Unit 01

1. Define the following terms
(i) Load factor
(ii) Diversity Factor
(iii) Capacity Factor
(iv) Demand Fcator
(v) Reserve Factor
(vi) Use Factor
Answer:

(i) Load factor: It is defined as the ratio of the average load to peak load during a certain prescribed period of time.

Load factor = Average load/peak load

= $Kwh_{(avg.)}$ in a year/Kw_{max} x 8760

(ii) Diversity Factor: It is defined as the ratio of the sum of individual consumer group load to actual peak load of the system.

Diversity Factor = sum of individual load/actual peak load

(iii) Capacity Factor: It is defined as the ratio of average load to rated capacity of the plant.

Capacity Factor = Avg. load/rated capacity of the plant

(iv) Demand Factor: It is defined as the ratio of actual maximum demand to total connected demand.

(v) Reserve Factor: It is defined as the ratio of load factor to capacity factor.

(vi) Use Factor: It is defined as the ratio of peak load to plant capacity.

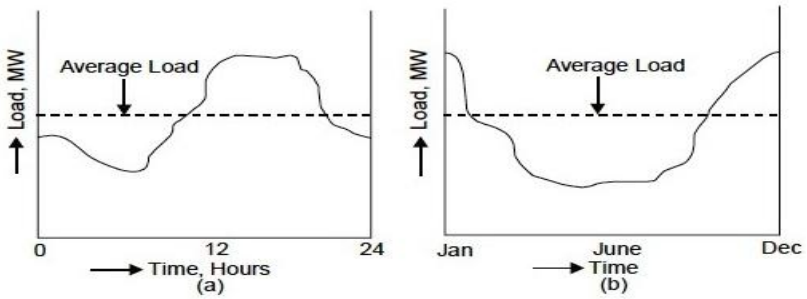
Load factor x Use factor = Capacity factor

2. (a) Discuss the load duration curve and energy load curve.
(b) A power plant supplies the following loads to the consumers:

Time in hours	*0-6*	*6-10*	*10-12*	*12-16*	*16-20*	*20-22*	*22-24*
Load in MW	*30*	*70*	*90*	*60*	*100*	*80*	*60*

Draw the load curve and estimate the load factor of the plant.

Answer: (a)



Load Curve

The load demand on a power system is governed by the consumers and for a system supplying industrial and domestic consumers, it varies within wide limits. This variation of load can be

considered as daily, weekly, monthly or yearly. Typical load curves for a large power system are shown in Figure above; these curves are for a day and for a year and these show the load demanded by the consumers at any particular time.

- The load duration curve indicates for how many hours a certain load has been required in the course of the day (24hrs) or for one month (720hrs) or one year (8760hrs).
- Daily, monthly and yearly load duration curves aid better planning for economical utilization of power plants.
- The area under the annual load duration curve represents the total energy supplied (KWh) by the utility's generating system during the year or a day or a month. It is usually divided into three parts:

(a) Base load: The base load is the load below which the demand never falls and is supplied 100% of the time.

(b) Peak load: Peaking load occurs for about 15% of the time i.e for small fraction of time

(c) Intermediate Load: it represents the remaining load region in middle.

so a careful study of the load duration curve helps to decide the capacity of base load plant and also peak load plant.

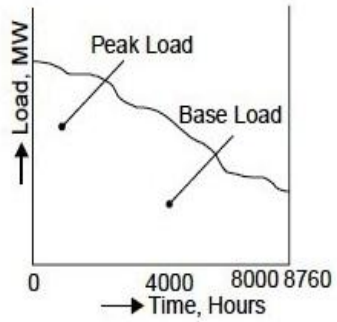


Fig: Load Duration Curve

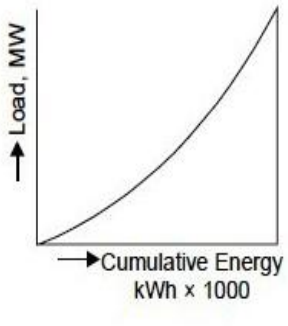


Fig: Energy Load Curve

The lower part of the curve consisting of the loads which are to be supplied for almost the whole number of hours in a year, represents the "Base Load", while the upper part, comprising loads which are required for relatively few hours per year, represents the "Peak Load".

(b) Solution: see class notes

3. The incremental fuel costs for two generating units a and b of a power plant are given by following relations,

$$dF_a/dP_a = 0.065\ P_a + 25$$

$$dF_b/dP_b = 0.08\ P_b + 20$$

where F is the fuel cost in rupees per hours and P is the power output in MW. Estimate (a) the economic loading of the two units when the total load supplied by the power plants is 200 MW, (b) the loss in fuel cost per hours if the load is equally shared by both units.

Sol:

Solution (a) The given data are

$$P_a + P_b = 200 \qquad (1)$$

The condition for economic loading demands equal incremental heat rates of the two units which leads to $dF_a/dP_a = dF_b/dP_b$

$$0.065\ P_a + 25 = 0.08\ P_b + 20 \qquad (2)$$

Solving Eq. (1) and (2), we get

$$P_a = 75.86 \text{ MW} \quad \text{and} \quad P_b = 124.14 \text{ MW}$$

(b) If the load is equally shared by the units, i.e. $P_a = P_b = 100$ MW, then the increase in cost of fuel for unit *a* is given by

$$\int \frac{dF_a}{dp_a} dp_a = \int_{75.86}^{100} (0.065\ P_a + 25)\, dP_a$$

$$= \left[0.065 \frac{P_a^2}{2} + 25 P_a \right]_{75.86}^{100} = 741.47$$

i.e., Rs 741.47 per hour.

The increase in cost for unit *b* is

$$= \int_{124.14}^{100} (0.08\ P_b + 20)\, dP_b$$

$$= \left[0.08 \frac{P_b^2}{2} + 20 P_b \right]_{124.14}^{100} = -699.23$$

that is, the cost of fuel for unit *b* decreases by Rs 699.23 per hour.

Therefore, the net increase in fuel cost due to departure from economic distribution of load

$$= 741.47 - 699.23 = \text{Rs } 42.24 \text{ per hour} \qquad \textit{Ans.}$$

4. Describe major sources of energy.

Answer:

Energy: Ability to cause changes or the capacity for doing work, generating heat and emitting light. Energy in Transition e.g. Heat and work (these only form of energy which can cross boundaries of a system). Most of our energy is originally derived from the sun.

Major sources of energy:

Biomass energy	Energy released from plants (wood, corn, etc) through combustion or other chemical process
Energy System	An energy system is made up of a sequence of conversions with inputs and outputs that transform an energy resource into a form usable for human work or heating
Fossil Fuel	A non-renewable energy resource that began to form millions of years ago from the remains of once living plants and animals. Its current forms include petroleum, coal and natural gas.
Geothermal Energy	Heat energy from the earth
Hydropower	Transformation of the energy stored in a depth of water into electricity
Non renewable energy	Resources, such as fossil fuels that cannot be replaced by natural processes at the same rate it is consumed
Peak oil	The point at which the rate that a non-renewable resource (oil) can be produced declines due to the limitations of extraction processes and the availability of the resource.
Photovoltaic	A chemical process that releases electrons from a semi-conductor material in the presence of sunlight to generate electricity.
Renewable energy	Resources, such as wind and water, that can be recycled or replaced at a rate faster than they are consumed.
Solar Energy	Energy from the sun; often captured directly as heat or as electricity through a photovoltaic process.
System Component	One process in a system comprised of many processes or components
Uranium	An element that releases heat as it undergoes radioactive decay
Wind energy	Energy transferred with the motion of air in the lower atmosphere that arises from differential heating of the earth. The energy in the wind can be extracted as mechanical energy to do work such as grind grains (a wind mill) or generate electricity (wind turbine)

5. Explain power plant economics and selection.

Answer:

Economy is the main principle of design of a power plant. Power plant economics is important in controlling the total power costs to the consumer. Power should be supplied to the consumer at the lowest possible cost per kWh. The total cost of power generation is made up of fixed cost and operating cost.

The cost of power generation can be reduced by,

(i) Selecting equipment of longer life and proper capacities.

(ii) Running the power station at high load factor.

(iii) Increasing the efficiency of the power plant.

(iv) Carrying out proper maintenance of power plant equipment to avoid plant breakdowns.

(v) Keeping proper supervision as a good supervision is reflected in lesser breakdowns and extended plant life.

(vi) Using a plant of simple design that does not need highly skilled personnel.

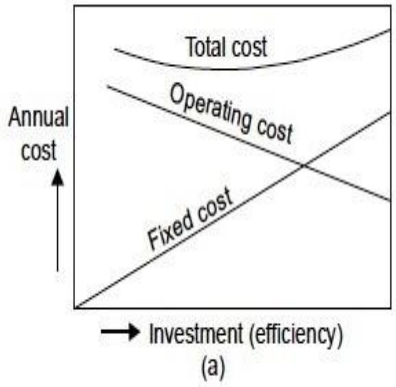


Fig (a) shows the variation of fixed cost and operation cost with investment

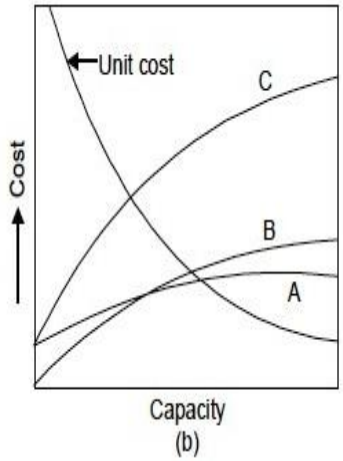


Fig (b) shows the variation of various costs of power plant versus its capacity

Effect of power plant type on cost

The cost of a power plant depends upon, when a new power plant is to set up or an existing plant is to be replaced or plant to be extended. The cost analysis includes

Fixed Cost: It includes Initial cost of the plant, Rate of interest, Depreciation cost, Taxes, and Insurance.

Operational Cost: It includes Fuel cost, Operating labour cost, Maintenance cost, Supplies, Supervision, Operating taxes.

Initial cost of a power station includes the following:

i. Land cost
ii. Building cost
iii. Equipment cost
iv. Installation cost
v. Overhead charges, which will include the transportation cost, stores and storekeeping charges, interest during construction etc.

RATE OF INTEREST: All enterprises need investment of money and this money may be obtained as loan, through bonds and shares or from owners of personal funds. Interest is the difference between money borrowed and money returned. It may be charged at a simple rate expressed as % per annum or may be compounded, in which case the interest is reinvested and adds to the principal, thereby earning more interest in subsequent years.

DEPRECIATION COST:

Depreciation accounts for the deterioration of the equipment and decrease in its value due to corrosion, weathering and wear and tear with use.It also covers the decrease in value of equipment due to obsolescence.

The elements that make up the operating expenditure of a power plant include the following

(i) Cost of fuels.
(ii) Labour cost.
(iii) Cost of maintenance and repairs
(iv) Cost of stores (other than fuel).

(v) Supervision.
(vi) Taxes

Effect of power plant type on rates

Rates are the different methods of charging the consumers for the consumption of electricity. It is desirable to charge the consumer according to his maximum demand (kW) and the energy consumed (kWh). The tariff chosen should recover the fixed cost, operating cost and profit etc.

Tariff should satisfy the following requirements:
(i) It should be easier to understand.
(ii) It should provide low rates for high consumption.
(iii) It should encourage the consumers having high load factors.
(iv) It should take into account maximum demand charges and energy charges.
(v) It should provide less charges for power connections than for lighting.
(vi) It should avoid the complication of separate wiring and metering connections.

Effect of power plant type on Fixed Element

Various types of fixed element are :
(i) Land
(ii) Building
(iii) Equipment
(iv) Installation of Machine
(v) Design and planning

The fixed element means which are not movable, and for any types of power plant, the fixed elements play a major role. Since each cost is added to the final cost of our product. So when a power plant is established, the first selection is fixed element. Effect of plant on land is as cost of land.

Effect of power plant type on Customer Element

The costs included in these charges depend upon the number of customers. The various costs to be considered are as follows:
(i) Capital cost of secondary distribution system and depreciation cost, taxes and interest on this capital cost.
(ii) Cost of inspection and maintenance of distribution lines and the transformers.
(iii) Cost of labour required for meter reading and office work.
(iv) Cost of publicity.

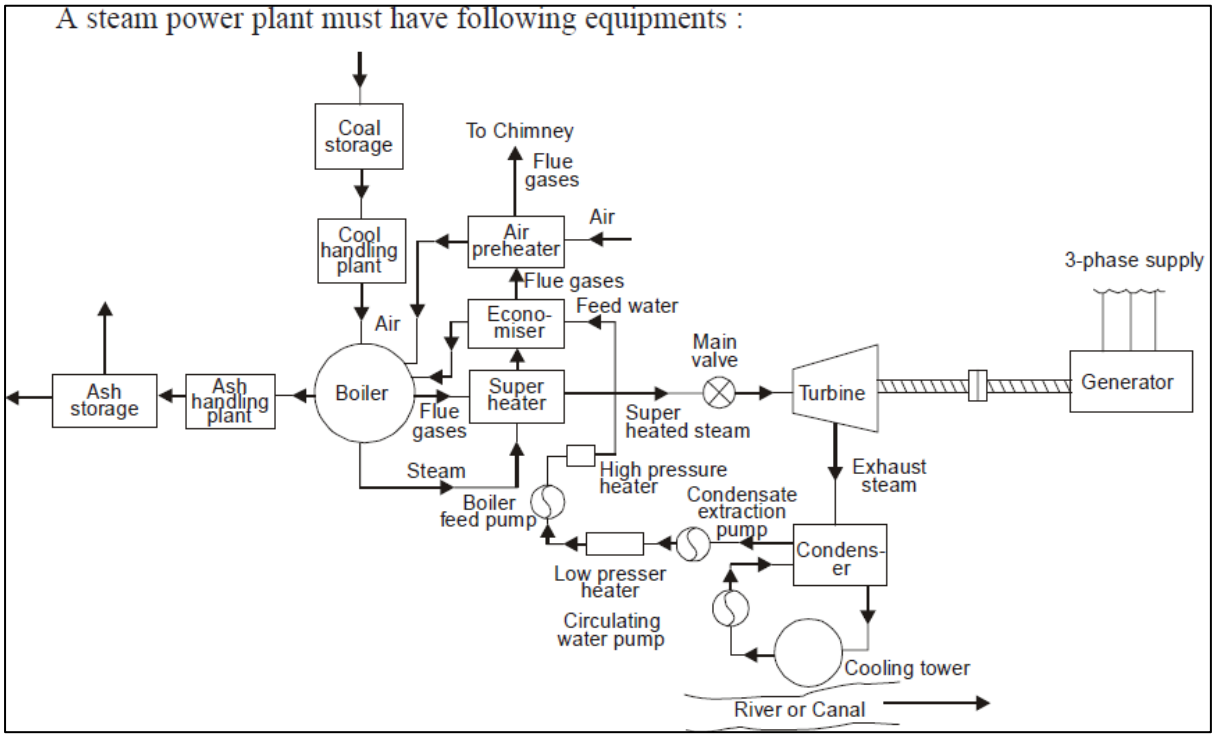
Effect of power plant type on Investor's profit

- If the power plant is the public property, as is the case in India, then the customers will be the taxpayers to share the burden of the government. For this purpose, there is an item in the rates to cover taxes in place of the investor's profit. The consumers in the form of electric consumption bills will pay these taxes.
- The investor expects a satisfactory return on the capital investment. The rate of profit varies according to the business conditions prevailing in different localities.

Unit 02

1. Draw general layout of Steam power plant.

Answer:



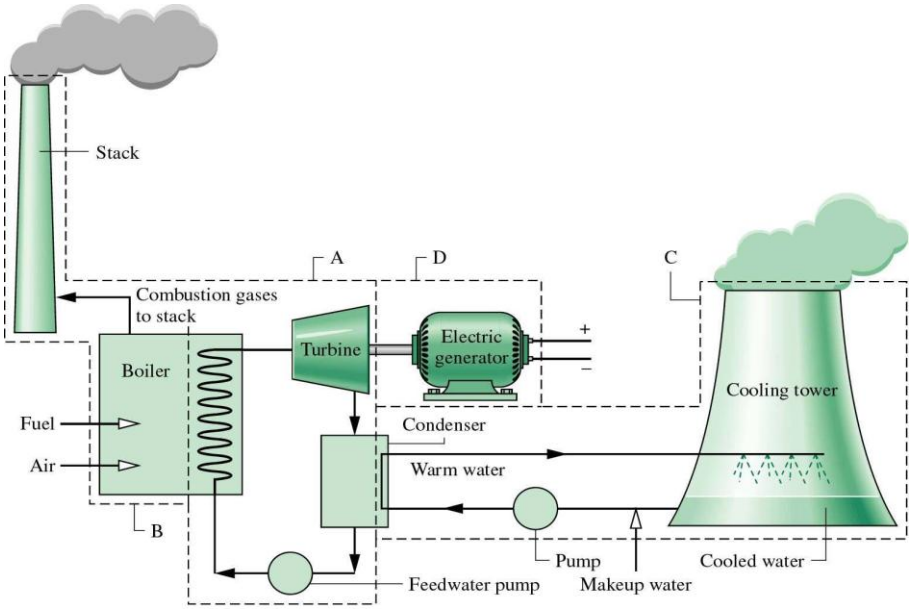
(i) A furnace to burn the fuel.

(ii) Steam generator or boiler containing water. Heat generated in the furnace is utilized to convert water in steam.

(iii) Main power unit such as an engine or turbine to use the heat energy of steam and perform work.

(iv) Piping system to convey steam and water.

In addition to the above equipment the plant requires various auxiliaries and accessories depending upon the availability of water, fuel and the service for which the plant is intended.



The Flow Circuit of Thermal Power plant (Steam Power plant)

- Feed water and steam flow circuit

- Coal and ash circuit
- Air & Gas circuit
- Cooling water circuit

- A steam power plant using steam as working substance works basically on Rankine cycle.
- Steam is generated in a boiler, expanded in the prime mover and condensed in the condenser and fed into the boiler again and cycle repeated

The different types of systems and components used in steam power plant are as follows:

(i) High pressure boiler
(ii) Prime mover
(iii) Condensers and cooling towers
(iv) Coal handling system
(v) Ash and dust handling system
(vi) Draught system
(vii) Feed water purification plant
(viii) Pumping system
(ix) Air preheater, economizer, super heater, feed heaters.

Coal received in coal storage yard of power station is transferred in the furnace by coal handling unit. Heat produced due to burning of coal is utilized in converting water contained in boiler drum into steam at suitable pressure and temperature. The steam generated is passed through the superheater. Superheated steam then flows through the turbine. After doing work in the turbine, pressure of steam is reduced. Steam leaving the turbine passes through the condenser which maintains the low pressure of steam at the exhaust of turbine.

Steam pressure in the condenser depends upon flow rate and temperature of cooling water and on effectiveness of air removal equipment. Water circulating through the condenser may be taken from the various sources such as river, lake or sea. If sufficient quantity of water is not available the hot water coming out of the condenser may be cooled in cooling towers and circulated again through the condenser.

Air taken from the atmosphere is first passed through the air pre-heater, where it is heated by flue gases. The hot air then passes through the furnace. The flue gases after passing over boiler and superheater tubes, flow through the dust collector and then through economiser, air pre-heater and finally they are exhausted to the atmosphere through the chimney.

2. Classify the Boilers of steam generator. Compare Fire tube and water tube boilers.

Answer:

Based on relative flow of flue gases and water

- Fire tube Boiler
- Water tube boiler

Based on circulation of water

- Forced circulation
- Natural Circulation

Based on the pressure of steam production

- High pressure boiler

Low pressure boiler

Based on Steam Delivery Condition

- Wet
- Dry saturated
- Super heated

Based on position of furnace

Internally fired

Externally fired

Based on position of principle axis

Vertical

Horizontal

Inclined

Based on Position

Stationary

Mobile, (Marine, Locomotive)

Fire Tube Boiler	Water Tube Boiler
(a) Hot gases pass through the tubes which are surrounded by water. (b) Any leak of water into tube will lead to explosion. (c) Because smoke or fire tubes are subjected to compressive stresses maximum pressure is restricted (d) Suitable for low capacity (e) Efficiency is low (f) Periodic tube cleaning is necessary to remove the deposits to enhance the heat transfer rate.	(a) Water passes through the tube and hot gases surround the tube and heat it from outside (b) Leakage of water cannot cause service damage. (c) Water/steam can be at very high pressures and tube failure rarely occurs (d) Suitable for large – very large capacity. (e) Efficiency is high. (f) With the use of boiler feed water tube inside cleaning is not needed.

3. What are the boiler mountings? Explain briefly.

Answer:

Boilers mountings: The boiler mountings are the part of the boiler and are required for proper functioning. In accordance with the Indian Boiler regulations, of the boiler mountings is essential fitting for safe working of a boiler.

- Safety valve
- Pressure gauge
- Water gauge
- Steam stop valve
- Feed check valve

- Fusible plug, and
- Blow off cock

Safety valve: Safety valves are located on the top of the boiler. They guard the boiler against the excessive high pressure of steam inside the drum.
These are availablein three designs :
(a) Dead weight,
(b) Lever loaded, and
(c) Spring loaded.
All high pressure
boilers have spring loaded safety valves.

- It provided to keep the boiler pressure within the safety limit.
- The spring is set in such a way that the upward thrust of the steam is balanced by the downward thrust of the spring. If the operating steam pressure exceeds this value, the difference in the thrust open the lid upward as a result of which steam will be released with hissing sound, the steams pressure inside the shell will go down till the lid is forced down to be back on its seat or initial place

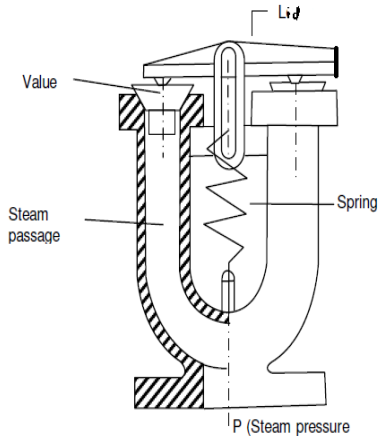


Fig: Spring Loaded Safety Valve

Pressure gauge:
A pressure gauge is fitted in front of boiler in such a position that the operator can conveniently read it. It reads the pressure of steam in the boiler and is connected to steam space by a siphon tube.
Water gauge or water level indicator: Water level indicator is located in front of boiler in such a position that the level of water can easily be seen by attendant.
Steam stop valve: The steam stop valve is located on the highest part of the steam space. It regulates the steam supply to use. The steam stop valve can be operated manually or automatically.
Fusible plug: It is very important safety device, which protects the fire tube boiler against overheating. It is located just above the furnace in the boiler.
Blow off cock: The function of blow-off cock is to discharge mud and other sediments deposited in the bottom most part of the water space in the boiler, while boiler is in operation.

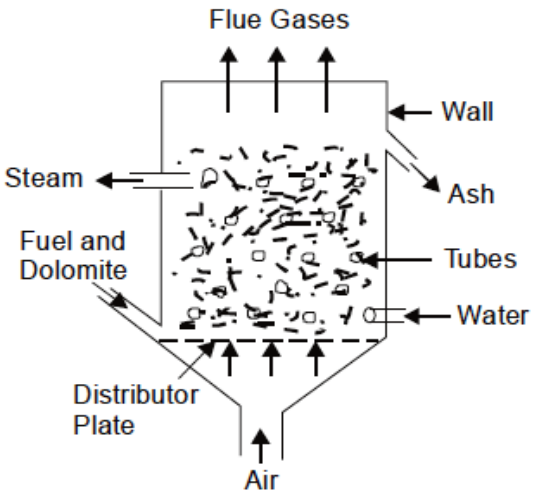
It can also be used to drain-off boiler water. Hence it is mounted at the lowest part of the boiler. When it is open, water under the pressure rushes out, thus carrying sediments and mud.

4. Explain the working of FBC (Fluidised Bed Combustion) with neat sketch. State the advantages of FBC system over conventional system.

Answer:

Fluidised bed boiler produce steam by using fluidized bed combustion technique. In these techniques, pulverised coal is put in form of bed on a grate and air is passed from dew side. Due to air drag, the small particle is suspended in air and complete coal bed is appeared to be flowing in air like fluid. Due to this inter mixing of particle is very good and complete combustion is achieved so it has higher efficiency.

These are two types:
Bubbling fluidised bed boiler
Circulating fluidised bed boiler
Fluidised bed combustion (FBC)

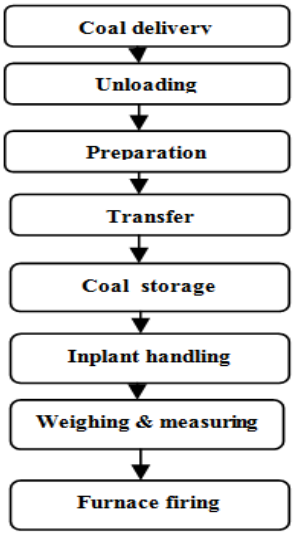
Principle of FBC: When a gas is passed through a packed be of finely divided solid particle, it experiences a pressure drop drop across the bed. At low gas velocities, this pressure drop is small and doesn't the particles. But if gas velocity is increased further, a state is reached, when particles are suspended in the gas stream and the packed bed becomes a fluidised bed. With further increase in gas velocity, the bed become turbulent and rapid mixing of particle occurs. In general, the behavior of this mixture of solid particles and gas is kike a fluid burning of a fuel in such a state is know as a fluidised bed combustion	

Various advantages of FBC system are as follows:
(i) FBC system can use any type of low grade fuel including municipal wastes and therefore is a cheaper method of power generation.
(ii) It is easier to control the amount of SO2 and NOX, formed during burning. Low emission of SO2 and NOX will help in controlling the undesirable effects of SO2 and NOX during combustion. SO2 emission is nearly 15% of that in conventional firing methods.
(iii) There is a saving of about 10% in operating cost and 15% in the capital cost of the power plant.
(iv) Ability to burn coal especially of high ash content and inferior coals.
(v) Reduced environmental impact in terms of air pollution.
(vi) Reduced water requirement.
(vii) Higher reliability and availability

5. Explain briefly coal handling system.

Answer:

The following Stages are involved in handling the coal



(*i*) **Coal Delivery:** The coal from supply points is delivered by ships or boats to power stations situated near to sea or river whereas coal is supplied by rail or trucks to the power stations.
(*ii*) **Unloading:** The type of equipment to be used for unloading the coal received at the power station depends on how coal is received at the power station. In case the coal is brought by railway wagons, ships or boats, the unloading may be done by car shakes, rotary car dumpers, cranes, grab buckets and coal accelerators. If coal is delivered by trucks, there is no need of unloading device as the trucks may dump the coal to the outdoor storage.
(*iii*) **Preparation:** When the coal delivered is in the form of big lumps and it is not of proper size, the preparation (sizing) of coal can be achieved by crushers, breakers, sizers driers and magnetic separators.
(*iv*) **Transfer:** After preparation coal is transferred to the dead storage by means of the following systems :
1. Belt conveyors.
2. Screw conveyors.
3. Bucket elevators.
4. Grab bucket elevators.
5. Skip hoists.
6. Flight conveyor.

(*v*) Storage of coal: It is desirable that sufficient quantity of coal should be stored. Storage of coal gives protection against the interruption of coal supplies when there is delay in transportation of coal or due to strikes in coal mines.
(*vi*) In Plant Handling: From the dead storage the coal is brought to covered storage (Live storage) (bins or bunkers). In plant handling may include the equipment such as belt conveyors, screw conveyors, bucket elevators etc. to transfer the coal
(*vii*) Coal weighing methods: Weigh Lorries, hoppers and automatic scales are used to weigh the quantity coal.
(viii) **Furnace Firing:** The solid fuels are fired into the furnace where combustion takes place.

Unit 03

1. With the help of neat diagram, explain and describe the complete diesel cycle power plant.

Answer:

A generating station in which diesel engine is used as the prime mover for the generation of electrical energy is known as **diesel power station.** In a diesel power station, diesel engine is used as the prime mover. The diesel burns inside the engine and the products of this combustion act as the working fluid to produce mechanical energy. The diesel engine drives alternator which converts mechanical energy into electrical energy.

This power plant is used when:

- Demand of power is less
- Sufficient quantity of coal and water is not available
- Transportation facilities are inadequate
- This plants supply power to hospitals, radio stations, cinema houses and telephone exchanges.

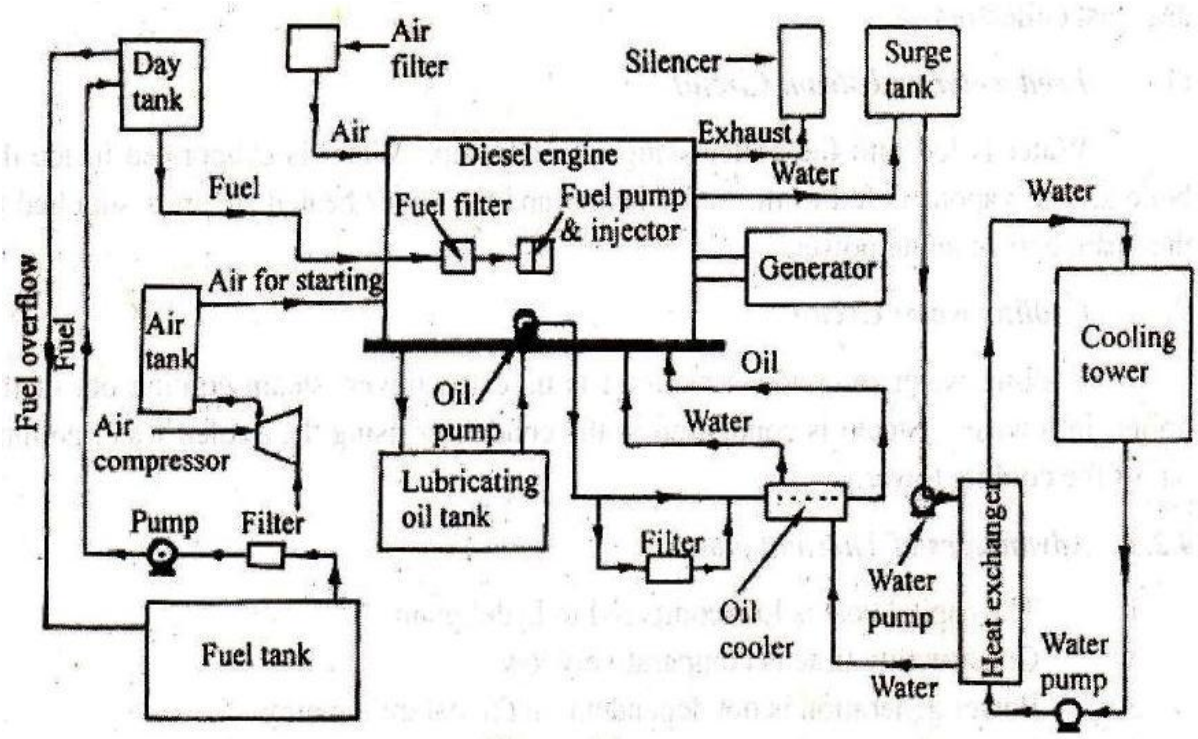


Fig. Lay-out of Diesel power plant

The essential components of diesel electric plants are:

Engine: This is the main component of the plant which develops required power. The engine is generally directly coupled to the generator.

Air-filter and supercharger: The function of the airfilter is to remove the dust from the air which is taken by the engine. The function of the supercharger is to increase the pressure of the air supplied to the engine to increase the power of the engine. The superchargers are generally driven by the engines

Exhaust system: This includes the silencers and connecting ducts. The temperature of the exhaust, gases is sufficiently high, therefore, the heat of the exhaust gases many times is used for heating the oil or air supplied to the engine.

Fuel system: It includes the storage tank, fuel pump, fuel transfer pump, strainers and heater. The fuel is supplied to the engines according to the load on the plant.

Cooling system: This system includes water circulating pumps, cooling towers or spray ponds and water filtration plant. The purpose of cooling system is to carry the heat from the engine cylinder to keep the temperature of the cylinder in safe range and extend its life.

Lubrication system. It includes the oil pumps, oil tanks, filters, coolers and connecting pipes. The function of the lubrication system is to reduce the friction of moving parts and reduce the wear and tear of the engine parts.

Starting system: This includes compressed air tanks. The function of this system is to start the engine from cold by supplying the compressed air.

Governing system: The function of the governing system is to maintain the speed of the engine constant irrespective of load on the plant. This is done generally by varying fuel supply to the engine according to load.

Unit 04

1. What are the principles of nuclear energy?

Answer: There are two process in the production of nuclear energy fission and fusion. In fission , the nuclei of uranium or plutonium atom split with released of energy. In fusion, energy is released when small nuclei combine or fuse. The fission process is used in all present nuclear power plant, because fusion cannot be controlled.

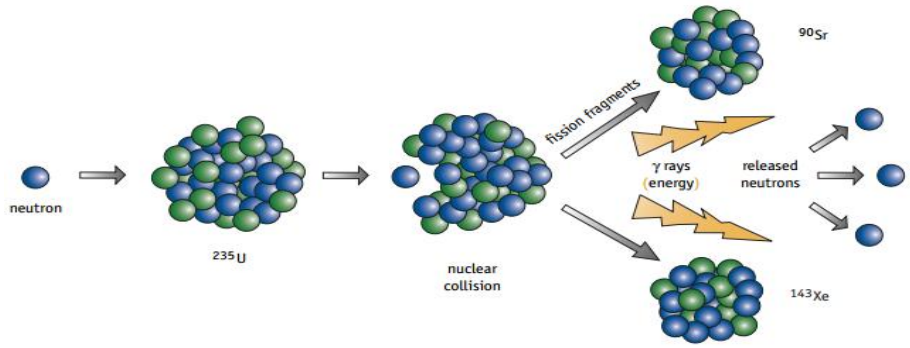


Fig: Fission Process

There are many fission reactions that release different energy values. Another

$$_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{56}Ba^{137} + {}_{36}Kr^{97} + 2{}_{0}n^{1}$$

has the mass balance

$$235.0439 + 1.00867 \longrightarrow 136.9061 + 96.9212 + 2 \times 1.00867$$

$$236.0526 \longrightarrow 235.8446$$

$$\Delta m = 235.8446 - 236.0526 = -0.2080 \text{ amu}$$

Thus $$\Delta E = 931 \times -0.2080 = -193.6 \text{ MeV} = -3.1 \times 10^{-11} \text{ J}$$

On the average the fission of a U235 nucleus yields about 193 MeV. The same figure roughly applies to U^{233} and Pu^{239}.

3. Draw a neat diagram of nuclear reactor and level different components. Discuss the function of different components of nuclear reactor briefly.

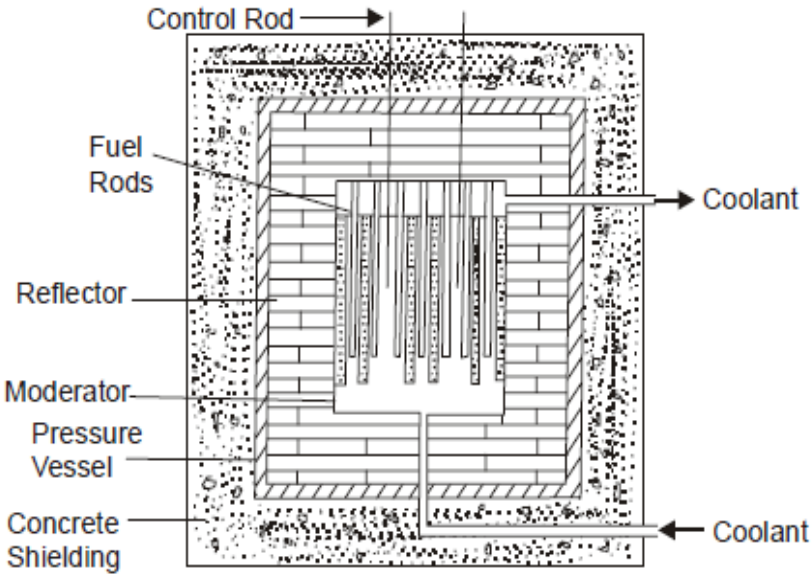
Answer:

Nuclear Reactor: A nuclear reactor is an apparatus in which nuclear fission is produced in the form of controlled self-sustaining chain reaction. It produces many useful products like heat, neutron, and radioisotopes.

Components are:

- Reactor core
- Reflector
- Control mechanism
- Moderator
- Coolant

- Measuring Instruments
- Shielding



Nuclear Reactor

NUCLEAR FUEL: Fuel of a nuclear reactor should be fissionable material which can be defined as an element or isotope whose nuclei can be caused to undergo nuclear fission by nuclear bombardment and to produce a fission chain reaction. It can be one or all of the following U233, U235 and Pu239.

Control Rods: The energy produced in the reactor due to fission of nuclear fuel during chain reaction is so much that if it is not controlled properly the entire core and surrounding structure may melt and radioactive fission products may come out of the reactor thus making it uninhabitable. This implies that we should have some means to control the power of reactor. This is done by means of control rods.

Control rods in the cylindrical or sheet form are made of boron or cadmium. These rods can be moved in and out of the holes in the reactor core assembly. Their insertion absorbs more neutrons and damps down the reaction and their withdrawal absorbs less neutrons. Thus power of reaction is controlled by shifting control rods which may be done manually or automatically.

Control rods should possess the following properties :

1. They should have adequate heat transfer properties.
2. They should be stable under heat and radiation.
3. They should be corrosion resistant.
4. They should be sufficient strong and should be able to shut down the reactor almost instantly under all conditions.
5. They should have sufficient cross-sectional area for the absorption.

Reflector: The aim of reflector is to reflect back all neutrons to the core so as to decrease the loss of neutrons. The neutrons produced during the fission process will be partly absorbed by the fuel rods, moderator, coolant or structural material etc. Neutrons left unabsorbed will try to leave the reactor core never to return to it and will be lost. Such losses should be minimized. It is done by surrounding the reactor core by a material called reflector which will send the neutrons back into the core. The returned neutrons can then cause more fission and improve the neutrons economy of' the reactor. Generally the reflector is made up of graphite and beryllium.

Moderator: The purpose of moderator in a nuclear reactor is to reduce the speed of fast moving neutrons. Fast moving neutrons are far less effective in causing the fission of U235 and try to escape from the reactor. To improve the utilization of these neutrons their speed is reduced. It is done by colliding them with the nuclei of other material which is lighter, does not capture the neutrons but scatters them. Each such collision causes loss of energy, and the speed of the fast moving neutrons is reduced. Such material is called Moderator. The slow neutrons (Thermal Neutrons) so produced are easily captured by the nuclear fuel and the chain reaction proceeds smoothly. Graphite, heavy water and beryllium are generally used as moderator.

REACTOR VESSEL:

It is a strong walled container housing the cure of the power reactor. It contains moderator, reflector, and thermal shielding and control rods.

BIOLOGICAL SHIELDING

During fission of nuclear fuel, alpha particles, beta particles, deadly gamma rays and neutrons are produced. A protection must be provided against them to protect, the operating men from the harmful effects. Thick layers of lead or concrete are provided round the reactor for stopping the gamma rays. Thick layers of metals or plastics are sufficient to stop the alpha and beta particles.

COOLANT:

Coolant flows through and around the reactor core. It is used to transfer the large amount of heat produced in the reactor due to fission of the nuclear fuel during chain reaction. The coolant either transfers its heat to another medium or if the coolant used is water it takes up the heat and gets converted into steam in the reactor which is directly sent to the turbine.

REACTOR CORE:

Reactor core consists of fuel rods, moderator and space through which the coolant flows.

3. Discuss, how pollutants from nuclear power plant are controlled.

Answer:

Radioactive waste is waste that contains radioactive material. Radioactive waste is usually a by-product of nuclear power generation and other application of nuclear fission or nuclear technology.

Radioactive waste is hazardous to most form of life and environment and is regulated by government agencies in order to protect human health and the environment

- Radioactivity naturally decays over time, so radioactive waste has to be isolated and confined in appropriate disposal facilities for a sufficient period until it no longer poses a threat.
- The time radioactive waste must be stored for depends on the type of waste and radioactive isotopes. It can range from a few days for very short-lived isotopes to millions of years.
- Current major approaches to managing radioactive waste have been segregation and storage for short-lived waste, near-surface disposal for low and some intermediate level waste, and deep burial or partitioning / transmutation for the high-level waste.
- Radioactive Pollution
- Waste from Reactor
- Thermal Pollution

Radioactive waste typically comprises a number of radionuclides unstable configurations of elements that decay, emitting ionizing radiation which can be harmful to humans and the environment. Those isotopes emit different types and levels of radiation, which last for different periods of time.

Method of disposal of radioactive waste material are:

- Storage Tank
- Dilution
- Sea Disposal
- Absorption by soil

5. Write shorts notes on combined cycle power plant.

Answer:

It has been found that a considerable amount of heat energy goes as a waste with the exhaust of the gas turbine. This energy must be utilized. The complete use of the energy available to a system is called the total energy approach. The objective of this approach is to use all of the heat energy in a power system at the different temperature levels at which it becomes available to produce work, or steam, or the heating of air or water, thereby rejecting a minimum of energy waste. The best approach is the use of combined cycles.

- Combined gas turbine and steam turbine
- Heating feed water to exhaust gas

- Employing the gases from a supercharged boiler to expand in the gas turbine
- Employing gases as combustion air in the steam boiler

❑ Combined gas turbine and diesel power plant

- Turbo-charging
- Gas-generator
- Compound Engine

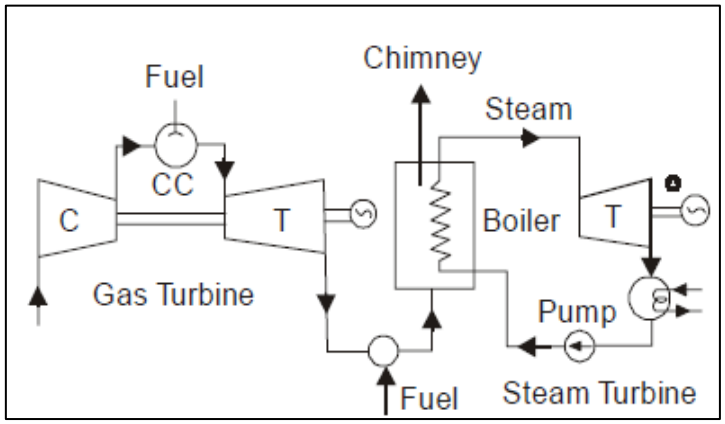


Fig. Combined Cycle (Co-generation

Above figure shows a combination of an open cycle gas turbine and steam turbine. The exhaust of gas turbine which has high oxygen content is used as the inlet gas to the steam generator where the combustion of additional fuel takes place. For a given total power output the energy input is reduced (*i.e*., saving in fuel) and the installed cost of gas turbine per unit of power output is about one-fourth of that of steam turbine. In other words, the combination cycles exhibit higher efficiency.

others

1. List the major electrical components used in power plant. Discuss briefly.

Answer:

Modern power plants have an extensive electrical distribution system to provide reliable power to all of the support equipment in the power plant. The utility operating the power plant is in the business of generating electrical power twenty four hours a day, seven days a week. Since electrical power cannot be economically stored the plants must be online to produce power when the electrical demand is present. In this regard, the power plants must be highly reliable. Backup power sources within the plant must be ready to supply needed power within moments. This course will provide an overview of these systems and the relationships between the different systems.

1. Main Generator:

The generator produces the electrical power the utility is in business to produce and sell. The three primary components of the generator are the rotor, exciter, and stator.

Rotor: The rotor on the main generator is composed of a steel shaft to which a field winding has been added. This shaft connects to the main turbine shaft and rotates at the same rotational speed as the turbine. The field winding is located in slots machined into the rotor. When DC current is passed through the field windings, the rotor forms an electromagnet with North and South poles. The resultant magnetic flux rotates through the coils of the armature (in the stator) inducing a voltage.The rotor has a fan mounted on each end of the shaft. This fan is used to force gas into the generator for cooling. The gas used is hydrogen due to its heat transfer capability.

Exciter: The exciter provides the DC current which is provided to the field windings. The exciter output can be varied to control the armature voltage. This is done by varying the amount of DC current to the field windings and thus varying the power of the rotor field; thus, the amount of voltage induced in the armature windings (stator) is changed. The exciter is typically a self-excited AC generator mounted on the same shaft as the rotor and turbine. Its output is rectified through a series of power diodes providing a DC current for the rotor field windings.

Stator: The Stator has two primary parts: the stator core and the armature windings.

The core is constructed out of donut shaped laminated iron alloy sheets that have slots around the inner circumference. The stator core has a dual purpose of supporting the armature windings and concentrating the magnetic flux around the conductors of the armature. The armature windings for the generator are located in the stator core slots. The induced voltage from the rotating field produces current in the conductors.

2. Isolated Phase Bus Duct:

Isolated Phase Bus Duct (Iso-Phase) is used to connect the high voltage and high current output of the generator to transformers that either transform the voltage higher for the transmission of the power over the utility transmission grid or steps the voltage down for use in the station.

3. Step-up transformer:

The Step-up transformer transforms the voltage from the generator to a higher voltage necessary for the transmission of the generator's power over the utility's electric grid (transmission network). These large power transformers come in two basic configurations: Single three phase transformer or three single phase individual transformers.

4. Station Startup Transformer:

The Station Startup Transformer is a power transformer used to connect the power station to the transmission system so that power is available for the plant equipment when the plant is being started. Power plants are routinely brought down for servicing of major pieces of equipment or when the demand for power is low such as in the spring and fall. This transformer provides the so called "Startup" power. The Start-up transformer is also used when the plant is being shutdown to power the station equipment that operates regardless of whether the plant is producing power. Finally, the Start-up transformer is used whenever the Station Auxiliary Transformer is un-available such as planned maintenance or repair.

5. Station or Unit Auxiliary Transformer:

The Station Auxiliary Transformer is connected to the generator output by a tap off of the Isolated Phase Bus Duct. The high voltage winding of the transformer is designed to match the generator output voltage which is 22,000 Volts or 22KV in this example. This particular transformer is shown as a three winding transformer. It has a primary winding and two separate secondary windings at different voltages. This allows the station to have two different voltage levels one at 6900 Volts or 6.9kV and the other at 4160 Volts or 4.16KV.

6. Non-segregated Phase Bus Duct:

Non-segregated Phase Bus Duct (Non-seg Bus) is typically used to connect the station auxiliary transformers low voltage windings to the station switchgear. Some stations use parallel runs of cable or more isolated phase bus duct in lieu of Non-seg Bus; however, the author's experience has been with Non-seg bus designs. The drawing below shows a cross section of Non-segregated Bus Duct.

7. Medium Voltage Switchgear:

Switchgear refers to a line-up of equipment to house circuit breakers, protective relays and control wiring. The switchgear is completely enclosed in a metal structure that prevents individuals from coming in contact with the lethal voltages within this equipment. Switchgear is made up of a series of cubicles which are bolted together in a row.

8. Secondary Unit Substations:

Secondary Unit Substations (SUSs) are essentially a repeat of the configuration of the station auxiliary transformer and the Medium Voltage Switchgear but at a lower voltage. Breakers from one of the plant switchgear will feed a transformer (in the one-line diagram the feed breakers is the 2A-3 breaker on the 2A 4160 Volt Bus) that will reduce the voltage to 480 Volts. This transformer is an integral part of a line-up of 480 Volt Switchgear.

9. Motor Control Centers:

Based upon shear numbers of components fed, Motor Control Centers feed to most components in the power plant. These include motor operators for valves, small to medium motors, lighting panels, receptacle power panels to name a few. Motor control centers are comprised of vertical sections of cubicles or buckets. Each bucket contains a molded case circuit breaker, motor starter, control transformer, control fuses and wiring.

2. Explain the function of the following

(a) Economiser:

(b) Air pre-heater

(c) Superheater

Answer:

To increase the efficiency of boilers equipment like economiser, air pre heater and super heater are added to the boiler. These are known as boiler accessories.

(a) Economiser: This is also a heat exchanger but heats the feed water again using flue gases. It is placed in the path of flue gas just ahead of the air pre heater.

(b) Air pre-heater: It is a heat exchanger used to heat the air entering furnace by extracting heat from flue gas. Combustion of fuel using hot air improves furnace temperature and also improves the thermal efficiency of the boiler.

(c) Superheater: The function of a superheated is to increase the temperature of the steam above its saturation point.

There are two type of superheaters:

1. Convective superheater
2. Radiant superheater

Superheated steam has the following advantages:

- Steam consumption of the turbine is reduced.
- Losses due to condensation in the cylinders and steam pipes are reduced.
- Erosion of turbine blade is eliminated.
- Efficiency of the steam plant is increased.
-

3. Why feed water treatment is necessary? State different methods of feed water treatment and discuss any one of them.

Answer: Water used for steam plants contains impurities which must be treated before use.
Classification of impurities:
i.Visible impurities: Suspended insoluble matter
ii.Dissolved gas: oxygen, carbon dioxide, nitrogen, methane, hydrogen sulphide
iii.Minerals and salts: sodium and potassium salts, iron & manganese, fluorides, silica
iv.Mineral acids: there presence in water is always undesirable as it may result in the chemical reaction with the boiler material.
v. Hardness: the salts of calcium and magnesium as bicarbonates, chlorides, sulphates etc are mainly responsible for the formation of a very hard surface which resists heat transfer and clogs the passages in pipes. Presence of these salts is known as hardness.

Effects of impurities in water

- **Scale formation:**

->Formation of scale reduces heat transfer and simultaneously raises the temperature of the metal wall.

-> Scale is due to mainly the salts of calcium and magnesium.

- **Corrosion**

-> Corrosion in power plant equipment produces pits, grooves and cracks or wastage of wall material. Allowed to continue corrosion ultimately makes metal parts fail.

-> Presence of oxygen and carbon dioxide is mainly responsible for corrosion among all other factors

- **Carry over**

  -> Water solid carried over in the steam leaving a boiler-drum are called "carry-over"
- Embrittlement

  -> Presence of certain concentration of sodium hydroxide cause Embrittlement

  -> It is the weakening of boiler steel as a result of inner crystalline cracks.

Method of Feed water treatment

- Mechanical treatment
- Thermal treatment
- Chemical Treatment
- Demineralisation
- Blow down

Mechanical treatment

- **Sedimentation:** In this process the water is allowed to stand at stand still in big tanks so that solid matter settles down. These solid matters settle down could be removed from the bottom either periodically or continuously. Clear water is then drained out from the tank surface.
- **Coagulation:** Coagulation of colloidal suspensions make them settle out easily. Adding coagulation like aluminum sulphate or sodium aluminates improve the sedimentation or filtration process.
- **Filtration:** The suspended matter can't be removed during sedimentation are removes with the help of filtration. The water is allowed to pass through a bed of fine sand or graded sand and then a larger of gravels etc. the suspended matter adheres to the filter material leaving the water clear as it drained from the bottom

Thermal treatment

- **Deaeration:** The process of removing dissolved oxygen is known as deaeration. This is done in a deaerating heaters. If the water is heated to a temp. of about 110 ºC with subsequent agitation, the dissolved oxygen is expelled.
- **Distillation by evaporators:** An evaporator's function is to produce from raw water, vapor that can be condensed to distilled water for boiler feed make-up
- **Demineralisation:** The mineral content of water may be removed by evaporation or by series of cation and anion exchangers to produce essentially distilled water

4. List the points to be considered for the selection of site for hydro power plant.

Answer: While selecting a suitable site, if a good system of natural storage lakes at high altitudes and with large catchment areas can be located, the plant will be comparatively economical. Anyhow the essential characteristics of a good site are: large catchment areas, high average rainfall and a favorable place for constructing the storage or reservoir. For this purpose, the geological, geographical and meteorological conditions of a site need careful investigation. The following factors should be given careful consideration while selecting a site for a hydro-electric power plant:

a. Water Available: To know the available energy from a given stream or river, the discharge flowing and its variation with time over a number of years must be known.

Preferably, the estimates of the average quantity of water available should be prepared on the basis of actual measurements of stream or river flow. The recorded observation should be taken over a number of years to know within reasonable, limits the maximum and minimum variations from the average discharge. the river flow data should be based on daily, weekly, monthly and yearly flow ever a number of years. Then the curves or graphs can be plotted between tile river flow and time. These are known as hygrographs and flow duration curves. The plant capacity and the estimated output as well as the need for storage will be governed by the average flow. The primary or dependable power which is available at all times when energy is needed will depend upon the minimum flow. Such conditions may also fix the capacity of the standby plant. The, maximum of flood flow governs the size of the headwords and dam to be built with adequate spillway.

b. Water-Storage: As already discussed, the output of a hydropower plant is not uniform due to wide variations of rain fall. To have a uniform power output, a water storage is needed so that excess flow at certain times may be stored to make it available at the times of low flow. To select the site of the dam ; careful study should be made of the geology and topography of the catchment area to see if the natural foundations could be found and put to the best use.

c. Head of Water: The level of water in the reservoir for a proposed plant should always be within limits throughout the year.

d. Distance from Load Center: Most of the time the electric power generated in a hydro electric power plant has to be used some considerable distance from the site of plant. For this reason, to be economical on transmission of electric power, the routes and the distances should be carefully considered since the cost of erection of transmission lines and their maintenance will depend upon the route selected.

e. Access to Site: It is always a desirable factor to have a good access to the site of the plant. This factor is very important if the electric power generated is to be utilized at or near the plant site. The transport facilities must also be given due consideration.

5. Explain with the diagram, the working principle of

(i) wind mills

(ii) Geo-thermal power plant

Answer:

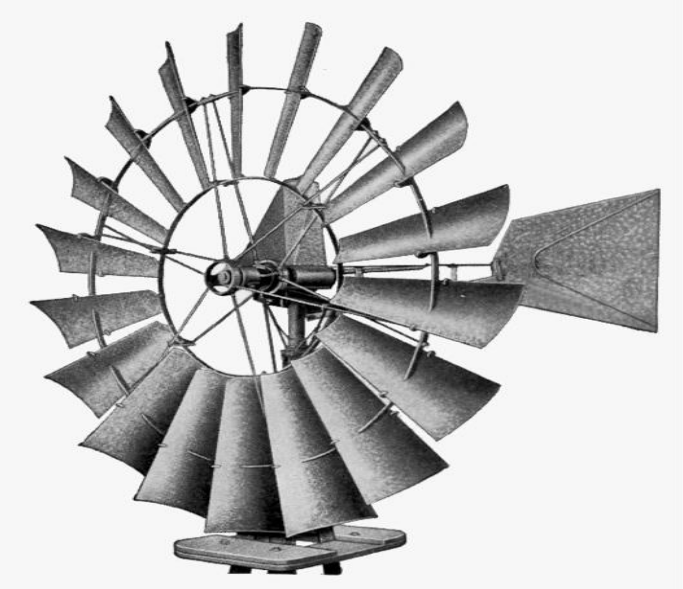
(i) Wind mills:

The wind wheel, like the water wheel, has been used by man for a long time for grinding corn and pumping water. Ancient seamen used wind power to sail their ships. In recent years, however, as a result of energy crisis in the world, it has been decided to investigate all possible means of developing power, as alternatives to fuel fired plants. The wind could supply a significant portion of the world's energy demand. Wind as a source of energy is plentiful, inexhaustible and pollution free but it has the disadvantage that the degree and period of its availability are uncertain. Also, movement of large volumes of air is required, to produce even a moderate amount of power. As a result, the wind power must be used as and when it is available, in contrast to conventional methods where energy can be drawn upon when required. Wind power, therefore, is regarded as a means of saving fuel, by injection of power into an electrical grid, or run wind power plant in conjunction with a pumped storage plant.

Design of Wind Wheels:

Several types of wind wheels have been used but the advantage of propeller rotating about a horizontal shaft, in a plane perpendicular to the direction of the wind make it the most likely type to realise economic generation on a large scale. A propeller consisting of two or three blades (with an aerofoil section) and capable of running at

the high speeds is likely to be the most efficient. Present technology has been able to build systems with 60 m long blades, on towers as high as 305 m. A large tower system, to support many small rotor-generator units, can also be built. Wind pressure rotates the wind vanes or propellers attached to a shaft. The revolving shaft rotates the rotor of a generator, through a mechanism of gears couplings etc. Thus, electricity is generated.
The wind power plants can be operated in combination with steam or hydro power station, which will lead to saving in fuel and increase in firm capacity, respectively of these plants. Wind energy can prove to be a potential source of energy for solving the energy problem. It can certainly go a long way to supply pollution-free energy to millions of people, living in the villages all over the world.



wind turbine

(ii) Geo-thermal power plant

Many geothermal power plants are operating throughout the world. Although larger geothermal power plants are in operation in America today, it is to the credit of the Italians that the first impressive breakthrough in geothermal power exploitation was achieved. The oldest geothermal power station is near Larderello in Italy, which has an installed capacity of 380 MW. In Newzealand geothermal power accounts for 40% of the total installed capacity, whereas in Italy it accounts for 6%. It is a common knowledge that the earth's interior is made of a hot fluid called 'magma'. The outer crust of the earth has an average thickness of 32 Km and below that, is the magma. The average increase in temperature with depth of the earth is 1°C for every 35 to 40 metre depth. At a depth of 3 to 4 Kms, water boils up and at a depth of about 15 Kms, the temperature is, in the range of 1000°C to 1200°C. If the magma finds its way through the weak spots of the earth's crust, it results into a volcano. At times, due to certain reasons the surface water penetrates into the crust, where it turns into steam, due to intense heat, and comes out in the form of springs or geysers. Moveover, the molten magma also contains water, which it releases in the form of steam, which could be utilized for electric power generation.

Principle of Operation

Various types of cycles have been suggested for geothermal power generation. Only two important ones, which are being used in practice, are discussed here. *Indirect Condensing Cycle* While developing Larderello power plant, it was thought, that geothermal steam may corrode the turbines. Therefore, an indirect system was adopted, which involved the use of a heat exchanger by means of which clean steam was raised from\ contaminated natural steam (Fig. 1.4). In spite of the fact that about 15% to 20% of the steam power potential had to be sacrificed in the heat exchanger, the cycle was considered economical, because of the recovery of minerals and non-condensible gases from the new steam.

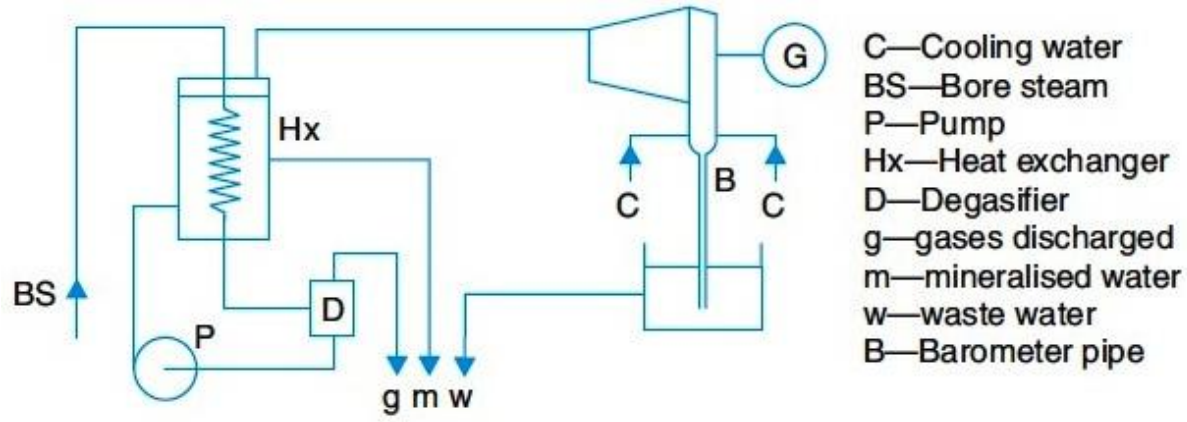


Fig.Indirect Condensing Cycle

This is the simplest, cheapest and most widely used geothermal cycle. Bore steam, either direct from dry bores, or after separation (using centrifugal separator) from wet bores, is simplypassed through a turbine and exhausted to atmosphere.