MODULE 1

Content:

Introduction to Mechanical Engineering (Overview only): *Role of Mechanical Engineering in Industries and Society- Emerging Trends and Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors and contribute to the GDP.*

Steam Formation and Application: *Formation of steam and thermodynamic properties of steam (Simple Problems using Steam Tables), Applications of steam in industries namely, Sugar industry, Dairy industry, Paper industry, Food processing industry for Heating/Sterilization, Propulsion/Drive, Motive, Atomization, Cleaning, Moisturization, Humidification*

Energy Sources and Power Plants: *Review of energy sources: Construction and working of Hydel power plant, Thermal power plant, nuclear power plant, Solar power plant, Tidal power plant, Wind power plant.*

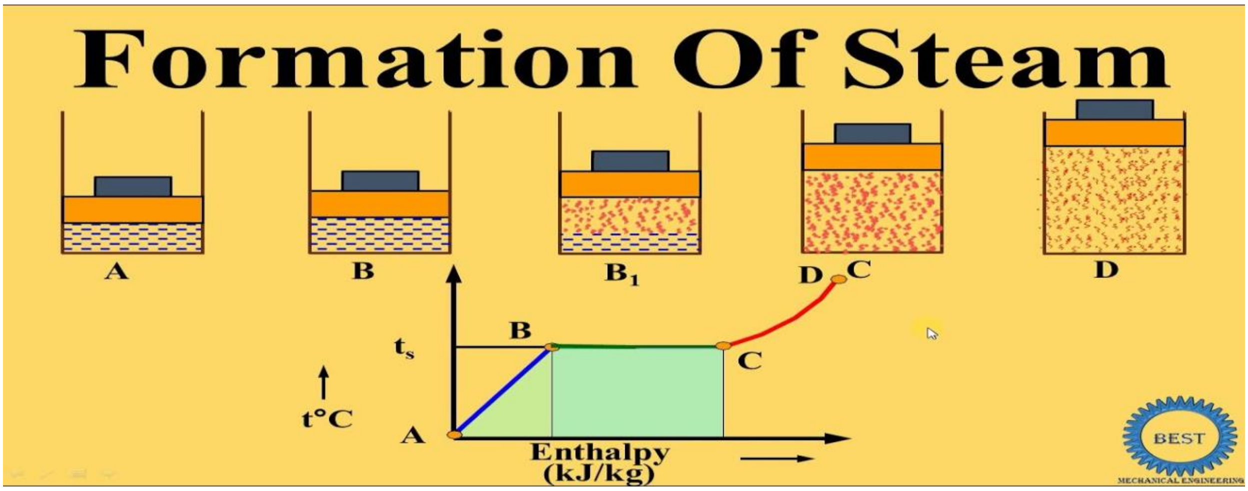
Introduction to basics of Hydraulic turbines and pumps: *Principle and Operation of Hydraulic turbines, namely, Pelton Wheel, Francis Turbine and Kaplan Turbine. Introduction to working of Centrifugal Pump.*

Steam Formation and Application:

Steam:

- Steam is the gaseous phase of water.
- It utilizes heat during the process and carries large quantities of heat later.
- Hence, it could be used as a working substance in thermodynamic devices.
- Steam is generated in boilers at constant pressure.
- Generally, steam may be obtained starting from ice or straight away from the water by adding heat to it.

Formation of steam:



The steam formation from water at 0^0C is shown in the diagram above along with the temperature- enthalpy (t-h) diagram. As the heat is supplied the temperature of the water increases from point A to point B. The point B is the saturated liquid point (boiling point) of water for the pressure at which steam is formed. It should be noted the saturation temperature of water depends on the pressure at which the steam is formed. During heating A to B, the enthalpy of water increases, and this heat is called sensible heat (h_f). Further supply of heat to water results in formation of steam without rise in temperature. It should be noted that during phase of change of any substance the temperature and pressure remains constant. It is evident form the t-h diagram that the line BC is horizontal indicating constant temperature process. The point C is dry saturated vapour point, where water gets converted completely into steam with no entrained water particles in it. The amount heat supplied during the phase change process from B to C is known as latent heat of vaporization (h_{fg}). Further addition of heat to the dry saturated steam increases its temperature and steam becomes superheated steam. The curve C-D shows superheated steam. The final temperature of the steam is called superheat temperature.

Steam Terminologies

- **Saturation temperature (Ts °C)-** the temperature at which the water begins to boil at the given pressure.
- **Sensible heat (h_f):** the amount of heat required to raise the temperature of 1kg of water from 0°C to saturation temperature at a given constant pressure. Also known as enthalpy of liquid.
- **Latent heat of evaporation (h_{fg}):** The amount of heat required to evaporate 1kg of water at saturation temperature Ts °C to 1kg of dry steam at the same temperature at a given constant pressure.is called as enthalpy of evaporation.
- **Amount of superheat (h_{sup}):** The amount of heat required to increase the temperature of dry steam from its saturation temperature to any desired higher temperature at a given constant pressure is called as amount of super heat or enthalpy of superheat.
- **Degree of superheat:** The difference between the superheated temperature and the saturation temperature.

Different States of Steam

Wet steam

Two phase mixture of entrained water molecules and steam at the saturation temperature corresponding to a given pressure.

Dry saturated steam

A saturated steam at the saturation temperature corresponding to a given pressure and having no water molecules entrained in it.

Superheated steam

The steam which is heated beyond its dry saturated state to temperatures higher than its saturated temperature at a given pressure.

Dryness fraction of steam:

It is defined as the ratio of mass of the dry steam in a known quantity of wet steam to the total mass of the wet steam.

Specific Volume:

Specific volume of wet steam

When the steam is wet, its specific volume will be equal to the sum of the volume occupied by the dried-up portion of the steam in 1 kg of wet steam and the volume occupied by the entrained water molecules in the same 1 kg of wet steam.

Specific volume of dry saturated steam- v_g (m^3/kg)

Is defined as the volume occupied by 1 kg of dry saturated steam at a given pressure.

Specific volume of superheated steam

Defined as the volume occupied by 1 kg of superheated steam at a given pressure and superheated temperature.

Enthalpy:

It is the sum of the internal energy and the product of pressure and volume. It is denoted by h and is given by $h = u + pv$.

Enthalpy of wet steam

It is the total amount of heat supplied at constant pressure to convert 1 kg of water at 0^0C to 1 kg of wet steam at the specified dryness fraction. $h = h_f + xh_{fg}$.

Enthalpy of dry saturated steam- h_g (KJ/kg)

It is the total amount of heat supplied at constant pressure to convert 1 kg of water at 0^0C to 1 kg of saturated steam. $h = h_f + h_{fg} = h_g$

Enthalpy of superheated steam

It is the total amount of heat supplied at constant pressure to convert 1 kg of water at 0^0C to 1 kg of superheated steam. $h_{sup} = h_g + C_{ps}(T_{sup} – T_s)$.

Steam tables:

Generally, the properties of steam which are likely to be used are pressure, saturation temperature, specific volume, enthalpy, entropy etc., These properties have been determined experimentally at various pressures and tabulated in a table known as steam table.

Sample steam table is shown below.

Simple Problems using Steam Tables:

1. **Find the enthalpy of 1kg of steam at 12 bar when, (a) steam is dry saturated (b) steam in 22% wet and (c) superheated to 250^0C. Use steam table. Assume the specific heat of superheated steam as 2.25 KJ/Kg/K. (Ans: 2782.73 KJ/Kg, 2346.18 KJ/Kg, 2922.23 KJ/Kg).**
2. **A steam at 10 bar and dryness fraction 0.98 receives 140 KJ/Kg at the same pressure. What is the final state of the steam (superheated at 224.2 ^0C).**

3. **Find the specific volume and enthalpy of 1 kg of steam at 0.8 MPa when (a) the dryness fraction is 0.9 (b) when the steam is superheated to 300 ^{0}C. Take C_{ps} = 2.25 KJ/Kg/K. (Ans: 2.627 m^3/Kg, 0.3105 m^3/Kg, 2562.8 KJ/Kg, 3059.1 KJ/Kg.**
4. **1 kg of superheated steam at 1.5 MPa contains 3000 KJ of heat energy. Find the superheated temperature. If 500 KJ of heat energy is removed at the same pressure, what is the condition of the steam? Take C_{ps} = 2.25 KJ/Kg/K. (T_{sup} = 291.66^{0}C, x = 0.85).**

		Specific volume m^3/kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/kg-K		
Temp. T °C	Sat. Press. P_{sat} kPa	Sat. Liquid v_f	Sat. Vapor v_g	Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2556
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292

Simple Problems using Steam Tables:

5. 5 Kg of wet steam of dryness fraction 0.8 passes from a boiler to a superheater at a constant pressure of 1MPa abs. In the superheater its temperature increases to 350^{0}C. Determine the amount of heat supplied in the superheater. The specific heat superheated steam C_{ps} = 2.25 KJ/Kg/K. (Ans: 2373.5 KJ/Kg, 3159 KJ/Kg, 785.5 KJ/Kg, 3927.5 KJ).

6. Determine the density of 1 Kg of steam initially at a pressure of 10 bar absolute, having a dryness fraction of 0.78. If 500 KJ of heat is added at constant pressure, determine the condition and internal energy for the final state of the steam. Given specific heat of superheated steam = 2.1 KJ/Kg/K. (Feb/ Mar 2022)

7. Calculate the specific volume and enthalpy of 5 Kg of steam at 1.2MPa, i) when the steam is 12% wet ii) when the steam is superheated at 360^{0}C. (Feb/ Mar 2022)

Applications of steam in Sugar industry

- In the sugar factory, steam is mainly used to generate electricity, concentrate sugar juice and dry sugar.
- Steam boilers are pivotal in the processing operations of crystallization and drying in sugar mills.
- Boilers in sugar industry primarily use bagasse, coal, and biomass as fuel.
- Additionally, boilers in sugar industry also generate electricity through cogeneration plants.
- For optimal performance of the steam boiler in sugar processing, it is advisable to reduce the excess air for the combustion of solid fuels.
- It helps in improving energy efficiency and reducing emissions.

Applications of steam in Dairy industry

- Steam Boilers play a major part in any processing industry and an unarguable fact is that they are the backbone of the dairy and milk processing industries and require to be highly efficient, resilient, and preferably compact for seamless operations.
- Boilers in the dairy industries mainly perform the processes of milk pasteurization and Ultra Heat Temperature (UHT) to ensure that the milk is safe for consumption and free from harmful bacteria for optimal shelf life
- The milk processing plants utilize steam for processing and pasteurizing raw milk and dairy products under heat treatment.
- It leads to the process and production of various dairy products such as milk powder, yogurt, cheese, condensed milk, skimmed milk, butter, ghee, and cream.

Applications of steam in Paper industry

Why are Steam Boilers Important in the Paper Industry?

- Steam is pivotal in the paper industry for the process of drying the paper, energy requirement, and the cooking of wood chips in the digester. Some of the essential requirements of steam in paper processing are,
- Uniform Heating:

The utilization of rolls in paper processing requires it to be heated internally with steam. Therefore, it is essential to maintain an even temperature across the surface of the rolls for uniformity and high-quality products. Steam is an ideal choice as it condenses and distributes heat evenly.

- Steam Carries Ample Heat:

Most processing plants require a considerable amount of energy, and the paper industry is no different. One of the optimal ways to carry energy for processing operation is through latent heat in steam.

- Precision in Steam Temperature:

As temperature demand increases or the higher-grade papers are manufactured, higher pressure and temperature are needed. The plant operators can control the pressure and set the steam temperature inside the roll. The saturated steam maintaining the same temperature at a given pressure allows the operators to control the pressure and steam temperature as required.

- Efficient Process Operations:

Steam boilers are highly efficient for generating steam and power for processing purposes. The generated steam is operated in an insulated, closed-loop system. Hence, steam boilers are efficient and reliable for the process industry's operations.

Applications of steam in Food processing industry

Direct heat or heat from the hot water is an essential factor of food processing industry. Inside the beverage business, steam is used for cooking, drying, and warming, and for general utilize-cleaning. Steam is also used to eliminate microbiological risk in food.

- Steam boilers are an integral part of the food processing industry.

They rely heavily on steam for the different processes in the plant.

- Sterilization And Disinfection: Food safety is paramount in any food processing plant to ensure the food produced is fit for human consumption. Food processing plants in India are regulated by the Food Safety and Standard Authority of India and the State Food Safety Authority. They ensure the plant follows stringent standards to clean, sterilize, and disinfection of all the tools/utensils/surfaces used for food processing. Safety has become even more paramount after the current Covid-19 pandemic as processing units need to follow protocols for their workers and equipment to ensure product safety. Utensils and surfaces need to be sterilized before preparing food.

Applications of steam in Food processing industry

- Reducing Microbiological Risks: There is an inherent risk of food getting contaminated by parasites or bacteria or microbes that can cause food-borne diseases. Steam pasteurization is one of the popular methods to control microbiological risks.
- Cooking, Curing, And Drying: Tertiary food processing units cook the food before it is packed. Steam and hot water are used to ensure the food produced is smooth,

soft, and easy to digest. Complex cooking processes such as curing or drying also require steam. These plants require large quantities of steam for processing.

Applications of steam in propulsion/ drives

- Steam is regularly used for propulsion (as a driving force) in applications such as steam turbines. The steam turbine is a piece of equipment that is essential for the generation of electricity in thermal electric power plants.

Applications of steam in motive fluid

- Steam can also be used as a direct "motive" force to move liquid and gas streams in piping. Steam jet ejectors are used to pull vacuum on process equipment such as distillation towers to separate and purify process vapor streams.

Applications of steam in atomization

- Steam atomization is a process where steam is used to mechanically separate a fluid. In some burners, for example, steam is injected into the fuel to maximize combustion efficiency and minimize the production of hydrocarbons (soot).

Applications of steam in cleaning

Uses for Steam Cleaners

- Cleaning Grout.
- Wiping Ceiling Fans.
- Sanitizing Light Switches and Doorknobs.
- Cleaning Grills.
- Cleaning the Oven.
- Disinfecting Pet Cages.
- Refreshing Outdoor Furniture.
- Eliminating Refrigerator Gunk.

Applications of steam in moisturization/ humidification

Steam is sometimes used to add moisture to a process while at the same time supplying heat. For example, steam is used for moisturization in the production of paper, so that paper moving over rolls at high speed does not suffer microscopic breaks or tears. Another example is pellet mills.

Energy sources and power plants:

Review of energy sources

Sun is the only source of energy for the planet earth.

Renewable sources of energy:

- Energy sources which are continuously renewed in nature and are essentially inexhaustible are called renewable energy sources.
- Direct solar energy
- Wind energy
- Tidal energy
- Hydel energy
- Ocean thermal energy
- Bio energy
- Geo-thermal energy

Non-renewable energy sources:

- Energy sources which have been accumulated over the ages and not replaced once they are exhausted

1. Fossil fuels.
2. Nuclear fuels etc.,

Advantages of renewable energy sources

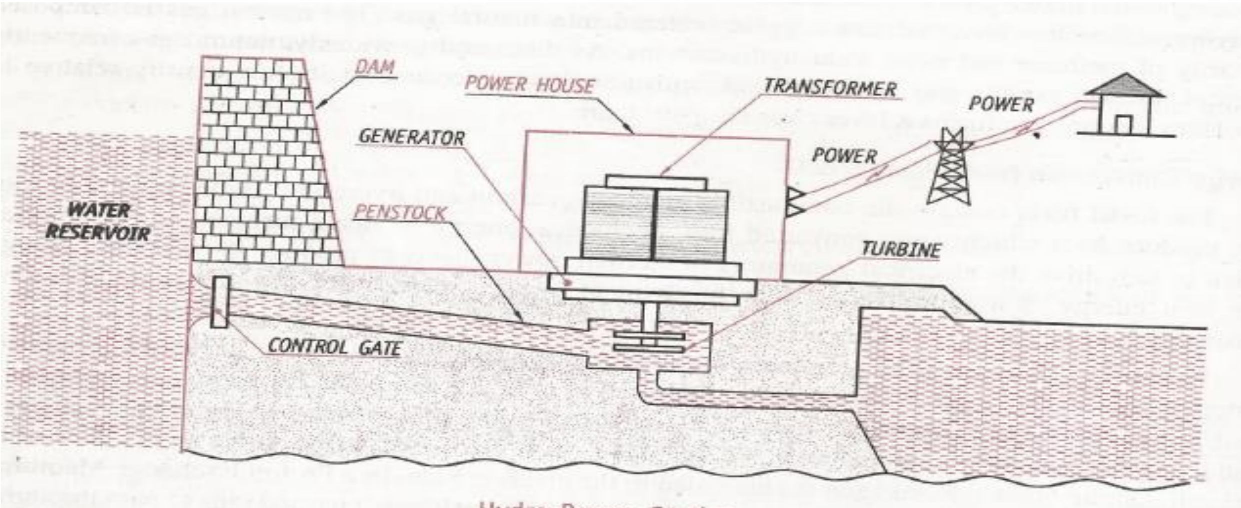
- Non exhaustible.
- Can meet the demand need if develop proper technology to harvest all available sources.
- Can be built near the load point.
- Local self-sufficiency be achieved using locally available sources.
- Except biomass, all other sources are pollution free.

Disadvantages of renewable energy sources

- Intermittent nature of availability of energy such as solar, wind, tidal etc. is a major setback.
- Solar energy received at the earth depends on
    - Local Geographic position
    - Time of the day
    - Part of the year etc.
- Sources such as wind, tidal etc. are concentrated only in certain regions.

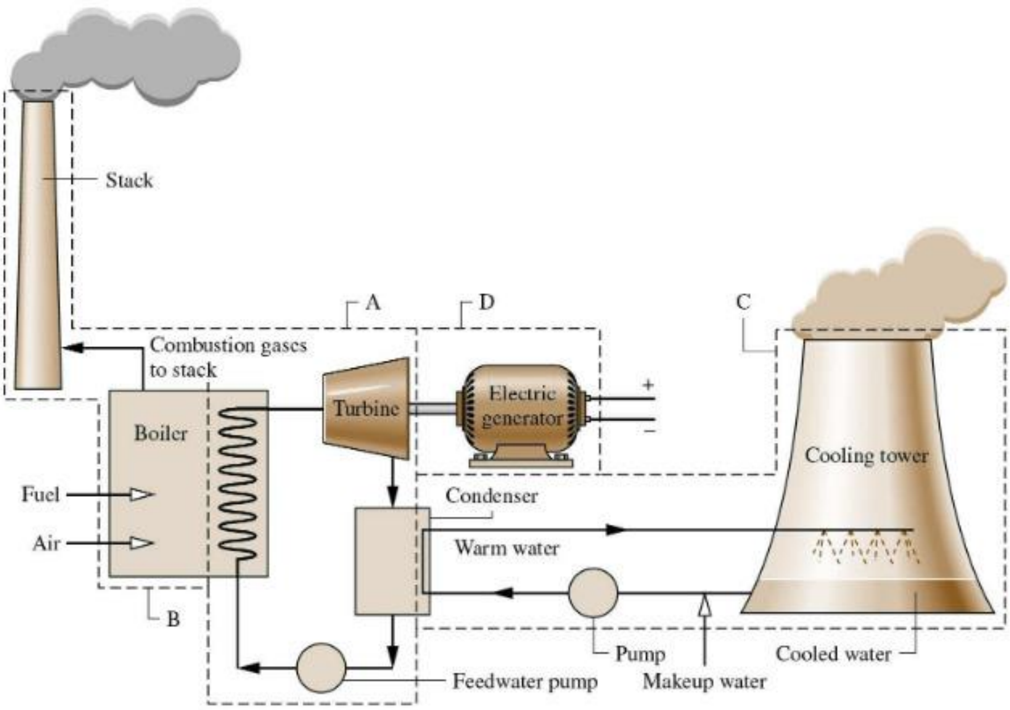
Construction and working of hydel power plant

- Dam or reservoir stores water. Energy stored in the form of PE.
- Water is made to pass through penstock to the turbine.
- The potential energy of water is converted into KE.
- The KE of water while passing over the blades of turbine gets converted into mechanical energy.
- The mechanical energy is supplied to the generator where it is converted into electrical energy.



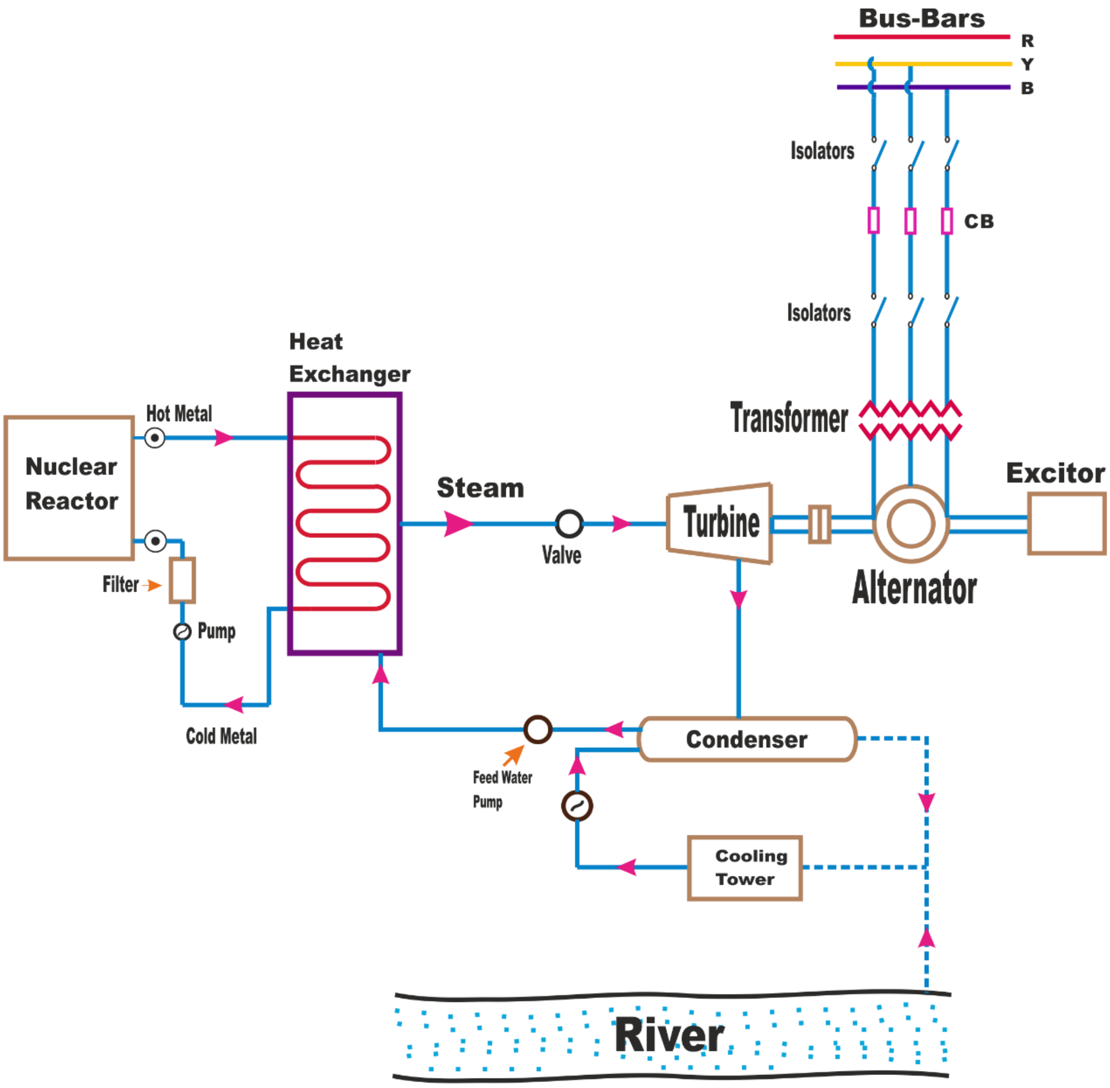
Hydro-Power Station

Construction and working of thermal power plant



- Water or steam is used as the working substance.
- Boiler converts water into steam by utilizing the heat of fuel.
- The high pressure and temperature steam passes over the blades of steam turbine where this heat energy is converted into mechanical energy.
- The turbine rotates the generator coupled it. The generator converts mechanical energy into electrical energy.
- The exhaust steam from the turbine is made to pass through the condenser where it is condensed to water and this water is pumped back to the boiler.
- Cooling towers are used to cool the water used in the condenser for condensing steam.

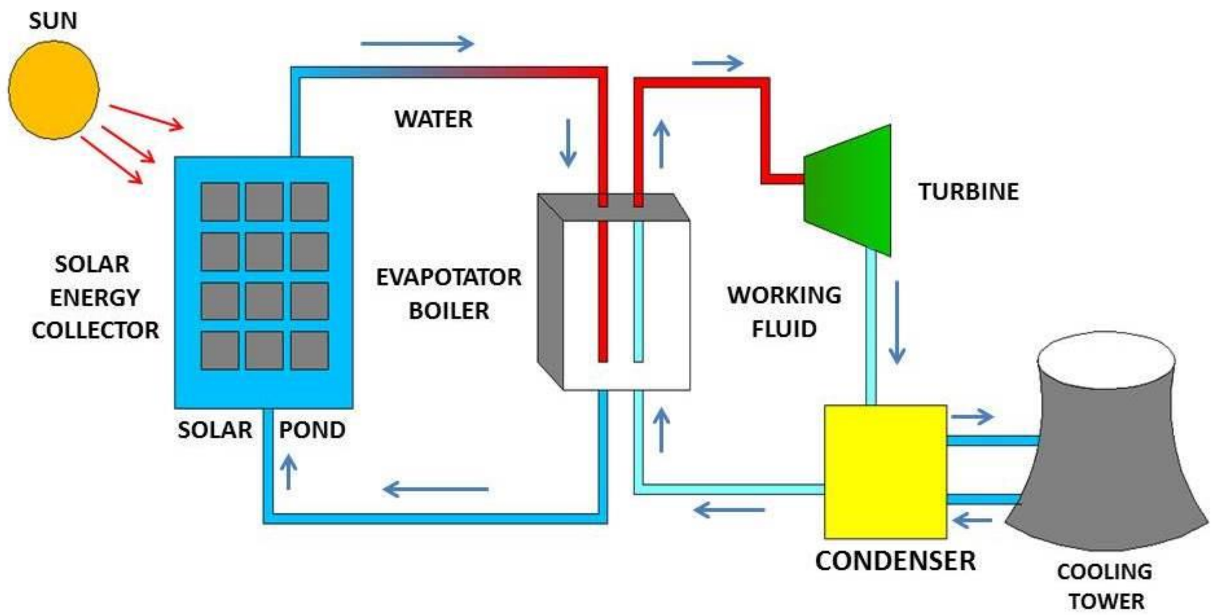
Construction and working of nuclear power plant



- Nuclear fuels like Uranium is the main element required to run a nuclear reactor.
- Nuclear fission or fusion process produce tremendous amount of heat energy.

- The energy released during nuclear reaction is absorbed by a working fluid which is further transferred to water in the boiler/ heat exchanger.
- The water passing through the heat exchanger absorbs this heat and gets converted into steam.
- The steam is made to pass over the turbine where heat energy is converted to mechanical energy.
- The turbine drives an alternator which converts this mechanical energy into electrical energy.

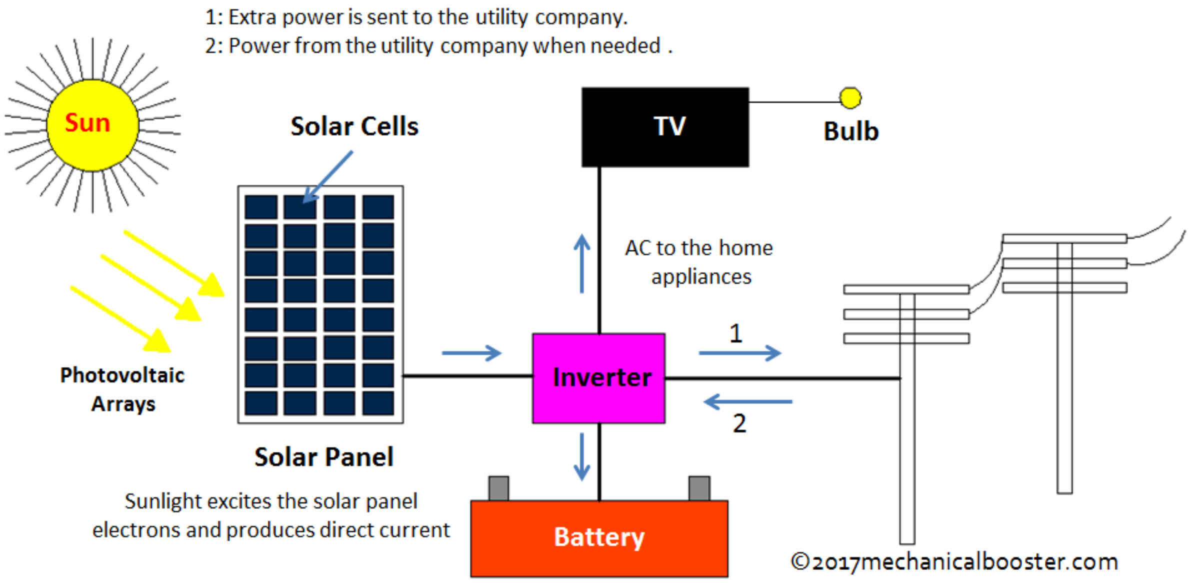
Construction and working of solar thermal power plant



SOLAR THERMAL POWER PLANT

- In these solar collectors are used to absorb heat from solar radiation in a solar pond.
- The heat is used to heat water flowing through the solar pond.
- This high temperature heat is given to the working fluid water in a heat exchanger where steam is produced.
- This high heat energy content of this steam is converted to mechanical energy in the turbine.
- The turbine drives the generator where mechanical energy is converted to electrical energy.
- Thus, the solar energy is converted into electrical energy in a solar thermal power plant.

Construction and working of solar power plant



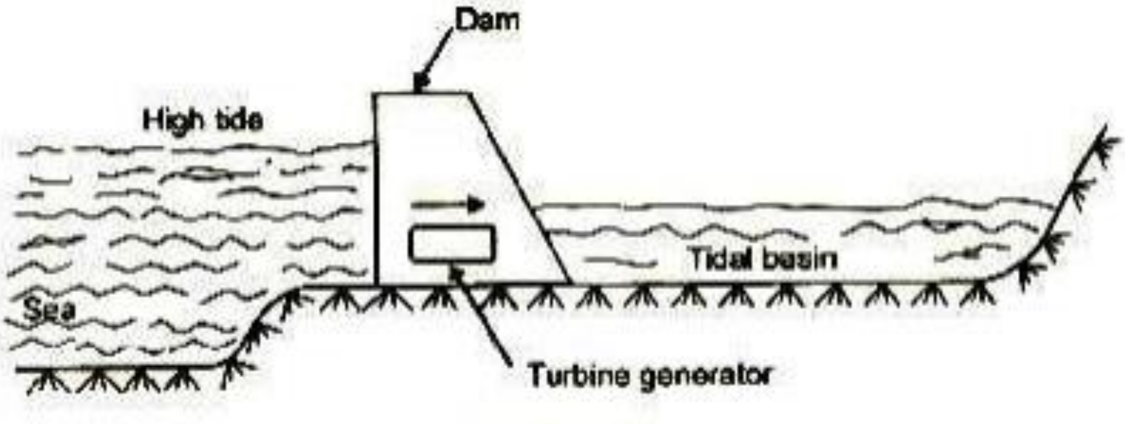
Working of Solar Power Plant

- A photovoltaic cell, commonly called a solar cell or PV, is a technology used to convert solar energy directly into electricity. A photovoltaic cell is usually made from silicon alloys.
- Particles of solar energy, known as photons, strike the surface of a photovoltaic cell between two semiconductors.
- These semiconductors exhibit a property known as the photoelectric effect, which causes them to absorb the photons and release electrons. The electrons are captured in the form of an electric current - in other words, electricity.
- This electrical energy can be directly used to run the electrical appliances or can be supplied to the grid.

Construction and working of tidal power plant

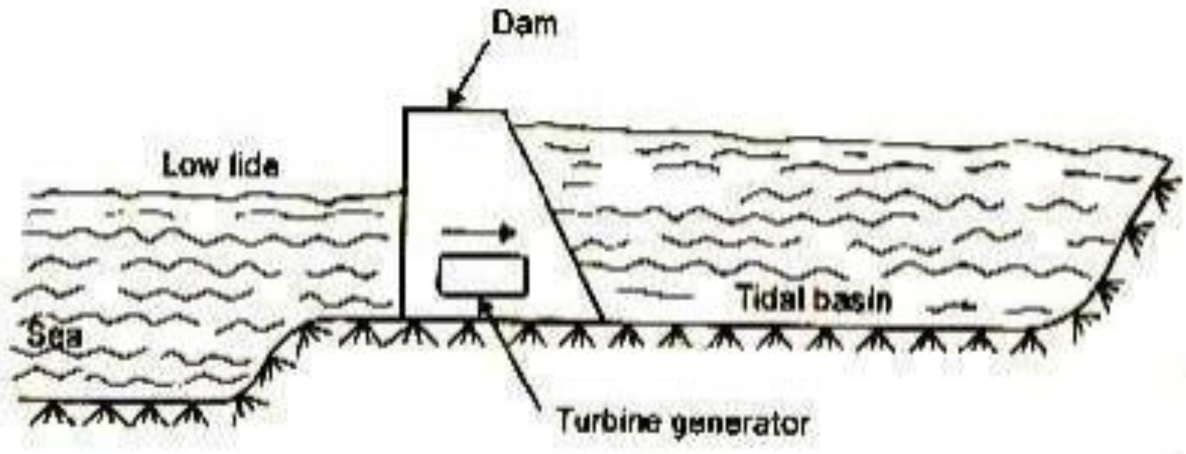
- Tide or wave is periodic rise and fall of water level of the sea.
- Tides occur due to the attraction of sea water by the moon.
- Tides contain large amount of potential energy which is used for power generation.
- When the water is above the mean sea level, it is called flood tide. When the water level is below the mean level it is called ebb tide.
- The ocean tides rise and fall, and water can be stored during the rise period, and it can be discharged during fall. A dam is constructed separating the tidal basin from the sea and a difference in water level is obtained between the basin and sea.

- During high tide period, water flows from the sea into the tidal basin through the water turbine. The height of tide is above that of tidal basin. Hence the turbine unit operates and generates power, as it is directly coupled to a generator.



(a) High tide

Figure: High tide



(b) Low tide

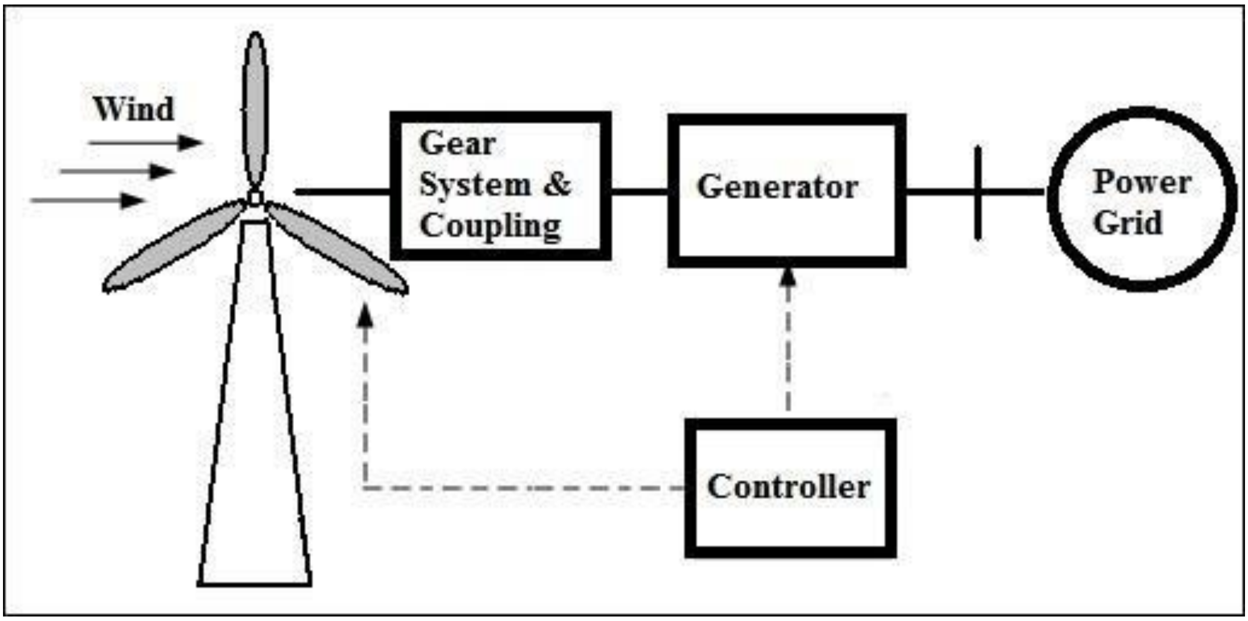
- During low tide period, water flows from tidal basin to sea, as the water level in the basin is more than that of the tide in the sea. During this period also, the flowing water rotates the turbine and generator power.

Construction and working of wind power plant

Wind is a form of solar energy caused by a combination of three concurrent events:

- The sun unevenly heating the atmosphere
- Irregularities of the earth's surface
- The rotation of the earth.

The terms "wind energy" and "wind power" both describe the process by which the wind is used to generate mechanical power or electricity. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity.



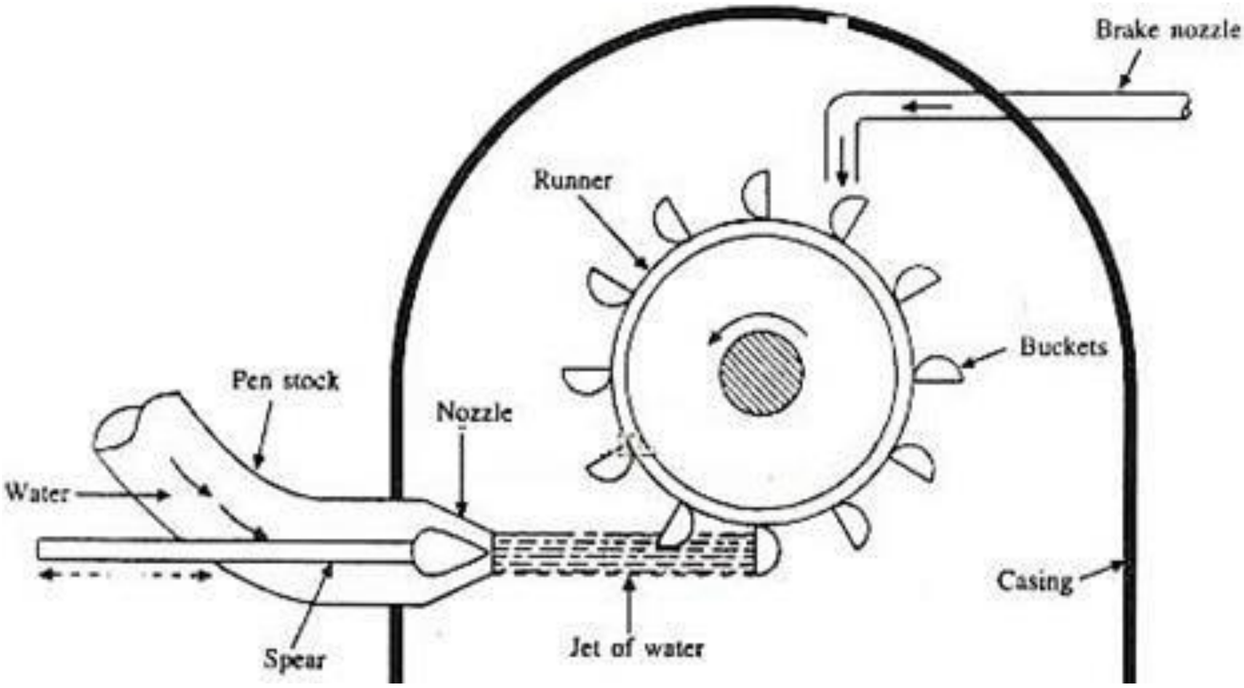
- A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade.
- When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag.
- The force of the lift is stronger than the drag and this causes the rotor to spin.
- The rotor connects to the generator, either directly (if it's a direct drive turbine) or through a shaft and a series of gears (a gearbox) that speed up the rotation and allow for a physically smaller generator. This translation of aerodynamic force to rotation of a generator creates electricity.

Introduction to basics of Hydraulic turbines and pumps:

Principle and operation of Pelton wheel

- Pelton turbine is an impulse turbine named after an American engineer Lester A. Pelton.
- Pelton turbines are suitable for power extraction when water energy is available at a high head and low flow rate.
- Pelton Turbine is a Tangential flow impulse turbine in which the pressure energy of water is converted into kinetic energy to form high speed water jet and this jet

strikes the wheel tangentially to make it rotate thereby converting KE to mechanical energy. It is also called as Pelton Wheel.

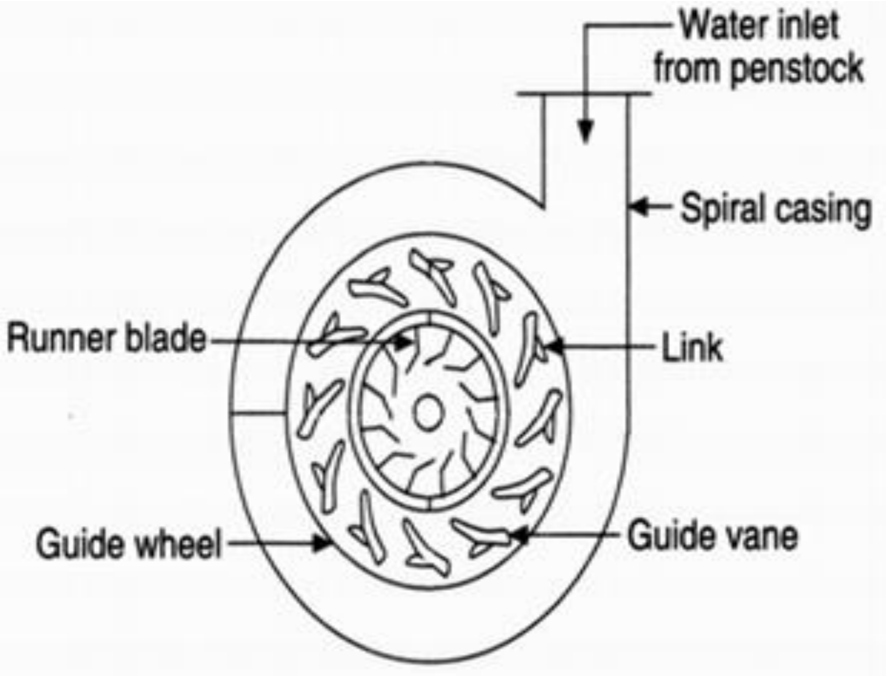


- The water from source is transferred through penstock to which end a nozzle is provided. Using this nozzle, the high-speed water jet can be formed. To control the water jet from nozzle, a movable needle spear is arranged inside the nozzle.
- A Pelton turbine consists of a runner, which is a circular disc on the periphery of which several buckets are mounted with equal spacing between them.

Principle and operation of Francis Turbine

- Francis turbine is a mixed flow turbine.
- In a Francis turbine, the water enters radially to the impeller blades while exits axially.
- It is a combination of a reaction turbine and an impulse turbine.
- Mostly it uses in large or medium hydropower plants.
- These types of turbines can be used for heads from a maximum of 300 meters to a minimum of 2 meters.
- The water flowing from the reservoir or dam is made to pass through the spiral/ volute casing at high pressure and this water passes through the guide blades and stationary blades.
- The guide blades' angle determines the angle of attack of the water on the impeller blades and ensures the performance of the turbine. The impeller blades are fixed and cannot be changed or modified their angles.

- In the case of the Francis turbine, the impeller blades divide into two sections. The bottom section is shaped like a small bucket so that this section uses the water's impulse action to turn the turbine. The upper section of the blade utilizes the reaction action of moving water.

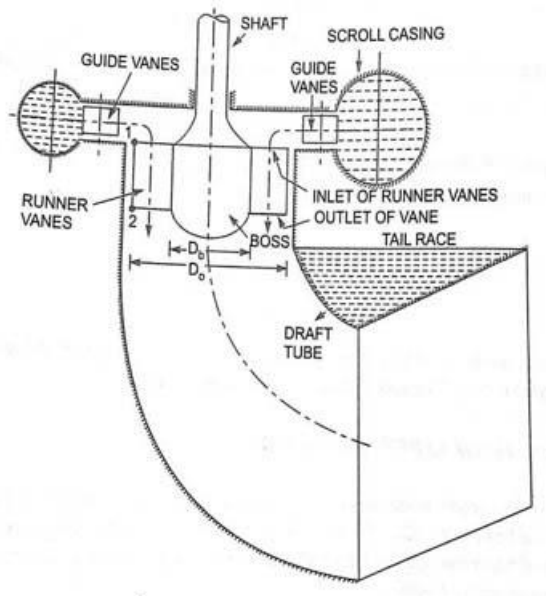


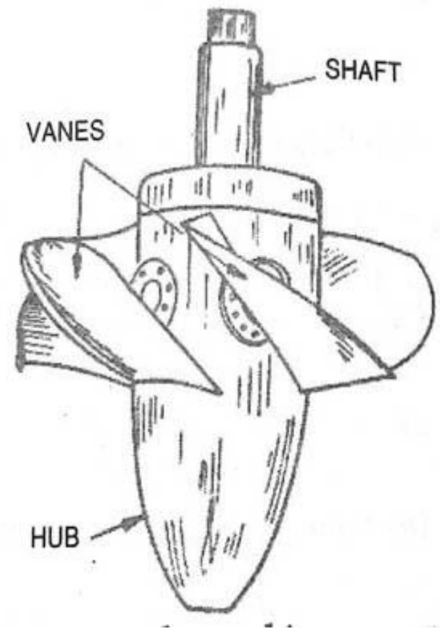
- Due to the presence of both impulse and reaction forces on the impeller blades, the blade uses the water kinetic and pressure energy to turn the impeller in the most effective way.
- The water exiting the impeller will lack kinetic energy and pressure energy. Therefore, the draft tube uses to relieve pressure and move it towards the tailrace.

Principle and operation of Kaplan Turbine

- Kaplan Turbine works on the principle of axial flow reaction.
- In axial flow turbines, the water flows through the runner along the direction parallel to the axis of rotation of the runner.
- The water at the inlet of the turbine possesses both kinetic energy as well as pressure energy for effective rotation the blades in a hydro-power station.
- The water coming from the penstock is made to enter the scroll casing.
- The scroll casing is made in the required shape that the flow pressure is not lost.
- The guide vanes direct the water to the runner blades.
- The vanes are adjustable and can adjust itself according to the requirement of flow rate.
- The water takes a 90 degree turn, so the direction of the water is axial to that of runner blades.

- The runner blades start to rotate as the water strikes due to reaction force of the water.





- The runner blades have twist along its length to have always optimum angle of attack for all cross section of blades to achieve greater efficiency.
- From the runner blades, the water enters the draft tube where its pressure energy and kinetic energy decreases.
- Kinetic energy is gets converted into pressure energy results in increased pressure of the water.
- The rotation of the turbine is used to rotate the shaft of generator for electricity production.

Principle and operation of Centrifugal pump

- Centrifugal pump is a hydraulic machine which converts mechanical energy into hydraulic energy using centrifugal force acting on the fluid.
- These are the most popular and commonly used type of pumps for the transfer of fluids from low level to high level. It is used in places like agriculture, municipal (water and wastewater plants), industrial, power generation plants, petroleum, mining, chemical, pharmaceutical and many others.
- When a certain mass of liquid is made to rotate by an external source, it is thrown away from the centrifugal axis of rotation and a head is impressed which enables it to rise to a higher level. Centrifugal Pumps can be used for viscous and non-viscous liquids and has higher efficiency.
- The major components of a centrifugal pump are impeller, casing, delivery pipe and suction pipe.

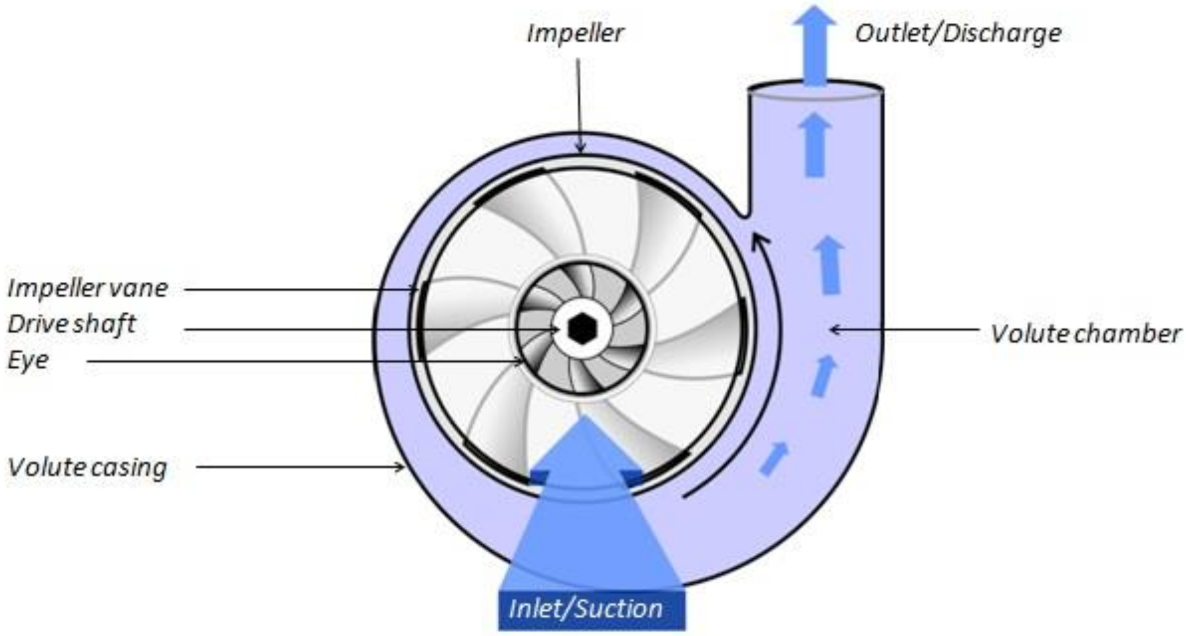


Figure 2. Volute case design

- The first step in the operation of a centrifugal pump is priming. Priming is the operation in which suction pipe casing of the pump and the casing is filled with the liquid which is to be pumped so that all the air from the pump is driven out and no air is left. The necessity of priming of a centrifugal pump is since the pressure generated at the centrifugal pump impeller is directly proportional to density of fluid that is in contact with it.
- A centrifugal pump operates through the transfer of rotational energy from one or more driven rotors, called impellers.
- The action of the impeller increases the fluid's velocity and pressure and directs it towards the pump outlet.