

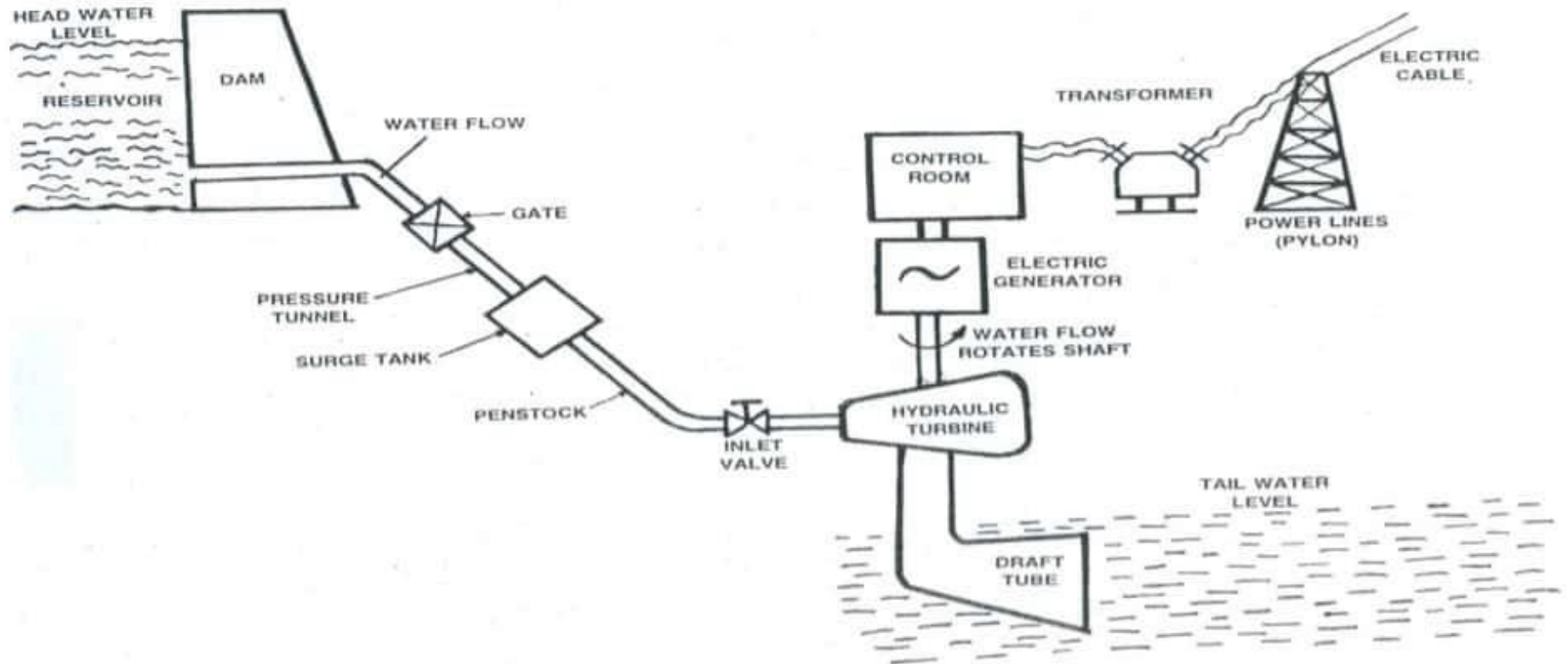
# Power Plant Engineering

## **Module 2**

# Hydroelectric power plant

- Energy of water is used to run the turbine which rotates the generator that coupled with the turbine.
- KE of water → Mechanical energy of turbine rotor → Electrical energy of electric motor.
- Basic elements of hydroelectric plant
  - Reservoir
  - Dam
  - Sluice gate
  - Penstock
  - Surge tank
  - Spill way
  - Turbine
  - Power house

# Layout of Hydroelectric power plant



- Reservoir: A huge amount of water is being stored and energy is stored here as **potential energy**.
- Dam: It is used as a barrier to restrict the flow of surface water or underground streams.
- Sluice gate: It is used to control and measure the water levels in reservoir. Vertical rising sluice gates are the most common type.
- Penstock: It is a large metallic pipe that takes water from reservoir to turbine as the control gate is opened.
- Surge tank: Surge tank is used to accumulate the water in penstock pipe when the valves are suddenly closed. It prevents the chances of **water hammering**.

- Spillway: It is a structure used to provide a safe path for the excess water in reservoir to a downstream area. Spillways are constructed as concrete piers over the dam.
- Turbine: Turbine is a machine that converts kinetic energy of water into mechanical energy.
- Powerhouse: It is the place where power is stored and being transferred to different substations via transformers.

# Working

- Water from reservoir or headrace level is taken to turbine through penstock pipes.
- The water with high pressure starts flowing and strikes to the turbine blades through the nozzle.
- The turbine blades start rotating, Kinetic energy of water → Mechanical energy of turbine rotor.
- In the turbine blade, an electric motor is coupled to the turbine shafts.
- As the turbine rotor rotates, electric motor also rotates results in generation of electricity.
- The energy generated is sent to the powerhouse, transformer and transmission line.
- The water after striking the turbine is sent to the river via a tailrace.

# Types of Hydroelectric plants

Advantages and Disadvantages

# 1. Classification of Hydroelectric plants based on **head of available water**

## 1. Low head plant

- Head is less than 50m.
- Surge tank is not required.
- Usually low head powerplant uses Kaplan or propeller turbine as the prime mover or turbine.

## 2. Medium head plant

- Head lies between 50m and 300m.
- Surge tank is required.
- Usually Francis turbine is used for medium head applications.

## 3. High head plant

- Head is greater than 300m.
- Surge tank is required to reduce water hammering effect.
- Pelton turbine is used.



## 2. According to nature of load

### 1. Base load plant

- Generates power output continuously without any delay.
- Meets the average demand of electricity

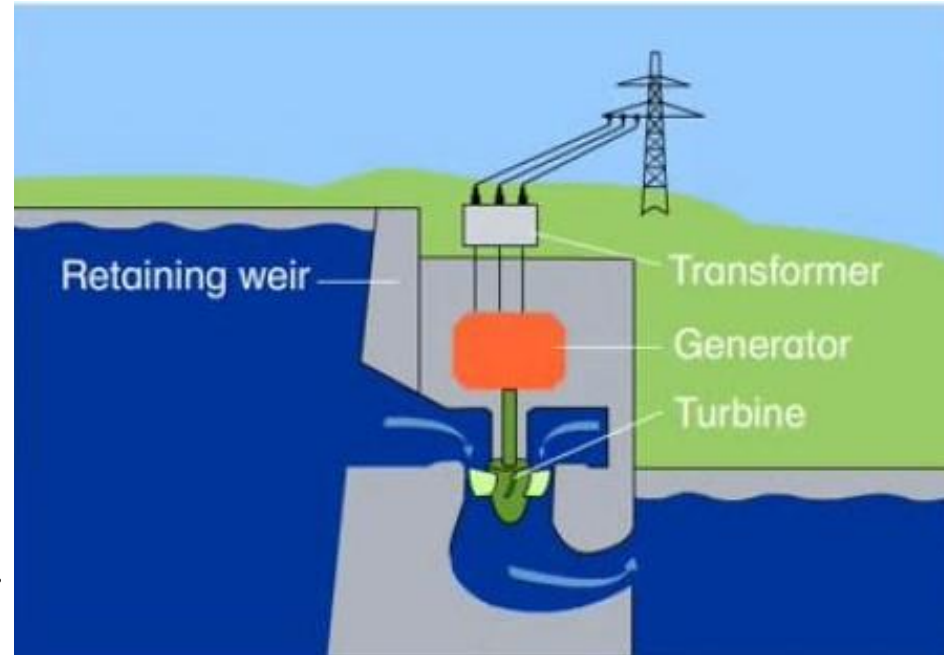
### 2. Peak load plant

- Generates power during the peak load hours.
- Meets the demand of electricity during specific hours only.

### 3. According to quantity of water available

#### 1. Run-off river plant

- Turbine is submerged in rivers in hilly areas.
- Water is directly fed to submerged runners instead of storing in reservoirs.
- The output or capacity of plant is limited.
- Hence the utility of plant is limited.



## 2. Run off river plant with reservoir

- The usage of run-off river plant is increased by providing a reservoir.
- The reservoir stores water during off peak hours and used during peak hours of the same day.

## 3. Storage type plant

- Water is stored during rainy season and supplied the same during dry season.
- The size of reservoir would be having enough capacity.

## 4. According to quantity of available water

### 1. Pump storage plant

- This is preferred when less amount of water is available.
- Water after passing through the turbine is pumped back to reservoir from the tailrace.

### 2. Mini & Micro power plant

- When power develops from low head (between 5m and 20m), plant is known as **mini power plant**.
- When power develops from a head which is less than 5m, plant is known as **micro power plant**.

# Advantages and Disadvantages of Hydroelectric Power plant

- Advantages

- Fuel cost is zero, since water is used.
- No harmful emissions during the working.
- Low maintenance cost.
- Construction is simple.
- Longer life time.

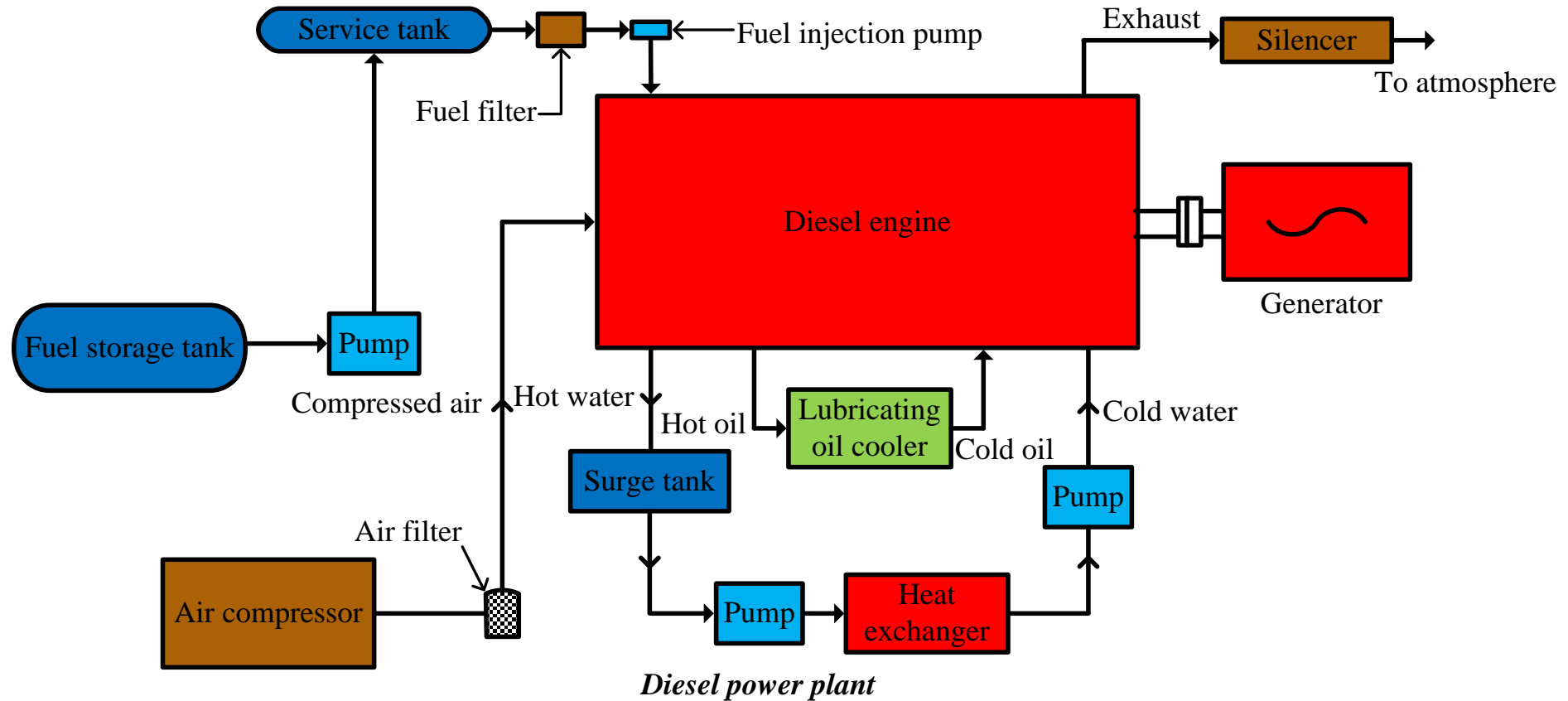
- Disadvantages

- Capital cost is high.
- Highly skilled workers are required during installation.
- Availability of water is necessary.
- Transmission cost is high.

# Diesel Power Plant

- A diesel engine is used to rotate the generator for the power production.
- Main components include:
  - Engine
  - Air supply system
  - Fuel system
  - Exhaust system
  - Cooling system
  - Lubricating system
  - Starting system
  - Governing system

# Layout of Diesel Powerplant



# Main Components

1. **Engine**: A 4 stroke diesel engine is used which is directly coupled to the motor.
2. **Air supply system**: Air from atmosphere after filtering is admitted to the engine.
3. **Exhaust system**: It discharges engine exhaust to the atmosphere, which is incorporated with a silencer to reduce the noise level.
4. **Fuel system**: Fuel from main storage tank is transferred to service tank on daily basis or hourly basis. It is then fed to the engine via a filter and injector.



5. **Cooling system**: Cold water from cooling water is circulated and takes away the heat of engine.
6. **Lubricating system**: Lubricating system provides lubricating oil to moving parts of the system to reduce the friction and wear and tear.
7. **Starting system**: It is used for the initial starting of engine until firing starts and it starts running by its own power.
8. **Governing system**: It is used to maintain the engine speed according to the load on the plant.

# Working of Diesel Power plant

- A diesel engine where diesel fuel is burnt in the presence of compressed air.
- Fuel is supplied using an injector and compressed air supplied by a compressor.
- As fuel burns, engine crank rotates and the generator rotor also rotates, thus electricity is produced.

# Advantages and Disadvantages

## Advantages

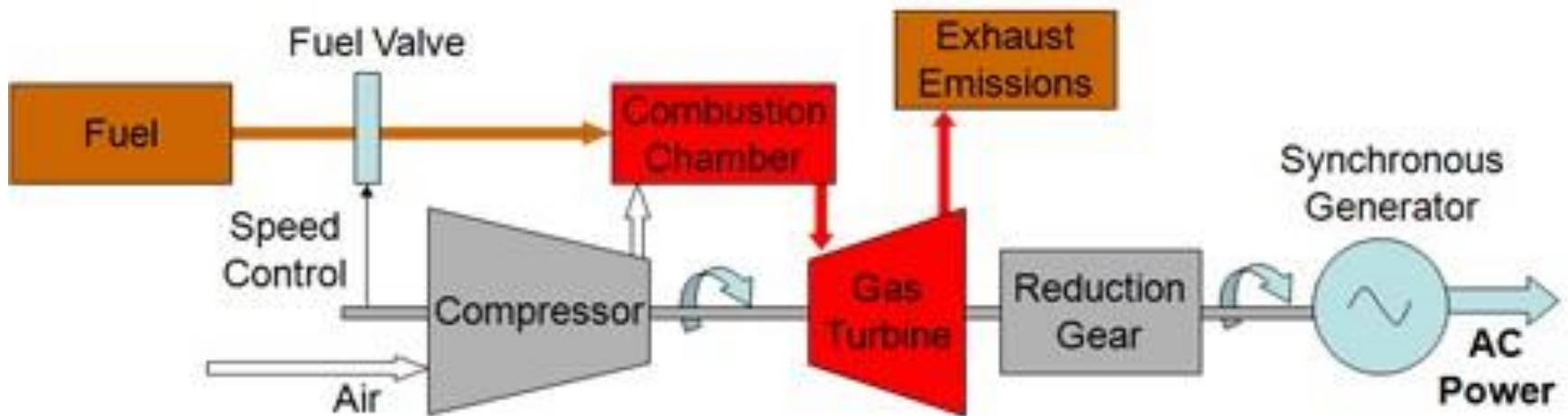
- Layout is simple and cheap.
- Part load efficiency is high.
- Starting is easy.
- Thermal efficiency is high.
- Can be designed for portable uses.

## Disadvantages

- Cost of diesel is higher compared to coal.
- Life is less.
- Noise pollution.
- High maintenance and lubrication cost.
- Capacity is limited.

# Gas Turbine Power plant

- In gas turbine power plants, products of combustion is expanded through a series of **fixed and moving blades**.

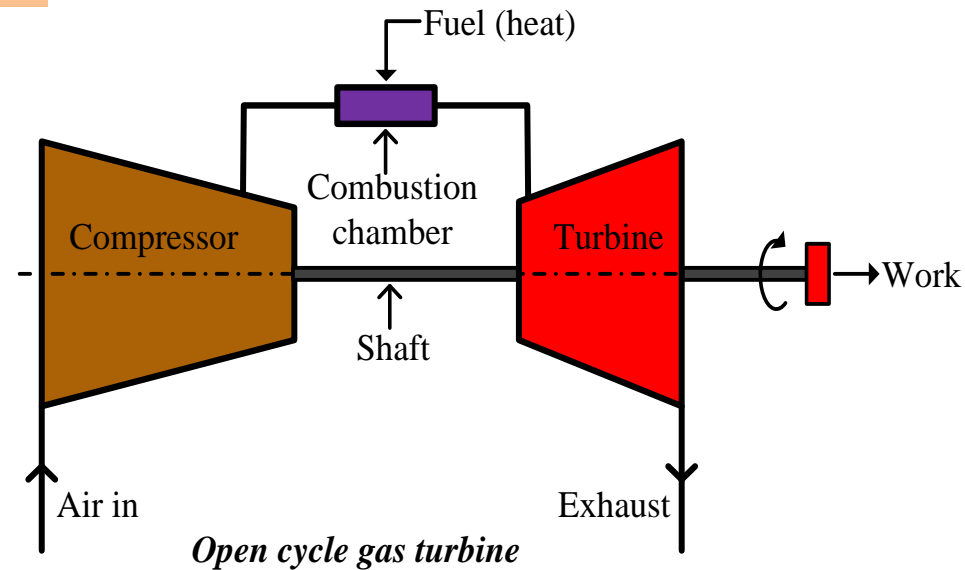


# Main Components and Working

- **Compressor**: It is used to raise the pressure of working medium. Normally **centrifugal** and **axial** compressors are used. It is driven by turbine, therefore it is coupled to turbine shaft.
- **Combustion Chamber**: The working medium is then taken to the combustion chamber where it is burned by proper mixing of air and fuel. The temperature of working medium is raised.
- **Turbine**: The high pressure high temperature working medium is then expanded in a gas turbine.
  - **Radial flow** and **axial flow** turbines are generally used.

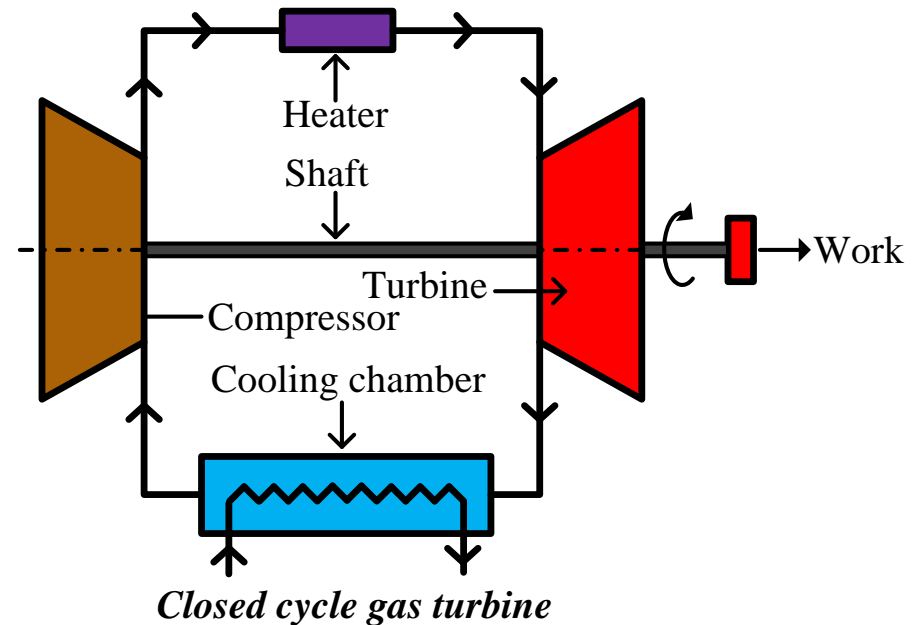
# Open cycle gas turbine

- The air from the atmosphere is drawn into the compressor.
- After compression, it is passed into a combustion chamber.
- The hot gas is then made to flow over the turbine blades.
- The gases after expansion get exhausted to the atmosphere.



# Closed cycle gas turbine

- The working medium after expansion through turbine, is sent to a cooling chamber.
- After cooling, the working medium is sent back to the compressor for further compression.
- These processes are repeated.



# Advantages and Disadvantages

## Advantages

- Mechanical efficiency of a gas turbine is high as compared to an IC engine.
- Compact in design.
- Smooth running.
- Requires little or no water for cooling.
- Relatively low maintenance costs.

## Disadvantages

- Thermal efficiency is low compared to an IC engine.
- Overall efficiency is low as  $3/4^{\text{th}}$  of the power is used to drive the compressor.
- Operation involves noise.