

**3<sup>RD</sup> SEMESTER, ELECTRICAL ENGINEERING**  
**INTRODUCTION TO ELECTRIC GENERATION SYSTEMS(TH-1)**

**CHAPTER-1**

**2 Marks short Question**

1. Write the principle of generation of electrical energy.

The main principle for electrical energy generation is electromagnetic induction Based on Faraday's law. It is the process of inducing a voltage and current in a Conductor, when it moves through a magnetic field. This is achieved by using a generator, which is typically powered by a turbine. The turbine converts mechanical energy from sources like water, steam or wind into rotational motion, which is then used to rotate the generator and finally it converts mechanical energy into electrical energy.

**2. What is the primary function of a boiler in a thermal power plant?**

A boiler converts water into high-pressure steam by utilizing heat energy from fuel combustion. This steam is then used to drive turbines, which generate electricity.

**3. What is the function of super heater in Thermal Power Plant?**

A super heater in a thermal power plant converts saturated steam into superheated steam by removing moisture and increasing its temperature.

**4. Define the calorific value of fuel?**

It is the amount of heat energy released by the combustion of a unit mass of fuel. It is the measure of the fuel's energy content and is expressed in J/kg, KJ/Kg in SI unit. Coal with higher calorific value is preferable.

**5. What is the basic difference between fusion and fission in nuclear reactions?**

There are two ways of getting energy from nuclear reactions. They are nuclear fission and fusion. Fission is the process of splitting a heavy nucleus into lighter ones, while fusion is the process of combining two or more light nuclei to form a heavier one. In both cases, a huge amount of energy is released.

**6. Why shielding is necessary in a nuclear power plant?**

Shielding is necessary in a nuclear power plant to protect workers and the public from dangerous radiation, specifically high-energy neutrons and gamma rays, by containing and reducing the intensity of radiation to safe levels. It is achieved using layers of materials like concrete, steel, and lead for gamma rays and hydrogen-rich materials for neutrons.

**7. What is the function of moderator in nuclear power plant?**

The function of a moderator in a nuclear reactor is to slow down fast neutrons produced during fission to a speed at which they are more likely to cause further fission in other atomic nuclei, thereby sustaining a controlled chain reaction.

Example- Ordinary water, Heavy water, Graphite.

**8. What is water-tube boiler and give example?**

A boiler in which the water flows through a number of small tubes which are Surrounded by hot combustion gases.

Example- Babcock and Wilcox boiler, Benson boiler etc.

**9. Define IC Engine, give example.**

An Internal Combustion Engine is a type of heat engine where combustion of fuel occurs within the engine's cylinder, transforming chemical energy into mechanical energy.

Example- Petrol engine, Diesel engine etc.

**10. What is an economizer and what is the function of economizer?**

An economizer is a heat exchanger used in boilers .It preheats the feed water using waste heat from flue gases, improving boiler efficiency

**5 Marks Question**

**1. Discuss the applications of diesel power plants and gas turbine plants.**

**A. Diesel Power Plant Applications:**

1. Used as standby (emergency) power supply in hospitals, industries, and institutions.
2. Suitable for small power generation (2–50 MW).
3. Used in remote and hilly areas where grid power is unavailable.
4. Mobile power units for military, ships, and railways.
5. Peak load plants to meet sudden demand in large systems.

**B. Gas Turbine Plant Applications:**

1. Used in aircraft propulsion and jet engines.
2. Suitable for medium power generation (10–100 MW).
3. Used as standby and peak load plants.
4. Used in combined cycle plants with steam turbines for high efficiency.
5. Used for offshore oil and gas platforms.

**2. Write the difference between Fire tube and Water tube boiler.**

Sl.no	Fire tube boiler	Water tube boiler
1	In this boiler the hot flue gases is present inside the tubes and water surrounds them	The water is present inside the tubes and the hot flue gases surrounds them
2	They are low pressure boilers. The operating pressure is about 20 bar.	They are high pressure boilers and the operating pressure is about 250 bar.
3	Load fluctuations cannot be handled	Load fluctuations can easily handle
4	The overall efficiency of this boiler is upto 75%.	The overall efficiency is up to 90% with the economizer.

5	It can works on fluctuating loads for shorter period of time.	It works on fluctuating loads all the times.
6	Water doesn't circulate in a definite direction	Direction of water circulation in water tube boiler is well defined.
7	Operating cost is low.	Operating cost is high.
8	They are light in weight.	They are heavy in weight.

### 3. Write the difference between Diesel and Petrol Engine.

Sl.no	Diesel Engine	Petrol Engine
1	A diesel engine is type of internal combustion engine that uses diesel as combustion fuel.	A petrol engine is type of internal combustion engine that uses diesel as combustion fuel.
2	These engines work on the Diesel cycle	Works on the Otto cycle
3	The fuel is mixed with air inside the cylinder	Air and the fuel are mixed in a carburetor
4	High power production	Relatively low amounts of power are produced in a Petrol engine
5	Generally used in heavy vehicles such as trucks and buses	Used in light vehicles such as motorcycles and cars.
6	Relatively low fuel consumption	High fuel consumption.
7	Heavy in weight	Light in weight

### 4. Write the selection of site of nuclear power plant?

Ans- The location of the nuclear power plant is selected based on the following points

- 1. Water availability:** The cooling process required a huge amount of water. The plant site should be such that sufficient water is available at that location. It is better to select a location near the river or sea.
- 2. Waste Disposal:** Nuclear fission developed radioactive waste products. This must be disposed of to avoid health hazards. It must either be buried in a deep trench or disposed of in the sea at a sufficient distance from the sea shore.
- 3. Distance from the populated area:** It should be situated away from the populated area since it is dangerous due to the presence of radioactivity.
- 4. Transportation facility:** There must be an adequate transportation facility to transport heavy equipment to the plant.

**5. Meteorology:** It is an important factor to be considered while selecting a site for nuclear power plant. Wind and atmospheric stability are two main meteorological factors. These factors are involved in atmospheric transport and dilution of airborne contamination.

### **5. Write the Properties of gaseous fuel used in thermal power plants.**

#### **High calorific value**

Gaseous fuels, particularly natural gas, have a very high calorific value. This means they produce a large amount of heat energy for a given amount of fuel, making the thermal power plant more efficient.

#### **Clean combustion**

Compared to solid fuels like coal, gaseous fuels burn much more cleanly. The combustion process results in significantly fewer emissions of sulfur oxides and particulate matter. This reduces air pollution and minimizes the need for complex and expensive post-combustion cleanup systems.

#### **No ash content**

Unlike solid fuels that leave behind ash as a residue after combustion, gaseous fuels burn completely, leaving no solid waste. This eliminates the need for ash storage and disposal, simplifying plant operations and reducing costs.

#### **Easy to transport and handle**

Gaseous fuels can be transported through pipelines, a far more efficient and convenient method than moving solid fuels by rail or truck. This also simplifies the handling and storage systems at the power plant, which for solid fuels require extensive infrastructure like conveyor belts and large storage yards.

#### **Higher thermal efficiency**

Gas-fired power plants, especially combined-cycle plants, can achieve higher thermal efficiencies than coal-fired plants. In these systems, the hot exhaust gases from the gas turbine are used to generate steam for a second turbine, capturing more energy from the fuel.

### **10 Marks Question**

#### **1. Explain the working principle and components of a Steam Power Station Plant with a neat labeled diagram.**

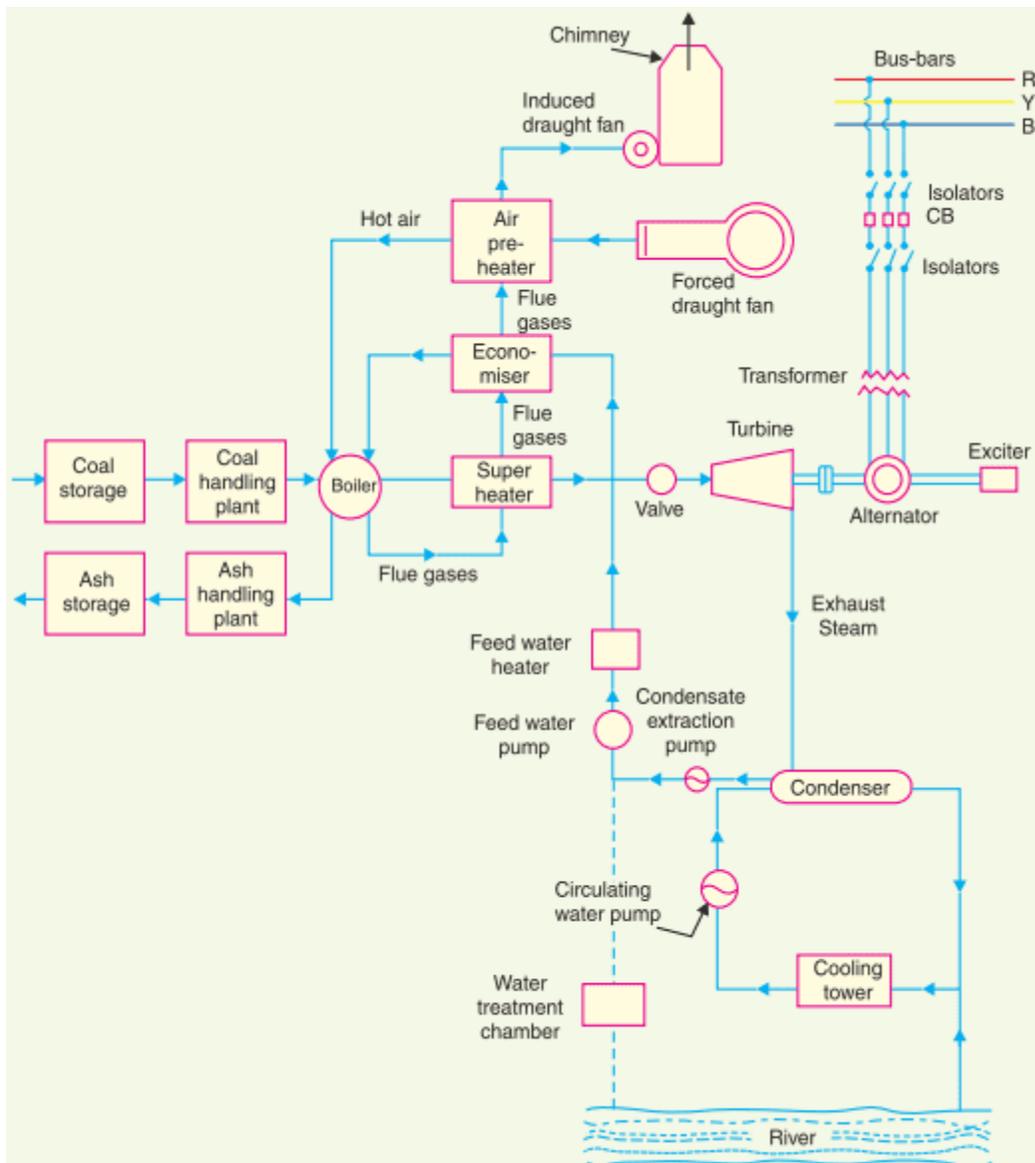
A generating station which converts heat energy of coal combustion into electrical energy is known as a steam power station.

A steam power station basically works on the Rankine cycle. Steam is produced in the boiler by utilizing the heat of coal combustion. The steam is then expanded in the prime mover and is condensed in a condenser to be fed into the boiler again. The steam turbine drives the alternator which converts mechanical energy of the turbine into electrical energy. This type of power station is suitable where coal and water are available in abundance and a large amount of electric power is to be generated.

#### **Schematic Arrangement of Steam Power Station**

The whole arrangement can be divided into the following stages for the sake of simplicity:

1. Coal and ash handling arrangement
2. Steam generating plant
3. Steam turbine
4. Alternator
5. Feed water
6. Cooling arrangement



**1. Coal and ash handling plant.** The coal is transported to the power station by road or rail and is stored in the coal storage plant. Storage of coal is primarily a matter of protection against coal strikes, failure of transportation system and general coal shortages. From the coal storage plant, coal is delivered to the coal handling plant where it is pulverized (i.e., crushed into small pieces) in order to increase its surface exposure, thus promoting rapid combustion without using large quantity of excess air. The pulverized coal is fed to the

boiler by belt conveyors. The coal is burnt in the boiler and the ash produced after the complete combustion of coal is removed to the ash handling plant and then delivered to the ash storage plant for disposal. The removal of the ash from the boiler furnace is necessary for proper burning of coal.

## **2. Steam generating plant.**

The steam generating plant consists of a boiler for the production of steam and other auxiliary equipment for the utilization of flue gases.

**(i) Boiler.** The heat of combustion of coal in the boiler is utilized to convert water into steam at high temperature and pressure. The flue gases from the boiler make their journey through superheater, economizer, air pre-heater and are finally exhausted to atmosphere through the chimney.

**(ii) Superheater.** The steam produced in the boiler is wet and is passed through a super heater where it is dried and superheated (i.e., steam temperature increased above that of boiling point of water) by the flue gases on their way to chimney.

**(iii) Economizer.** An economizer is essentially a feed water heater and derives heat from the flue gases for this purpose. The feed water is fed to the economizer before supplying to the boiler. The economizer extracts a part of heat of flue gases to increase the feed water temperature.

**(iv) Air preheater.** An air preheater increases the temperature of the air supplied for coal burning by deriving heat from flue gases. Air is drawn from the atmosphere by a forced draught fan and is passed through air preheater before supplying to the boiler furnace.

## **3. Steam turbine.**

The dry and superheated steam from the super heater is fed to the steam turbine through main valve. The heat energy of steam when passing over the blades of turbine is converted into mechanical energy. After giving heat energy to the turbine, the steam is exhausted to the condenser which condenses the exhausted steam by means of cold water circulation.

**4. Alternator.** The steam turbine is coupled to an alternator. The alternator converts mechanical energy of turbine into electrical energy. The electrical output from the alternator is delivered to the bus bars through transformer, circuit breakers and isolators.

**5. Feed water.** The condensate from the condenser is used as feed water to the boiler. Some water may be lost in the cycle which is suitably made up from external source. The feed water on its way to the boiler is heated by water heaters and economizer. This helps in raising the overall efficiency of the plant.

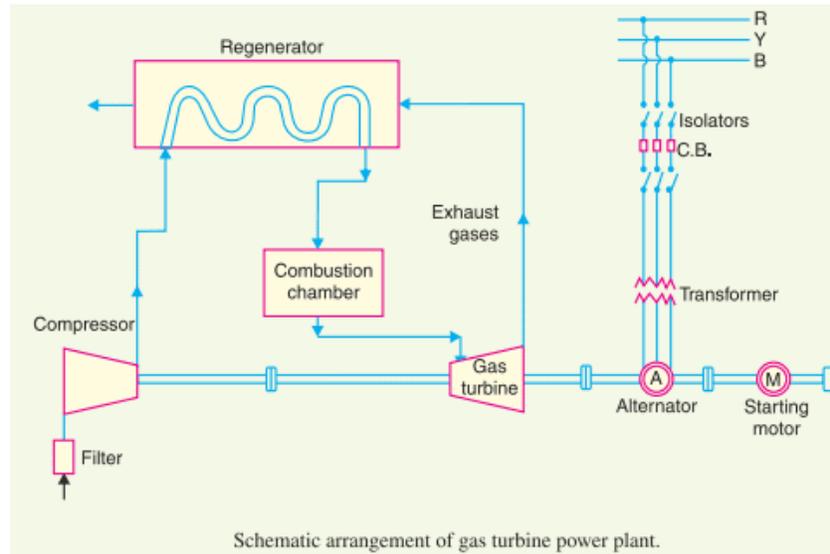
**6. Cooling arrangement.** In order to improve the efficiency of the plant, the steam exhausted from the turbine is condensed by means of a condenser. Water is drawn from a natural source of supply such as a river, canal or lake and is circulated through the condenser. The circulating water takes up the heat of the exhausted steam and itself becomes hot. This hot water coming out from the condenser is discharged at a suitable location down the river.

## **2 . Explain the working principle and components of a Gas Turbine Power Plant with a neat labeled diagram.**

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

In a gas turbine power plant, air is used as the working fluid. The air is compressed by the compressor and is led to the combustion chamber where heat is added to air, thus raising its temperature. Heat is added to the compressed air either by burning fuel in the chamber or by the use of air heaters. The hot and high pressure air from the combustion chamber is then passed to the gas turbine where it expands and does the mechanical work. The gas turbine drives the alternator which converts mechanical energy into electrical energy.

Schematic Arrangement of Gas Turbine Power Plant turbine Power Plant The schematic arrangement of a gas turbine power plant is shown in Fig.



The main components of the plant are :

(i) Compressor (ii) Regenerator (iii) Combustion chamber (iv) Gas turbine (v) Alternator (vi) Starting motor

**(i) Compressor.** The Compressor used in the plant is generally of rotatory type. The air at atmospheric pressure is drawn by the compressor via the filter which removes the dust from air. The rotatory blades of the compressor push the air between stationary blades to raise its pressure. Thus air at high pressure is available at the output of the compressor.

**(ii) Regenerator.** A regenerator is a device which recovers heat from the exhaust gases of the turbine. The exhaust is passed through the regenerator before wasting to atmosphere. A regenerator consists of a nest of tubes contained in a shell. The compressed air from the compressor passes through the tubes on its way to the combustion chamber.

**(iii) Combustion chamber.** The air at high pressure from the compressor is led to the combustion chamber via the regenerator. In the combustion chamber, heat is added to the air by burning oil. The oil is injected through the burner into the chamber at high pressure to ensure atomization of oil and its thorough mixing with air. The result is that the chamber attains a very high temperature (about 3000o F). The combustion gases are suitably cooled to 1300o F to 1500o F and then delivered to the gas turbine.

**(iv) Gas turbine.** The products of combustion consisting of a mixture of gases at high temperature and pressure are passed to the gas turbine. These gases in passing over the turbine blades expand and thus do the mechanical work. The temperature of the exhaust gases from the turbine is about 900o F.

(v) **Alternator.** The gas turbine is coupled to the alternator. The alternator converts mechanical energy of the turbine into electrical energy. The output from the alternator is given to the bus-bars through transformer, circuit breakers and isolators.

(vi) **Starting motor.** Before starting the turbine, compressor has to be started. For this purpose, an electric motor is mounted on the same shaft as that of the turbine. The motor is energized by the batteries. Once the unit starts, a part of mechanical power of the turbine drives the compressor and there is no need of motor now.

## CHAPTER-2

### 2 Marks short Question

**1. What form of energy is converted into electrical energy in a hydro power plant?**

Ans- In a hydro power plant, the potential energy of water stored at a height is converted into electrical energy through the action of a turbine and generator.

**2. State the head range for high, medium, and low head hydro power plants.**

Ans- The head ranges for hydro power plants are:

- High head: Above 300 m
- Medium head: Between 30 m to 300 m
- Low head: Below 30 m

**3. What is the function of a turbine in a hydro power plant?**

Ans- The function of a turbine in a hydro power plant is to convert the kinetic energy of flowing water into mechanical energy by rotating the turbine blades, which then drives the generator to produce electricity.

**4. What is the function of penstock in hydro power plant ?**

Ans. The function of a penstock in a hydroelectric power plant is to carry water from a high-elevation reservoir to the turbines at a lower elevation, converting the water's potential energy into kinetic energy

**5. Which turbine is used for high head and low discharge conditions?**

Ans- The Pelton turbine is used for high head and low discharge conditions in hydro power plants.

**6. What is the function of surge tank in large hydro power plant?**

Ans- A surge tank's primary function in a large -hydro power plant is to protect the penstock (water pipe) from pressure surges caused by sudden changes in water flow.

**7. Which type of turbine is commonly used for medium head hydro power plants?**

Ans- The Francis turbine is commonly used for medium head hydro power plants.

**8. What type of turbine is suitable for low head and high discharge conditions?**

Ans- The Kaplan turbine is suitable for low head and high discharge conditions in hydro power plants.

**9. List any two safety practices followed in hydro power plants.**

Ans- Two safety practices in hydro power plants are:

1. Regular inspection and maintenance of equipment to prevent failures.
2. Proper training of staff to handle emergencies and operate machinery safely.

**10. Why is regular maintenance important in hydro power stations?**

Ans- Regular maintenance in hydro power stations is important to ensure efficient operation, prevent unexpected breakdowns, and enhance the safety and life span of equipment.

**5 Marks Question**

**1. Explain the energy conversion process in a hydro power plant in detail.**

Ans- Energy Conversion Process in a Hydro Power Plant:

In a hydro power plant, the energy conversion process involves transforming the potential energy of water stored at a height into electrical energy as the water falls:

**1. Potential Energy of Water:**

Water stored in a reservoir behind a dam possesses potential energy due to its height.

**2. Conversion to Kinetic Energy:**

When water is released, it flows down through large pipes called penstocks, converting potential energy into kinetic energy.

**3. Mechanical Energy through Turbine:**

The fast-moving water strikes the blades of the turbine, causing it to rotate. This rotation converts the kinetic energy of water into mechanical energy in the turbine shaft.

**4. Electrical Energy through Generator:**

The turbine shaft is connected to a generator. As the turbine rotates, it turns the generator rotor, which converts mechanical energy into electrical energy using electromagnetic induction.

**5. Power Transmission:**

The generated electrical energy is then transmitted through transformers and power lines to homes, industries, and other consumers.

**2. Classify hydro power plants based on head and describe the characteristics of high, medium, and low head plants.**

Ans- Classification of Hydro Power Plants Based on Head:

Hydro power plants are classified according to the vertical height (head) of water available between the reservoir surface and the turbine. The three main categories are:

**1. High Head Hydro Power Plants:**

- Head Range: Above 300 meters
- Characteristics:
  - Water falls from a large height, resulting in high pressure and velocity.
  - Typically have low discharge (flow rate) but high-water pressure.

- Use Pelton turbines which are impulse turbines suited for high head and low flow.
- Suitable for mountainous or hilly regions with steep terrain.

## 2. Medium Head Hydro Power Plants:

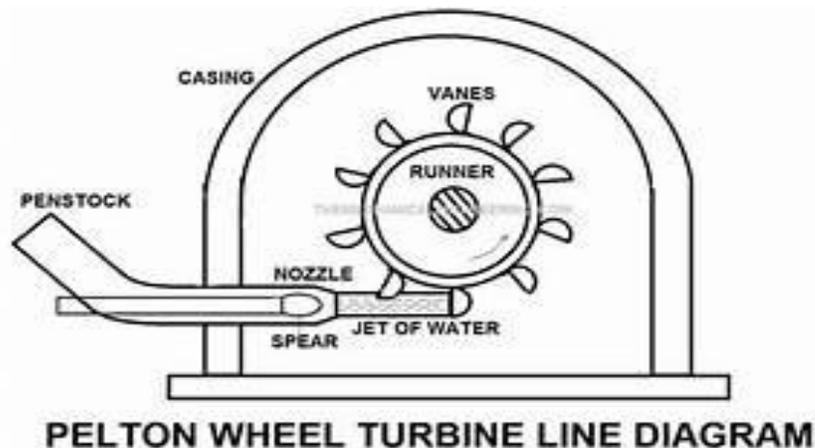
- Head Range: Between 30 meters to 300 meters
- Characteristics:
  - Moderate water head and flow rate.
  - Use Francis turbines, which are reaction turbines suitable for medium head and medium discharge.
  - Commonly found in river valleys or moderate elevation sites.

## 3. Low Head Hydro Power Plants:

- Head Range: Below 30 meters
- Characteristics:
  - Low water head but high discharge (large volume of water).
  - Use Kaplan turbines, which have adjustable blades and are efficient for low head, high flow conditions.
  - Often constructed on wide rivers or flat terrain.

### 3. Describe the construction and working of the Pelton turbine used in high head hydro power plants.

Ans-



**Construction:**

- The Pelton turbine is an impulse turbine designed for high head and low discharge conditions.
- It consists of a runner mounted on a shaft with bucket-shaped blades arranged around its periphery. Each bucket is split into two halves by a central ridge to efficiently deflect the water jet.
- Water is supplied to the turbine through a penstock and directed by a nozzle that converts pressure energy into a high-velocity jet.
- A governor controls the flow of water by adjusting a needle valve inside the nozzle to regulate turbine speed.
- The whole assembly is enclosed in a casing to protect the runner and direct the water flow.

**Working:**

- Water from the reservoir is channelled through the penstock and exits at high velocity through the nozzle as a jet of water.
- The high-speed water jet strikes the buckets on the runner tangentially, imparting impulse force to the runner.
- As the water jet hits the bucket, it splits and flows off on either side, changing its direction almost 180°, which results in a large transfer of momentum and kinetic energy to the runner.
- This causes the runner to rotate, converting the kinetic energy of the water jet into mechanical energy.
- The rotating shaft of the turbine is connected to a generator that converts mechanical energy into electrical energy.
- After hitting the runner, water is discharged into the tailrace at low velocity and pressure.

**4. What are the safe practice for large hydro power plant?**

**Ans-1.** Always wear protective helmets, safety shoes, gloves, ear protection and life jackets.

2. Regular training in first aid, fire safety, electrical hazards.
3. All electrical installations must be properly insulated and insulated.
4. Avoid working with electrical panel in wet conditions.
5. Keep all turbines, shaft and generator parts covered during operations.
6. Check bearings, seals and gates to prevent mechanical failure.
7. Only trained staff should operate intake gates.
8. Follow environmental guidelines for aquatic life near the dam.

**5. Write down 5 location of large hydro power plant in India.**

Sl. No	Plant Name	Location	State	River	capacity
01	Koyna Hydroelectric Project	Satar	Maharashtra	Koyna	1960MW

02	Nathpa Jhakri	Kinnaur	Himachal Pradesh	Sutlej	1500MW
03	Sardar Sarovar Project	Kevadia	Gujarat	Narmada	1450MW
04	Indra Sagar	Khandwa	Madhya Pradesh	Narmada	1000MW
05	Tehri Dam	Tehri	Uttarakhand	Bhagirathi	1000MW
06	Karcham Wangtoo	Kinnaur	Himachal Pradesh	Sutlej	1000MW
07	Uri Hydroelectric Project	Baramulla	Jammu and Kashmir	Jhelum	480MW

### 10-Marks Question

1. Explain the construction and working of the Francis turbine and its suitability for medium head hydro power plants.

Ans-

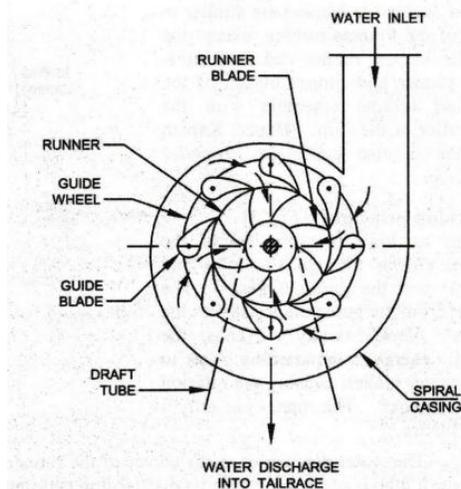


FIG. 2 FRANCIS TURBINE

**Construction:**

- The Francis turbine is a reaction turbine commonly used for medium head (30–100 m) hydro power plants.
- It consists of a spiral casing (or scroll casing) that surrounds the turbine and distributes water evenly around the runner.
- Inside the casing are fixed guide vanes (or wicket gates) arranged around the runner. These vanes can adjust their angle to control the flow rate and direct water at the optimal angle onto the runner blades.
- The runner has curved blades mounted on a shaft; these blades are designed to convert both the pressure and kinetic energy of water into mechanical energy.
- Water exits through a draft tube, which helps recover kinetic energy by slowing down the flow before discharge.

**Working:**

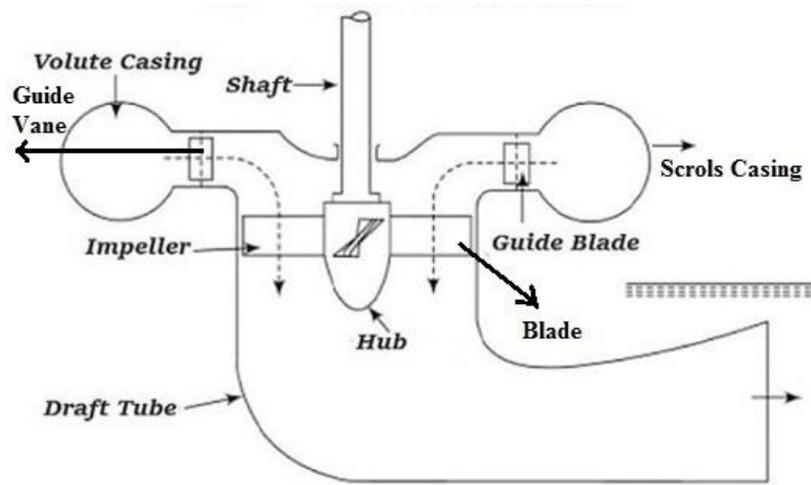
- Water enters the spiral casing under pressure and is directed by the adjustable guide vanes towards the runner blades.
- As water passes through the runner, its pressure and velocity decrease, transferring energy to the runner, causing it to rotate.
- The runner converts the hydraulic energy (both pressure and kinetic) of water into mechanical energy by spinning the shaft.
- The rotating shaft drives a generator, which converts mechanical energy into electrical energy.
- Water then leaves the turbine through the draft tube at a lower velocity and pressure.

**Suitability for Medium Head:**

- The Francis turbine is ideal for medium head hydro power plants because it efficiently handles water at moderate pressure and flow rates.
- Its design allows for smooth control of water flow through adjustable guide vanes, making it flexible for varying load conditions.
- The reaction principle allows it to utilize both pressure and velocity energy of water, making it highly efficient for medium head sites.

**2. Explain the construction and working of the Kaplan turbine and its suitability for low head hydro power plants.**

A Kaplan turbine is an axial-flow, propeller-type reaction turbine with adjustable blades, making it ideal for medium-head, high-flow hydroelectric plants. Water enters a spiral casing, is guided by wicket gates through a runner with curved, adjustable blades that spin the shaft, and then exits through a draft tube which recovers the water's kinetic energy. The adjustable blades allow the turbine to maintain high efficiency across a wide range of flow rates, which is why it is suitable for plants with variable water supply.



## Construction

- **Spiral casing:** A spiral-shaped casing that ensures water is fed uniformly around the entire circumference of the runner.
- **Wicket gates:** A ring of stationary blades that can be rotated to control the flow rate of water and guide it onto the runner blades at the correct angle.
- **Runner:** A propeller-like wheel with adjustable, curved blades. The ability to change the blade angle is the key feature for maintaining efficiency.
- **Draft tube:** A diverging tube at the outlet that slows the water down, converting its remaining kinetic energy into pressure energy before it is discharged.
- **Shaft:** Connects the runner to a generator to convert rotational energy into electrical energy.

## Working principle

1. **Water enters:** Water from a dam or reservoir flows through a penstock and enters the spiral casing.
2. **Flow is regulated:** The wicket gates pivot to control the volume of water and direct it towards the runner blades.
3. **Runner spins:** As water flows axially through the runner, its pressure and kinetic energy cause the curved blades to rotate, similar to an airplane wing.
4. **Energy conversion:** A portion of the water's energy is converted into rotational mechanical energy.
5. **Power generation:** The rotating shaft turns a generator, producing electricity.
6. **Energy recovery:** Water exits the runner and passes through the draft tube. The draft tube's expanding shape slows the water's velocity, recovering energy that would otherwise be lost.
7. **Blade adjustment:** The wicket gate angle and runner blade pitch are adjusted automatically to maintain peak efficiency as water flow rates vary.

## Suitability for low-head plants

- **Ideal for variable flow:** Kaplan turbines excel in situations with a low head (typically 1.5 to 20 meters) and high, often variable, flow rates.
- **Adjustable blades:** The ability to adjust the blade angle is crucial. It allows the turbine to operate efficiently at different flow rates, making it the best choice for rivers or reservoirs with fluctuating water levels and supply.
- **High efficiency:** This adjustability results in consistently high efficiency, compared to fixed-blade turbines that would lose efficiency under varying loads.
- **Reaction turbine:** As a reaction turbine, it harnesses both the pressure energy and kinetic energy of the water, which is ideal for the lower head conditions found in many medium-head applications.

## CHAPTER 3

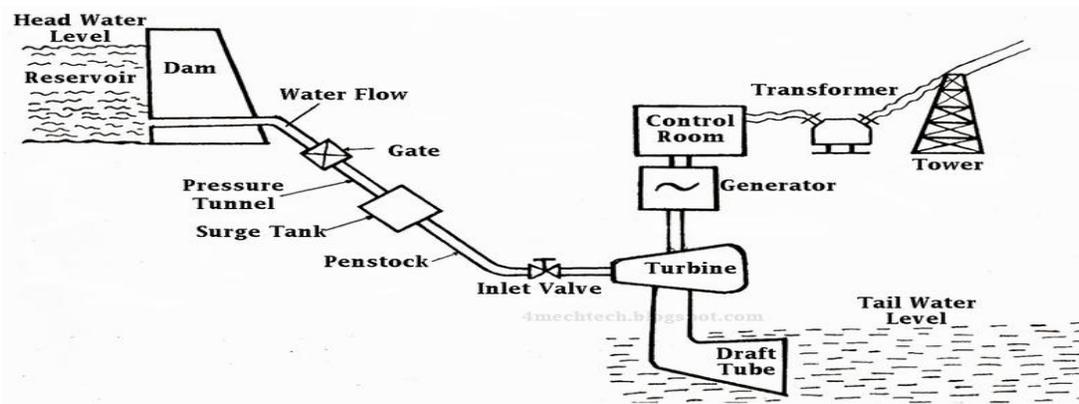
### 2 Marks short Question

1. What is micro hydro power plant.

Ans- A Micro hydro power plant is a small-scale hydroelectric system that generates electricity from 5KW to 100 KW.

2. Draw the layout of micro hydro power plant.

Ans-



3. Write the name of two turbines used in low head Micro hydro power plant.

Ans. Kaplan turbine and propeller turbine.

5. Write the function of Pelton turbine in micro hydro power plant.

Ans-In a micro hydro power plant, a Pelton turbine's function is to convert the kinetic energy of a high-velocity water jet into mechanical energy to spin a generator.

6. Write two advantage of Micro hydro power plant.

1. Low operating and maintenance cost
2. Reliable and Continuous power supply

7. What is the function of surge tank in micro hydro power plant and where it is situated.

Ans. A surge tank's primary function in a micro-hydro power plant is to protect the penstock (water pipe) from pressure surges caused by sudden changes in water flow. A surge tank in a micro hydro power plant is placed just upstream of the penstock and very close to the powerhouse.

8. What is the largest hydroelectric power plant in India and where it is situated.

**Ans.** The largest hydro power plant in India is the Tehri Hydropower Complex in Uttarakhand, with a capacity of 2,400 MW. It is located on the Bhagirathi River.

**9. What type of turbine is generally used in Micro hydro power plant.**

**Ans.** Pelton turbine is used for high head and low discharge.

. Francis turbine is used for medium head and medium discharge.

. Kaplan turbine is used for low head and high discharge.

**10. Write two environmental benefits of Micro Hydro power plant.**

**Ans.** The two environmental benefits on micro hydro power plant are

1. Low environmental impact.
2. No air pollution.

**Short Question (5 Marks)**

**1. Write the advantage and Disadvantage in micro hydro power plant.**

**Advantage.**

1. Renewable and sustainable energy source.
2. Low environmental impact.
3. Reliable and Continuous power supply.
4. Low operating and maintenance cost.
5. Suitable for rural and remote areas.
6. Long lifespan.

**Disadvantage**

1. Depend on water flow.
2. High initial and installation cost.
3. Limited power generation.
4. Possible impact on aquatic life

**2. Write the construction of Kaplan turbine with neat sketch.**

**Ans. 1.** A special-shaped casing that gradually decreases in cross sectional area to maintain constant water velocity and pressure, directing water to the guide vanes.

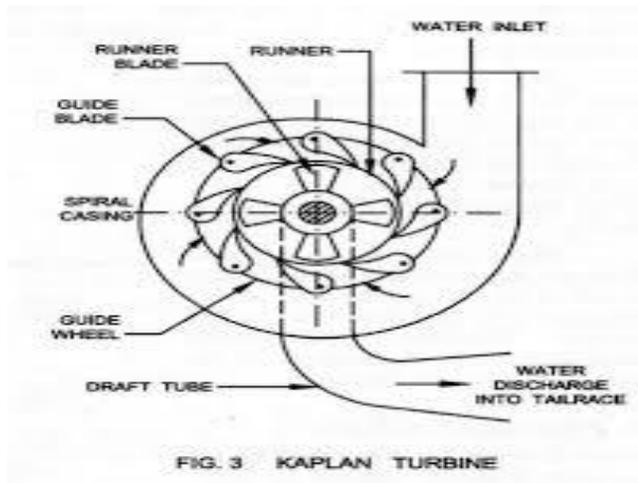
2. Guide vanes are adjustable vanes located after the scroll casing that control the water flow and direct it axially and at a specific angle onto the runner blades.

3. Runner Is the rotating part of the turbine, consisting of the hub and the runner blades.

4. Hub is a widened, central parts of the runner shaft onto which the blades are attached.

5. Runner blades are propeller likes adjustable blades that are twisted to ensure an optional angle of attack along their entire length efficiently extracting energy from the water.

A central shaft that connects the runner to the generator.



**3. Write differentiate between pelton and Kaplan turbine.**

<b>Pelton Turbine</b>	<b>Kaplan Turbine</b>
It is an impulse turbine	It is a reaction turbine
It used for high head and low discharge conditions	It used for low head and high discharge conditions
Water strikes the buckets on the runner	Water flows through blades of the runner
It operates with jet of water from a nozzle	It operates with completely field flow passage
Not suitable for variable head or discharge	Suitable for variable flow and load conditions
Efficiency decreases with part load	High efficiency even at part load
Commonly installed in hilly regions	Commonly installed in plains areas

**4. Write differentiate between Kaplan and Francis turbine.**

<b>Kaplan Turbine</b>	<b>Francis Turbine</b>
It is a reaction turbine	It is a mixed flow turbine
It used for low head and high discharge conditions	It is used for medium and medium discharge
Water flows through blades of the runner	It has relatively low specific speed
It operates with completely field flow passage	Runner blades are not adjustable

Suitable for variable flow and load conditions	Roter has (10-25) Blades
High efficiency even at part load	High frictional losses

**5. Write five Micro hydro power plant in India with capacity.**

Location	State	Capacity
Chitkul village, Kinnaur	Himachal Pradesh	100 kw
Badyar Micro Hydro Plant	Uttrakhand(Chamoli)	50 kw
Alehi Micro Hydro	Ladakh(leh)	30 kw
Mukto Village, Tawarg	Arunanchal Pradesh	60 kw
Lingee Payong	Sikkim	50KW

**LONG QUESTION (10 Marks)**

**1. Write down the construction and working of Pelton turbine.**

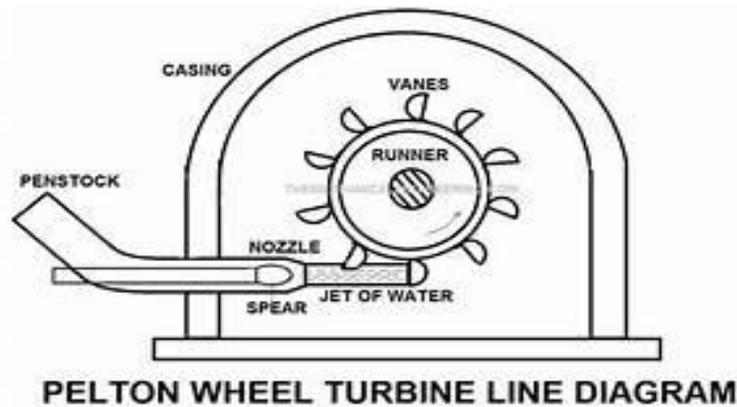
Ans. Pelton turbine converts the kinetic energy of a water jet into mechanical energy. It consists of a wheel with buckets evenly spaced around its edge. Water is directed at high speed through one or more nozzles, striking the buckets and causing the wheel to spin.

**Construction**

- A circular disc mounted on a shaft.
- Around its periphery are hemispherical bucket that catch and deflect water jets.
- Made from stainless bronze or composite material for durability.
- The nozzle converts high pressure water from the penstock into a high velocity jet.
- Some turbines may use multiple nozzle for higher power output.
- Used to stop the runner by directing a jet onto the back side of the buckets.
- The runner is mounted on the shaft supported by ball or roller bearing.

**Working**

- Water from a high head is carried through a penstock to the turbine.
- The pressure energy gets converted into kinetic energy at the nozzle exit.
- As the water jet changes the direction it exerts a force on the buckets.
- This impulse force causes the runner to rotate.
- The rotating runner turns the shaft which is connected to an electric generator.
- After striking the bucket under the fall into the casing and drained through the tailrace.



## 2. Write the construction and working of Francis Turbine.

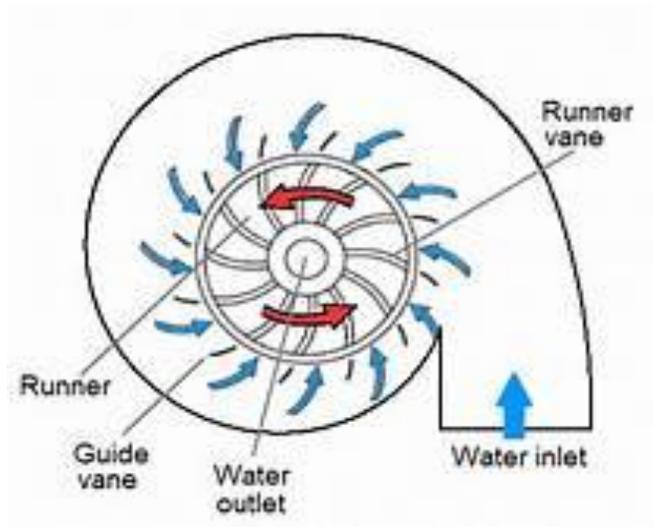
Francis turbine is a type of reaction turbine used extensively in hydroelectric power plant to convert the energy of flowing a falling water into mechanical energy which is then converted into electricity.

### Construction.

- Spiral casing encircles the turbine and gradually reduces in diameter as it moves towards the runner it directs water from the penstock to the runner maintaining a uniform pressure and momentum.
- Stay vanes guide the water flow towards the runner blades. They also help prevent swirling caused by radial flow of water.
- Guide vanes control the flow rate of water entering the runner and the angle at which the water strikes the blades, optimizing efficiency.
- The runner is the heart of the turbine, consisting of curved blades that rotates when strike by the water flow. In Francis turbine the runner blades are designed to utilize both impulse and reaction forces of the water.
- Draft tube is diverging tube that connect the runner outlet to the turbine. It helps to recover some kinetic energy of water leaving the runner and also maintains pressure balance.

### Working.

- Water enters the turbine through a spiral casing and is directed towards the runner by guide vanes.
- The guide vanes regulate the flow rate and angle of the water entering the runner Ensuring optimum performance under varying conditions.
- Water flows over the runner blades, creating pressure difference and also impacting the blades.
- The combined effect of the pressure difference and the impulse force causes the runner to rotate.
- After passing through the runner, the water flow into draft tube, which gradually expand in area. This expansion reduces the water velocity and removes some pressure, minimizing energy loss.
- The rotating shaft of the runner is connected to generator, converting mechanical energy into electrical energy.



## CHAPTER-4

### 2 MARK QUESTIONS: -

#### 1. What is load duration curves?

Ans: - It is a graph between time duration of loads the loads arranged in descending order of magnitude.

#### 2. What is demand factor?

Ans: - It is the ratio of maximum demand on the power station to its connected load

i.e., Demand factor =  $\frac{\text{Maximum demand}}{\text{Connected load}}$

The value of demand factor is usually less than 1.

#### 3. What is plant use factor?

Ans: - It is ratio of kWh generated to the product of plant capacity and the number of hours for which the plant was in operation.

Plant use factor =  $\frac{\text{Station output in kWh}}{\text{Plant capacity} \times \text{hours of use}}$

#### 4. What is hot reserve?

Ans. It is generating capacity of the plant in operation but not in service.

#### 5. Define base load?

Ans. It is the fixed load which remains on the power plant almost the whole day.

#### 6. Define load factor?

Ans: - The ratio of average load to the maximum demand during a given period is known as load factor i.e.,

Load factor =  $\frac{\text{Average load}}{\text{Maximum demand}}$

Load factor is always less than 1 because average load is smaller than the maximum demand.

#### 7. Define diversity factor?

Ans: - The ratio of the sum of individual maximum demands to the maximum demand on power station is known as diversity factor i.e.,

Diversity factor =  $\frac{\text{Sum of individual max.demands}}{\text{Max.demand on power station}}$

Diversity factor will always be greater than 1.

The greater the diversity factor, the lesser is the cost of generation of power.

#### 8. What is brownout?

Ans: - A brownout is a brief interruption in power service. A brownout only causes a drop in system voltage; the electrical power source is never completely disrupted.

### 9. What is blackout?

Ans: - A blackout is the complete loss of electricity service in a specific location. In more severe situations, blackouts can last anywhere from a few minutes to weeks. Typically, blackouts are caused by equipment/system breakdowns or weather-related issues

### 10. The maximum demand on a power station is 100 MW. If the annual load factor is 40%, calculate the total energy generated in a year.

Ans: - Energy generated/year = Max. demand  $\times$  L.F.  $\times$  Hours in a year  
 $= (100 \times 10^3) \times (0.4) \times (24 \times 365) \text{ kWh}$   
 $= 3504 \times 10^5 \text{ kWh}$

### 5 MARK QUESTIONS: -

#### 1. What is the difference between blackout and brownout?

Ans: -

<b>Brownout</b>	<b>Blackout</b>
A temporary and partial drop in voltage supplied by the power grid.	A complete and total loss of all electrical power.
Typically lasts from minutes to a few hours, and is often known in advance by the utility company.	Can last for an indefinite period, ranging from minutes to days or even weeks.
Lights may dim or flicker. Some appliances, especially those with motors, may run poorly, behave erratically, or stop working.	All electrical devices and appliances stop functioning completely.
High risk for sensitive electronics and appliances with electric motors. The low and inconsistent voltage can cause them to overheat or malfunction.	While there is no power during the outage, the abrupt return of power can cause a surge, which can damage devices.
Can be detected by flickering lights, unreliable electronics, and reduced appliance performance.	Immediately obvious by the complete loss of all power and light.

#### 2. What are the causes, impact and reason of grid system fault? State grid and National grid?

Ans: -Electrical power Grids (EPGs) are one of the most critical infrastructures in the globe. This study analyses new threats to EPGs, their various effects, and various strategies that can be used to prevent or lessen such effects, thereby enhancing EPG resilience.

Electrical power systems must increasingly be able to withstand such occurrences; hence, it is critical to comprehend the causes and effects of faults.

Electrical power systems must increasingly be able to withstand such occurrences; hence, it is critical to comprehend the causes and effects of faults. This study shows several fault types and their corresponding causes, demonstrating which ones are more frequently discussed in the literature. The severity of the cause will affect the specific effects of the originating fault.

If a small cause arises, it will lead to a minor fault that only affects a few residential homes and will be simple to fix, maybe taking just a few hours to complete. A large-scale

fault, such as a blackout or a cascade failure, can instead be caused by a large-scale cause, such as a hurricane or terrorist attack, which could affect a wide area and take days or weeks to recover from. Large-scale disruptions have major economic and social repercussions for consumer

Three key cause clusters are listed in the entry:

Natural Causes: A variety of natural events, including hurricanes, floods, flooding, earthquakes, tornadoes, heat waves, and solar flares, could cause a fault in the EPG;

Errors: mistakes made by people or technical problems with equipment;

Attacks: can be either cyber-attacks, like denial of service, or attacks by people, like terrorism.

### 3. Explain and classify the cost of generation?

Ans: - The cost of power generation can be categorised into three classes-

(i) Fixed cost

(ii) Semi fixed cost and

(iii) Variable cost.

(i) Fixed cost—This type of cost does not depend upon the maximum demand on the generating station and units produced. This type of cost is present even if power plant is not running. For example, salaries of high officials, interest paid on capital, investment on plant & machinery etc.

(ii) Semi fixed cost—This type of cost depends upon maximum demand but is independent of units generated. For example, depreciation of capital cost of plant and machinery, civil work, transmission & distribution network, taxes and insurance, salaries of clerical staff, compensation given to workers etc.

(iii) Variable cost—This type of cost is proportional to number of units generated. For example, fuel cost, repair & maintenance cost, wages of operational staff, cost of spares and consumables etc.

The total annual cost of generation is represented by following expression-

$$\text{Total cost} = A + B \text{ kW} + C \text{ kWh}$$

Where A, B and C are constants. First term represents fixed cost, second term represents semi fixed cost and last term represents variable cost.

### 4. A generating station has a connected load of 43MW and a maximum demand of 20 MW; the units generated being $61.5 \times 10^6$ per annum. Calculate (i) the demand factor and (ii) load factor.

$$\text{Solution: - i) Demand factor} = \frac{\text{Max.demand}}{\text{Connected load}} = \frac{20}{43} = 0.46$$

$$\text{ii) Avg. demand} = \frac{\text{Connected load}}{\text{Hours in a year}} = \frac{61.5 \times 10^6}{8760} = 7020 \text{ kWh}$$

$$\therefore \text{load factor} = \frac{\text{Average demand}}{\text{Max.demand}} = \frac{7020}{20 \times 10^3} = 0.351 \text{ or } 35.1\%$$

### 5. A diesel station supplies the following loads to various consumers: Industrial consumer = 1500 kW; Commercial establishment = 750 kW Domestic power = 100 kW; Domestic light = 450 kW, If the maximum demand on the station is

**2500 kW and the number of kWh generated per year is  $45 \times 10^5$ , determine (i) the diversity factor and (ii) annual load factor.**

Solution: - i) Diversity factor =  $\frac{1500 + 750 + 100 + 450}{2500} = 1.12$

ii) Average demand =  $\frac{\text{kWh generated / annum}}{\text{Hours in a year}} = \frac{45 \times 10^5}{8760} = 513.7 \text{ Kw}$

$\therefore$  Load factor =  $\frac{\text{Average load}}{\text{Average load}} = \frac{513.7}{2500} = 0.205 = 20.5 \%$

### **LONG QUESTION (10 Marks)**

**1. (a) What are the factor consider for determine the size and number of generating units?**

Ans: - The following are the factors that are considered for determining the size and number of generating units.

- a) The total generating capacity of the generating units should be able to meet the peak demand of the power plant.
- b) The number of units must be selected in such a way that all the machines run at maximum efficiency.
- c) There must be a spare generating unit of capacity nearly the same as that of the largest unit of the power station. Keeping spare capacity unit increase supply reliability.
- d) There may be an increase in demand in the future. While deciding the size and number of units this aspect also should be kept in mind.
- e) The generating capacity of the power station should be decided by keeping 15 or 20% additional capacity to meet the expected maximum demand.

**(b) What are the advantages of interconnected power system?**

Ans: -

Several generating plants are connected to form an interconnected grid system. There are many advantages of the interconnected grid system. They are given below.

- a) The amount of reserve plant capacity in the system as a whole was reduced. Load factor and Efficiency of operation improve.
- b) Reliability of supply increased.
- c) The diversity factor is of the whole system improved.
- d) Interconnection of hydro and thermal power plants is economical.
- e) Generators of larger size can be employed resulting in reduce cost/ kWh.

**2. Explain load curve with diagram? What information we will get from Load curve?**

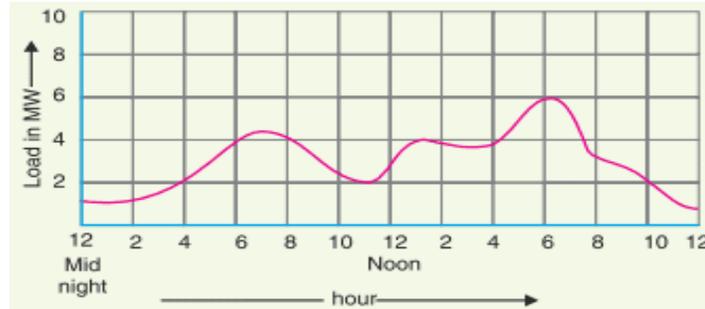
The curve showing the variation of load on the power station with respect to (w.r.t) time is known as a load curve.

The load on a power station is never constant; it varies from time to time. These load variations during the whole day (i.e., 24 hours) are recorded half-hourly or hourly and are plotted against time on the graph. The curve thus obtained is known as daily load curve as

it shows the variations of load w.r.t. time during the day. Fig. below shows a typical daily load curve of a power station.

It is clear that load on the power station is varying, being maximum at 6 P.M. in this case. It may be seen that load curve indicates at a glance the general character of the load that is being imposed on the plant. Such a clear representation cannot be obtained from tabulated figures. The monthly load curve can be obtained from the daily load curves of that month. For this purpose, average values of power over a month at different times of the day are calculated and then plotted on the graph. The monthly load curve is generally used to fix the rates of energy.

The yearly load curve can be obtained from the monthly load curves of that year



The daily load curves have attained a great importance in generation as they supply the following information readily:

- (i) The daily load curve shows the variations of load on the power station during different hours of the day.
- (ii) The area under the daily load curve gives the number of units generated in the day. Units generated/day = Area (in kWh) under daily load curve.
- (iii) The highest point on the daily load curve represents the maximum demand on the station on that day.
- (iv) The area under the daily load curve divided by the total number of hours gives the average load on the station in the day.

$$\text{Average load} = \frac{\text{Area (in kWh) under daily load curve}}{24 \text{ hours}}$$

\*\*\*\*\*