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Internal Assesment Test - I

Sub:	Power Generation and Economics							Code:	17EE42
Date:	07/03/2019	Duration:	90 mins	Max Marks:	50	Sem:	4	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1.a	Explain the factors to be considered for the selection of site for a hydroelectric power plant.	[6]	CO2	L1
1.b	Explain how the hydroelectric plants are classified.	[4]	CO1	L1
2.a	Describe merits and demerits of hydroelectric power plants?	[5]	CO1	L1
2.b	Explain the characteristics of water turbines.	[5]	CO2	L2
3.a	With a neat schematic diagram, explain the essential elements of hydroelectric power plant.	[7]	CO2	L2
3.b	Define Hydrological cycle with neat figure.	[3]	CO1	L1
4.a	With a neat diagram explain the working of turbine governing.	[6]	CO2	L1
4.b	Neatly draw the plan layout for hydel power plants with impulse turbine and reaction turbine.	[4]	CO2	L1
5.a	Prepare a short note on surge tank.	[6]	CO2	L1
5.b	Define the phenomenon “Water hammer”? Explain how surge tanks help to reduce water hammer effect.	[4]	CO2	L1
6.a	With a neat layout describe diesel power plant.	[7]	CO2	L1
6.b	Discuss the advantages and disadvantages diesel power plant.	[3]	CO2	L1
7.a	Mention the applications of diesel –electric power plants.	[3]	CO1	L2
7.b	Define supercharging? Give its advantages and disadvantages.	[7]	CO2	L1

ANSWER SCHEME

1. a) Explain the factors to be considered for the selection of site for a hydroelectric power plant.

1. **Availability of Water:**

Since in such power stations potential energy of waterfall or kinetic energy of flowing stream is utilized for generation of electric power, therefore such stations should be built where there is adequate water available at good head or huge quantity of water is flowing across a given point.

2. **Water Storage:**

Since storage of water in a suitable reservoir at a height or building of dam across the river is essential in order to have continuous and perennial supply during the dry season, therefore, convenient accommodation for the erection of a dam or reservoir must be available.

3. **Water Head:**

The available water head depends upon the topography of the area. Availability of head of water has considerable effect on the cost and economy of power generation. An increase in effective head reduces the quantity of water to be stored and handled by penstocks, screens and turbines and, therefore, capital cost of the plant is reduced.

4. **Distance from Load Centre:**

Hydroelectric power plant is usually located far away from the load centre. Hence for economical transmission of electric power, the routes and the distances need active considerations.

5. **Accessibility of the Site:**

Adequate transportation facilities must be available or there should be possibility of providing the same so that the necessary equipment and machinery could be easily transported.

6. **Water Pollution:**

Polluted water may cause excessive corrosion and damage to the metallic structures. Hence availability of good quality water is essential.

7. **Sedimentation:**

Gradual deposition of silt may reduce the capacity of the storage reservoir and may also cause damage to the turbine blades. Silting from forest areas is negligible but the regions subject to violent storms and not protected by vegetation contribute lot of silt to the run-off.

8. **Large Catchment Area:**

The reservoir must have a large catchment area so that level of water in the reservoir may not fall below the minimum required in dry season.

9. **Availability of Land:**

The land available should be cheap in cost and rocky in order to withstand the weight of the large building and heavy machinery.

10. There should be possibility of stream diversion during period of construction.

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1. b)Explain how the hydroelectric plants are classified.

According to Head of water,

a) Low head plant
b) Medium head plant
c) High head plant

According to Nature of load,

a) Base load plant
b) Peak load plant

According to Capacity of plant,

a) Low capacity plant (100-999 kW)
b) Medium capacity plant (1 MW-10 MW)
c) High capacity plant (above 10 MW)

According to Quantity of water available,

a) Run-off river plants without pondage
b) Run-off river plants with pondage
c) Pumped storage plant

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2. a) Describe merits and demerits of hydroelectric power plants?

Hydroelectric power plants offer many distinct advantages over other power plants.

These advantages can be summarised as under:

(i) No fuel is required by such plants as water is the source of energy. Hence operating costs are low and there are no problems of handling and storage of fuel and disposal of ash.

(ii) The plant is highly reliable and it is cheapest in operation and maintenance.

(iii) The plant can be run up and synchronized in a few minutes.

(iv) The load can be varied quickly and the rapidly chang-ing load demands can be met without any difficulty.
(v) Very accurate governing is possible with water tur-bines so such power plants have constant speed and hence constant frequency.
(vi) There are no standby losses in such plants.
(vi) Such plants are robust and have got longer life (around 50 years).
(viii) The efficiency of such plants does not fall with the age.
(ix) It is very neat and clean plant because no smoke or ash is produced.
(x) Highly skilled engineers are required only at the time of construction but later on only a few experi-enced persons will be required.
(xi) Such plants, in addition to generation of electric power, also serve other purposes such as irrigation, flood control and navigation.
(xii) Hydroelectric plants are usually located in remote areas where land is available at cheaper rates.
However, **the hydroelectric power plants have the fol-lowing disadvantages also:**
(i) It requires large area.
(ii) Its construction cost is enormously high and takes a long time for erection (owing to involvement of huge civil engineering works).
(iii) Long transmission lines are required as the plants are located in hilly areas which are quite away from the load centre.
(iv) The output of such plants is never constant owing to vagaries of monsoons and their dependence on the rate of water flow in a river. Long dry season may affect the power supply.
(v) The firm capacity of hydroelectric plants is low and so backup by steam plants is essential.
(vi) Hydroelectric power plant reservoir submerges huge areas, uproots large population and creates social and other problems.

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2. b)Explain the characteristics of water turbines.

Characteristics of Water Turbines:

1. Head:

Reaction turbines of various types can be used for operating heads up to 500 m and Peltonturbines are used for operating heads above 500 m.

2. Specific Speed.

3. Turbine Setting:

A Pelton wheel is always set at a higher level than the highest tailrace level (usually 2 m above) while a Francis turbine runner is placed at a level very near or below the lowest tailrace level.

4. Runaway Speed:

This is the maximum speed at which a turbine wheel would run under the worst operating conditions with all gates open so as to allow all possible water inflow under maximum head. The generator coupled to the turbine must be capable of withstanding the full runaway speed of turbine under permissible head.

5. Constant Speed Curves:

In hydroelectric power plants, the turbines operate at constant speed and, therefore, vari-ables are operating head H and discharge Q. As the discharge and head vary so as to keep the speed constant, the turbine output P_t is measured by brake arrangement. The turbine

efficiency η is then calculated for various values of Q and H. Now the output discharge (P_t– Q), efficiency- discharge (η – Q) curves, as shown in Fig. 2.19 and efficiency-percentage full load curves are drawn as shown in Figs. 2 20 and 2.21. From the curves drawn, it can be concluded that the Kaplan and Pelton turbines perform well at part loads but Francis and Propeller turbines do not.

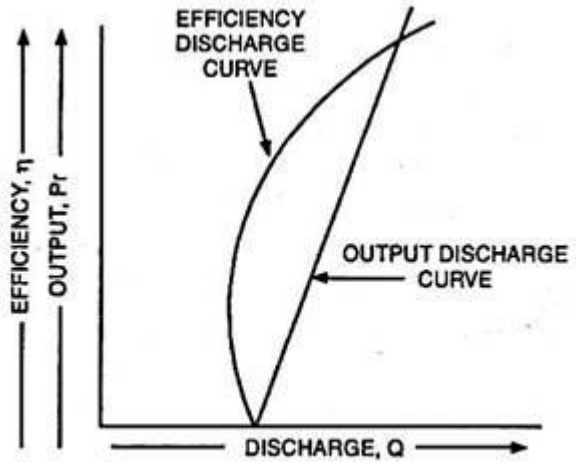

Fig. 2.19. ***Efficiency-Discharge Curve***

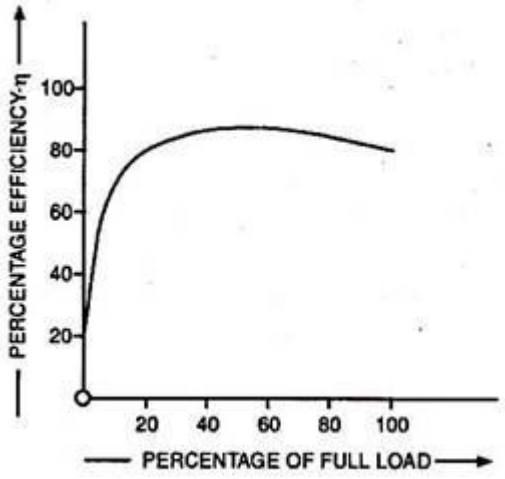

Fig. 2.20. ***Efficiency Curve of Impulse Turbine***

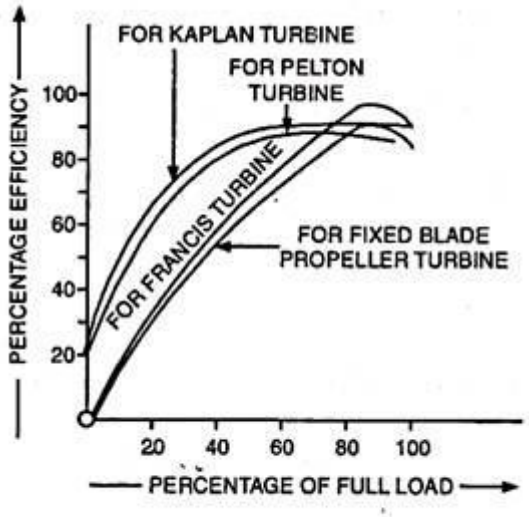

Fig. 2.21. ***Efficiency Curve of Reaction Turbines***

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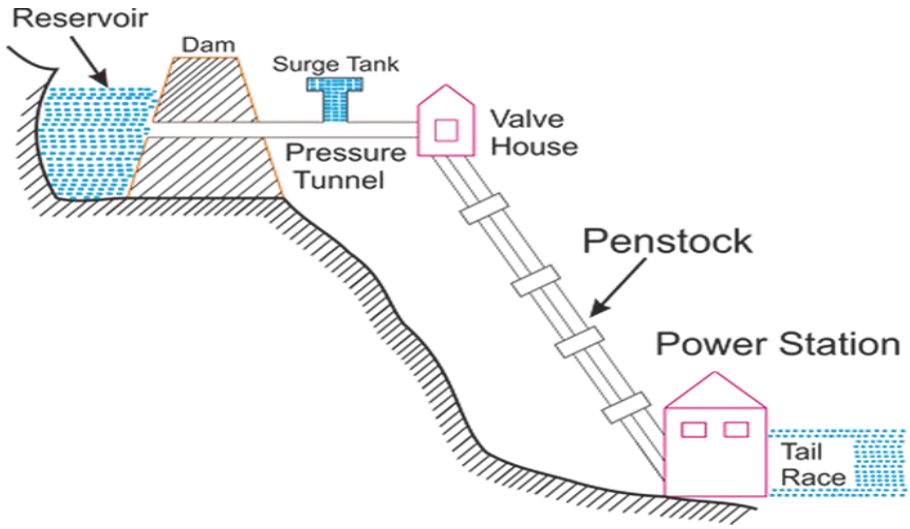
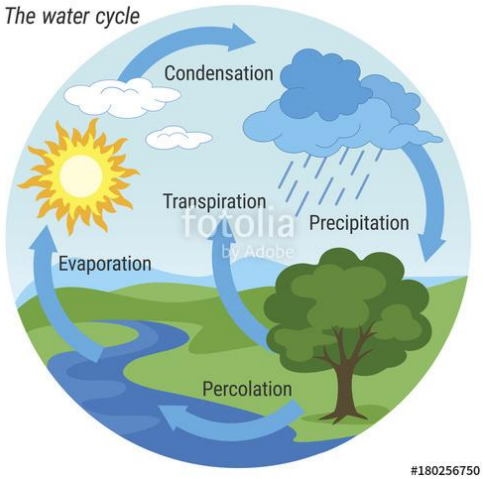
3. a) With a neat schematic diagram, explain the essential elements of hydroelectric power plant.

Working principle of hydroelectric power plant depends on the conversion of hydraulic energy into electrical energy. To get this hydroelectricity,hydroelectric power plant needs some arrangements for proper working and efficiency. The block diagram of hydroelectric power plant is shown below:
Hydroelectric power station needs huge amount of water at sufficient head all the time. So a hydroelectric dam is constructed across the river or lake.an artificial storage reservoir where water is stored, is placed back side of the dam. This reservoir creates sufficient water head. A pressure tunnel is placed in between the reservoir to valve house and water is coming from reservoir to penstock via this tunnel. An automatic controlling sluice valve is placed in valve house and it controls water flow to the power station and the letter cuts off supply of water in case the penstock bursts. Penstock is a huge steel pipe in which water is taken from valve house to turbine. A surge tank is also provided just before the valve house for better regulation of water pressure in the system. Now water turbine converts hydraulic energy into mechanical energy and an alternator which is couple to the water turbine converts this mechanical energy into electrical energy.



3.b) Define Hydrological cycle with neat figure.

The Hydrologic Cycle (also called the Water Cycle) is the continuous movement of water in the air, on the surface of and below the Earth. This cycle is the exchange of energy which influences climate. When water condenses, it releases energy and warms the environment. When water evaporates it takes energy from the surrounding environment, dropping temperatures.



4. a) Neatly draw the plan layout for hydel power plants with impulse turbine and reaction turbine.

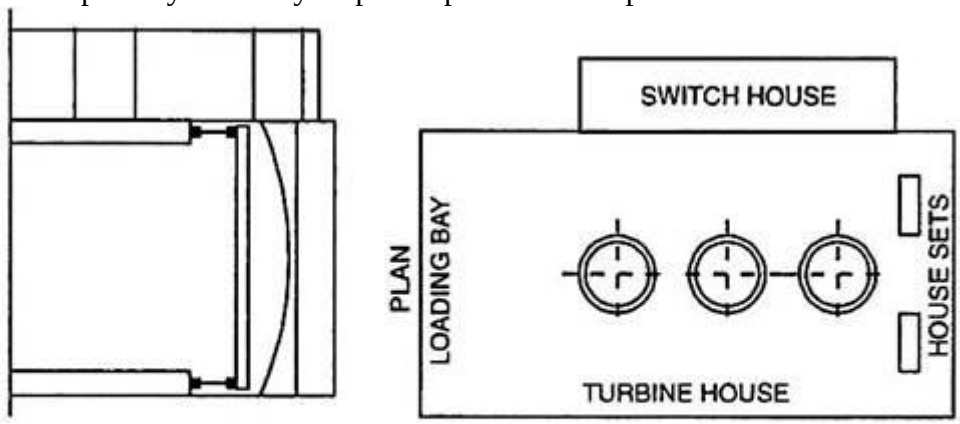


Fig. 2.26. ***Typical Plan Layout of Hydro Power Plant with Vertical Reaction Turbines***

4.b) With a neat diagram explain the working of turbine governing.

In order to have electrical output of constant frequency it is necessary to maintain speed of the alternator driven by the turbine constant. This is achieved by controlling the flow of water entering the turbine by the automatic adjustment of guide vanes in case of reaction turbines and of the nozzle needle in the case of impulse turbines. Such an operation of speed regulation is called the governing, and it is attained automatically by means of a governor. In case of impulse turbine the governor also operates the auxiliary relief valves or jet deflectors.

For the regulation of water below the penstock connection, at the time of decrease in load on the impulse turbines, the governor reduces the water flow from the power nozzle and the surplus water is diverted with the help of auxiliary relief nozzles. In the case of multi-nozzle turbines, a deflector plate deflects some water from the runner buckets by swinging into the water jet from each nozzle. With the movement of deflector plate out of the path of water jets, the needles slowly reduces the flow of water so as to keep the output of the turbine constant at the level of new load.

In the case of Francis turbine, there are pressure regulators for discharging the water from the casing to the tailrace at the time of drop in load. The regulators close as fast as the guide vanes open and vice versa.

The governor should be quite sensitive to variations in the shaft speed and should be rapid in action but not so rapid as to cause water hammer in the penstock. The governing systems for the modern hydraulic turbines have a regulating time of 3-5 seconds.

Simplified arrangement of a water turbine governor is illustrated in Fig. 2.22. The principal elements of the governor are:

1. The speed-responsive element—usually flyball mechanism or speed (centrifugal) governor.

2. Control valve or relay valve to supply fluid under pressure to the power cylinder (servomotor) in order to actuate the turbine control mechanism. The use of control valve and servomotor is to amplify the small force created by the flyballs.

3. The restoring mechanism or follow-up linkage to hold the servomotor in required fixed position when the turbine output and load demand are equalised.

4. The fluid pressure supply required for the action of servomotor.

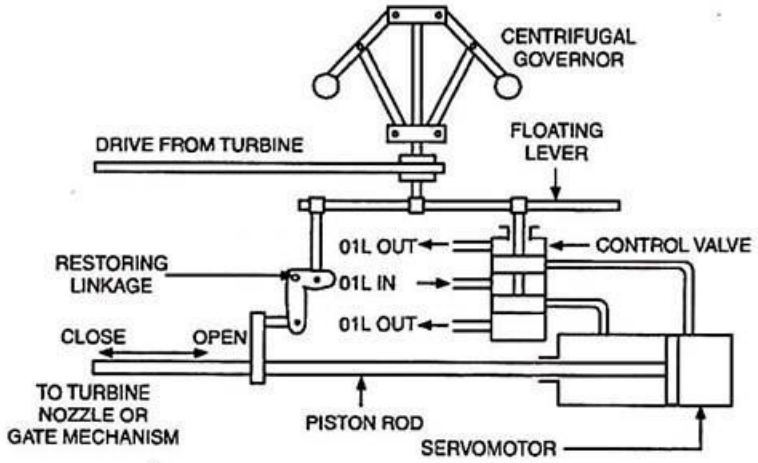


Fig. 2.22. ***Governing of Water Turbines***

The flyballs may be belt driven, as shown in Fig. 2.22 or driven by a small electric motor fed from a separate generator operated in synchronism with the turbine. When the load on the turbine decreases, the speed of the turbine increases, consequently, the flyballs also rotate at high speed and move outwards. The floating lever gets lifted up, control valve is displaced upwards from its central or dead beat position, the upper port is

uncovered and the oil flows from a pressure tank through the port into the right hand end of the servomotor cylinder.

The piston moves to the left and closes the nozzle with the help of a spear in the case of Pelton wheels and adjusts the guide vanes in the case of reaction turbines. In case of increase of load on the generator, the speed of the turbine will decrease and the reverse action would take place. The restoring or follow up linkage resets the relay; pilot or control valve after the servomotor piston has adjusted the water control mechanism.

In case of Pelton wheel a combined spear and deflector regulation is employed in order to avoid water hammer in the penstock. In case of decrease of load on turbine, the deflector, which is usually a plate connected to the servomotor by means of levers, is brought in between the nozzle and buckets, thereby, diverting water away from the runner and directing into the tailrace. In the mean time, the spear has been adjusted to the new position of equilibrium and the deflector plate is moved out of the path of water nozzle.

5.a) Prepare a short note on surge tank.

A surge tank, in its simplest design, is a supplementary reservoir within a pipe system subject to variable flow rates. Surge tanks are used to protect piping and turbines from pressure waves that occur when the flow rate quickly decreases. Most commonly surge tanks are used within hydroelectric power plants where large size piping is used at relatively high flow rates, however they can be applied to many other piping systems such as waste water management, water supplied for manufacturing, and even the automotive industry. Surge tanks for handling water flow come in a variety of styles ranging from 40 gallon pressurized units to thousands of gallon reservoirs open to the atmosphere. Surge tanks have been used for many years however it is still a topic that sees active research and improvements are frequently proposed. Figure 3 below shows The Elwha dam which was once located on the Elwha river in Olympic National Park. In the center of the picture a surge tank can be seen rising to the height of the dam before it.

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5 b.) Define the phenomenon “Water hammer”? Explain how surge tanks help to reduce water hammer eff*ec*t.

Water Hammer is a pressure surge or wave that occurs when there is a sudden momentum change of a fluid (the motion of a fluid is abruptly forced to stop or change direction) within an enclosed space (Water Hammer). This commonly occurs in pipelines when a valve is closed suddenly at the end of a pipeline where the velocity of the fluid is high. The pressure wave created will propagate within the pipeline. Cause and Effect Water hammer is caused by a change in fluid momentum. The most common cause of this change in momentum is sudden closure of a valve on a pipeline. When this occurs, a loud hammer noise can be produced and vibrations can be sent through the pipe (Water Hammer). The pressure wave produced from this event can cause significant damage to pipe systems. The large increase in pressure can cause pipes to crack and in some cases burst. It also causes cavitation within pipe lines and if is severe enough can cause the pipe line to implode (Water Hammer)

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6 a) With a neat layout describe diesel power plant.

The layout of the diesel power station illustrates the main and auxiliary components of the plant and the importance of each component as:

Diesel engine:

Also known as compression ignition engine consists of a cylinder, cylinder head, piston, inlet valve, an inlet port, exhaust valve, valve spring, cooling fins, wrist fines, wrist pin, connecting rod, crankcase, crank pin, crank, and crankshaft.

And it’s classified into a two-stroke engine and four-stroke engines.

Engine starting system:

It’s an arrangement to initially rotating the engine, we used a compressed air for starting the engine until it runs with its own power.

Fuel handling system:

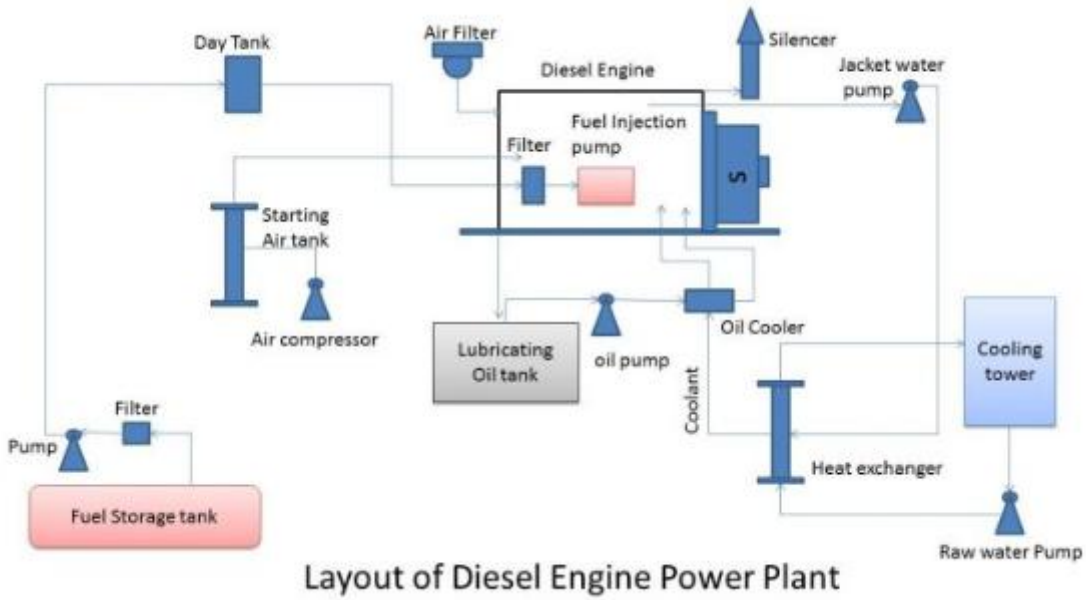
We use trucks, railway wagons (barges) or oil tankers to deliver the fuel oil to the plant site, and we deliver the oil to the main tanks from engine day tanks which capable to store oil equivalent to 8-hour consumption through strainers.
And we heat the oil by hot water or steam to reduce viscosity and in order reduce the pumping power input
Fuel injection system:
We can say that this system is the heart of the diesel engine as it can uses as:

- Filter the ensuring oil from dirt.
- Meters the correct quantity of fuel to be injected into the cylinder.
- Also, regulates the fuel supply.
- Atomize the fuel oil for better mixing with the hot oil.
- And finally distribute the atomized fuel properly in the combustion chamber.

Air intake system:
It's used to transfer fresh air through louvers and air filter to the cylinder by an intake manifold, and we can fit a supercharger driven by the engine between the filter and the engine to augment the power.
Exhaust system:

- It's used to discharge the engine exhaust to the atmosphere with minimum noise.
- We use an exhaust manifold to connect the engine cylinder exhaust to the exhaust pipe to demand the fluctuating pressure of the exhaust line with a muffler or silencer to in turn reduces most the noise resulted when gases discharged directly to the atmosphere.
- There is also a flexible tubing system to take up the facts of expansion and isolate the exhaust system from the engine vibration. And we may also use a heat recovery steam generator to generate low-pressure steam for process work.

Engine lubrication system:
It's used to provide sufficient quantity of cool filtered oil to give adequate lubrication to the moving parts of the engine, it consists of lubricating oil tank, pump, filter, and oil cooler. and it's classified into:
Mixed lubrication system: it's usually used in the two-stroke engine where we mix a small quantity of lubricating oil in the fuel tank.
Wet sump lubrication system: which may be splash system, pressure fed system or splash or pressure feed system.
Dry sump lubrication system: it's usually used in a large stationary marine engine where we carry the supply of oil in an external tank with some help of scavenging pump through a strainer and filter.
Cooling system:
It consists of a water source; a pump which circulates water through a cylinder and head jacket; and cooling tower in which it can cool the hot water from the engine.



Layout of Diesel Engine Power Plant

6 b) Discuss the advantages and disadvantages diesel power plant.

Advantages of diesel power plant:

- The low initial cost which makes it easy to quickly install and commission it.
- The design is very simple and requires small space.
- It can start and stop with quick facilities; as small generators can start and stop in few seconds without any standby loss in the system.
- The thermal efficiency is quite higher than other types.
- We can build it near the load center and doesn't cause a problem of ash disposal exists.
- The size of the plant is quite smaller than steam plants also they have the same capacity.
- It's easy to design it for portable use.
- The cooling is easy and requires a small quantity of water.
- There isn't any difficulty with varying loads.
- Also, the fuel cost required for operation is low.
- Replacement losses are smaller
- And it also requires fewer members of engineers.

Disadvantages of diesel power station:

- The higher running costs due to the high cost of the diesel.
- The general use of this plant is to produce small power requirement.
- It can't stand up for a long period of overload conditions.
- The lubricants cost is high.
- Complex and high-cost maintenance; which makes the life of the plant small from 7 to 10 years.
- Its capacity is only about 50 MW.
- It's difficult to construct it for large scale.
- Also, the noise produced by the plant is high.

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7. a) Mention the applications of diesel –electric power plants.

- A central station for medium or small power supplies.
- And for emergency services as a stand by plant to hydroelectric power plants and steam power plants.
- We can Use with thermal or hydro power plants as a peak load plant in combinations.
- For mobile power generation, transportation systems like automobiles, railways, airplanes, and ships.
- A nursery station to transport the power from stations to small power plants, or supply power to small towns.
- It's economical for industries where they require a small power in the order of 500 KW as it offers high overall efficiency.
- And also used for electrical power generation in capacities 100 to 500 H.P.

7.b) Define supercharging? Give its advantages and disadvantages.

- Increased amount of air at pressure greater than atmosphere is supplied to the cylinder to increase the output of the cylinder
- It simply makes available a greater weight of air to effect combustion with the result that greater quantity of fuel can be burned in each power stroke without change in engine's :
    - ✓ Efficiency
    - ✓ Capacity
    - ✓ Speed
    - ✓ temperature
- Used at high altitudes to get sea level output
- Requires power
- **Advantages :**

❖ 30 – 50 % increased output
❖ Fuel economy
❖ Better mechanical efficiency
❖ Reduced knocking

- Better scavenging
- **Methods of supercharging :**
- Positive displacement type super charger
- Centrifugal supercharger
  Exhaust turbo charger