Chapter-5 Hydel Power Plant

5.1 State advantages and disadvantages of hydroelectric power plant.

5.2 classify and Explain the genereal arerecangement of storeage type hydroelectric projeat and Explain its opereation.

Hydel powere plant

It is also known as hydreo electreic powere plant. The powere plant which utilizes the potential energy of watere to produce electric energy is known as hydreo electrric powere plant.

Basic principle of hydel powere plant

PE → KE → ME → EE

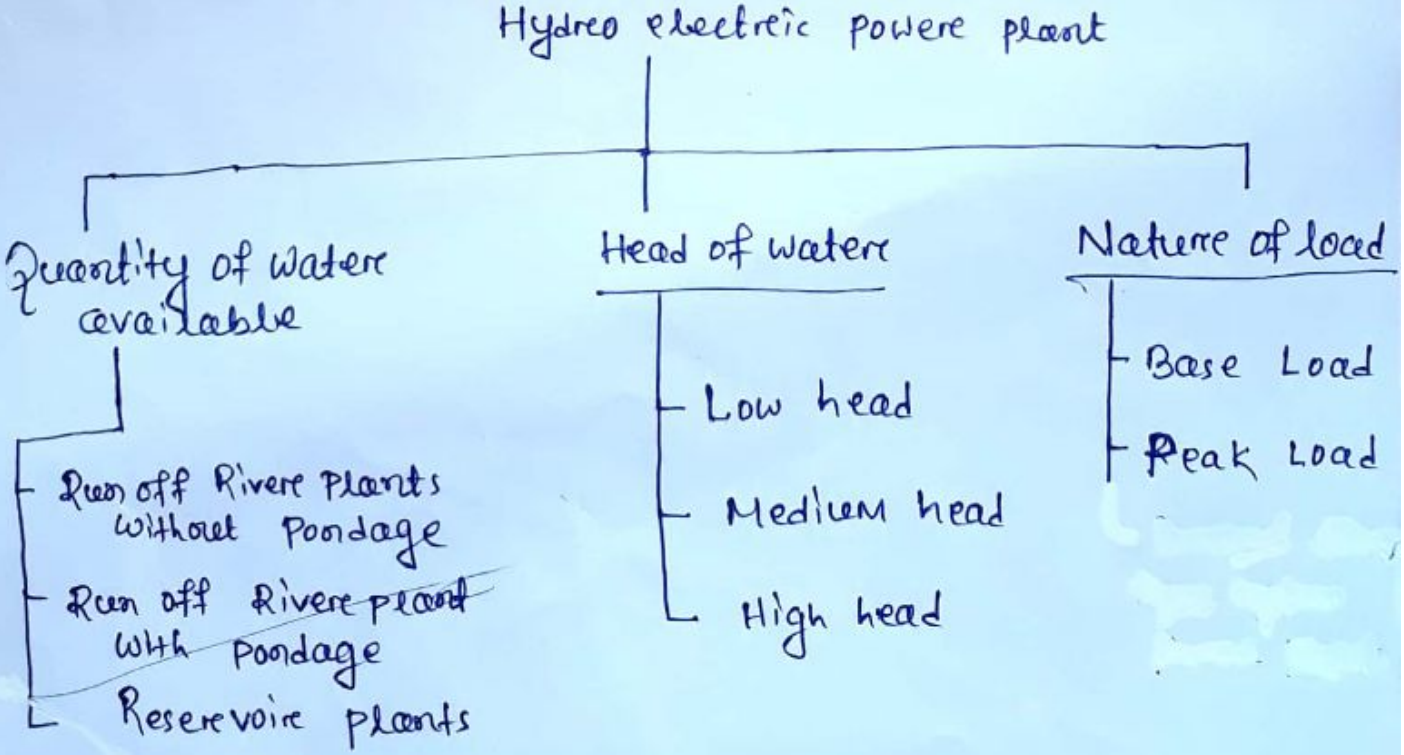
PE – Potential energy

KE – Kinetic energy

ME – Mechanical energy

EE – Electreical Energy

Classifration of Hydreo-electreic powere plant



Run of River plants without pondage

- In this type of plant, the available water from river or lake is not stored in pond.
- Whenever water is available it is directed used to run water turbine.
- Its capacity depends on rate of flow of water.
- It may run during rainy season.

Run off River plants with pondage.

- In this type of power plant the water from rivers or lakes are stored in a pond.
- Due to storage of water in pond, this plant can be run during off peak and peak periods.
- The capacity of this type of plants depends upon the size of pond.

Reserevoire plants

- A reserevoire can store a large quantity of water during rainy season which is useful throughout the year.
- It may be used as base load power plant.
- It has better capacity as compared to the other two.

According to available water head

Low head plants

These plants have waterehead below 30 M.

Medium head plant

If the available head is between 30 and 100 M the plant is called a medium head plant.

High head plant

If the available is more than 300 M, the plant is called high head plant.

According to Nature of load

Base load plants

The conveying load which occures almost the whole day on the powere station is known as Base load. such plants are called base load plants.

Peak load plants

The plants which ~~reven~~ fore Peak demands of load overe & above the base load is known as peak load plants.

Major components of hydro-electric power plant. Storage type

The main components are

- Catchment Area
- Reserevoire
- Treacy rash
- Dam
- Spill Way
- Penstock
- Surege tank
- Valve house
- Powere house
- Preime Movere ore Turebine
- Dreaft tube
- Tail race.

1. Catchment Area

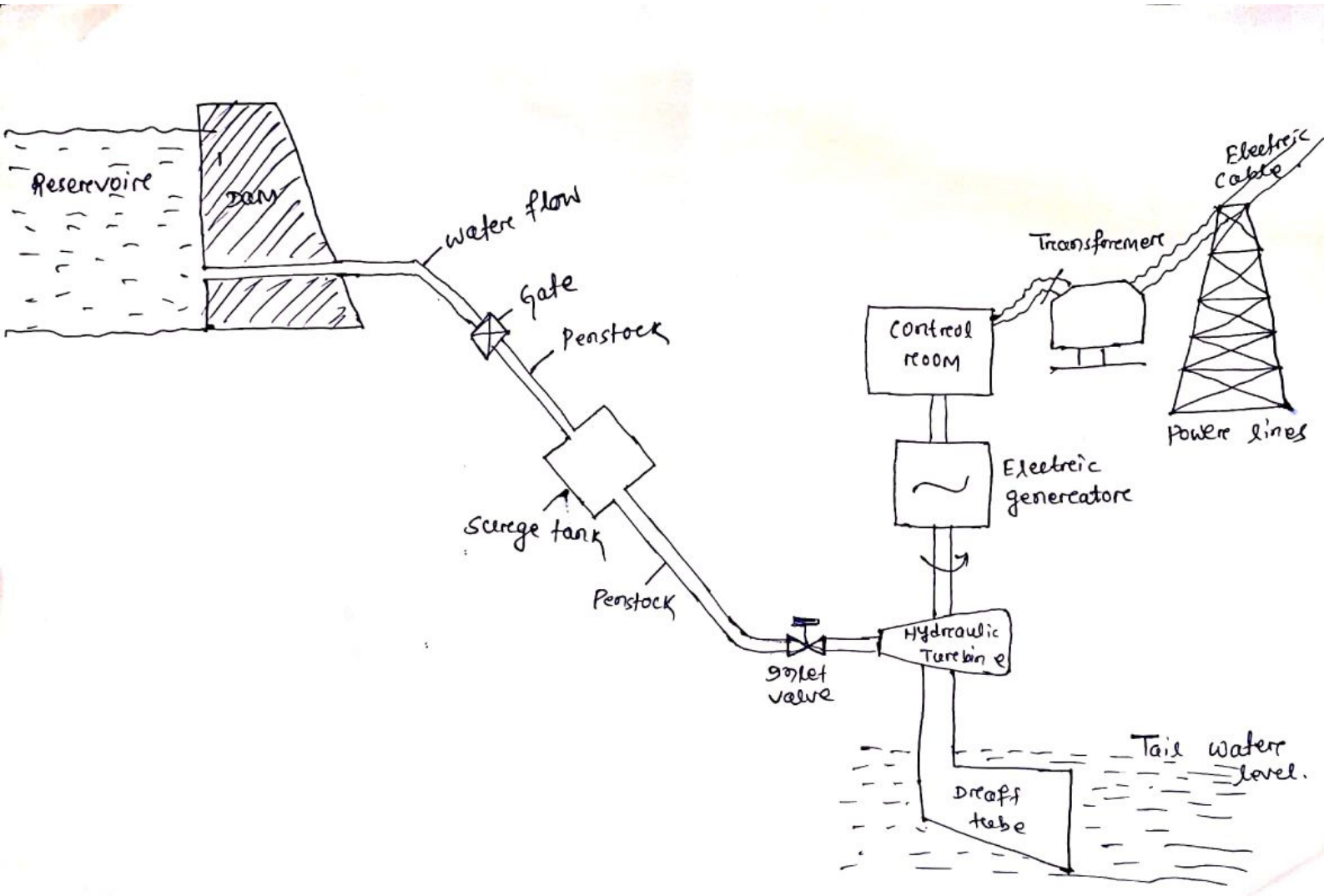
A hydro electric powere plant collects rain watere through surerererending hilly areas, those areas are known as catchmeat area.

2. Reserevoire

The function of reserevoire is to storee the watere which is latere usefol fre producmey powere.

3. Treacy rash

It is used in hydro-electric powere plant to fistere the watere befree it flous towards turebine thus removes impureitres, present stirred watere.



Storage Type hydro electric power plant

Dam

- The dam is used to store water in hydel power plant.
- It provides a suitable head to stored water
- This water is useful through out the year to run hydro electric power plant.
- It is Made up of cement, concrete and sand Material

Spill way

The excess water from dam is discharges through spillway at a permissible level.

Penstock

- A penstock in a hydro-electric power plant carry water down from the reservoire to the turbines.
- It converts potential energy of water into Kinetic energy.
- It is made up of cast iron or concrete Material.

Surege Tank

- Surge tank is a watere storeage device used as pressure reelefe regulatore in hydro-electric powere plant to resists excess pressure rise and pressure conditions.

Valve house

It is installed neare powere house, its function is to start or stop the flow of watere towards turebine.

Powere house

The powere house of a hydro electric powere plant is the place where kinetic energy of the watere ~~flowing~~ ~~the~~ is transformed in to mechanical energy of rotating turebines and which is then further converted to electrical energy by generators.

Draft tube

- Draft tube ~~connects~~ is a pipe of gradually increasing area which connects the outlet of the runner to the tail race
- By using draft tube the KE at outlet of turebine is converted to pressure energy.
- By using draft tube the turebine may be placed above the tail race and hence it can be inspected properely.

Tail race

After powere generation in the hyded powere plant the water from turebine discharges to river or

lake through tail reace.
from ground level to the turebine some height is maintained to discharge the water.

Working of Hydel plant

- Initially water flows from catchment area to the dam.
- At the dam the water gets accumulated. Thus the potential energy of the watere increases due to the height of the dam.
- When the gates of the dam are opened then the watere moves with high KE in to the penstock and then to turebine house.
- In the power house the pressure of the watere is controlled by the controlling valve as per the requirements.
- When the watere with high KE strikes the turebine blades, the shaft of the turbine which is coupled to generatore starts rotating.
- Due to the rotation of generatore the ac current is produced which is used for commercial purposes.

Advantages

1. There is no fuel cost as water is available in nature.
2. There is no fuel transportation cost.
3. There is no air pollution
4. Operating & maintenance cost are very low.
5. Efficiency of the plant is very high.
6. The life of the plant is longest.
7. In addition to generation of electric energy H.P.P is also useful for supply of ~~drinking~~ water for drinking, irrigation etc.

Disadvantages

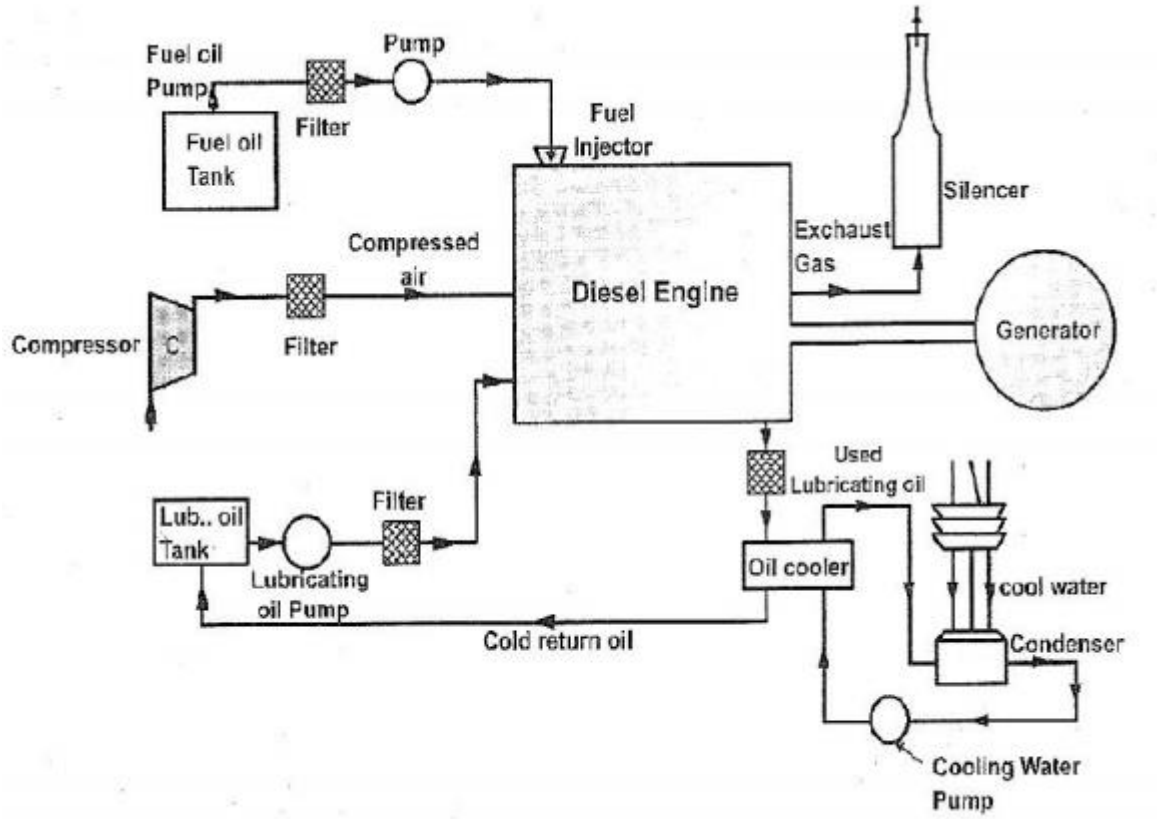
1. High capital cost due to construction of dam.
2. It depends on nature as it requires huge amount of water which is stored during rainy season.
3. Power output of the Plant depends on Monsoon.
4. It takes a long time for establishing such plants.
5. It requires larger area.
6. There is limitation to select the sites of Hydel power plant.

DIESEL POWER PLANT

INTRODUCTION

- Diesel engine power plants are installed *where supply of coal and water is not available in sufficient quantity* or *where power is to be generated in small quantity* or *where standby sets are required for continuity of supply such as in hospitals, telephone exchanges, radio stations and cinemas.* These plants in the range of 2 to 50 MW capacity are used as *central stations* for supply authorities and works and they are universally adopted to supplement hydro-electric or thermal stations where standby generating plants are essential for starting from cold and under emergency conditions.
- In several countries, the demand for diesel power plants is increased for electric power generation because of difficulties experienced in construction of new hydraulic plants and enlargement of old hydro-plants. A long term planning is required for the development of thermo and hydro-plants which cannot keep the pace with many times the increased demand by the people and industries.
- The diesel units used for electric generation are *more reliable* and *long-lived piece of equipment* compared with other types of plants.

LAYOUT OF DIESEL POWER PLANT



OPERATION OF DIESEL POWER PLANT

When diesel alternator sets are put in parallel, "*hunting*" or "*phase swinging*" may be produced *due to resonance* unless due care is taken in the design and manufacture of the sets. This condition occurs *due to resonance between the periodic disturbing forces of the engine and natural frequency of the system.* The engine forces result from uneven turning moment on the engine crank which are corrected by the flywheel effect. *"Hunting" results from the tendency of each set trying to pull the other into synchronism* and is characterised by flickering of lights.

To ensure *most economical operation of diesel engines* of different sizes when working together and sharing load it is necessary that they should carry the same percentage of their full load capacity at all times as the fuel consumption would be lowest in this condition. For best operation performance the manufacturer's recommendations should be strictly followed.

In order to get good performance of a diesel power plant the following points should be taken care of :

1. It is necessary to maintain the *cooling temperature* within the prescribed range and use of very cold water should be avoided. The cooling water should be free from suspended impurities and suitably treated to be scale and corrosion free. If the ambient temperature approaches freezing point, the cooling water should be drained out of the engine when it is kept idle.

2. During operation the *lubrication system* should work effectively and requisite pressure and temperature maintained. The engine oil should be of the correct specifications and should be in a fit condition to lubricate the different parts. A watch may be kept on the consumption of lubricating oil as this gives an indication of the true internal condition of the engine.

3. *The engine should be periodically run even when not required to be used and should not be allowed to stand idle for more than 7 days.*

4. *Air filter, oil filters and fuel filters* should be periodically serviced or replaced as recommended by the manufacturers or if found in an unsatisfactory condition upon inspection.

5. Periodical checking of engine compression and firing pressures and also exhaust temperatures should be made.

- The engine exhaust usually provides a good indication of satisfactory performance of the engine. *A black smoke in the exhaust is a sign of inadequate combustion or engine overlocding.*
- *The loss of compression resulting from wearing out of moving parts lowers the compression ratio causing inadequate combustion.* These defects can be checked by taking *indicator diagrams* of the engine after reasonable intervals.

APPLICATION

The diesel power plants find wide application in the following fields :

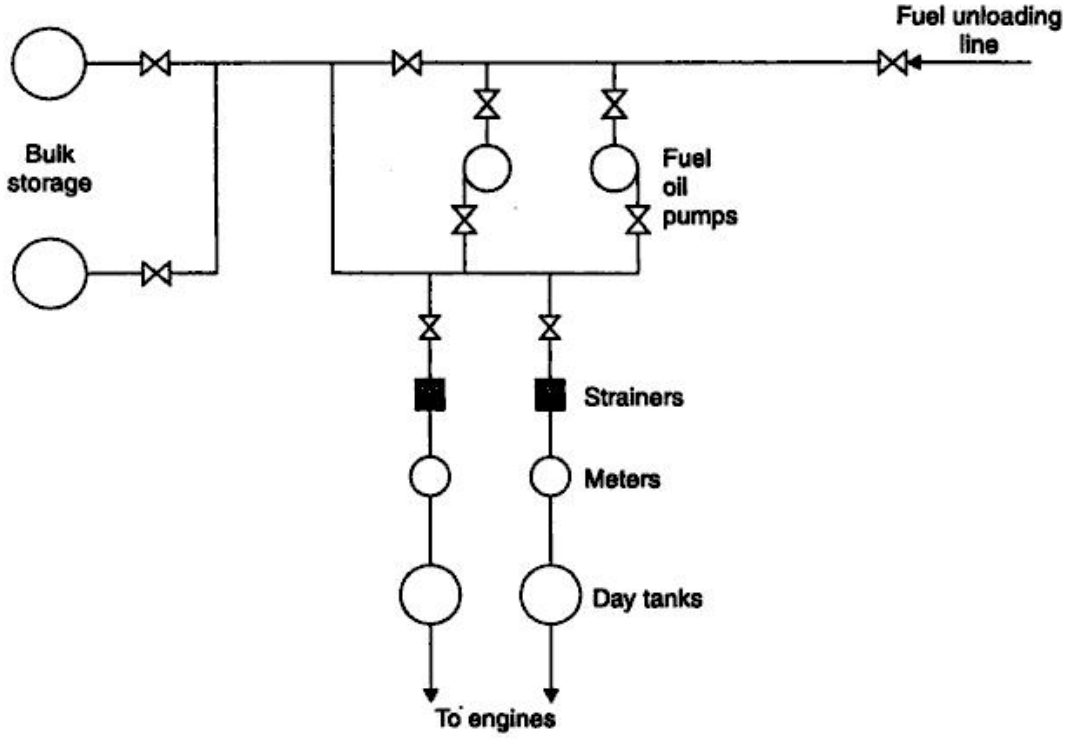
1. Peak load plant
2. Mobile plants
3. Standby units
4. Emergency plant
5. Nursery station
6. Starting stations
7. Central stations—where capacity required is small (5 to 10 MW)
8. Industrial concerns where power requirement is small say of the order of 500 kW, diesel power plants become more economical due to their higher overall efficiency.

FUEL SYSTEM

The fuel oil may be delivered at the plant site by trucks, railroad tank cars or barge and tankers. From tank car or truck the delivery is through the unloading facility to main storage tanks and then by transfer pumps to small service storage tanks known as *engine day tanks*. Large storage capacity allows purchasing fuel when prices are low. The main flow is made workable and practical by arranging the piping equipment with the necessary heaters, by passes, shut-offs, drain lines, relief valves, strainers and filters, flow meters and temperature indicators. The actual flow plans depend on type of fuel, engine equipment, size of the plant etc. The tanks should contain manholes for internal access and repair, fill lines to receive oil, vent lines to discharge vapours, overflow return lines for controlling oil flow and a suction line to withdraw oil. *Coils heated by hot water or steam reduce oil viscosity to lower pumping power needs.*

The minimum storage capacity of at least a month's requirement of oil should be kept in bulk, but where advantage of seasonal fluctuations in cost of oil is to be availed, it may be necessary to

provide storage for a few month's requirements. *Day tanks* supply the daily fuel need of engines an may contain a minimum of about 8 hours of oil requirement of the engines. These tanks are usuall placed high so that oil may flow to engines under gravity.



For satisfactory operation of a fuel oil supply system the following points should be taken care of :

1. There should be provisions for cleanliness and for changing over of lines during emergencies.
2. In all suction lines the pipe joints should be made tight.
3. Before being covered, all oil lines should be put under air pressure and the joints tested with soap solution. Small air leaks into the line can be the source of exasperating operating difficulties and are hard to remedy once the plant is in operation.
4. The piping between filter and the engine should be thoroughly oil flushed before being first placed in service.
5. Considerable importance should be given for cleanliness in handling bulk fuel oil. Dirt particles will ruin the fine lap of injection pumps or plug the injection nozzle orifices. So *high-grade filters* are of paramount importance to the diesel oil supply system.

FUEL INJECTION SYSTEM

The mechanical heart of the Diesel engine is the *fuel injection system*. The engine can perform no better than its fuel injection system. A very small quantity of fuel must be measured out, injected, atomised, and mixed with combustion air. The mixing problem becomes more difficult—the larger the cylinder and faster the rotative speed. Fortunately the high-speed engines are the small-bore automotive types ; however, special combustion arrangements such as precombustion chambers, air cells, etc., are necessary to secure good mixing. *Engines driving electrical generators have lower speeds and simple combustion chambers.*

FUNCTION OF FUEL INJECTION SYSTEM

1. Filter the fuel.
2. Meter or measure the correct-quantity of fuel to be injected.
3. Time the fuel injection.
4. Control the rate of fuel injection.
5. Automise or break up the fuel to fine particles.
6. Properly distribute the fuel in the combustion chamber.

The injection systems are manufactured with great accuracy, especially the parts that actually meter and inject the fuel. Some of the tolerances between the moving parts are very small of the order of *one micron*. Such closely fitting parts require special attention during manufacture and hence the injection systems are *costly*.

TYPES OF FUEL INJECTION SYSTEM

The following fuel injection systems are commonly used in diesel power station :

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

Atomisation of fuel oil has been secured by (*i*) *air blast* and (*ii*) *pressure spray*. Early diesel engines used air fuel injection at about 70 bar. This is sufficient not only to inject the oil, but also to atomise it for a rapid and thorough combustion. The expense of providing an air compressor and tank lead to the development of "*solid*" injection, using a liquid pressure of between 100 and 200 bar which is sufficiently high to atomise the oil it forces through spray nozzles. Great advances have been made in the field of solid injection of the fuel through research and progress in fuel pump, spray nozzles, and combustion chamber design.

EXHAUST SYSTEM:

Refer to Fig. 3.3. The purpose of the exhaust system is to discharge the engine exhaust to the atmosphere outside the building. The exhaust manifold connects the engine cylinder exhausts outlets to the exhaust pipe which is provided with a muffler to reduce pressure in the exhaust line and eliminate most of the noise which may result if gases are discharged directly into the atmosphere.

The exhaust pipe leading out of the building should be short in length with minimum number of bends and should have one or two flexible tubing sections which take up the effects of expansion, and isolate the system from the engine vibration. Every engine should be provided with its independent exhaust system.

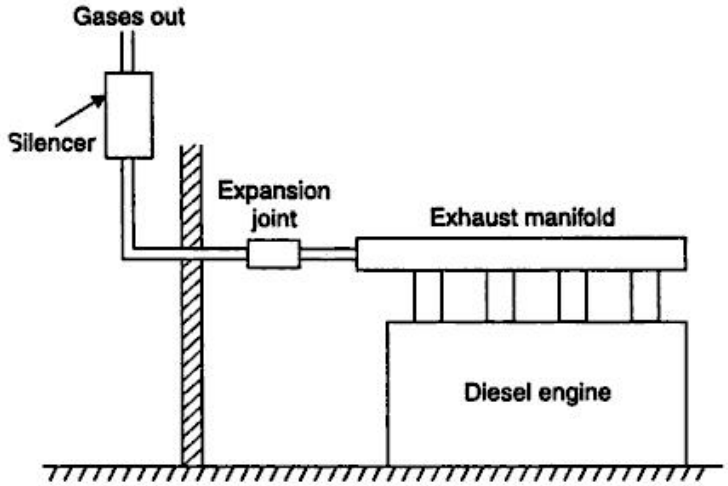


Fig. 3.3. Exhaust system.

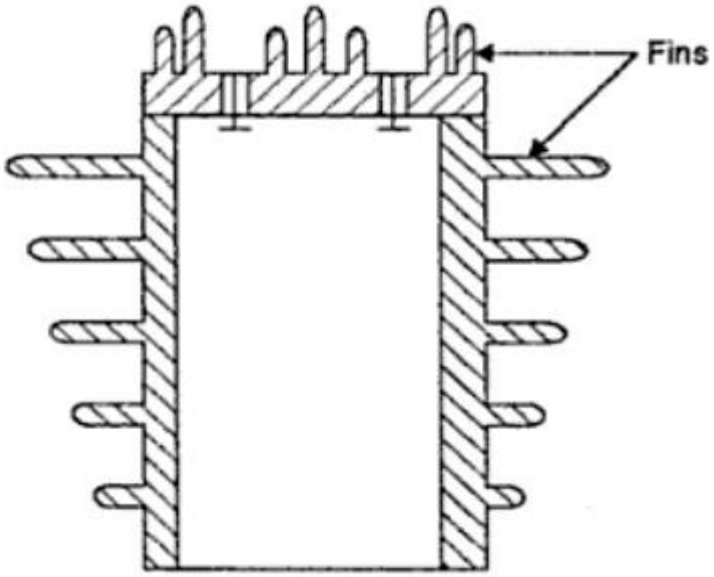
The waste heat utilisation in a *diesel-steam* station may be done by providing waste-heat boilers in which most of the heat of exhaust gases from the engine is utilised to raise low pressure steam. Such application is common on *marine plants*. On the *stationary power plant* the heat of exhaust may be utilised to heat water in gas-to-water heat exchangers consisting of a water coil placed in exhaust muffler and using the water in the plant suitably. If air heating is required, the exhaust pipe from the engine is surrounded by the cold air jacket, and transfers the heat of exhaust gases to the air.

COOLING SYSTEM

Almost 25% to 35% of total heat supplied in the engine is removed by the cooling medium. An additional 3% to 5% heat loss occurs through lubricating oil and radiation.

- **There are two methods of cooling I.C. engines: 1. Air cooling 2. Liquid cooling**

Air cooling : In this method, heat is carried away by the air flowing over and around the cylinder. Fins are added on the cylinder which provide additional mass of material for conduction as well as additional area for convection and radiative modes of heat transfer.



ADVANTAGES OF AIR COOLING

- **Simpler engine design as no liquid coolant jackets are needed.**
- **Absence of cooling pipes and radiator makes cooling system simpler.**
- **No danger of coolant leakage etc.**
- **Engine is not subjected to problems associated with frozen coolant during winter as is the case with water cooled engines.**
- **For a given power, the weight of an air cooled engine is less than that of a liquid cooled engine.**
- **Engine is self contained and easier to install.**

DISADVANTAGES OF AIR COOLING

- **Noisy movement**
- **Non uniform cooling**
- **Output of an air cooled engine is less than that of a liquid cooled engine.**
- **Smaller useful compression ratio**
- **Maintenance is not easy**
- **Not practical for diesel engines**

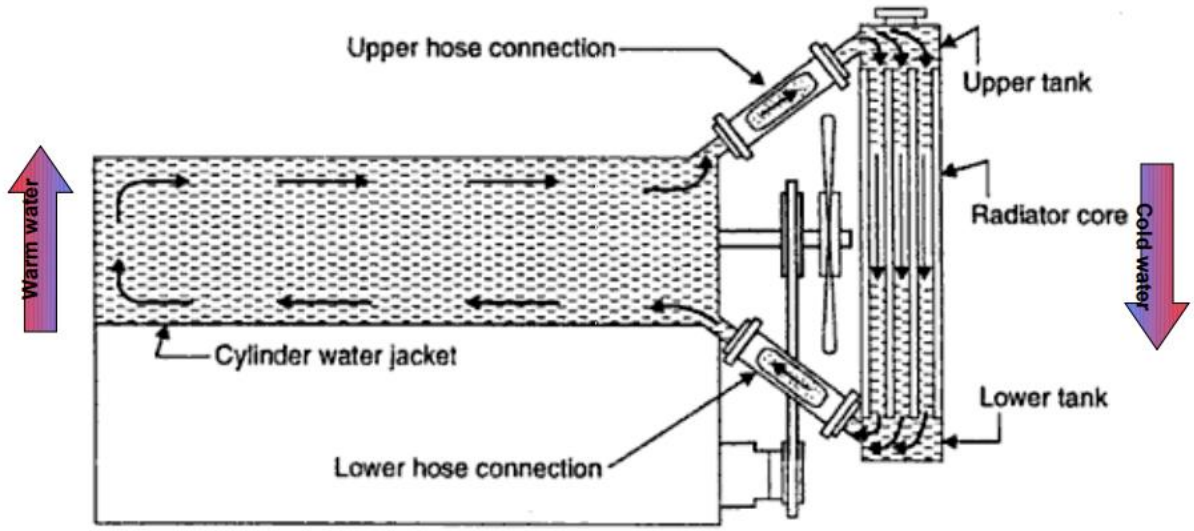
LIQUID COOLING :

In this method, the cylinder walls and head are provided with jackets through which the cooling liquid can circulate. The heat is transferred from the cylinder walls to the liquid by convection and conduction. The liquid gets heated during its passage through the cooling jackets and is itself cooled by means of an air cooled radiator system. The heat from liquid in turn is transferred to air. There are several methods of circulating coolant liquid around the cylinder walls and head:

- **Thermo-syphon cooling**
- **Forced or pump cooling**
- **Cooling with thermostatic regulator**
- **Pressurised cooling**
- **Evaporative cooling**

THERMO-SYPHON COOLING: In this method works on the fact that water becomes lighter with increase in temperature.

Schematic of a thermo-syphon cooling system is shown in the figure. Top and bottom ends of radiator are connected to the top and bottom water jackets of the engine. Water travels down the radiator across which air is passed to cool it. Air flow across the radiator can be due to the motion of the vehicle or by a fan. The system is simple and works on the basis of convective currents of water – hot water raises within the engine water jacket due to reduction of density and cold water drops down in the radiator due to increase in density. Disadvantage is that the cooling depends only on temperature differences and not on engine speed. Circulation of water starts only after the engine begins to work.



FORCED OR PUMP COOLING :**In this method, a pump is used to cause circulation of coolant in the water jacket of the engine. The pump is usually belt driven from the engine**.

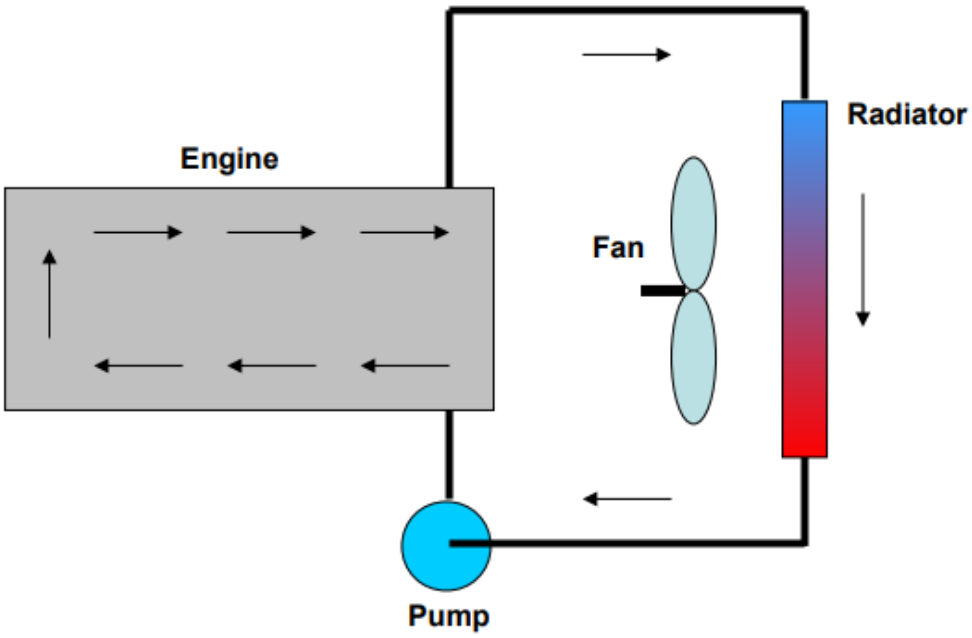
Schematic of a forced pump cooling system is shown in the figure . Advantage of this system is that cooling is ensured under all conditions of operation.

The system has following disadvantages:

•Cooling is independent of temperature. This may result overcooling the engine.

• While moving uphill, cooling requirement is more but the coolant circulation may reduce because of reduced engine speed. This may result in overheating of engine.

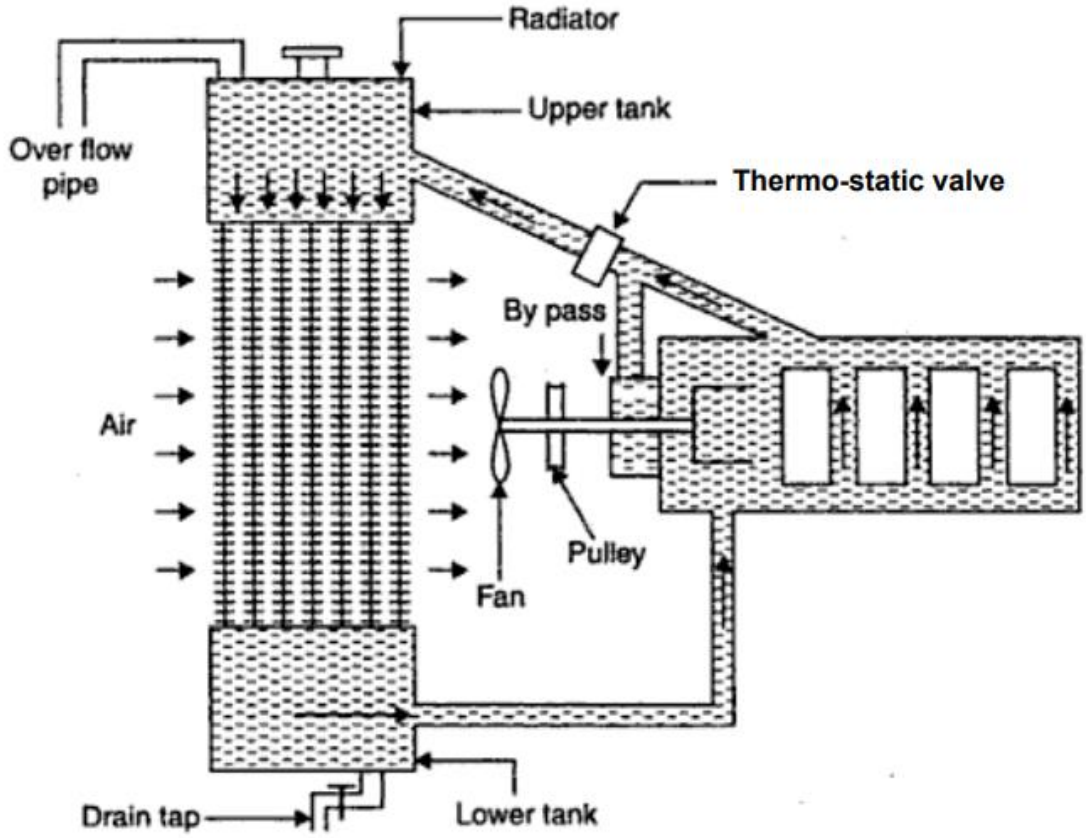
• Cooling stops as soon as engine stops. Residual heat in engine can cause overheating. This is undesirable as cooling should continue until engine reaches normal temperature.



COOLING WITH THERMOSTATIC REGULATOR -A thermostat is a temperature controlling device used to stop flow of coolant below a preset cylinder barrel temperature.

Modern cooling systems employ thermostatic valves to prevent coolant in the engine jacket from circulating through radiator for cooling until its temperature has reached a value suitable for efficient engine operation. A thermostat consists of thin copper bellows filled with volatile liquid like ether or ethyl alcohol. The volatile liquid changes to vapour at the correct working temperature, thus creating enough pressure to expand the bellows. The movement of the bellows opens the main valve in proportion to the temperature, thus increasing or decreasing the flow of coolant from

engine to radiator . When the thermostat valve is not open, engine operation raises the coolant pressure. This opens the bypass pressure relief valve to maintain coolant circulation within the engine block.



PRESSURISED COOLING :**This system employs high pressure coolant to increase its boiling point and thereby increased heat transfer. The boiling point of the coolant can be increased by increasing its pressure. This allows a greater heat transfer to occur in the radiator due to larger temperature differential between radiator and ambient. Usually the coolant pressure is maintained between 1.5 and 2 bar. Pressurised cooling system requires an additional valve called "vacuum valve" to avoid formation of vacuum when the coolant temperature drops on shutting down the engine. A safety valve in the form of pressure relief valve is provided on the radiator top tank so that whenever the radiator cap is opened, the pressure is immediately relieved.**

EVAPORATIVE COOLING :

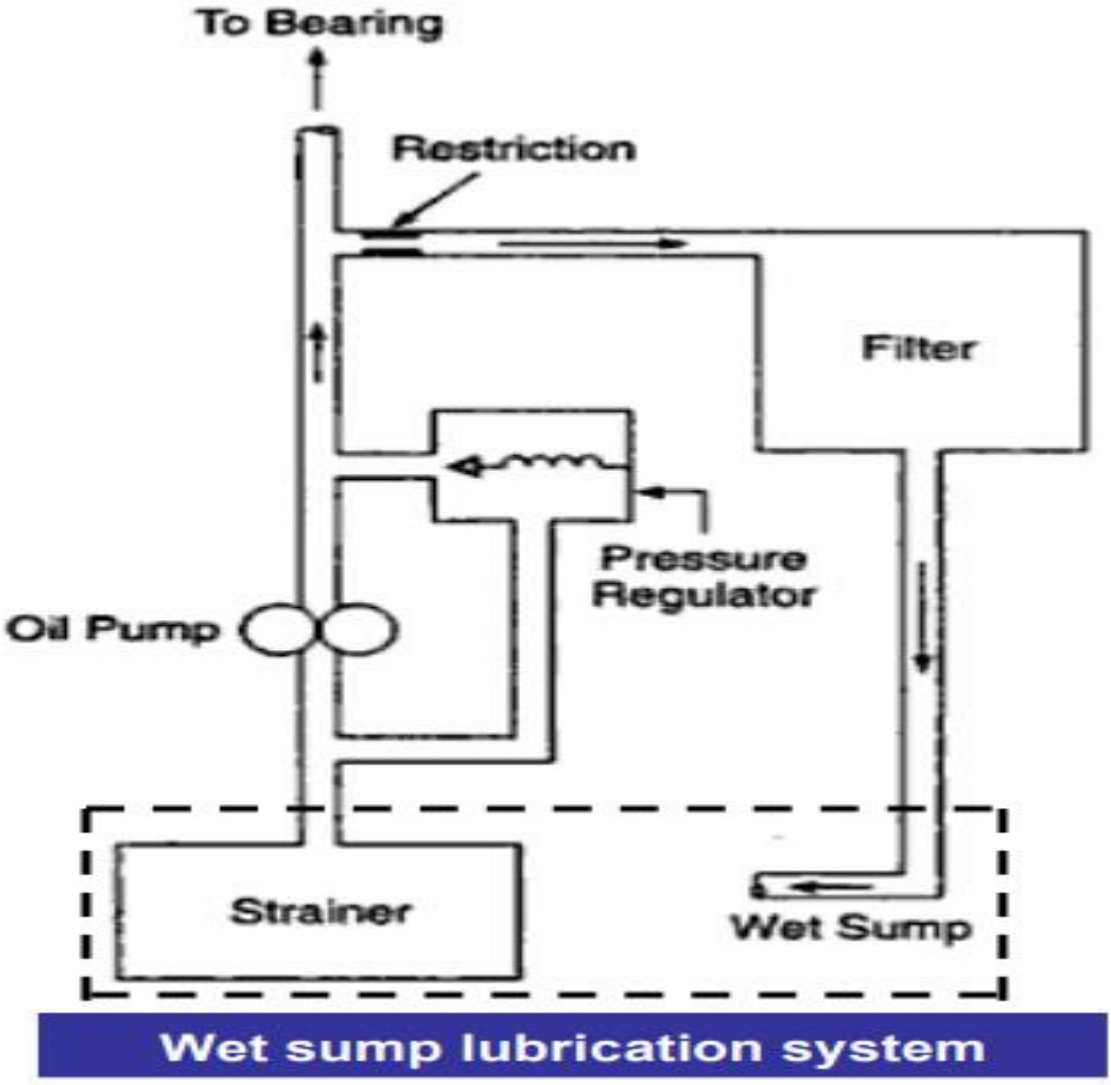
In this system, also called steam or vapour cooling, the temperature of cooling water is allowed to reach 100°C. This type of cooling utilises the high latent heat of vapourisation of water to obtain cooling with minimum water. In this system, the coolant is always liquid but the steam formed is flashed off in a separate vessel to condense.

LUBRICATION SYSTEM:

1. Wet sump lubrication system
2. Dry sump lubrication system
3. Mist lubrication system

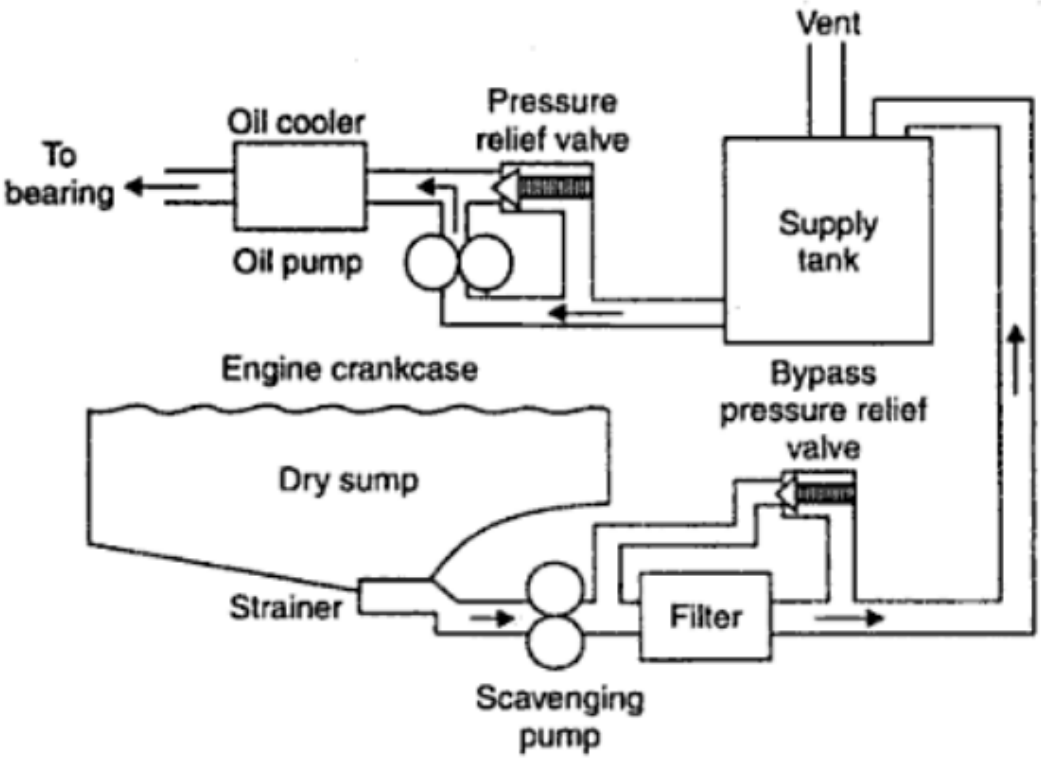
Wet sump lubrication system:

This system uses a large capacity oil sump at the base of crank chamber, from which the oil is drawn by a low pressure oil pump and delivered to various parts. Oil then returns back to the sump after serving the purpose.



Dry pump lubrication system:

Oil from the sump is carried to a separate storage tank outside the cylinder block. Oil from the sump is pumped to storage tank by a scavenging pump. Oil from the storage tank is pumped to the engine cylinder through another pump and oil cooler. Oil pressure varies from 3 to 8 bar. This type of lubrication is generally adopted for high capacity engines.



MIST LUBRICATION SYSTEM:

• This system is used for 2-stroke engines.

• Most of these engines are crank charged i.e., they employ crank case compression and therefore, are not suitable for crank case lubrication.

• These engines are lubricated by adding 2 to 3% lubricating oil in the fuel tank.

• The oil and fuel mixture is induced through the carburettor.

• The gasoline is vapourised and the oil in the form of mist, goes via crank case into the cylinder.

• The oil, which impinges on the crank case walls, lubricates the main and connecting rod bearings, and the rest of the oil which passes in to the cylinder during charging and scavenging periods, lubricates the piston, piston rings and the cylinder.

ADVANTAGES AND DISADVANTAGES OF DIESEL POWER PLANTS

The *advantages and disadvantages* of diesel power plants are listed below :

Advantages :

1. Design and installation are very simple.
2. Can respond to varying loads without any difficulty.
3. The standby losses are less.
4. Occupy less space.
5. Can be started and put on load quickly.
6. Require less quantity of water for cooling purposes.
7. Overall capital cost is lesser than that for steam plants.
8. Require less operating and supervising staff as compared to that for steam plants.
9. The efficiency of such plants at part loads does not fall so much as that of a steam plant.
10. The cost of building and civil engineering works is low.
11. Can burn fairly wide range of fuels.
12. These plants can be located very near to the load centres, many times in the heart of the town.
13. No problem of ash handling.
14. The lubrication system is more economical as compared with that of a steam power plant.
15. The diesel power plants are *more efficient than steam power plants* in the range of 150 MW capacity.

Disadvantages :

1. High operating cost.
2. High maintenance and lubrication cost.
3. Diesel units capacity is limited. These cannot be constructed in large size.
4. In a diesel power plant noise is a serious problem.
5. Diesel plants cannot supply overloads continuously whereas steam power plant can work under 25% overload continuously.
6. The diesel power plants are not economical where fuel has to be imported.
7. The life of a diesel power plant is quite small (2 to 5 years or less) as compared to that of a steam power plant (25 to 30 years).

MODEL TEST - I

POWER PLANT ENGG.
(Code : MET-604E(i))

Full Marks : 80 Time : 3 hours

Answere any five questions including Q.1 & Q.2
Figurres in the right-hand margin indicates Marks
Use steam table and Mollierc chart allowed

Q.1 Answere all [2×10]

(a) Define powere plant and name any two types of it.

(b) What is Geothermal energy ?

(c) what is captive powere plant ?

(d) What is specific steam consumption ?

(e) Write down foure mounting used in a boilere.

(f) What is the function of steam condensere ?

(g) what is nuclear fuel ?

(h) what is hydel powere plant ?

(i) What is the function of surege tank ?

(j) what is the function of economisere in steam Power plant ?

Q.2 Answere any six [5×6]

(a) Explain Rankine cycle with neat flow diagream, P-V and T-S diagream.

(b) Explain the lay out of steam power plant.

(c) A simple Rankine cycle works between pressures 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption.

(d) Define and classify steam turebine.

(e) What is compounding and explain about pressure velocity compounding in impulse turebine.

(f) Explain the disposal of nuclear waste.

(g) Explain fuel storage and supply system of Diesel power plants.

Q3 Explain the various sources of energy.

Q4 Explain the construction and working of a hydroelectric power plant.

Q.5 Explain the working of BWR and PWR power plant with neat line diagram

Q6 What is draught system? Explain different type of draught system used in steam power plant.

Q7 Expain briefly different systems of diesel power plant.

MODEL TEST - 2

POWER PLANT ENGG
(code : MET - 604 EC)

Full Marks : 80 Time : 3 hours

Answere any five questions including 1 & 2
Figures in the right-hand maregin indicates Marck
Use of steam table and Mollier chart is allowed

Q.1 Answere all [2×5]

(a) What is central power station ?
(b) what is Tidal power ?
(c) what do you mean by reheating ?
(d) what is natural draught ?
(e) what is goverening of steam turebine
(f) What is nuclear fission reaction.
(g) What is the function of steam condenser ?
(h) List the various boiler accessories.
(i) what is the function of control rod in nuclear reactore.
(j) what is the function of surege tank in hydroelectric power plant ?

Q.2 Answere any six [5×6]

(a) Explain briefly the various sources of energy.
(b) What is the difference between central and

captive powere station.

(c) Explain regenerative cycle with P-V and T-S diagram.

(d) Describe aboret nucleare reactore.

(e) Explain PWR Powere plant.

(f) State the advantages and disadvantages of diesel powere plant.

(g) Explain fuel injection system in diesel powere plant.

(h) Explain Nozzle goverening in steam turebine.

Q.3 In a steam turebine steam at 20 bare, 360°c is expanded to 0.08 bare. It then enter a condensere where it is condensed to saturated liquid watere The pump feeds back the watere in to the boilere. Assume ideal processes, find pere kg of steam the net worck and the cycle efficiency.

Q.4 Explain comporending in steam turebine.

Q.5 Describe the vareious types of cooling towere.

Q.6 Explain disposal of nucleare waste.

Q.7 State advantages and disadvantages of hydroelectreic powere plant