SUBJECT- P0WER STATION ENGINEERING
(TH-3)

BRANCH-MECHANICAL ENGINEERING

(6TH SEMESTER)

PREPARE BY:- *ER.AMALAN NAYAK*

NILASAILA INSTITUTE OF SCIENCE AND TECHNOLOGY
SERGARH, BALASORE,756060
(Approved By AICTE and Affiliated To SCTE&VT, Odisha)SERGARH, BALASORE-756060, ODISHA
Email: nist.bls@gmail.com / Visit us: www.nist.org.in

CHAPTERS

CHAPTER-01

INTRODUCTION

DEFINITION OF SOURCES OF ENERGY

A source from which energy can be obtained to provide heat, light, or power. The term energy is used to describe an amount of work performed**.**

Concept of central power station

A central power station (CPS) is a centralized electricity generation facility located remotely and connected to a network of high-voltage transmission lines. The electricity generated is distributed to the end-users through the electric power grid.

DESCRIBE SOURCES OF ENERGY

Energy sources are categorized as **renewable** or **non-renewable**.

- **Renewable energy** is collected from renewable resources. A source of energy is considered renewable if it comes from natural sources or processes that are constantly replenished. Examples are solar (from the sun), wind, water, geothermal (from the earth) and biomass (from organic materials).

- **Non-renewable energy** sources don't replenish, and are formed when prehistoric plants and animals died and were gradually buried by layers of soil rock. The kind of fuel that was created varied depending on the conditions like what kind of organic material (from plants or animals), how long it was buried, at what temperature and under what pressure. Types of non-renewable energy are natural gas, coal and oil.

Types of energy

- **Chemical energy** – stored within bonds between molecules. Sources include natural gas, gasoline, coal and batteries. Even the food we eat is considered chemical energy.
- **Electrical energy** – comes from tiny charged particles called electrons. A lightning bolt is one form of electrical energy. The electricity in our homes is made by humans.
- **Gravitational energy** – associated with a gravitational field, like the one that surrounds the Earth. If you've ever fallen down, you've experienced the power of gravitational

energy. Gravitational energy is the reason why riding your bike downhill is faster than riding your bike uphill.

- **Kinetic energy** – anything that moves is using this kind of energy. Examples include running, cycling, climbing – even swiping your finger across your smart phone! Wind turbines capture the kinetic energy in wind and transform it into mechanical energy.
- **Mechanical energy** – stored in objects by tension. When the tension is released, motion occurs. A compressed spring contains mechanical energy as does a stretched rubber band.
- **Nuclear energy** – stored inside tiny atoms that are invisible, but make up the elements of the entire universe. Nuclear energy is released when atoms join together (fusion) or split (fission). The fusion reaction in the sun provides warmth and light, while the fission reaction at a nuclear power plant creates enough energy to power large cities.
- **Solar (radiant) energy** – energy that comes from the movement of light.
- **Sound energy** – produced when an object is made to vibrate producing a sound. Your voice and musical instruments use sound energy.
- **Thermal (heat) energy** – created from moving molecules. The energy that comes from a fire is thermal energy.

CONCEPT OF CAPTIVE POWER STATION

A captive power plant is a facility that provides a localized source of power to an energy user. These are typically industrial facilities, large offices or data centers. The plants may operate in grid parallel mode with the ability to export surplus power to the local electricity distribution network.

CLASSIFY POWER PLANTS

There are several types of power plants that generate electricity using various sources such as fossil fuels, nuclear energy, hydroelectricity, and renewable sources like solar and wind. Some common types include coal-fired, gas-fired, nuclear, hydroelectric, geothermal, biomass, and solar power plants. Each type has its advantages and disadvantages, and the choice depends on several factors such as cost, location, and availability of resources.

There are different types of Power Plants depending on the type of resource used for generating power.

- Thermal power Plant
- Nuclear power Plant
- Hydropower Plant
- Geo Thermal power Plant
- Biogas power Plant
- Biomass power Plant

- Solar power Plant
- Wind Power Plant
- Tidal power plant

IMPORTANCE OF ELECTRICAL POWER IN DAY TODAY LIFE

Electricity Is Generally the Movement of Electrons. Electricity Is It of Energy That Use to Power Different Things Like Lights, Appliances, And Electronic Devices Etc. A Conductor Is a Material That Allows Electricity to Pass Through It Copper and Iron. Electricity Was Discovered Is Benjamin Franklin.

The Use of Electricity Is a Basic Need. Electricity Is as Important as Food and Water to People in the 21st Century. However, With the Growing Human Population and The Need of Electricity in Our Lives, Humans Have Found Different Ways to Generate Electricity. These Are the Sources That Generate Electricity.

1 Lights is electricity

Light Is Most Important, The Use of Electricity to Illuminate Light Bulbs Is the Main Reason We Need Electricity in Our Lives. Light Bulbs Give Us Light and We Can Do Our Work Dark Night Too. The Use of Electricity and The Invention of Light Bulbs, People Used Gas Lamps or Oil Lamps. He Used Oil to Illuminate the Room That One Could See Correctly.

2 Home Appliance

Today, Everyday Products and Appliances. TV, Fridge, Iron, Electric Bulb, Microwave, Mobile Phones, Vacuum Cleaners, Heaters, Computers, Etc. Require Electricity to Run. No Doubt These Appliances Have Made the Lives of Humans Easy and Have Increased the Importance of Electricity in Our Lives.

3 Hospital and Medical Facilities

The Hospitals Are Fully Dependent on Electricity. The Medical Tests That Are Necessary for A Proper Diagnosis Like X-Ray, CT scan, PET Scan, Etc. Use Electricity to Run. Without This Technology, The Functioning of a Hospital Is Impossible.

4 Environmentally Friendly Transportation Facilities

The Transport Services in Many Countries Are Dependent Upon Electricity. Underground Subways and Electric Buses Are the Main Forms of Public Transport for Many Countries. Other Than That, In Recent Years, Many Leading Automobile Companies Have Successfully Developed Electric Cars or Electric Bike.

5 Communications and Internet

The World Without the Internet and Communication Is Impossible to Imagine. All Of This Could Be Made Possible Because Of Electricity. Communication Devices Run on Electricity Like Mobile Phones, Computers, Laptops, Telephones, Etc.

Environmentally Friendly Transportation Facilities

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METHOD OF ELECTRICAL POWER GENERATION

There are different methods and techniques to generate the power and Electricity in the world with help of machinery and equipment as below.

- COAL POWER GENERATION. ...
- THERMAL POWER GENERATIONS. ...
- NUCLEAR POWER GENERATION. ...
- HYDRO-POWER GENERATION. ...
- GEOTHERMAL POWER GENERATION. ...
- BATTERY POWER GENERATION. ...
- WAVES POWER GENERATION

CHAPTER-02

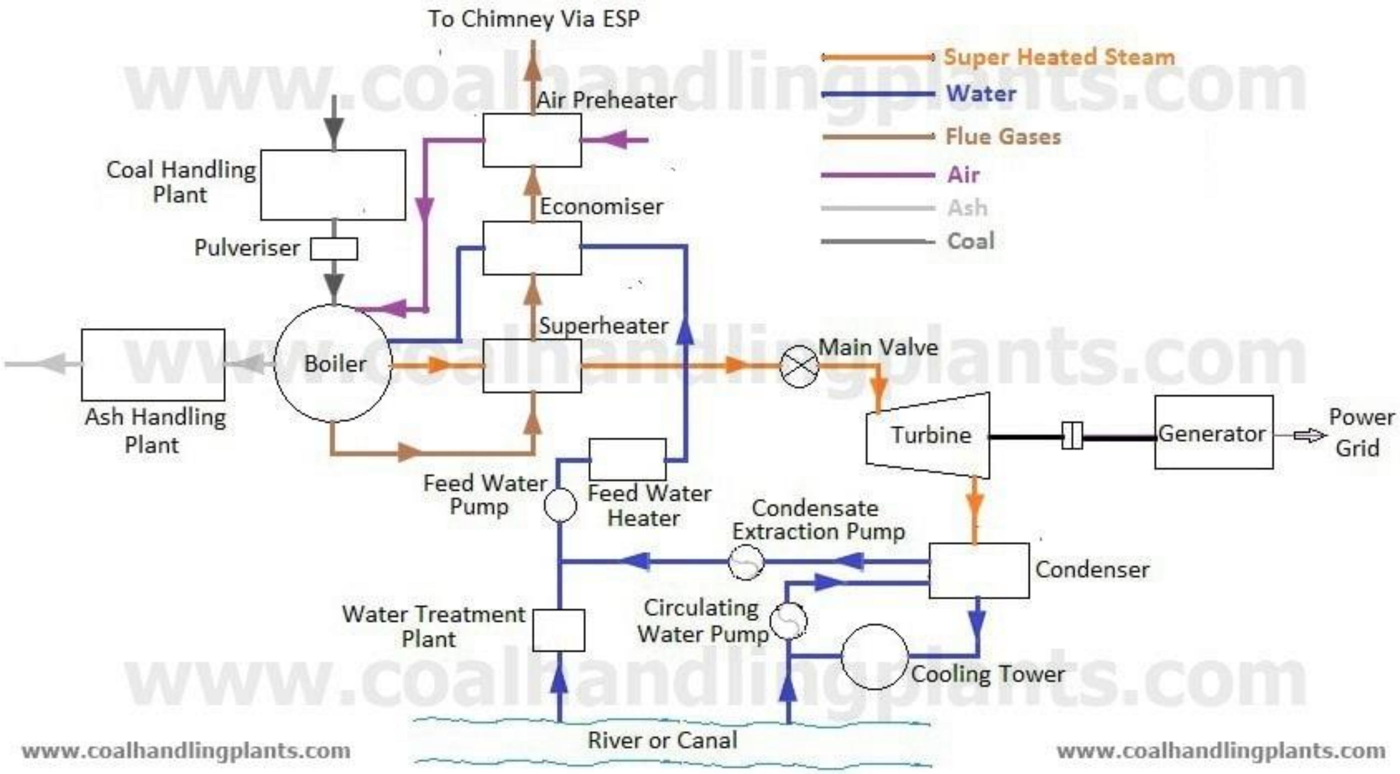
THERMAL POWER STATIONS

DEFINATION OF THERMAL POWER PLANT

A **thermal power station** is a type of power station in which heat energy is converted to electrical energy. In a steam-generating cycle heat is used to boil water in a large pressure vessel to produce high-pressure steam, which drives a steam turbine connected to an electrical generator. The low-pressure exhaust from the turbine enters a steam condenser where it is cooled to produce hot condensate which is recycled to the heating process to generate more high pressure steam. This is known as a Rankin cycle.

The design of thermal power stations depends on the intended energy source: fossil fuel, nuclear and geothermal power, solar energy, biofuels, and waste incineration are all used. Certain thermal power stations are also designed to produce heat for industrial purposes; for district heating; or desalination of water, in addition to generating electrical power.

LAYOUT OF STEAM POWER STATIONS



STEAM POWER CYCLE

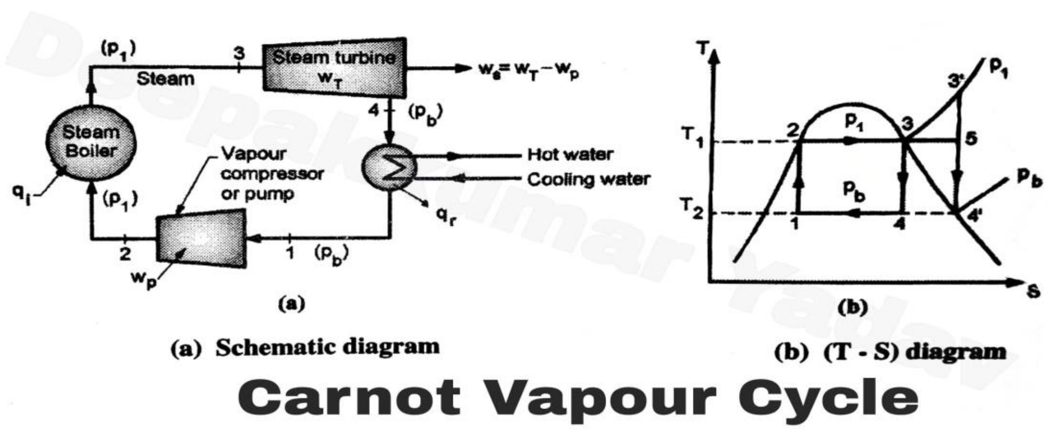
In steam power plants and refrigeration cycles, the working fluid changes from liquid to vapour and back to liquid state. This succession of processes is called vapour cycle. In steam power plants, water is the working fluid in the form of steam and vapour. In refrigeration cycles gasses such as Freon, CO_2, and ammonia (aqua-ammonia) are used as working substances.

Explain Carnot vapor cycle with P-V,T-S diagram and determine thermal efficiency.

In a vapour cycle, all the theory remains the same as thermodynamic cycle except the working substance, which is steam. The steam may be in any form, i.e. wet, dry or saturated or superheated.

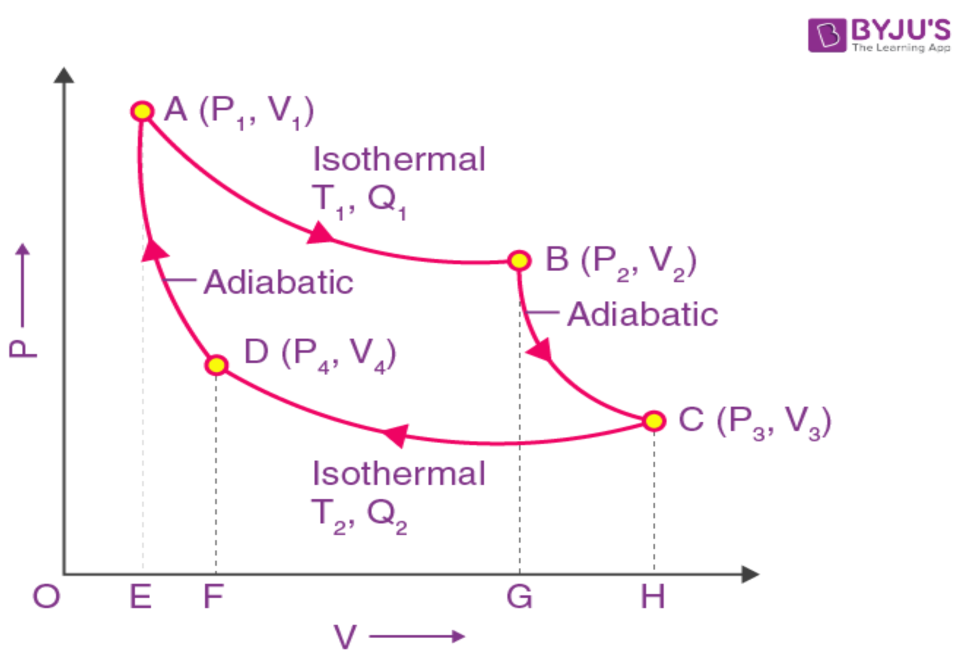
A Carnot cycle steam as a working substance is represented on the p-v and T-s diagram in Figure.

Carnot Vapour Cycle P-V Diagram



Isothermal Expansion

The cylinder is first placed on the source so that the gas acquires the temperatures T_1 of the source. It is then allowed to undergo quasi-static expansion. As the gas expands, its temperature tends to fall. Heat passes into the cylinder through the perfectly conducting base, which is in contact with the source. The gas, therefore, undergoes slow isothermal expansion at the constant temperature T_1.



Let the working substance during isothermal expansion go from its initial state A (P_1, V_1, T_1) to state B (P_2, V_2, T_1) at constant temperature T_1 along AB. In this process, the substance absorbs heat Q1 from the source at T_1 and does work W_1 given by,

Adiabatic Expansion

The cylinder is now removed from the source and placed on the insulating stand. The gas is allowed to undergo slow adiabatic expansion, performing external work at the expense of its internal energy until its temperature falls to T_2, the same as that of the sink.

This operation is represented by the adiabatic BC, starting from state B (P_2, V_2, T_1) to state C (P_3, V_3, T_2). In this process, there is no transfer of heat, the temperature of the substance falls to T_2, and it does some external work W_2, given by,

Isothermal Compression

The cylinder is now removed from the insulating stand and is placed on the sink, which is at a temperature of T_2. The piston is now very slowly moved inwards so that the work is done on the gas. The temperature tends to increase due to heat produced by compression since the conducting base of the cylinder is in contact with the sink, the heat developed passes to the sink, and the temperature of the gas remains constant at T_2. Thus, the gas undergoes isothermal compression at a constant temperature of T_2 and gives up some heat to the sink.

This operation is represented by the isothermal CD, starting from state (P_3, V_3, T_2) to state D (P_4, V_4, T_2). In this process, the substance rejects heat Q_2 to the sink at T_2, and work W_3 is done on the substance given by,

Adiabatic Compression

The cylinder is now removed from the sink and again placed on the insulating stand. The piston is slowly moved inwards so that the gas in adiabatic compression is continued till the gas comes back to its original condition, i.e., state A (P_1, V_1, T_1), thus completing one full cycle.

Definition Rankine cycle

The Rankine cycle is an idealized thermodynamic cycle describing the process by which certain heat engines, such as steam turbines or reciprocating steam engines, allow mechanical work to be extracted from a fluid as it moves between a heat source and heat sink.

Explain Rankine cycle

The Rankine cycle is an ideal thermodynamic cycle involving a constant pressure heat engine which converts heat into mechanical work. The heat is supplied externally in this cycle in a closed loop, which uses either water or any other organic fluids (Pentane or Toluene) as a working fluid.

Components of the Rankine Cycle

Before we move ahead to learn the working, we need to understand the components of this cycle. Refer to the image below.

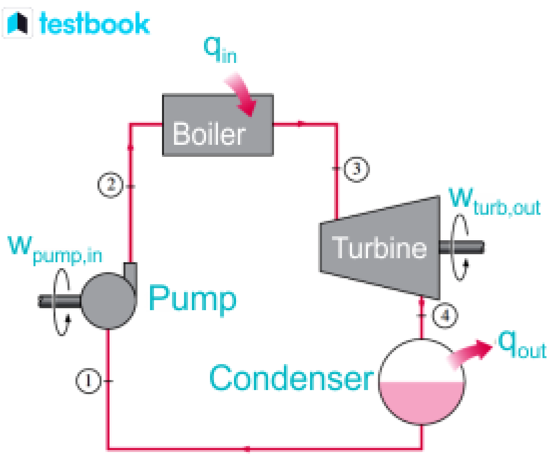


Fig 1: Schematic of Rankine Cycle

(1) Pump: They can be centrifugal pumps in industrial applications. Water as saturated liquid enters the pump and is compressed.

(2) Boiler: Boilers are generally heat exchangers as in thermal power plants. The compressed liquid enters the boiler to be converted to superheated steam.

(3) Turbines: Turbines or steam turbines are machines that use pressurised steam to produce mechanical work. The superheated steam entering the turbine expands and rotates the shaft to produce work which generates electricity.

(4) Condenser: Condenser has a set of tubes with a cooling medium surrounding it. The cooling medium may be air or water depending upon the placement of the power plant. Steam, in a saturated liquid-vapour state, is condensed at constant pressure and the heat is rejected to a cooling medium.

The power plants are cooled by air in areas where the water supply is limited. This cooling method is called ‘dry cooling’, which is used in car engines.

Working Principle of Rankine Cycle

The study of components in the cycle helps us understand that the cycle operates in a closed loop where the working fluid is reused. Let us consider the Rankine cycle P-v and T-s diagrams with the h-s diagram to understand the working.

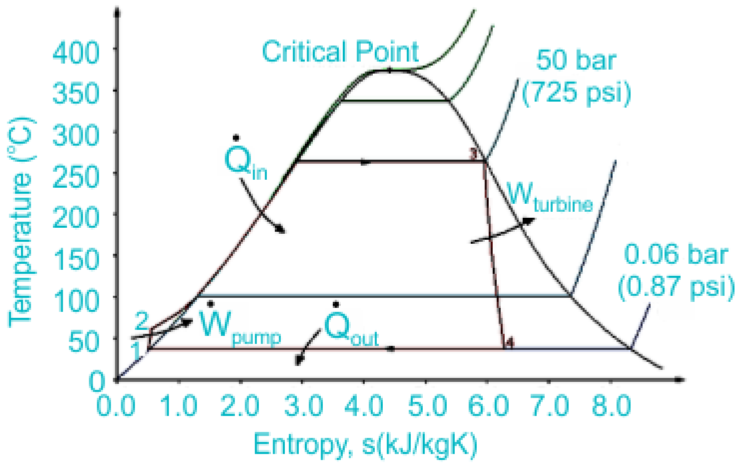


Fig 2: Temperature-Entropy (T-s) Diagram

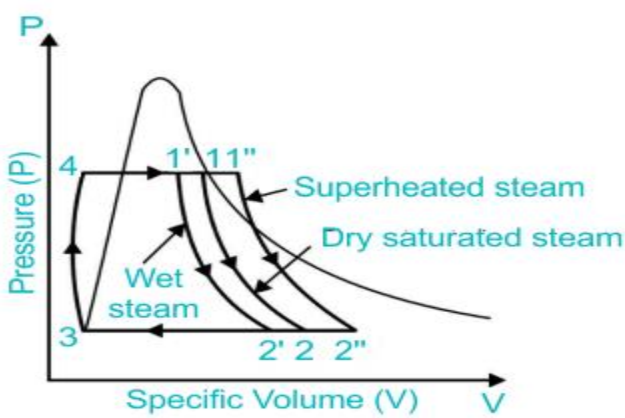


Fig 3: Pressure-Volume (P-v) Diagram

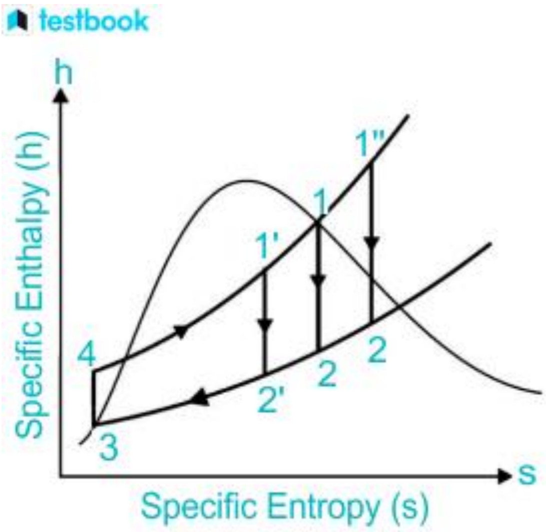


Fig 4: Specific Enthalpy-Specific Entropy (h-s) Diagram

A typical Rankine cycle has four thermodynamic processes which are explained below referring to all the diagrams. Let us assume that the cycle is operating at temperatures ranging from 0 °C to 400 °C.

- **Process 1-2:** The working fluid (saturated liquid) entering the pump, is pumped from a low to high pressure. This is also known as isentropic compression. The input energy is needed at this stage.
- **Process 2-3:** Liquid at a high pressure entering the boiler is heated by an external heat source at a constant pressure. The liquid is converted to dry saturated steam by constant pressure heat addition in the boiler.
- **Process 3-4:** The dry saturated steam from the boiler expands as it enters the turbine. It is also known as isentropic expansion. Due to this, the temperature and pressure of the steam decrease.
- **Process 4-1:** The wet vapour entering the condenser at this stage is condensed at a constant pressure. It is then converted to saturated liquid. This process is also known as constant pressure heat rejection in the condenser. This saturated liquid is again circulated back to the pump, and the cycle continues. The heat rejected or the exhaust heat after the final stage is represented.

Thermal power station in the state with their capacities

Uttar Pradesh	• **Singrauli Super Thermal Power Plant (**Shakti nagar in Sonebhadra district), The power plant is the first power plant of NTPC • **National Capital Power Station** (NCPS) Or NTPC Dadri (Dadri, G.Noida)

	• **Rihand Super Thermal Power Project (**at Renukut, Sonebhadra in Sonbhadra district) • **Anpara Thermal Power Station (**Anpara in Sonbhadra district) • **Obra Thermal Power Project (**Kanpur district) • **Rosa Power Plant (**at Rosa village in Shahjahanpur) • **Feroze Gandhi Unchahar Thermal Power Plant (**Unchahar in Raebareli district)
Telangana	• **NTPC Ramagundam (**at Ramagundam in Peddapalli district)
Odisha	• **Talcher Thermal Power station (**Angul district) • **Vedanta Jharsuguda Power Station (**Jharsuguda town in Jharsuguda district) • **Hirakud Power Plant (**Sambalpur district)
Chhattisgarh	• **Korba Super Thermal Power Plant** (at Jamnipali in Korba district) • **Sipat Super Thermal Power Station or Rajiv Gandhi Super Thermal Power Station** (at Sipat in Bilaspur district) • **The NSPCL Bhilai Power Plant (at** Bhilai in Durg district)
Madhya Pradesh	• **The Vindhyachal Thermal Power Station** (Singrauli district) • **Satpura Thermal Power Plant (**Betul district) • **Sanjay Gandhi Thermal Power Plant (**Umaria district) • **Shree Sungari Super Thermal Power Project (**Khandwa District) • **Amarkantak Thermal Power Plant (**Anuppur district)
West Bengal	• **Farakka Super Thermal Power Plant (**at Nabarun in Murshidabad district) • **Durgapur Steel Thermal Power Station (**Bardhaman district)
Gujarat	• **Mundra Thermal Power Station or Mundra Thermal Power Project (**at Mundra in Kutch district)

- **Sikka Thermal Power Station (**Jamnagar)
- **Wanakbori Thermal Power Station (**in Kheda district)
- **Ukai Thermal Power Station (**located on the bank of the Tapi river.
- **Gandhinagar Thermal Power Station (**bank of Sabarmati river near Gandhinagar)
- **Hirakud Power Plant (**Hirakud in Sambalpur district)

Function of Boiler

The function of a boiler is to either produce hot water or steam. Hot water boilers heat water for the purpose of domestic or commercial heating and hot water supply. Steam boilers generate steam in order to power turbines for power generation and various other industrial heating applications.

Describe Boiler Accessories

Boiler Accessories

The boiler accessories are required to improve the efficiency of the steam power plant and to enable for the proper working of the boiler. The boiler accessories aren't mounted directly on the boiler.

The essential boiler accessories are:

1. Economiser
2. Air pre-heater
3. Superheater
4. Feed pump
5. Steam Separator
6. Steam trap

Economiser

The combustion gases coming out of the boiler contain a large quantity of heat. Therefore the maximum amount of heat from the gases should be recovered before it escapes to the chimney.

In the economiser, heating the feed water does the recovery of heat in the flue gases. The economiser is placed in the path of the gases. They improve the overall efficiency of the boiler by reducing fuel consumption.

Air Pre-heater

The air preheater is an accessory that recovers the heat in the exhaust gas by heating the air supplied to the furnace of the boiler. Supplying preheated air into the furnace produces a high furnace temperature and accelerates the combustion of the fuel. Thus the thermal efficiency of the plant will be increased.

The advantages of air pre-heater are,

1. Increase in the steam generation rate.
2. Better combustion with less soot, smoke and ash, and
3. Low-grade fuels can be used.

Superheater

The superheater is used in boilers to increase the temperature of the steam above the saturation temperature.

The dry saturated steam generated in the boiler is passed through a set of tubes placed in the path of the flue gases, in which it will be heated further by the hot gas to increase its temperature about the saturation temperature.

Feed Pump

A feed pump is a boiler accessory required to force the feed water at high pressure into the boiler. Commonly used pumps are,

1. Reciprocating pumps
2. Rotary pumps

The reciprocating pumps are driven directly by coupling them to the steam engine. The rotary pumps are driven by the steam turbines or by electric motors.

Explain boiler the Boiler Mountings in steam turbine

Ans- Steam boiler mountings are fittings, mounted on the steam boiler to ensure its proper functioning. Boiler mountings include water level indicator, safety valve, pressure gauge, etc. It is necessary to note that a boiler cannot function safely without the mountings. These fittings mounted on the steam boiler are required mandatorily for the safe and proper operation of the boiler system.

The primary mountings in the steam boiler are:

- Water level indicator
- Pressure gauge
- Safety valve
- Steam stop valve
- Blow off valve
- Feed check valve
- Fusible plug

- **Water Level Indicator:**

A water level indicator is installed outside the steam boiler shell to determine the water level in the boiler through a glass tube. It is safety equipment that ensures the safe operation of the steam boiler.

The Water-tube indicator consists of a vertical hard glass tube that is fitted with two gunmetal tubes A and B. Tube A and B join the steam space of the boiler and the water space of the boiler with the glass tube respectively.

Tube A is fitted with a valve, called a steam valve, and tube B is provided with another valve called a water valve. Additionally, a third valve called the drain valve is fitted to the water level indicator. The drain valve helps in periodically draining the water together with condensed steam from the gunmetal tube A.

- **Pressure Gauge:**

A pressure gauge indicates the steam pressure in the boiler. It is mounted usually on the front top of the steam boiler.

The pressure gauge consists of a circular spring tube A. One end of the tube is closed and joined to a link, while the other end is to a hollow block. The link connects the closed end of the tube to the toothed sector that is hinged. The toothed sector gears with a pinion that carries a pointer. The pointer moves on a dial, indicating the pressure units.

- **Safety Valve:**

The safety valve is a safety mounting fitted on the steam boiler shell and is crucial on the boiler shell to ensure the safety of the boiler against high pressure. It prevents explosions due to excessive internal steam pressure in the boiler system.

The safety valve is equipment to prevent the increasing steam boiler pressure above its operating pressure. It opens automatically as the pressure in the steam boiler exceeds the normal working pressure. Therefore, it allows excess steam to release into the atmosphere until the pressure returns to its normal valve. A safety valve ensures the safety of the steam boiler from damages due to excessive steam pressure.

DRAUGHT SYSTEMS

Draught is an essential part in thermal power plant. The functions of the draught system are:

1. To supply required quantity of air to the furnace for combustion of fuel.
2. To draw the combustion products through the system.
3. To remove burnt products from the system.

Draught is defined as the small pressure difference required between the fuel bed (furnace) and out side air to maintain constant flow of air and to discharge the gases through chimney to the atmosphere. Draught can be obtained by using chimney fan, steam (or) air jet (or) combination of these.

Classification of Draught System:

1. Natural draught: In this, only chimney is used for producing the draught.

2. Artificial draught: In this, the draught is produced by steam jet or by fan.

- **Steam jet draught:** Steam jet is used for creating draught in the system.
- **Mechanical draught:** Fan or blower is used for creating draught in the system.
- **Induced draught:** The flue gas is sucked through the system by a fan or steam jet.
- **Forced draught:** The air is forced into the system by a blower or steam jet.

Natural draught:

In natural draught, a tall chimney is erected. The chimney is a vertical tubular masonry structure or reinforced concrete. It is constructed for enclosing a column of exhaust gases to produce draught. The flue gases are discharged at enough height so that the air pollution is prevented. The natural draught created by the tall chimney is due to the temperature difference between hot gases in the chimney and cold atmospheric air outside the chimney.

The pressure difference in chimney should be between 10 to 12 mm of water head.

Merits of natural draught:

1. No external power is required.
2. Since the gases are discharged at high level, air pollution is less.
3. Maintenance cost is practically low.
4. It has longer life.
5. Capital cost is less than the artificial draught.

Demerits of natural draught:

1. Maximum pressure available for producing draught is less.
2. Flue gases have to be discharged at high temperature for better draught resulting in wasting of heat.
3. Heat cannot be extracted for economizer, superheater (or) air-pre heater since the effective draught would be reduced.
4. Overall efficiency of the plant is reduced because the gases are discharged at high temperature.
5. Poor combustion and increased specific fuel consumption.
6. Not flexible under peak load.

Artificial draught:

In modern power plants, the draught should be flexible to meet the fluctuating loads and it should be independent of atmospheric conditions. Nowadays, the modern power plants produce 20,000 tons of steam per hour. To achieve this, the aid of draft fans become must and by employing the draft fans, the height of the chimney would be reduced. The artificial draught is more economical when the required draught is above 40 mm of water. The artificial draught is classified into forced draught, induced draught and balanced draught.

Forced draught:

In this draught system, the blower is located at the base of the boiler near the grate. The blower is driven by steam or electricity.

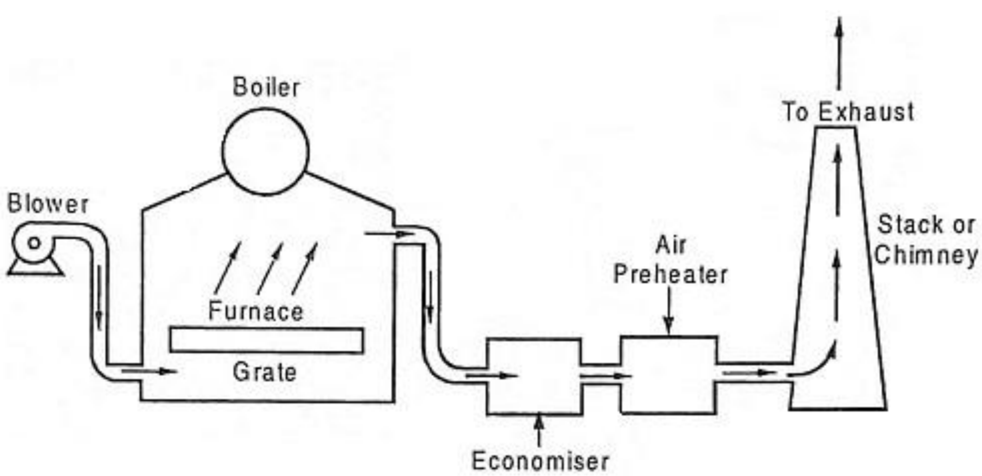


Fig:1.75 Forced Draught

Air is forced to the furnace by forced fan and the flue gases are forced to chimney through economiser and air preheater. This system is known as positive draught system since the pressure of air and hot gases in this draught system are above atmospheric pressure. The chimney discharges the hot gases at higher level to prevent air pollution.

Merits:

1. Since the fan handles cold air, the fan size and the power required is less.
2. No need of water cooled bearings because the air being handled is cold air.
3. Pressure throughout the system is above atmospheric pressure so the air leakage into the furnace is reduced.

Demerit:

1. The furnace cannot be opened for firing and inspection because while opening, the high pressure air will try to blow out suddenly and furnace may stop.

Induced draught:

In a induced draught, a blower is placed near (or) at the base of the chimney. The fan is driven by steam or electricity. The fan sucks the flue gas from the furnace creating a partial vacuum inside the furnace. Thus atmospheric air is induced to flow through the furnace to aid the combustion of fuel. The flue gases drawn by the fan passes through chimney to the atmosphere.

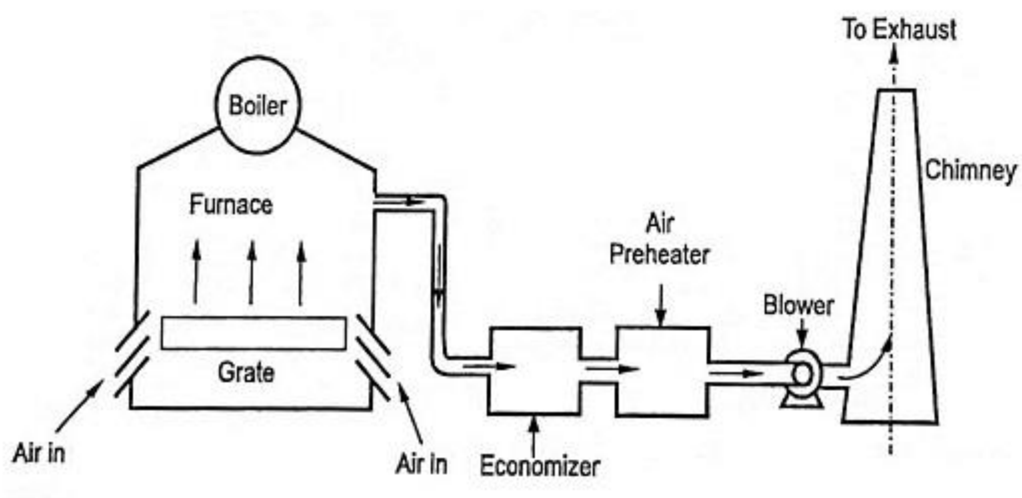


Fig. 1.76. Induced Draught

Merits:

1. The gases could be discharged at lower temperature after recovering most of their heat in economizer and air pre heater.
2. The chimney height can be reduced since it discharges flue gases only.

Demerits:

1. The furnace cannot be opened for firing and inspection because while the furnace is opened the cold air enters the furnace and dilute the combustion and hence the heat may be lost.

2. Water cooled bearings are needed for the fan to with stand high temperature of the flue gases.
3. Air leakage into the furnace is possible since the pressure inside the furnace is below atmospheric

Balanced draught system:

In this induced draught system, when the furnace is opened for firing, the cold air enters the furnace and dilutes the combustion. In the forced draught system, when the furnace is opened for firing, the high pressure air will try to blow out suddenly and furnace may stop. Hence the furnace cannot be opened for firing or inspection in both the systems, if they are used separately.

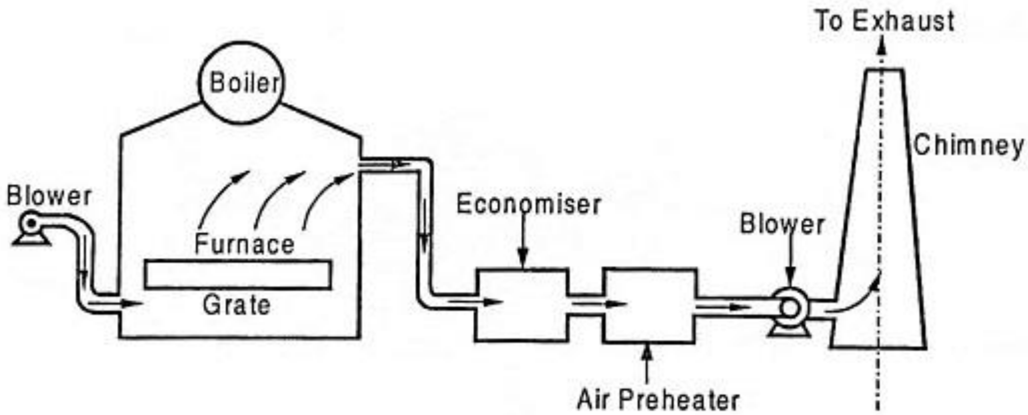


Fig:1.77 Balanced Draught

Balanced draught which is a combination of induced and forced draught is used to overcome the above stated difficulties.

In this, one blower is located at the base of the boiler and other is placed at the base of the chimney. The pressure distribution in the balanced draught is uniform. The pressure of air below the grate is above atmospheric pressure. This helps uniform combustion. The pressure of air above the grate is below atmospheric. This helps in removing hot flue gases quickly from the combustion zone. The pressure inside the furnace is nearly atmospheric. Hence, there is no blow out of flames or no entry of outside air into the furnace if the doors are opened for firing and inspection.

Steam Prime Movers (Turbine) in Thermal Power Plant

- Steam prime movers are either reciprocating steam engines or steam turbines. Due to reciprocating motion steam engines have become obsolete in now-a-days, and steam turbines are usually used as prime movers.
- They have several advantages over steam engines as prime mover. It has higher thermodynamic efficiency.

- Its construction is simple, there is no need of piston rod mechanism and slide valves, no fly wheel is required.
- They can be built in large sizes as much as **1000 MW**. No wearing action is involved. Maintenance is much simple. Problems of vibration are also much less compared to steam engines.
- According to the action of steam on moving blades the steam turbines are of two types namely impulse and reaction type.
- They differ in working principle. In impulse turbines as shown in Figure (A) the steam expands in nozzles only and when passing over the blades, its pressure remains constant. The jet passes over several rings of moving blades until its kinetic energy is expanded.
- In reaction type turbines as shown in bap Figure (B) the steam does not expand in nozzles, but expand as it flows over the blades. The blades will therefore act also as nozzles.

ADVANTAGES AND DISADVANTAGES OF STEAM TURBINE

Advantages

- Since the steam turbine is a rotary heat engine, it is particularly suited to drive an electrical generator.
- The thermal efficiency of a steam turbine is usually higher than that of a reciprocating engine.
- The very high power-to-weight ratio, compared to reciprocating engines.
- Fewer moving parts than reciprocating engines.
- Steam turbines are suitable for large thermal power plants. They are made in various sizes up to 1.5 GW (2,000,000 hp) turbines used to generate electricity.
- In general, steam contains a high amount of enthalpy (especially in the form of heat of vaporization). This implies lower mass flow rates compared to gas turbines.
- In general, the turbine moves in one direction only, with far less vibration than a reciprocating engine.
- Steam turbines have greater reliability, particularly in applications where sustained high power output is required.

Disadvantages

Although approximately 90% of all electricity generation in the world uses steam turbines, they also have some disadvantages.

- Relatively high overnight cost.

- Steam turbines are less efficient than reciprocating engines at part load operation.
- They have longer start up than gas turbines and surely than reciprocating engines.
- Less responsive to changes in power demand compared with gas turbines and with reciprocating engines.

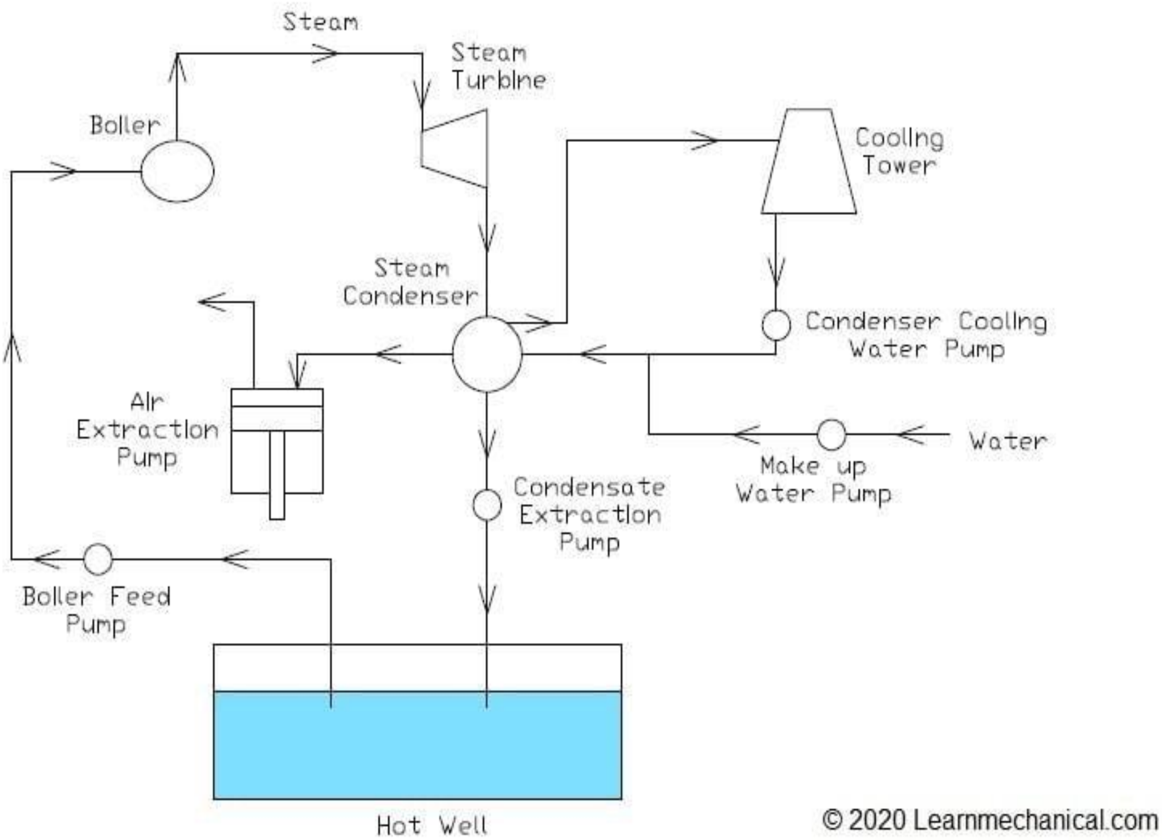
STEAM CONDENSER

A steam condenser is a closed vessel heat exchanger that is used to convert low-pressure steam to water. The pressure inside a steam condenser is kept below the atmospheric pressure to increase efficiency. It is generally used for lowering the backpressure of the exhaust of the turbine end.

The Functions Of A Steam Condenser

The **functions of the condenser** in a steam power plant are the following:

- The steam condenser is used to maintain the low back pressure of the exhaust end of the turbine to increase efficiency and decrease the specific steam consumption of a plant.
- It is used for converting low-pressure steam to liquid i.e. water and we can feed this water again into the boiler without doing any further treatment.
- It also increases the heat transfer rate by eliminating other non-condensable gases from the exhaust steam.



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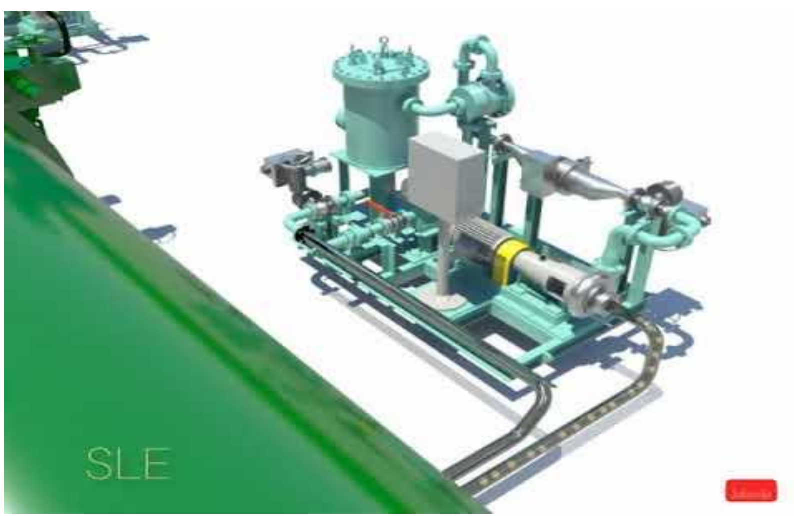
Basic Working Principle Of Steam Condenser

Inside a **steam condenser**, there is a flow of cooling water that is continuously circulating from the condenser to the cooling tower and cooling tower to the condenser. So when exhaust low-pressure steam comes from the turbine and passes through the condenser, it (steam) gets condensed to water, as the steam loses the heat, the extracted heat from the steam is carried out via the circulating cooling water.



There are two types of devices fitted on the condenser, one is the condensate extraction pump, and the other one is the air extraction pump. So when the steam condensed into water, with the help of a condensate extraction pump it is again re-circulated to the steam generator. And via air-extraction pump, the vacuum inside the condenser is created so that cooling water can circulate easily and also the flow of condensate can be stabilized.

Classifications Of Steam Condenser

The condenser can be broadly classified into two types which are as follows

- Direct Contact type Condenser
- Surface Condenser

Surface Condenser

Surface condensers are generally used in power plants. This type of condenser is also called shell and tube type condenser. Here there is no contact between exhaust steam and cooling water. So the extracted condensate can be reused in the boiler without any water treatment.

Within the condenser space, there are several horizontal tubes, inside which cooling water is flowing. At the above portion of the condenser, the exhaust steam enters and flows downwards, when the steam in contact with the tubes inside which cooling water is flowing, the steam gets condensed, here the heat transfer is done by conduction and/or convection. A condensate extraction pump is fitted at the bottom which helps to extract the condensed water from the condenser.

There are two types of water pass, one is a single pass where water is flowing in one direction and the other one is a double pass or two passes where water circulated within the condenser tube in both directions. The details figure of the Single-Pass and Two-Pass condensers are shown in the figure.

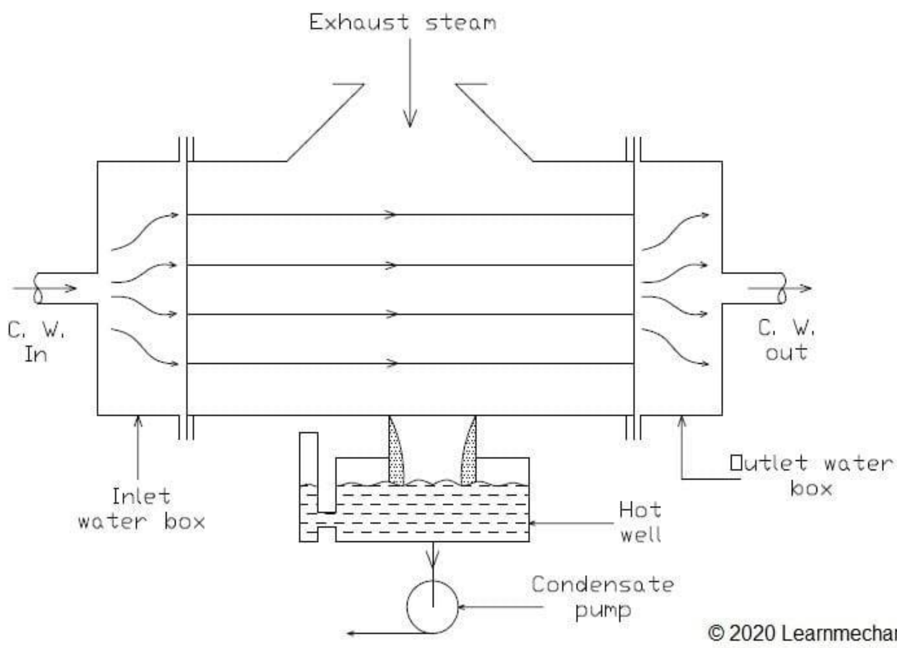


Figure of Single-Pass Condenser, Dizz

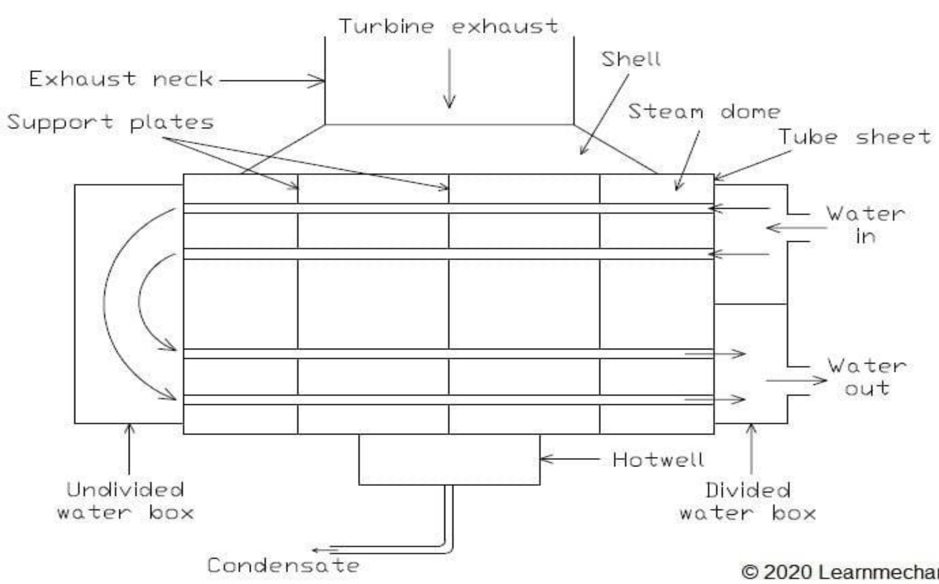


Figure of Two-Pass condenser, Dizz

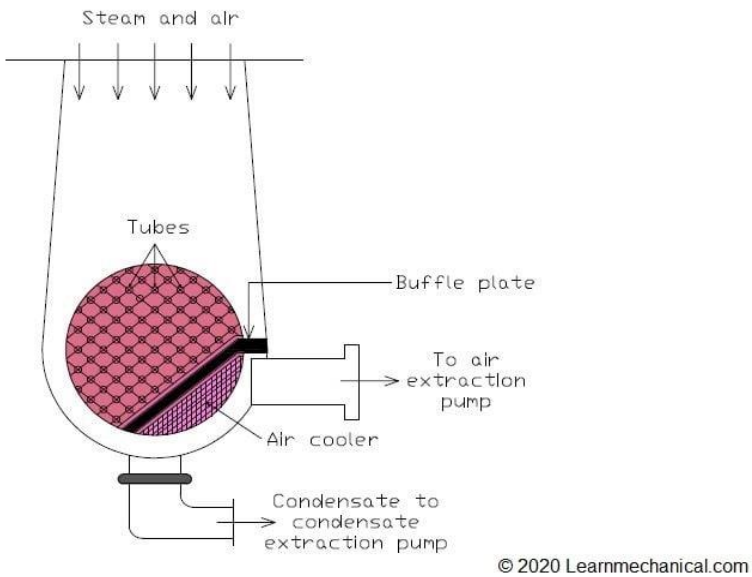
Also in this type of condenser, there is a tube sheet is fitted at each end of the condenser where the water tubes are rolled to avoid leakage. Surface Condenser are further categorized into four types

- Down flow surface condenser
- Central flow condenser
- Regenerative condenser
- Evaporative condenser

Down Flow Surface Condenser

In the **down flow surface condenser** exhaust steam from the prime mover enters from the top of the condenser and flows downwards due to the gravitational force and the effect of the air-extraction pump.

When the steam flows downwards it's in touch with several cooling tubes and loses the heat and gets condensed. Later on, the condensed water is extracted from the bottom surface of the condenser with the help of a Condensate Extraction Pump.

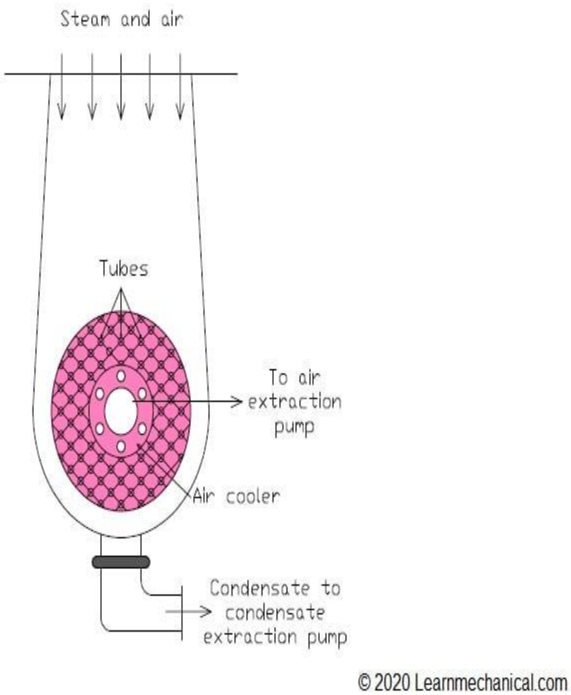


Down

Central Flow Condenser

In **central flow condenser**, steam enters from the top of the condenser. The suction end of the air extraction pump is fitted at the center of the condenser or tube.

Due to this design, steam is forcefully passed radially which ensures better heat transfer as the contact area of tubes and steam is now more. After heat exchange, the condensate is stored at the bottom of the condenser, and with the help of a condenser removal pump, it is extracted.



Central Flow Condenser Diagram, Dizz

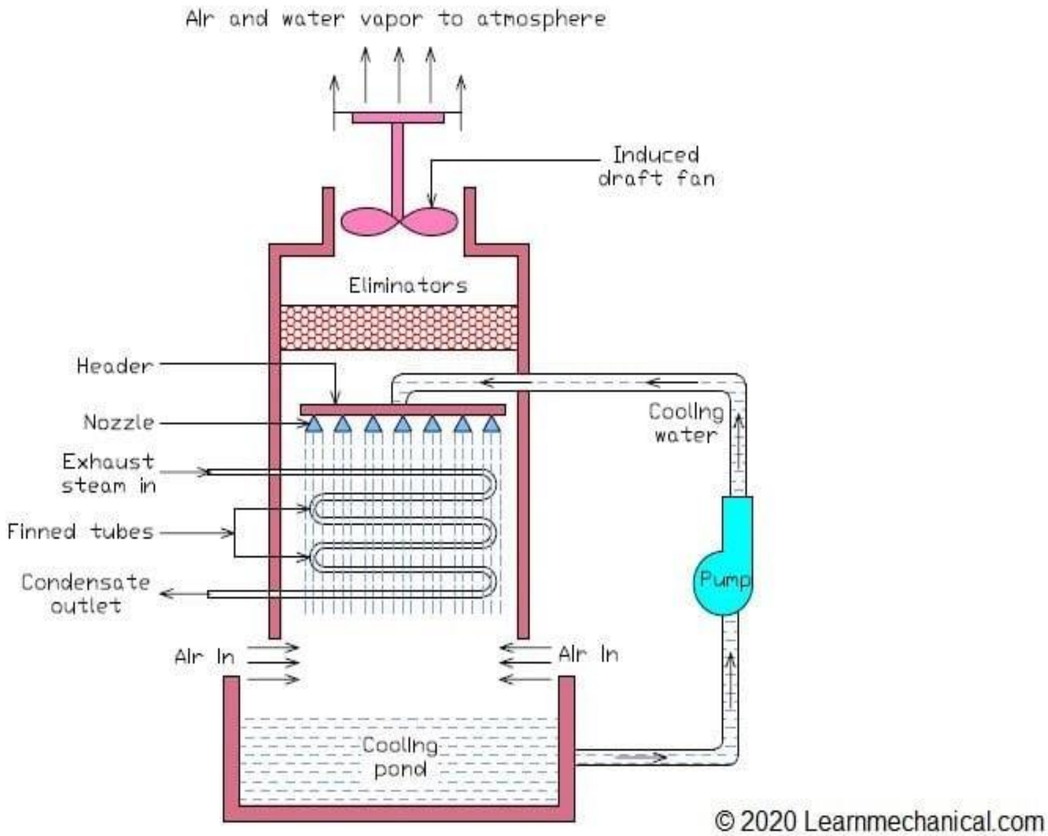
Regenerative Condenser

In a **Regenerative condenser**, the condensate is also heated with the help of exhaust steam which comes into the condenser, and then the condensate is fed to the steam generator. It dramatically improves the efficiency of the steam generation plant.

Evaporative Condenser

In the **evaporative condenser** the exhaust steam comes from the turbine and enters the condenser within a tube. At the above section of the condenser, there are a couple of nozzles fitted from which cooling water is sprayed.

When the cooling water is coming into the contact with the tube inside which steam is following then some portion of the cooling water is absorbed heat and vaporized. As the heat is now taken from the steam so it is now converted into water and collected outside of the condenser.



Evaporative Condenser Diagram, Dizz

Direct Contact Type Condenser

In a **direct contact type condenser** the steam (Condensate) and the cooling water mix and come together as a single stream. It's generally available in the market at a low cost, and the design of this type of condenser is pretty much simple. However, where the mixture of cooling water and condensate is not permissible we can't use this type of condenser.

Direct contact type condensers are further classified into three sub-types

- Jet Condenser
- Barometric Condenser
- Spray Condenser

Jet Condenser

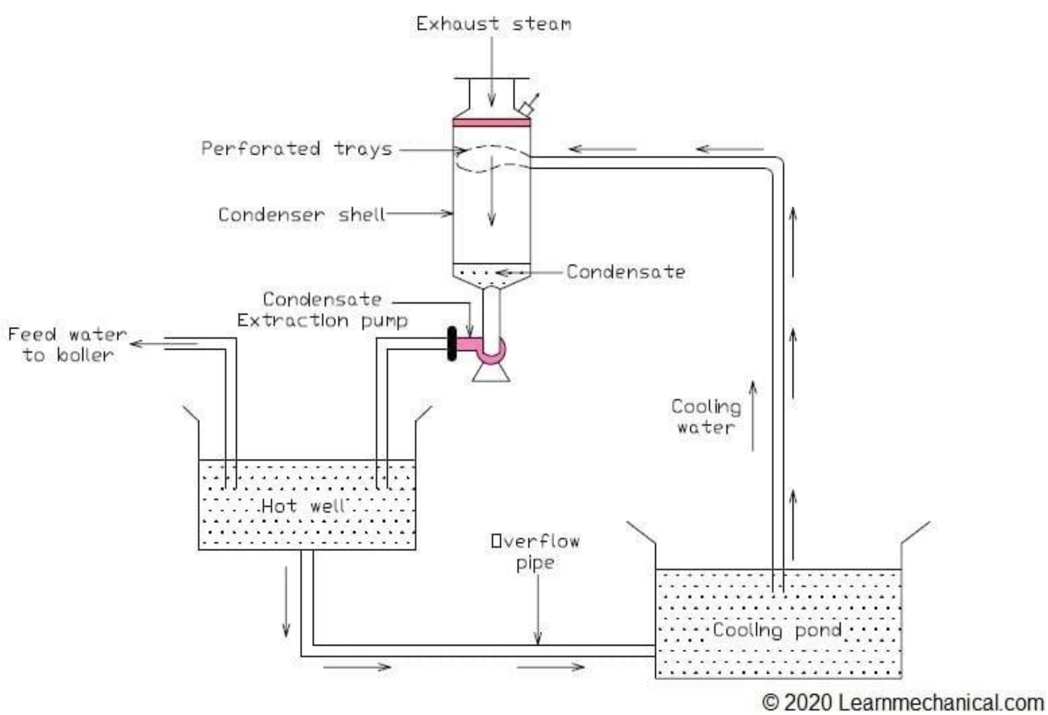
As it is one type of direct contact type condenser that's why here condensate and the cooling water is mixed and comes out. Here as the steam comes with the cooling water that's why recirculating the cooling water to the boiler is not possible until it passes through a water treatment plant. However, the condensing capability of the **jet condenser** is very much higher than the other.

The jet condenser are further classified into four sub-types

- Parallel flow jet condenser
- Counterflow or Low-level jet condenser
- Barometric or High-level jet condenser
- Ejector Condenser

Parallel Flow Jet Condenser

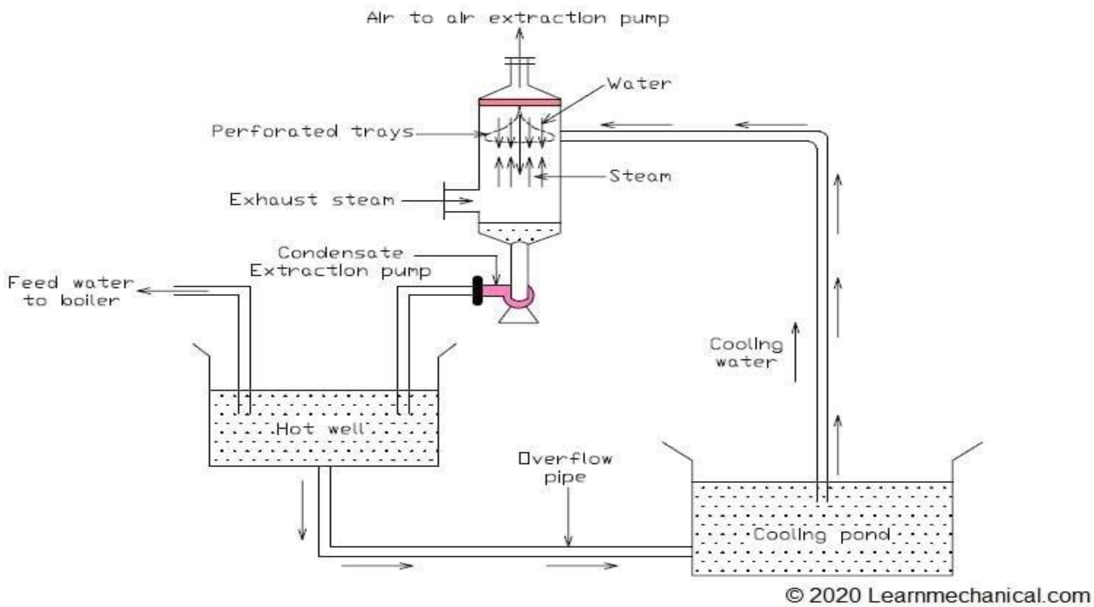
In a **parallel flow jet condenser**, the direction of flow of the steam and the direction of flow of the cooling water is the same, both of these come from the top of the condenser and come out after mixing from the bottom of the condenser.



Parallel Flow Jet Condenser Diagram, Learn Mechanical

Counter Flow Or Low-Level Jet Condenser

It is just the opposite of a parallel flow jet condenser, here cooling water comes from the top of the condenser, and exhaust steam enters to the condenser from the bottom side section of the condenser. So the direction of the cooling water is downwards, and the direction of exhaust steam is upward. That's why this type of condenser is called a Counter flow condenser.

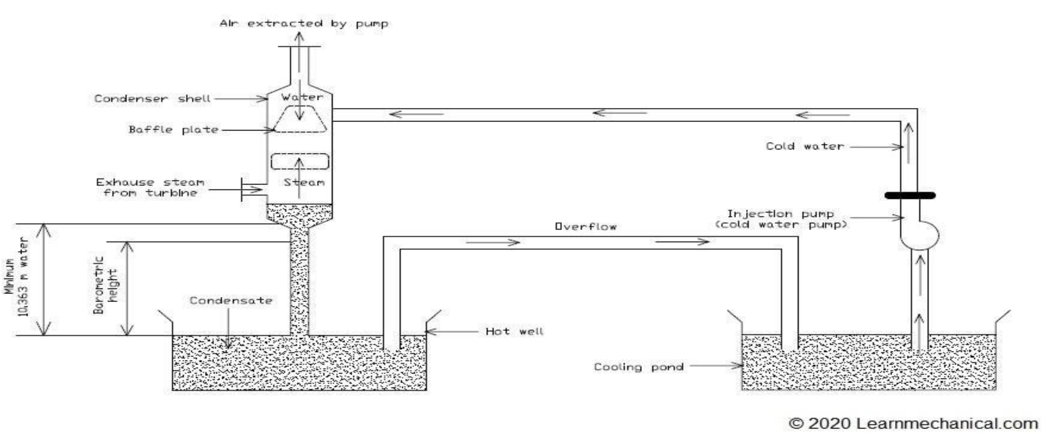


Counter flow or Low-level Jet Condenser Diagram, Dizz

Barometric Or High-Level Jet Condenser

In the **barometric condenser**, the condenser shell is fitted above the hot well at a height of 10.36 m. To achieve this the discharge section of this type of condenser is fitted with a long vertical pipe, or it is also called a tailpipe.

In this type of condenser, there is no condensate extraction pump is there, the flow is completely done with the help of gravitational force. However, a cooling water injection pump is there to deliver the cooling water from the top of the condenser. The other working of this type of condenser is the same as the Counter flow condenser.

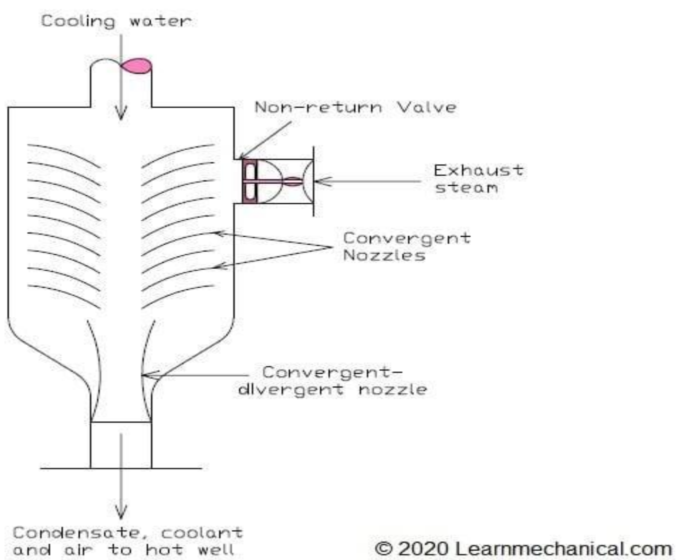


Barometric or High-level Jet Condenser Diagram, Dizz

Ejector Condenser

An **ejector condenser** has a no-return valve through which exhaust steam enters to the condenser. It also has several convergent nozzles which help to decrease the pressure of the inner section of the condenser, hence due to low pressure, the exhaust steam draws into the condenser through the no-return valve, and mixes with the cooling water and condensate.

In the end, there is again a divergent nozzle where the kinetic energy is again converted to the pressure energy, and an increase in the pressure at the exhaust of the condenser helps to extract the condensate out of the condenser.



Ejector Condenser

Applications Of Steam Condenser

The applications of Steam Condenser are as follows

- The condenser like the surface condenser is used in the thermal power plant to condensate the exhaust steam from the turbine.
- Steam condensers are used in many food processing industries as well.

Advantages Of Steam Condenser

Steam Condenser has some advantages depending on its types which are as follows

Advantages Of Direct Contact Condenser

- The jet condenser is simple in design.
- Built-in cost is very much less.

Advantages Of Surface Condenser

- In the case of a surface condenser, it dramatically improves vacuum efficiency.

- As in a surface condenser, there is no mixing occurs, so we can get the pure condensate which can be reused in the boiler.
- The quantity of cooling water needed for heat exchange purposes is relatively low.

Disadvantages Of Steam Condenser

Steam Condenser has some disadvantages depending on its types which are as follows

Disadvantages Of Direct Contact Condenser

- As cooling water and condensate come out in one stream, so here it is not possible to reuse the condensate without water treatment.
- Vacuum efficiency is low in direct contact condensers like the jet condenser.

Disadvantages Of Surface Condenser

- Design is complicated so the initial cost is more.
- The maintenance cost of this type of condenser is relatively higher.
- The size of this type of condenser s large so needs more floor space

COOLING TOWER

Cooling towers are indispensable for cooling process water and keeping equipment from overheating. They are useful in industrial facilities such as oil refineries, chemical plants and thermal power stations, and they are common in manufacturing facilities and many buildings with HVAC systems.

Cooling towers come in various types, and it's important to choose the correct one for your plant's needs. In the guide below, we'll explain how these apparatuses work and discuss some of the different types of cooling towers.

Fans:
A cooling tower may contain large fans that circulate significant volumes of air. Though not all cooling towers require fans, many models use them to create and direct airflow through the tower. They may push or pull air through the tower, and they may be axial or centrifugal depending on the specific needs of the application. Axial fans are more efficient, whereas centrifugal fans are quieter and can deal with higher levels of static pressure.

Fill:
Fill, also called wet deck or surface, typically consists of textured polyvinyl chloride (PVC) that is integral to the cooling tower function. It usually features ridges with open spaces for the air and water to travel through. Its purpose is to allow water to collect on it, thereby maximizing the surface area of the water and facilitating heat transfer between the water and the air. Fill can come in a couple of different types. Film-type fill increases the water's surface area by spreading it into a thin film. Splash-type fill increases the water's surface area by

breaking a falling stream of water into smaller droplets.

Spray nozzles:

Spray nozzles in the cooling tower can also be useful in increasing the surface area of the water. In some types of cooling towers like counter flow towers, spray nozzles disperse small droplets of water into the air. The spray helps ensure a uniform distribution of the water over the fill, and the droplets provide a large surface area for air contact.

Distribution basin:

The distribution basin, or hot water basin, is often used in cross flow cooling towers. A distribution basin takes the place of the spray nozzles by distributing the hot water evenly throughout the tower. It sits atop the tower and typically consists of a pan with holes or nozzles along its base. Hot water flows in through the top of the tower, and the holes or nozzles release it evenly over the fill material below.

Collection basin:

The collection basin, or cold water basin, sits at the bottom of the tower to collect the water after it has cooled. In field-built models, these basins are often built of concrete to support the tremendous weight of the water coming down the tower.

Inlets and outlets: Inlets and outlets in the cooling tower take in cool air from the environment and release the warm air after it has absorbed the water's heat.

Drift eliminators:

Drift, or water loss, in a cooling tower is undesirable, but it sometimes occurs when droplets of water escape into the outlet and flow out with the exiting air. Drift eliminators help keep the water secure in the tower. They point the airflow in multiple directions to prevent it from whisking water away.

Types of Cooling Towers

1**. Cross flow**

Cross flow cooling towers get their name because the air they use cuts perpendicularly across the flow of water. Cross flow towers use splash fills that allow incoming air to flow horizontally through the cooling tower. At the same time, gravity sends hot water flowing down from distribution basins at the top of the tower.

Cross flow cooling towers offer the advantage of great height, and they are some of the simplest models to maintain. Because they use gravity to aid air-to-water contact, they can use smaller pumps, so they are cost-effective and easy to maintain — even while in use. And because their spray is non-pressurized, they allow for more variable water flow.

They are more prone to freezing than counter flow towers, though, and they can be more inefficient. Their design also makes their fill more likely to become clogged with dirt or debris, especially in windy, sandy and dusty regions.

3. Counter flow

Counter flow cooling towers get their name because the air and water enter from opposite ends of the tower. In a counter flow cooling tower, as in a cross flow tower, water flows down from the top of the tower. In this case, though, the air also moves vertically across the splash fill, from the bottom of the tower to the top. Because the airflow is upward, counter flow towers cannot use gravity-flow basins, so these towers use pressurized spray nozzles to distribute the water over the splash fill.

Counter flow towers are more modest in size than cross flow towers, which mean they can sometimes provide greater efficiency. And because of their spray distribution, they offer more resistance to freezing than cross flow towers. The extensive surface area of the large volume of spray they produce also makes heat transfer more efficient.

However, the greater energy expenditures and larger pumps required to push air against the flow of water can also lead to operational inefficiencies and increased utility bills. Counter flow towers also sometimes struggle with variable water flow because it can impede the tower's spray characteristics. And they can often be noisier than their cross flow counterparts because the water has farther to fall from the bottom of the fill into the collection basin.

4. **Natural Draft**

Unlike mechanical cooling towers such as induced and forced draft models, natural draft or passive draft cooling towers use natural convection. Air flows naturally through the tower, and differences in air density create specific patterns of movement.

The cold, dry air flowing into the tower is less dense than the warm, moist air flowing out after contact with the hot water, so the warm air naturally rises while the cold air falls. These movements create a stable, constant pattern of air circulation that helps cool incoming water and release heat. Natural draft towers often feature steep chimney architecture to enhance the natural vertical flow of air.

5. Induced Draft

Induced draft cooling towers use mechanical means — such as fan systems — to move air through the tower. An induced draft tower typically has fans located at the top of the air outlet. These fans pull cool air through the tower. They get their name from the induction of warm, moist air out of the discharge outlet.

One of the benefits of an induced draft cooling tower is that the force of the induction means the air is moving at a high velocity when it exits the tower. That high velocity sends the air far enough away to prevent unwanted recirculation.

6. Forced Draft

A forced draft tower is similar to an induced draft tower, but the placement of its fans is different. A forced draft tower typically has fans located in the air intake rather than the air outlet. These fans, located on the sides or at the base of the tower, push air directly into the tower instead of pulling it.

Forced draft cooling towers take air in at a high velocity, but they tend to discharge it as a lower velocity, since friction slows the air as it passes through the tower. This lower velocity means forced draft towers are more susceptible to undesirable air recirculation. Their design also makes them costlier and more inefficient to run because they require more power. And like cross flow towers, forced draft towers are more susceptible to freezing than other types of towers.

Selection of Site for Thermal Power Plant

1. Supply of Fuel: The Steam power station should be located near the coal mine so that transportation cost of fuel is minimum. If the land is not available near to coal mines then provide adequate facilities for transportation of fuel.
2. Available of Water: A huge amount of water is required in boiler & condenser, so that the plant should be located near the river, lake etc.
3. Transportation Facility: For steam power station provide better transportation facility for the transportation of man, machinery etc.
4. Cost & Type of Land: The Steam Power Station should be located where the cost of land is chief & also future extension is possible.
5. Near to Load Center: In order to reduce transmission & distribution losses the plant should be located near to load center.
6. Distance from Populated Area: As the thermal power plant produces flue gases, these gases will effect to live human being, so that the plant should be located away from thickly populated area.
7. Disposal Facility Provided: As the thermal power plant produces ash, while burning of coal. So, disposal of ash facility should be provided.
8. Earth-Quake: The area under the thermal power plant should be free from earth quake.
9. Availability of labour: Skilled and unskilled labour should be available nearly. To the extent possible, the thermal station should be far away from an aerodrome.

CHAPTER-03

NUCLEAR POWER STATIONS

FUNCTION OF NUCLEAR POWER PLANT

Nuclear reactors are the heart of a nuclear power plant. They contain and control nuclear chain reactions that produce heat through a physical process called fission. That heat is used to make steam that spins a turbine to create electricity.

CLASSIFY NUCLEAR FUEL

Fissile and fertile materials

All heavy nuclides have the ability to fission when in an excited state, but only a few fission readily and consistently when struck by slow (low-energy) neutrons. Such species of atoms are called fissile. The most prominently utilized fissile nuclides in the nuclear industry are uranium-233 (^{233}U), uranium-235 (^{235}U), plutonium-239 (^{239}Pu), and plutonium-241 (^{241}Pu). Of these, only uranium-235 occurs in a usable amount in nature—though its presence in natural uranium is only some 0.7204 percent by weight, necessitating a lengthy and expensive enrichment process to generate a usable reactor fuel (*see below* Nuclear fuel cycle).

As an alternative to processing and enriching uranium-235, it is possible to go through the process of generating quantities of other fissile nuclides that are not as prevalent as uranium-235. Prominent sources of these nuclides are thorium-232 (^{232}Th), uranium-238 (^{238}U), and plutonium-240 (^{240}Pu), which are known as fertile materials owing to their ability to transform into fissile materials. For example, thorium-232, the predominant isotope of natural thorium, can be used to generate uranium-233 through a process known as neutron capture. When a nucleus of thorium-232 absorbs, or "captures," a neutron, it becomes thorium-233, whose half-life is approximately 21.83 minutes. After that time the nuclide decays through electron emission to protactinium-233, whose half-life is 26.967 days. The protactinium-233 nuclide in turn decays through electron emission to yield uranium-233.

Neutron capture may also be used to create quantities of plutonium-239 from uranium-238, the principal constituent of naturally occurring uranium. Absorption of a neutron in the uranium-238 nucleus yields uranium-239, which decays after 23.47 minutes through electron emission into neptunium-239 and ultimately, after 2.356 days, into plutonium-239.

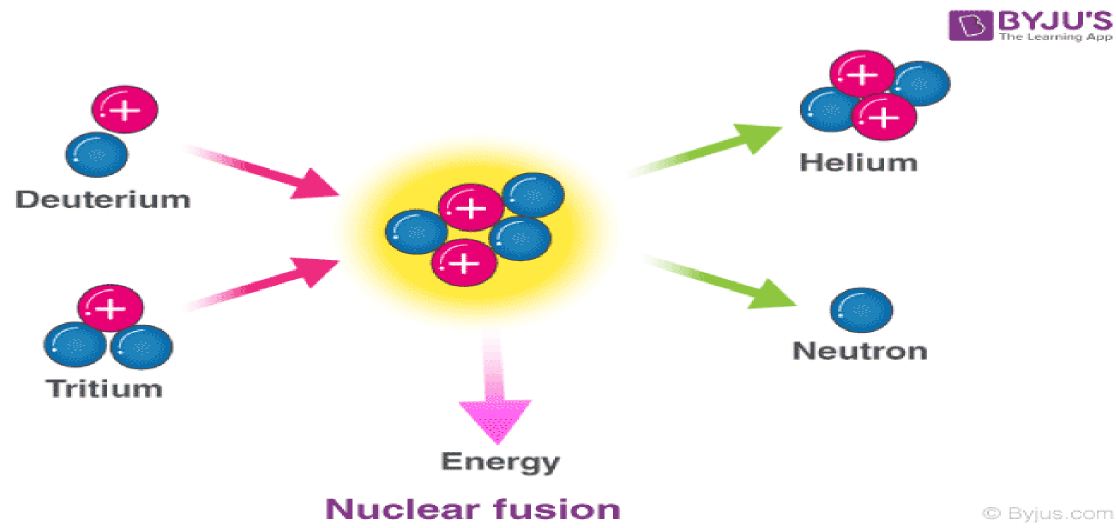
If desired, plutonium-241 may be generated directly through neutron capture in plutonium-240, following the formula $^{240}Pu + ^{1}n = ^{241}Pu$.

A power reactor contains both fissile and fertile materials. The fertile materials partially replace fissile materials that are destroyed by fission, thus permitting the reactor to run longer before the amount of fissile material decreases to the point where criticality is no longer manageable. Plutonium-240 is particularly found to build up in reactors after long periods of operation, as it has a longer half-life than all its parent nuclides.

Explain fusion and fission reaction

Fusion reaction

Fusion is essentially the opposite of fission: instead of splitting open an atomic nucleus, two light nuclei are combined to make a heavier element.
For example, hydrogen atoms are found in several isotopes, including deuterium and tritium (also known as hydrogen-3). At high temperatures, such as in the core of the sun, the isotopes of hydrogen fuse with other particles to create helium atoms.
On Earth, we haven't yet discovered a way to harness fusion power. Fusion reactions release a large amount of energy — even more than fission — but they require more energy to get started and are harder to control. On the positive side, fusion doesn't produce any carbon emissions, making it a promising alternative to fossil fuels.
Nuclear fusion is a reaction that occurs when two or more atoms combine together to form to a single heavier nucleus. An enormous amount of energy is released in this process, much greater than the energy released during the nuclear fission reaction.



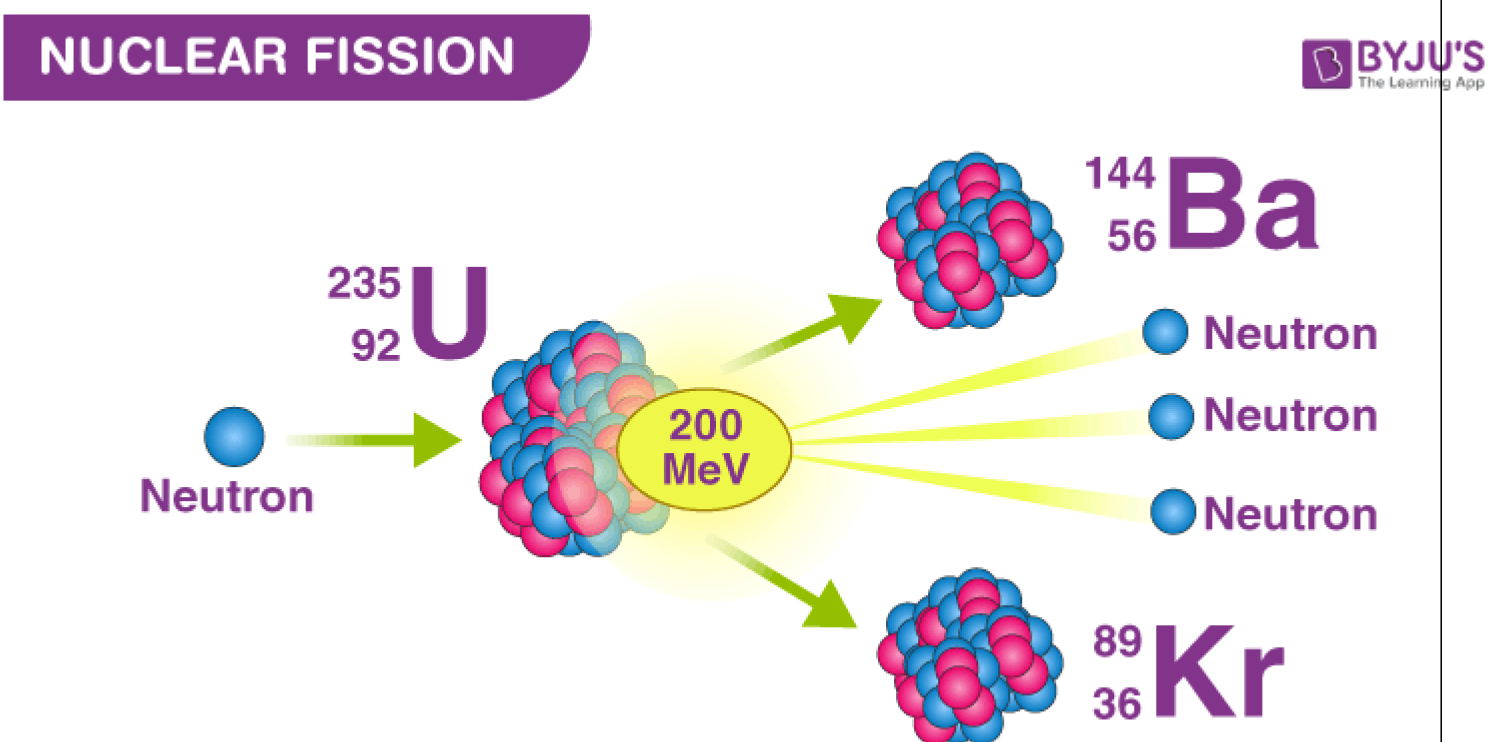
Fusion occurs in the sun where the atoms of (isotopes of hydrogen, hydrogen-3, and hydrogen-2) deuterium and tritium combine in a high-pressure atmosphere with extremely high temperatures to produce an output in the form of a neutron and an isotope of Helium.

Also, the amount of energy released in fusion is way greater than the energy produced by fission.

Fission reaction

A fission reactor is probably what first comes to mind when you picture a nuclear power plant. The sight of nuclear cooling towers is more common in some parts of the country than others — nearly all of the 92 American reactors are in the East or Midwest.
According to the World Nuclear Association, nuclear reactors are essentially just “large kettles” that generate steam. Because fission is a chain reaction, it doesn’t require a lot of energy to keep it running, and nuclear power plants can operate for decades simply by replacing the uranium pellets that provide the fissile material.
There are several drawbacks to using nuclear fission vs. fusion, though, including the amount of radioactive waste it generates, and the risk of a nuclear meltdown.

Nuclear fission is a nuclear reaction in which the nucleus of an atom is bombarded with low-energy neutrons which splits the nucleus into smaller nuclei. An abundant amount of energy is released in this process. Nuclear fission reactions are used in nuclear power reactors since it is easy to control and produces large amounts of energy.



When uranium-235 is bombarded with slow-moving neutrons, the heavy nucleus of the uranium splits and produces krypton-89 and barium-144 with the emission of three neutrons.

Difference between fusion and fission reaction

Nuclear Fission	**Nuclear Fusion**
When the nucleus of an atom splits into lighter nuclei through a nuclear reaction, the process is termed nuclear fission.	Nuclear fusion is a reaction through which two or more light nuclei collide with each other to form a heavier nucleus.
When each atom splits, a tremendous amount of energy is released	The energy released during nuclear fusion is several times greater than the energy released during nuclear fission.
Fission reactions do not occur in nature naturally	Fusion reactions occur in stars and the sun
Comparatively, less energy is needed to split an atom in a fission reaction	High energy is needed to fuse two or more atoms together in a fusion reaction
Atomic bomb works on the principle of nuclear fission	Hydrogen bomb works on the principle of nuclear fusion.

Explain working of nuclear power plants with block diagram

Nuclear power is the most controversial of all forms of electricity generation. Evaluating its importance involves weighing political, strategic and often emotional considerations alongside the more usual technical economic and environmental factors that form the core elements of any power technology.

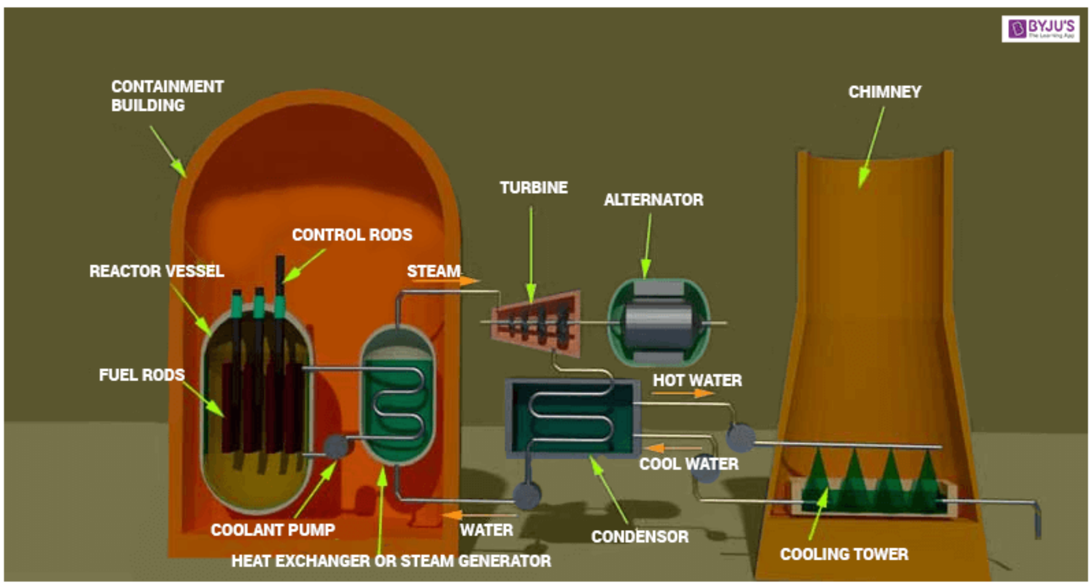
Nuclear energy provides around ***15% of the electricity generated worldwide***. It avoids around 2.5bn tonnes of CO_2 emissions, so it makes a major contribution towards a sustainable electricity supply which achieves the goals in terms of economics, capability and the environment to a large extent.

Working of Nuclear Power Plants

Generating Electricity by Nuclear Power Plants

Basically, nuclear power plants work in the same way as coal and gas fired plants converting heat to electricity. Whereas fossil fuel fired power plants run on energy media such as oil, lignite or hard coal, nuclear power plants use the heat given off when atomic nuclei split.

The working of a nuclear power plant with a pressurized water reactor model is shown below.

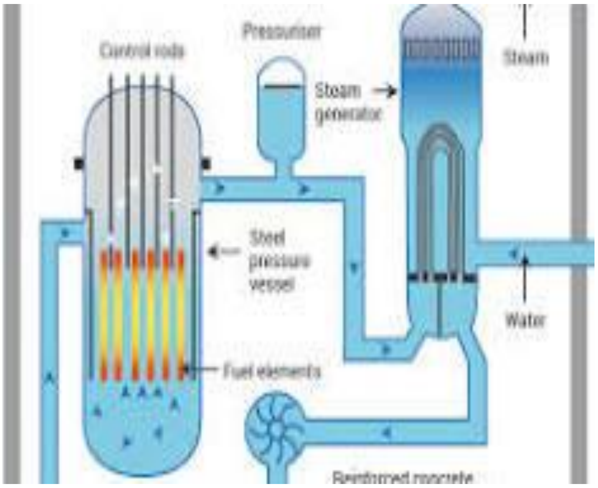


Nuclear fission inside the reactor pressure vessel generates heat, which heats water until it evaporates, turning thermal energy into latent energy in steam. This team which is under high pressure then drives the turbines, which turn the generators connected to them generating electrical energy like a bicycle dynamo. Condensing the steam required to drive the turbines is done either by direct flow or seawater cooling or via a cooling system using a cooling tower.

Nuclear reactor

Nuclear reactor is the heart of the nuclear power station, where a tremendous amount of heat energy is released as a result of the nuclear fission of radioactive materials. This heat is utilized to heat the coolant which in turn generates steam. The working of a nuclear reactor can be explained from the following basic components of a nuclear reactor:

: Construction and working of nuclear reactor Diagram



Fuel: The fuels generally used in the reactor are92U235, 94U239, and 92U233,92U238,90Th232

etc . Fuel should be shaped and located in the reactor such that uniform heat should be produced.

Reactor Core:

It is built of graphite bricks, having channels machined through them. The core is cylindrical in shape and is placed on a large pressure vessel totally enclosed in a thick-walled shielding structure of concrete about 2-3 meters thick. The size of the core is just sufficient to maintain a chain reaction.

Moderator:

The purpose of the moderator is to moderate or slow down neutron speed to a value that increases the probability of the fission process. Graphite, Heavy water an most commonly used as moderators. Beryllium and ordinary water can also be used as moderators with natural uranium and enriched uranium respectively. It is the central part of the core.

Shielding: The purpose of shielding is to prevent the escape or leak of neutrons (fast and slow), α,β particles and γ−rays from the reactor as these radiations are harmful to a human being. Lead iron or concrete shields are used for this purpose.

Control rods:

The control of the chain reaction inside the reactor is obtained by inserting control rods into the reactor core. The control rods are made with cadmium (or boron because cadmium is a strong neutron absorber. When control rods are pushed into the core they absorb some of the neutrons and hence few neutrons are available for a chain reaction. However, when they are pulled out from the reactor core more neutrons are available for the fission process.

Therefore pulling out and pushing them into the supply of neutrons for fission purposes can be regulated. These rods are in practice suspended from the top of the reactor in the channel of the core and are lowered or raised by a special mechanism according to the load requirements.

Reflector:

To avoid the leakage or escape of neutrons from the reactor it is essential to surround the reactor with material acting as a Reflector. As the name indicates, the function of the reflector is to reflect as many leakage neutrons as possible back into the reactor. The reflector gets heated due to the collision of neutrons with its atoms, hence cooling is essential. The materials used for the reflector are the same as the materials used for the moderator i.e. Graphite, Heavy water.

Coolant:

A coolant is a medium through which heat produced in the reactor is transferred to the heat exchanger for further utilization in power generation. Liquid sodium is generally used as a coolant. When water is used as a coolant it takes up heat and gets converted into steam in the reactor itself, which is directly used to drive the turbine. The commonly used coolants are gas ($CO2$

, air, hydrogen, helium), and some organic liquids.

Reactor Vessel:

The Reactor vessel encloses the reactor core, reflector, and shield. It is a strong-walled container generally cylindrical in shape and provides the exit for the passage of coolant. It should withstand high pressures. The holes are provided at the top of the vessel to insert the control rods.

Types of Nuclear reactors

The nuclear reactors can be classified as follows:

On the basis of fission:

(a) Fast reactors

(b) Thermal (slow) reactor

(c) Intermediate reactor

(a) Fast Reactors: In the fast reactor the fission is affected by fast neutrons without the use of moderators. In fast reactors most of the neutrons have energies of about 1000 eV

(b) Thermal Reactors: In a thermal reactor, most of the neutrons have energies of about 0.03 eV.

(c) Intermediate Reactors: In the Intermediate reactor fission takes place by neutrons In course of slowing down.

which can be used for further fission. In most thermal reactors, the conversion ratio is less than unity. However, under proper conditions this ratio exceeds unity and the reaction produces more fissile material. A reactor in which the conversion ratio (the ratio of fissile nuclei formed to fissile nuclei consumed) is greater than unity is called a breeder reactor.

Working of Nuclear Power Plant

The block diagram of the Nuclear Power plant is shown below. The concept of nuclear power generation is much similar to that of conventional steam power generation. Nuclear power plant working is similar to the boiler of the steam power plant is replaced by a Nuclear reactor and Heat exchanger

The essential components of a Nuclear Power Plant are :

Nuclear reactor

Heat exchanger

Steam turbine

Alternator

Condenser etc.

nuclear-power-plant

The Nuclear reactor is the heart of the nuclear power plant. A tremendous amount of heat energy is produced in the reactor in the breaking of atoms of Uranium or other fission materials by the fission process. This heat is extracted by pumping coolant (molten metal) generally a Sodium metal or gas: The coolant carries heat to the heat exchanger. The heat exchanger converts water into steam by utilizing the heat of the coolant.

After giving up heat, the coolant is again pumped into the reactor. The steam produced in the heat exchanger is fed to the steam turbine through a steam valve. After doing used work in the turbine the steam is allowed to condenser. The condenser condenses the steam and is pumped to the heat exchange by a feed water pump. The steam drives the turbine coupled to an Alternator which converts the mechanical energy of the turbine to electrical energy. The output of the alternator is stepped-up and fed to the bus bars through isolators and circuit breakers.

Nuclear fuels

The fuel used in Nuclear power stations are called nuclear fuel, as like all radioactive elements there are only specific uses for nuclear fuels. Elements or isotopes whose nuclei can be used to undergo nuclear fission by nuclear bombardment and sustain the chain reaction is called “Nuclear fuel”

The main fuels used in nuclear reactors are uranium, thorium, and plutonium. The most commonly used are natural uranium, uranium oxide, and uranium carbide.

Radioactive materials, mainly rare earth elements can be easily transmuted. The fuels generally used in Nuclear Power Generation are

Uranium U235 U238 U234

Thorium Th232

Difference between Thermal Power Plant and Nuclear Power Plant

Both thermal power plant and nuclear power plant convert steam energy into mechanical energy and then electrical energy. However, there are several differences between thermal power plant and nuclear power plant that are highlighted in the following table −

Basis of Difference	Thermal Power Plant	Nuclear Power Plant
Definition	A power generating station which converts heat energy of coal combustion into electricity is known as thermal power plant.	A power generating station which converts nuclear energy into electricity is known as nuclear power plant.
Method of heat production	In thermal power plants, heat is produced by the burning of coal.	The heat is produced by the nuclear fission of heavy elements.
Location of plant	Thermal power plant is located at a place where huge water and coal is available and the transportation facilities are adequate.	The nuclear power plants are located quite away from the populated areas because they uses radioactive materials that can harm humans and animals.
Capital cost	The capital cost of thermal power plant is low.	The capital cost of nuclear power plant is very high.
Operating cost	Thermal power plant involves high operating cost because it requires huge amount of coal.	The operating cost of nuclear power plant is comparatively lower than thermal power plant. It is because a small amount of nuclear fuel can produce relatively large amount of power.

Basis of Difference	Thermal Power Plant	Nuclear Power Plant
Fuel used	Fossil fuels, mainly coal, are used in the thermal power plants.	Radioactive elements such as uranium, thorium, etc. are used as fuel in nuclear power plants.
Fuel transportation cost	In thermal power plant, huge amount of coal is transported to the plant site, which causes high cost of fuel transportation.	Nuclear plants need small quantity of fuel. Hence, the cost of fuel transportation is low.
Maintenance cost	The maintenance cost of thermal power plant is less than nuclear power plant.	Maintenance cost of nuclear power plant is comparatively high because highly trained persons are required for maintenance.
Standby losses	In thermal power plants, the standby losses are very high because the boiler remains in operation even when the turbine is not working.	The standby losses in a nuclear power plant are less.
Plant size	Thermal power plants require large area for installation.	The area required to install a nuclear power plant is comparatively smaller than thermal power plant.
Starting time	Thermal power plants require a lot of time for starting.	For nuclear power stations, the starting times are comparatively less.
Lifespan	The lifespan of a thermal power plant is small.	Nuclear power plant has relatively longer life span.
Environmental impact	Thermal power plants produce ash, smoke which causes pollution of atmosphere.	Nuclear power plants cause radioactive pollution.

Disposal of nuclear waste

Radioactive waste is a kind of perilous waste that contains radioactive material. Radioactive waste is a side-effect of different nuclear innovation forms. Businesses creating radioactive waste incorporate nuclear medication, nuclear exploration, nuclear force, producing, development, coal and rare-earth mining and nuclear weapons reprocessing. Radioactive waste is controlled by government organizations so as to ensure human health and the environment. Radioactive waste commonly involves various radionuclides: precarious arrangements of elements that rot, emanating ionizing radiation which is hurtful to people and the environment. These isotopes discharge various sorts and levels of radiation, which keep going for various timeframes. In this article, we will learn about the nuclear waste, nuclear waste disposal, the best way to dispose of nuclear waste, the different types of nuclear waste, the different sources of nuclear waste, and the causes of nuclear hazards.

Types of Nuclear Waste

1. High-level Waste

This kind of waste is unsafe to individuals for some reasons, yet particularly in light of the fact that it stays radioactive. Significant level waste records for 95% of the complete radioactivity delivered in the nuclear reactor. This kind of nuclear waste is hazardous. It should reliably experience a procedure to keep it cool and the radioactive material levelled out. High-level waste can have short and extensive parts relying on the time it will take for the radioactivity to diminish to levels that aren't viewed as hurtful for people and the general environment.

2. Intermediate-level Waste

Intermediate level waste contains a higher measure of radioactivity than low-level and not exactly elevated level. This sort of waste commonly requires protection during taking care of and interval stockpiling. This kind of waste regularly incorporates restoration waste, particle trade pitches, concoction slimes and metal fuel cladding. The transitional level waste contains 4% of all the radioactivity. Intermediate level waste that requires long haul management is moved to an approved waste management administrator.

3. Low-level Waste

A large portion of the radioactive waste that is around today is viewed as a low level. Truth be told, about 90% of all nuclear waste is low level. Nuclear reactors, clinics, dental workplaces, and comparative sorts of offices frequently utilize low-level nuclear waste materials every day and it is required so as to offer the types of assistance that are offered inside these offices. Low-level nuclear waste isn't perilous, and any of it very well may be disposed of within a landfill. This is the motivation behind why it doesn't require protecting during dealing with and transport.

4. Mining and Milling

Clean and mineralized waste stone is delivered during mining exercises which must be uncovered to get to the uranium metal body. It has next to zero convergence of uranium. While clean waste stone can be utilized for development purposes mineralized waste stone could create corrosive when left on the surface inconclusively that could influence the general environment.

Sources of Nuclear Waste

Radioactive waste originates from various sources. In nations with nuclear force plants, nuclear combat hardware, or nuclear fuel treatment plants, most of waste begins from the nuclear fuel cycle and nuclear weapons reprocessing. Different sources incorporate medical and industrial wastes, just as normally happening radioactive materials (NORM) that can be concentrated because of the handling or utilization of coal, oil and gas, and a few minerals, as talked about beneath.

1. Nuclear fuel cycle
   - front end
   - back end
   - Fuel synthesis and long haul radioactivity
   - Expansion concerns
2. Nuclear weapons decommissioning
3. Heritage waste
4. Medication
5. Ventures and industries
6. Naturally occurring radioactive material like
   - coal
   - oil and gas
   - Rare-earth mining
   -

SELECTION OF SITE FOR NUCLEAR POWER STATIONS

SELECTION OF SITE FOR NUCLEAR POWER PLANT The various factors to be considered while selecting the site for nuclear plant are as follows :

1. Availability of water. At the power plant site an ample quantity of water should be available for condenser cooling and made up water required for steam generation. Therefore the site should be nearer to a river, reservoir or sea.

2. Distance from load center. The plant should be located near the load center. This will minimise the power losses in transmission lines.

3. Distance from populated area. The power plant should be located far away from populated area to avoid the radioactive hazard.

4. Accessibility to site. The power plant should have rail and road transportation facilities.

5. Waste disposal. The wastes of a nuclear power plant are radioactive and there should be sufficient space near the plant site for the disposal of wastes.

LIST OF NUCLEAR POWER STATIONS

Nuclear Power Plants in India – Operational			
Name Of Nuclear Power Station	**Location**	**Operator**	**Capacity**
Kakrapar Atomic Power Station – 1993	Gujarat	NPCIL	440
(Kalpakkam) Madras Atomic Power Station – 1984	Tamil Nadu	NPCIL	440
Narora Atomic Power Station- 1991	Uttar Pradesh	NPCIL	440
Kaiga Nuclear Power Plant -2000	Karnataka	NPCIL	880
Rajasthan Atomic Power Station – 1973	Rajasthan	NPCIL	1,180
Tarapur Atomic Power Station – 1969	Maharashtra	NPCIL	1,400

Kudankulam Nuclear Power Plant – 2013	Tamil Nadu	NPCIL	2,000

CHAPTER-04

DIESEL ELECTRIC POWER STATIONS

An electric power generating station in which the chemical energy of diesel is converted into electrical energy is known as diesel power plant. In other words, the diesel power plant is a power generating plant in which diesel engine is used as the prime mover for the generation of electrical energy

DIESEL ELECTRIC POWER STATIONS

The diesel power uses a diesel engine to rotate alternators and produce electrical energy. The diesel engine is used as a prime mover and this power plant is known as a diesel power plant.

Due to the combustion of diesel, rotational energy is generated. The alternator is connected with the same shaft of the diesel engine. And the alternator is used to convert the rotational energy of the diesel engine into electrical energy.

In most cases, the diesel power plant is used to generate electrical energy for small-scale production and at the load end. When the grid power is not available, the diesel engine is used to supply load in emergency conditions.

Components, Working & Schematic Diagram of Diesel Power Plant

- Diesel engine
- Air intake system
- Exhaust system
- Cooling water system
- Fuel supply system
- Lubrication system
- Diesel engine starting system

Diesel Engine

A diesel engine is the main component of a diesel power plant. It is used to generate mechanical power in form of rotation energy with the help of the combustion of diesel. An alternator is connected to the same shaft as the diesel engine.

There are two types of diesel engines;

- Two-stroke engines
- Four-stroke engines

In two-stroke engines, every revolution of the crankshaft, one power stroke is developed. And in four-stroke engines, one power stroke is developed every two revolutions of the crankshaft.

Compared to four-stroke engines, two-stroke engines have a low weight-to-power ratio, are more compact, easy to start, and have low capital cost. But the thermodynamic efficiency of a two-stroke engine is less compared to four-stroke engines. Two-stroke engines require more cooling water and consume more lubricants.

Four-stroke engines are more preferred over two-stroke engines for the application of small-scale generation and DG sets. And for large-scale production, two-stroke engines are preferred. The required capacity of a diesel power plant can be calculated by the below equation.

Capacity of Plant = (Connected Load × Demand Factor) / (Diversity Factor)

The diesel engine power plant below 3 MW capacity is used as standby plants and 3 to 25 MW plants are used as baseload plants. Generally, in this type of plant, four-stroke engines are used. The plants used for baseload plants have a capacity of above 10 MW capacity and for these plants, two strokes engines are used.

Air Intake System

Large diesel engine power plant requires air in the range of 4-8 m^3/kWh. In natural air, lots of dust particles are available which may damage the cylinders of engines. Therefore, air filters are used in the air intake systems.

The air filters are made of cloth, wood, or felt. In some cases, oil bath filters are used. In oil bath filters, the dust particles are oil-coated. The design of an air intake system is done in such a way that it causes minimum pressure loss during airflow.

If the pressure losses are high, it may increase fuel consumption and reduce engine capacity. To avoid clogging, the air filters must be cleaned periodically. In a large capacity power plant, a silencer is used between the engine and intake system to reduce noise pollution.

Exhaust System

While combustion of diesel, gases are produced. The system that is used to remove these gases is known as an exhaust system. The exhaust system aims to discharge gases from the engine into the atmosphere.

The exhaust systems are designed in such a way that they will remove gases without losing pressure. If pressure releases, it requires more work to do to exhaust gases. And it will increase fuel consumption and reduce the power output of diesel engines.

To reduce the noise level, the exhaust system must be provided with mufflers and silencers. With the help of flexible exhaust pipes, the vibration must isolate from the plant.

The exhaust system is needed to cover by asbestos to avoid heat transfer and it must be cleaned periodically.

Cooling Water System

The IC engine works by burning fuel with air and the percentage utilization of energy is as below;

1. 30-37% – useful work
2. 30-35% – carried by exhaust gases
3. 0-12% – lost by radiation, convection, and conduction
4. 22-30% – heat energy flows from gases to cylinder walls

Therefore, in an IC engine, 22-30% of energy is lost in form of heat energy. And to avoid overheating of the engine, it requires a cooling system. There are two types of cooling systems;

- Direct cooling
- Indirect cooling

Direct cooling is also known as air cooling and indirect cooling is also known as water cooling. Generally, air cooling is used for small-capacity engines. And it uses cooling fins and baffles to remove heat from the engine. A water-cooling system is used for large and medium capacity engines. The water-cooling system is used a water jacket, radiator, and piping connections.

- ***Related Post: Solar Power Plant – Types, Components, Layout and Operation***

Fuel Supply System

In a diesel power plant, as the name suggests, diesel is used as a fuel. The fuel supply system has to perform the below functions.

- Depending upon the capacity of the engine and supply hours, the storage tank is required to store the diesel.
- Before supplying fuel to the engine, the fuel must be filtered and it does not contain any impurities.
- Metering of fuel is necessary.
- According to the load in each cycle, it must inject the exact quantity of fuel.
- Provide return path to unused fuel.

- In a multi-cylinder engine, it is required atomization of fuel and even distribution of fuel to each cylinder.

There are three types of mechanical fuel injection systems;

- Common rail system
- Individual pump system
- Distributor system

Lubrication System

In the IC engine, the piston-cylinder arrangement is referred to a very large variation of temperature. It works at a maximum temperature of around 2000˚ C or higher than this. At such a high temperature, the lubricating material may convert into gummy material. And it results in sticking piston rings.

The engines run on high load conditions and cause friction loss in case if the lubrication system fails. Therefore, the lubrication system is necessary for the IC engine and it requires an adequate quantity of oil reach to all parts of the engine.

The lubrication system prevents direct contact between two metals and will reduce the wear and tear in moving parts. The below-listed components of the IC engine must be lubricated;

- Piston and cylinder
- Main crankshaft bearings
- Cam, camshaft, and its bearings
- Ends of bearings at connecting rod

There are three types of lubricating systems;

- Mist or charge lubricating system
- Wet sump injection system
- Dry sump injection system

Diesel Engine Starting System

At the time of starting, the temperature and pressure of the cylinder are not sufficient to initiate the combustion. Hence, starting of the engine is not conductive for initiation of combustion. There are several methods introduced to start a diesel engine. Some of these methods

Advantages & Disadvantages of Diesel Power Plants

Advantages

The advantages of diesel power plants are listed below.

- It can start and stop quickly when required.
- This plant can be located at any place and it is easy to install for a small capacity power plant.
- It does not require more space.
- For varying loads, this plant responds quickly.

- The water is required only for cooling purposes. So, a very little quantity of water is required.
- The thermal efficiency of this plant is higher than a steam power plant.
- The diesel power plant can be efficiently used up to 100 MW.
- Less manpower is required.
- It can burn a wide range of fuel.
- Fewer fire chances.

Disadvantages

The disadvantages of diesel power plants are listed below.

- The generation cost per unit is very high. As the operation of this plant depends on the price of diesel. And diesel prices are high.
- The capacity of a diesel power plant is less compared to a steam power plant and hydroelectric power plant.
- It creates noise pollution and carbon pollution by the combustion of diesel.
- It requires high maintenance and lubrication costs.
- This plant is not capable to meet continuous overload demand.
- The life of this plant is less compared to other power plants.

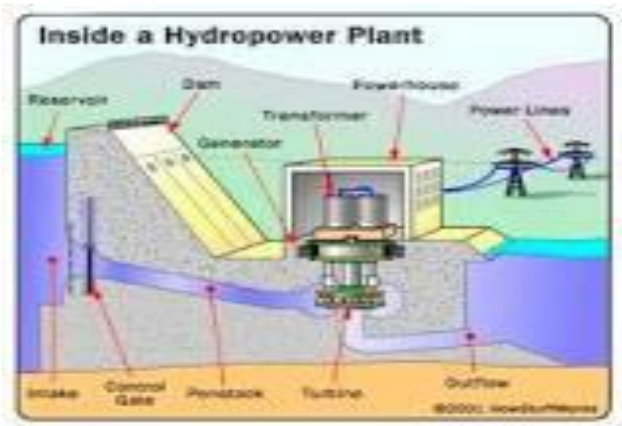
Site Selection of Diesel Power Plant

The factors affecting a selection of a location for diesel power plant are listed below.

1. **Bearing capacity:** The diesel engine is placed on a foundation. If the bearing capacity of selected land is high then it does not require high depth for a foundation. And it will save the initial cost of a power plant.
2. **Transportation facility:** The plant requires heavy pieces of machinery. Hence, the selected site must have an adequate transportation facility.
3. **Labor:** Large capacity diesel power plant requires several labors.
4. **Availability of water:** The diesel power plant requires water for cooling purposes.
5. **Future expansion:** There is some extra land available for future expansion.
6. **Availability of fuel:** This plant requires a high volume of fuel (diesel). So, a site should be selected where fuel is available easily.
7. **Distance from the populated area:** The operation of a diesel engine pollutes nearby areas. Hence, the plant must be located at a far distance from the human being.
8. **Distance from load center:** To avoid transmission loss, the site should be selected near the load center.

CHAPTER-05

HYDEL POWER STATIONS



A hydroelectric power plant comprises a set of facilities and electromechanical equipment used to transform water's potential energy into electrical energy, and can operate constantly. The available electrical energy is proportional to the flow rate and the drop in elevation.

-Hydroelectric power plants are used to convert the hydraulic potential energy from water into electrical energy.

Hydro-electric power stations are generally located in hilly areas where dams can be built and large water reservoirs can be obtained**.**

Working of Hydroelectric Power Plant

A dam is constructed across a water body.

•Water from the catchment area collects at the back of the dam to form reservoir.

•Water is brought to valve house at the start of penstock.

•The valve house contains main sluice valves and automatic isolating valves.

.Water is taken to water turbine through a huge steel pipe known as penstock.

•The water turbine converts hydraulic energy into mechanical energy.

•The turbine drives the alternator which converts mechanical.

Hydraulic Structures

- Dams
- Spillways
- Headwork
- Surge Tanks
- Penstock
- Power Stations

Dams

Dam are structures built over rivers to stop the water flow and forma reservoir.

A dam performs following two basic functions:

- It develops a reservoir of the desired capacity to store water and;
- It builds up ahead for power generation.

Catchment Area

The whole area behind the dam draining into a stream or river across which the dam has been built at a suitable place is called the catchment area.

Reservoir

It is the area where the water is stored and utilized for power generation. A reservoir may be natural or artificial.

A natural reservoir is a lake in high mountains. An artificial tank is built by erecting a dam across the river.

Spill Ways

It is a safety valve for a dam. It is provided to discharge the excess water from the dam to safeguard the dam against floods.

Penstock

It is a pipe connected between the surge tank and prime mover, usually, these are of steel-reinforced concrete pipes.

Surge Tank

There is a sudden increase in pressure in the penstock due to the sudden decrease in the rate of water flow to the turbine when the gates admitting water to the turbines are suddenly closed owing to the action of the governor.

> This happens when the load on the generator decreases. This sudden rise of pressure in the penstock above normal due to reduced load on the generator is known as the "water hammer Prime Mover

These are the turbines used to convert the kinetic energy of the water into mechanical energy to produce electric energy.

Draft Tube

It is a diverging discharge passage connected to the tailrace. It supports the runner in utilizing the remaining kinetic energy of the water at the discharge end of the runner. **Power House**

A powerhouse consists of two main parts, a substructure to support the hydraulic and electric equipment such as turbines, generators, valves, pumps, governors, etc., and a superstructure to house and protects these types of equipment.

Advantages of Hydroelectric Energy

1. Electricity can be produced at a constant rate once the dam is constructed

2. The gates of the dam can be shut down if electricity is not needed, which stops electricity generation. Hence by doing this, we can save water for further use in future when the demand for electricity is high.

3. One of the biggest advantages of hydroelectric power plants is that they are designed to last many decades, and so they can contribute to the generation of electricity for years.

4. Large dams often become tourist attractions because the lake that forms in the reservoir area behind the dam can be used for leisure or water sports.

5. The water from the lake of the dam can be used for irrigation purposes in farming.

6. Since the water is released to produce electricity, the build-up of water in the dam is stored to produce extra energy until needed.

7. Hydroelectric energy generation does not pollute the atmosphere because the hydroelectric power plant does not produce greenhouse gases.

8. Hydropower plants can be considered a reliable energy generation source. Since hydropower totally depends on water present on this planet, this energy source will remain inexhaustible because of the water cycle as it continuously keeps on maintaining balance on the Earth.

Disadvantages of Hydroelectric Energy

1. It is not an easy task to assemble a hydropower plant because the dams are extremely expensive to build, and they require extremely high standards and calculations for their construction.

2. It becomes important that the hydropower plant must serve for many decades because of its high cost of construction, and this totally depends on the availability of water resources.

3. If flooding happens due to natural calamities or the failure of dams, it would impact a large area of land, which means that the natural environment can be destroyed.

4. People are forcibly removed from the particular area where a hydropower plant is going to be assembled. This affects the day-to-day life of people living in that area.

5. A serious geological damage can be caused due to the construction of large dams.

6. To construct a hydro plant, it is important to block the running water source due to which the fishes can’t arrive at their favourable place, and as the water stops streaming, the areas along the riverside start to vanish out which eventually influences the life of creatures that depend on fish for food.

SELECTION OF SITE OF HYDEL POWER PLANT

1**. Availability of water**

2.Waterstorage
3. Geological investigation
4. Water pollution

5. Sedimentation Environmental effect

6. Aces to site

1. Availability of water

the river run off data pertain to many years should be available so that and estimate of the power potential of the project and the made . the data should include minimum Flo and maximum flow and their periods.

2. Water storage

Because of white fluctuation in stream flows storage is needed most hydroelectric project to store the water during high flow periods and use it during the leading flow periods. the storage capacity can be calculated from the hydro graph.

3. Geological investigation

It is need to see that the foundation roof from the demand and other structure is stable and strong enough to with stand water thrust and other stress.

4. Water pollution

Polluted water may cause excessive corrosion and damage to metallic structure. this may make the operation of the plant un reliable and UN economical so it is necessary to sea the water is of good quality .

5. Sedimentation

The capacity of storage reserve wire is reduced dew to the gradual deposition of snit snit may cause damage to turbine plate.

6. Environmental effect

Hydro project submerge use areas and many villages the environmental effect are also importation. The site should ensure safe soundings; avoid health hazard and presser important cultural and storage aspect of the area.

7. Access to site

A hydroelectric plant installed at the suitable location should be connected through the rail and road facilities so that row material and heavy machinery can be transfer at the suitable location very easily it is also a important factor for selecting the suitably location for hydroelectric plant.

. List of hydro power station with their capacities and number of units in the state

Andhra Pradesh	Krishna	Nagarjunasagar Hydro Electric Power plant

Andhra Pradesh	Krishna	Srisailam Hydro Electric Power plant
Andhra Pradesh, Orissa	Machkund	Machkund Hydro Electric Power plant
Gujarat	Narmada	Sardar Sarovar Hydro Electric Power plant
Himachal Pradesh	Baira	Baira-Siul Hydroelectric Power plant
Himachal Pradesh	Sutlej	Bhakra Nangal Hydroelectric Power plant
Himachal Pradesh	Beas	Dehar Hydroelectric Power plant
Himachal Pradesh	Sutlej	Nathpa Jhakri Hydroelectric Power plant
Jammu and Kashmir	Chenab	Salal Hydro Electric Power plant
Jammu and Kashmir	Jhelum	Uri Hydro Electric Power plant
Jharkhand	Subarnarekha	Subarnarekha Hydroelectric Power plant
Karnataka	Kalinadi	Kalinadi Hydro Electric Power plant
Karnataka	Sharavathi	Sharavathi Hydroelectric Power plant
Karnataka	Kaveri	Shivanasamudra Hydroelectric Power plant
Kerala	Periyar	Idukki Hydro Electric Power plant
Madhya Pradesh	Sone	Bansagar Hydroelectric Power plant

Explain types of turbine and generation used Hydroelectric power plant

There are two main types of hydropower turbines: reaction and impulse.

The type of hydropower turbine selected for a project is based on the height of standing water—referred to as "head"—and the flow, or volume of water over time, at the site. Other deciding factors include how deep the turbine must be set, turbine efficiency, and cost. Here are some of the most commonly used turbines in the United States today.

REACTION TURBINE

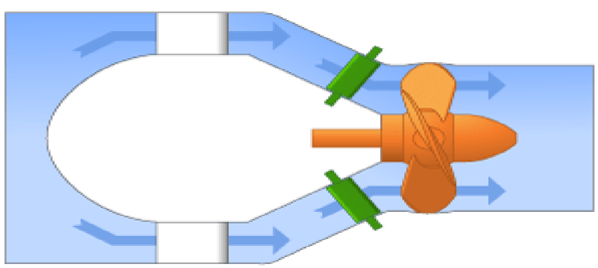
A reaction turbine generates power from the combined forces of pressure and moving water. A runner is placed directly in the water stream, allowing water to flow over the blades rather than striking each individually. Reaction turbines are generally used for sites with lower head and higher flows and are the most common type currently used in the United States.

The two most common types of reaction turbines are Propeller (including Kaplan) and Francis. Kinetic turbines are also a type of reaction turbine.

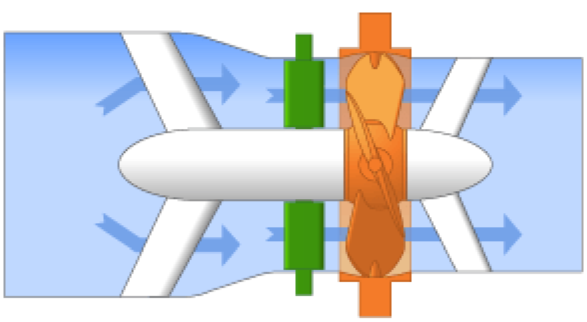
Propeller Turbine

A propeller turbine generally has a runner with three to six blades. Water contacts all of the blades constantly. Picture a boat propeller running in a pipe. Through the pipe, the pressure is constant; if it wasn't, the runner would be out of balance. The pitch of the blades may be fixed or adjustable. The major components besides the runner are a scroll case, wicket gates, and a draft tube. There are several different types of propeller turbines:

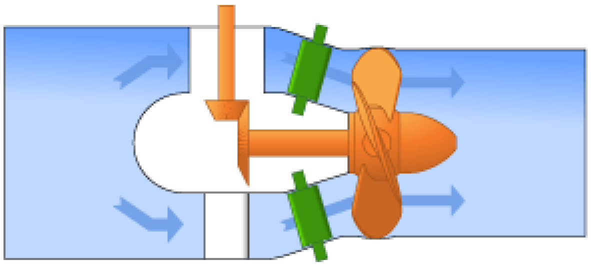
Bulb turbine: The turbine and generator are a sealed unit placed directly in the water stream.



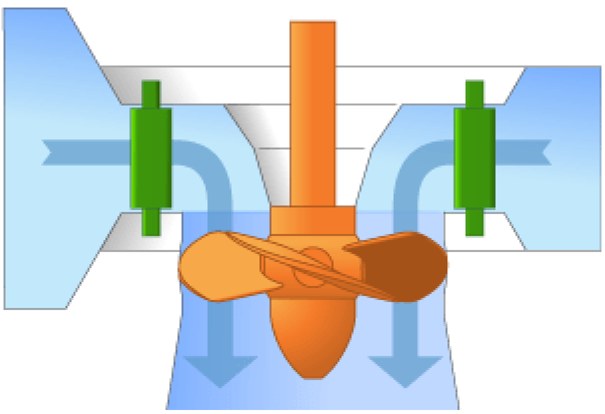
Straflo: The generator is attached directly to the perimeter of the turbine.

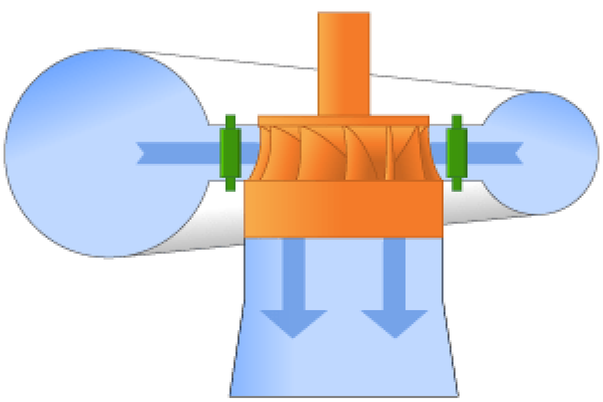


Tube turbine: The penstock bends just before or after the runner, allowing a straight-line connection to the generator.



Kaplan Turbine: Both the blades and the wicket gates are adjustable, allowing for a wider range of operation. This turbine was developed by Austrian inventor **Viktor Kaplan** in 1919.



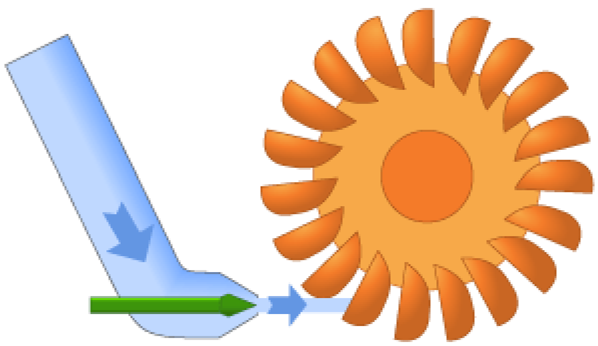


Francis Turbine

The Francis turbine was the first modern hydropower turbine and was invented by British-American engineer James Francis in 1849. A Francis turbine has a runner with fixed blades, usually nine or more. Water is introduced just above the runner and all around it which then falls through, causing the blades to spin. Besides the runner, the other major components include a scroll case, wicket gates, and a draft tube.

IMPULSE TURBINE

An impulse turbine generally uses the velocity of the water to move the runner and discharges at atmospheric pressure. A water stream hits each bucket on the runner. With no suction on the down side of the turbine, the water flows out the bottom of the turbine housing after hitting the runner. An impulse turbine is generally suitable for high-head, low-flow applications. The two main types of impulse turbine are Pelton and cross-flow turbines.



Pelton Turbine

The Pelton turbine was invented by American inventor Lester Allan Pelton in the 1870s, A Pelton wheel has one or more free jets discharging water into an aerated space and impinging on the buckets of a runner. Pelton turbines are generally used for very high heads and low flows.

CHAPTER-06

GAS TURBINE POWER STATIONS

A gas turbine, often referred to as a jet engine, is a powerful and versatile mechanical device used in various applications, including aircraft propulsion, power generation, and industrial processes. It operates on the principle of compressing and combusting air with fuel to produce high-speed exhaust gases that drive a turbine, converting energy into useful mechanical work. This efficient technology plays a crucial role in modern transportation and energy production.

SELECTION OF SITE FOR GAS TURBINE STATIONS

1. **Availability of fuels :** The fuels should be easily available at reasonably cheaper rates.
2. **Transportation :** Transportation facility be available.
3. **Distance from the load center :** To minimize losses and transmission line cost, the station shall be located near load center.
4. **Availability of good quality land :** Land must be capable of withstanding station load vibrations transmitted to foundations. It should be cheaper in cost to have low capital cost.
5. **Pollution :** The station is polluted by gas outlets, noise, so the station should be away from populated area

Gas turbine Fuels

Various fuels used by gas turbine power plants are liquid fuels and gaseous fuels such as natural gas, blast furnace gas, producer gas coal gas and solid fuels such as pulverized coal. Care should be taken that the oil fuel should not contain moisture and suspended impurities.

The different types of oils used may distillated oils and residual oils. The various paraffins used in gas turbine are methane, ethane, propane, octane (gasoline) and dodecane (kerosene oil). Out of these gasoline and kerosene or blend of the two are commonly used.

ELEMENTS OF SIMPLE GAS TURBINE POWER PLANT

Components and Accessories of Gas Turbine Power Plant

Components :

The main components of a gas turbine power plant are compressor, combustor, gas turbine with auxiliary components as intercoolers and regenerators. Some of these are described below.

1. Combustion chamber (Combustor) :

Various requirements of a combustion chamber are :

1. Carryout complete combustion of fuel.
2. High rate of combustion with minimum pressure losses.
3. Carbon deposits must not be formed under any expected conditions of operation.
4. Ease of ignition and starting. Ignition must be reliable under various operating conditions. It is more important in case of aircraft application since they operate under variable conditions of pressure and temperature which vary with altitude.
5. It should have minimum heat losses.

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5. It should have minimum heat losses.
6. Keep the temperature of gases as per the requirements of blade materials used.
7. It should have desired temperature and velocity distribution at inlet to turbine.
8. Volume and weight must be kept within reasonable limits depending on its application.
9. Reliability and serviceability with reasonable life.
10. Thorough mixing of cold and hot air.
11. Flame should be self sustaining and stable. All the above criteria must be satisfied to some degree; however their importance is decided based on its application.

- A swirl vane types of combustion chamber is shown in Figure A.
- The air from compressor is supplied to the combustion chamber, 15% to 20% of air enters into the primary zone to provide A.F. ratio of about 15 : 1 and remainder air is passed through the casing.
- The high velocity of air from compressor is reduced in the diffuser section. Fuel is sprayed through fuel nozzle into the air stream.

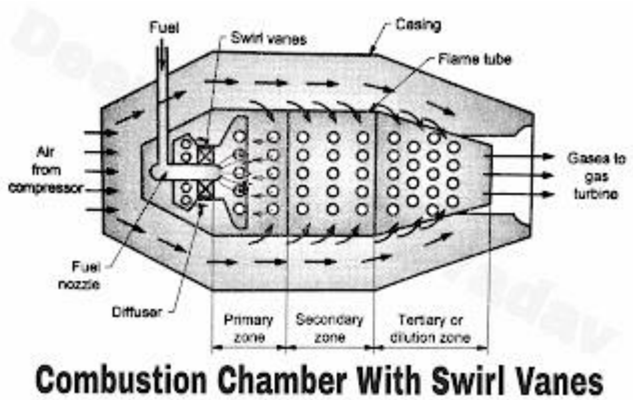


Figure A

- To give a self piloting flame in the air stream, some of the burning mixture in the primary zone is re-circulated back on to the incoming air and fuel.
- It is done by introducing the primary air through twisted radial vanes called swirl vanes. It results into a vortex motion and will induce a region of low pressure along the axis of combustion chamber.
- There are other methods of flame stabilization which shall be discussed later. At a distance away, the free vortex created by swirl vanes dies down and the pressure becomes almost uniform.
- The flame travels in the forward direction and it mixes with the secondary air passed through the perforations in the tube at a velocity of about 30 to 60 m/s. It helps in completing the combustion efficiently.
- Finally, the gases are diluted by the remainder air called tertiary air. It helps in limiting the maximum temperature of gases suitable for blade materials of gas turbine.
- In order to reduce heat losses, the combustion chamber is provided with lining of refractory materials. It has an ignition system to provide a spark across the electrodes of a spark plug for burning of fuel and air. Flame tube is provided with liner of nickel alloys or cobalt alloys to sustain high temperatures of the flame tube.

2. Intercoolers :

- Multistage compressors with intercooler in between the stages are used to reduce the work of compression and increase the volumetric efficiency in case of gas turbine power plants using high pressure ratio.
- A cross-flow type of intercooler is shown in Figure B.

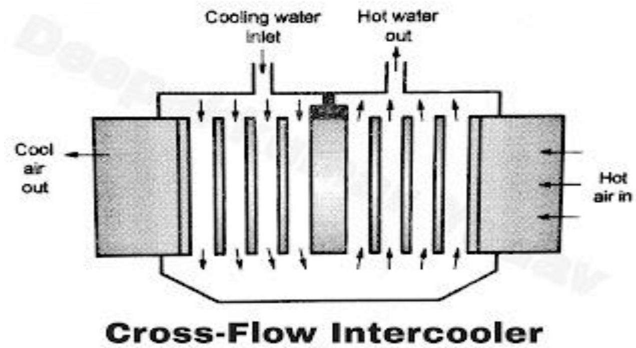


Figure B

3. Regenerator :

- A regenerator is used to heat the compressed air by exhaust hot gases from the turbine before discharged to the surroundings as shown in Figure C.
- It reduces the fuel consumption and improves the thermal efficiency of the plant.
- A regenerator is shown in Figure D.

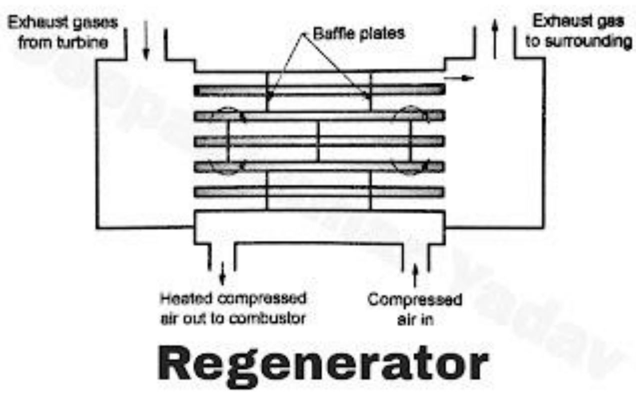


Figure C

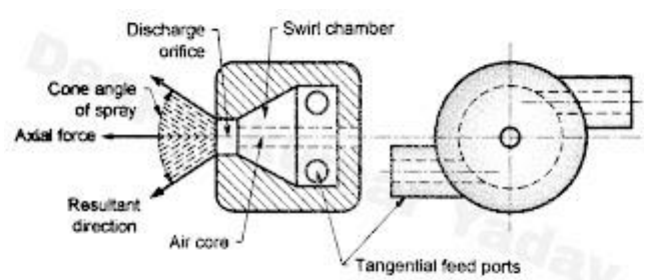
4. Fuel Injection system :

- Combustion chambers using liquid fuels needs to be injected in metered quantity under pressure as to form conical spray of very fine particles of the size 50 to 100 microns.
- It helps in rapid evaporation of fuel and mixing of fuel vapour with air.
- Thus, the basic requirements of a fuel injection system are:

1. To supply the metered quantity of fuel flow.
2. To atomize the fuel.

- The requirement of injectors for combustion chambers of a gas turbine are to have wide spread spray over a large area to provide additional surface for oxidation. The penetration is not an important consideration for these injectors as in the case of diesel engine applications.

- The type of injectors generally used are centrifugal or swirl type atomizer as shown in Figure E.
- In this the fuel is fed to a conical vortex swirl chamber via the tangential feed ports which imparts a swirling action to the flow.
- The swirl chamber does not run full but has a vapour/air core. The combination of axial and tangential components of velocity causes a hollow conical sheet of fuel to issue from the discharge orifice.
- The cone angle of spray depends on the ratio of axial and tangential components of velocity.
- This conical sheet of fuel then breaks up into the air stream into a spray of fine droplets.
- The breakup of fuel droplets and its distance from orifice is the function of injection pressure.
- There will be a certain minimum fuel pressure at which a fully developed spray will be issued by the orifice, however the actual needed pressures are slightly above this.



Injectors with Swiral Type Atomizer

Figure D

Accessories of Gas Turbine Power Plant :

Following accessories are usually fitted in a gas turbine power plant :

1. **Tachometer :** To measure the speed of turbine. It is driven from gas turbine shaft through gears.
2. **Lubricating oil pump :** It is used to supply the lubricating oil under pressure for lubrication of bearings of the plant.
3. **Filters** at inlet to the compressor to remove dust and other impurities of surrounding air.
4. **Starting motor** for starting the plant as discussed earlier in Section.
5. **Governor mechanism** to control the fuel supply according to the load on the plant so that the speed of the turbine is maintained within prescribed limits.
6. **Mufflers** at inlet and exhaust for noise control.
7. Oil coolers.

Advantages Gas Turbine Power Plant:

- Operating speed is high in this plant.
- In this plant there is no smoke combustion has occurred.
- Gas turbine power plant required less space.
- The capacity of work produced for 1 kg of air is high in this type of plants.
- In this plant the lubrication is process is simple.
- Capital cost is less compared to other power plants.
- In this there is no problem with ash content.
- It has higher mechanical efficiency.
- Required maintenance is less than another one.
- This plants has high reliability.
- At the time of operation, these plants are more flexible.

Disadvantages of Gas Turbine:

- In this plant there is a need of external energy to start a compressor before the turbine gets to start.
- This plant has the different type of metals required than other plants.
- Gas turbine power plant required a special type of cooling system or methods.
- The lifetime of gas turbine power plant is less.
- Layout of this plant is complex than diesel plant.
- Gas turbine plants are more danger or risk than diesel plants.

Applications of Gas Turbine Power Plant:

- Gas turbine plants are used to produce electricity.
- Gas turbines are with different types according to the requirement like small, medium, and large sizes.
- This is used in turbo pumps, rotary compressors.
- This is also used in aircraft.
- This type of plants are used in heavy engines like diesel engines.
- This also used in marine engines.

END