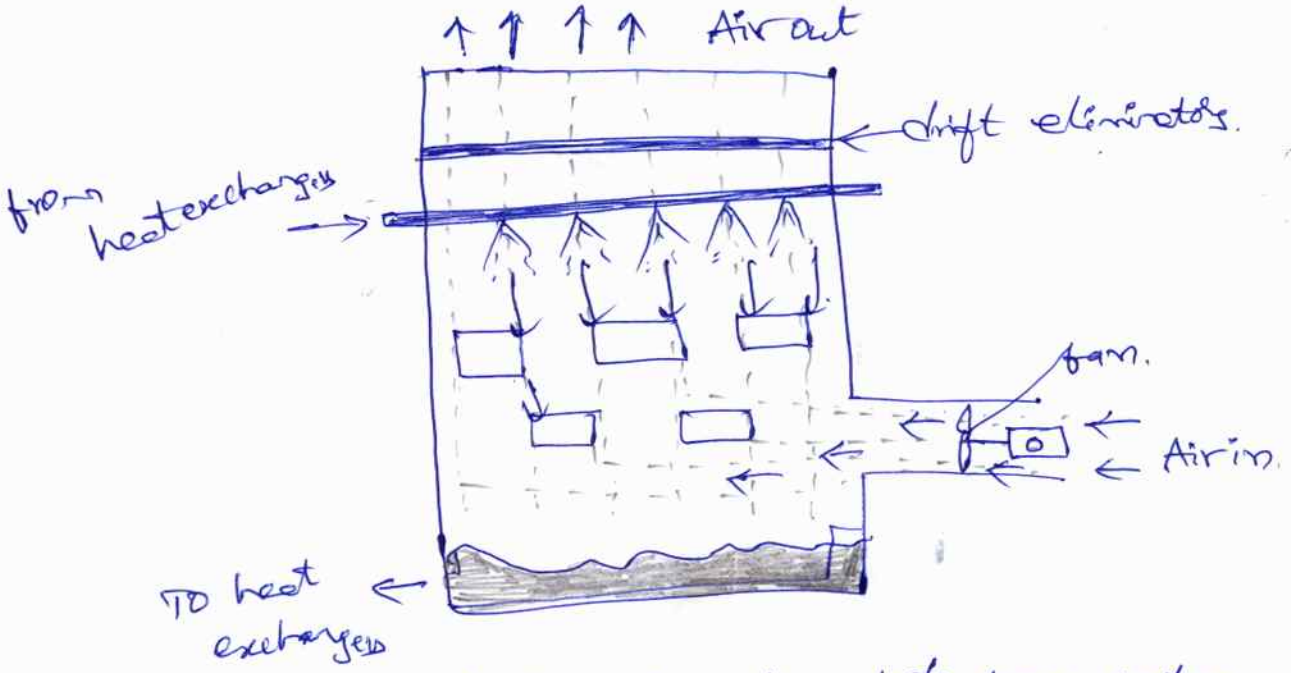
fan is used to circulate the air.

To rotate fan, it uses motor with speed around 1000 rpm.

→ The working principle is same as natural draught cooling tower, only difference is that here fan is mounted on cooling tower.

→ If fan is mounted at top of tower it is called as induced draught CT which is most popular for very large capacity installation & requires large capacity of fan.

→ so FDCT contains horizontal shaft for the fan & it is placed at bottom of tower & induced draught cooling tower contains vertical shaft & it is placed at top of FCT.



drift eliminator → It is not allowed to pass water. It is placed at top of tower, from which only hot air can pass.

Cooling Tower :-

These are specialized heat exchangers that remove heat from water mainly by means of latent heat loss from evaporation while coming into contact with an airstream.

→ Aside from evaporative cooling, water is also cooled by sensible heat transfer due to temperature difference b/w air & water.

→ Cooling towers are basically heat exchangers but instead of usual conduction - convection of shell & tube & plate heat exchangers, it generates cooling by bringing water & air into contact.

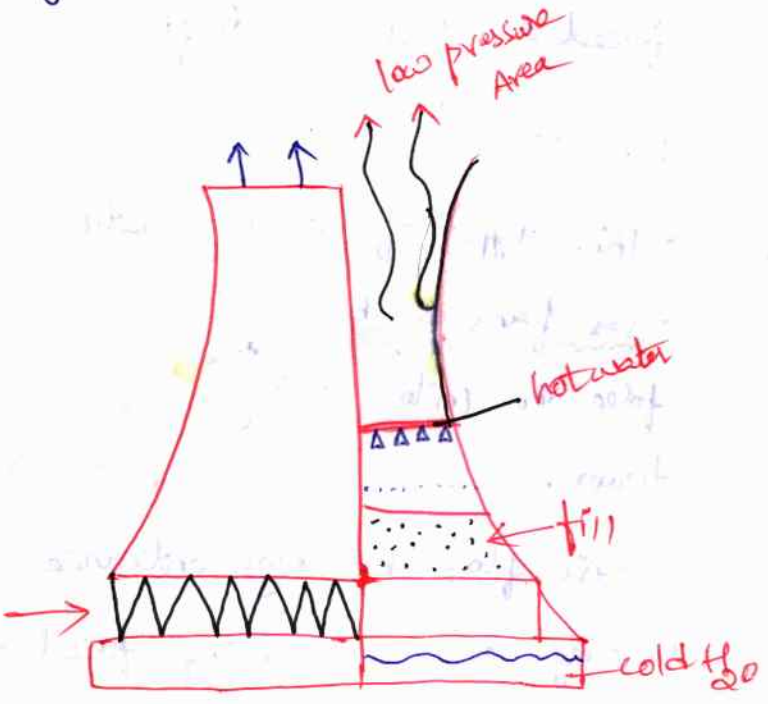
Types of Cooling Towers :-

1) Air flow Generation :- Cooling towers vary on how air flow is introduced into the system.

This may be by natural, mechanical, & hybrid draft.

→ Mechanical draft cooling towers are further divided into forced draft & induced draft.

1) Natural draft -



Natural draft cooling towers utilize no mechanical drivers of fans to create air flow through the cooling tower.

→ This cooling tower takes advantage of difference in ambient air densities below & above the tower.

→ Air flow is created as the denser air at the bottom of the tower travels to a lower pressure area above the tower.

→ These towers are inexpensive but can only be installed outdoors.

Also these towers have lower reliability as they are more affected by ambient wind & temperature changes.

2) Mechanical draft :-

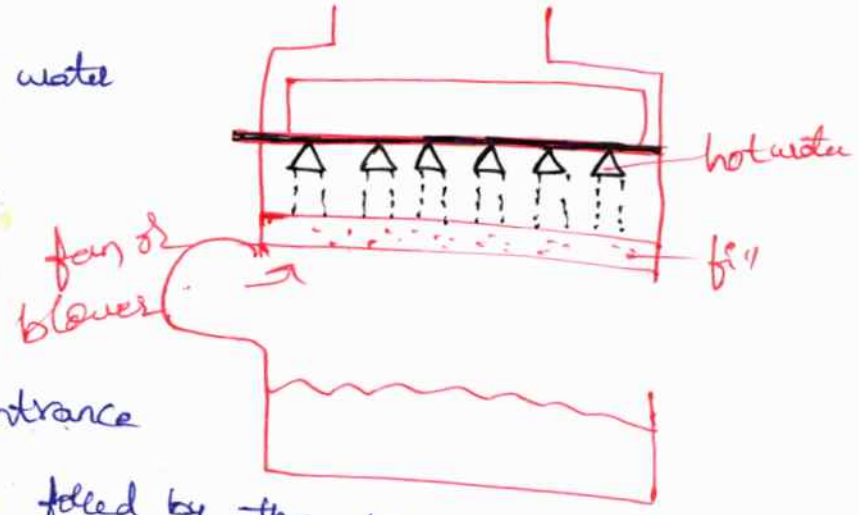
These towers use either single or multiple fans to generate air flow through the tower.

Mechanical draft cooling towers are more reliable & stable than natural draft towers since air flow can be manipulated according to the cooling load required.

Mechanical draft cooling towers can be further classified as forced & induced draft.

1) Forced draft :-

This type of cooling water uses fans & blowers to force air into cooling tower.



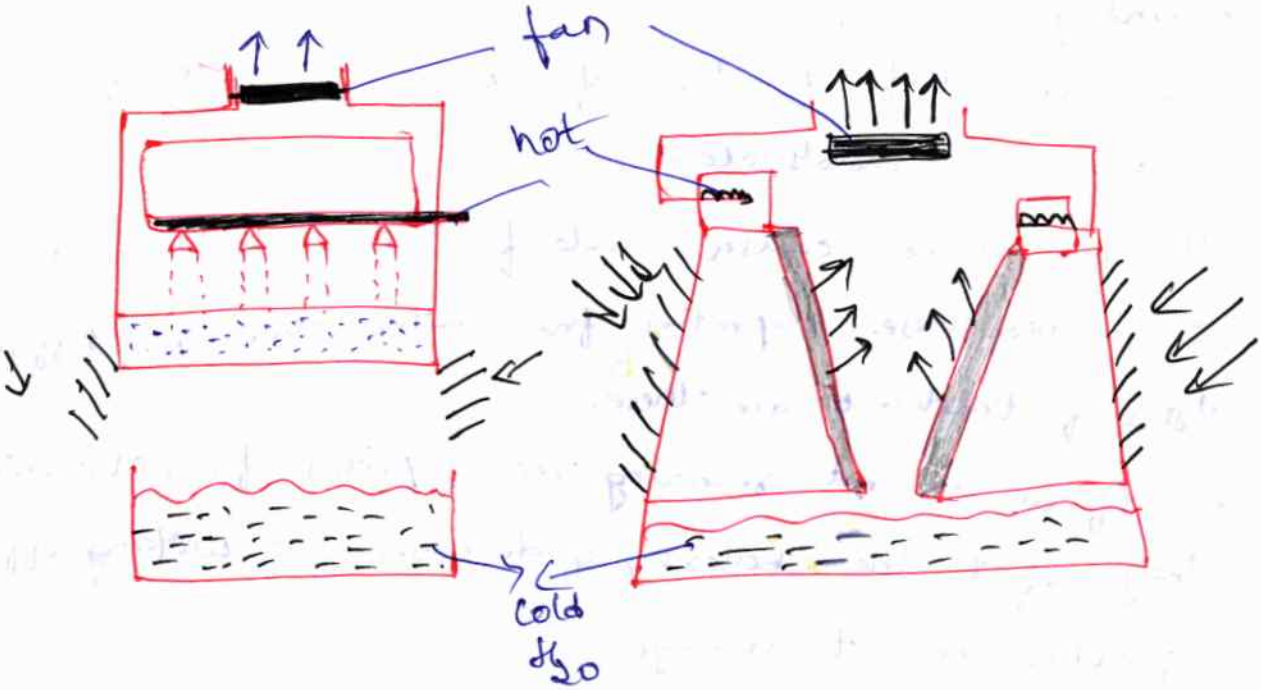
→ Air flow has high entrance velocity as it is being forced by the blower.

As it passes through the tower, air flow slows down.

→ They performance is less stable compared to induced draft towers due to recirculation.

→ These are used in indoor applications where high static pressure is a concern.

2) Induced draft :-



These have their fans located at the top that draws air from the air intake louvers at the bottom & sides of the towers.

Contrary to forced draft cooling towers, this arrangement has low entrance & high exit velocity, which results in reduced recirculation.

→ used in industrial plants requiring stable performance.

Feed water Treatment :-

Feed water in power plant must be pure & they should not contain any type of impurities in it.

Water is the important material used in power plant, by this, there are many effects caye in power plant if we are not eliminating the impurities.

There are different types of impurities in water gases, salts, acids, minerals etc.

Impure water causes scale formations, corrosion etc.

→ To reduce these impurities from water there are different types of treatments are there.

→ If we are not removing the impurities from the water they affect the boilers, & decreases the working efficiency & makes them to damage.

Different types of water Treatments :-

They are :-

1) Mechanical Treatment :- This method is done by filtration & coagulation by this treatment the solid particles in water is removed.

2) Chemical Treatment :-

by this treatment, the salts in the water removed by the help of Calcium hydroxide & sodium Carbonate, $Ca(OH)_2$ & Na_2CO_3

This is called Lime soda softening process.

The hardness of water can be removed, this is done by the exchanging the anions & cations of zedite with feed water. This is called the ion exchange process. Na is one compound of softening cell, Cl is other. It exchanges Na for Ca & mg.

3) Thermal Treatment :-

In this method, water is heated up to 116°c, by this the dissdved oxygen is removed.

This is done by converting the water into vapour form by this distilled water is olluted.

→ Impure water effects in boiler :-

1) Scale formation — It reduces heat transfer & increases the temp of the metal wall, overheating & rupturing.

2) Corrosion - by these pits, cracks, grooves are formed.

3) Carryover — This increases the tube metal temp, this reduces efficiency.

Advantages :-

1) The process takes place at a faster rate
2) efficiency is high
3) Very fine particles can also be separated.

Disadvantages :-

1) energy input is more.
2) large amount of air has to be introduced.
3) Requires special equipment.

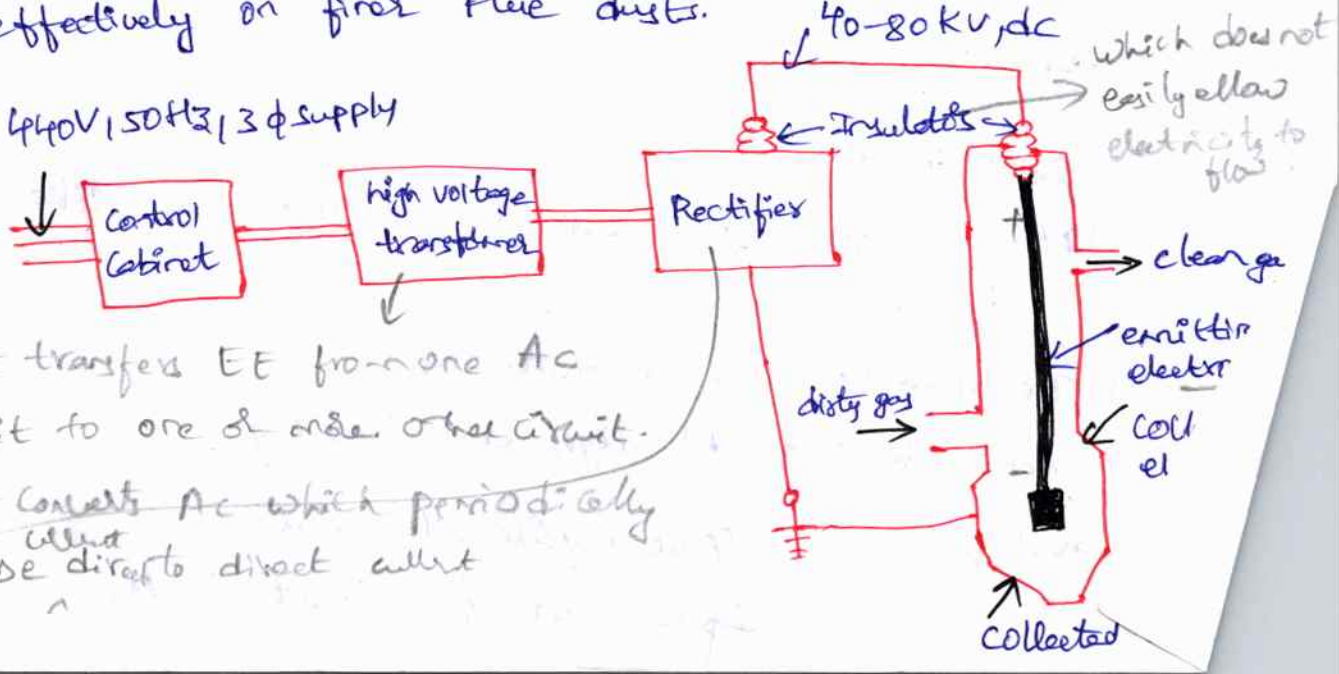
Applications :-

1) It is used for the separation of solids from liquids (liquid cyclone).
2) It can also be used for the separation of fines & dust particles from coarse particles.
3) used for separation of crystal magma such as lactose & sodium bisulfate.

Electrical dust collector :-

Electrostatic precipitators :-

This type also called cottrell precipitators works effectively on finer flue dusts.



that transfers EE from one Ac circuit to one or more other circuit.

that converts Ac which periodically reverse direction to direct current

Fig shows the basic elements of an electrostatic precipitator. These are :-

1) Source of high voltage
2) Ionizing & collecting electrodes
3) dust removal mechanism
4) shell to house the elements.

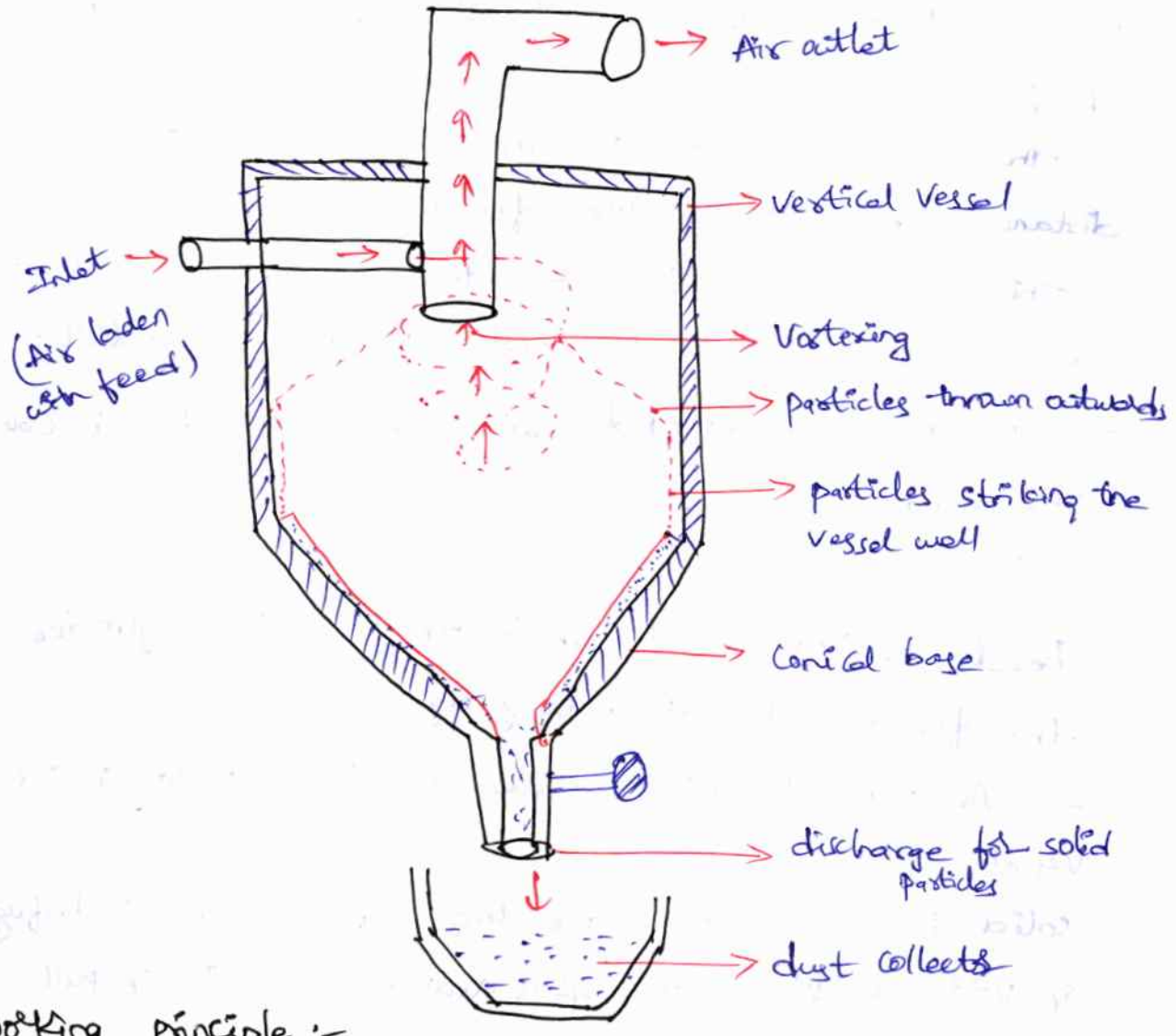
→ The precipitator has two sets of electrodes, insulated from each other, that maintain an electrostatic field b/w them at high voltage.
→ The field ionizes dust particles that pass through it, attracting them to the electrode of opposite charge.
→ The high voltage system maintains a negative potential of 30,000 to 60,000 volts with the collecting electrodes grounded.
→ The collecting electrodes have a large contact surface.
→ Accumulated dust falls of the electrode when it is rapped mechanically.
→ A wet type of this unit removes dust by a water film flowing down on inner side of collecting electrode.
→ These units have collection efficiency of order of 90%.

Advantages :-

1) Easy operation.
2) It can effectively remove very small particles like smoke, mist, flyash.
3) The draught loss is quite less.
4) most effective for high dust loaded gas.

disadvantages :- 1) Space requirement is more.
2) Capital cost of equipment is high

Cyclone separator :-



working principle :-

Centrifugation is the main principle involved in the separation of solids from fluids through cyclone separator.

→ such separation is done on basis of particle size as well as particle density.

→ larger particles with greater density under the influence of centrifugal force are thrown outwards & are collected first then successive particles with relatively less size & density are collected.

Construction :-

It consists of a vertical cylinder which is conical at the bottom.

→ The top portion of cylinder consists of a flat plate. The equipment posesses an inlet for feed (solid & air mixture) towards the lateral side & an air outlet on the top portion.

→ The air outlet extends into the separator for certain distance much below the feed inlet.

→ This arrangement prevents the air from short circuting directly from the feed inlet to the air outlet.

→ The base is provided with an outlet for recovery of the solids.

Working :-

Feed is introduced into the vertical cylinder through the feed inlet at a very high velocity.

→ As a result, rotary movement takes place inside the vessel.

Solid particles are under the influence of centrifugal force & vortexing force (air spins around very fast & pulls the solid particles into its empty centre).

→ Larger particles with greater density are thrown outwards, they strike the vessel wall & as the velocity is reduced they fall to the base of the vessel.

→ They are then collected from the bottom of the vessel through the solid outlet into a hopper or chute.

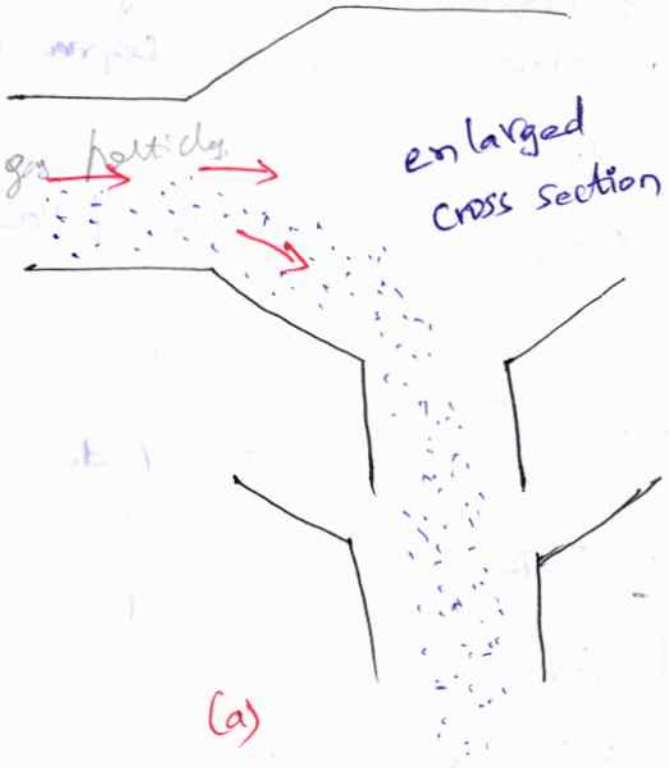
→ Later particles with relatively smaller size & low density are collected successively.

Air leaves the vessel through the air outlet at the top.

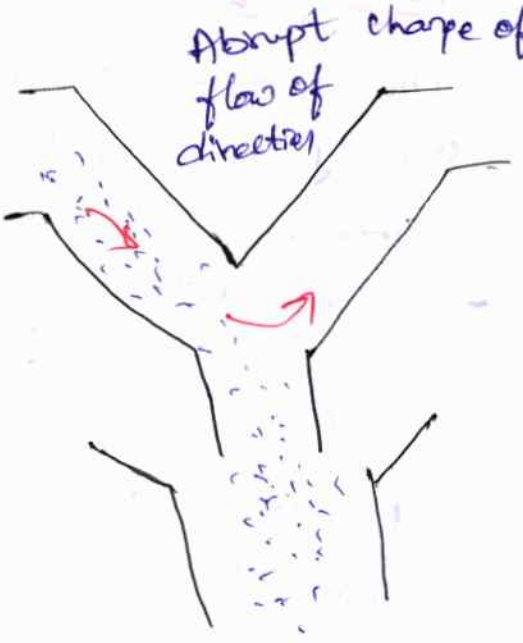
(a) Enlarging the duct cross sectional area to slow down the gas gives the heavier particles a chance to settle out.

b) when a gas makes a sharp changes in flow direction, the heavier particles tend to keep going in the original direction & so settle out.

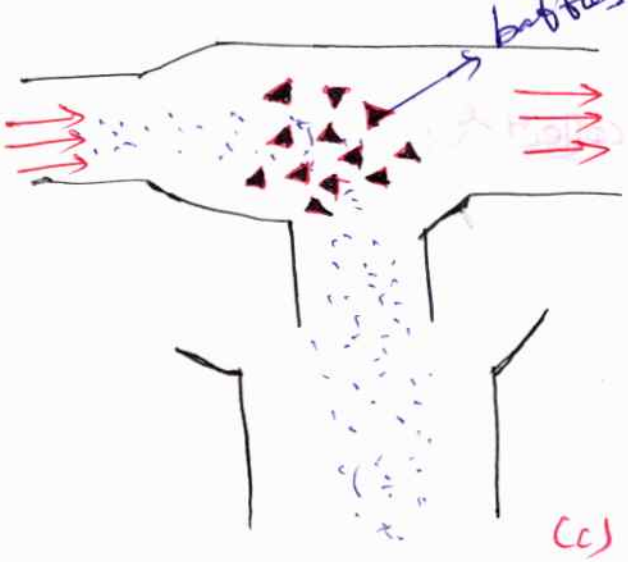
c). Impingement baffles have more effect on solid particles than the gas, helping them to settle out.



(a)



(b)



(c)

large vol of gas to be stood

Dust collection :-

The products of combustion of coal-fed fires contain particles of solid matter floating in suspension. This may be smoke & dust.

Removal of smoke :-

Smoke is produced due to the incomplete combustion of fuels.

Smoke particles are less than 1 micron in size.

Removal of dust & dust collectors :-

The removal of dust & cinders (a small piece of partly burned coal) from flue gases can usually be effected to the required degree by commerical dust collectors.

→ The dust collectors may be classified as follows :-

- Mechanical dust collectors
  - 1) wet type (Scrubbers)
    - → Spray type
    - → packed "
    - → Impingement "
  - dry type
    - → Gravitational type
    - → Cyclone separators
- Electrical dust collectors
  - Roof type
  - plate type

(1) Mechanical dust collectors :-

(2)

(i) wet type dust collectors :- wet types called scrubbers, operate with water sprays to wash dust from the air.

→ such large quantities of wash water are needed for central gas station gas washing that this system is seldom used.

→ It also produces a waste water that may require chemical neutralization before it can be discharged into natural bodies of water.

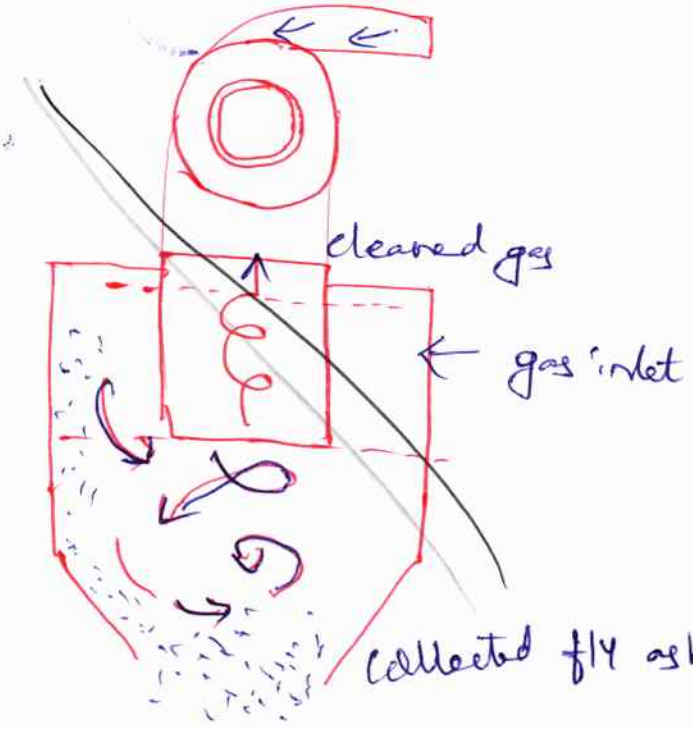
(i) dry type dust collectors :-

It is a commonly used dust collector

(a) Gravitational separators :- These collectors act by slowing down gas flow so that particles remain in a chamber long enough to settle to the bottom.

They are not very suitable because of large chamber volume needed.

(b) Cyclone separators :-



The cyclone is a separating chamber where in high speed gas rotation is generated for the purpose of centrifuging the particles from the carrying gases.

→ Usually there is an outer downward flowing vortex which turn into an inward flowing vortex.

→ Involute inlets & sufficient velocity head pressure are used to produce the vortices.

→ As multiple, small diameter vortices with high pressure drops appear to have high cleaning efficiency, that type is now being exploited.

→ skimming cyclones shave off the dust at the periphery of the vortex along with a small portion of gas flow.

→ This concentrated flow is then led to a secondary chamber for final separation.

→

Advantages of a Thermal power plant :-

1) The unit capacity of a Thermal power plant is more.
The cost of unit decreases with the increase in unit capacity.
2) Life of plant is more (25-30 years) as compared to diesel plant (2-5 years)
3) Repair & maintenance cost is low when compared with diesel plant.
4) Initial cost of plant is less than nuclear plants.
5) Suitable for varying load conditions.
6) NO harmful radio active wastes are produced as in the case of nuclear plant.
7) unskilled operators can operate the plant.
8) The power generation does not depend on water storage.
9) There are no transmission losses since they are located near load centres.

Disadvantages of Thermal power plants :-

1) Thermal plants are less efficient than diesel plants.
2) Starting up the plant & bringing into service takes more time.
3) Cooling water required is more.
4) Space required is more.
5) Storage required is more.
6) " " for fuel is more.
7) Ash handling is a big problem.
8) Not economical in areas which are remote from coal fields.
9) Fuel transportation, handling & storage charges are more.

(o) Number of persons for operating the plant is more than that of nuclear plants. This increases operation cost.

(v) For large units, the capital cost is more.

Initial expenditure on structural materials, piping, storage mechanism is more.

Diesel power plant :-

Introduction :-

A heat engine is a device which converts chemical energy of fuel into thermal energy which is then utilized to perform mechanical work (useful work).

Heat engines

- External combustion engine
- Internal combustion engine

(1) External combustion Engine :-

The combustion of fuel by air takes place outside the engine whereas in the case of an int

(2) Internal combustion Engine :-

The combustion of fuel & air takes place inside the engine.

Example :-

In a steam engine & steam turbine, the heat produced due to burning of fuel is utilised to generate high pressure in a boiler.

Classification of IC engines :-

IC engines can be classified on the basis of the following features.

1) design of the engine

Reciprocating engines & rotary engines.

↓ that uses to and fro motion (ups & down) pistons in order to convert it into rotating motion

which produces rotary motion of which has a rotating part.

2) working cycle :-

engines working on otto cycle are termed as spark ignition engines & those working on diesel cycle are termed as compression ignition engine.

3) No of strokes -

four stroke & two stroke engines (both SI & CI engines)

4) Fuel used -

Gasoline (petrol), Compressed Natural gas (CNG), LPG, diesel oil, fue oil alcohols.

5) Fuel supply & injection

It is an internal combustion engine for mixing air with a fine spray of liquid fuel.

a) Carburetted type - fuel supplied through Carburettor

b) Injection type - fuel supplied through an injector.

6) Method of cooling

Water cooled & air cooled

7) Cylinder arrangement

In line engine, V-engine, radial engine, opposed piston engine, opposed cylinder engine & delta type engine.

8) Value & port location

Classification based on value location & design is applicable only for 4 stroke engines where as classification based on port design & location is applicable of only for 2-stroke engine.

4S - over head (I head) & side Valves (L head)

2S - cross scavenging, uniflow scavenging & loop scavenging

Basic Engine Components :-

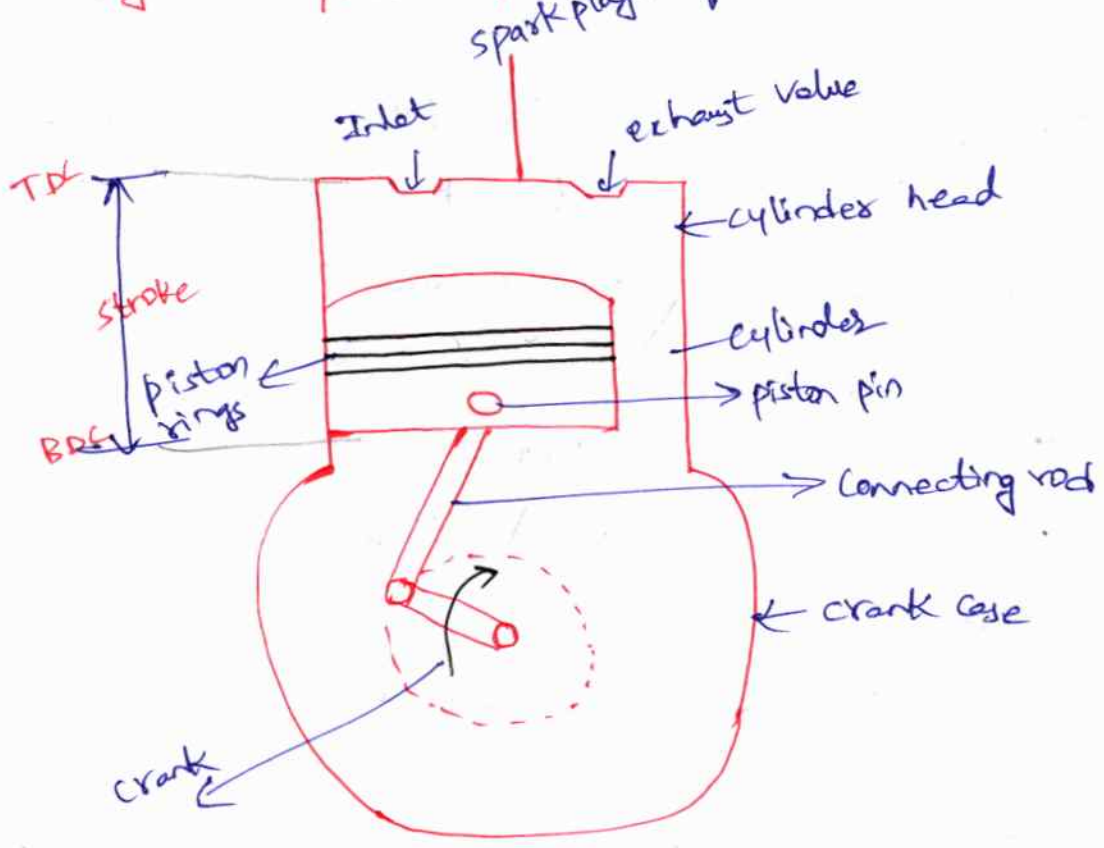


fig: parts of an IC engine

1) Cylinder :- It is a cylindrical space or container inside which the piston executes reciprocating motion.

→ The cylinder is supported in the cylinder block.

→ The top of the cylinder is covered by cylinder head.

2) piston :-

It is a cylindrical shaped component that fits perfectly into the cylinder providing a gas tight pace i.e it does not allow the gases of combustion to pass from the top side of combustion chamber to the bottom side.

→ The space formed b/w the cylinder head & top of the piston during the precess of combustion is known as combustion chamber.

3) Inlet Manifold :- The duct or pipe through which the air fuel mixture passes into the cylinder is called inlet manifold.

4) Exhaust Manifold :-

They are provided either on the cylinder head or on the side of the cylinder for the purpose of charging the cylinder (inlet valve) & for discharging the products of Combustion from cylinder (exhaust valve)

5) Spark plug :-

It is a component fitted on the cylinder head to initiate the spark for igniting the charge inside the cylinder.

It is used only in S.I engines.

(6) Connecting rod :-

It connects the piston & crankshaft, there by transmitting the force exerted on the piston to the crankshaft.

(7) crankshaft :-

It converts the reciprocating motion of the piston in to the rotary motion of the output shaft.

It is enclosed in the crankcase.

(8) piston rings :-

They are fitted into the grooves provided around the piston.

They provide a gas tight seal b/w the piston & the cylinder wall there by preventing the leakage of gases Combustion.

9) piston pin :-

It controls the opening & closing of values. The drive for camshaft is taken from the crankshaft

through timing gears. This shaft also provides drive to the ignition system.

10) Cam shaft :-

It controls the opening & closing of valves. The drive for the camshaft is taken from the crankshaft through timing gears.

→ This shaft also provides drive to the ignition system

(11) Cams :-

It is a machine element designed in such a way as to open the valves at the correct instant & also to keep them open for required time interval.

They are integral parts of the camshaft.

12) Flywheel :-

It is a heavy wheel mounted on the crankshaft. It stores the excess energy delivered by the engine during power stroke & supplies the energy needed during other strokes.

→ Thus it keeps the fluctuations in the crankshaft speed within desired limits.

13) Push rod & Rocker arm :-

The motion of the cam is transmitted to the valve through the pushrod & rocker arm.

These are together known as valve gear.

14) Crankcase :-

It forms the base of the engine block which supports the cylinder & the crankshaft.

It serves as a reservoir of sump for lubricating oil.

Engine Nomenclature :-

1) Cylinder bore – The nominal inside dia of cylinder is called bore.

2) Stroke (L) – The max distance travelled by the piston inside the cylinder in one direction is known as stroke.

3) Dead Centre –

The position of the piston in the cylinder at the moment its direction of motion is reversed is known as dead centre.

There are two dead centres in an engine.

i) TDC Dead Centre – It is the dead centre when the piston is located farthest from the crankshaft.
It is also called as Inner dead centre (IDC) in horizontal engines.

ii) Bottom Dead Centre :–

It is the dead centre when the piston is located nearest to the crankshaft. It is also called as outer dead centre in horizontal engines.

4) Swept volume – It is the volume swept by piston during its travel from one dead centre to another.

5) Clearance volume – The volume of the space b/w cylinder head & top of the piston when piston is at the TDC is called clearance volume.

6) Compression ratio –
It is ratio of total cylinder volume to the clearance volume.

Four stroke diesel engine :-

There are distinctly 4 strokes, suction, stroke; compression stroke; expansion stroke, exhaust stroke for different operations in a cycle.

The internal combustion engines are classified as four stroke & two stroke engines.

In the 4 stroke engine, there is one power stroke in every four strokes or during two revolutions of the crank.

→ The 4 stroke engines are further classified as 4 stroke petrol engine & 4 stroke diesel engine according to the type of fuel used in the engine.

Four stroke cycle engine :-

1) Suction engine — during suction stroke, the inlet value (I) opens & the exhaust value (E) remains closed.

The piston travels downwards from TDC.

Air is drawn in, from outside to enter the cylinder through the inlet value till the piston reaches BDC.

The air taken in is at atmospheric pressure.

2) Compression stroke —

At the end of the suction stroke, both inlet & exhaust values remain closed.

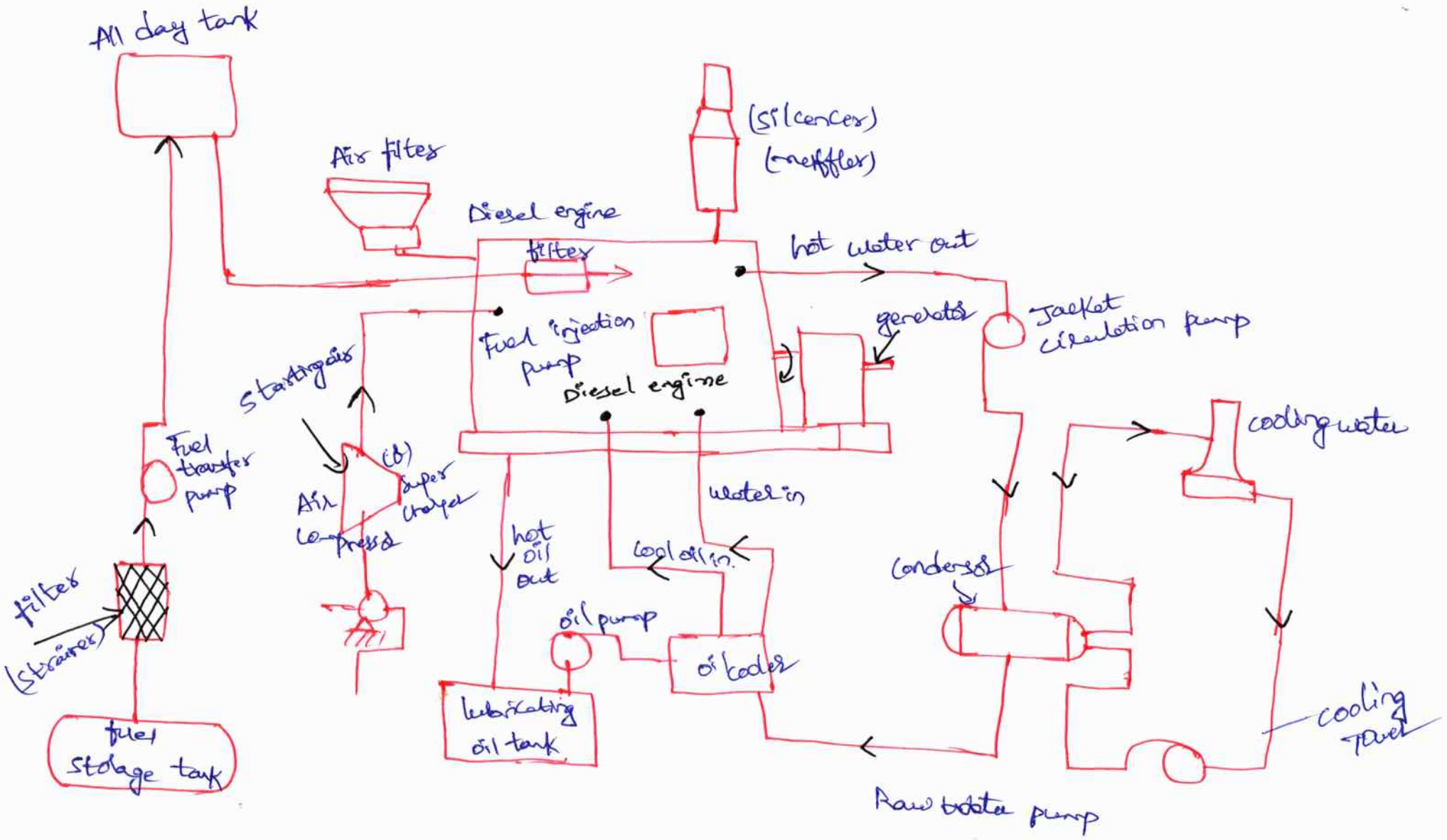
The piston moves upwards from BDC to TDC.

The air sucked in during suction stroke is compressed to a high pr & temperature with a decrease in a volume.

3) expansion or power stroke

Just before the beginning of this stroke, the diesel is

layout of diesel power plant :-



Diesel power plant - diagram - parts - working, Advantages & disadvantages.

Introduction :-

This is a fossil fuel plant since diesel is a fossil fuel. Diesel engine power plants are installed where supply of coal & water is not available in sufficient quantity.

1) These plants produce the power in range of 2 to 50 MW.

2) They are used as stand by sets for continuity of supply such as hospitals, telephone exchanges, radio stations, cinema treatres & industries.

(3) They are suitable for mobile power generation & widely used in railways & ships.

(4) They are reliable compared to other plants.

(5) Diesel power plants are becoming more popular because of difficulties experienced in construction of new hydel plants & thermal plants.

Layout of DPP:- Plant layout with Auxilliaries

The essential components of diesel power plant are:-

1) Diesel engine 2) Airfilter & super charger 3) engine starting system 4) Fuel system 5) Lubrication system 6) Cooling system 7) Governing system 8) exhaust system.

(1) Diesel Engine:-

This is the main component of a diesel power plant.

The engines are classified as two stroke engine & four stroke engines.

engines are generally directly coupled to the generator for developing power.

In diesel engines air admitted in to the cylinder is compressed.

At the end of compression stroke, fuel is injected.

→ The fuel is burned & burning gases expand & do work on the piston.

→ The shaft of engine is directly coupled to the generator.

→ After the combustion, the burned gases are exhausted to the atmosphere.

(2) Air filter & Super Charger :-

The Air filter is used to remove the dust from the air which is taken by the engine.

Air filters may be of dry type, which is made up of felt, wool or cloth.

In oil bath type of filters, the air is swept over a bath of oil so that dust particles get coated.

→ The function of supercharger is to increase the pressure of air supplied to the engine & thele by the power of engine is increased.

Engine Starting System :-

Diesel engine used in diesel power plants is not self starting.

It includes air compressor & starting air tank.

→ This is used to start the engine in cold conditions by supplying the air.

(3) Fuel System :-

It includes the stolage tank, fuel pump, fuel transfer pump, strainess & heaters.

pump draws diesel from the stolage tank & supplies it to the small day tank through the filter.

Day tank supplies the daily fuel need for the engine.

→ The day tank is usually placed high so that diesel flows to engine under gravity.

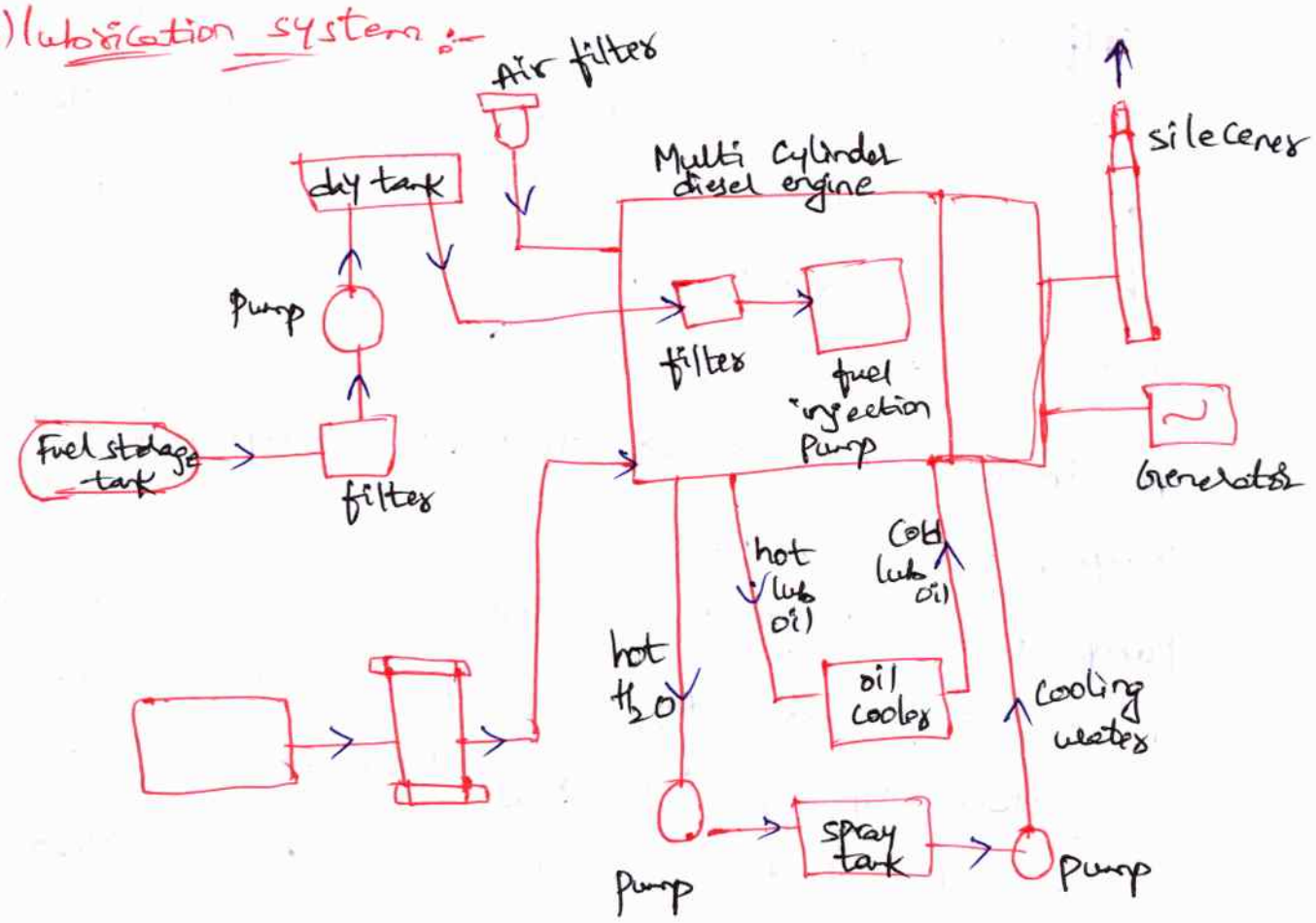
Diesel is again filtered before being injected into the engine by fuel injection pump.

→ The fuel injection system performs the following functions :

1) filter the fuel
2) meter the correct quantity of fuel to be injected.
3) Time the injection process.
4) Regulate the fuel supply.
5) Secure fine atomization of fuel oil.
6) distribute the atomized fuel properly in Combustion Chamber.

→ The fuel is supplied to engine according to load on the plant.

(3) lubrication system :-



It includes oil pumps, oil tanks, coolers & pipes.

→ It is used to reduce the friction of moving parts & reduce wear & tear of the engine parts such as cylinder walls & piston.

→ lubrication oil which gets heated due to friction of moving parts is cooled before re circulation.

→ In the lubrication system the oil is pumped from the lubricating tank through the oil cooler where oil is cooled by the cold water entering the engine.

→ The hot oil after cooling the moving parts return to the Lubricating oil tank.

(4) Cooling system :-

The temp of burning fuel inside the engine cylinder is in the order of 1500°C to 2000°C.

In order to lower this temperature, water is circulated around the engine.

The water envelopes (water jacket) the engine, the heat from the cylinder, piston, combustion chamber etc, is carried by the circulating water.

The hot water leaving the jacket is passed through the heat exchanger.

The heat from the heat exchanger is carried away by the raw water circulated through the heat exchanger & is cooled in the cooling tower.

(5) Governing system :-

It is used to regulate the speed of the engine. This is done by varying the fuel supply according to the engine load.

(6) Exhaust system :-

The exhaust gases coming out of the engine is very noisy.

In order to reduce the noise a silencer (muffler) is used.

working :-

The air & fuel mixture act as a working medium in diesel engine power plant.

The atmosphere air enters inside the combustion chamber during suction stroke & fuel is injected through the injection pump.

The air & fuel is mixed inside the engine & charge is ignited due to high compression inside the engine cylinder.

→ The basic principle in diesel engine is that the thermal energy is converted into mechanical energy & this mechanical energy is converted into electrical energy to produce the power by using generators or alternators.

Applications :-

1) peak load plant → Diesel plants can be used in combination with thermal & hydro plants as peak load units.

They can be easily started & stopped at a short notice to meet peak demand.

2) mobile plant → Diesel plants mounted on trailers can be used for temporary & emergency purposes such as for supplying power to large civil engineering works.

3) stand by unit :- If the main unit fails & cannot cope up with the demand, a diesel plant can supply the necessary power.

For example :- if water available in a hydro plant is not adequately available due to less rainfall, the diesel station can operate in parallel to generate the short fall in power.

4) emergency plant -

during power interruption in a vital unit like a key industrial plant & a hospital, a diesel electric plant can be used to generate the needed power.

5) Nursey station :-

In the absence of main grid, a diesel plant can be installed to supply power in a small town.

In course of time, when electricity from main grid becomes available in the town, the diesel unit can be shifted to some other area which needs power on a small scale. Such a diesel plant is called nursery station

6) Starting stations :-

Diesel units can be used to run the auxiliaries (like FD & ID Fans, BFD, etc) for starting a large steam power plant.

7) Central stations :-

It can be used as central station where capacity required is small.

Advantages :-

1) It is easy to design & install these electric stations.
2) They are easily available in standard capacities.
3) There are less standby losses.
4) They occupy less space.
5) They can be started & stopped quickly.
6) They require less cooling tower.
7) Capital cost is less.
8) less operating & supervising staff if required.
9) High efficiency of energy conversion from fuel to electricity.
10) efficiency at part loads is also higher.
11) less of civil engineering work is required.
12) They can be located near the load centre.
13) There is no ash handling problem.
14) easier lubrication system.

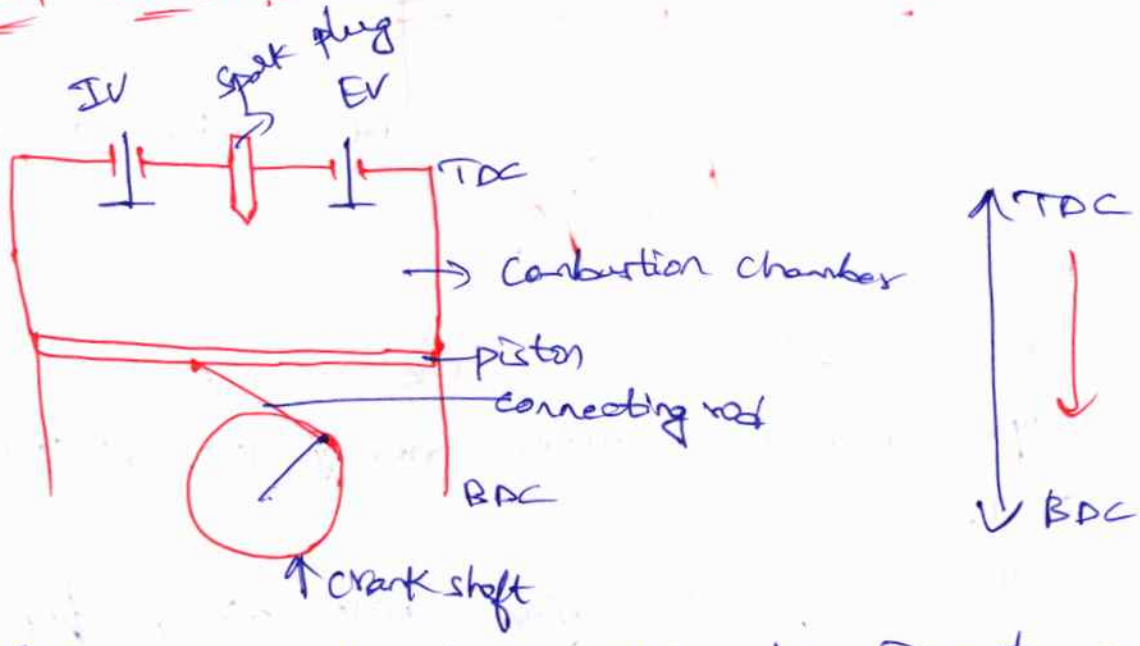
Disadvantages :-

1) High operating cost
2) High maintenance & lubrication cost
3) Noise problem.
4) Cannot supply overload.
5) Capacity is restricted. Cannot be of very big size.
6) Unhygenic emissions.
7) The life of diesel power plant is less (7 to 10 Years) as compared to that of a steam power plant which has a life span of 25 to 45 Years.
The efficiency of diesel plant decreases to less than by. after its life period.

Four stroke cycle ~~diesel~~ ~~Engine~~ :-

This type of engine comprises of following 4 strokes.

(1) Suction stroke :-



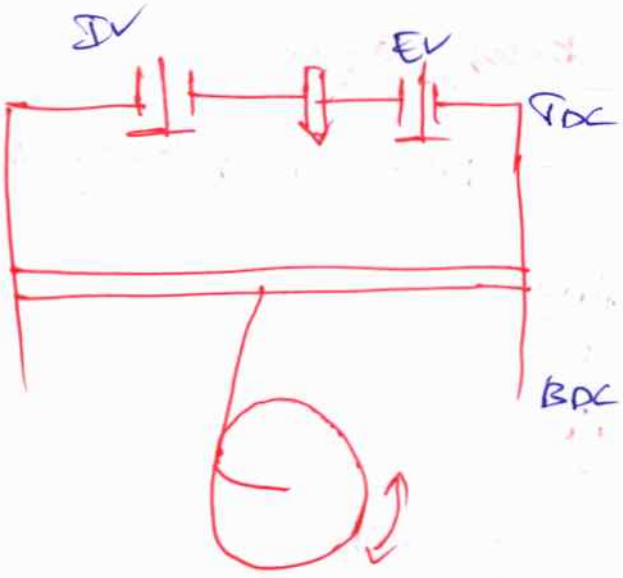
with the movement of the piston from TDC to BDC. during this stroke, the inlet valve opens & air at atmospheric pressure is drawn inside the engine cylinder, the exhaust valve remains closed.

→ In case of compression ignition (CI) by diesel engine, only air has first compressed & then fuel is injected.

→ In case of spark ignition (SI) of petrol engine, both Air & fuel mixture has to enters in to the Combustion chamber.

Thus suction stroke completed.

(2) Compression stroke :-



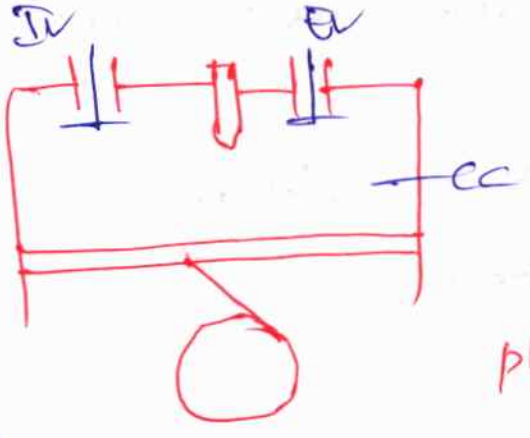
In Case of CI engine, the air has to be compressed more manner nearly 12:1 (or) 16:1 (or) 22:1.

→ In Case of SI engine both Air & fuel mixture has to taken the compression has to be occured.

→ piston moves from BDC to TDC, Inlet & exhaust Value closed.

→ The minimum compression occured in SI engine is 10:1 ratio. Thus compression stroke completed.

(3) expansion (or) power stroke :-

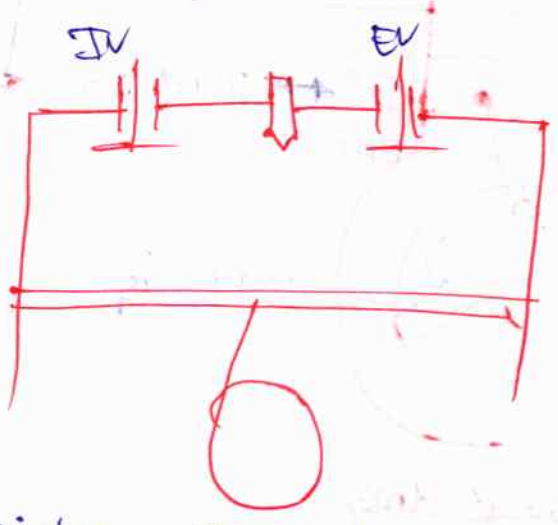


piston stalts from TDC to BDC.

→ In Case of compression stroke, the fuel enters through fuel Injector then Combustion occurs through pavel then piston moves downwards is Called P & E.

In SI engine, the air & fuel mixture has to be taken then piston moves downward then at the time of spark produced is called power & expansion stroke.

(4) Exhaust stroke :-



The piston moves from BDC to TDC & exhaust gases escape to the atmosphere through exhaust valve. when piston reaches the TDC, the exhaust valve closes & cycle is completed.

Inlet valve is closed, exhaust valve is opened & set to gases to the atmosphere.

Two strokes engine :-

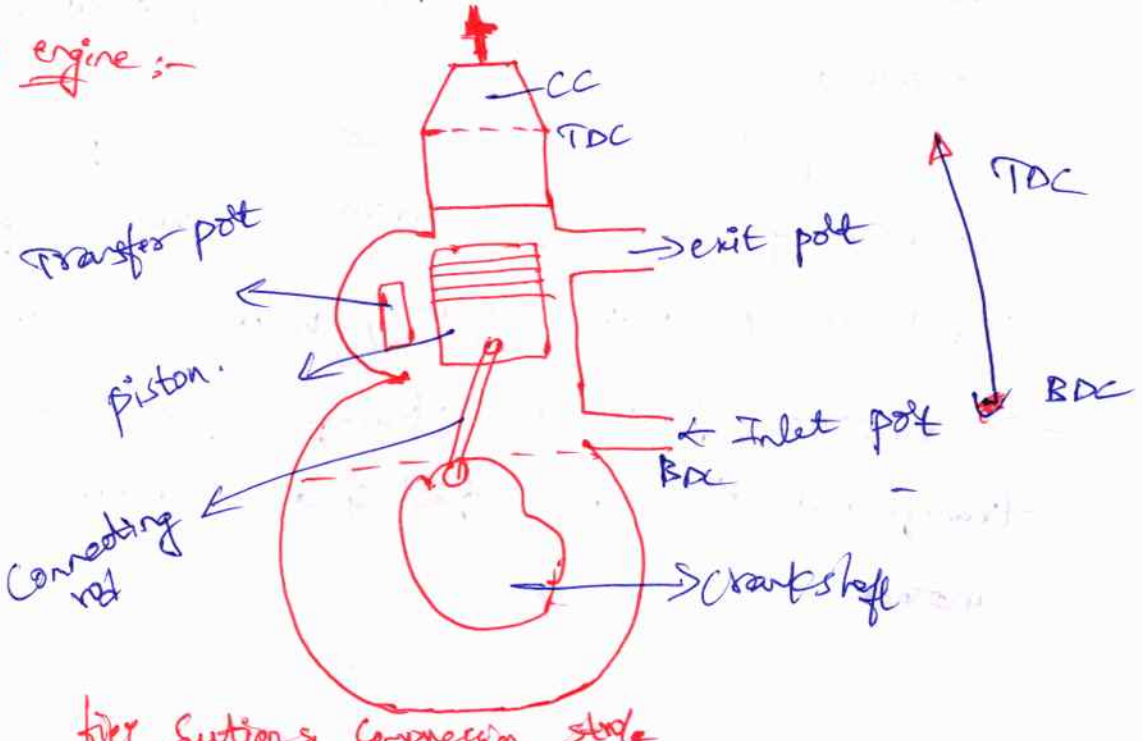
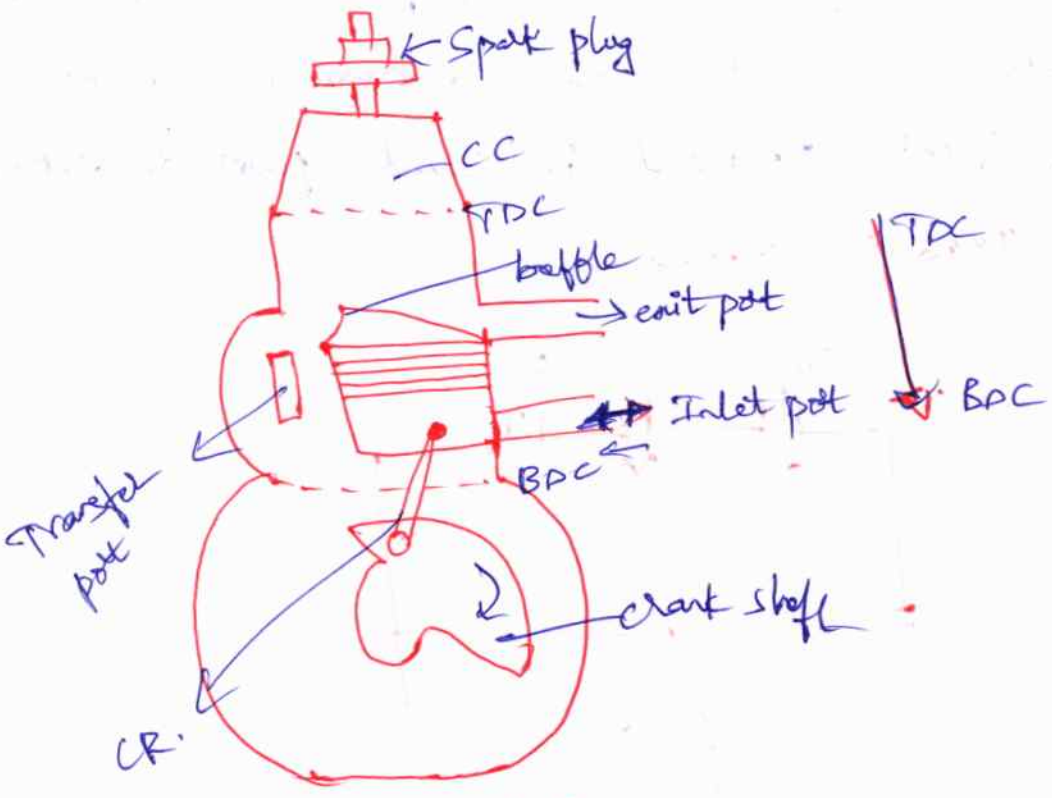


Fig Suction & Compression stroke



expansion & exhaust stroke

Working:-

The operations whatever worked in four stroke engine the same operations repeated in two stroke also.

→ In the name itself, two stroke the piston has to works in two strokes the four processes (or) operations like suction, compression, expansion & exhaust stroke completed.

→ here ports are to be considered for inlet & outlet to entering the fuel mixture & waste gases outlet.

→ but in 4 stroke engine, values are used.

→ Another part is transfer port it has to be transfered to the fuel & air mixture from one place to another.

→ first of all the air & fuel mixture has to be enters through inlet port the already the fuel mixture on top of piston has to be compressed.

→ At a time both suction & compression both has to be completed. Thus one stroke completed.

→ here piston moves from BDC to TDC, one stroke completed.

→ by using spark plug the combustion has to be occured then spark occured in petrol engine then piston moves TDC to BDC then expansion & power has to be produced at the same time the waste gases has to be removed out by exit port.

→ so hole pista moves TDC to BDC, then another stroke completed of both expansion & exhaust stroke.

→ If piston moves from BDC to TDC, then again inlet port opened the same process repeated.

Advantages of 4 stroke E

→ Cycle complete in two stroke of piston during one crank shaft revolution.

→ ports are used.

→ Height power to weight ratio.

→ lighter in weight.

Comparision of Four stroke & Two stroke cycle engines:- (4)

Four stroke	Two stroke
(1) The cycle is completed in 4 strokes of the piston & in two revolutions of the Crankshaft. Thus one power stroke is obtained in every two revolutions of the crank shaft	(1) The cycle is completed in two strokes of the piston & in one revolution of the CR. Thus one power stroke is obtained in each revolution of the CR.
2) Turning moment is not so uniform & hence heavier flywheel is needed.	(2) more uniform turning ~~moment~~ movement & hence lighter flywheel is needed.
(3) Again because of one power stroke for two revolutions, power produced for same size of engine is small & for the same power the engine is heavy & bulky.	(3) Because of one power stroke for one revolution, power produced for same size of engine in more & for the same power the engine is light & compact.
(4) Because of one power stroke in two revolutions lesser cooling & lubrication requirements. lesser rate of wear & tear.	(4) Because of one power stroke for one revolution, ~~power produced for same size of engine is more~~, greater cooling & lubrication requirement. Greater rate of wear & tear.

(5) The four stroke engine contains Valve & Valve mechanism.	(5) Two stroke engines have no Valves but only ports.
(6) Because of heavy weight & Complication of Valve mechanism, higher is the initial cost.	(6) Because of light weight & simplicity due to absence of Valve mechanism, Cheaper in initial cost.
(7) Volumetric efficiency more due to more time of induction.	(7) Volumetric efficiency less due to lesser time for induction.
(8) Thermal efficiency higher, part load efficiency better than two stroke cycle engine.	(8) Thermal efficiency lower, part load eff lesser than four stroke cycle engine.
9) Applications Cars, buses, trucks, tractors, aeroplane, power generators, Industrial engines.	(9) lawn mowers, scooters, motor cycles.

Petrol Engine	Diesel Engine
(1) Air petrol mixture is sucked in the engine cylinder during suction stroke.	(1) only air is sucked during suction stroke.
(2) Spark plug is used.	(2) Employs an injector.
(3) power is produced by spark ignition.	(3) power is produced by Compression ignition.
(4) Thermal efficiency up to 25%.	(4) Thermal efficiency up to 40%.
(5) occupies less space.	(5) occupies more space.
(6) more running cost	(6) less running cost.
(7) Light in weight.	(7) Heavy in weight.
(8) Fuel (petrol) costlier	(8) Fuel (diesel) cheaper.
(9) petrol being volatile is dangerous.	(9) Diesel is not dangerous as it is non-Volatile.
(10) pre-ignition possible.	(10) pre-ignition not possible.
(11) works on otto cycle.	(11) works on diesel cycle.
(12) less dependable	(12) more dependable.
(13) used in Cars & motor cycles.	(13) used in heavy duty vehicles like trucks, buses & heavy machinery.

Cooling systems :-

The cooling medium used in the cooling system can be air & water.

→ There are two types of cooling systems.

(1) Liquid & indirect cooling systems

(2) Air & direct " "

1) Liquid cooling systems :-

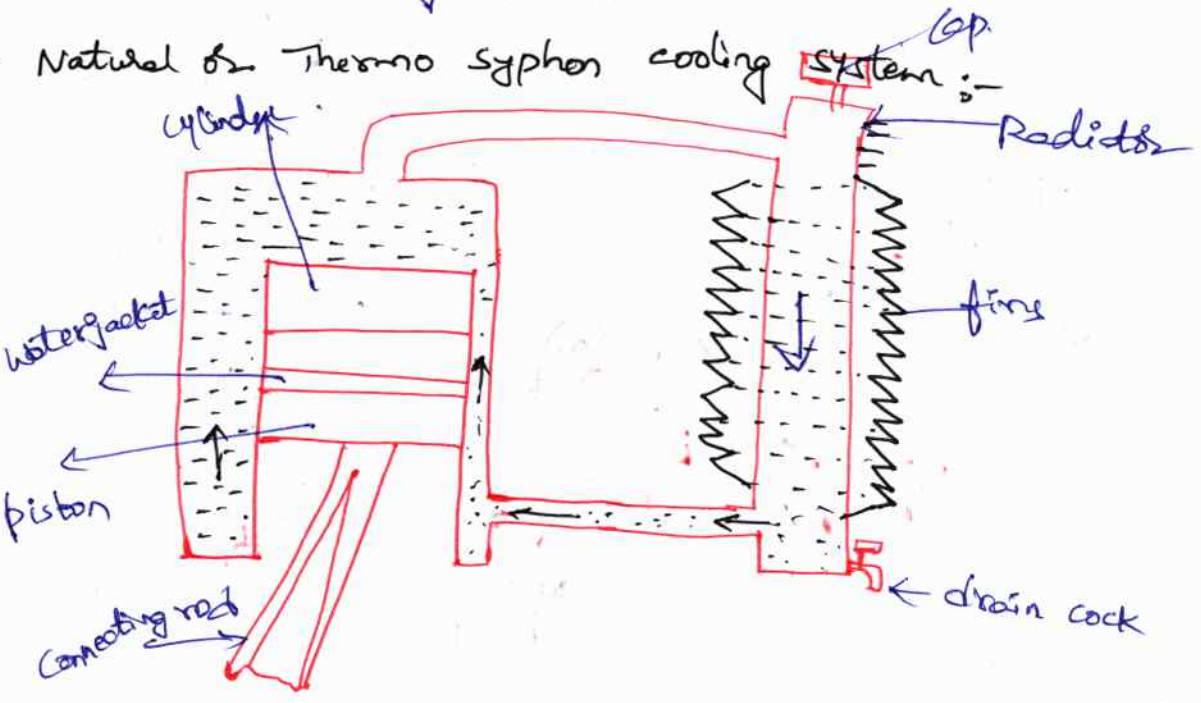
This system can be classified under three types.

1) Natural circulation type & thermo syphon system.

2) Forced circulation system

3) Thermostatic cooling system.

a) Natural & Thermo syphon cooling system :-



This system is based on the principle that water on being heated rises up due to decrease in its density & cold water consequently comes down thus establishing a 'natural circulation'.

→ The cold water comes in contact with the engine cylinder there by taking away its heat.

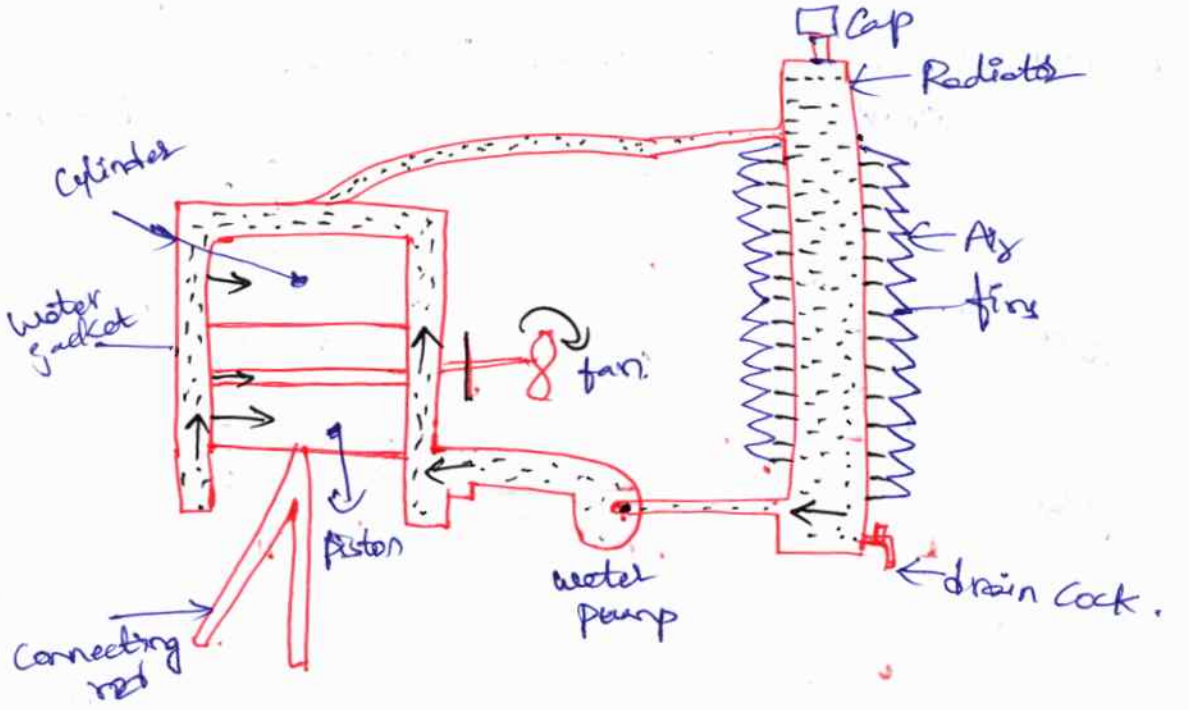
→ Thus its density decreases & it rises up & enters the radiator where it losses its heat to the oncoming air

(due to forward motion of the vehicle) thus becoming relatively cool.

Then this cold water once again enters the engine cylinder & this process is repeated.

→ This system is advantageous in the sense that it is simple. However it is not able to meet the requirement of high output engines which require a large flow rate of water for dissipating large amounts of heat. The process of circulation is slow in this system.

b) Forced circulation cooling system :-



This system is used in automobiles like cars, buses & heavy trucks.

As in the natural circulation system, water or coolant is kept circulated, around the cylinder, in the cylinder jackets.

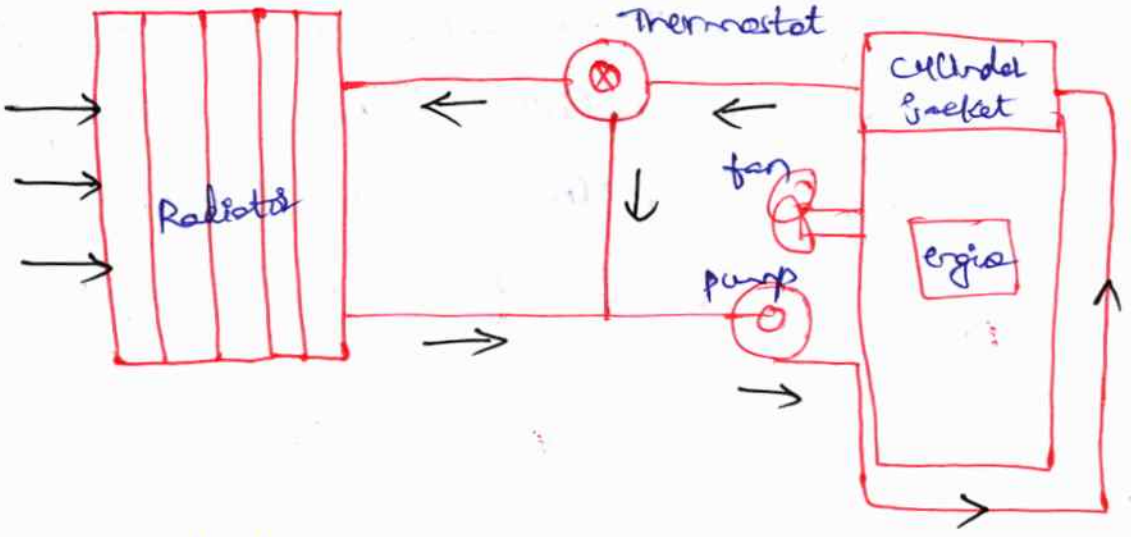
→ The main difference b/w natural circulation system & forced circulation system is that in the forced circulation system,

the circulation is achieved mainly by a centrifugal pump driven by the engine.

The water on receiving the heat from the engine cylinder, gets heated up, rises up & then enters the radiator where it is cooled by oncoming air.

The pump draws water from the lower part of radiator & feed the cold water to the bottom part of water jacket for further circulation.

c) Thermostatic cooling system :-



The need for thermostatic cooling system is to start the engine easily in cold weather.

It is necessary to have a minimum water temp around the engine for starting.

It helps to achieve this purpose.

It consists of following parts.

1) pump →

In automotive engines, the pump, usually of the centrifugal type, is attached on front end of the

cylinder block & is driven by the engine through a belt.

The main function of pump is to circulate the water through the water jackets to remove the heat from the engine & through the radiator, where water is cooled by the flow of air over the radiator.

The cooled water enters the pump & cycle is repeated.

2) Radiator —

The purpose of radiator is to dissipate the heat from hot water received from water jacket of the engine.

It is basically a heat exchanger where energy from water flowing through the radiator tubes is transfered to the air flowing around the radiator tubes.

The air flow is due to forward motion of vehicle & due to fan.

3) Thermostat

It is usually present in upper hose connection

Thermostatic Valves are two in no & they automatically maintain the minimum water temp & help in quick warm up of engine after starting.

during warm up period - during starting of engine from cold, the thermostatic valves are closed & pump circulates the water through cylinder water jacket only.

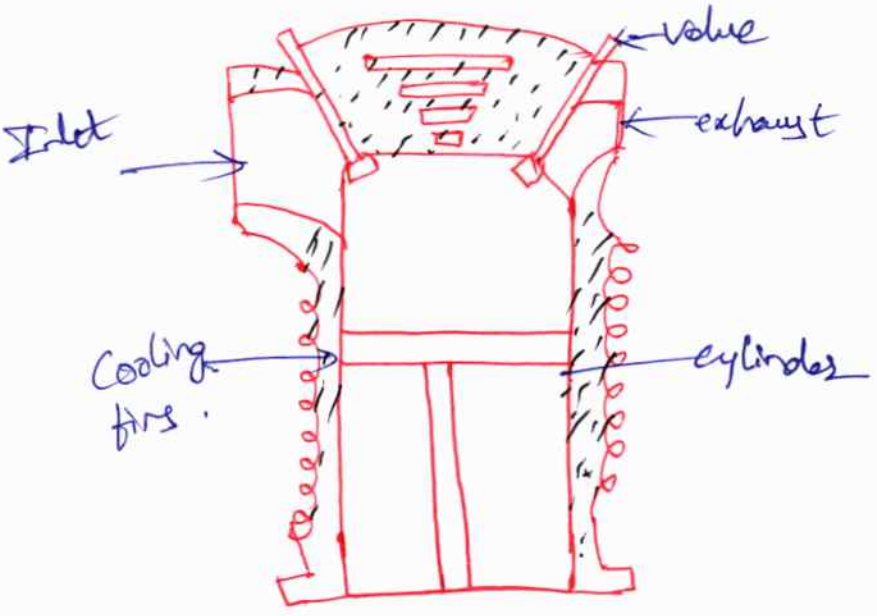
when normal operating temp is reached, the valve opens & water circulates through the radiator.

4) Fan :-

12

At low vehicle speeds, sufficient amount of cooling air must be provided & freed through the Radiator core in order to sufficiently the cool water.

2) Air cooling system -



In this system, a stream of air is made to blow over the outside of the cylinder.

The outer surface area is adequately increased by providing fins which are also known as extended surfaces.

→ It is used in motor cycles, small cars, air planes etc, where forward velocity of vehicle is high enough to ensure a good circulation of air around the engine cylinder for cooling.

— fins are 25-50mm long.

Gas Turbine plant :-

Introduction :-

→ Air standard cycle for gas turbine plants is Brayton Cycle.

→ Gas Turbines are used mostly for electricity generation in the periods of peak electricity demand.

Gas Turbine power plant :-

It is working principle similar to steam Turbine.

A generating station which employs gas turbine as the prime mover for the generation of electrical energy is known as a GTPP.

Natural sources → prime mover → mechanical energy.

ex:- Air

Coal

"A Gas Turbine is a combustion engine with in a power plant that can convert natural gas (or) other liquid fuels to mechanical energy!

This energy then drives a generator that produce the electrical energy that moves along power lines to homes & business.

→ The fundamental working principle of a GTPP is same as that of STPP. The only difference is there that in steam Turbine power plant we use compressed steam to rotate the Turbine, but in gas Turbine power plant we use compressed Air to turn the turbine.

classification of GTPP :-

The GTPP may be classified according to the following criteria.

1) By application :-

i) In Aircraft a) Jet propulsion b) prop-jet

ii) Locomotives iii) Marines iv) Transport.

2) By cycle :- 1) open cycle 2) closed cycle

3) Semi closed cycle

open - closed cycles → constant pressure combustion gas Turbine.

Semi closed cycle → " volume "

3) A/c to Arrangement :-

i) Simple ii) single shaft iii) multi shaft iv) Inter cooled

v) Reheat 6) Regenerative 7) Combination

4) A/c to Combustion :-

i) continuous combustion ii) Intermittent combustion

5) by fuel :-

iii) Gaseous fuel ii) liquid fuel i) solid fuel

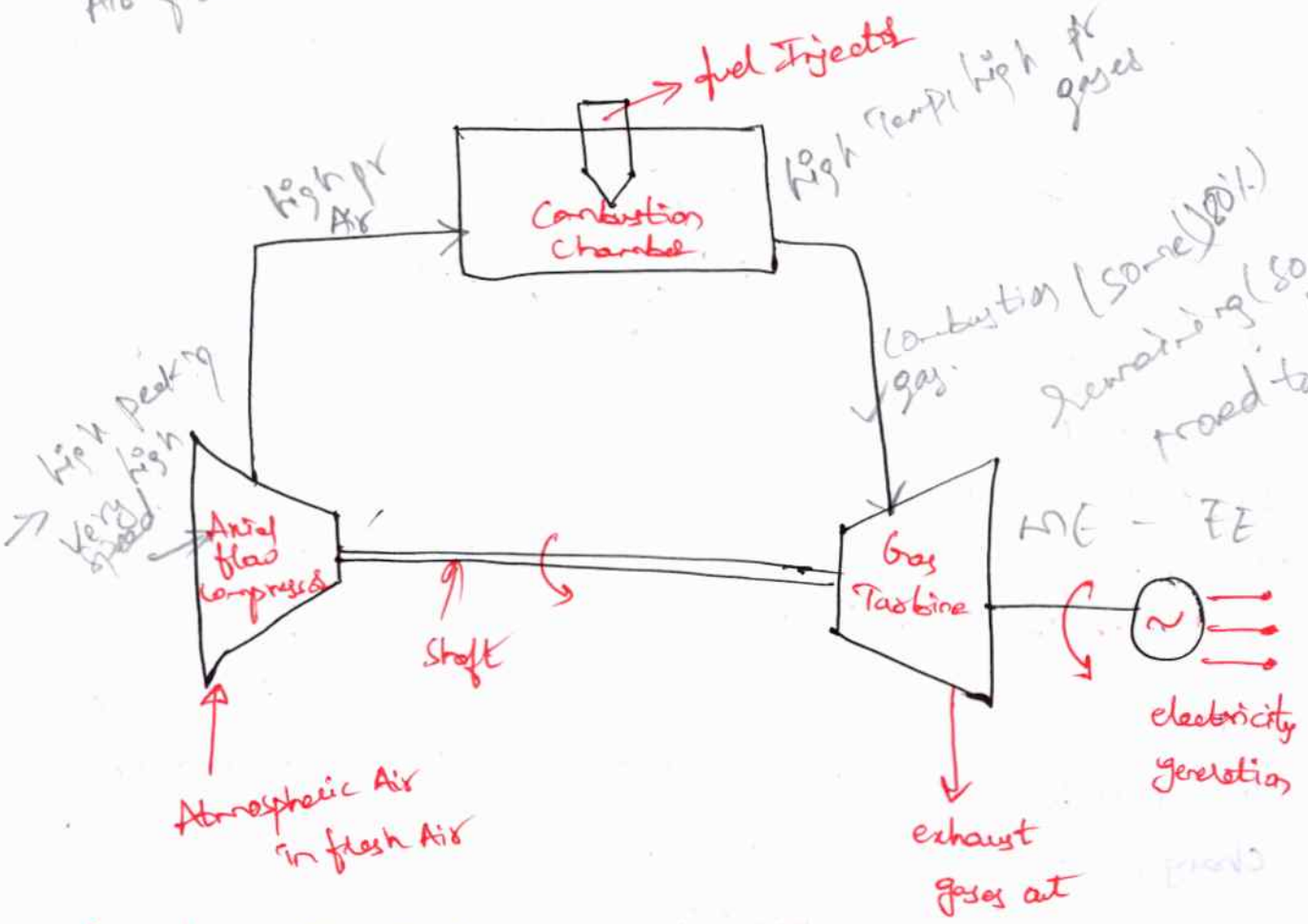
Construction :-

The Gas Turbine Components mainly include Compressor, shaft, Combustion Chamber, exhaust.

The working of this Turbine includes different processes like suction, Compression, Combustion, turbine & electricity generation.

→ The GT parts & their functions are explained below :-

Air flows ||el to the axis of rotation.



1) Suction :- In suction process, the Turbine sucks the air from the atmosphere to the compression chamber then the air is transmitted to the compressor.

2) Compression :- In the compression process, once the air comes into the compressor, then it reduces the air & changes the energy from kinetic to pressure. After this, the energy changes the air into high pressure Air.

3) Combustion :-

After the process of compression, the compressed air moves into the combustion chamber. This Chamber includes an injector that injects fuel into the combustion chamber & mixes the fuel with air. once mixing is done, the chamber ignities the mixture of air & fuel. This mixture changes into high-Temp & high-pr gases because of the ignition process.

4) Turbine :- As the combusted gas enters into the Turbine section, some energy of this gas transforms into mechanical energy & some energy is exhausted. As the combustion gas expands through the Turbine, it rotates the Turbine blades.

→ The rotating blades have a dual function :-

1) They run the Compressor to draw in more air for operation purpose.

2) And also drive a gas generator connected with the Turbine.

5) Electricity generation :-

It is connected through the shaft of the turbine, so the generator gets mechanical energy from the Turbine & changes into electrical power.

Working & operation principle :-

The Gas Turbine working principle mainly depends on the brayton cycle (or) Joule cycle.

"The brayton cycle states that it is a cycle that explains a particular heat engine operation that gas (or) air as its working fluid.

Sometimes it is also called Joule cycle.

Throughout this brayton cycle the mixture of air fuel is burned, pressurized & supplied through a turbine & discharged.

→ once the air enters into the inlet of the Turbine, the Compressor in the Turbine increases the pressure of

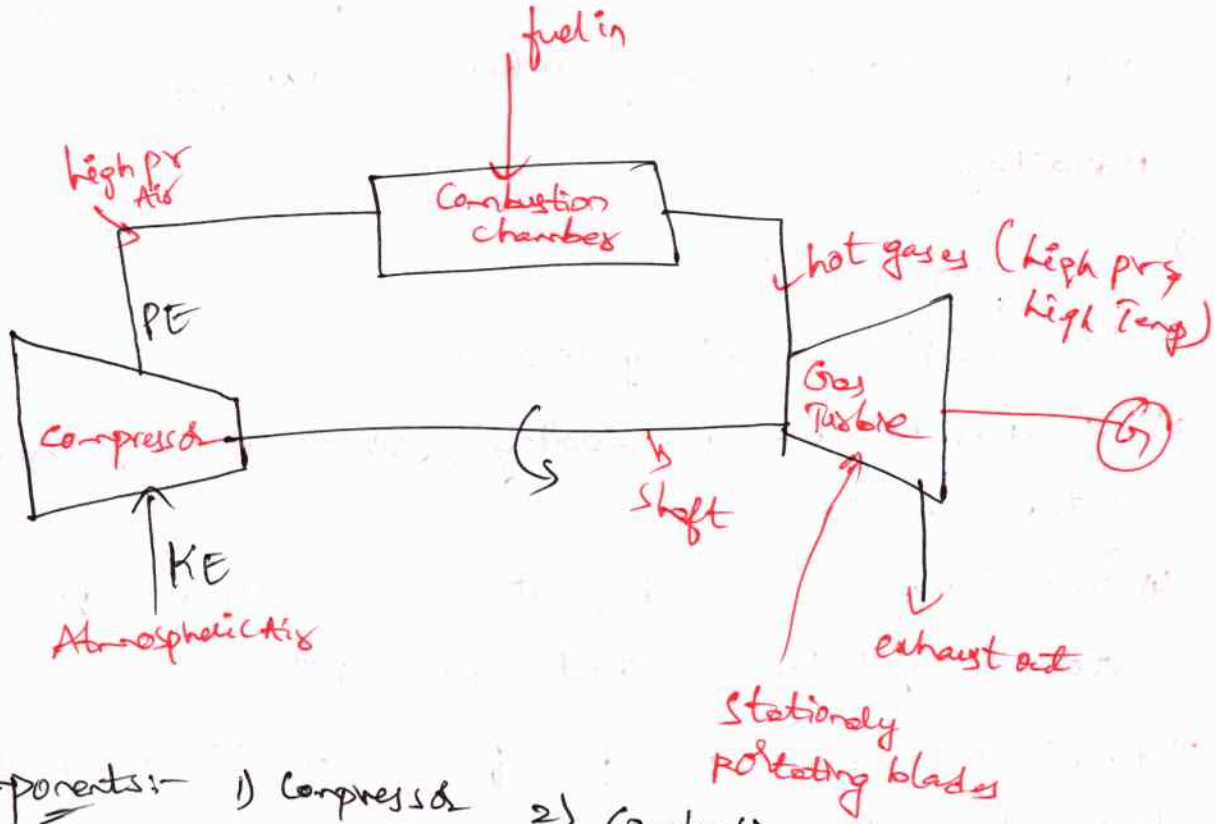
Advantages:-

1) They are small in size, weigh less & have low initial cost per unit output.
2) They are easy to install within short periods.
3) " " quick starting & smooth running.
4) They offer flexibility by supplying electricity for power generation as well as by supplying compressed air for process needs.
5) water consumption is less compared to steam PP.

Disadvantages:-

1) An electric motor or an IC engine is necessary for starting the plant.
2) It will have less vibrations when compared with reciprocating engines of same speed.

principle of working of open cycle gas Turbines :-



Components:- 1) Compressor 2) Combustion Chamber
3) Gas Turbine 4) Shaft 5) Generator.

→ The Compressor takes the ambient Air & raises its pressure by Compression.

→ Heat is added to the air in the combustion chamber by burning the fuel & increasing the air temperature.

→ The heated gases coming out of the combustion chamber are then passed to the Turbine where it expands. doing the mechanical work.

→ The part of generated power by turbine is utilized in driving the Compressor & other accessories & remaining is used for power generations.

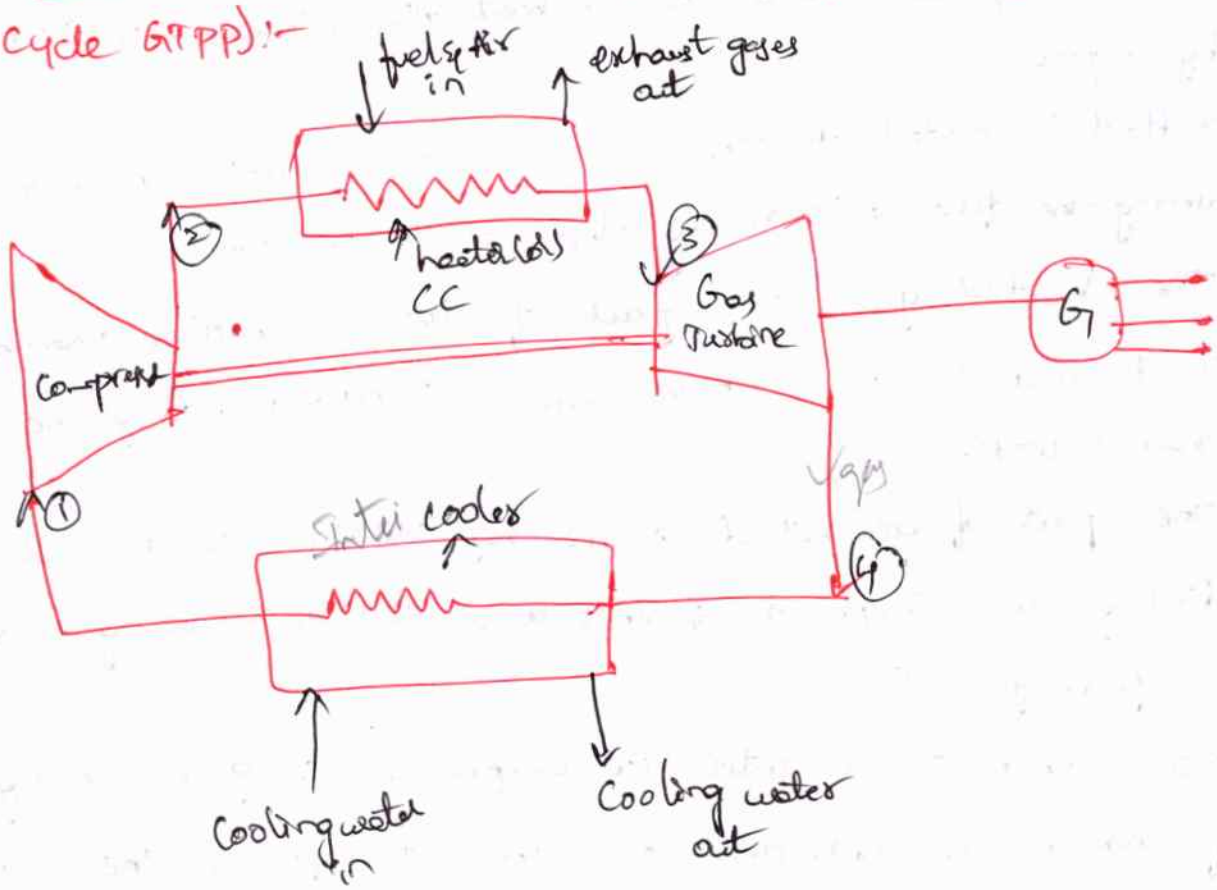
→ since ambient air enters the Compressor & gases coming out of turbine are exhausted in to the atmosphere the working medium must be replaced continuously.

→ This type of cycle is known as open cycle gas. Turbine power plant & is mainly used in majority of GTPP as it has many inherent advantages.

Advantages :-

1) low weight & size.
2) It occupies relatively less space.
3) It does not require cooling water except for having an intercooler
4) once Turbine started, it will accelerate from cold start to full load without warm up time.
5) Almost any hydrocarbon fuel from high octane gasoline to heavy diesel oils can be used in the combustion chamber.

(2) Closed cycle GTPP :- (principle of working of closed cycle GTPP) :-



→ The working fluid may be air & any other suitable gas coming out from compressor with high pressure & is heated in a heater by an external source at constant pressure.

→ The high temp & high pr air coming out from the CC are passed through gas Turbine where it expands doing the mechanical work.

→ The fluid coming out from the Turbines is cooled to its original temperature in the cooler using an external cooling source before passing to the compressor.

→ The working fluid is continuously used in system without its change in phase & the required heat is given to working fluid in the heat exchanger.

⇒ Atmospheric Air is drawn in to the compressor & compressed to high pr.

→ The Compressed Air is supplied to the CC where heat is added to the air by burning the fuel & raising its temperature.

→ The hot gas coming out from the CC is then passed to Turbine where it expands during mechanical work.

→ part of power developed by the T is used to drive the Compressor & other auxiliary equipment & the remaining is used for power generation.

→ The gas coming out of the Turbine is exhausted into the atmosphere. This cycle is known as open cycle GTPP

→ If the gas coming out from the Turbine is cooled to its original temp in a cooler, then it is recirculated to the compressor for doing work such a cycle is known as closed cycle PP.

Advantages:-

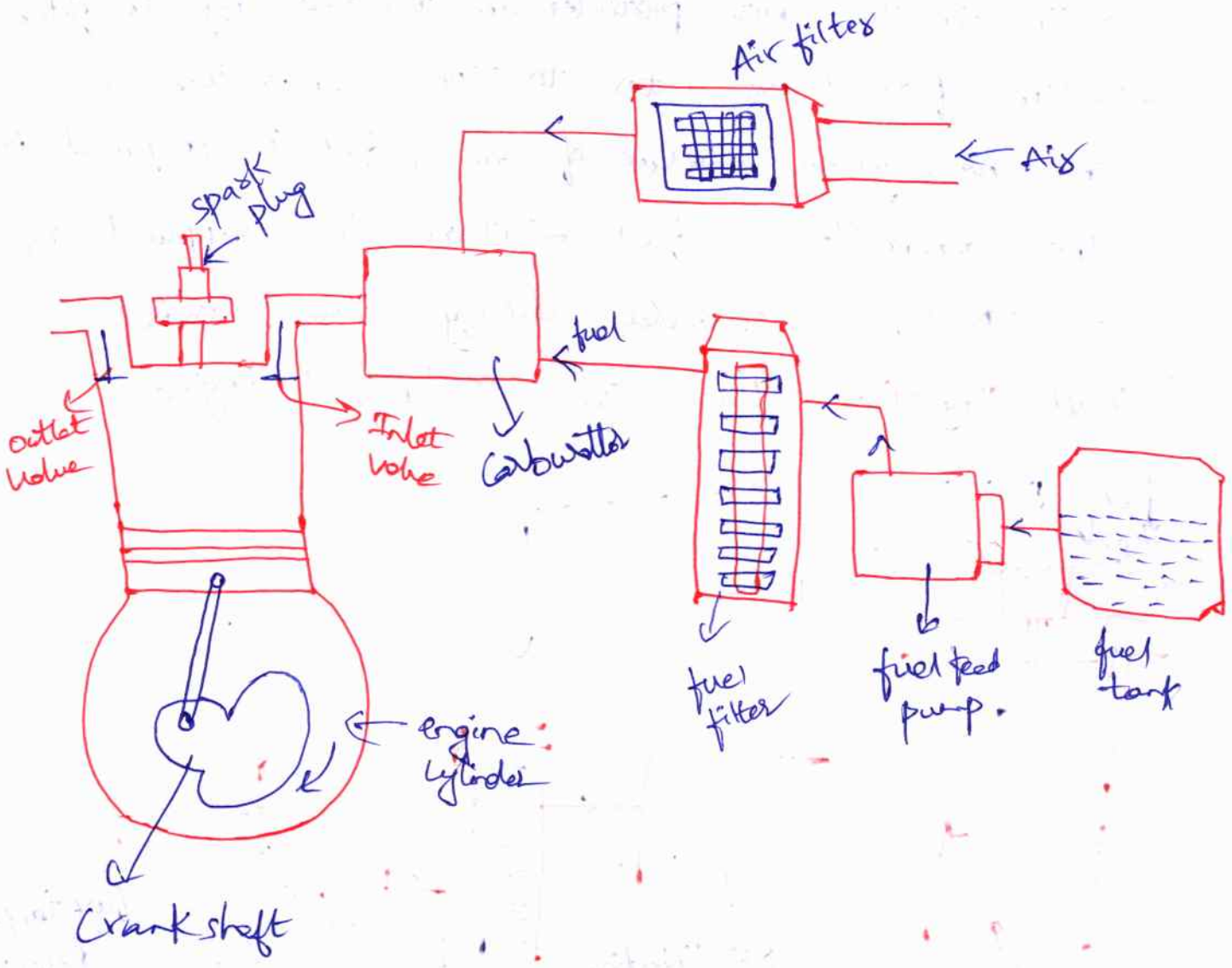
1) NO contamination
2) Higher Thermal efficiency
3) Improved load part efficiency
4) No loss of working medium
5) expensive fuel
6) Reduced size
7) Improved heat transmission
8) less fluid friction
9) Greater output

disadvantages

1) Complicated in design.
2) The high initial cost of plant
3) It requires a high quality of cooling water
4) poor response to a load variations.
5) It requires a very big heat exchanger.

Fuel Supply System :-

Fuel Injection System in SI (petrol) engine :-



Main components of fuel Injection system :-

1) Fuel tank 2) Fuel feed pump 3) Fuel filter.
4) Air filter 5) Carburettor 6) Spark plug

working process :-

→ In this fuel from fuel tank enters the fuel feed pump.

In fuel feed pump the pressure of fuel is increased.

→ Then the fuel is enters in to the fuel filter where all the dust particles are removed.

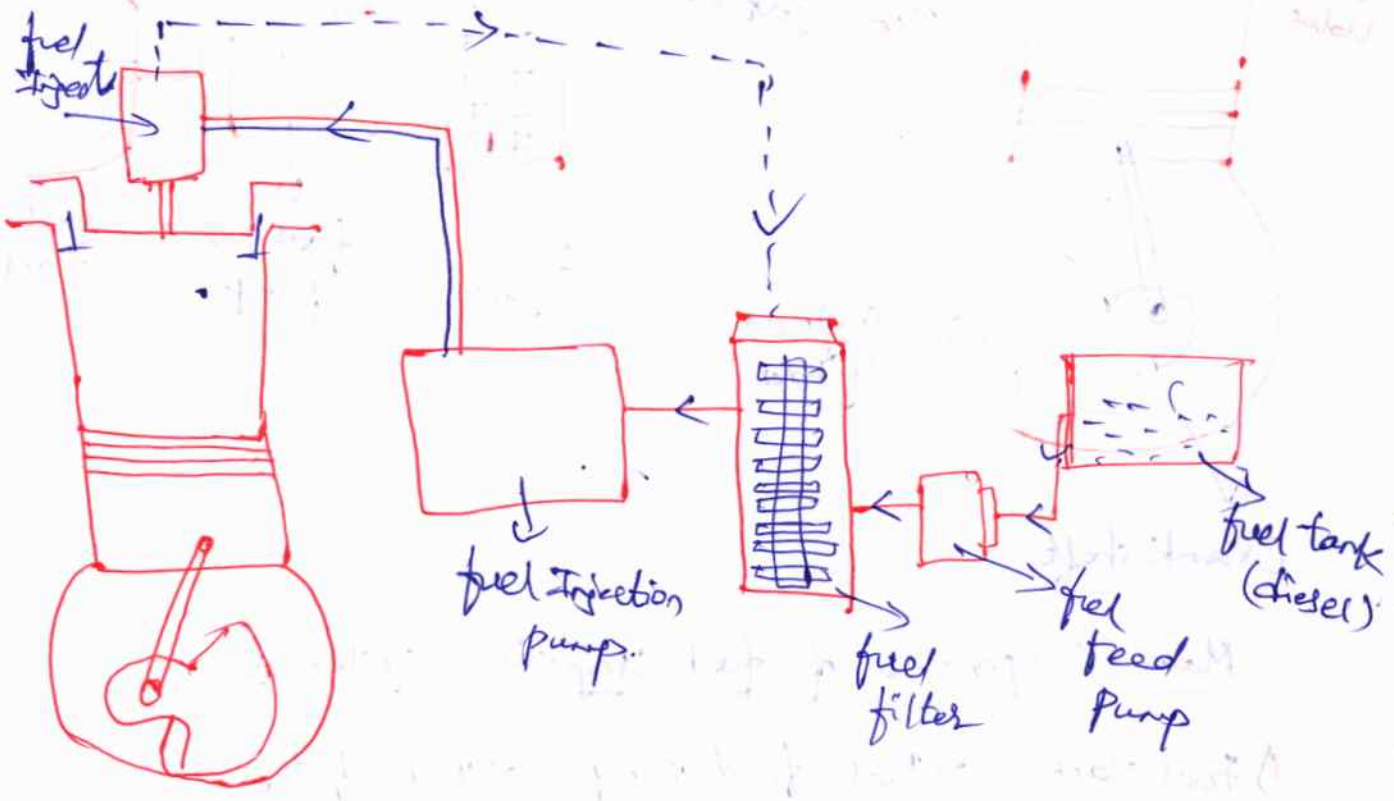
→ from the filter the fuel enters into the carburetter.

→ In air the dust particles are removed by air filter.

→ The filtered air enters to the Carburettor.

The homogenous mixture of air & fuel is prepared in the Carburettor & fuel mixture is supplied in to the engine cylinder during suction stroke.

Fuel Injection system in CI (diesel) Engine:-



main components of solid Injection system

1) Fuel tank 2) Fuel feed pump 3) Fuel filter

4) Fuel Injector pump 5) Injector

working process :-

In this the fuel from the fuel tank enters the fuel feed pump.

In fuel feed pump the pressure of the fuel is partially increased.

Then the fuel is enters in to the fuel filter where all the dust particles are removed.

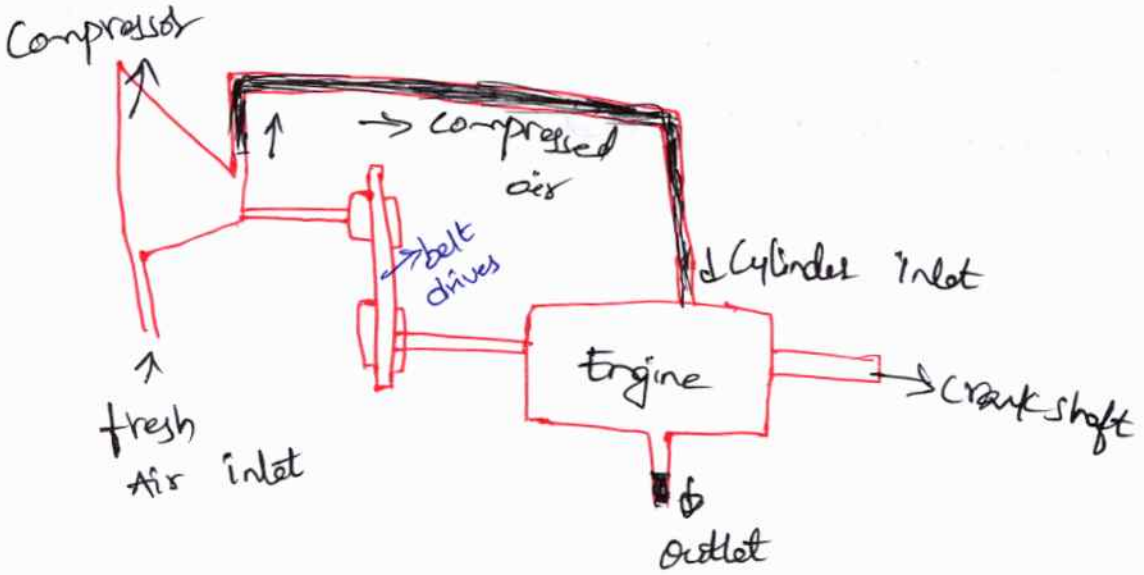
→ From the filter the fuel enters in to the injection pump where pressure of fuel is increased above the pressure of air in the cylinder at the end of compression.

→ At high pressure fuel is sprayed in to the engine cylinder by means of fuel Injector.

→ Any spill over fuel in the Injector is returned to the fuel filter.

→ The fuel is injected by injector at the end of the compression stroke in 4 stroke diesel engine.

Supercharging of IC engine :-



A Supercharger is an air Compressor which increases the pressure of air supplied to an internal Combustion engine Cylinders.

This supply each suction stroke of the engine more oxygen, due to this it burn more fuel & do more work, they increasing the power output.

working :-

Super charges are basically Compressors which takes air from atmosphere & Compresses it & pushes it into engine.

→ The compressor is drive from engine power.

→ The addition of extra amount of air fuel mixture in to the Cylinder increases the mean effective pressure of the engine.

→ An increment in MEP makes the engine produce more power.

Advantages :-

1) better Air/fuel mixture
2) higher power output
3) Smooth & complete combustion
4) less exhaust smokes
5) mechanical η is improved.

disadvantage

1) Increased heat loss due to increased turbulence.
2) cooling requirement of engine is high
3) Increased thermal stresses

Comparision b/w open cycle and closed cycle gas Turbines :—

Particulars	open cycle gas Turbine	closed cycle gas Turbine
1) Operation cycle	1) The same working fluid is not recirculated again & again. The fresh charge is supplied to each cycle & after combustion & expansion it is discharge to the atmosphere	1) The working fluid is recirculated again & again.
2) working fluid	2) Air fluid mixture	2) The working fluid air (or) any other suitable gas as argon, helium, CO_2 mixture etc Can be used which more favourable properties than air.
3) Manner of hT	3) Fuel is directly mixed with Air, direct heat supply & heat is generated in CC itself.	3) Fuel is not mixed with working medium & heat produced by fuel is transfer to working fluid through HE.
4) Type of fuel	4) It requires high quality of oil (or) gaseous fuel combustion occurs intensly.	4) Any type of fuel Can be used because heat is transfer externally.
5) efficiency	5) lower Thermal η	5) higher Thermal η.

Advantages of GTPP :-

1) They are small in size, weigh less & have low initial cost per unit output.
2) They are easy to install within short periods.
3) They are quick-starting & smooth running.
4) Water consumption is less compared to SPP.
5) They offer flexibility by supplying electricity for power generation as well as by supplying compressed air for process needs.
6) They are capable of using a range of liquid & gaseous fuels including synthetic fuels.

Disadvantages of GTPP :-

1) An electric motor or an IC engine is necessary for starting the plant. The starting motor must bring the compressor well towards the operating speed.
2) GT plants have less vibrations.

Combined power cycles :-

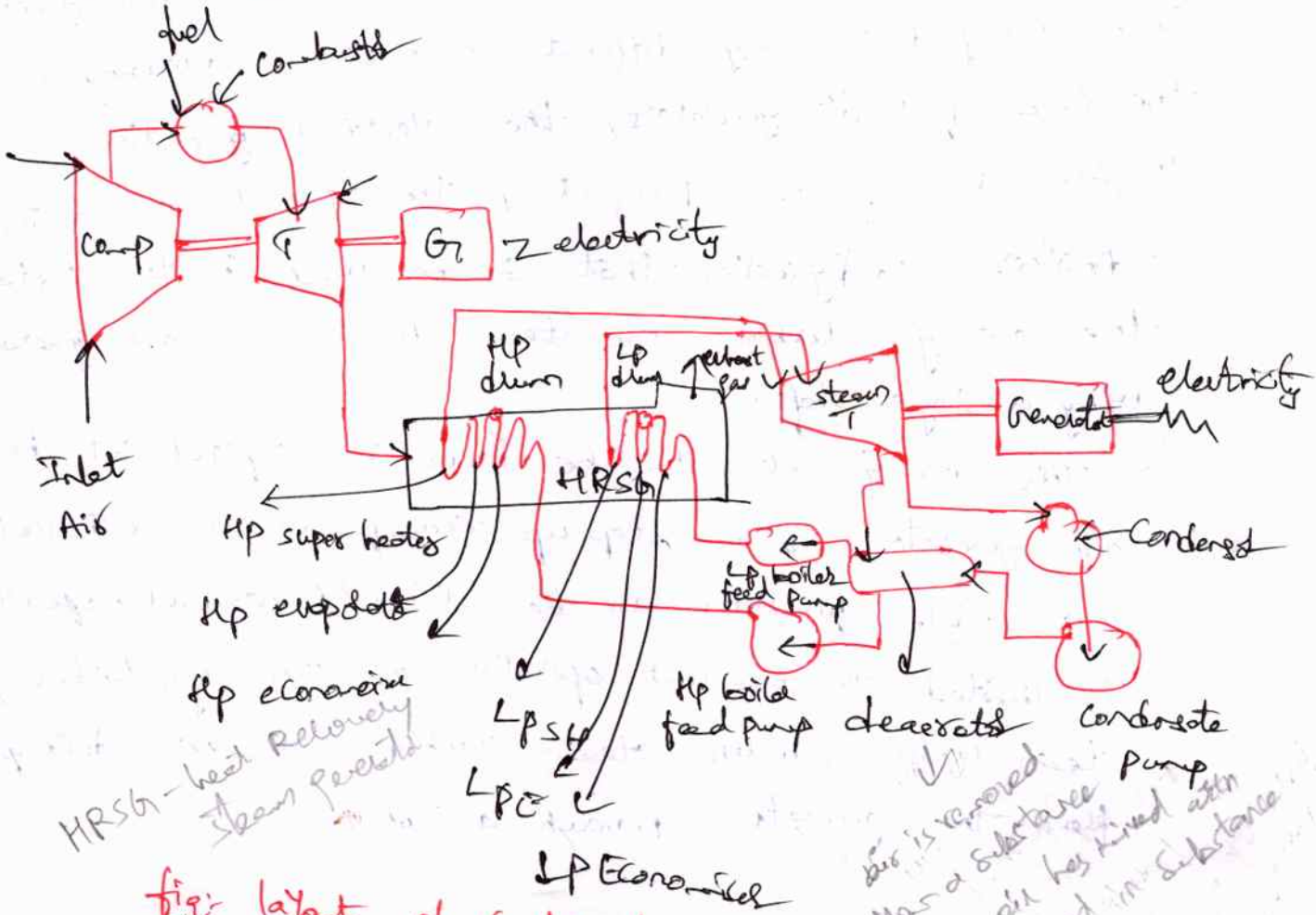


fig: layout of combined power cycle

These are generally arranged with one of more gas Turbines with each Turbine driving a dedicated electrical generator.

→ The exhaust gas from the gas Turbine is directed through an HRSG that generates steam at one of more pressure levels.

→ The steam is fed to a steam Turbine that drives a dedicated electrical generator.

→ With this arrangement, the gas Turbine can be decoupled from the operation of steam Turbine allowing for steam Turbine shutdown with continued gas Turbine operation.

→ Gas Turbine - generators, HRSGs & steam Turbine - generators can be arranged in many different combinations depending on the size of a GT generators, the electrical generation requirements of the project & the project economics.

→ Another configuration that can be used is to install the one gas turbine, one steam turbine & one generator using a single shaft.

→ This arrangement can be lower in capital cost because one generator & one step up transformer is eliminated & a single foundation can be utilized. However, operation is limited to concurrent operation of the gas turbine & steam Turbine, unless steam Turbine can be decoupled from the generator through a clutch.

UNIT-IV

Hydro power plant :-

It is an electricity-producing plant in which water is an essential fuel, the PE is being converted into KE & KE is further converted into ME & in to EE with the help of a turbine & motor.

Construction of HPP :-

1) Reservoir or Head pond :-

There is one reservoir which is having a large area in which a huge amount of water is being stored here.
So the energy here is in the form of PE.

2) Control gate :-

There are having multiple control gates in a single hydro power plant.
The work of control gate is to regulate the flow of water.
When the control gate is fully opened the speed of water flowing is maximum.

3) Pen stock :-

The penstock is also called pipe.
The water stored at the dam or head pond is being released by the control gate, the water starts moving to the turbine.
The head pond is having high heights & the turbines is situated below.
So the speed of water gets increased because of the gravitational force.
The material of penstock is hardsteel being used.

4) Valve & Nozzle :-

The valve work is similar to the control gate & Nozzle work is striking water in a specific direction. (Pr is high) that is a turbine blade.

5) Surge tank :-

It is an additional & essential component which is used to accumulate the water which is in pipe when we want to close the turbine working of it is used for avoiding the pipe burst.

6) Turbine :-

It is a device used for generation of electricity.

Turbine work is the fluid having KE is being converted into rotational energy.

The high KE water comes through the penstock to the Nozzle & strikes the turbine blades.

The turbine blades start rotating, so the rotational energy can also be called mechanical energy.

7) Draft tube :-

It is a mechanical component which is used for enlarging the area of pipe for sending maximum fluid to the other side.

8) Tail Race :-

It carries water away from the plant. hence water is sent to the river.

9) Transmission line :-

The Transmission line carries power from the power unit of transformers & transfers or supplies from one source to the another. It is made up of conductor.

10) Generator :-

when the turbine buckets starts rotating, the turbine shafts also rotating, the rotors are attached to the turbine shafts which is also rotating & generator is attached to them which generates electricity.

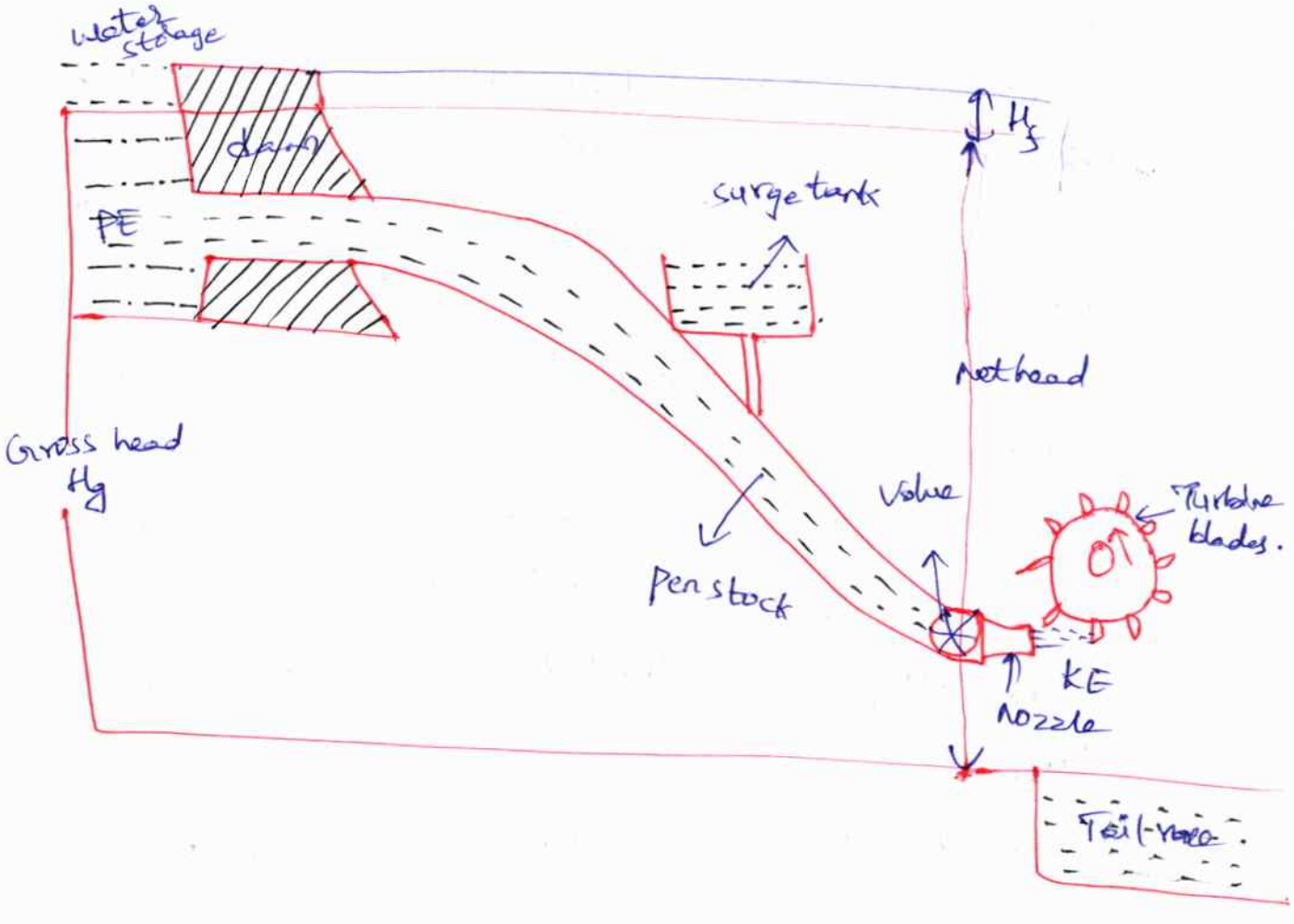
11) Transformer :-

The Transformer is attached to the generator. The electricity generated is now controlled by the transformer. The work of transformer is to set up or set down the voltage.

12) power house :-

It means there is a house in which power is being stored & released to the transformers so on.

working :-



In a large amount of water is available. The water is being stored in the reservoir which is in the form of PE.

→ with the use of control gate, the water is being released & water starts flowing into the penstock.

→ here two components are attached.

1) surge tank 2) Valve & Nozzle.

→ Initially the Valve is closed. but when the water reaches up to the max level that can create high pressure in to the Valves.

→ The water with high pressure starts flowing & strikes to the turbine blades Through the nozzle.

→ The Turbine blades start rotating. so till now, we observed the water which is having PE is now converting into KE.

→ In the turbine blade, an electric motor is attached to the turbine shafts.

So rotation of turbine blades also rotates the turbine shafts, which also rotates the electric motor.

hence KE into ME & then further it is converted into EE.

→ The energy generated is sent to the power house, transformer & transmission line.

→ The water which is rotating the turbine blades is now sent to the river via a tail race.

→ The HPP is constructed to store the water in a large amount.

→ when the water reaches up to max level then it is

being released which also causes the flood in some area.

→ HPP site selection :-

The factor which includes for selection of HPP are :-

1) environmental effect — hazards & chemical effects.
2) water availability — It is needed for rotating turbine blades & generating electricity.
3) water storage — store water in a dam.
4) Head of water — to increase flow of water from dam to turbine blades.
5) site Accessibility — It should have transportation facility be road or train
6) distance from load center — If there is more distance b/w PP to load center then transmission Cable is used more & hence cost will be increased.
7) Types of land of site — needs more space, land cost may be cheap.
8) water pollution — plants should be free from water pollution, then causes of loss of equipment is much.
9) Gelogical Investigation — It can withstand natural Calamities like thunderstorms & earthquake etc

Advantages :-

1) supply of electric power is maintained consistently.
2) The water can be stored & used when the demand is high.
3) The Hydro electric power generation is renewable & eco friendly.

Disadvantages :-

1) The construction of dams are very expensive since it is in a large scale & has to be well protected.

2) At time of building a hydroelectric p dams, the habitants in & around the area are moved out of their houses & the business. This creates a disturbance.

3) dams create a kind of disturbance with neighbouring states & countries which connects the rivers.

since dams are created by blocking the rivers which creates an irregular supply of H_2O.

Applications

→ It also helps in flood Risk management.

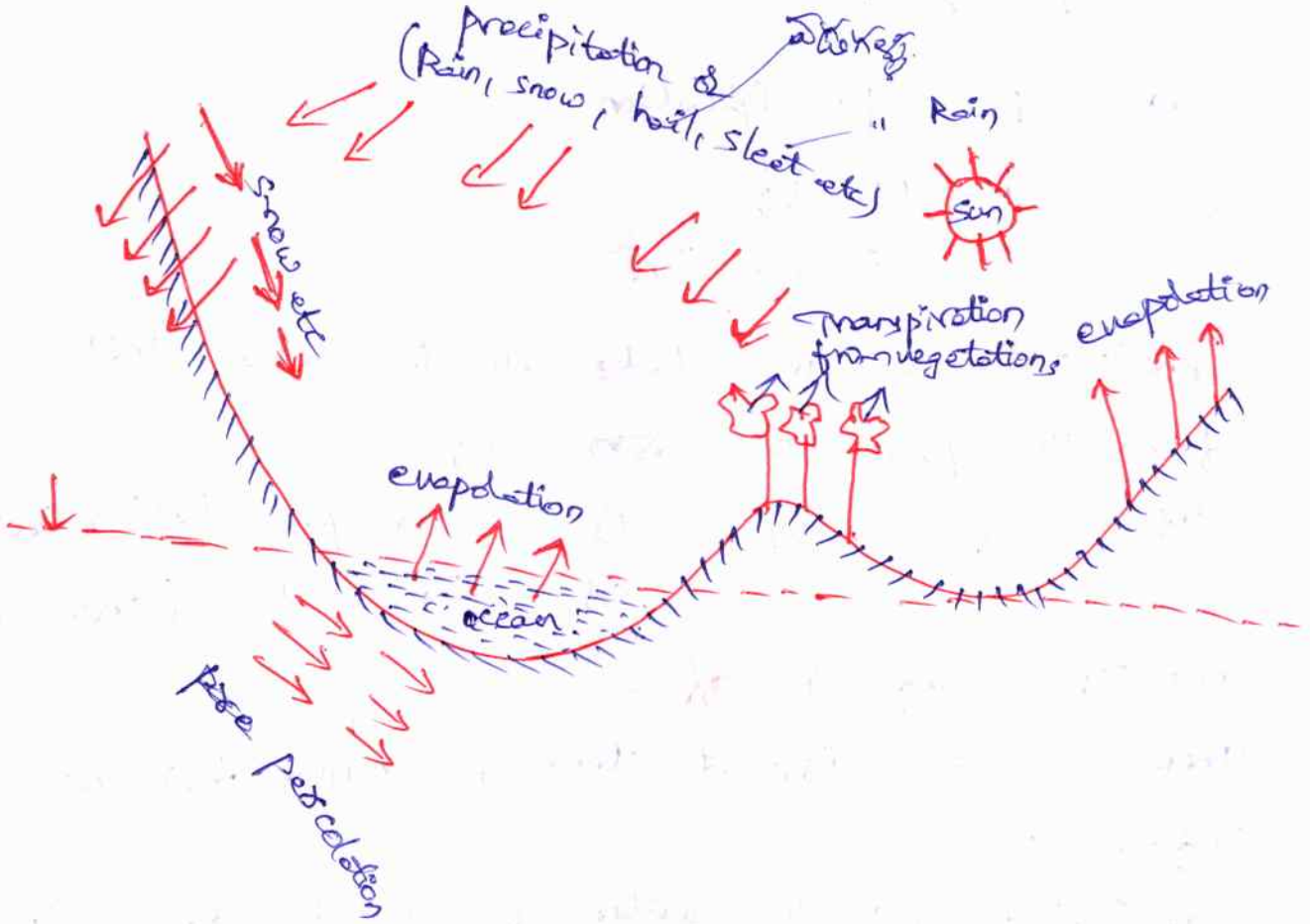
→ The H_2O from dam is used for Agricultural Irrigation facility.

→ They helps in creating Recreational facilities.

Hydrology :-

It may be defined as the science which deals with the depletion & replenishment of water resources.
It deals with surface water as well as the ground water.
It is also concerned with the transportation of water from one place to another, & from one form to another.
It helps us in determining the occurrence & availability of water.

Hydrologic Cycle :-



most of the earth's water sources such as rivers, lakes, oceans & underground sources etc get their supplies from rains, while rain water itself is the evapolation from these sources.

water is the lost to the atmosphere as vapour from earth, which is then precipitated back in the form of rain, snow, hail, dew, sleet or frost etc.

→ This evapotation & precipitation continues for ever & thole by a balance is maintained b/w the two.

This process is known as hydrologic cycle.

It can be represented graphically as shown in fig.

→ hydrologic eq is expressed as follows :-

$$P = R + E$$

where P = precipitation

R = Run off

E = Evapotation.

precipitation :- It includes all the water that falls from atmosphere to earth surface.

It is of 2 types. 1) Liquid precipitation (rain fall)

2) solid " (snow, hail)

Run off & surface run off :-

There are two different terms & should not be confused.

It includes all the water flowing in stream channel at any given section.

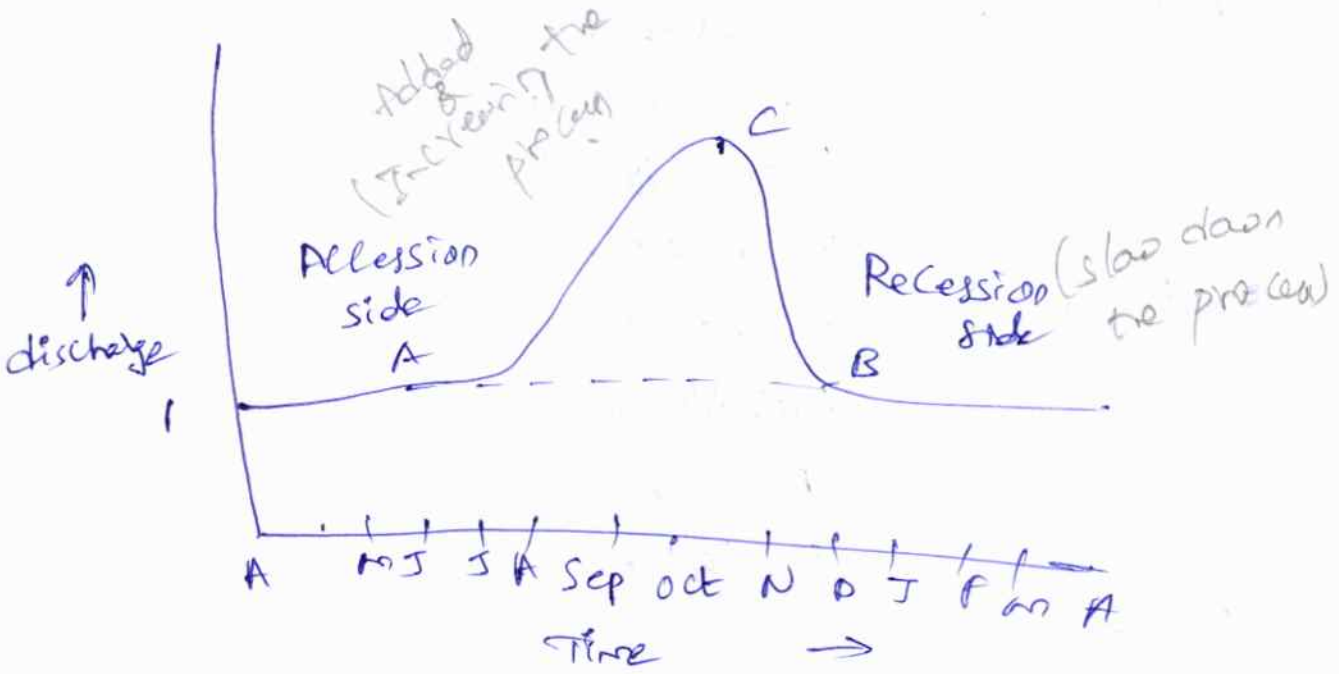
→ while surface run off includes only the water that reaches the stream channel without first percolating down to the water table.

Run off can also be named as discharge & stream flow. Rainfall duration, its intensity & areal distribution influence the rate & volume of run off.

evapotation → transfer of H_2O from liquid to vapour state is called E.

Transpiration → the process by which H_2O is released to the atmosphere by plants is called Tran

Hydrograph :-



It is defined as a graph showing discharge of flowing H_2O w.r. to time for a specified time.

→ discharge graphs are known as flood & run off graphs.

→ Time period for discharge are hour, day, week & month.

Hydrograph of stream of river will depend on the characteristics of the catchment & precipitation over the catchment.

It will access the flood flow of rivers hence it is

essential that anticipated hydrograph could be drawn for river for a given storm.

It indicates the power available from the stream at different times of day, week & Year.

classification of dams & spill ways:-

Dams can be classified based on their purpose, structure & size.

1) purpose → Irrigation dams
hydroelectric power dams
flood control dams
water storage "

2) structure → concrete dams
earthfill "
Arch "
gravity "

3) size — small
medium
large

→ Spillways can also be classified based on their structure:-

overflow spillways
siphon "
morning Glory "
bell mouth "
Chute "
Tunnel "

Drainage Area Characteristics :-

It is generally used to study the hydrographs, flow duration curve, mass curve for estimation of storage capacity of a reservoir.

→ There are three types of streams based on nature of flow.

1) steady flow rivers
2) flashy " "
3) perennial flow.

1) steady flow rivers :-

If the variation of discharge is less for a considerable time such streams are termed as steady streams.

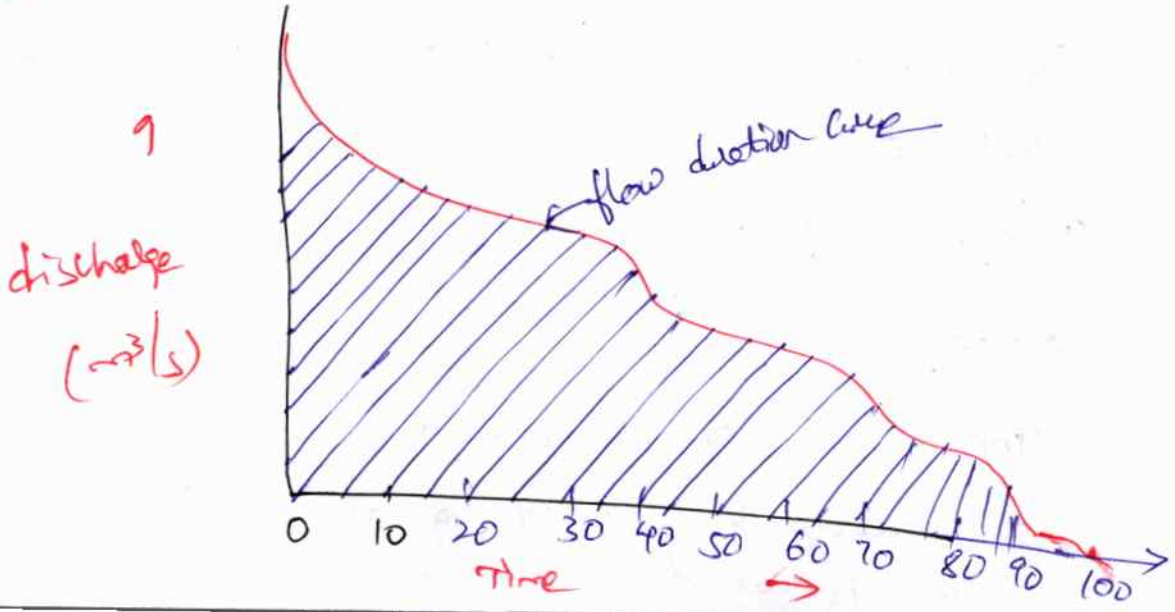
2) Flashy Flow :-

In certain areas where soil surfaces are impervious (solid), irregular distribution & slope.

3) Perennial streams :-

The streams in the geographical areas of monsoon lands generally river flow levels are low in summer & high during monsoon time. such streams are called as perennial stream. (June to sep)

1) Flow duration curve :-



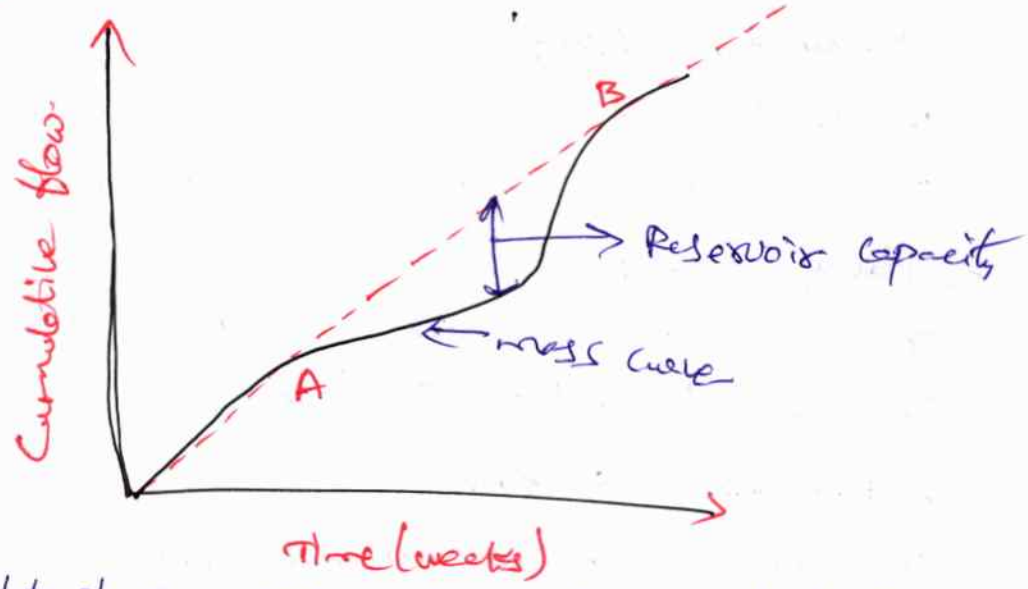
It is a polt of discharge versus percentage of time for which the discharge is available.

It is obtained from hydrograph data

The flow of discharge can be expressed as cubic meters per second, per week of unit of time.

The flow duration curve is also known as power duration curve.

Mass curve :-



It is a plot of cumulative volume of water that can be stored from a stream flow versus time in days, weeks or months.

It shows a mass curve, maximum intercept between line AB & mass curve is known as reservoir capacity.

Slope of mass curve at a point gives the rate of inflow at that instant.

Storage & pondage :-

Storage :-

The collection of water in a reservoir upstream of the plant & increasing the capacity of stream for a long period of time is called a storage.

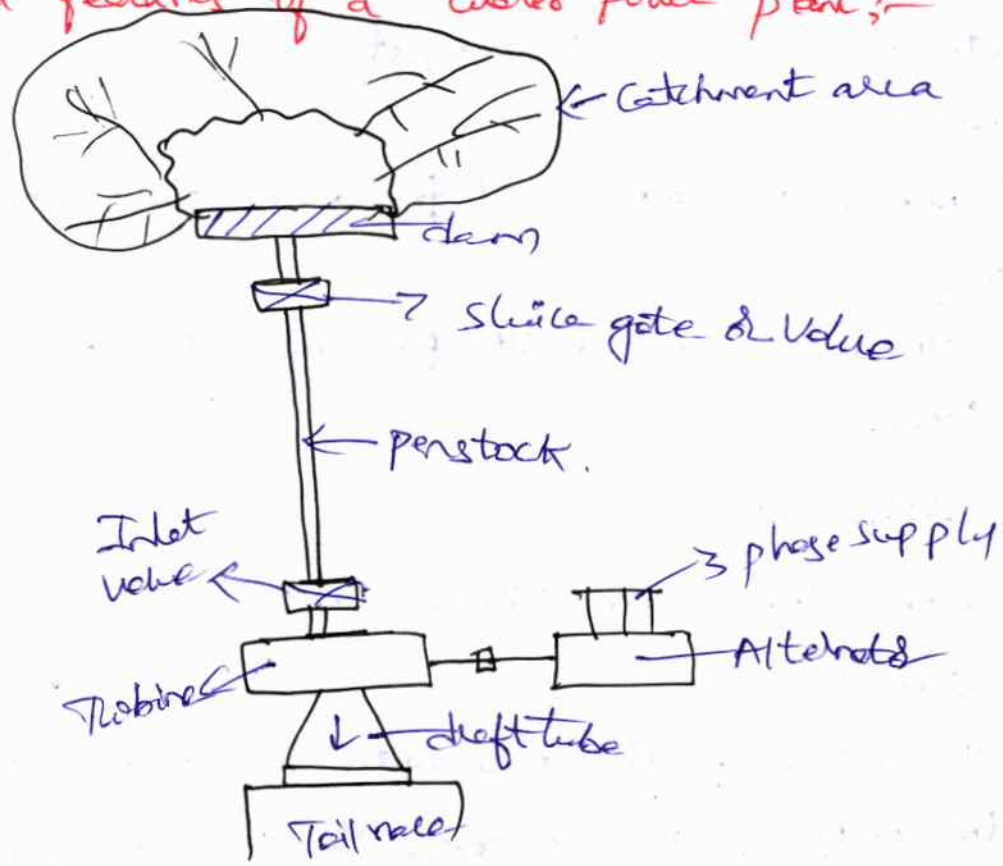
storage plants work as base load stations.
base load plants are of high capacity & takes the load on the base portion of the load curved.
peak load plants are designed for taking care of peak loads.

pondage:-

For a short period of time the pondage increases the stream capacity behind a dam near the plant.
Pond permits to store water during off peak hours & this could be used during peak hours of the same day.

→ If there is a considerable distance b/w plant & the reservoir, pond is needed at the plant to regulate the flow.

Essential features of a water power plant:-



1) Catchment Area :- The Catchment Area of a hydro plant is the whole area behind the dam, draining in to a stream & river across which the dam has been built at a suitable place.

2) Reservoir :- whole of the available from the catchment area is collected in a reservoir behind the dam.
The purpose of storing of H_2O in the reservoir is to get a uniform power output throughout the year.
It can be either natural or artificial.
It is a lake in high mountains & an artificial reservoir is made by constructing a dam across the river.

3) dam :- It is built across a river for two functions :
to impound the river water for storage & to create the head of H_2O.
dams may be classified according to their structural materials such as Timber, steel, earth, rock filled and masonry.
Timber & steel are used for dams of height 6m to 12m only.
earth dams are built for larger heights upto about 100m.

4) Spill ways :-
when the water enters the reservoir basin level of water rises.
To relieve of this excess water a structure is provided in the body of dam & near the dam or on the periphery of the dam.

The safeguarding structure is called spill ways.

5) Conduits :-

A headrace is a channel which leads water to a turbine & a tailrace is a channel which conducts water from the wheels.

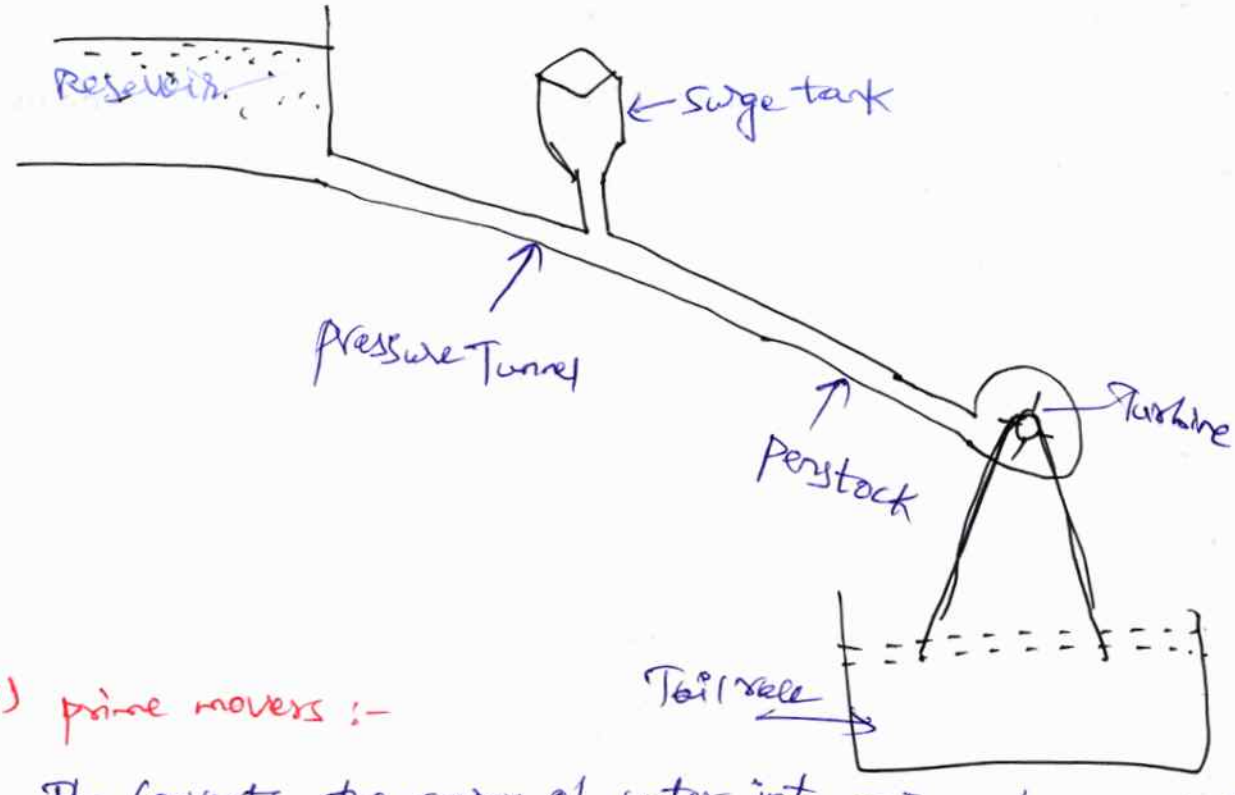
It may be open & close.

open conduit – canals & flumes

closed " – Tunnels, pipelines

6) Surge Tanks :-

It is a small reservoir & tank in which the water level rises & falls to reduce the pressure swings so that they are not transmitted in full to a closed circuit.



7) prime movers :-

It converts the energy of water into ME & further into EE.

They are classified into impulse & reaction turbine.

8) draft tube :- It serves two purposes.

It allows the turbine to be set above tail water level without loss of head.

It regains by diffuser action, the majority of KE delivered to it from the runner.

9) power house :-

It is a building in which the turbines, alternators & the auxiliary plant are housed.

classification of dams :-

1) masonry dams
   i) gravity dams
   ii) buttress "
   iii) Arch "
2) Fill dams
   i) earth fill dams
   ii) Rock fill "

→ dam is a concrete or stone masonry barrier to raise water for storage & also hydraulic head.

The dam must fulfil two fundamental functions.

1) It develops a reservoir which has a capacity to store water.
2) " builds up head & thus potential for the river i.e water head.

→ different types of dams 1) masonry dams
2) fill "
3) Timber "

Masonry dams :-

This dam is constructed using masonry concrete.

It is bulky & massive than other types.

Sand rock foundation is required.

The height of dam is limited by the strength of the base

The design is simple but it consumes heavy materials.

The dams are more economical at small river valleys.

These dams provide safe & economical spillway facilities.

Classification of dams :- Naturally / Artificial (1)

Dam is a concrete or stone masonry barrier to raise water for storage & also to create a hydraulic head.

→ dam must fulfil two fundamental functions

1) It develops a reservoir which has a capacity to store water.
2) It builds up head & thus potential of the river is water head.

→ different types of dams :- mud & sand / stone

1) masonry dams 2) Fill dams 3) Timber dams

→ masonry dams are classified into 3 categories.

1) solid gravity dam 2) buttress dam 3) Arch dams.

Masonry dams :-

a) solid gravity dam :- → Negative dam

It is constructed using masonry. Concrete.

It is bulky & massive than other types.

Sound rock foundation is required.

The height of dam is not limited by the strength of the base.

The design is simple but it consume heavy materials.

→ This type of dams are more economical at small river valleys.

These dams provide safe & economical spillway facilities.

b) Arch dams :- → ⌒ → corrugated plane

These are curved in plane. Hollow

Structure is curved upstream. retaining water

This type of dams are more economical & stronger than gravity dams.

This type of dams are only suitable for narrow valleys with steep slopes of solid rock to support the actuated thrust of the structure.

The water thrust is compression.

(c) Buttress dam :- They are also known as hollow gravity dams inclined upstream face so that the pressure of water create large downward force which provides stability of sliding & overturning.

The force of is transmitted to a row of buttress.

They are also safe against earthquakes.

Hence countries like Japan & Italy are going for these dams.

It requires 1/3rd of material required for solid gravity dam.

These dams are generally triangular in shape.

Fill Dams :-

1) Earth fill dams :- It is generally used for small capacity power plants.

Advantages :-

Cheaper than masonry dams.

Can be built at any locations.

It is suitable for relatively pervious foundation.
gets stronger with age.
Can be erected quickly.

Disadvantages

1) requires more maintenance.
2) Spill way is required
3) fails suddenly without any warning
4) subjected to erosion & flood damage
5) limited in height.

Fill dam :-

Rock fill dam :- [old villages]

These dams are eventually constructed in mountainous regions where rock is rather than earth is available.

=> It consists of → Timber (wood) dams :- This are gully blocks that are used both to slow the flow of H2O downstream & to create pods.
base rock fill

Spill ways :- They are found just beside one. It is used when dam is full, to pass floodwater safely & in a controlled way and a dam around it.

The part of the dam which discharges the flood flow to the downstream side is called as spillway.

It act as a safety valve to a dam.

They are provided on dams to avoid damage to dams.

They keep the reservoir level below the predetermined max level.

It must always be provided as a safe passage.

Types:

1) Overall spillways :-

This is the simplest, low in cost & suitable for concrete dams.

When dam reaches full reservoir level stream overflows from the top.

There may be gate control at the top of the dam.

→ used as gravity arch & buttress dam.

2) Chute spillways - upstream flow of H2O to down stream flow of H2O.

It is a channel made of reinforced concrete

The water is discharged into steep sloped open channel called chute.

Simple in design & suitable for all foundations.

3) Shaft spillways

In this, water drops through vertical shaft & passes through a conduit horizontally & sends the H2O water down stream.

When there is a very limited space for spillways this type is adopted.

4) Side channel

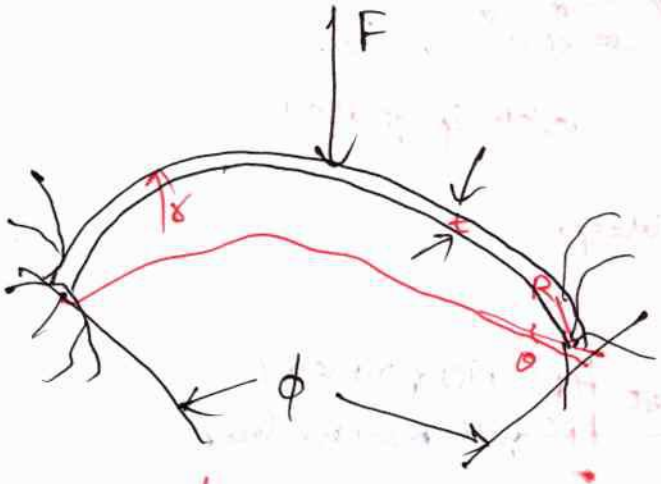
→ employed at narrow gorges

→ very less, this type is employed.

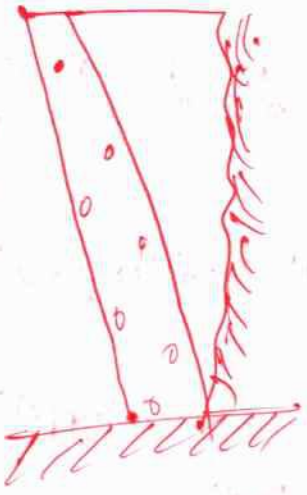
→ Siphon :- When all air is removed in siphon the space gets filled with H2O, siphon action acts & H2O starts flowing out

→ This will continue until reservoir level becomes down

Arch dams :-

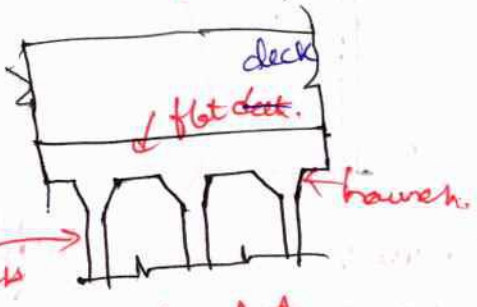


plan

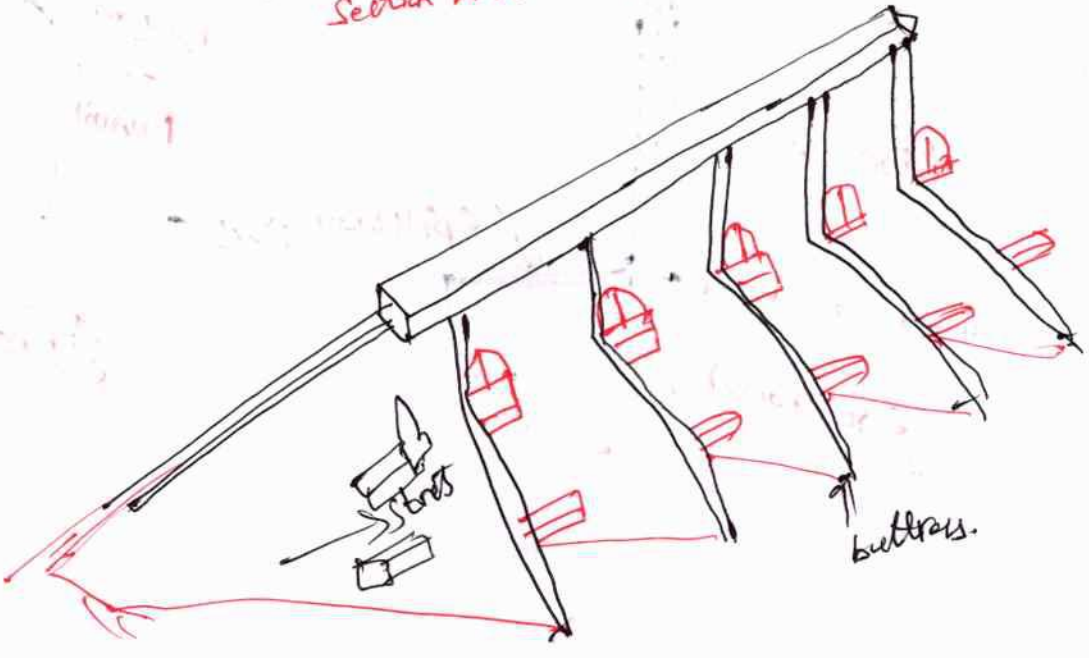


Section.

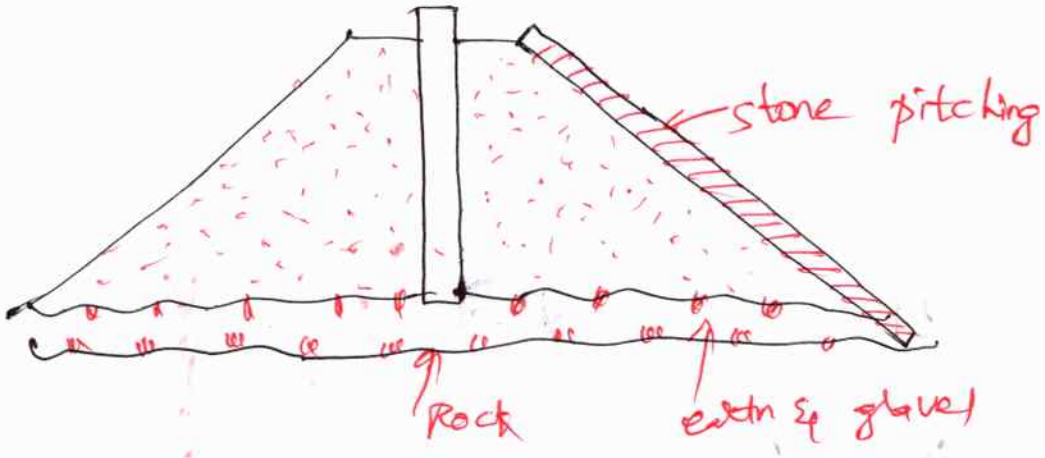
Buttress dam :-



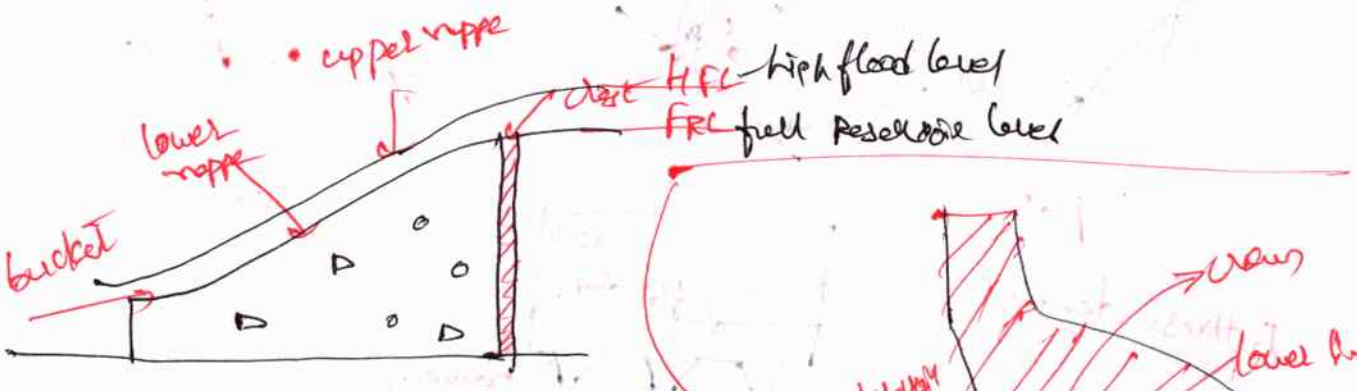
Section A-A



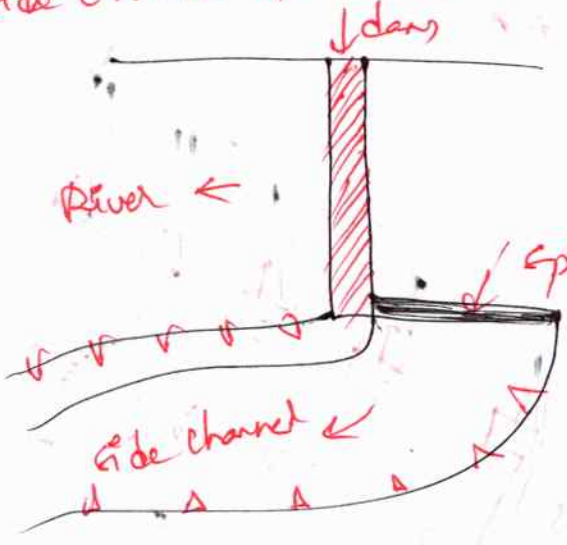
earth fill dam:-

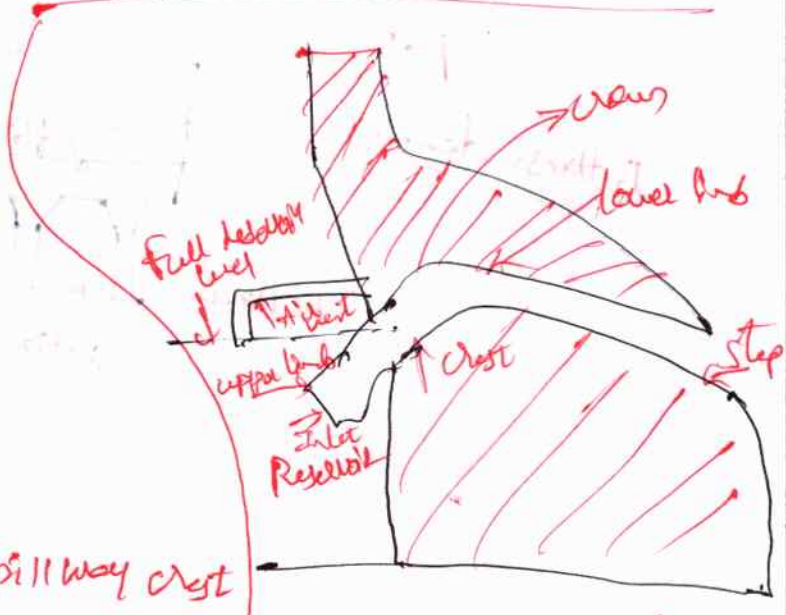


Overfall or Solid gravity spillway:-



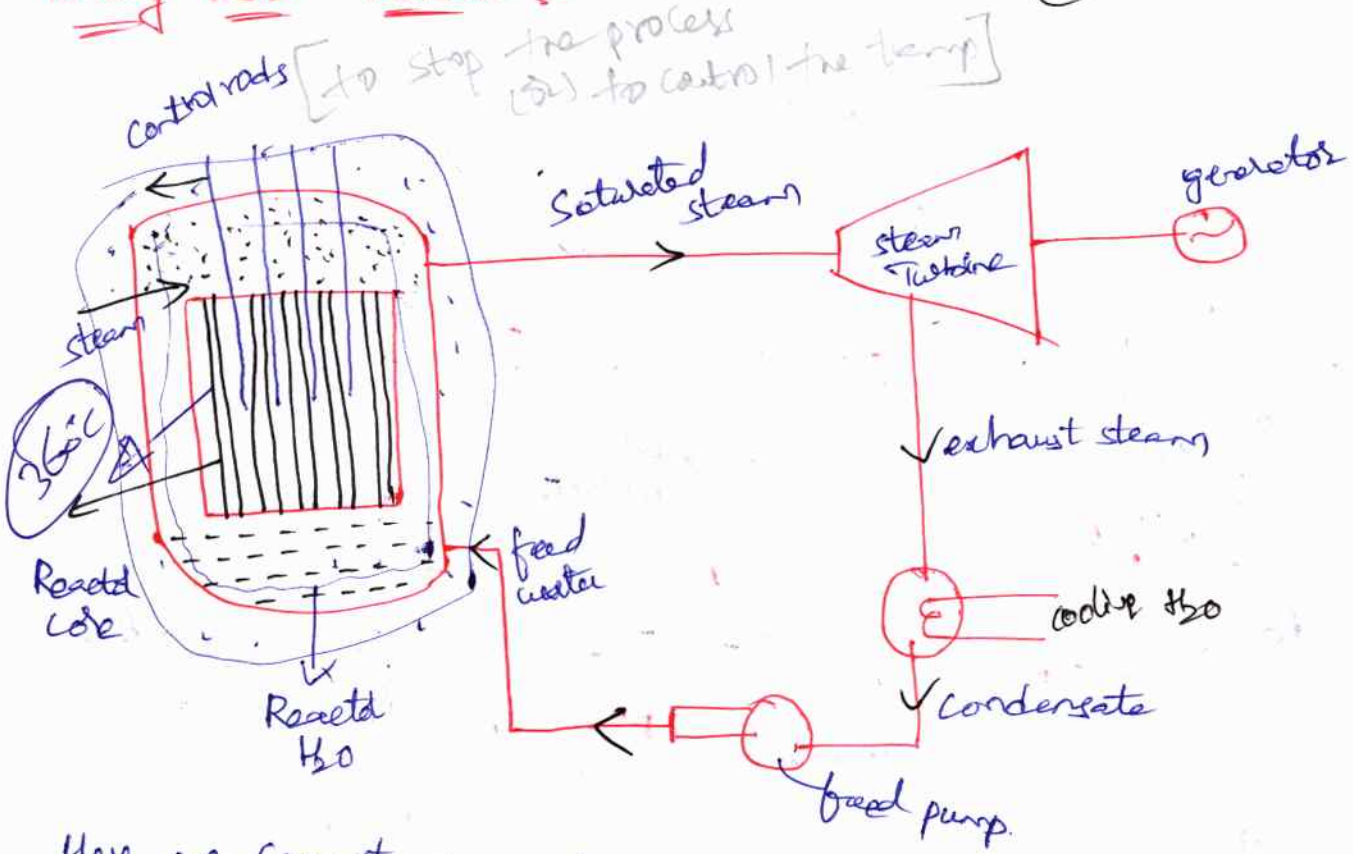
2) Side Channel spillway.





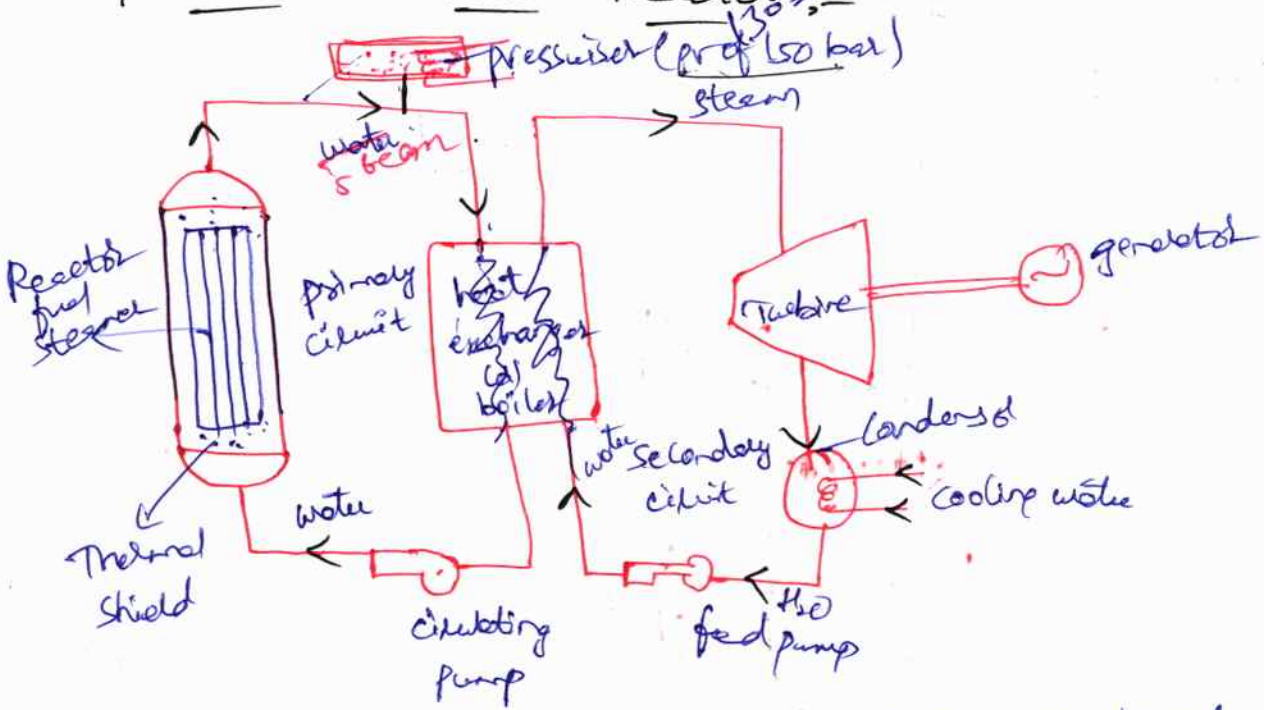
Siphon spillway

Boiling water reactor :-



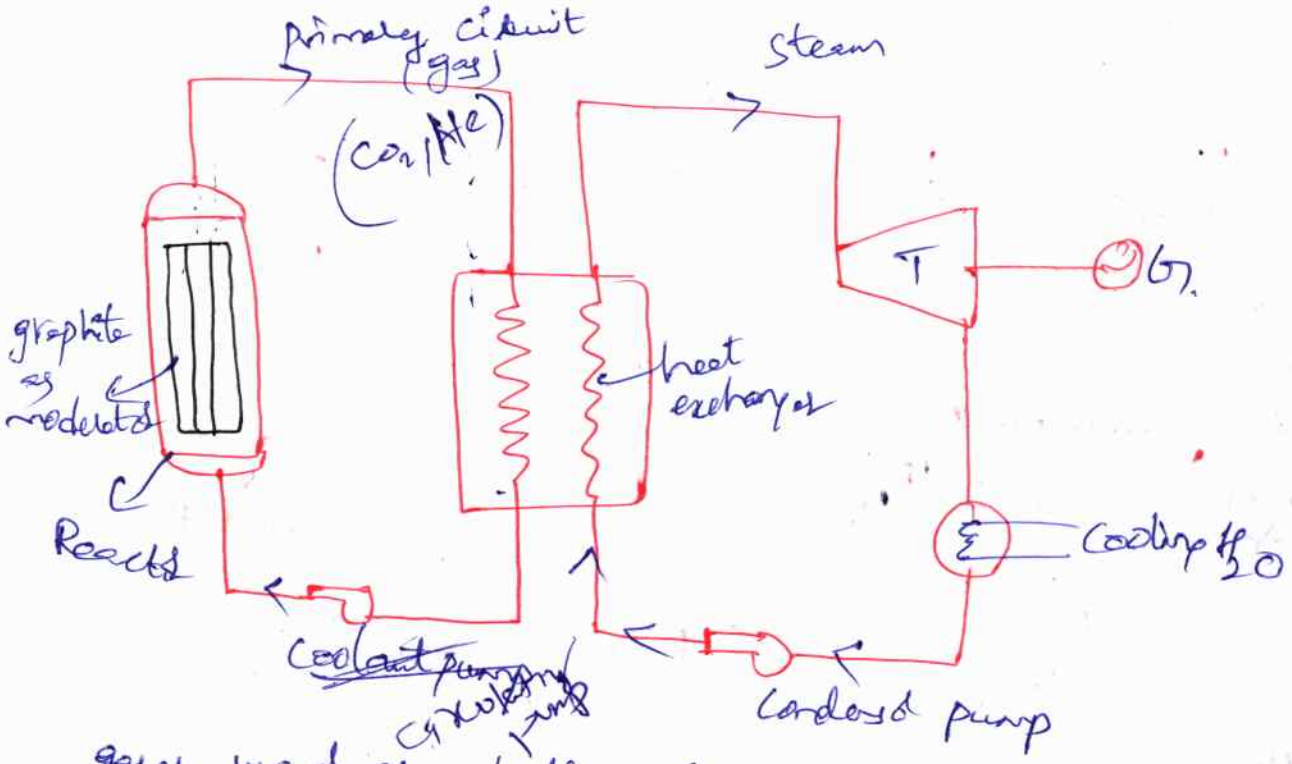
Here we cannot use steam generator.

Pressurized water Reactor :-



main parts :- pressure vessel, Reactor thermal shield, fuel elements, control rods, heat exchanger, Turbine, generator, condenser

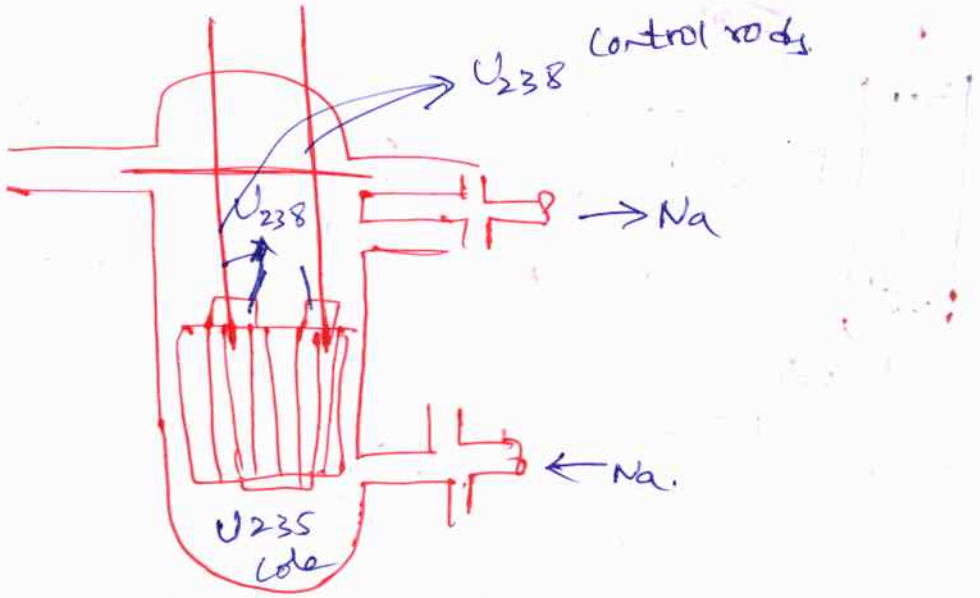
Gas cooled reactor :-



gases used as helium (or) CO_2, H_2, O_2

moderate - graphite

Fast Breeder Reactor :-



here power generation will generate maximum.

we cannot used for moderator (or) heat exchanger.

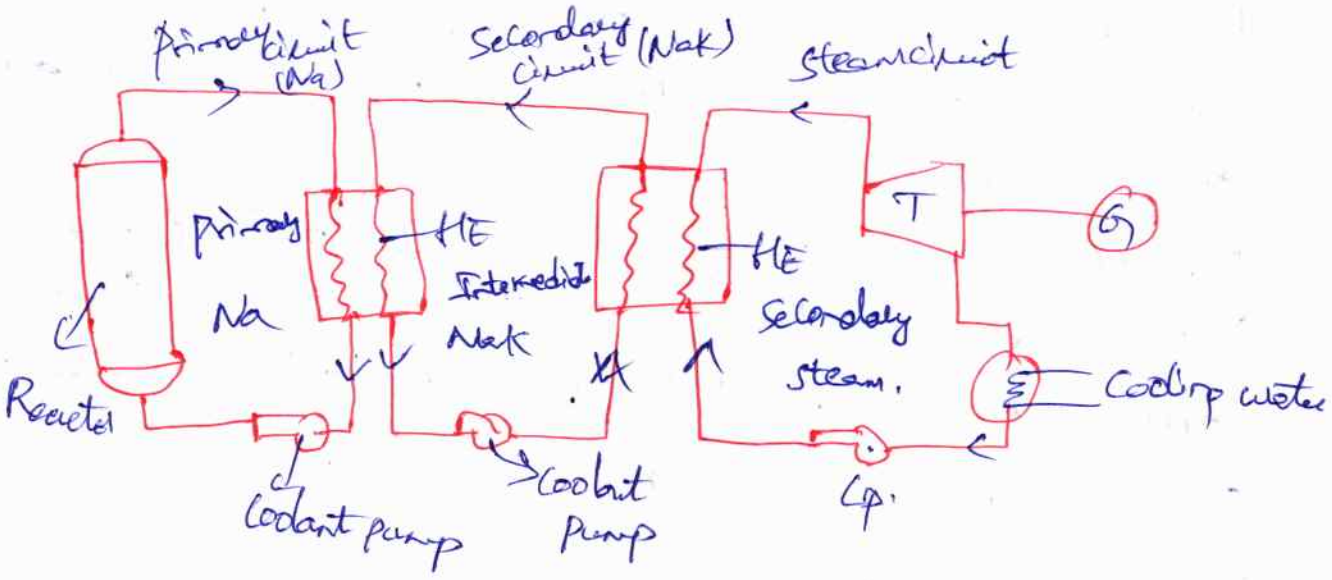
only used as reactor core once generated steam directly drives the steam Turbine.

→ here sodium (Na) will as used to generate heat of inlet material.

If you are using control rods then U235 will generate fission process & finally produce power minimum (or) otherwise if you are pull out control rods then power produce will be maximum because of max fission process.

here drawback is fuel consumption is very high.

liquid metal cooled Reactor :-



Waste disposal :-

It is common in every industry. wastes from atomic energy installations are radioactive, create radioactive hazard & require strong control to ensure the radio activity is not released into the atmosphere to avoid atmospheric pollution.

The wastes produced in a nuclear power plant may be in the form of liquid, gas & solid & each is treated in a different manner.

i) liquid waste – The disposal of liquid wastes is done into two ways.

i) Dilution :- The liquid wastes are diluted with large quantities of H_2O & then released into the ground. This method suffers from the drawback that there is a chance of contamination of underground water if the dilution factor is not adequate.

ii) Concentration to small volumes & storage :-

When the dilution of radioactive liquid wastes is not desirable due to amount & nature of isotopes, the liquid wastes are concentrated to small volumes & stored in under ground tanks.

The tanks should be of assured long term strength & leakage of liquid from the tanks should not take place otherwise leakage of contents, from the tanks may lead to significant underground water contamination.

iii) Gaseous waste :-

It can most easily result in atmospheric pollution. Gaseous wastes are generally diluted with air, passed through filter & then released to atmosphere through large stacks (Chimneys).

iv) Solid waste :-

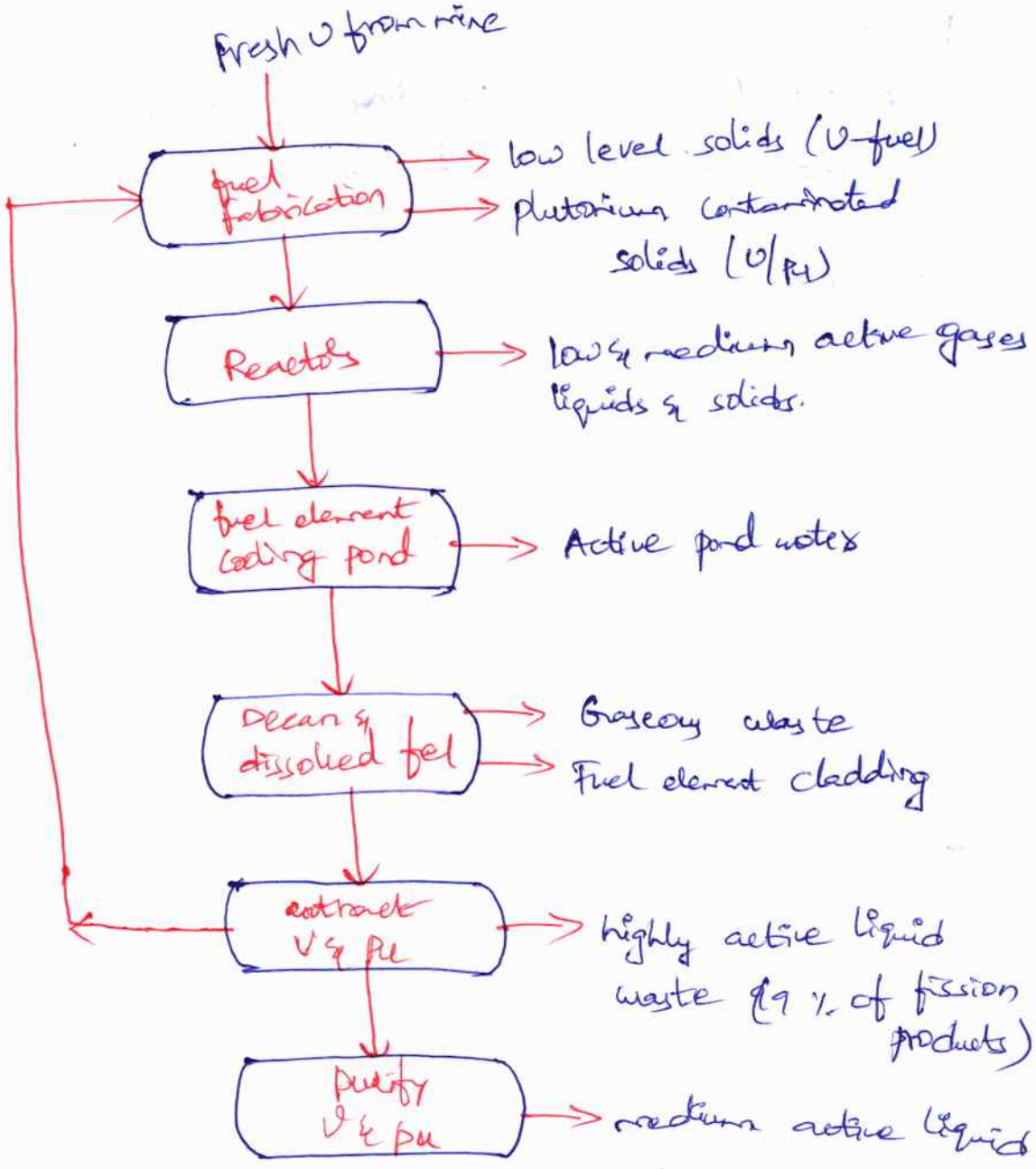
It consists of scrap material & discarded objects contaminated with radioactive matter.

These wastes if combustile are burnt & the radioactive matter

These wastes if concrete, are drummed & shipped for burial.

Non combustible solids wastes are always buried deep in the ground.

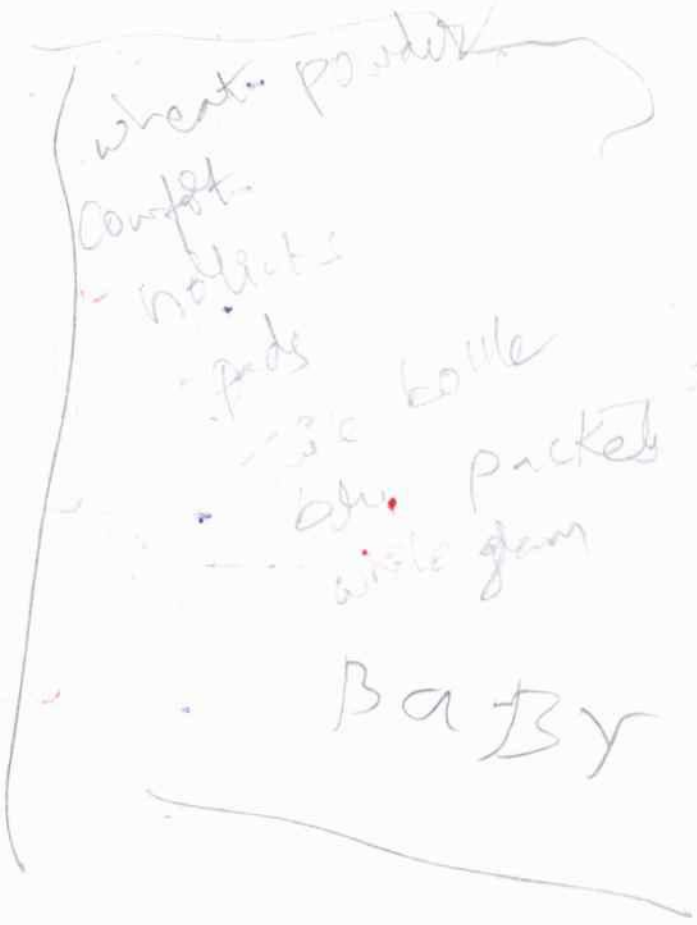
Types of Nuclear waste on different stages :-



The reactor is a source of intense radioactivity. These radiations are very harmful to human life.

It requires strong control to ensure that this radioactivity is not released into the atmosphere to avoid atmospheric pollution.

A thick concrete shielding & a pressure vessel are provided to prevent the escape of these radiations to atmosphere.



UNIT-IV

Hydro projects and plant classification:-

Hydro electric power plant

- Availability of Head
  - low head (<15m)
  - medium (15 to 70m)
  - high (>70m)
- Quantity of water available
  - Runoff river plant without pondage
  - Runoff river plant with pondage
  - storage type
  - pump storage
  - mini & micro hydro plant
- Nature of load
  - Base load plant
  - peak "

Hydro projects and plant :-

Classification of Hydraulic Turbines :-

The hydraulic turbines are classified accoding to the type of energy available at the inlet of the Turbine, direction of flow through the vanes, head at the inlet of the Turbine & specific speed of the Turbines.

Important classifications of the Turbines :-

1) According to the type of energy at inlet
   a) Impulse Turbine b) Reaction Turbine
2) According to the direction of flow through runner.
   a) Tangential flow Turbine b) Radial flow T
   c) Axial " " d) mixed " "
3) According to the head at the inlet of Turbine
   a) High head Turbine b) medium head Turbine
   c) low " "
4) According to the specific speed of the Turbine.
   a) Low specific speed Turbine b) medium specific speed Turbine
   c) High " "

Impulse Turbine :- If at the inlet of the Turbine, the energy available is only K.E. the Turbine is known as Impulse Turbine. (pelton wheel)

Reaction Turbine :- As the water flows over the vanes, the pressure is atmospheric from inlet to outlet of the Turbine. inlet of
If at the Turbine, the water possesses KE as well as PE, the Turbine is known as Reaction Turbine.
(Kolpan & Francis Turbine)

Tangential flow Turbine :-

If the water flows along the tangent of the runner, the Turbine is known as

Radial flow Turbine :-

If the water flows in the radial direction through the runner, the Turbine is known as

Inward Radial flow Turbine :-

If the water flows from outwards to inwards, radially the Turbine is known as

Outward Radial flow Turbine :-

water flows radially from inwards to outwards, the Turbine is known as

Axial flow Turbine :-

If the water flows through the runner along the direction parallel to the axis of rotation of the runner, the Turbine is known as

Mixed flow Turbine :-

If the water flows through the runner in the radial direction but leaves in direction // to axis of the rotation of the runner, the Turbine is called

⟹ Hydro plants are classified accdding to the head of water under which they work.

1) High head power plant :- when the operating head of water exceeds 70m, the plant is known as high head power plat

→ peltonn Turbine is used as prime mover in such pp.

2) Medium head plant :-

when the head of water ranges from 15 to 70 m then the power plant is known as medium head plant.

→ Francis Turbine.

3) Low head plant :-

when the head is less than 15m the plant is named as low head plant.

→ Francis or Kalpan Turbine.

HPP is classified based on :-

1) Availability of water flow
2) " " Head
3) Accdding to load type.

→ based on Availability of water flow :-

This is of 3 types. They are

1) Run off River power plant without pondage

In this type, the water availability plays a very important role.

here PP works only when there is enough water since there is no storage or pondage facility available.

The facility is placed where there is connectivity directly to the road & pond

The development cost of this plant is to utilise excessive water during flood situation of rainy season.

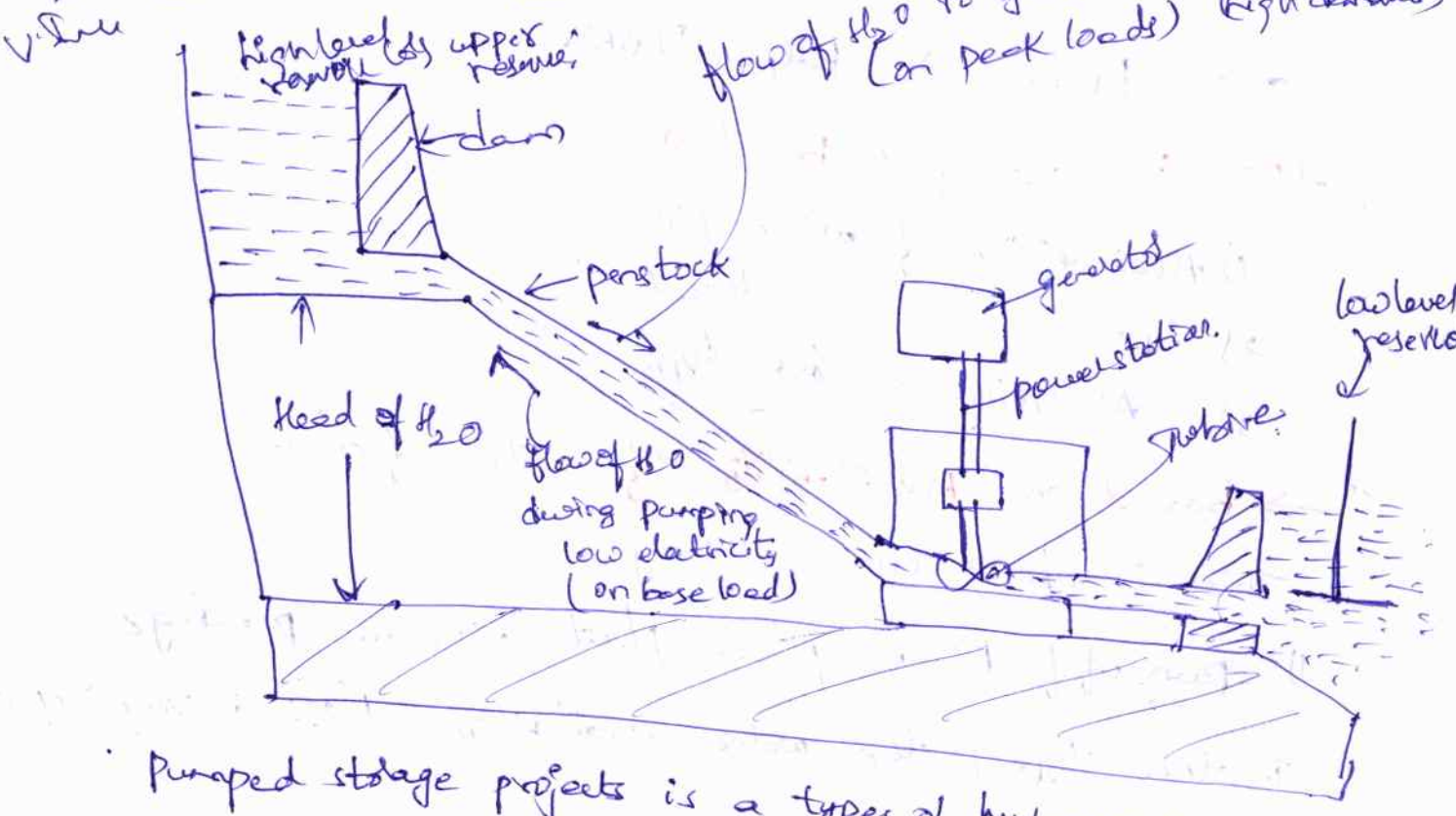
Run off River power plants with pondage :-

It is used as storage for the water along with increasing in its capacity.

It is used mostly during fluctuating load period depending on pondage size.

These types of PP save conservation of coal.

Pumped storage plants :-



Pumped storage projects is a types of hydro power projects which move water b/w two reservoirs located at different elevations to store energy & generate electricity.

→ This project water is pumped back to the upper reservoir with the help of pump.

TWO Conditions :-

Pumped storage plant will depend on two conditions,

1) peak load condition

2) base " "

on peak load condition, the flow of water flows down to generate electricity on high demand. The flow of water passes through penstock b/w high level reservoir to low level reservoir.

~~$H = H_g - h_f$~~ ~~H_g = Gross head~~ .

$h_f = \frac{4 \times f \times L \times V^2}{d \times 2g}$ where V = velocity of flow in penstock

L = length of penstock

D = diameter "

Head loss due to friction

→ on base load condition, the flow of H_2O pumping from low level reservoir to high level reservoir when the electricity on low demand.

Advan 1) low operating cost & long service life

2) Renewable & sustainable. 3) Controlling 4) low losses

5) High efficiency.

disad 1) energy loses 2) High cost relative to other technology

3) High capital cost 4) large unit sizes.

Nuclear fuel :-

A nuclear power plant is very similar to a conventional steam power plant except how that energy is evolved.

The heat is produced in the nuclear power plant by fission, where as in steam & gas turbine plants, the heat is produced by combustion in the furnace.

Nuclear reactor acts as a furnace where nuclear energy is evolved by splitting & fissioning of the nucleus of fissionable materials like Uranium U_{235}.

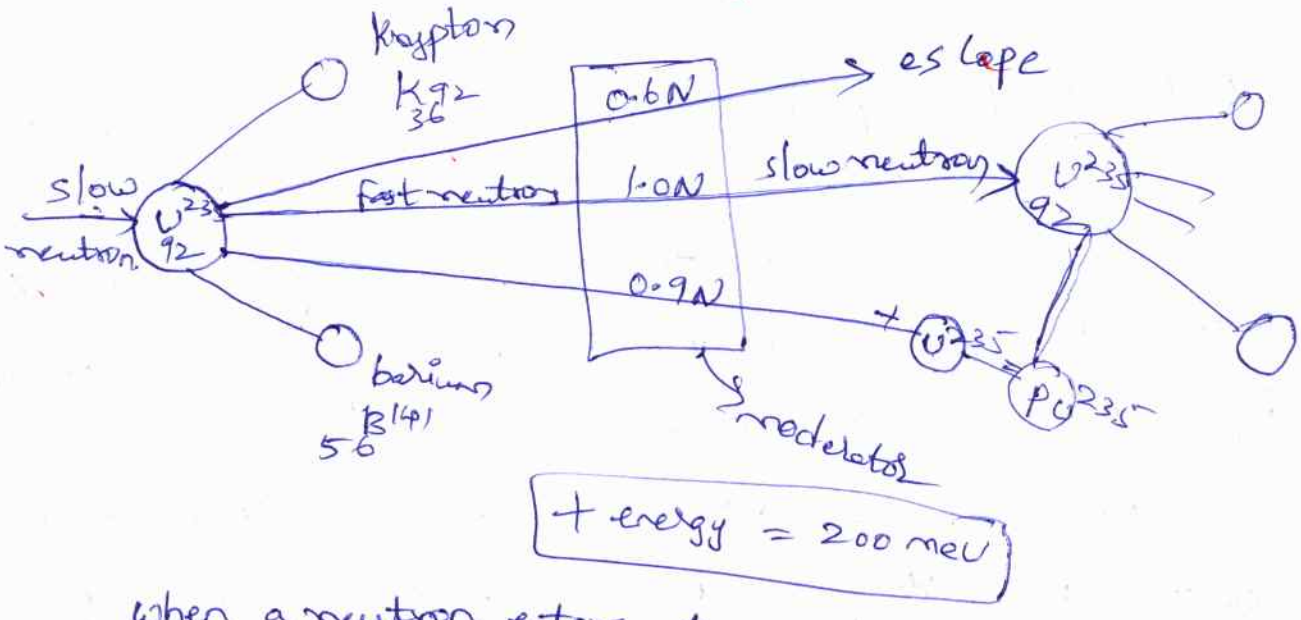
It can claim that 1kg U_{235} can produce as much heat energy that can be produced by burning 4500 tonnes of high grade coal & 1700 tons of oil.

→ nuclear energy is desired from splitting (or) fissioning of the nucleus of fissionable materials like Uranium U_{235}.

→ Uranium has several isotopes (Isotopes are atoms of same element having different atomic masses) such as U_{234}, U_{235}, U_{238} of several isotopes.

U_{235} is the most unstable isotope which is easily fissionable & hence used as fuel in an atomic reactor.

Nuclear fission (or) fission energy



When a neutron enters the nucleus of an unstable U^{235}, the nucleus splits into two equal fragments (krypton & barium) and also releases 2.5 fast moving neutrons with a velocity of 1.5×10^7 m/s & along with this produces a large amount of energy, nearly 200 million electro-volts. This is called nuclear fission.

Breeding & fertile materials :-

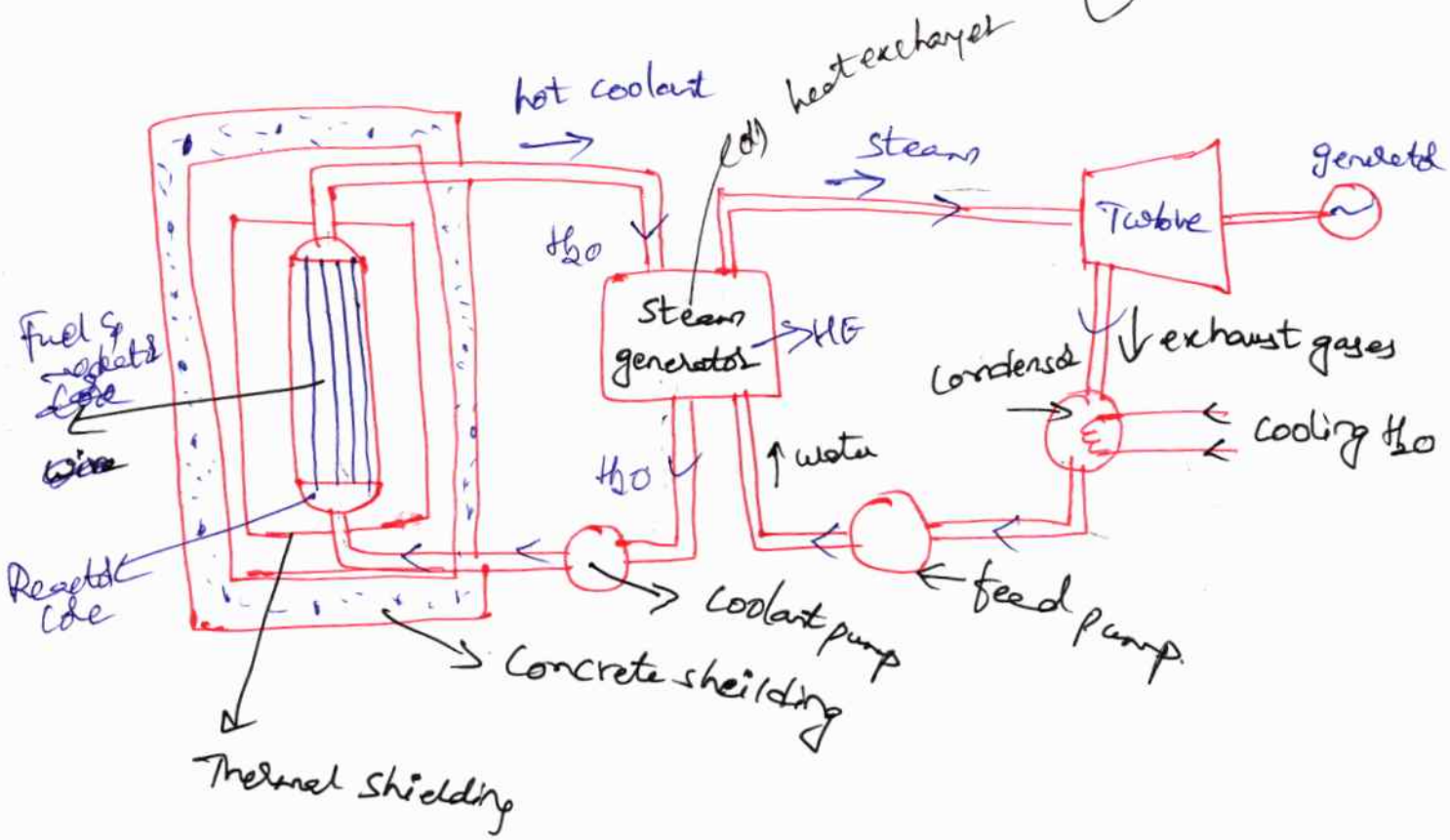
→ Nuclear fuels are mainly classified into two groups.

1) Breeding & Fissionable materials :- These are the material which is capable of sustaining a fission chain reaction.
U-235 is the only fissionable isotope found in nature.

2) Fertile materials :-

These are non-fissionable materials that can be converted into fissionable materials.
U-238 & Th-232 can be converted into fissionable materials

layout of Nuclear power plants :-



main components of NPP :-

1) moderator :- In any chain reaction, the neutrons produced are fast moving neutrons. These are less effective in causing fission of U^{235} & they try to escape from the reactor. It is thus implict that speed of these neutrons must be reduced if their effectiveness in carrying out fission is to be increased. This is done by making these neutrons collide with lighter nuclei of other materials, which does not absorb these neutrons but simply scatter them.

Each collision causes

Nuclear power plant :-

It is a facility that converts atomic energy into usable power.
The heats produced by a reactor is generally used to drive a turbine which in turn drives an electric generator.

N pp Layout :-

Nuclear Reaction :-

Nuclear reaction is like splitting the main atoms which release KE & further used for power generation.

diagram

Working :-

There is a concrete shield, there uranium atoms are bombarding to produce enough amount of heat & that heats comes to contact with water & water gets heated & converted into steam. &
Now from heat exchanger device the steam sends to the turbine for rotating blades & generating electricity with the use of generator & some amount of steam which is not used comes through the condensor where it loss the heat property & goes to the heat exchanger & then again water sends to Concrete shield for repeating the process.

Main parts :-

1) Nuclear Reactor → These are used at nuclear power plants for the generation of electricity & in nuclear marine propulsion.

The heat generates from nuclear fission is passed to a working fluid which is (water or gas) which in turns runs through steam turbine.

These either drive a ships propellers & turn electrical generators shafts.

Nuclear generated steam can be used for industrial process heat & some reactors are used to produce isotopes for medical & industrial use & production of weapons - grade plutonium.

Coolant circulating pump :-

It circulates the water which is further going to be heated & used for turbine blade rotating.

Heat exchanger :- It sends the water from condensed to heat exchanger & from there by the use of a circulating pump it sends to the concrete shield system.

Condenser :- It is the component ~~that~~ is used for extracting the heat from the working fluid & in simple you can say it cools the working fluid because it is having a low temp.

Turbine :- It is a device that is used for power generation. Here fluid strikes to turbine blades which is further connected to KE in to mE & generator & convert that mE in to EE.

Generator :-

It is further used for converting in to EE & op we got is power.

working:- The heat is generated in a reactor by the fission reaction.

The coolant in the primary circuit gets heated by observing the heat & enters into the heat exchanges.

In HE, the feed water is heated & converted in to steam by the hot coolant using heat transfer.

→ The steam from the HE will enter in the turbine to rotate turbine blades & generates power.

→ The steam after doing the work & enters into the condensor & converted into H_2O which is pumped again to the HE by the feed pump.

→ The hot coolant gets cold in the heat exchanges is recirculated into reactor by the coolant circulating pump.

→ The cycle is repeated continuously for generation of power.

Advantages :-

(1) It requires less space as compared to other power plants

(2) well suited for large demands.

(3) It gives better performance at high load factor 80 to 90%.

(4) less fuel consumption & no fuel handling.

(5) The transportation cost of fuel is very less

(6) Increased reliability of operation.

7) water required is less.

8) The high capacity of plant can be installed.

9) Simple in maintenance.

disadvantages :-

1) It has high initial cost
2) The danger of radioactivity hazards is always possible
3) Not suitable for varying load conditions.
4) The disposal of fission products is a big problem.
5) The maintenance cost is always higher.
6) working condition is always detrimental to the health of the workers.

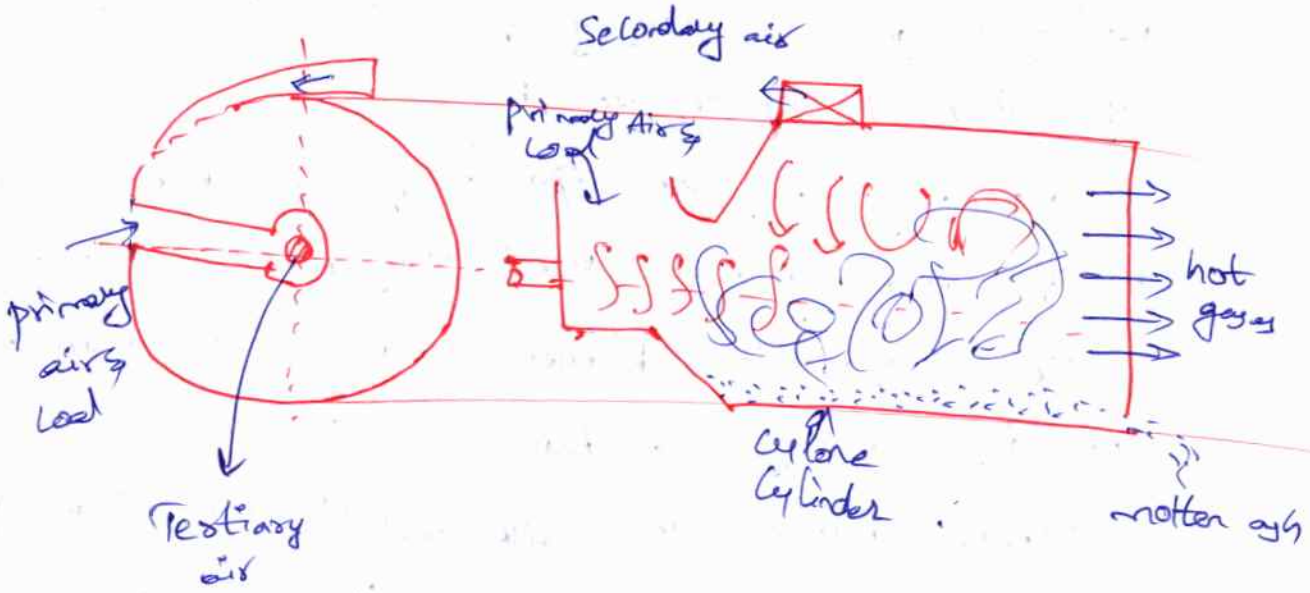
Applications :-

1) Generating a good amount of electricity
2) It now provides about 11% of world's electricity from about 450 power reactors.
3) which will be transformed into ME & EE

In India locations

1) Maharashtra
2) Rajasthan
Tamil Nadu
Karnataka
Gujarat
Tamil Nadu
Uttar Pradesh

Cyclone burners :- (6) Cyclone furnaces :-



Two main disadvantages associated with pulverised coal firing are :- 1) high cost

2) 70% of ash escapes as fly ash which requires expensive dust collectors in flue gases path.

These disadvantages are offset by a cyclone burner.

→ In a cyclone burner coal is crushed to a maximum size of 6mm & blows into a cylindrical cyclone furnace.

→ The fuel is quickly consumed & liberated ash forms a molten film flowing over the inner wall of the cylinder.

→ owing to inclination of the furnace, the molten ash flows to an appropriate disposal system.

The description of a cyclone burner is given below:-

It consists of a horizontal cylindrical drum having a diameter varying from 2 to 4m depending upon the capacity of the boiler.

→ depending upon the capacity of the burner the No of cyclone burners used may be one or more.

→ If No of cyclone burners used is more than one the diameter of each burner is less.

→ These burners are attached to the side of the furnace wall & have vents for primary air, crushed coal (6mm dia max size) & secondary air.

→ It is water cooled. The horizontal axis of the burner is slightly deflected towards the boiler.

→ The cyclone burner receives crushed coal carried in primary air (at 80cm water pressure) at left end.

→ Tangential entry of coal throws it to the surface of the cylindrical furnace.

→ Secondary air enters the furnace through tangential ports at the upper edge at high speed & creates a strong & highly turbulent vortex.

→ extremely high heat liberation rate & use of preheated air cause high temperature to the tune of 2000°C in the cyclone.

→ The fuel supplied is quickly consumed & liberated ash forms a molten film flowing over the inner wall of a cylinder.

— due to horizontal axis of the burners being tilted the molten ash flows to an appropriate disposal system.

→ The cyclone furnace gives best results with low grade fuels.

Advantages:-

→ High furnace temperatures are obtained.

→ Simplified coal existing equipments can be used instead of costly pulverised mills.

→ The cyclone burners reduce the % of excess air used.

→ boiler efficiency is increased.

UNIT-V

Actually solar energy is used into two ways :-

1) Solar Thermal energy
2) " photo voltaic cells

1) Solar collectors (or) solar Thermal energy collectors :-

It is an equipment in which the solar energy is collected by observing a radiation in an observer & then transferring to a fluid.

These are two types of collectors.

1) Flat plate collectors (or) non concentrating type collectors (or) Focusing type of collectors.
2) Concentrating type collectors (or) focusing type of collectors.

1) Flat plate Collectors (or) Non concentrating type collectors :-

It is a heat exchanger device which convert the solar energy into heat energy.

(or)

It is a device which is used to collect the heat from solar radiation.

→ The main function of collectors is to collect the heat from sun radiation.

→ we use the heat energy for domestic purpose.

→ It is used for below 90°C.

It has rectangular in shape.

It absorbs both direct & diffuse radiation.

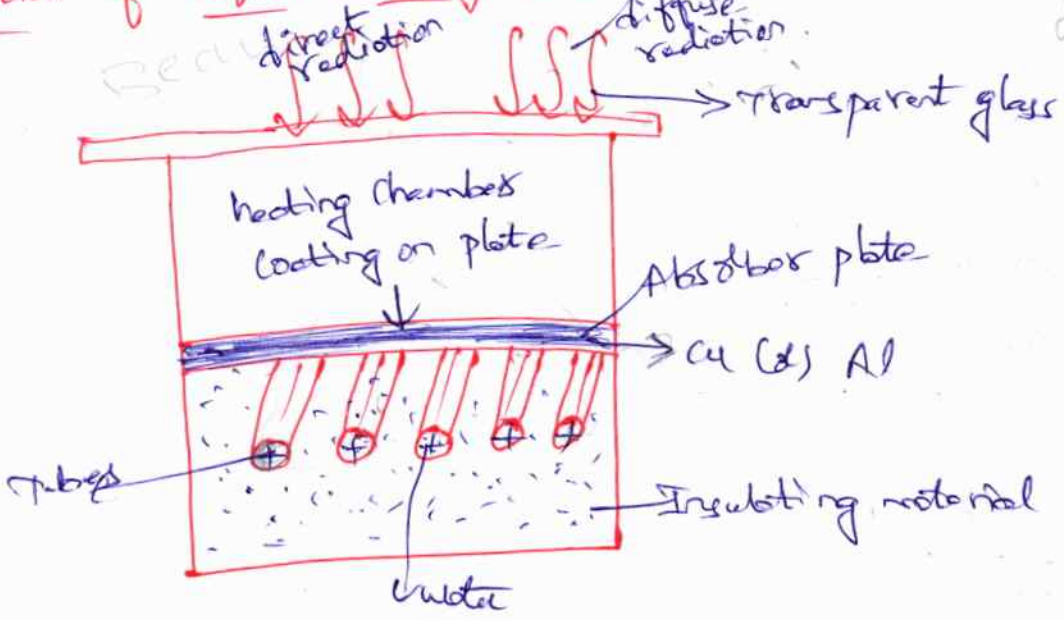
Direct radiation :- when radiation of sun directly reach to earth known as direct radiation.

Diffuse radiation :- when radiation reaches to earth i.e scatter some part of its reflect back & some part of it transmits known as diffuse radiation

There are two types of flat plate collectors

1) liquid heating collector 2) Air heating collector

Construction of liquid heating collector :-



→ outer surface of collector is made up of transparent glass. It consists of absorber plate is made up of copper (or) Aluminium & it is coated with black color.

→ The main function of absorber plate is used to absorb the heat from sun radiation.

→ Tubes are attached with absorber plate consists of diameters zero & these tubes are insulated by insulating material of foam, glass wool are used as insulating material.

→ The main function of insulation is to maintain the temperature around tubes

→ Insulation is maintained at thickness of 5 to 10cm.

All components are arranged in rectangular container.

Working :-

From sun the solar radiation receives the absorber plate which contains direct & diffuse radiation.

→ Temp of absorber plate increases by absorbing the heat from radiation.

→ Since absorber plate covered by transparent glass. Thats why heat stored in heating chamber do not get heat outside.

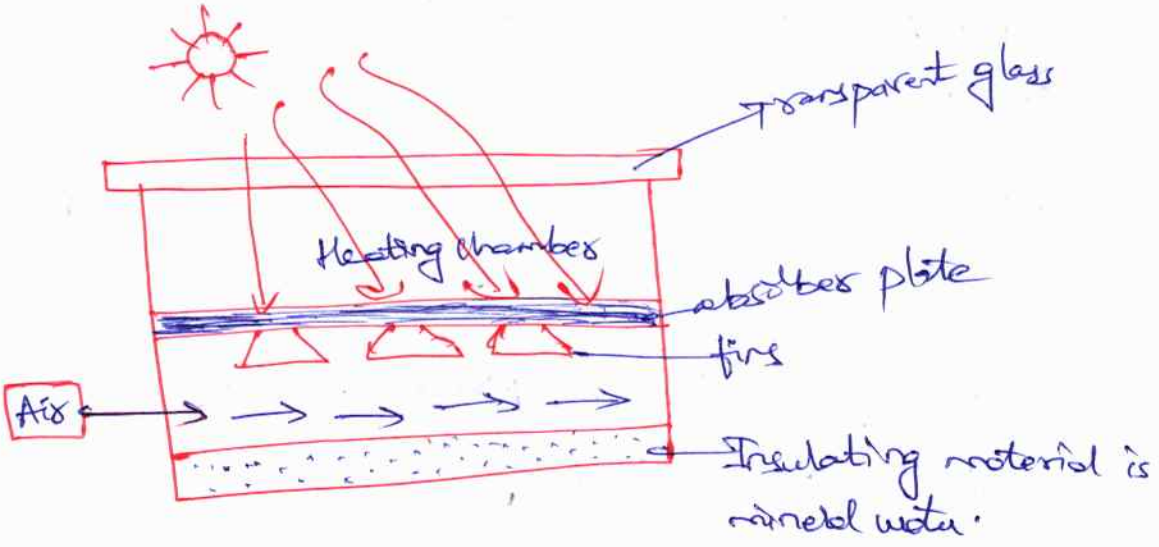
→ Insulation is also maintains the heat which does not despipiate outside.

→ Tube is attached with absorber plate so tube will also heat.

Liquid is started to heat inside the hot tube & temp increases.

After that hot water is used for domestic purpose.

2) Air heating Collector:-



Almost working & Construction is similar to the liquid heating collector.

The main difference is that tubes are not attached with absorber plate instead of that fins are used.

→ It is used to increase the contact area.

→ As a insulation ~~material~~ mineral wool is used which maintains the heat & does not desipate outside.

working:-

When direct & diffuse radiation directly incident on the absorber plate.

Then absorber plate absorb the radiation & that fins is also attached then fins temp increases.

→ when air flow along fins air is heated due to high temp & we uses that the hot air for general purpose.

→ There are two types of air heating collector.

1) porous type

→ It has Absorber plate

→ Air heated by flowing with porous absorber plate

2) Non porous type.

→ It has non porous Absorber plate.

→ Air will not flow with absorber plate.

Applications:-

1) Heating buildings
2) Drying agricultural produce & lumber
3) Heating green house
4) Air conditioing buildings
5) Solar Cooking
6) " drying
7) " heating

Advantages :-

(1) Flat plate collectors use both beam & diffuse radiation
2) They do not require orientation towards the sun.
3) They require little maintenance.
4) They are simple than the concentrating reflectors, absorbing surfaces & orientation devices of focusing collectors.

Wind Energy :-

It is a form of solar energy, wind energy or wind power describes the process by which wind is used to generate
→ wind turbines convert the kinetic energy in the wind into mechanical power.
A generator can convert mechanical power in to electricity.

(or)

wind turbines → KE → mechanical power → electricity.

→ The motion of air along that is parallel to the surface of the earth is called wind.
→ moving air is called wind.
→ Air moves from the regions of high pressure to the region low pressure.
→ It is one of the main factors responsible for the air movement in atmosphere.
→ The KE possessed by air due to its velocity is called wind energy.

Classification of wind Turbines :-

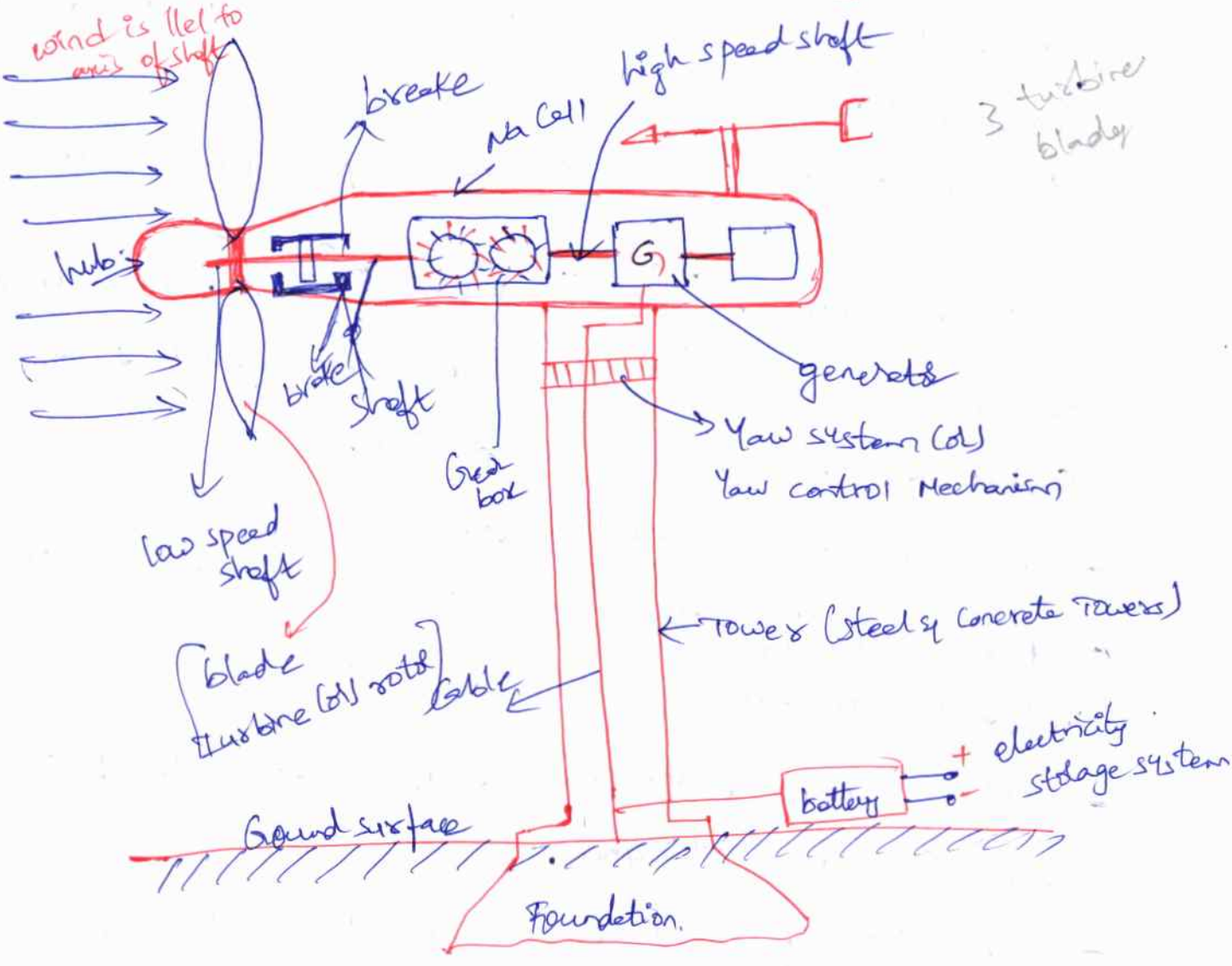
It is classified into two Categories.

→ when the axis of rotation is parallel to the air stream ie horizontal, the turbine is said to be a horizontal Axis wind Turbine (HAWT) &

when it is perpendicular to the air stream ie Vertical it is said to be a Vertical Axis wind Turbine (VAWT).

→ The size of the rotor & its speed depends on rotating of the turbine

Horizontal Axis wind Turbine (HAWT) :-



HAWT is a unique Technology.

It is produce the electricity with the help of some mechanism from the wind.

It has three turbine blades. The mechanism system are set horizontal.

Uses :-

→ generate electricity to save the electricity for future.

→ It mostly used in urban areas.

Construction :-

1) Turbine blades :-

These are made of high density wood (or) glass fibre & emp epoxy composites.

→ blades have an air foil type of cross section.

→ In addition to centrifugal force & fatigue due to continuous vibrations, many forces arising from wind turbulence, gravitational forces & directional changes in the wind.

→ The diameter of the rotor is 100m.

2) HUB :-

The central solid portion of the rotor wheel is known as hub.

All blades are attached to the hub. The mechanism for pitch angle control is provided inside the hub.

3) Nacelle :- It placed on the top of the tower & it contains the generator, brakes, Gear box, electricity Controller.

4) Gear box :- Spur gear is used & it is connected to the step planetary gear box while rotates from low speed box to high speed box from 50 to 80 rpm to produce electricity.

5) High speed shaft :- It drives the generator

6) low speed shaft :- The rotor turns the low speed shaft of speed of 30 to 60 rpm.

7) brakes :- A disc type of brake is applied electrically, mechanically to stop the rotors in emergency.

8) Rotor :- The blades & hubs together is called the rotor. The rotor having longer blades captures higher velocity of wind

9) Tower :- It is made up of steel & concrete to support all the parts.

Anemometer :- To measure the wind speed (rpm) in certain direction

Yaw control mechanism :-
The mechanism to adjust the nacelle around the vertical axis to keep it facing the wind is provided at the base of the nacelle.

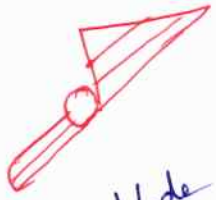
→ The Yaw control mechanism continuously orients the rotor in the direction of wind.

working :-
When the blades (or) turbine rotors are rotated when then wind is passes over the rotors in parallel direction with axis of shaft. The rotors rotate with the help of hub

→ The hub rotates by low speed shaft at a speed of 30 to 60 rpm. Gear box which is connects to the generator. High speed shaft which drives the generator.

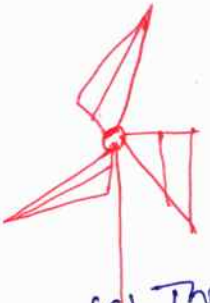
→ The cable which is connected finally to the battery to generate the electrical power. Finally convert wind energy into mechanical energy.

Types of rotors in HAWT:-

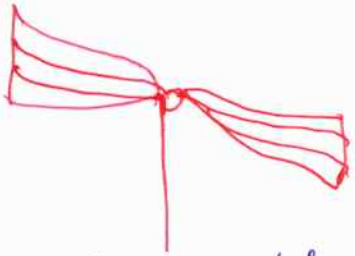


(a) single blade rotor

(b) Two blades

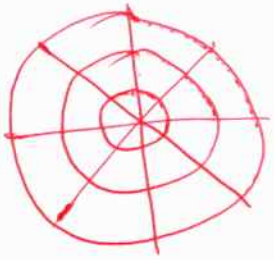


(c) Three blades

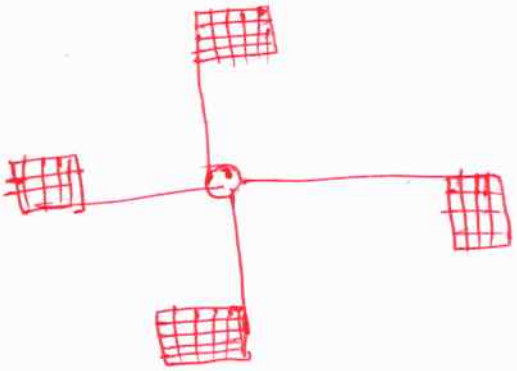


(d) Sail wing rotor

(e) chalk multi blade



(f) American multi blade



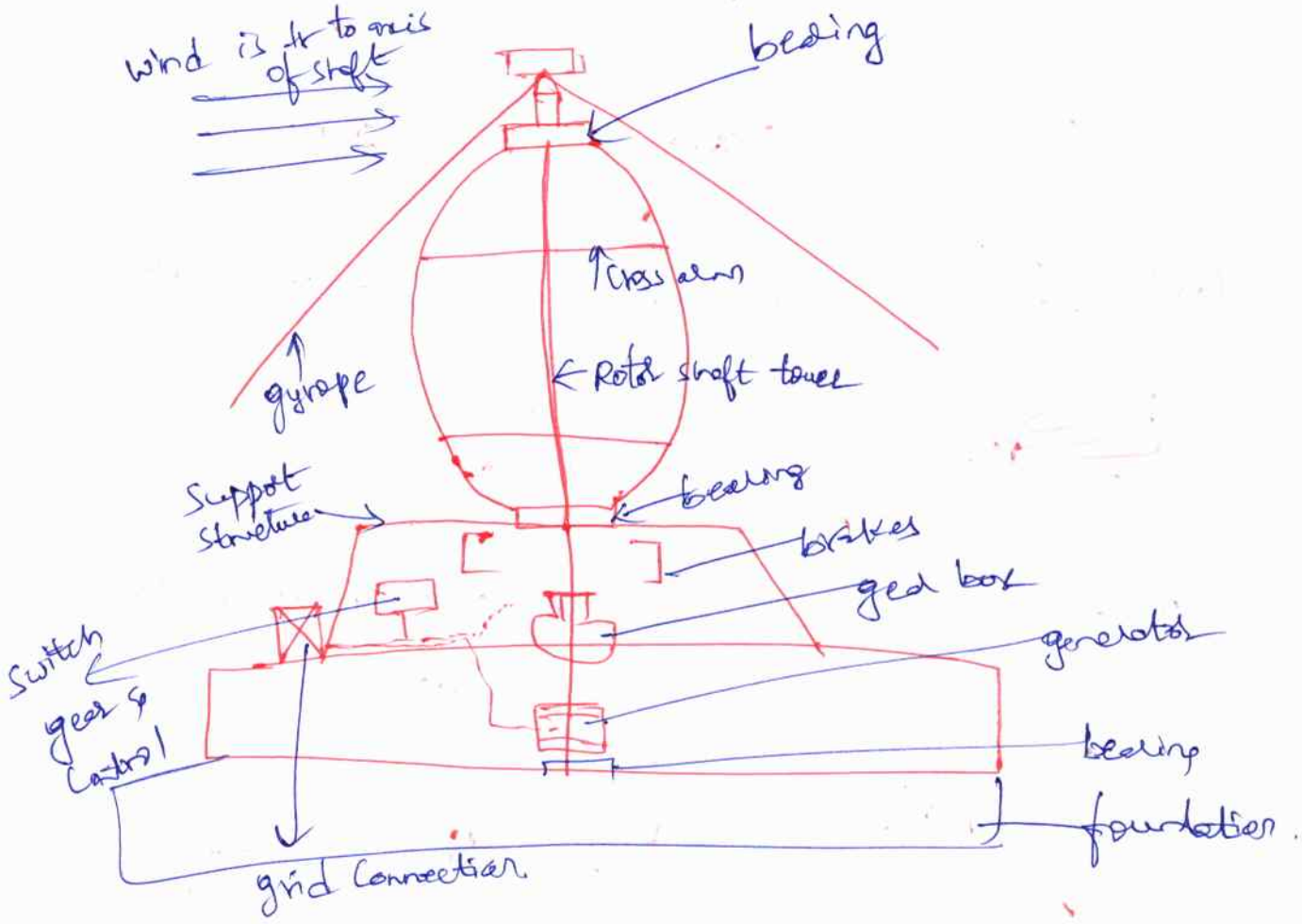
(g) dutch type blade

Vertical Axis wind Turbine (VAWT):-

VAWT's are in the development stage & many models are undergoing field trial. The main attractions of a VAWT are

1) It can accept wind from any direction, eliminating the need of Yaw control.

2) The gear box, generator etc are located at the ground, thus eliminating the heavy nacelle at the top of the tower thus simplifying the design & installation of the whole structure, including the tower
3) the inspection & maintenance also gets easier &
4) It also reduces the overall cost.



Construction (&) Components :-

The construction details of a vertical axis, wind (darrieus-type rotor) are shown in fig.

The details of main components are as follows :-

1) TOWER (&) Rotor shaft :-

The tower is a hollow vertical rotor shaft, which rotates about the vertical axis b/w top & bottom bearings.

It is installed above the structure.

→ The upper part of the tower is supported by guy ropes. The height of the tower is around 100m.

Blades

It has 2 & 3 thin, curved blades shaped that minimizes the bending stress caused by centrifugal force.

The blades is having air foil cross section.

Support structure

It is provided at the ground to support the weight of the rotor.

Gear box, generator, brakes, electrical switch gear & controls are housed with in this structure.

Working:

They are advocated as being capable of catching the wind from all directions & do not need. Yaw drive, Nacelle.

Their electrical generators can be positioned close to the ground for convenient way.

Actually in VAWT the wind is ⊥ to the blade.

It maintenance cost is low & occupy the large space.

→ The most commonly used in VAWT is darrieus type & savanious type of rotor height 94 m & diameter 65 m & produce 3-8 mW.

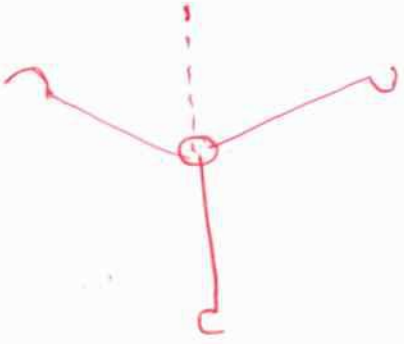
The tower is reinforced with guy wires for supporting purposes.

hele blades made from composite fibre glass stainless steel & light weight Aluminium are extremely strong & flexible.

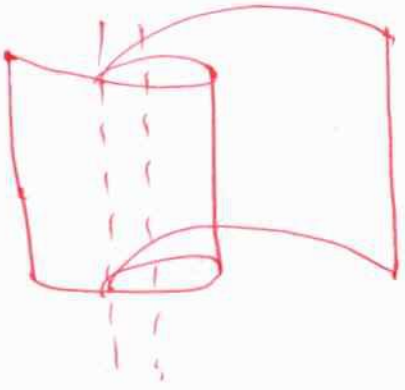
The main working is from Guy wire it should be rotated then rotor shaft rotates then the set of electrical gadgets (bearing, gear box, brakes) works then through grid connection then power needed.

VAWT Types :-

1) Cup type blade :-



2) Savonius rotor



3) Darrieous rotor

Advantages of wind energy:-

1) It is Renewable & available free of cost
2) helpful for supplying the energy in Rural areas
3) wind does not require any transportation it operates low cost
4) economically competitive

disadvantages:-

1) Available in low power density mainly variable with power & time
2) It used only in remote areas
3) The transmission loss are more
4) It produce noise pollution
5) Wind cannot be stored as a conventional source.

HAWT	VAWT
→ Tower required	→ No Tower
→ more speed	→ low speed
→ more cost	→ less cost
→ Need more maintenance	→ less maintaience
→ Require Yaw control	→ Yaw control / not required
→ less power generation	→ more power generation
→ Cp (power coefficient) is high & tsr (Speed ratio) is high	→ Cp & TSR is low.

UNIT-V

Economics of power plants :-

Basic definations :-

1) Connected load (CL) :-

It is the total sum of ratings (in Kw) of equipment installed in the consumer's premises.

Suppose if a consumer has connections for 5 power parts of 200w each & one electric heater consuming 1100w, then the total connected load of the consumers.

$$= 5 \times 200 + 1100 = 2100 w.$$

2) max demand :- (MD) :-

It is the maximum load which a consumer uses at any time & it can be less than (or) equal to connecting load.

3) demand Factor (DF) :-

$$DF = \frac{MD}{CL}$$

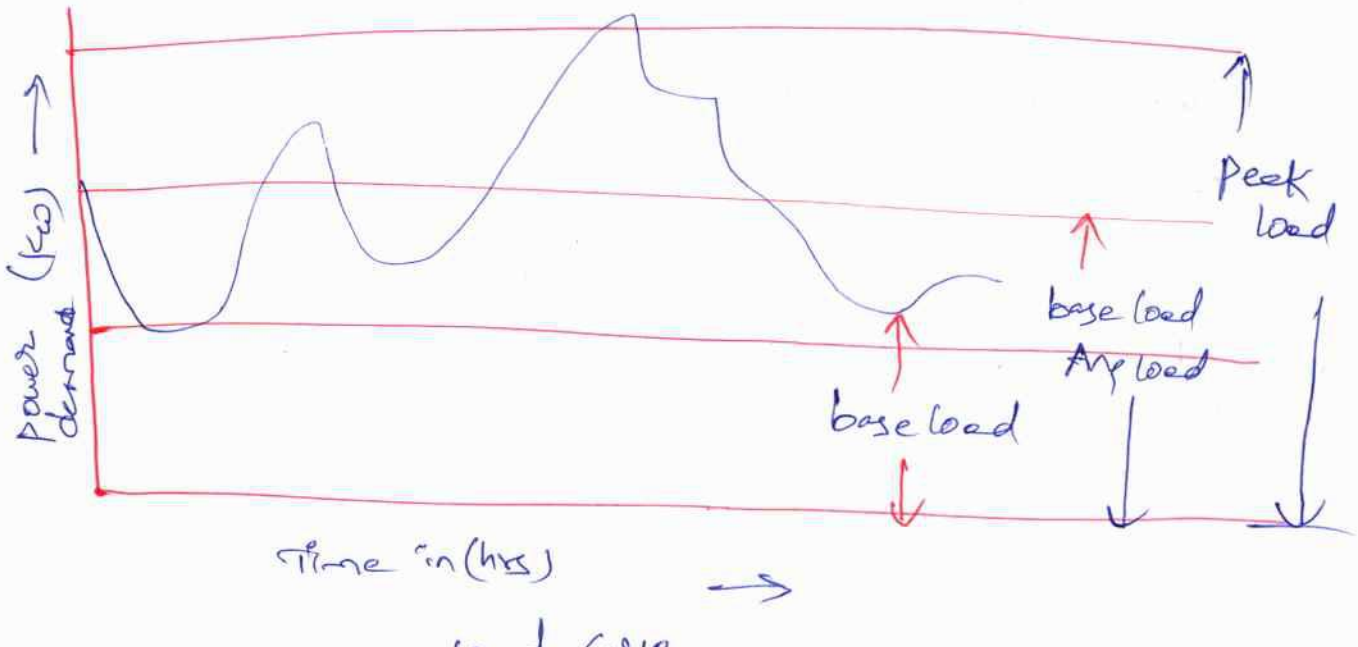
4) Load curve :-

It is the graphical representation b/w load in (Kw) & time (in hrs) it shows the variations of loads on power stations.

1) Daily load curve

2) Annual " "

Avg load (AL) = $\frac{\text{Area under the curve}}{\text{Total no of hours}}$



load curve

(5) load factor (LF) :-

$$LF = \frac{\text{Average load}}{\text{maximum demand}}$$

(6) Plant Capacity Factor (PCF) :- *

$$= \frac{\text{Actual energy produced in Kwh}}{\text{The max possible energy produced during the same period.}}$$

$$PCF = \frac{E}{C \times t}$$

where E = energy produced (Kwh) for given period

C = Capacity of the plant in Kw

t = total no of hours for the given period.

(7) plant use factor (PUF) :-

$$= \frac{\text{energy produced in Kwh}}{\text{The max possible energy during the actual no of hours of plant operation}}$$

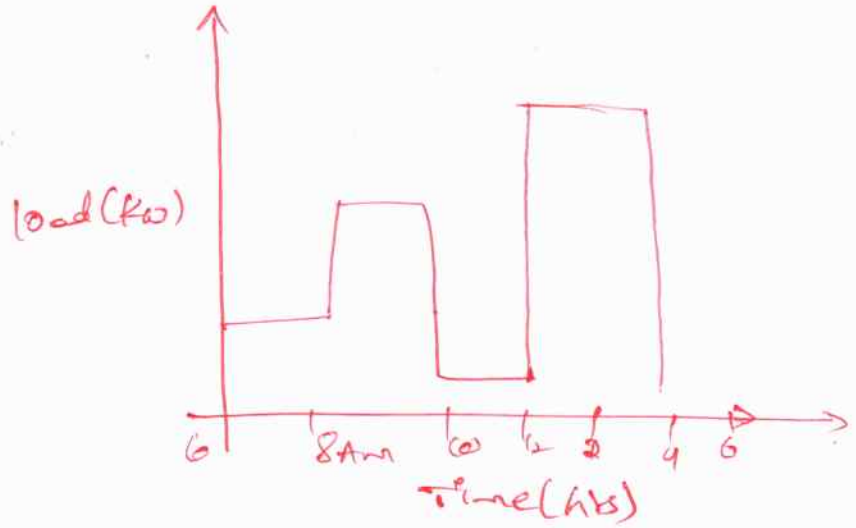
$$= \frac{E}{c \times t_1}$$

where t_1 = Actual no of hours plant operated.

8) Diversity Factor :-

$$= \frac{\text{Sum of individual max demand}}{\text{Simultaneous max demand of a system}}$$

9) load curve :-



It is a graph recold showing the power demands for every instant during the intervals.

b) load duration Curve :-

It represents the re arrangement of all the load elements of chronological load curve in order of descending magnitude - This curve is derived from the chronological load curve.

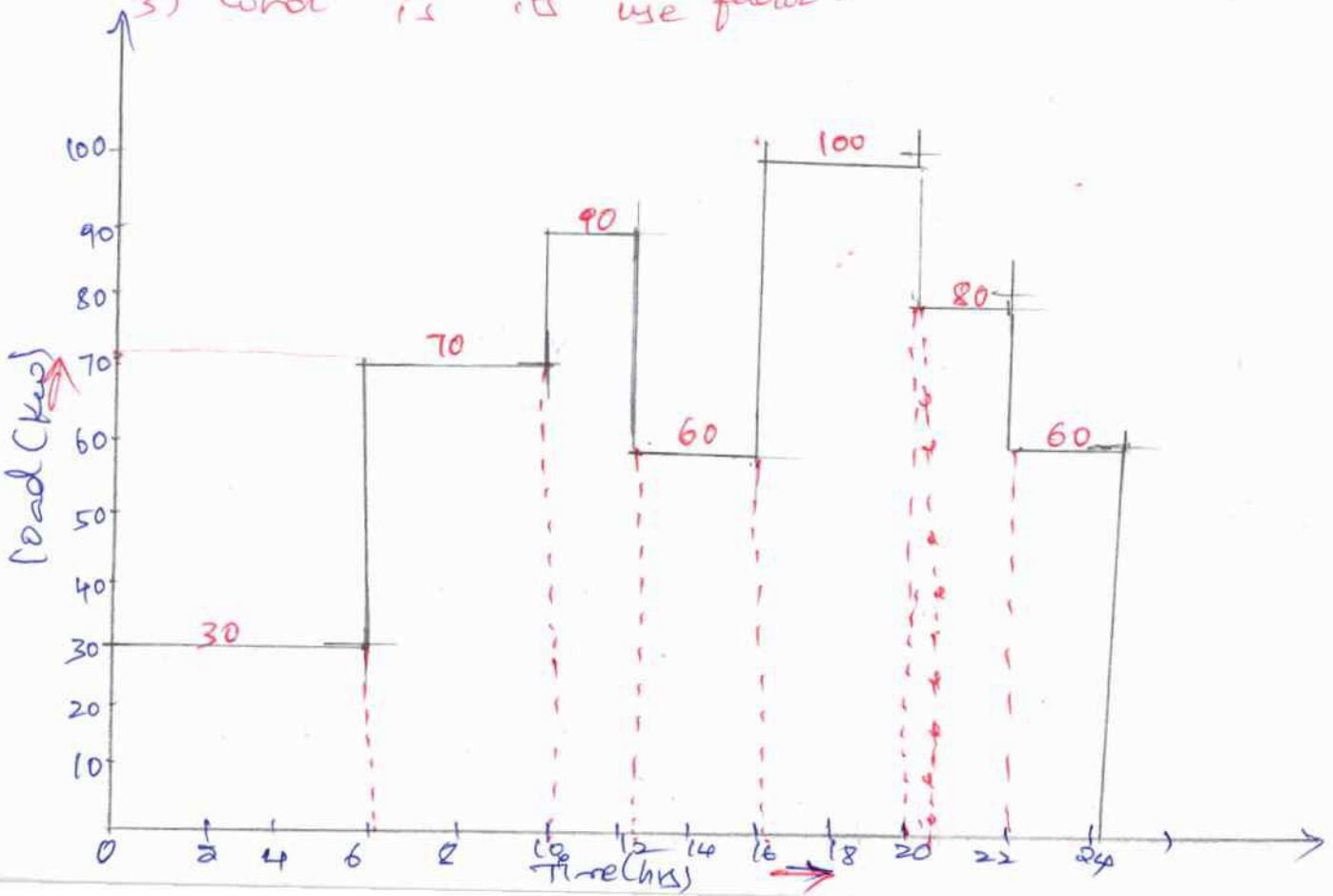
→ A power plant supplies the following loads to the consumers.

Time in hours	0-6	6-10	10-12	12-16	16-20	20-22	22-24
load in Mw	30	70	90	60	100	80	60

1) draw the load curve & estimate the load factor of the element

2) what is the load factor of a stand by equipment of 30MW capacity if it takes up all loads above 70MW.

3) what is its use factor.



Area under the curve indicates the energy generated.

$= (6\times30) + (4\times70) + (2\times90) + (4\times60) + (4\times100) + (2\times80) + (2\times60)$

$= 1560$ mwh.

$$\text{Average load} = \frac{\text{Area under the curve}}{\text{Total no of hours}}$$

$$= \frac{1560}{24} = 65 \text{ mw}$$

from the given data, max demand = 100 mw.

$$\text{load Factor} = \frac{\text{Avg load}}{\text{max demand}} = \frac{65}{100} = 0.65.$$

If the load above 70mw is supplied by the stand by equipment of 30mw capacity, then the energy generated by it :- $(80-70) = 10$mw for 2hrs

$(90-70) = 20$mw for 2hrs

$(100-70) = 30$mw for 4 hrs

Time taken by the stand by equipment for operation

$2+2+4 = 8$hrs

$= (10\times2) + (20\times2) + (30\times4)$

$= 180$ mwh.

$$\text{Average load} = \frac{\text{energy generated by stand by equipment}}{\text{Time taken}}$$

$$= \frac{180}{8} = 22.5 \text{ mw}.$$

$$\text{load Factor} = \frac{\text{Avg load}}{\text{max demand}} = \frac{22.5}{30} = 0.75$$

2) Plant Use factor = $\frac{\text{Actual energy Produced in Kwh}}{\text{The max possible energy that could have been produced during the same period}}$

$= \frac{E}{C \times t_1}$

Plant Use factor $= \frac{180}{30 \times 8} = 0.75$

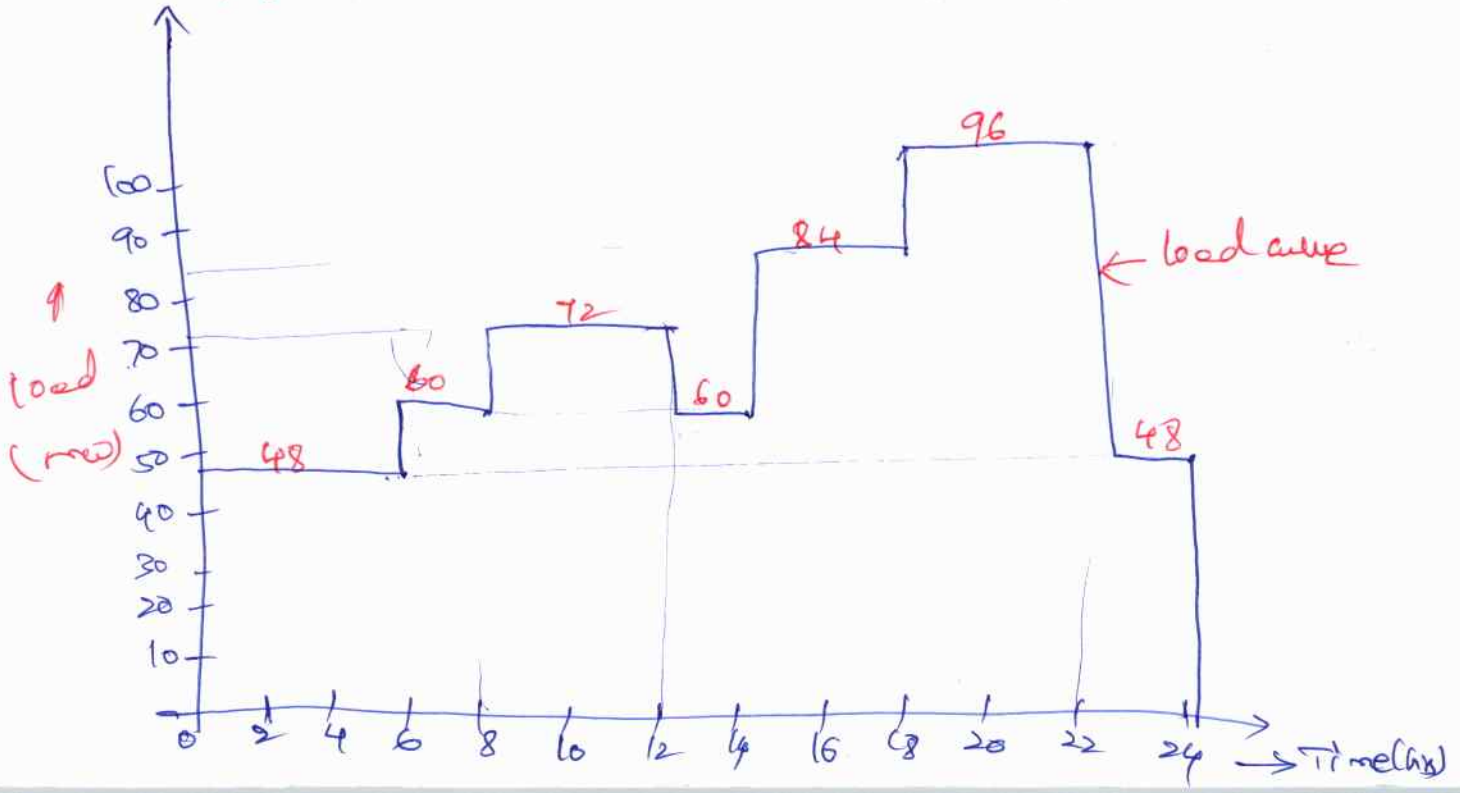
→ The maximum demand of a power station is 96000 Kw & daily load curve is described as follows :-

Time (hours)	0–6	6–8	8–12	12–14	14–18
load (mw)	48	60	72	60	84

18–22	22–24
96	48

i) determine the load factor of power station.

ii) what is the load factor of standby equipment rated at 30mw that takes up all load in excess of 72mw? Also Calculate its use factor.



Energy generated = area under the load curve

$= 48\times6 + 60\times2 + 72\times4 + 60\times2 + 84\times4 + 96\times4 + 48\times2$

$= 1632\times10^3$ Kwh.

1) load factor ;

Avg load $= \frac{1632\times10^3}{24} = 68000$ Kw.

max demand = 96000 Kw. (given)

load factor $= \frac{\text{Avg load}}{\text{max demand}} = \frac{68000}{96000}$

$= 0.71$

~~plant use factor~~ $= \frac{E}{Ext}$

2) load factor of ~~stand~~ by equipment :-

84-72 = 12mw for 4 hours (14-18)

96-72 = 24mw " (18-22)

∴ energy generated by stand by equipment

$= (12\times4 + 24\times4)\times10^3$

$= 144\times10^3$ Kwh.

Time for which stand by equipment remains in operation

$= 4+4 = 8$ hours

Average $= \frac{144\times10^3}{8} = 18\times10^3$ kw.

load factor $= \frac{18\times10^3}{24\times10^3} = 0.75$

$$\text{plant use factor} = \frac{E}{C \times t}$$

$$= \frac{144 \times 10^3}{30 \times 10^3 \times 8}$$

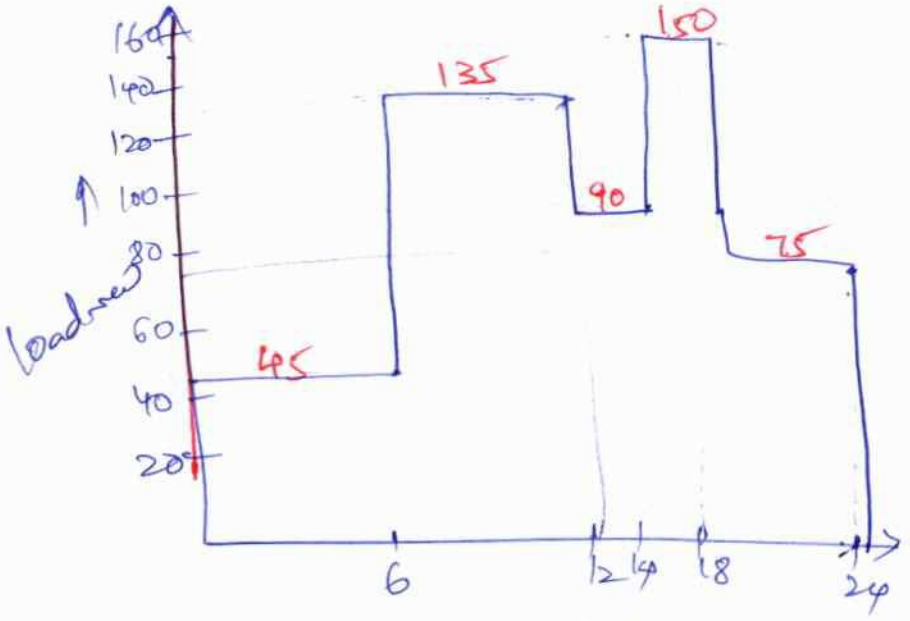
$$= 0.6$$

3) A power station has to supply load as follows :-

time (hours)	0-6	6-12	12-14	14-18	18-24
load (mw)	45	135	90	150	75

Generating station rating as 195 MW.

1) draw load curve
2) " load duration curve
3) Choose suitable generating units to supply the load
4) Calculate the load factor
5) Calculate the plant capacity factor.



energy generated = $45 \times 6 + 135 \times 6 + 90 \times 2 + 150 \times 4 + 75 \times 6$

$= 2310$ mwh.

Avg load = $\frac{2310 \times 10^3}{24}$ kw. $= 96250$ kw

maximum demand $= 150 \times 10^3 = 15 \times 10^4$ Kw.

load factor $= \frac{\text{Avg load}}{\text{max demand}}$

$= \frac{96250}{15 \times 10^4} = 0.64$

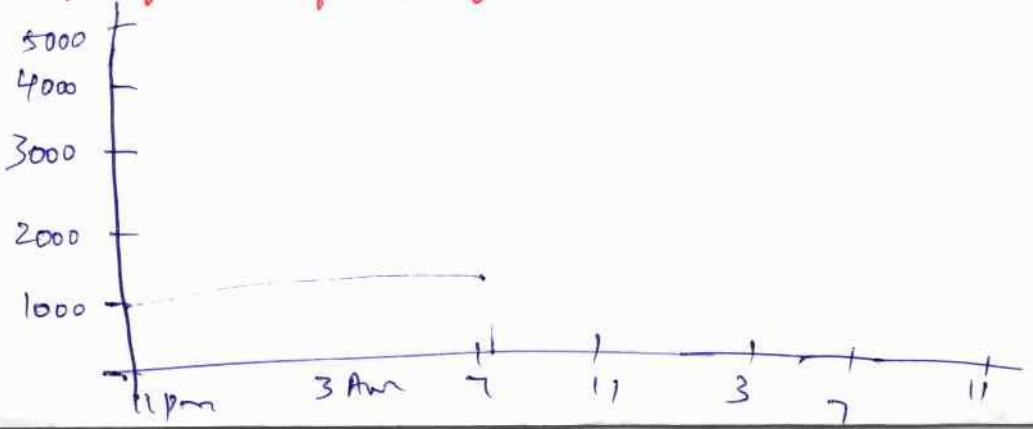
plant capacity factor $= \frac{E}{C \times t_1}$

$= \frac{9310 \times 10^3}{195 \times 10^3 \times 24} = 0.49$

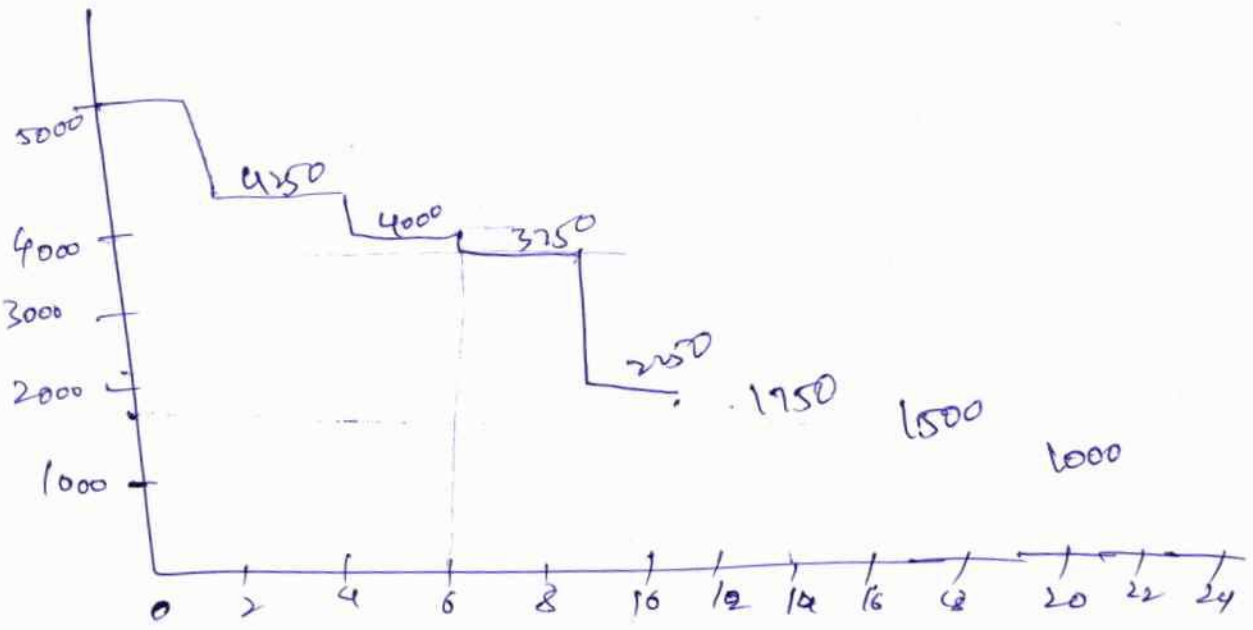
4) A generating station has a maximum demand of 5000Kw & the daily load on station is as follows :-

load (mw)	1000	1750	4000	1500
Time	11pm to 8Am	6Am to 8Am	8 to 12pm	12pm to 1pm.
load (mw)	3750	4250	5000	2250
Time (hours)	1pm to 5pm	5 to 7Am	7 to 9pm	9 to 11pm.

1) draw load curve
2) draw load duration curve
3) Select the size & no of generator units
4) what reserve plant would be necessary,
5) load factor
6) plant capacity factor



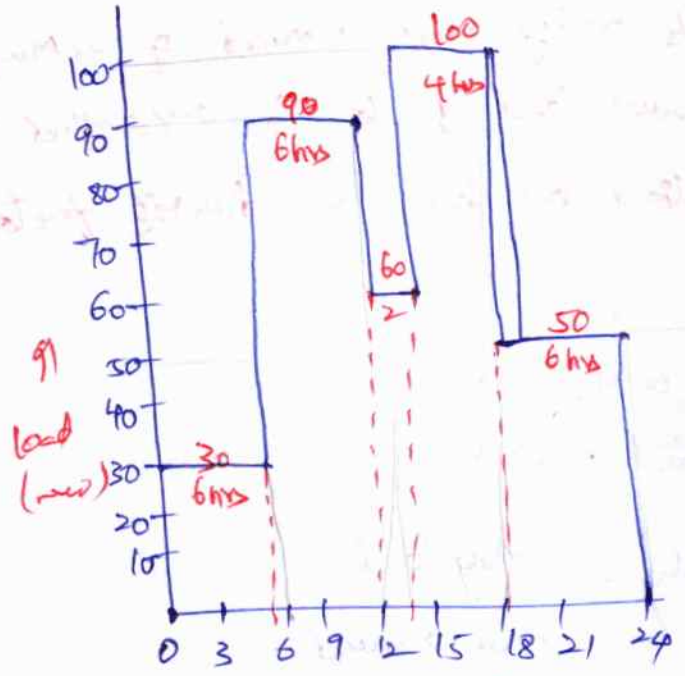
graph
load curve


5000
4000
3000
2000
1000
4350
4000
3750
2750
1750
1500
1000
0
2
4
6
8
10
12
14
16
18
20
22
24

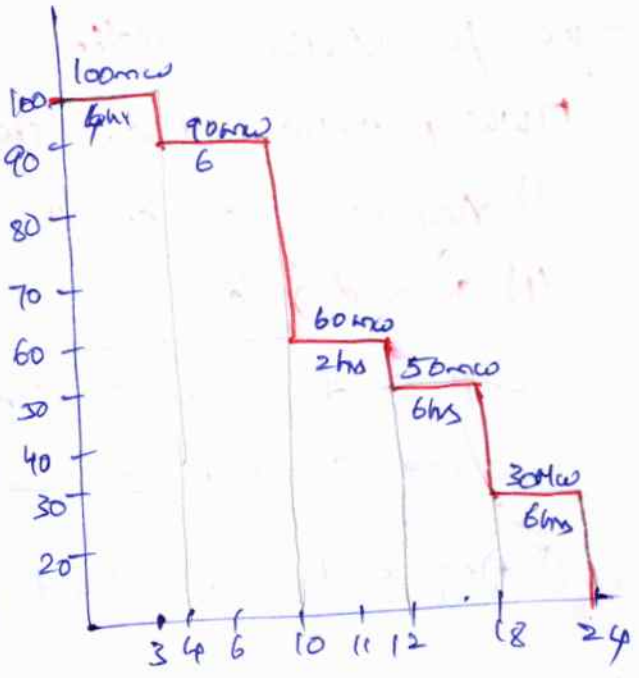
1) A power station has to supply load as follows :-

Time (hours)	0-6	6-12	12-14	14-18	18-24
Load (MW)	30	90	60	100	50

draw i) load curve 2) load duration curve & Calculate iii) load factor iv) Capacity of the plant & plant capacity factor.



Load curve



Load duration curve

i) load factor :- Area under the curve

$= 30\times6 + 90\times6 + 60\times2 + 100\times4 + 50\times6$

$= 1540$ MWh.

Average load $= \frac{1540}{24\text{ hrs}} = 64.167$ MW

Load factor $= \frac{\text{Avg load}}{\text{max demand}} = \frac{64.167}{100}$

$= 0.64167$

Capacity of the plant C = 100 MW

Plant Capacity factor = $\frac{\text{Actual energy produced per day}}{\text{max energy that can be generated}}$

$= \frac{E}{C \times t} = \frac{1540}{100 \times 24} = 0.64167$

2) A 60Mw power station has an annual peak load of 50Mw. The powerstation supplies loads having max demand of 20Mw, 17Mw, 10Mw, 9Mw. The annual load factor is 0.45 find
1) Avg load 2) energy supplied per year 3) diversity factor
4) demand factor.

Capacity of power station = 60Mw

max demand (or) peak load = 50Mw.

1) Avg load ; load factor = $\frac{\text{Avg load}}{\text{max demand}}$

$0.45 = \frac{\text{Avg load}}{50}$

Avg load = $50 \times 0.45 =$ 22.5Mw = Avg Load

2) energy supplied per year = Avg load × No of hours in 1 year

$= (22.5 \times 10^3) \times (365 \times 24) = 197.1 \times 10^6$ kwh.

3) diversity factor = $\frac{\text{Sum of individuals max demand}}{\text{Simultaneous max demand}}$

$= \frac{20+17+10+9}{50}$

$= 1.12$

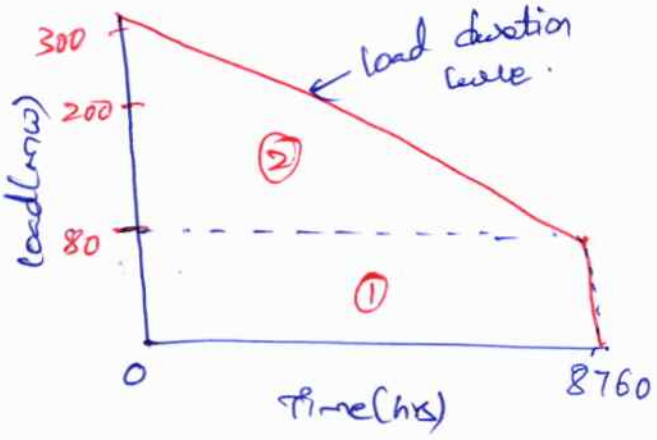
4) demand factor = $\frac{\text{max demand}}{\text{connected load}} = \frac{50}{20+17+10+9}$

$= 0.89$

3) The Yearly duration Curve of a Certain plant Can be Considered as a straight line from 300Mw to 80Mw power is supplied with generating unit of 200Mw Capacity & 2 units of 100Mw Capacity each. determine i) Installed Capacity ii) load factor iii) utilization factor iv) max demand.

Installed Capacity =

$(1 \times 200 + 2 \times 100) = 400$ Mw.



load factor = $\frac{\text{Avg load}}{\text{max demand}}$

Avg load = $\frac{\text{Total energy in load Curve for the period}}{\text{Total no of hours in the period}}$ $\quad A = \frac{1}{2}bh$

$= \frac{(80 \times 8760) + \frac{1}{2} \times 8760 \times (300 - 80)}{8760}$

$= 190$ Mw

2) load factor = $\frac{190\text{Mw}}{300\text{Mw}} = 0.633$

$365 \times 24 = 8760$

3) max demand = 300Mw

4) utilization factor = $\frac{\text{max load}}{\text{Rated Capacity of the plant}}$

$= \frac{300}{400} = 0.75$

5) plant factor = $\frac{\text{Avg load}}{\text{Capacity of the plant}}$

$= \frac{190}{400} = 0.475$

Cost Analysis :-

1) Capital cost - i) Initial cost ii) Interest iii) Taxes iv) depreciation cost v) Insurance

2) operational cost

i) Fuel cost ii) operating labour cost iii) supplies iv) maintanerance cost v) supervision vi) operating taxes.

1) A generating station has a maximum demand of 30Mw, a load factor of 0.6, a plant capacity of 0.48 & a plant use factor of 0.82, find i) the daily energy produced ii) The reserve capacity of the plant iii) the maximum energy that could be produced if the plant were running all the time iv) the max energy that could be produced daily, if the plant when running accolding to the operating schedule were fully loaded.

max demand = 30Mw; load factor = 0.6; plant capacity = 0.48; plant use factor = 0.82; load factor = $\frac{\text{Avg load}}{\text{max demand}}$

Avg demand = $30 \times 0.6 = 18$ Mw
$= 18000$ Kw

i) daily energy produced = Avg demand × No of hours
$= 18000 \times 24 = 4.32 \times 10^5$ Kwh.

ii) plant capacity factor = $\frac{\text{Avg demand}}{\text{Installed capacity}}$ $\Rightarrow 0.48 = \frac{18000}{IC}$

Installed capacity = 37500 Kw.

iii) Reverse capacity of the plant = Installed capacity - max demand
$= 37500 - 30,000$
$= 7500$ Kw.

Maximum daily energy produced when running all the time

$= 4.32 \times 10^5$ Kwh.

iv) max energy that could be produced, operating as per operating schedule $= \frac{\text{Actual energy produced}}{\text{plant use factor}}$

$\Rightarrow \frac{4.32 \times 10^5}{0.82} \Rightarrow 5.268 \times 10^5$ kwh.

Depreciation Methods :-

1) straight line method :

Life of equipment = 10 year (Assumption);

Cost of equipment = 12 lakhs

Salvage value after 10 years = 1 lakh.

Annual depreciation $= \frac{12-1}{10} = \frac{11}{10} = 1.1$ lakh/year

2) percentage method :-

different % of deterioration is considered for the equipment from year to year.

% reduces for successive years.

3) Sinking fund method :-

$$A = P - S\left[\frac{i}{(1+i)^n - 1}\right]$$

A = Annual sinking fund

n = life of the plant

S = Salvage value of the end of plant life

i = Annual rate compound interest on Capital.

P = initial investment

4) unit method :- In this method some factor is taken as standard one & depreciation is measured by that standard.

2) determine the Annual cost of a feed water from the following data ? cost = 96000/- , Salvage Value = 5% ; life = 10 years , Annual repair & maintenance cost = 3000/- Annual cost of chemicals = 6000/- , labour cost / month = 360/- Interest on sinking fund = 5%.

Capital cost P = Rs 96000

Salvage Value $S = \frac{5}{100} \times 96000 = 4800/-$

Rate of Interest , i = 5% (or) 0.05

Life n = 10 years

Annual sinking fund payment $A = (P-S)\left[\frac{i}{(1+i)^n - 1}\right]$

$= (96000 - 4800)\left[\frac{0.05}{(1+0.05)^{10} - 1}\right] = Rs\ 7250.8$

Total cost per year :

Annual sinking fund = Rs 7250.8

Annual repair & maintance = Rs 3000

Annual cost of chemicals = Rs 6000

Annual labour cost = (360 × 12) = 4320 Rs.

Total cost/year = 7250.8 + 3000 + 600 + 4320 = Rs 20570.8

3) From the following data, Calculate the cost of generation per unit delivered from the power plant.

Installed Capacity = 200 MW ; Annual load factor = 0.4

Capital cost of power plant = Rs 280 lakhs ; Annual cost of fuel, oil, salaries, taxation = Rs 60 lakhs , Interest & depreciation = 13%

(d) Installed Capacity = 200 Mw = 200×10^3 Kw

load factor = 0.4

Assuming max demand = Installed Capacity

Total units generated per annum = MD × LF × 365 × 24

= 700.8×10^6 Kwh.

Capital cost = Rs 281×10^6

Annual interest & depreciation = Rs $280 \times 10^6 \times \frac{15}{100}$

= Rs 3.64×10^6

Annual cost of fuel, salaries, Taxations = Rs 60×10^6

Total Annual cost = $3.64 \times 10^6 + 6 \times 10^6$ = Rs 9.64×10^6

$$\text{Generating cost} = \frac{\text{Total Annual cost}}{\text{Total units generated per annum}}$$

$$= \frac{9.64 \times 10^6}{700.8 \times 10^6}$$

$$= 0.0137 \text{ Rs}$$

$$= 1.37 \text{ Rs / Kwh.}$$