CBCS SCHEME

USN | | | | | | | | | | | | BEE405A

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2025
Electrical Power Generation and Economics

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Define the terms with graph : i) Hydrograph ii) Flow duration curve iii) Mass curve	06	L1	CO1
	b.	Explain with neat sketch the working of hydroelectric power plant station and explain the functions of each components in it.	10	L2	CO1
	c.	List out the merits and demerits of Hydro power plant.	04	L1	CO1
		OR			
Q.2	a.	Discuss with a schematic diagram. i) Low head hydro power plant ii) Medium head power plant iii) High head hydro power plant iv) Pumped storage hydro power plant.	12	L2	CO1
	b.	With a neat sketch, explain the function of governor used to control the speed of hydraulic turbine.	08	L2	CO1
		Module – 2			
Q.3	a.	With a neat sketch, explain overfeed and underfeed stokers.	07	L2	CO2
	b.	Explain the working of steam power plant with neat diagram.	07	L2	CO2
	c.	Discuss the advantages and disadvantages of diesel power plant.	06	L2	CO2
		OR			
Q.4	a.	Draw a layout of diesel power plant and explain its operation with its important components.	08	L2	CO2
	b.	Discuss in brief the methods of improving thermal efficiency of gas turbine power plant.	08	L2	CO2
	c.	With a flow diagram, explain the fuel handling system.	04	L2	CO2
		Module – 3			
Q.5	a.	Draw a neat diagram of pressurized water reactor and explain its advantages and disadvantages.	08	L2	CO3
	b.	Write briefly about Nuclear Waste Disposal.	06	L2	CO3
	c.	What is nuclear reactor? How are nuclear reactor classified?	06	L3	CO3
		OR			
Q.6	a.	With a neat sketch, explain main parts of Nuclear Reactor.	10	L2	CO3
	b.	Explain the construction and working of 'Gas-cooled reactor'. What are its advantages and disadvantages.	10	L2	CO3

		Module – 4			
Q.7	a.	Draw the line diagram of 66/11 KV substation.	06	L3	CO4
	b.	Explain resonant grounding with a neat diagram and also list the advantages and disadvantages.	08	L2	CO4
	c.	Define substation and mention different types of substation.	06	L1	CO4
		OR			
Q.8	a.	Explain Earthing transformer with neat diagram.	06	L2	CO4
	b.	Draw a neat single bus bar system and explain it.	08	L2	CO4
	c.	Write short notes on : i) Resistance grounding ii) Reactance grounding	06	L2	CO4
		Module – 5			
Q.9	a.	Define Tariff. Explain different types of tariffs. (Any two type)	06	L2	CO5
	b.	Explain the main disadvantages and causes of poor power factor.	06	L2	CO5
	c.	Discuss the measures by which low power factor can be avoided.	08	L2	CO5
		OR			
Q.10	a.	Define the following terms applied to power system. i) Load factor ii) Demand factor iii) Plant capacity factor	06	L1	CO5
	b.	An industrial undertaking has connected load of 200KW. The maximum demand is 150KW. On average each machine works for 70% of time. Find yearly expenditure on electricity if the tariff is Rs. 3000 + Rs. 700 per KW of maximum demand per year + Rs. 0.60 per KWh.	08	L4	CO5
	c.	Explain the concept of load sharing and choice of size and number of generating plants.	06	L2	CO5

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Electrical Power Generation and Economics.
(BEE405A)

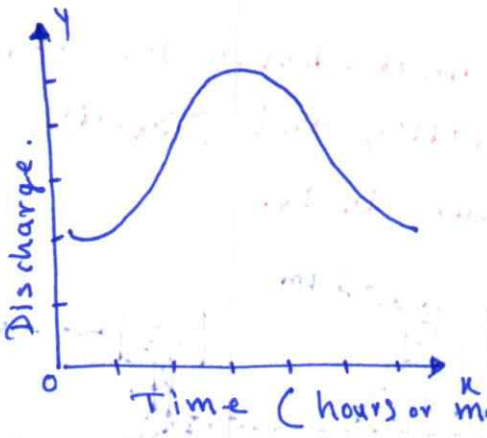
Prepared By :- prof. P. L. Charan.

Module-1

Q.1

a) a Define the terms with graph.
i) Hydrograph ii) Flow duration curve iii) Mass curve. (6M)

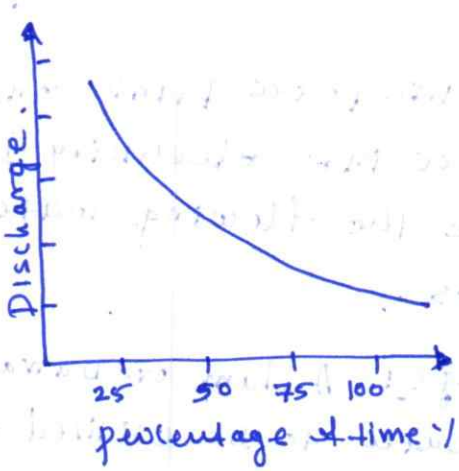
*) It is the plot between discharge versus time of the flow. Hydrograph is shown in figure below.
Discharge in plotted on Y-axis and the corresponding time that may be months, hours etc. is plotted on the X-axis.



2M

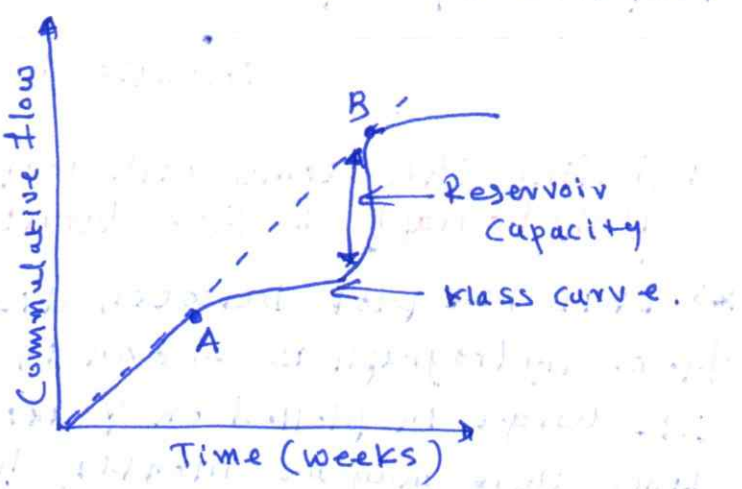
Flow duration curve :-

It is a plot of Discharge versus percentage of time for which the discharge is available. It is obtained from the hydrograph data. Discharge is plotted on -Y- axis and percentage of time is plotted on the X-axis.



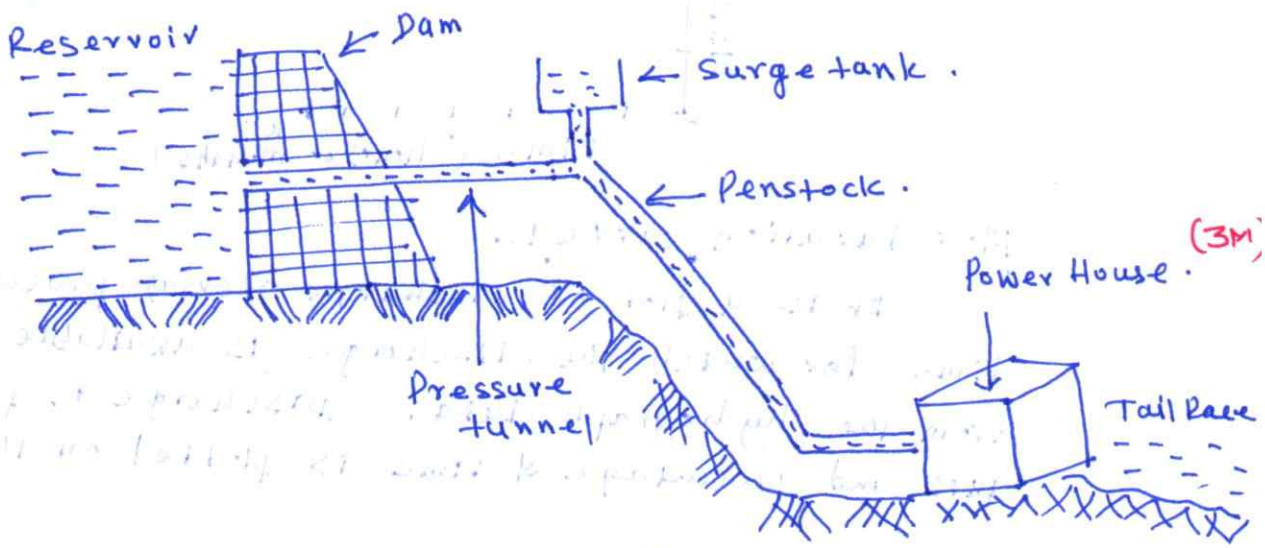
2M

Mass Curve:- It is a plot of commulative volume of water that can be stored from a stream flow versus time in days, weeks or months. Fig shows a mass curve. Maximum intercept between line AB and mass curve is known as reservoir capacity.



2M

4.b) Explain with neat sketch the working of hydroelectric power plant station and explain the functions of each components in it. (10M)



(3M)

A hydroelectric power plant converts the potential energy of stored water into electricity by releasing it through a dam, where the flowing water spins turbines connected to generators.

1) Dam or barrage: A dam or barrage is constructed to provide a head of water to be utilized in the water turbines. A

dam across the river is a very important in most of the high and medium head hydro power plants. Dams are also built on top of hills, in case of pump storage power plants, where is no inflow.

II) Reservoir and Forebay :- the main purpose of reservoir is to store water which may be used to generate electricity and for irrigation purposes.
Forebay is a regulating reservoir storing water temporarily when the load on turbine is reduced and provide water when load is increased.

III) Water conduit system :- A water conduit system carries water from the reservoir to the turbine of powerhouse through the pressure tunnel or pipes called penstock those may be laid above ground or underground. (7M)

IV) Tail Race : water is discharged into the tailrace after passing through the turbine, which carries it into the river.

V) Surge tank :- It is provided to act as pressure relase Valve of the water conduit system from the effect of water hammer, which is the sudden change of water pressure above the normal. When an additional storage Space (called surge tank), near turbine is provided which stores water during the turbine load reduction & release water when sudden increase in load is required. It controls the pressure variation of penstock.

V) prime mover :- The head of water is converted into the kinetic energy in prime mover, which rotates the shaft of the electric power generators (normally Synchronous alternators). Thus a prime mover also called a turbine, converts the kinetic and potential energy of water into the mechanical energy.

VII Power house :- Power house is normally located near the foot of the dam. It may be underground or open type. Water is brought to the power house with help of penstock and passed to the turbines to these rotate the alternators. In power house there are several in-house auxillaries and controls.

VIII Spillway :- It discharges the excess water of reservoir beyond the full permission level and acts as a safety valve of reservoir.

IX Trash rack :- It is provided to stop the entry of debris, which might damage the gates and turbines runners or choking of nozzles of the impulse turbines.

1 c) List out the merits and demerits of Hydro power plant. (4M)

Merits

1) It requires no fuel, as water is used for the generating of electrical energy.
2) It is quite neat and clean as no smoke or ash is produced
3) It requires very small running charges because water is the source of energy which is available free of cost. (3M)
4) It is comparatively simple in construction & requires less maintenance.
5) It does not require a long starting time like a steam power station.
6) It is robust and has longer life.
7) Such plants serves many purposes :- electricity, irrigation and controlling floods.

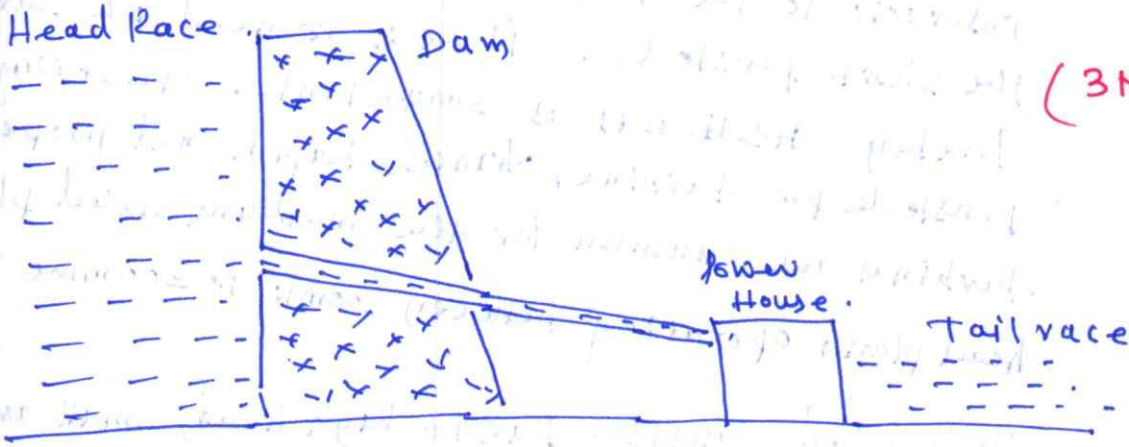
Demerits

1) It involves high capital cost due to construction of dam.
2) There is uncertainity about the availability of huge amount of water due to dependence on weather conditions. (1M)
3) Skilled and experienced hands are required to build the plant.
4) It requires high cost of transmission line as the plant is located in hilly areas which are quite away from the consumers.

Q2 (12 M)

a) Discuss with a schematic diagram
1) Low head hydro power plant
2) Medium head power plant
3) High head hydro power plant
4) Pumped storage hydro power plant.

1) Low head hydro power plant

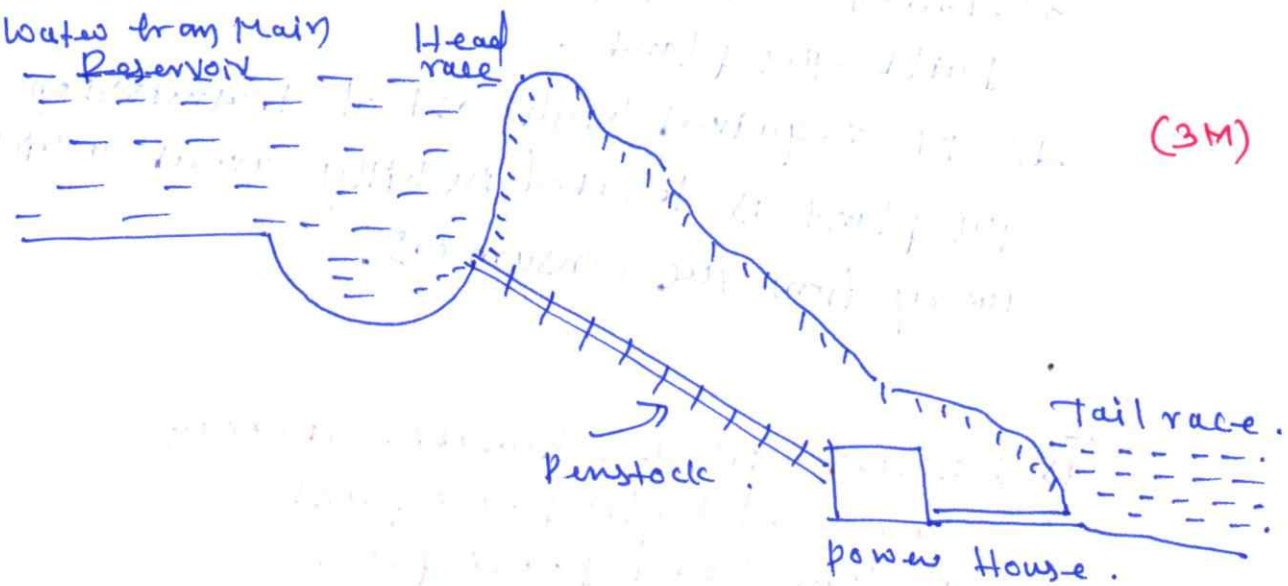


(3M)

To generate the same amount of power in such plants water required is much larger than the high head power plants. Generally run-off river plants, tidal plants & mid-set plants fall into this category. The

Catchment area and magnitude of peak flood area very large, the Spillway length being Considerable. Francis, kaplan (or) propelled turbines are used for low head plants. low heads plants work under heads below 30 mtrs.

Medium heead hydro power plant:-



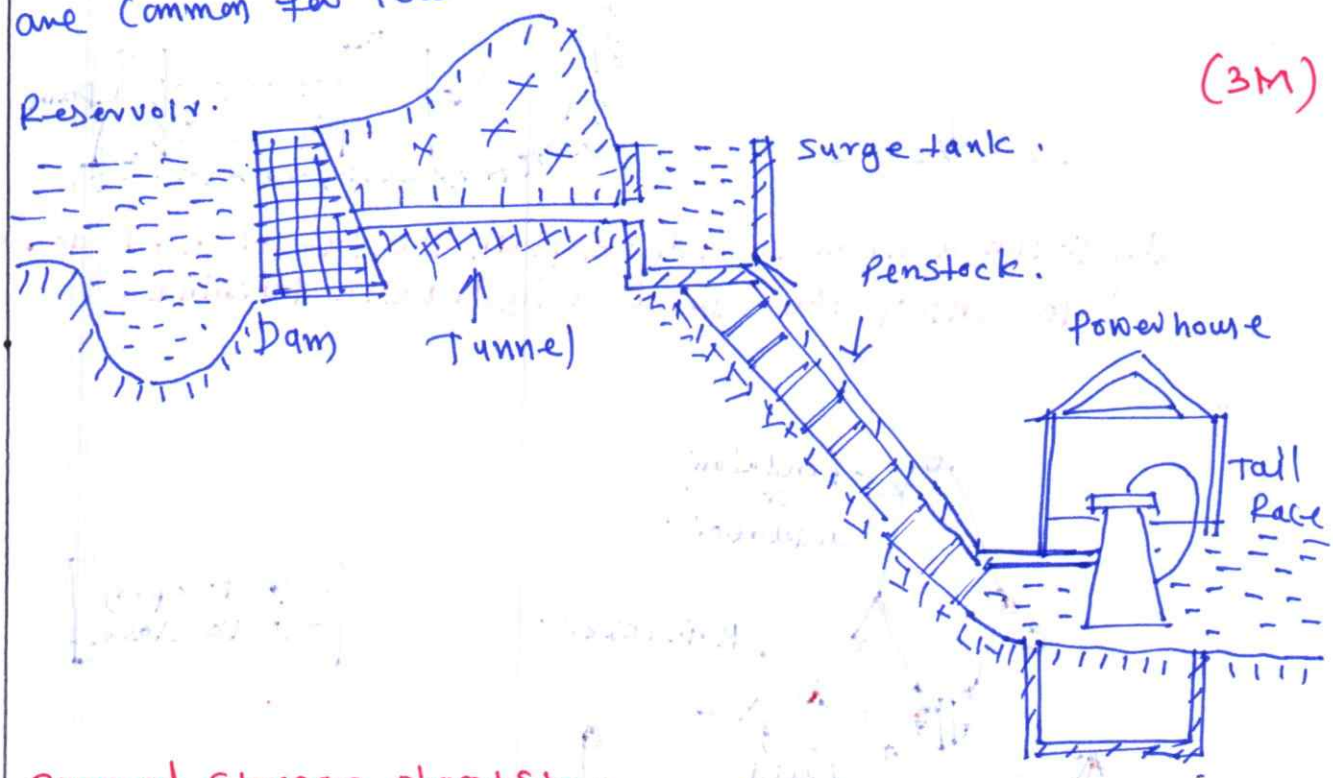
(3M)

Largew Volume of water is needed in such plants as Compared to high head plants. Therefore, a reservoir of large Capacity with large Catchment area is required. In these plants water is generally carried from main reservoir to the forebay and then to powerhouse through the short penstocks. There is no need of surge tank as forebay itself acts as surge tank. Generally there is one penstock per turbine, Francis, kaplan and propelled type of turbines are Common for the medium head plants. medium head plants operating between 30mtr to 300mtr head.

High head plants:- Due to high head, Small amount of water can produce large amount of power. Therefore these types of plants are very economical. Normally the reservoirs are high up in the mountains and the powerhouse is located at the foot, taking advantage of large level difference, The

catchment area is small and if water from one stream is not sufficient, then water from neighbouring streams can be diverted to the lake through the pipelines or tunnels. The water is carried from main reservoir by tunnel to power house. Via surge tank. The length of conduit system may be 15 km or more, for heads above 300 or 500 m, pelton turbine are used and Francis turbines are common for low head. (7)

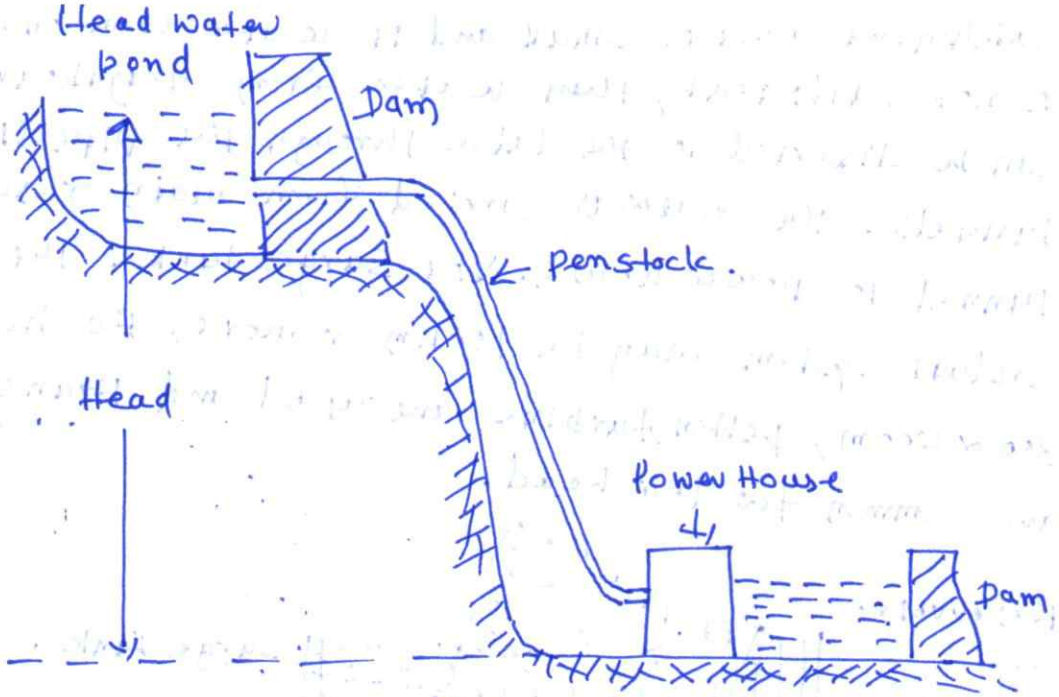
(3M)



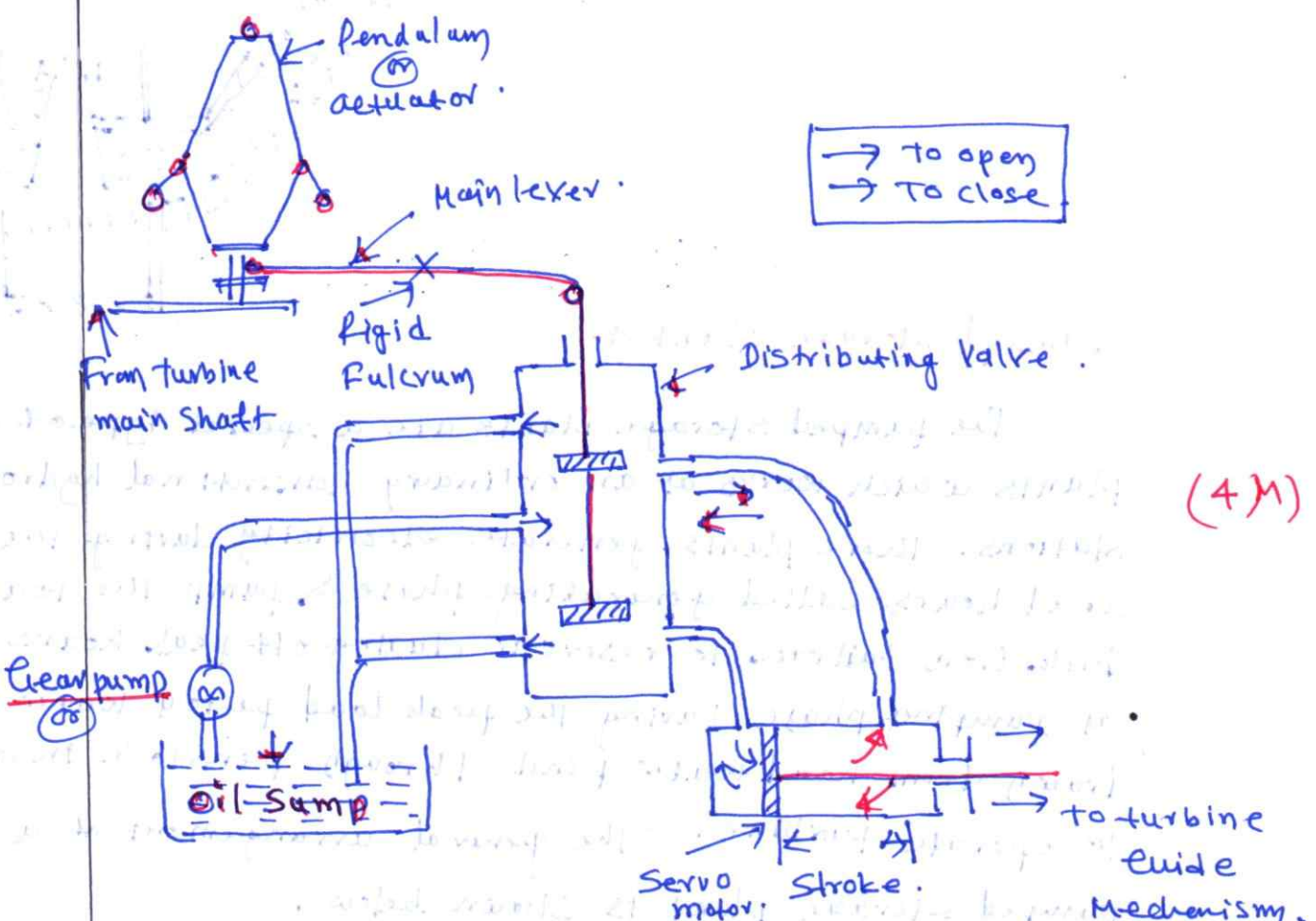
Pumped storage plants:-

(3M)

The pumped storage plants are a special type of power plants which works as an ordinary conventional hydropower stations. These plants generate electricity during the peak load hours, called generating phase & pump the water back from tailrace to reservoir during off peak hours known as pumping phase. During the peak load period water is drawn from head water pond through penstocks in order to operate turbine. The general arrangement of a pumped storage plant is shown below.



2.b With a neat sketch, explain the function of governor used to control the speed of hydraulic turbine. (8M)



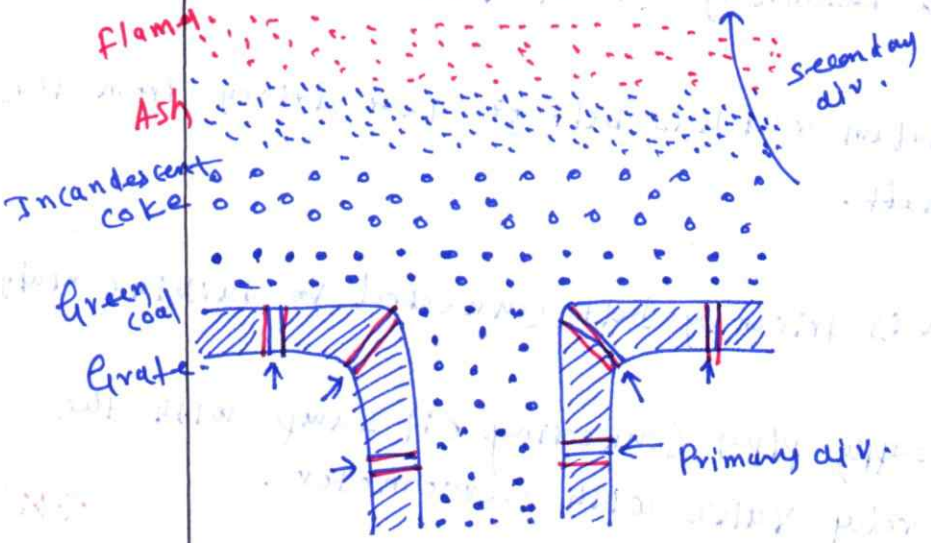
(4M)

The Components parts of a Governor are.

1) Servomotor also known as relay cylinder.
2) Relay Valve also known as Control Valve (or) distributing Valve
3) Actuated (or) pendulum which is belt (or) gear driven from the turbine main shaft.
4) Oil Sump
5) oil pump which is driven by belt connected to turbine main shaft
6) A system of oil supply pipes connecting oil sump with the relay valve and relay valve with servomotor. (4M)

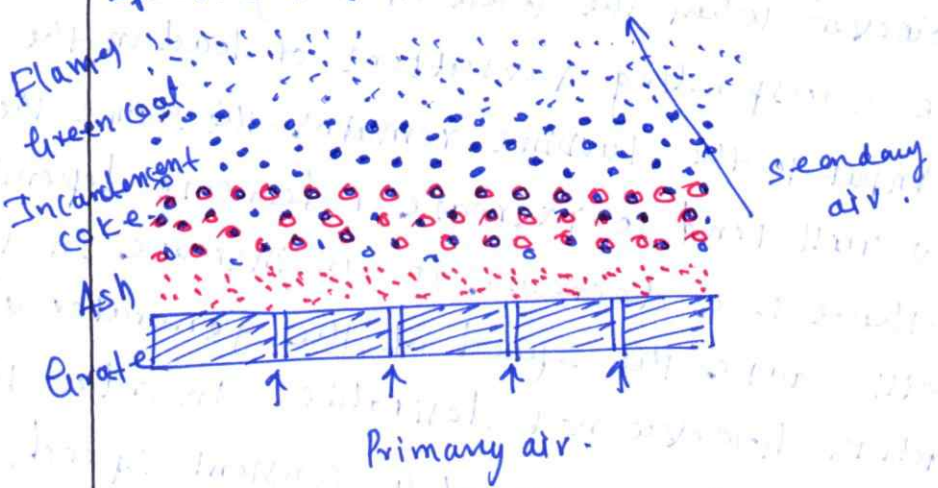
All hydraulic modern turbines are directly coupled to electric generators, irrespective of variations in the load the generators are required to turn at a constant speed which is fixed by the number of pair of poles are required frequency, however when the load on the generater varies there will be corresponding variations of load on the turbine also. If the input to the turbine remains the same the speed of the runner will tend to increase or decrease depending on whether there is a decrease (or) an increase in the load. This will cause the speed of the generater also to vary which is however not desirable. In order that the generater may always run at a constent speed, the speed of turbine runner must be maintained Constent. This is usually done by regulating the flow of water passing through the runner in accordance with variations in the load. Such an operation of speed regulation is known as governing.

3a) With a neat sketch, Explain overfeed and underfeed Stokers. (7M)



fig(a) An overfeed stoker.

Stoker firing is a method of firing coal is carried into the furnace for combustion and ash formed after combustion is discharged at appropriate point. Stokers are designed for meeting specific requirement of fuels. (4M)



fig(b)

An underfeed stoker. (3M)

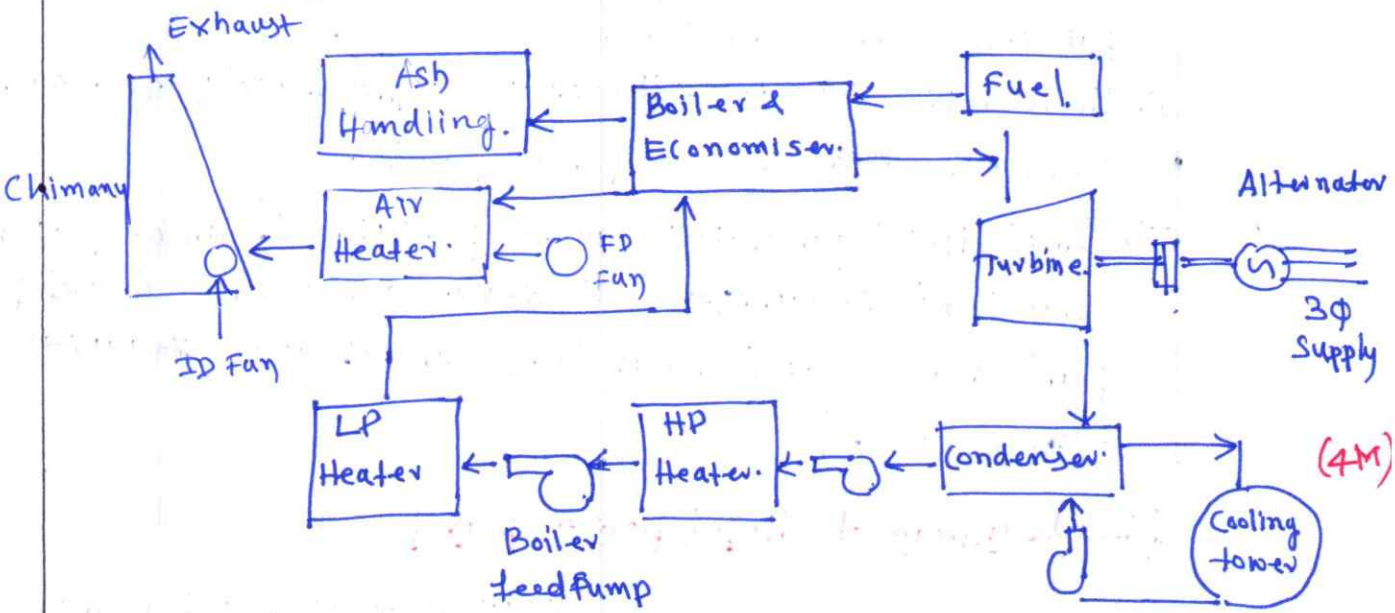
There are two main classes of stokers. These are overfeed and underfeed. The two differ in the manner of feeding of coal above (or) below the level at which primary air is admitted in the furnace.

The distinction between overfeed and underfeed stokers will be clear from a reference to fig(a) and fig(b). In the case of overfeed stoker coal is fed on to the grate above

the point of admission of air.

In the case of an underfeed stoker fuel is fed from underneath the fire and works gradually upward, primary air being supplied into the bed just below the level at which combustion takes place. Bituminous and semi Bituminous coal with small ash content and fusing temperature above 1300°c (caking or non-caking) can be burned very efficiently in these stokers.

3.b) Explain the working of steam power plant with neat diagram. (7M)



(4M)

fig: Layout of typical steam power plant

Working of steam plant:

A steam power station basically works on the principle of 'Rankin cycle'. Steam is produced in the boiler by utilising the heat of coal combustion. Then the steam is conveyed to the prime mover (steam turbine) and it is condensed in a condenser to be feed into the boiler again. The steam turbine drives the alternator (electric generator) which converts the rotary mechanical energy into electrical energy. (3M)

The prime movers of steam power plants may be operated either in non-condensing or condensing.

3c) Discuss the advantages and disadvantages of diesel power plant. (6M)

Advantages of diesel power plant

1) The capital cost per kw is low.
2) The design and installation are simple & cheap
3) It occupies less space as the number and size of the auxiliaries is small. (4)
4) There can be easily procured, installed & commissioned in less time,
5) Starting time & stopping time are very less. Thus can be put into service and taken out quickly.
6) There have the good efficiency (approximately 40-45%.) which is higher than thermal power plants.
7) Small diesel generators can be portable & can be put near any load requirment, However a big size diesel power plan can be located near load centres as it requires less time & space.

Disadvantages of diesel power plant

1) The operating cost of it is very high as diesel is more costly than coal.
2) The size of diesel unit is limited & Very large capacity is not possible with these prime movers. (3)
3) Their repair and maintenance costs are high.
4) The useful life is very less (approximately 5-10 yrs)
5) They have limited overload capacity.

4. a) Draw a layout of diesel power plant and Explain it's Operation with it's important Components. (8M)

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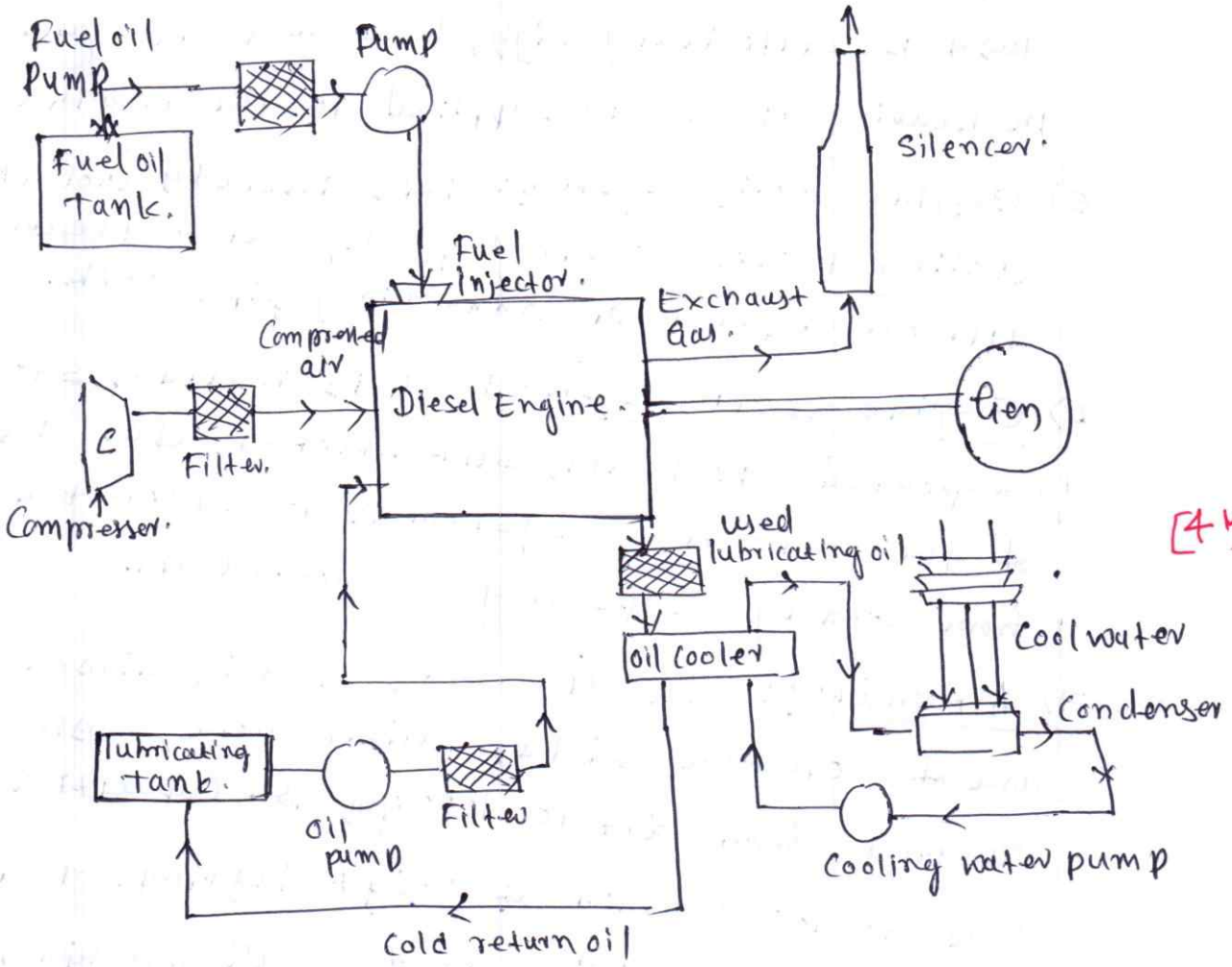


fig:- layout of diesel power plant

The essential components of a diesel electric plant are.

① Engine ② Engine fuel system ③ Engine air intake system ④ Engine exhaust system ⑤ Engine cooling system ⑥ Engine lubricating system ⑥ Engine Starting system.

[4M]

① Engine :- This is the main component of the plant which develops power, Generally engine is Coupled directly to the generator.

② Engine fuel system :- This includes the fuel storage tanks, fuel transfer pumps, strainers, heaters & connecting pipe work.

③ Engine air intake system : This includes air filters, ducts & Supercharger. The purpose of air filters is to remove

dust from the air to be supplied to the engine.

4) Engine exhaust system: This includes silencers & connecting ducts. As the temperature of exhaust gases is sufficiently high, heat of these gases is utilized in heating oil & air supplied to the engine.

5) Engine cooling system: This includes coolant pumps, cooling towers or spray ponds, water treatment or filteration plant & connecting pipe work.

6) Engine starting system: This includes storage battery, compressed air tanks, self starters etc. The function of the starting system is to start the engine from cold by supplying compressed air.

7) Alternator: The alternators used in diesel power plants are of rotating field, salient pole construction, speed ranging from 214 to 1000rpm & capacities ranging from 25 to 5000kwh at 0.8 pf lagging. Their output voltages are 440V. In case of small machines & as high as 2200V in case of large machines & voltage regulation is about 30%.

8) Governars: Modern diesel engines are equiped with either non-isochronous & isochronous governars. All diesel engine should be supplied with emergency over speed governer to stop the unit when the speed exceeds by 10%

4b) Discuss in brief the methods of improving thermal efficiency of gas turbine power plant. [8M]

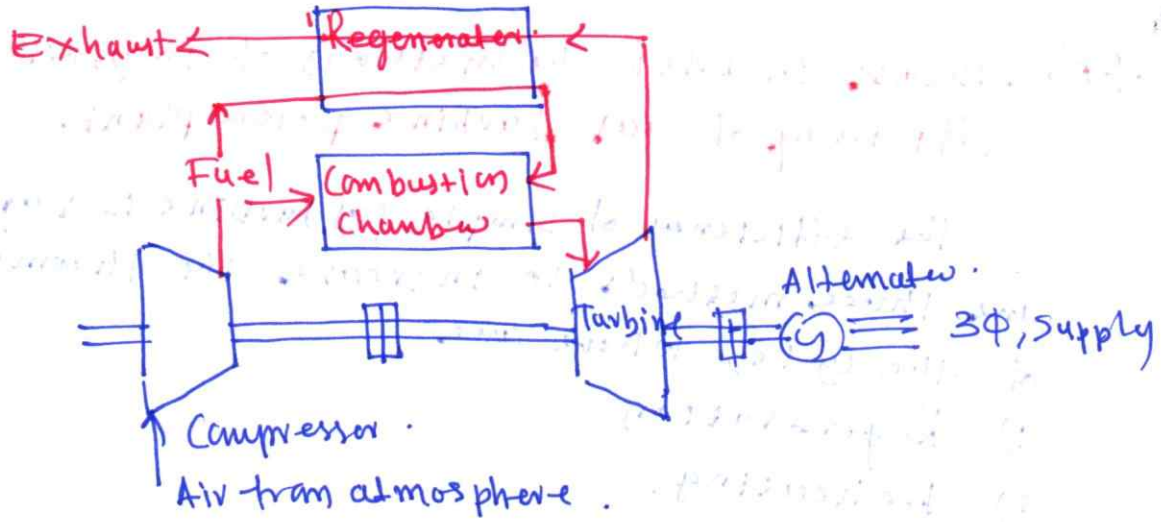
The efficiency of simple gas turbine is very low. There are three methods to increase the thermal efficiency of the cycle, where are

1) Regeneration
2) Reheating.
3) Intercooling.

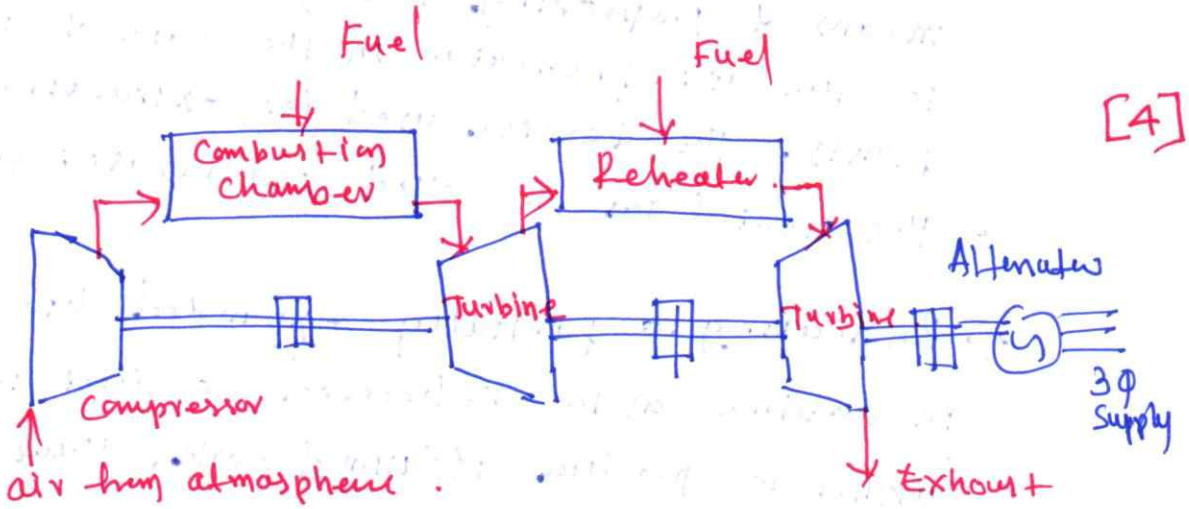
1) Regeneration :⇒ Recovering waste heat from the high temperature exhaust gases of a gas turbine is a means of improving the cycle efficiency. It is similar to the air preheater in the case of thermal power plants. The device used for extracting the heat from the heated gas is called regenerator (or) heat exchanger

2) Reheating :⇒ partially expanded high-temperature gas in turbine can be reheated so that it can be expanded further to produce additional work. There may be several stages of heating. If only one turbine is there, then there will be no use of reheating. In two-stage turbine, one reheater can be used, as it improves the performance of the gas turbine, by improving the output from the turbine due to multiple heating. [4]

3) Intercooling :- Compressor consumes very high energy & therefore two compressors are used with intercooling, which acts as a heat exchanger, the power required to run the compressor could be reduced because reduction in the volume of air-cooled. Intercooling result to the enhancement of thermal efficiency, air rate and work ratio.

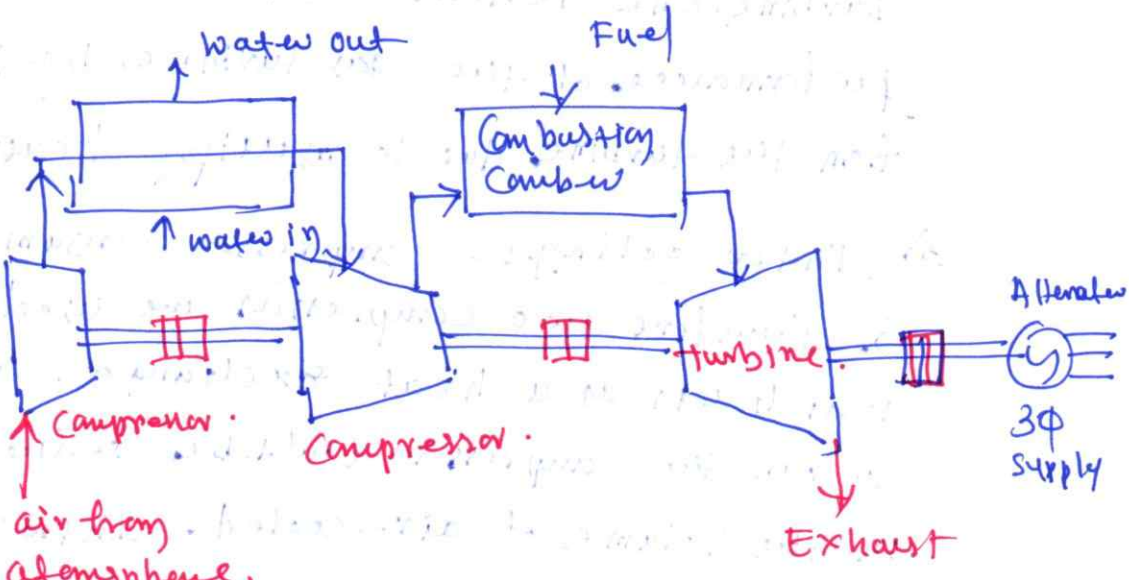


fig(a) Gas turbine plant with regenerater.



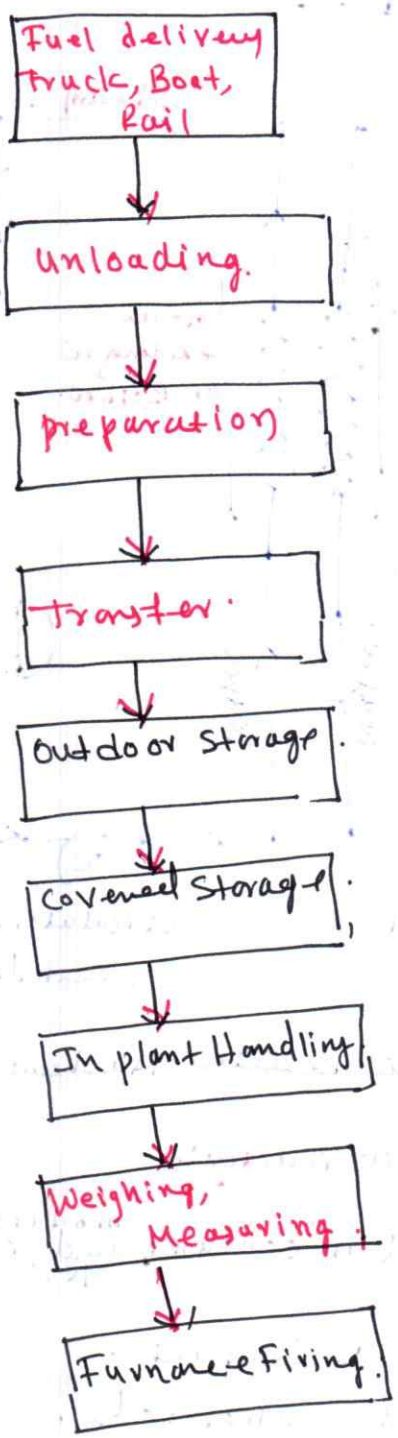
[4]

fig(b) Gas turbine plant with reheeater.



fig(c) Gas turbine plant with intercooler.

4c) With a flow diagram, explain the fuel handling system. [4]



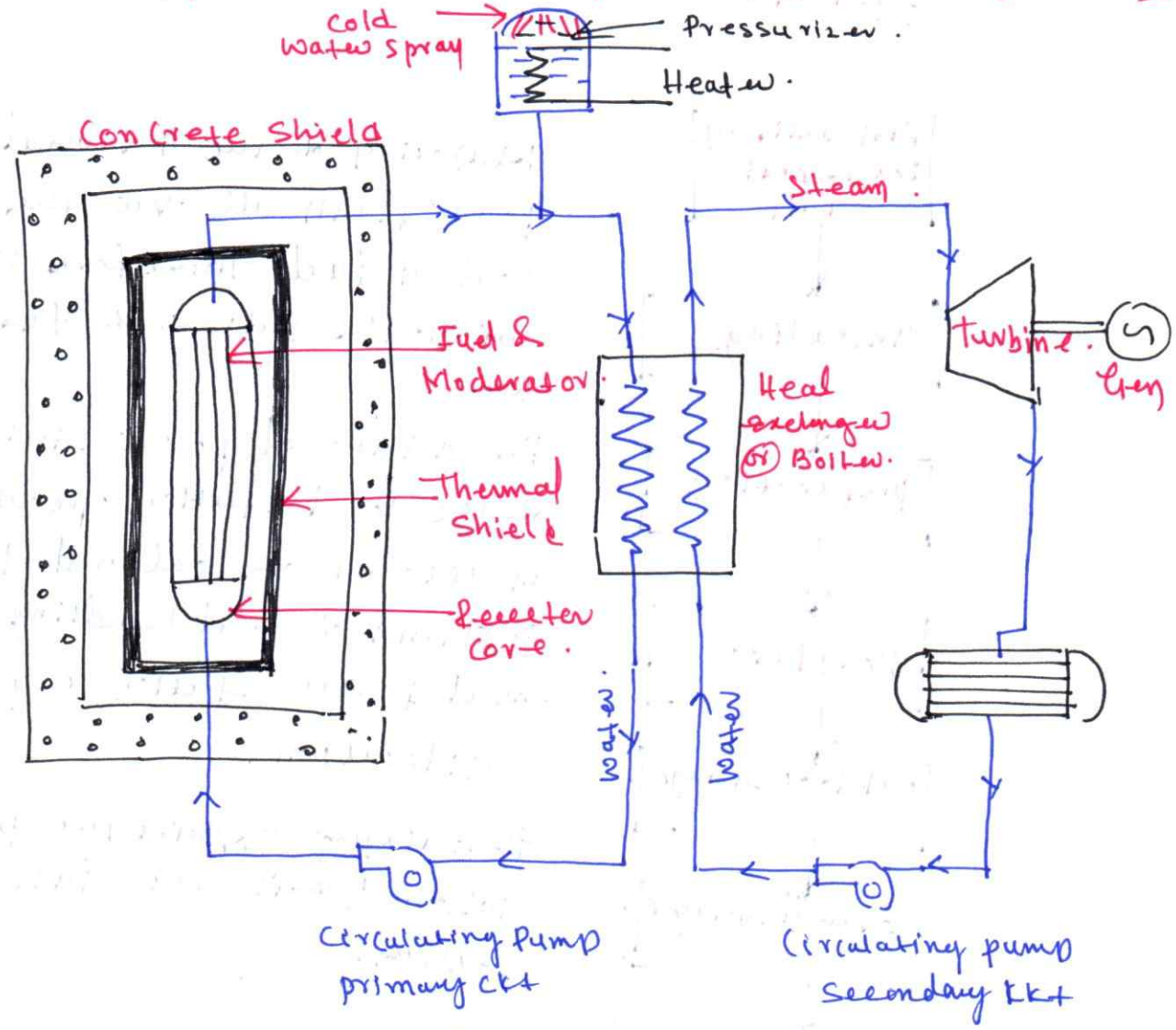
Majority of the thermal (steam) power plants all over the world use coal as fuel.

In a thermal power station half of the total station operating cost is on account of coal and therefore problems of coal handling for a thermal power station require careful consideration.

Flow diagram explains the process followed while the fuel handling system. [4]

fig. Flow diagram of fuel handling system.

5a) Draw a neat diagram of pressurized water reactor and explain it's advantages and disadvantages. [8]



fig(a) pressurized water Reactor Nuclear power plant

Advantages of pressurized water reactor:-

1) In this type, water is used as coolant, moderator & reflector

2) The pressurized water reactor is compact.

3) It requires less number of control rods.

4) The Separation of secondary ckt from primary provides the safety and prevents the radiation.

5) In this type, the turbine, feed heaters and condenser can be inspected freely.

6) It reduces the fuel cost.

Disadvantages

1) The cost of pressuriser is more.
2) Thermodynamic efficiency of this reactor is low.
3) The corrosion is accelerated in the presence of high pressure, high temperature water.
4) Fuel charging, it requires a lot of time.

5b) Write briefly about Nuclear Waste Disposal [6]

Nuclear waste disposal involves the management, storage and permanent isolation of radioactive materials resulting from nuclear power generation,

Key aspects of nuclear waste disposal include.

- Waste classification: Waste is generally categorized based on radioactivity level. [6]
- Storage Method: Before final disposal, high level waste is typically stored for several years in water-filled "cooling pools" at reactor sites, followed by long-term dry storage in concrete and steel containers (casks).
- Deep Geological Disposal: This is the internationally accepted, scientifically backed long term solution for HLW. It involves burying waste in deep, stable rock formations (300-1000 mtrs down) to isolate it from the biosphere.
- Near-Surface Disposal:- used for low-level radioactive waste (LLW), which involves placing waste in engineered concrete vaults or trenches.

- Reprocessing / Recycling :- Spent fuel can be reprocessed to recover uranium and plutonium, reducing the final volume of high-level waste.

5c) What is nuclear reactor? How are nuclear reactor classified? (6)

Nuclear Reactor: is an apparatus which is used to extract the heat produced by the nuclear fission chain reaction. In other words, a nuclear reactor is a controlled chain-reacting system supplying nuclear energy. (2M)

Classification of Reactors

Nuclear reactors can be classified on the following basis.

a) On the basis of neutron energy the reactors are classified as 1) Thermal reactors
2) Fast reactors.

b) On the basis of fuel used
1) Natural uranium
2) Enriched uranium (4M)

c) On the basis of Moderator used
1) Graphite reactors
2) Beryllium reactors.

d) Based on coolant used
(1) water cooled reactors
(2) Gas cooled reactors.
(3) liquid metal cooled reactors.

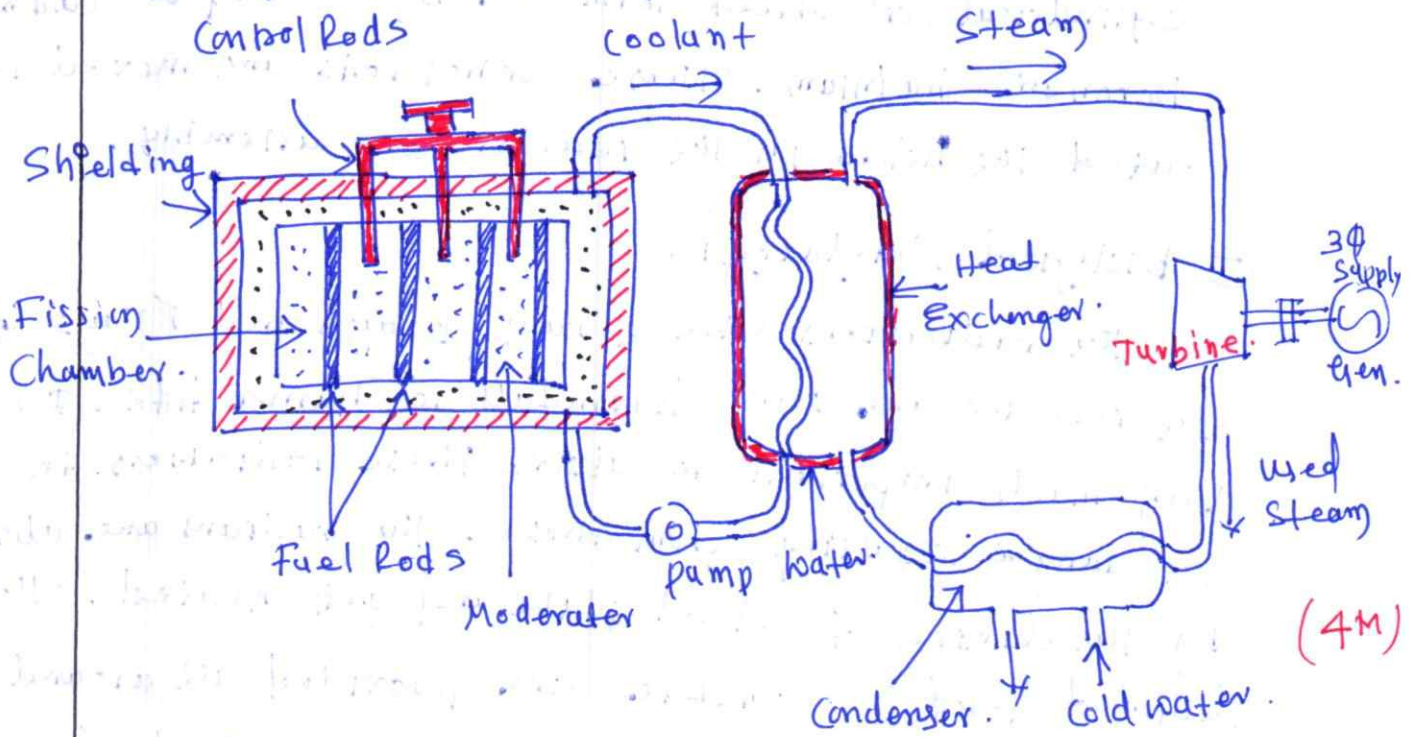
④ organic liquid cooled reactors.

e) Based on type of core used.

1) Homogenous reactor

2) Heterogenous reactors.

6 a) With a neat sketch, Explain main parts of Nuclear Reactors. [10]



(4M)

fig:- Nuclear Reactor.

① Nuclear fuel :- Nuclear fuel is the fissionable material used in nuclear reactor, generally U-233, U235, and Pu-239 is taken as nuclear fuel in form of cylindrical rods arranged in regular pattern in the active reactor core. However, the Valume of core is filled with material of light nuclei called moderator. (6M)

② Moderator :- Moderater is used to slow down the velocity of neutron. It reduces the kinetic energy of fast neutron to slow neutron. The chain reaction

can be maintained by the slow neutrons when the ordinary uranium is used as fuel. The graphite, heavy water (or) beryllium are used as moderator with natural uranium.

③ Control rods: Since the amount of energy released is enormous, a high control is necessary to prevent the melting of fuel rods, disintegration of coolant and destruction of reactor. The controller rods are in the cylindrical (or) sheet form and is made up of cadmium, boron (or) hafnium. These control rods are moved in and out of the holds in the reactor core assembly.

④ Biological shielding:-

The radiations like α rays, β rays and γ rays from the reactor are very harmfull to human life. It is very much important to absorb these radiations to prevent the danger resulting from these. The radians are absorbed by the lining of steel plate and gets heated. Thick layers of lead (or) concrete are provided all around the reactor for stopping the gamma rays. Thick layers of metal (or) plastics are sufficient to stop the alpha & beta particles.

⑤ Coolant: Coolant flows through the reactor core. The large amount of heat produced in the reactor due to fission of the nuclear fuel are transferred by the coolant. The coolant transfer heat taken from the reactor to another medium (or) Some time water will be acting as coolant. In this case, water gets heated up and converted into steam.

6.b) Explain the construction and working of 'Gas cooled reactor'. What are its advantages and disadvantages [10]

Gas cooled reactor uses a gas, CO_2 or helium as a coolant instead of water & graphite as a moderator. A heat exchanger is required. Gas is circulated through the reactor core & heat exchanger by means of a blower or a gas compression. even though gas is inferior to water from the view point of heat transfer property, but it offers numerous advantages which are not available with H_2O. A large quantity of gas is required for circulation, resulting in increased power consumption for auxiliary, therefore overall plant efficiency is low.

Advantages of gas cooled reactor:

1. Less severe corrosion problems
2. possibility of use of natural uranium as fuel.
3. Greater Safety in Comparision with water cooled reactors.
4. Contamination problems are moderate.
5. low pressure coolant and relatively high reactor temperature.

Disadvantages of gas cooled reactor:

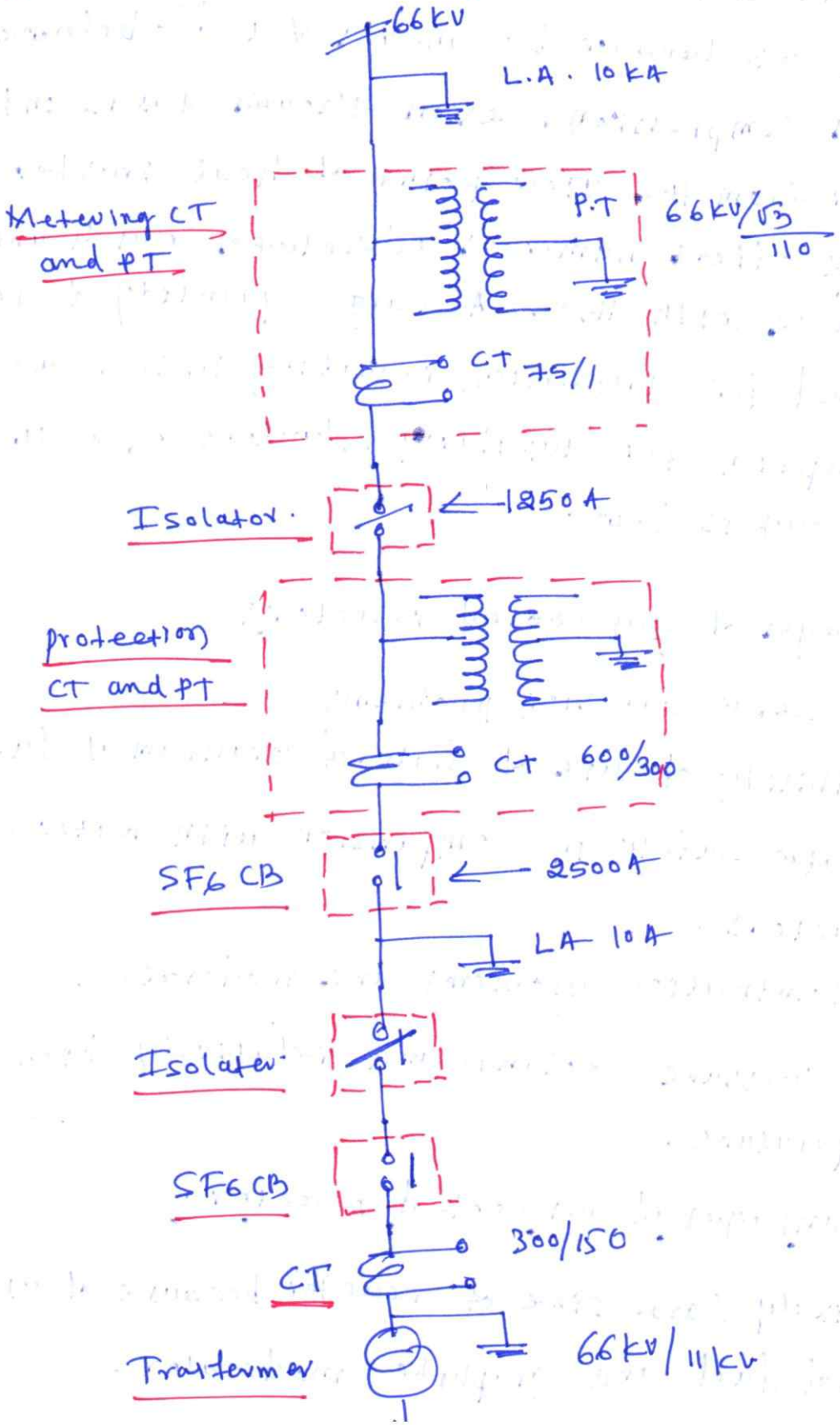
1) Relatively large size of reactor because of use of natural fuel and graphite moderator.

2) Extremly low power density

3) low steam pressure & temperature

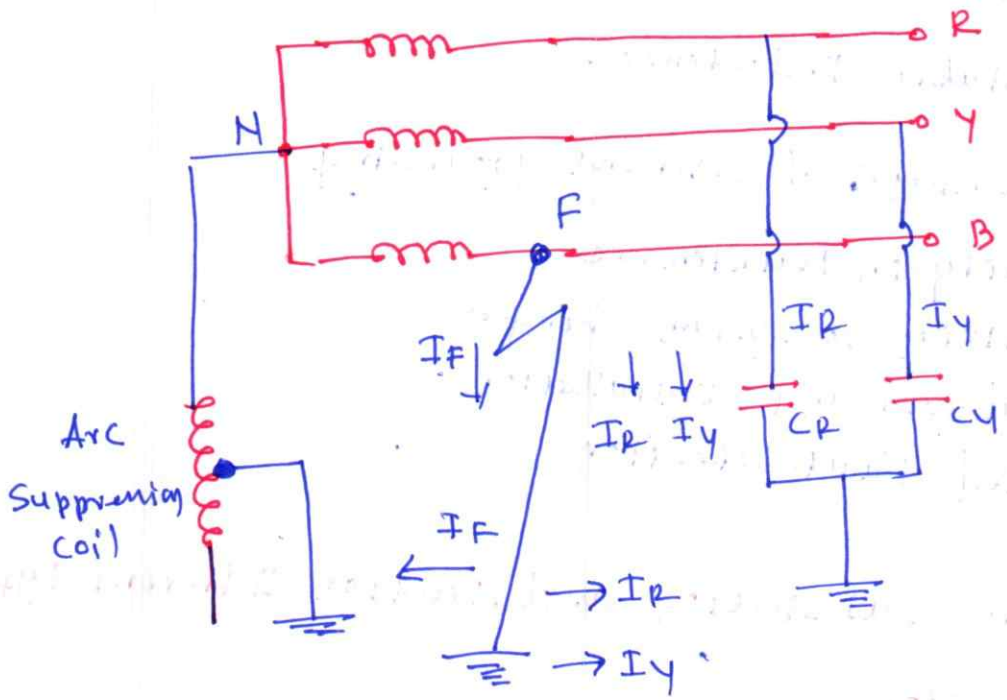
4) large energy Consumption by gas bellowers beeuse of poor heat trasfer characteristics of gases.

7a) Draw the line diagram of 66/11 KV substation (06)



(6M)

7b) Explain resonant grounding with a neat diagram and also list the advantages & disadvantages. (8)



(3)

fig. Schematic diagram of Resonant Grounding.

Resonant grounding is also known as arc suppression coil grounding as it uses an arc suppression coil in the neutral earthing circuit. i.e the neutral of the system is connected to the ground through an adjustable iron cored reactor known as arc suppression coil. It is a special case of reactance grounding. A three phase system with resonant grounding along with an earth fault at point F in phase R is shown in fig. (3)

Advantages of resonant grounding

1. Prevention of Arcing grounds.
2. Reduced Fault currents
3. Operational Continuity
4. Adjustable Inductance.

(2)

Disadvantages of resonant grounding

1. Complexity in Maintenance
2. Sensitivity to System Changes
3. Initial Cost and Installation
4. Limited Fault Detection

7c) Define Substation and Mention different types of Substation. (6)

A substation is a systematic arrangement of electrical equipment like transformers, circuit breakers, isolators, and more, which is designed and developed to change some electrical parameters like current, voltage, frequency, etc of the electrical supply.

* Types of substation According to service requirement
  1. Generating SS
  2. Transformer SS
  3. Switching SS
  4. power factor, correction Substation etc.

SS → Substation

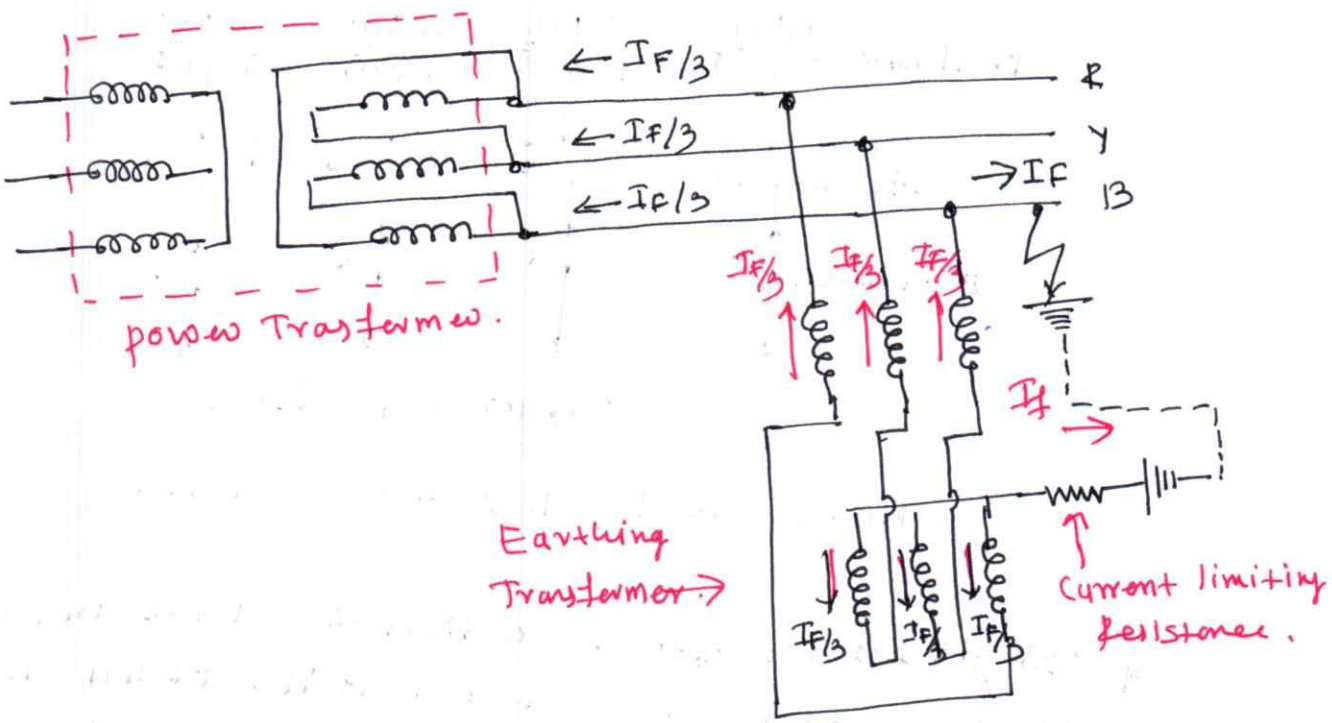
* Types of Substation based on Construction
  1. Indoor & outdoor substation
  2. underground Substation
  3. pole-mounted substation

* Based on Voltage level
  1. Step-up & step down substation
  2. primary grid substation
  3. Secondary substation
  4. Distribution substation.

(6)

* Based on Insulation Medium
  1. Air Insulated Substation (AIS)
  2. Gas Insulated substation (GIS)
  3. Hybrid substation.

8 a) Explain Earthing transformer with neat diagram (6)



fig(a) Earthing Transformer.

A earthing transformer is a type of auxiliary transformer used in three-phase electric power systems to provide a ground path to either an underground wye (or) a delta connected system. Grounding transformers are part of an earthing system of the network. They let three-phase (delta connected) systems accommodate phase to neutral

by providing a return path for current to a neutral.

8b) Draw a neat Single bus bar system and explain it. (8)

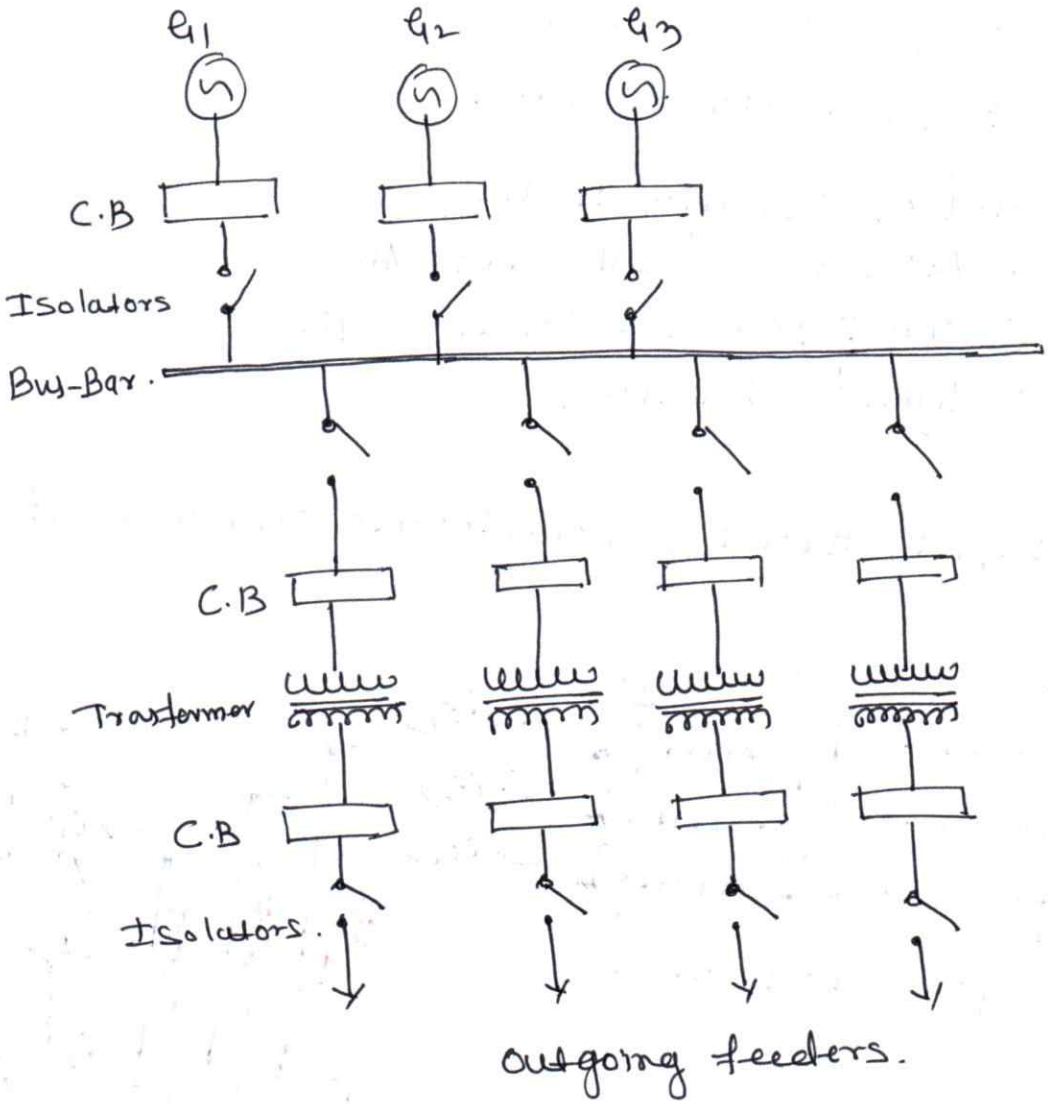


fig. Single Bus-Bar Arrangement.

[4]

* Single bus bar system consists of all the incoming and outgoing lines are connected to it. It has the following advantages such as 1) Low initial cost, 2) Less mentainance 3) Simple operation.

* Major drawbacks of this system are
  1) During the maintanance the complete supply will be interrupted.
  2) Difficult to do any maintanance.
  3) Bus cannot be extended without completely de-energizing the substation.

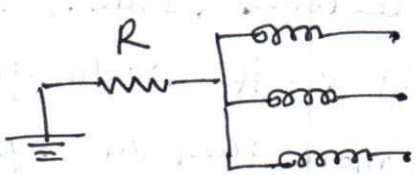
[4]

4) used only where loads can be interrupted or other supply arrangements.

8. c) Write a short Note on: (06)

1) Resistance grounding
2) Reactance grounding

1) Resistance grounding :⇒



* When the neutral point of 3φ system is connected to earth through a resistor is called as resistor grounding.
* To limit fault current to safe value, grounding resistor is inserted between neutral and the earth.
* R is chosen such that the earth fault current is carried to safe value but still sufficient to permit the operation of the earth fault protection system. (3)
* In practice 'R' is selected that limit the earth fault current 2 times the normal full load current of the earthed generator (or) trasformer.
* If R is very high system conditions becomes similar to ungrounded system.
* If R is too low system becomes similar to solid grounding system.

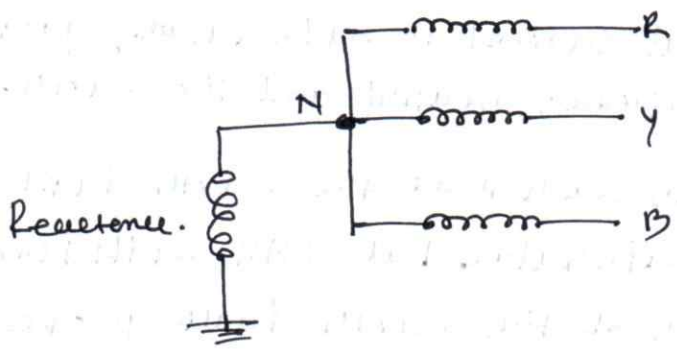
2) Reactance grounding :⇒

An impedance or reactance is connected between the neutral of the system and ground is called resistance grounding. This method is also used to limit the high fault current. the reactance grounding method is

employed for transmission whose fault current is very high and voltage is level between 3.3kV to 33kV.

The reactance grounding is used where the charging current of the circuit is high. In the reactance grounding system reactance is added in series with neutral of the system which increases the lagging current and the lagging current naturalized the capacitive current. (3)

If the selected reactance value is smaller than the system work as solidly or effectively grounded system. If the selected value is more than the system it works as an isolated system.



9a) Define tariff. Explain different types of tariffs (any two type) (6)

Electricity tariffs are pricing structure used to charge consumers based on energy consumption, demand, and other factors, with multiple types designed for different usage patterns and consumer categories.

1) Two part tariff [Hopkinson Demand Rate]

In this rate of electrical energy is charged on the basis of maximum demand of the consumer and units consumed called as two part tariff.

The total charge to be made to the consumer is split into two components namely fixed charge and running charge. (31)

Tariff = b + c.x = Fixed + (Rate) x No. of units.

Fixed charge depend upon the maximum demand of the consumer. (3)

Running charge depends upon the number of units consumed by the consumer.

Total charges = Rs [b x kw + c kwh]

Three part tariff (Dohirty Role)

In this total charge is split into three elements namely fixed, semi fixed and variable charges.

total charge = Rs [a + b.kw + c.kwh] (3)

a → Fixed charge made during each billing period
b → charge / kw of max. demand
c → charge / kwh energy consumed.

This type applicable to bulk supplies.

9b) Explain the main disadvantages and causes of poor power factor. (6)

Disadvantages of low (poor) power factor

1) large kVh rating of equipments → we know that kVA = kW / cos ϕ ∴ Low p.f. the kVA rating of the equipment is more to deliver the fixed value of kW and hence makes equipment larger and expensive.

b) Greater Conductor size :⇒ we know that $I = P/V\cos\phi$ to transmit or distribute a fixed amount of power at constant voltage the conductor will have to carry more current at low p.f. This makes use of large conductor size.

c) Large copper loss :⇒ large current at low power factor causes more I^2R losses in the elements of supply system ∴ poor efficiency. [4]

d) Poor Voltage regulation :⇒ The large current at low power factor causes greater voltage drops in alternators, transformers and in lines, Hence Voltage regulation is poor.

Causes of low power factor

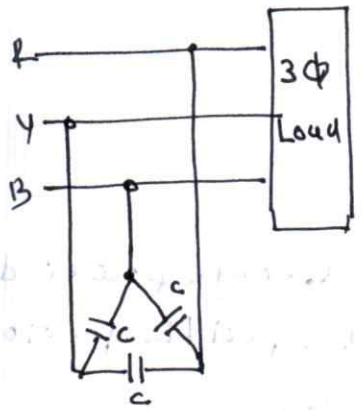
1) 1φ & 3φ Induction motor Operates on at LPF.
2) Arc lamps, electric discharge Lamps, Industrial heating furnaces operated at LPF. [2]
3) Incandescent lamp, Neon lamp, Fans, Induction Motors, Resistance furnaces, Arc furnaces, Arc welders are causes of Low power factor.

9c) Discuss the measures by which low power factor can be avoided. (8)

Equipments used For Improving p.f are as follows

a) Static Capacitors.
b) Synchronous Condensers
c) Phase advancers.

a) Static capacitors:



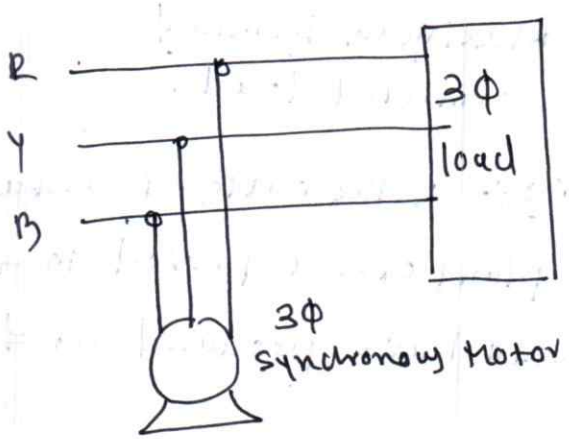
Capacitors connected across the load with the load which is operating at lagging power factor

advantages of static capacitors (3)

1) They have low lossy
2) No rotating parts and low maintenance
3) easily installed and require no fundation
4) work under ordinary atomspheric conditions.

b) Synchronous condenser:-

Synchronous motors take a leading current, when it is operated at over excited state. at this condition Synchronous motor acts as Synchronous Condenser. By connecting the Synchronous Condenser across the load the p.f is improved from ϕ_2 to ϕ_1.



(3)

c) phase advancers (diverter)

phase advancers is related to p.f improvement technologies. these devices work by providing the (2) necessary reactive power (leading current) to the motor's rotor circuit, reducing the lagging reactive power (KVAR) drawn from the supply, and thus bringing the power factor closer to unity.

10.a) Define the following terms applied to power system. (6)

1) Load factor
2) Demand factor
3) Plant Capacity factor.

1) **Load Factor** :- is the ratio of average power demand to maximum (peak) demand over a specific period.

$$\text{Load Factor} = \frac{\text{Average load}}{\text{Maximum Demand}}.$$

It measures electricity usage efficiency, with a high load factor (close to 1 to 100%) indicating consistent, efficient power consumption and lower costs, while a low factor suggests high, sporadic peak demands. (2)

2) **Demand Factor** :- is the ratio of the maximum demand to the total connected load, usually expressed as a value less than 1. (2)

$$\text{Demand Factor} = \frac{\text{Maximum Demand}}{\text{Connected load}}.$$

3) **plant Capacity Factor** :- is the ratio of actual energy produced by a power plant over a period to the maximum possible energy it could have produced at full rated capacity. (2)

$$\text{Plant Capacity factor} = \frac{\text{Average demand}}{\text{plant capacity}}.$$

10.b) An industrial undertaking has connected load of 800 kw. the maximum demand is 150 kw. on average each machine works for 70% of time, Find yearly expenditure on electricity if the tariff is Rs. 3000 + Rs. 700 per kw of maximum demand per year + Rs 0.60 per kwh. [8]

Given:- • connected load = 200 kW
• Maximum demand = 150 kW
• Average working time of each machine = 70%.

Tariff • Fixed charge = Rs 300 per year
• Demand charge = Rs 700 per kW of Max demand per year
• Energy charge = Rs 0.60 per kWh. [1]

Assume the plant operates throughout the year (8760 hours)

1) Average load

Average load = connected load × Avg work hours.

Average load = 200 × 0.7 [1]

Avg load = 140 kW

2) Annual Energy Consumption

Energy = Avg load × hours per year = 140 × 8760

= 1226 400 kWh [1]

3) Energy Charge

Energy cost = 1226 400 × 0.60

= Rs 735,840. [2]

4) Maximum Demand charge

Demand cost = 150 × 700

= Rs 105,00 [2]

5) Fixed charge:

Rs = 300

6) Total Yearly Expenditure

total cost = 735 840 + 105000 + 30

total cost = Rs 841,140 [1]

10.c. Explain the concept of Load sharing and choice of size and number of generating plants. [6]

Load sharing is the process of distributing the total load among the different generating units or power plants operating in a power system.

The main objective is to supply the required power demand economically, reliably, and efficiently.

Example :- Suppose a power station has three generators of capacities. 1) 20MW 2) 30MW 3) 50MW

if the total load demand is 70 MW, the load may be shared as

Gen 1 → 20MW, Gen 2 → 25MW, Gen 3 → 25MW

Thus, the total load is shared among all generators, [4]

Choice of size and number of generating units

The selection of the size and number of generating unit in a power station is an important design factor. It affects the efficiency, reliability and cost of power generation.

Factors Affecting the Choice [3]

1) Load demand
2) Load curve
3) Reliability and continuity
4) Efficiency
5) Maintenance Requirements
6) Future expansion
7) Economic Considerations.

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