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CMRIT — CMR Institute of Technology, Bengaluru. Accredited with A+ Grade by NAAC

Internal Assessment Test 2 – Oct. 2019

Sub:	Energy Engineering				Sub Code:	15ME71	Branch:	Mechanical
Date:	12/10/2019	Duration:	90 mins	Max Marks: 50	Sem / Sec:	7 A & B		OBE

Answer all Questions

		MARKS	CO	RBT
1	Give the layout of a modern steam power plant and explain it briefly.	[10]	CO1	L1
2(a)	Derive an expression for chimney height.	[5]	CO1	L2
(b)	A boiler is provided with a chimney of 26m height. The boiler house temperature is 30˚C and the temperature of flue gas leaving the chimney is 300˚C. If the air required to burn 1 kg of fuel is 20kg, estimate the draught in mm of water.	[5]		L3
3	What is Pulverized coal? Discuss the advantages and disadvantages of pulverized coal.	[10]	CO1	L1
4	Classify Hydro-electric plants.	[10]	CO2	L1
5	Explain the necessity of using components like surge tank, gates and valves in hydel power stations.	[10]	CO2	L1

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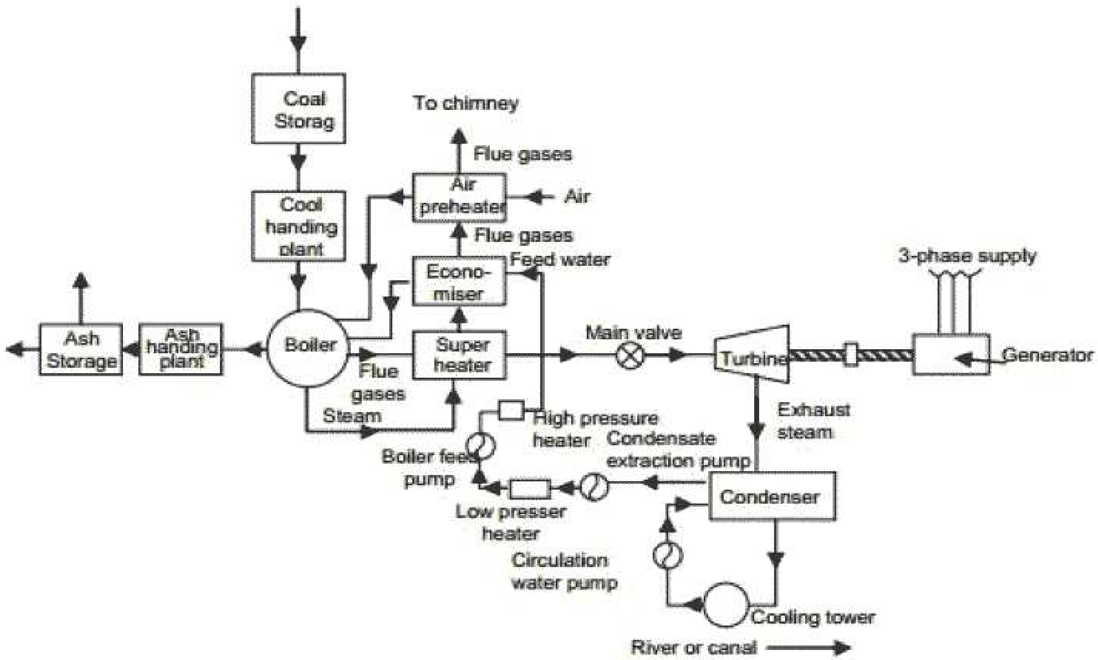
1)



Steam is an important medium of producing mechanical energy. Steam has the advantage that it can be raised from water which is available in abundance it does not react much with the materials of the equipment of power plant and is stable at the temperature required in the plant. Steam is used to drive steam engines, steam turbines etc. Steam power station is most suitable where coal is available in abundance. Thermal electrical power generation is one of the major methods. Out of total power developed in India about 60% is thermal.

A steam power plant must have following equipments:

- A furnace to burn the fuel,
- Steam generator or boiler containing water. Heat generated in the furnace is utilized to convert water into steam.
- Main power unit such as an engine or turbine to use the heat energy of steam and perform work.
- 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 thermal power plant consists of the following four main circuits:

- Feed water and steam flow circuit
- Coal and ash circuit
- Air and gas circuit
- Cooling water circuit.

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

- High pressure boiler
- Prime mover
- Condensers and cooling towers
- Coal handling system
- Ash and dust handling system

- Draught system
- Feed water purification plant
- Pumping system
- Air pre-heater, economizer, super heater, feed heaters

3) Coal ground to dustlike size is called pulverized coal. For use in power plants, coal is ground into dust using pulverizing mill. Pulverizing coal before combusting it improves the speed and efficiency of burning nadn makes it easy to handle the coal.

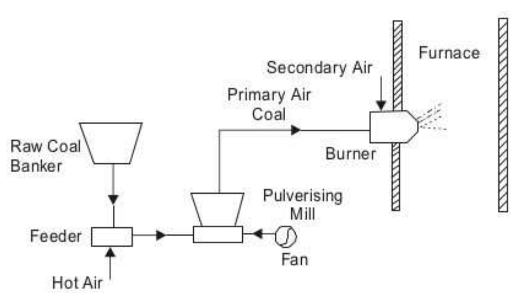
Advantages
The advantages of using pulverized coal are as follows

- It becomes easy to burn wide variety of coal. Low grade coal can be burnt easily.
- Powdered coal has more heating surface area. They permit rapid and high rates of combustion.
- Pulverized coal firing requires low percentage of excess air.
- By using pulverized coat, rate of combustion can be adjusted easily to meet the varying load.
- The system is free from clinker troubles.
- It can utilize highly preheated air (of the order of 700F) successfully which promotes rapid flame propagation.
- As the fuel pulverizing equipment is located outside the furnace, therefore it can be repaired without cooling the unit down.
- High temperature can be produced in furnace.

Disadvantages

- It requires additional equipment to pulverize the coal. The initial and maintenance cost of the equipment is high.
- Pulverized coal firing produces fly ash (fine dust) which requires separate fly ash removal equipment.
- The furnace for this type of firing has to be carefully designed to withstand for burning the pulverized fuel because combustion takes place while the fuel is in suspension.
- The flame temperatures are high and conventional types of refractory lined furnaces are inadequate. It is desirable to provide water cooled walls for the safety of the furnaces.
- There are more chances of explosion as coal burns like a gas.
- Pulverised fuel fired furnaces designed to burn a particular type of coal cannot be used to any other type of coal with same efficiency.

The size of coal is limited. The particle size of coal used in pulverized coal furnace is limited to 70 to 100 microns.



4) The hydro-power plants can be classified as below:

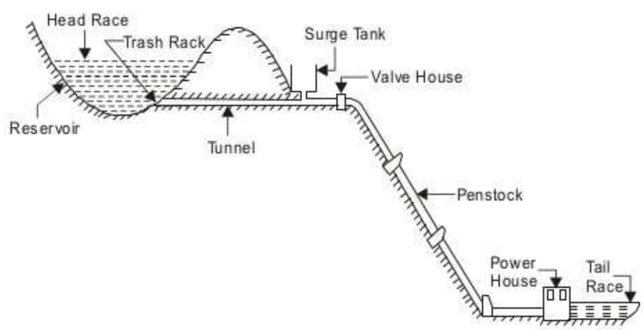
- Storage plant
  - High head plants
  - Low head plants
  - Medium head plants.

- Run-of-river power plants
  - With pondage
  - Without pondage.
- Pumped storage power Plants.

Storage Plants: These plants are usually base load plants. The hydro-plants cannot be classified directly on the basis of head alone as there is no clear line of demarcation between a high head and a medium head or between medium head and low head. The power plant can be classified on the basis of head roughly in the following manner:

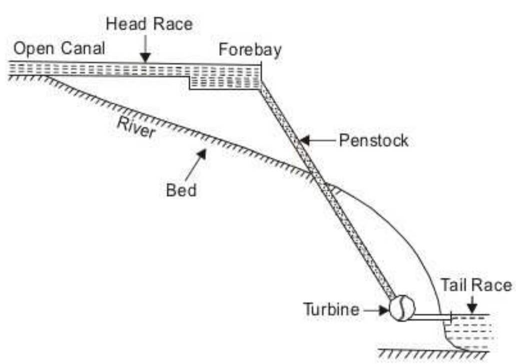
- High head plants: About 100 m and above.
- Medium head plants: about 30 to 500 m.
- Low head plants: Upto 50 m.

High Head Plants: A hydel plant with a water head of more than 100 meters is termed a high head plant. In this case, the water from the main reservoir is carried through tunnels up to the surge tank, from where it is taken through the penstock.



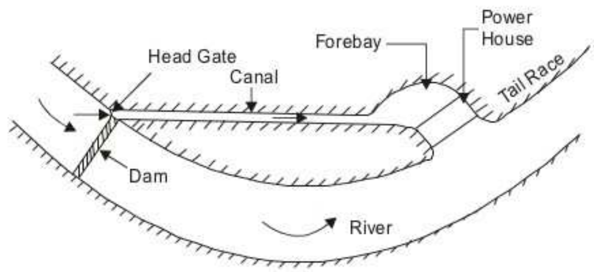
High Head Plant

Medium Head Plants: If the head of water available is more than 50 m, then the water from the forebay is conveyed to the turbines through penstocks. Such a plant will then be named as a medium head plant.



Medium Head Plant

Low Head Power Plants: Such a plant is shown in figure below. A dam is built on the river and the water is diverted into a canal which conveys the water into a forebay from where the water is allowed to flow through turbines. After this, the water is again discharged into the river through a tail race.

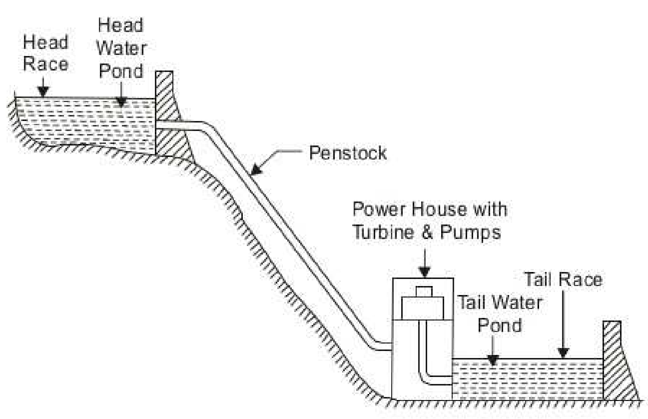


Low Head Plant

<u>Run-off River Plants without Pondage</u>: In such plants water is not stored, but only the running water is used for power generation. In such power plants the power generated directly depends upon the rate of flow available. Hence, during rainy seasons some excess quantity of water may run waste without doing any power generation. During dry periods the power production will be very poor, since the water flow rate will be low.

<u>Run-off River Plants with Pondage</u>: In such plants, the excess water available during rainy seasons is stored in the reservoirs. The plant works with the normal run-off during the rainy season, while the stored water from the reservoir is utilised to supplement the low flow rate during dry periods. Power production will not be affected by the dry seasons. Hence, plants with pondage can generate a constant rate of power throughout the year.

<u>Pumped Storage Power Plants</u>: These plants supply the peak load for the base load power plants and pump all or a portion of their own water supply. The usual construction would be a tail water pond and a head water pond connected through a penstock. The generating pumping plant is at the lower end. During off peak hours, some of the surplus electric energy being generated by the base load plant, is utilized to pump the water from tail water pond into the head water pond and this energy will be stored there. During times of peak load, this energy will be released by allowing the water to flow from the head water pond through the water turbine of the pumped storage plant.

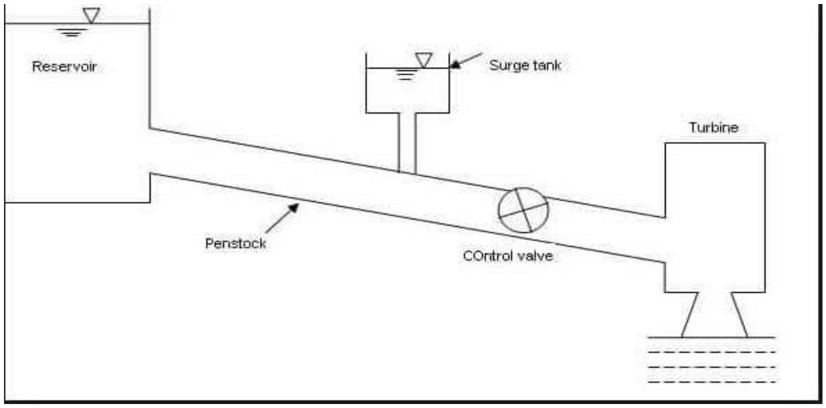


Pumped Storage Power Plants

5) <u>Surge tank:</u> Surge tank is an open tank which is often used with pressure conduit of considerable length. The main purpose of providing surge tank is to reduce the distance between the free water surface and turbine there by reducing the water hammer effect on penstock and also protect upstream tunnel from high pressure raises. It also serves as a storage tank when the water is accelerating during increased load conditions and as a storage tank when the water is decelerating during reduced load conditions. Function of Surge Tank

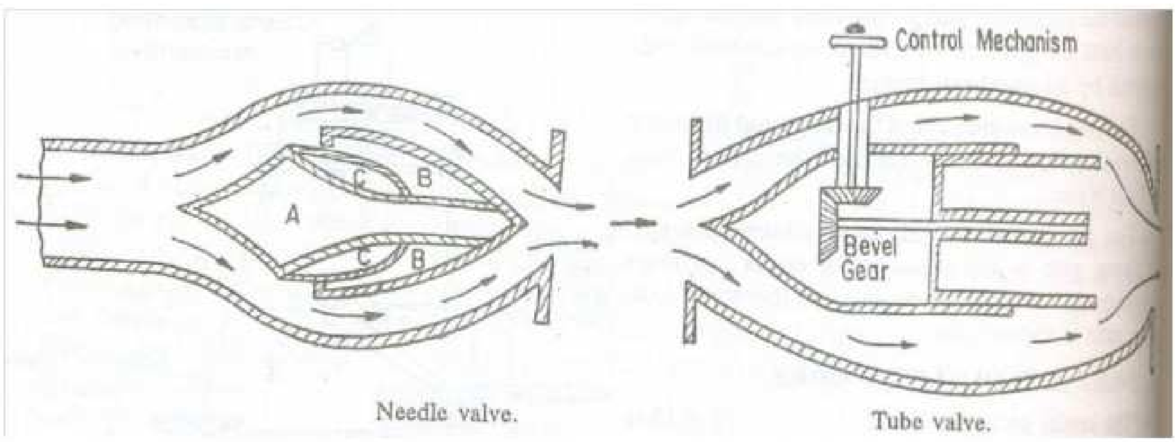
- Reduce the water hammer effective

- Acts as a temporary reservoi
- Acts as a relief valve



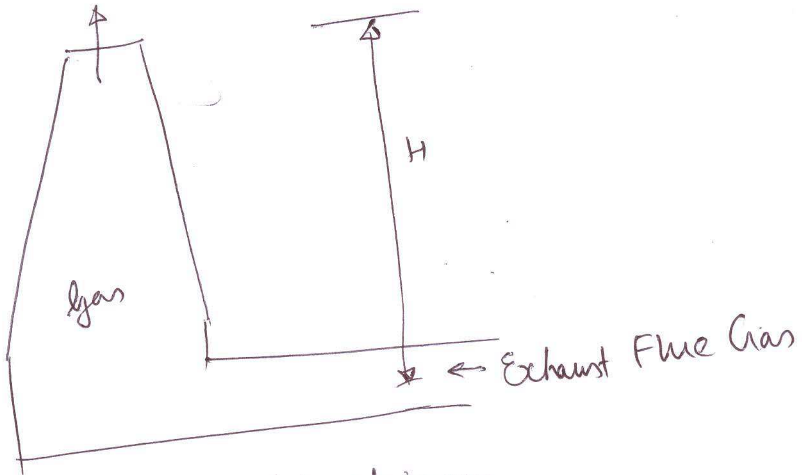
The control valves are used in hydel plants to regulate the flow of water at the intake and the discharge end. Two types of valves:

- Needle valve
- Tube valve



<u>Needle Valve</u>: Figure shows the arrangement of needle valve. It consists of three chambers A, B and C as shown in the figure. Its opening and closing are controlled by varying the pressures in the chambers A, B and C. The valve is opened by increasing the pressure in chamber C and releasing the pressures in chambers A and B which are interconnected by forcing the needle to the left. For closing the valve, the pressure in chamber C is released whereas the pressures in chambers A and B are increased which forces the needle valve towards the right.
<u>Tube Valve:</u> Figure shows the arrangement of the tube valve. This valve is opened or closed by mechanical operation. The cylinder (tube) is moved towards or away from the valve seat with the help of screw stem operated by bevel gear to open or close the valve as required. This valve is lighter in weight and shorter in length and occupies less space compared to needle valve.

2(a) <u>Derivation for height of Chimney</u>



The pressure difference produced by chimney

$\Delta p = g H (\rho_a - \rho_g)$

ρ_a = density of ambient air

ρ_g = Density of exhaust gas

It is assumed that the volume of products of combustion are equal to volume of air supplied, both volumes being measured at same temperature. If 'm' kg of air is required to burn 1 kg of fuel, then the mass of flue gas produced is (m+1) kg.

volume of (m+1) kg of flue gas = $\frac{(m+1)}{\rho'_a}$, ρ'_a = density of air at T_g, avg exhaust gas temperature.

$$P = \rho'_a R T_g \Rightarrow \rho'_a = \left(\frac{P}{R T_g}\right)$$

Also $P = \rho_a R T_a \Rightarrow \rho'_a = \frac{\rho_a R T_a}{R T_g} = \rho_a T$

$$\rho_g = \text{Density of flue gas} = \frac{(m+1)}{m/\rho'_a} = \rho'_a \left(\frac{m+1}{m}\right) = \left(\frac{P}{R T_g}\right)\left(\frac{m+1}{m}\right)$$

$$\Delta p = g H \left[\frac{P}{R T_a} - \frac{P}{R T_g}\left(\frac{m+1}{m}\right)\right]$$

$$\boxed{\Delta p = \left(\frac{P}{R}\right) g H \left[\frac{1}{T_a} - \left(\frac{m+1}{m}\right)\frac{1}{T_g}\right]}$$

2(b) $\Delta p = \left(\frac{p}{R}\right) gH \left[\frac{1}{T_a} - \left(\frac{m+1}{m}\right)\frac{1}{T_g}\right]$

Given $p = 1\,atm = 101.325 \times 10^3\ N/m^2$

$R = 287\ J/kg\,K$

$g = 9.81\ m/s^2, \quad H = 26\ m$

$T_a = 30^\circ C = 303\ K$

$T_g = 300^\circ C = 573\ K$

$m = 20\ kg$

$$\Delta p = \frac{101.325 \times 10^3}{287} \times 9.81 \times 26 \left[\frac{1}{303} - \left(\frac{21}{20}\right)\frac{1}{573}\right]$$

$= 131.755\ N/m^2$

$\Delta P = \rho_w g H_w \Rightarrow H_w = \left(\frac{\Delta p}{\rho_w g}\right) = \frac{131.755}{10^3 \times 9.81}$

$= 13.4$ mm of water