PPT ON
POWER PLANT CONTROL AND INSTRUMENTATION
V SEM (IARE-R16)

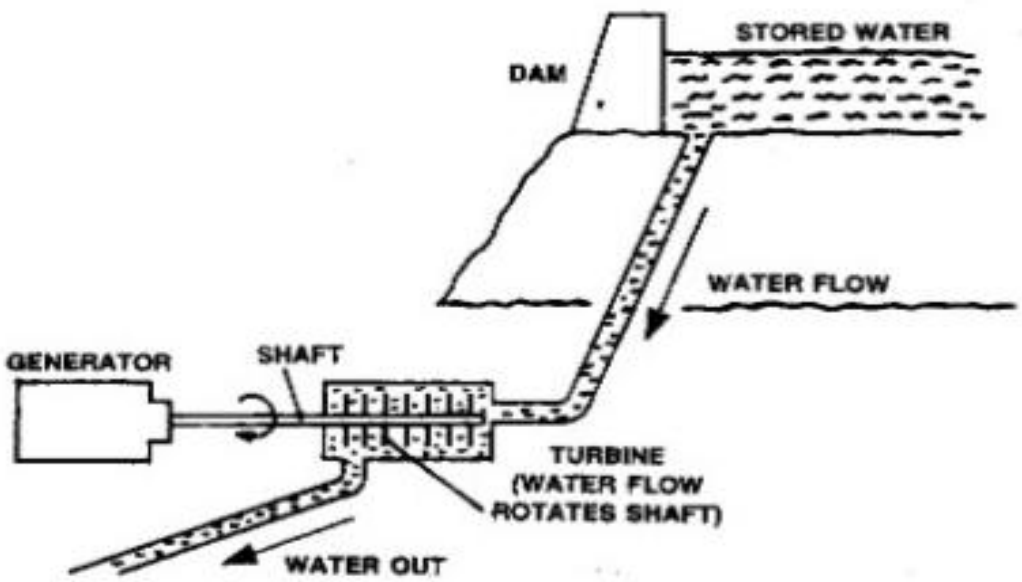
UNIT 1
OVERVIEW OF POWER GENERATION

HYDRO ELECTRIC (HYDEL) POWER PLANT

INTRODUCTION

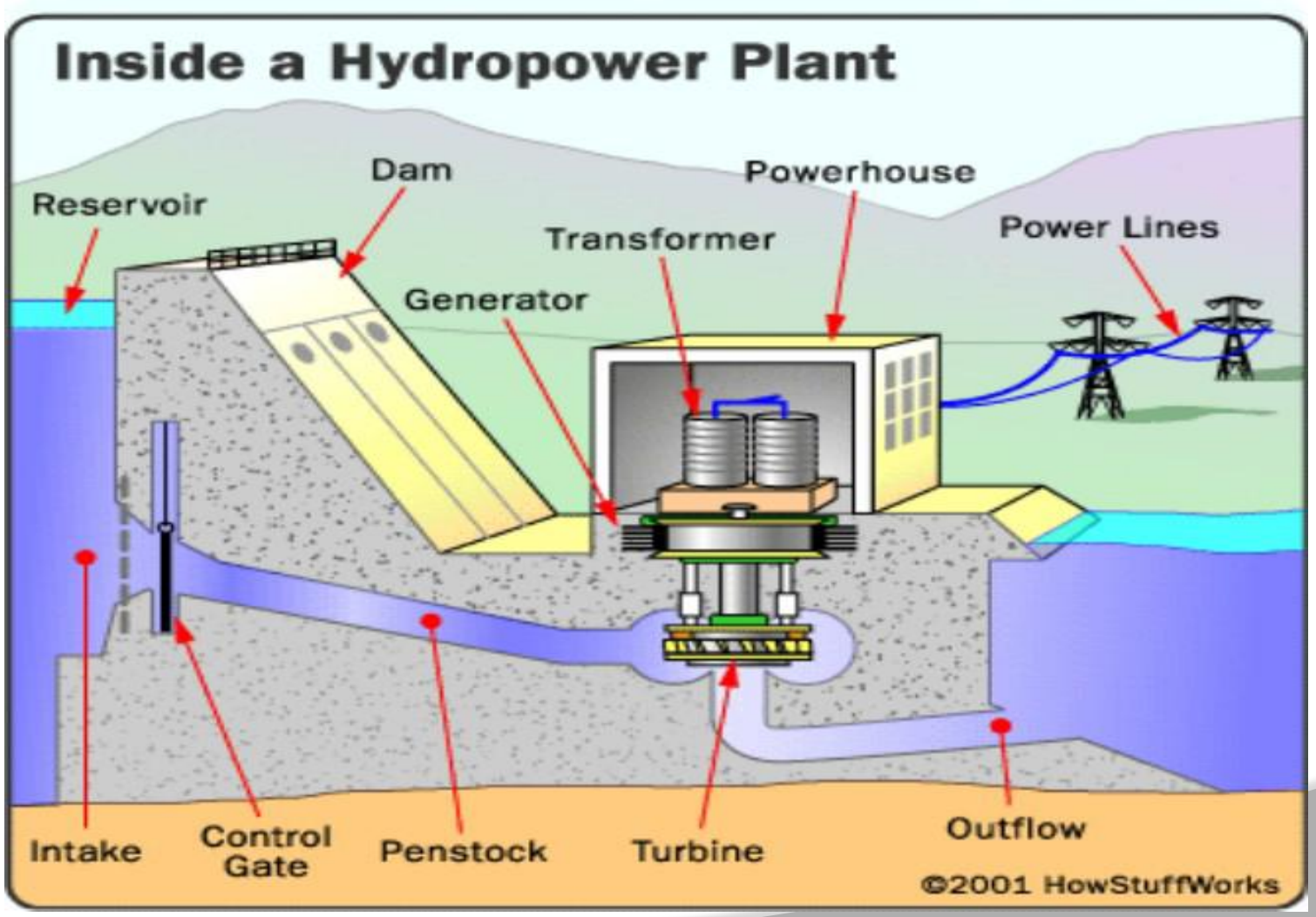
- Potential energy is the energy which a substance has due to its position or state. The water behind a dam has potential energy because of its position. The water can fall from this position and exert a force over a distance and therefore do work.
- In a Hydro-electric power plant the force is used to drive a turbine, which in turn drives the electric generator.
- Because gravity provides the force which makes the water fall, the energy stored in the water is called gravitational potential energy.

HYDRO ELECTRIC (HYDEL) POWER PLANT

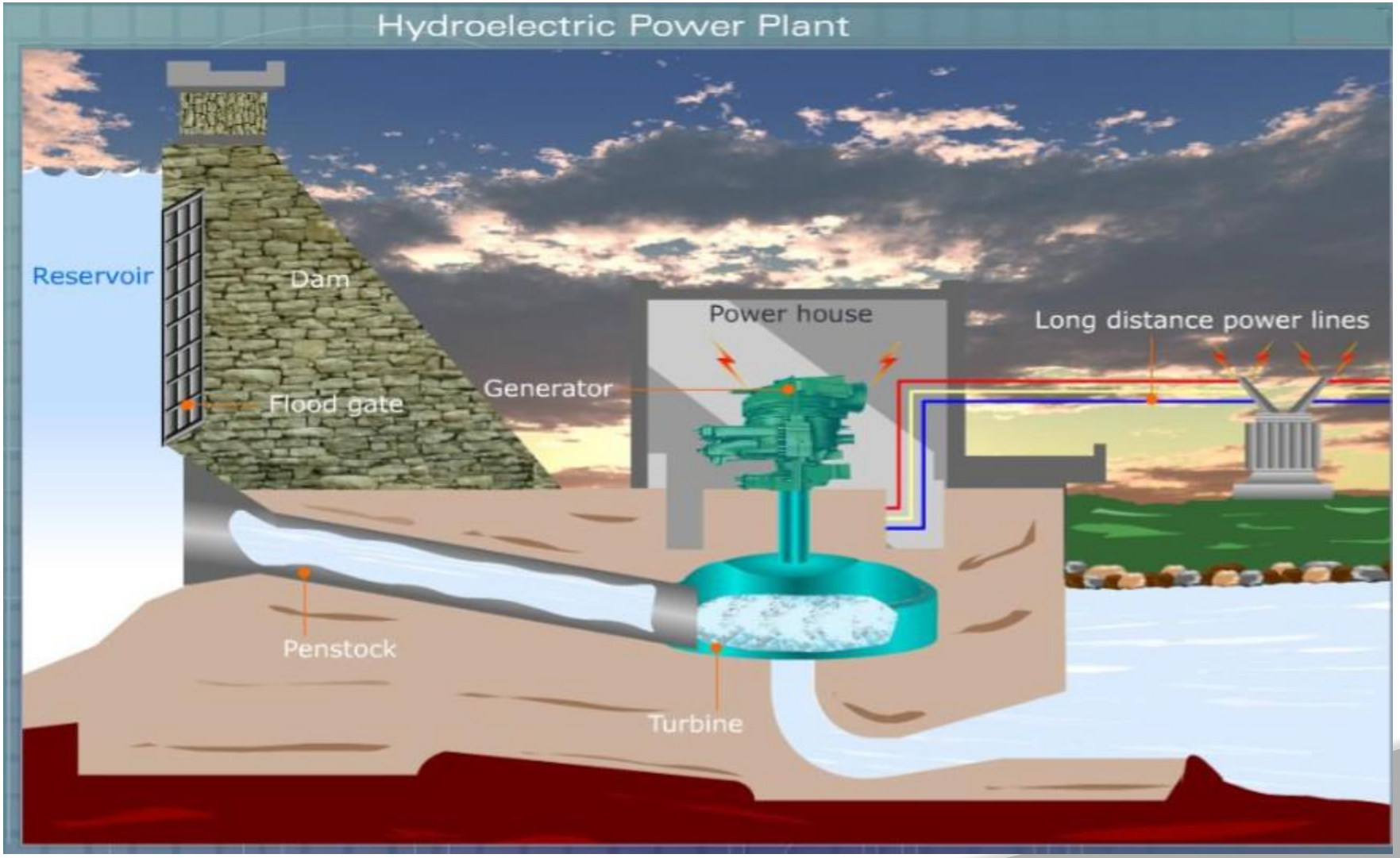


Principle of Hydro-electric power plant

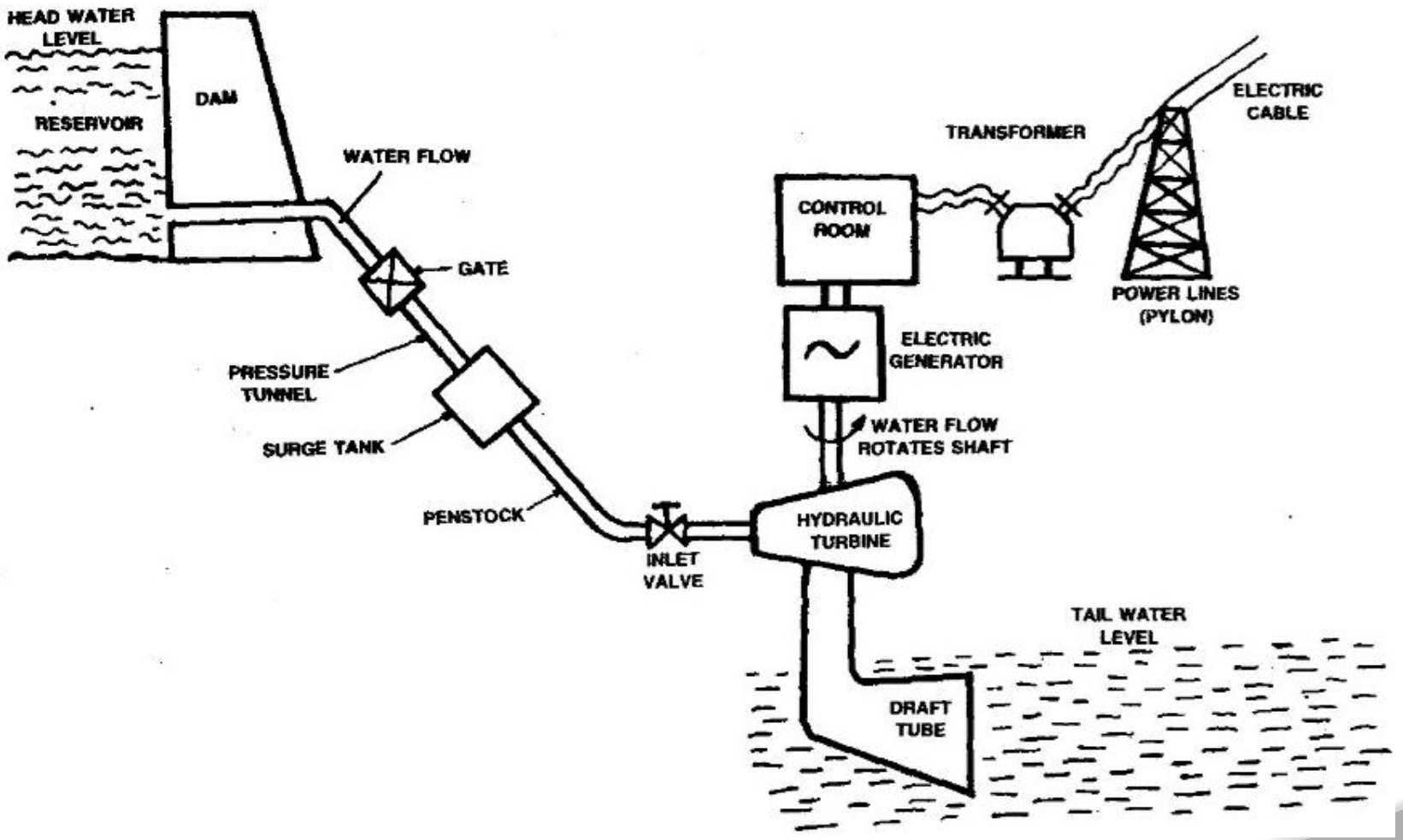
HYDRO ELECTRIC (HYDEL) POWER PLANT



HYDRO ELECTRIC (HYDEL) POWER PLANT



HYDRO ELECTRIC (HYDEL) POWER PLANT



Layout of hydro-electric power plant

HYDRO ELECTRIC (HYDEL) POWER PLANT

Water reservoir:

- In a reservoir the water collected from the catchment area is stored behind a dam.
- Catchment area gets its water from rain and streams.
- The level of water surface in the reservoir is called Head water level.

Dam :

- The purpose of the dam is to store the water and to regulate going flow of water.
- The dam helps to store all the incoming water. It also helps to increase the head of the water. In order to generate a required quantity of power it is necessary that a sufficient head is available.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Spillway:

• Excess accumulation of water endangers the stability of dam construction. Also in order to avoid the over flow of water out of the dam especially during rainy seasons
spillways are provided. This prevents the rise of water level in the dam.

• Spillways are passages which allows the excess water to flow to a storage area away from the dam.

Gate :

• A gate is used to regulate or control the flow of water from the dam.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Pressure tunnel:

- It is a passage that carries water from the reservoir to the surge tank.

Surge tank:

- A Surge tank is a small reservoir or tank in which the water level rises or falls due to sudden changes in pressure.
  Purpose of surge tank. To serve as a supply tank to the turbine when the water in the pipe is accelerated during increased load conditions and as a storage tank when the water is decelerating during reduced load conditions.
- To reduce the distance between the free water surface in the dam and the turbine, thereby reducing the waterhammer effect on penstock and also protect the upstream tunnel from high pressure rise.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Water-hammer effect :

• The water hammer is defined as the change in pressure rapidly above or below normal pressure caused by sudden change in the rate of water flow through the pipe, according to the demand of prime mover i.e. turbine

Penstock:

• Penstock is a closed pipe of steel or concrete for supplying water under pressure to the turbine.

Inlet valve :

• Water from the penstock flows to the turbine through the inlet valve. The valve may be partially closed or open thereby regulating the pressure of water flowing to the turbine.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Hydraulic turbine(Prime mover) :

- The hydraulic turbine converts the energy of water into mechanical energy. The mechanical energy(rotation) available on the turbine shaft is coupled to the shaft of an electric generator and electricity is produced. The water after performing the work on turbine blades is discharged through the draft tube.

- The prime movers which are in common use are Pelton wheel, Francis turbine and Kaplan turbine.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Draft tube:

- It is connected to the outlet of the turbine.
- It allows the turbine to be placed above the tail water level.

Tail water level or Tail race:

- Tail water level is the water level after the discharge from the turbine. The discharged water is sent to the river, thus the level of the river is the tail water level.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Electric generator, Step-up transformer and Pylon :

- As the water rushes through the turbine, it spins the turbine shaft, which is coupled to the electric generator. The generator has a rotating electromagnet called a rotor and a stationary part called a stator. The rotor creates a magnetic field that produces an electric charge in the stator. The charge is transmitted as electricity. The step-up transformer increases the voltage of the current coming from the stator. The electricity is distributed through power lines also called as pylon.

CLASSIFICATION OF HYDRO ELECTRIC POWER PLANTS

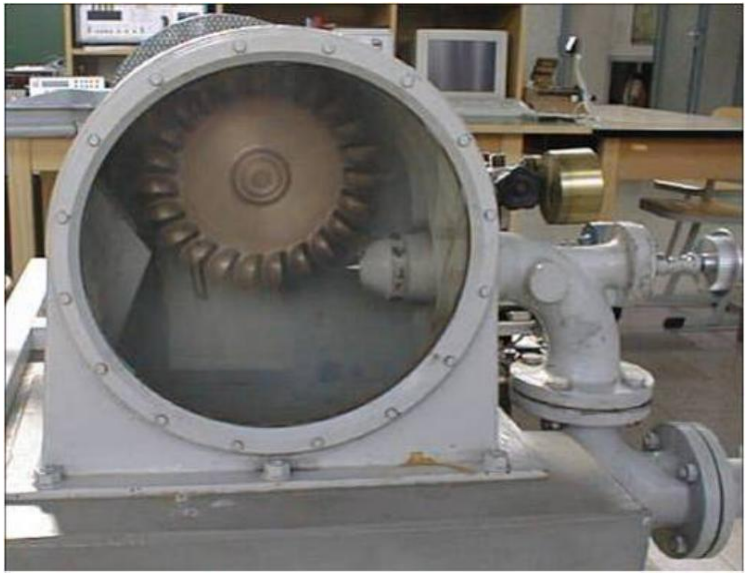
- Hydro –electric power plants are usually classified according to the available head of water.

High head power plants : Head of water is more than 500 metres. The turbine used in such plants is Pelton wheel.

Medium head power plants : Head of water ranges from 80 to 500 metres. The turbine used in such plants is Francis turbine.

Low head power plants : Head of water ranges from 1.5 to 80 metres. The turbine used in such plants is Kaplan turbine and Francis turbine

Turbines



Pelton wheel or Pelton turbine

Francis turbine

HYDRO ELECTRIC (HYDEL) POWER PLANT

Advantages of hydel power plant :

- Water is a renewable energy source.
- Maintenance and operation charges are very low.
- The efficiency of the plant does not change with age.
- In addition to power generation, hydro-electric power plants are also useful for flood control, irrigation purposes, fishery and recreation.
- Have a longer life(100 to 125 years) as they operate at atmospheric temperature.
- Water stored in the hydro-electric power plants can also be used for domestic water supply.
- Since hydro-electric power plants run at low speeds(300 to 400 rpm) there is no requirement of special alloy steel construction materials or specialised mechanical maintenance.

HYDRO ELECTRIC (HYDEL) POWER PLANT

Disadvantages of hydel power plant :

- The initial cost of the plant is very high.

- Since they are located far away from the load centre, cost of transmission lines and transmission losses will be more.

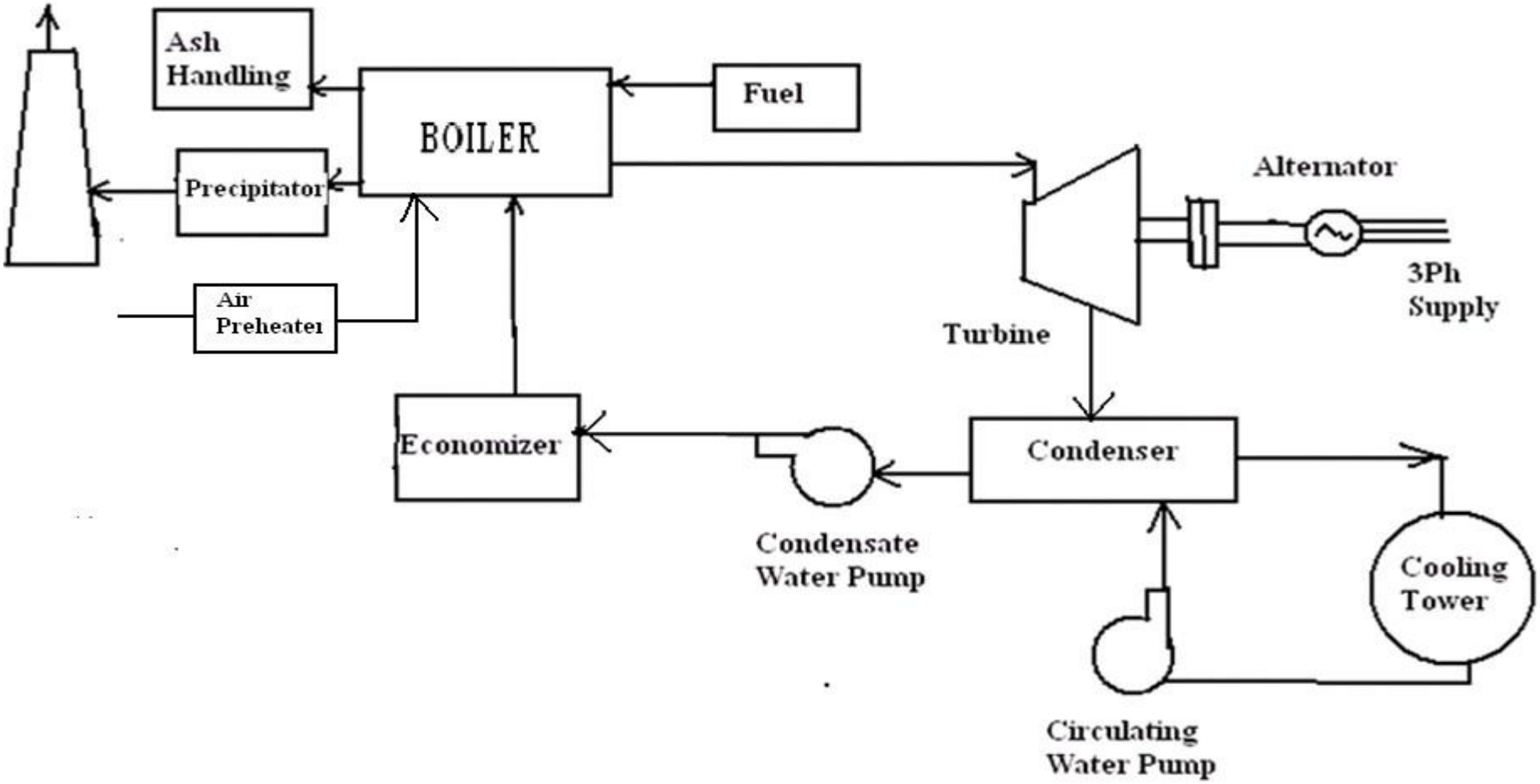
- During drought season the power production may be reduced or even stopped due to insufficient water in the reservoir.

- Water in the reservoir is lost by evaporation.

THERMAL POWER PLANT

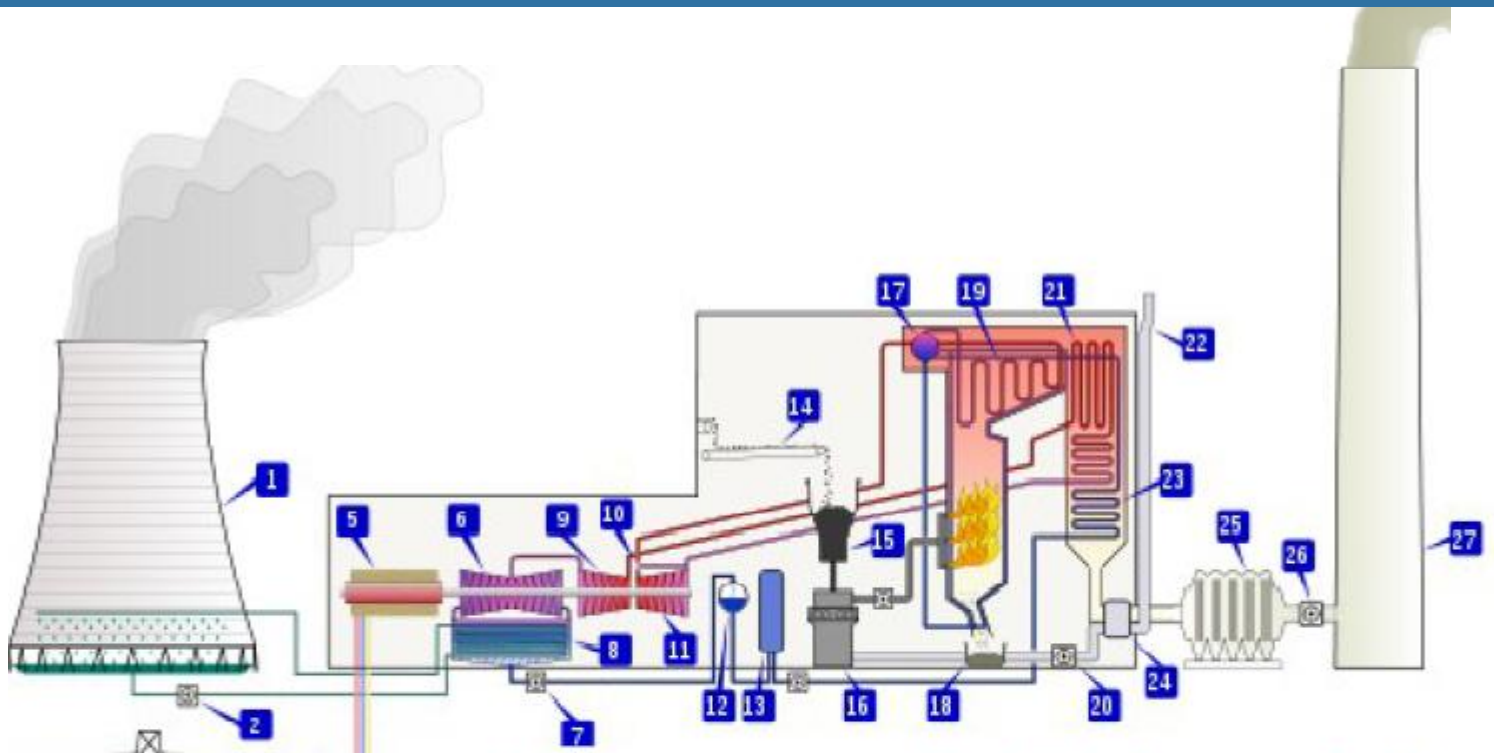
- INTRODUCTION
- WORKING PRINCIPLE
- GENERAL LAYOUT OF THERMAL POWER PLANT
- MAIN EQUIPMENTS
- WASTE GENERATED AND THEIR CONTROL
- ADVANTAGES AND DISADVANTAGES

THERMAL POWER PLANT



Layout of thermal power plant

THERMAL POWER PLANT



1. Cooling tower
2. Cooling water pump
3. transmission line (3-phase)
4. Step-up transformer (3-phase)
5. Electrical generator (3-phase)
6. Low pressure steam turbine
7. Condensate pump
8. Surface condenser
9. Intermediate pressure steam turbine
10. Steam Control valve
11. High pressure steam turbine
12. Deaerator
13. Feed water heater
14. Coal conveyor
15. Coal hopper
16. Coal pulveriser
17. Boiler steam drum
18. Bottom ash hopper
19. Superheater
20. Forced draught (draft) fan
21. Reheater
22. Combustion air intake
23. Economiser
24. Air preheater
25. Precipitator
26. Induced draught (draft) fan
27. Flue gas stack

MAIN AND AUXILIARY EQUIPMENTS

1. Coal handling plant
2. Pulverizing plant
3. Draft fans
4. Boiler
5. Ash handling plant
6. Turbine
7. Condenser
8. Cooling towers and ponds
9. Feed water heater
10. Economiser
11. Superheater and Reheater
12. Air preheater

MAIN AND AUXILIARY EQUIPMENTS

COAL HANDLING PLANT:

The function of coal handling plant is automatic feeding of coal to the boiler furnace.

- A thermal power plant burns enormous amounts of coal.
- A 200MW plant may require around 2000 tons of coal daily.

MAIN AND AUXILIARY EQUIPMENTS

PULVERISING PLANT

In modern thermal power plant , coal is pulverised i.e. ground to dust like size and carried to the furnace in a stream of hot air. Pulverising is a means of exposing a large surface area to the action of oxygen and consequently helping combustion.

Pulverising mills are further classified as:

3.Contact mill

4.Ball mill

5.Impact mill

MAIN AND AUXILIARY EQUIPMENTS

DRAFT SYSTEM

- The circulation of air is caused difference in pressure, known as Draft.
- Draft is a differential pressure atmosphere and inside the boiler.
- It is necessary to cause the flow of gases through boiler setting

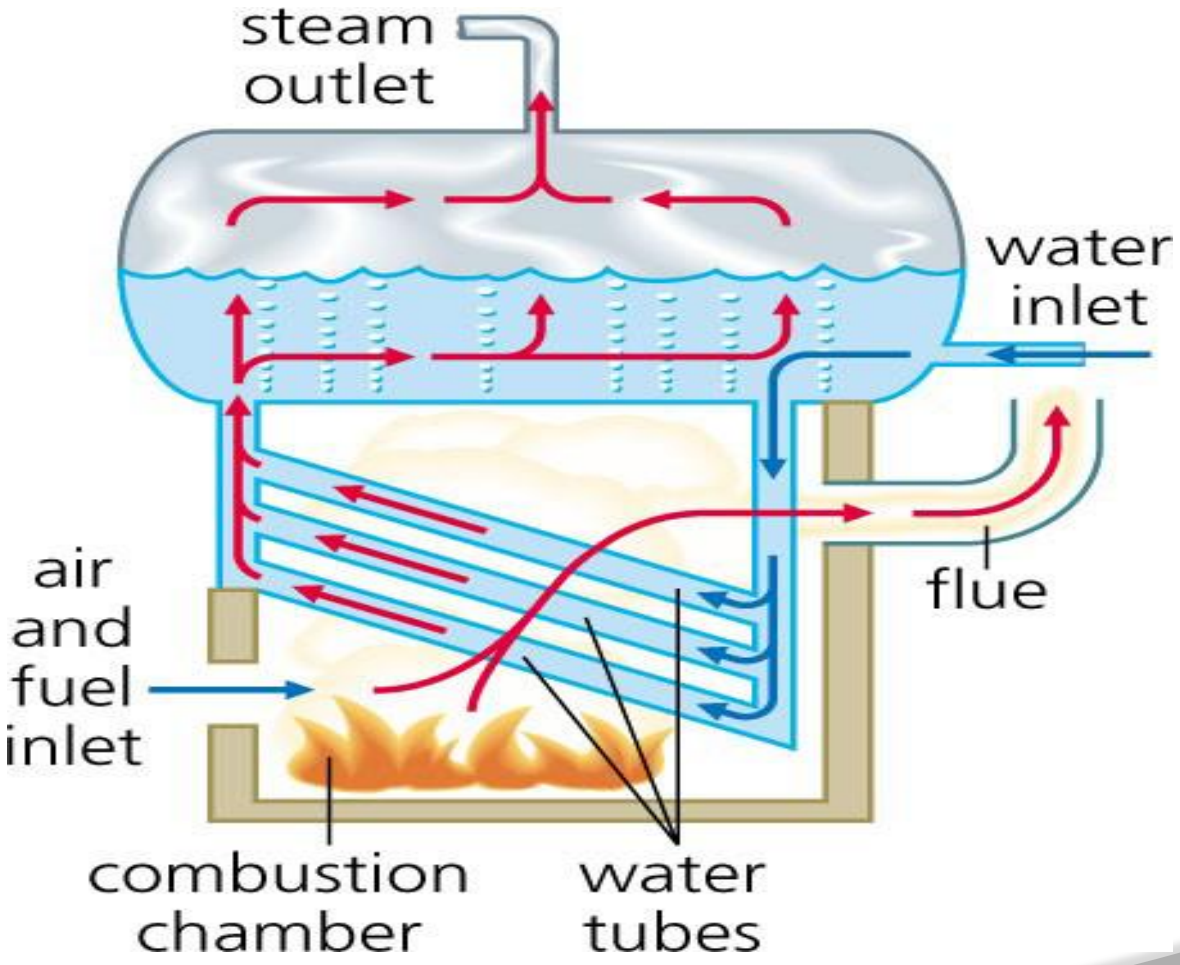
It may be

5. Natural draft

6. Mechanical draft

MAIN AND AUXILIARY EQUIPMENTS

BOILER



MAIN AND AUXILIARY EQUIPMENTS

A boiler or steam generator is a closed vessel in which water under pressure, is converted into steam.

- It is one of the major components of a thermal power plant
- Always designed to absorb maximum amount of heat released in the process of combustion.

Boilers are of two types-

5.Fire tube boiler

6.Water tube boiler

SUPERHEATER AND REHEATER

Most of the modern boilers are having Super heater and Reheater arrangement.

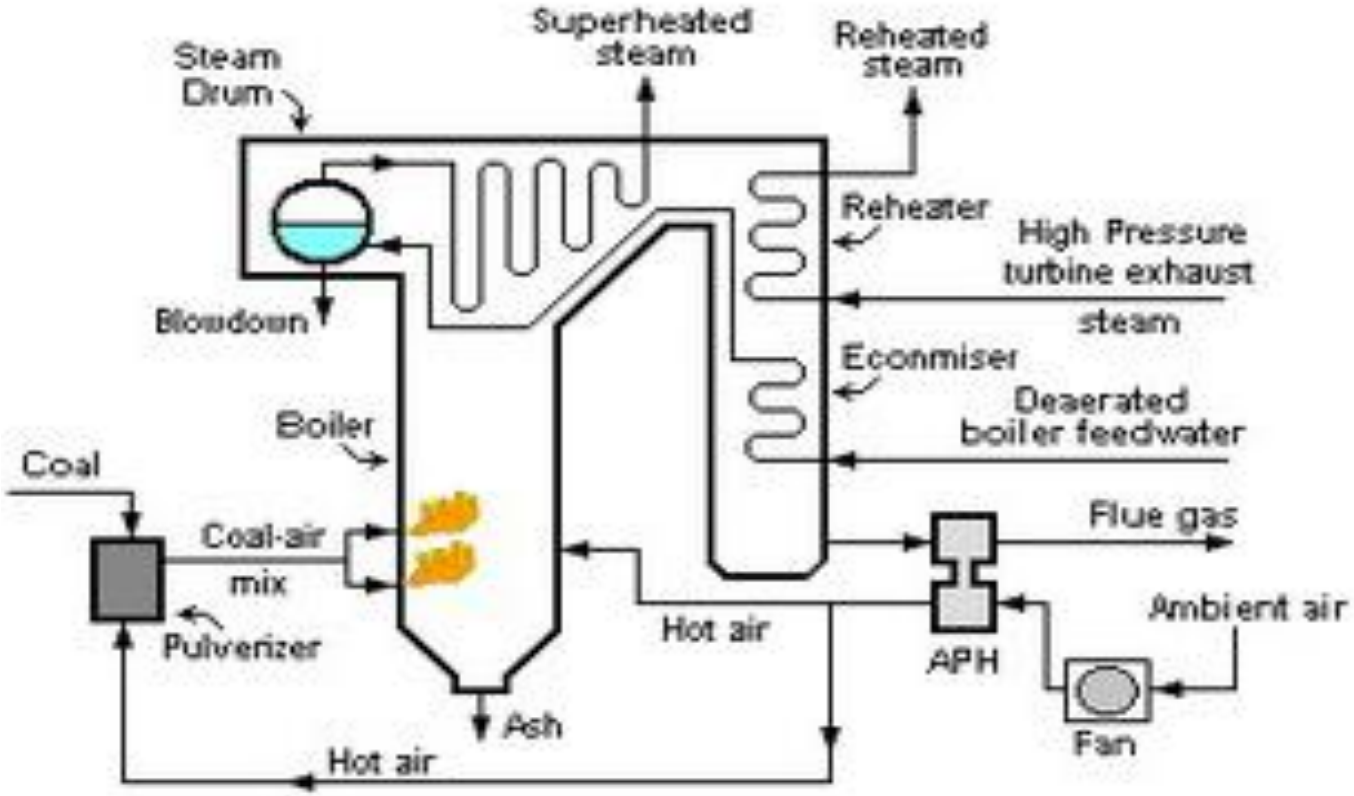
Superheater :

Superheater is a component of a steam-generating unit in which steam, after it has left the boiler drum, is heated above its saturation temperature. The amount of superheat added to the steam is influenced by the location, arrangement, and amount of super heater surface installed, as well as the rating of the boiler. The super heater may consist of one or more stages of tube banks arranged Super heaters are classified as convection , radiant or combination of these.

MAIN AND AUXILIARY EQUIPMENTS

Reheater : Some of the heat of superheated steam is used to rotate the turbine where it loses some of its energy. Reheater is also steam boiler component in which heat is added to this intermediate-pressure steam, which has given up some of its energy in expansion through the high pressure turbine. The steam after reheating is used to rotate the second steam turbine where the heat is converted to mechanical energy. This mechanical energy is used to run the alternator, which is coupled to turbine , there by generating electrical energy.

MAIN AND AUXILIARY EQUIPMENTS



MAIN AND AUXILIARY EQUIPMENTS

STEAM TURBINE

A steam turbine converts heat energy of steam into mechanical energy and drives the generator. It uses the principle that steam when issuing from a small opening attains a high velocity. This velocity attained during expansion depends on the initial and final heat content of the steam. This difference b/w initial and final heat content repesents the heat energy converted into kinetic energy.

These are of two types :-

- **Impulse turbine**
- **Reaction turbine**

MAIN AND AUXILIARY EQUIPMENTS

ASH HANDLING PLANT

- The percentage of ash in coal varies from 5% in good quality coal to about 40% in poor quality coal Power plants generally use poor quality of coal , thus amount of ash produced by it is pretty large.
- A modern 2000MW plant produces about 5000 tons of ash daily
- The stations use some conveyor arrangement to carry ash to dump sites directly or for carrying and loading it to trucks and wagons which transport it to the site of disposal.

MAIN AND AUXILIARY EQUIPMENTS

CONDENSER

Steam after rotating steam turbine comes to condenser. Condenser refers here to the shell and tube heat exchanger (or surface condenser) installed at the outlet of every steam turbine in Thermal power stations of utility companies generally.

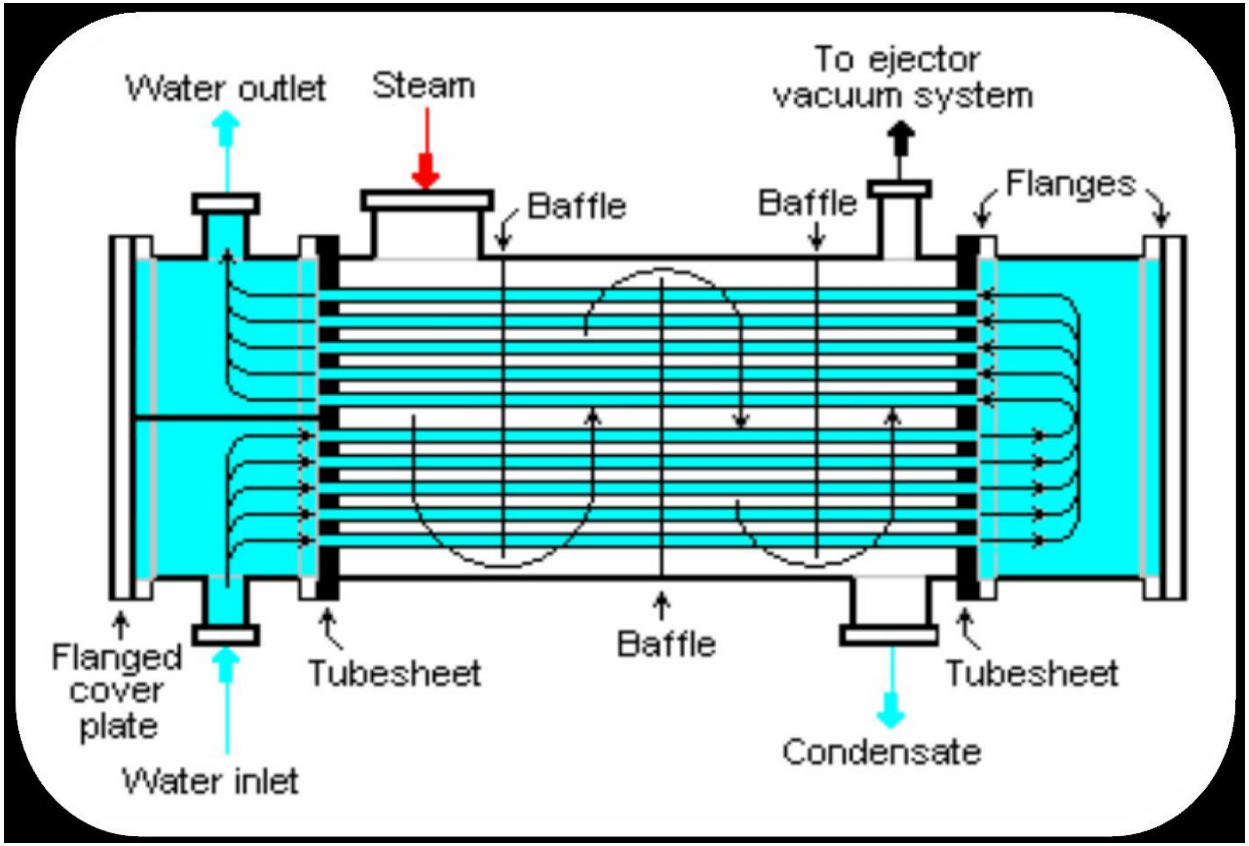
- These condensers are heat exchangers which convert steam from its gaseous to its liquid state, also known as phase transition.
- In so doing, the latent heat of steam is given out inside the condenser. Where water is in short supply an air cooled condenser is often used.

MAIN AND AUXILIARY EQUIPMENTS

- An air cooled condenser is however significantly more expensive and cannot achieve as low a steam turbine backpressure (and therefore less efficient) as a surface condenser.
- The purpose is to condense the outlet (or exhaust) steam from steam turbine to obtain maximum efficiency and also to get the condensed steam in the form of pure water, otherwise known as condensate, back to steam generator or (boiler) as boiler feed water.

MAIN AND AUXILIARY EQUIPMENTS

CONDENSER



MAIN AND AUXILIARY EQUIPMENTS

COOLING TOWERS AND PONDS

- A condenser needs huge quantity of water to condense the steam .
- Typically a 2000MW plant needs about 1500MGallon of water.
- Most plants use a closed cooling system where warm water coming from condenser is cooled and reused.
- Small plants use spray ponds and medium and large plants use cooling towers.
- Cooling tower is a steel or concrete hyperbolic structure having a reservoir at the base for storage of cooled water.
- Height of the cooling tower may be 150 m or so and diameter at the base is 150 m.

MAIN AND AUXILIARY EQUIPMENTS

COOLING TOWERS

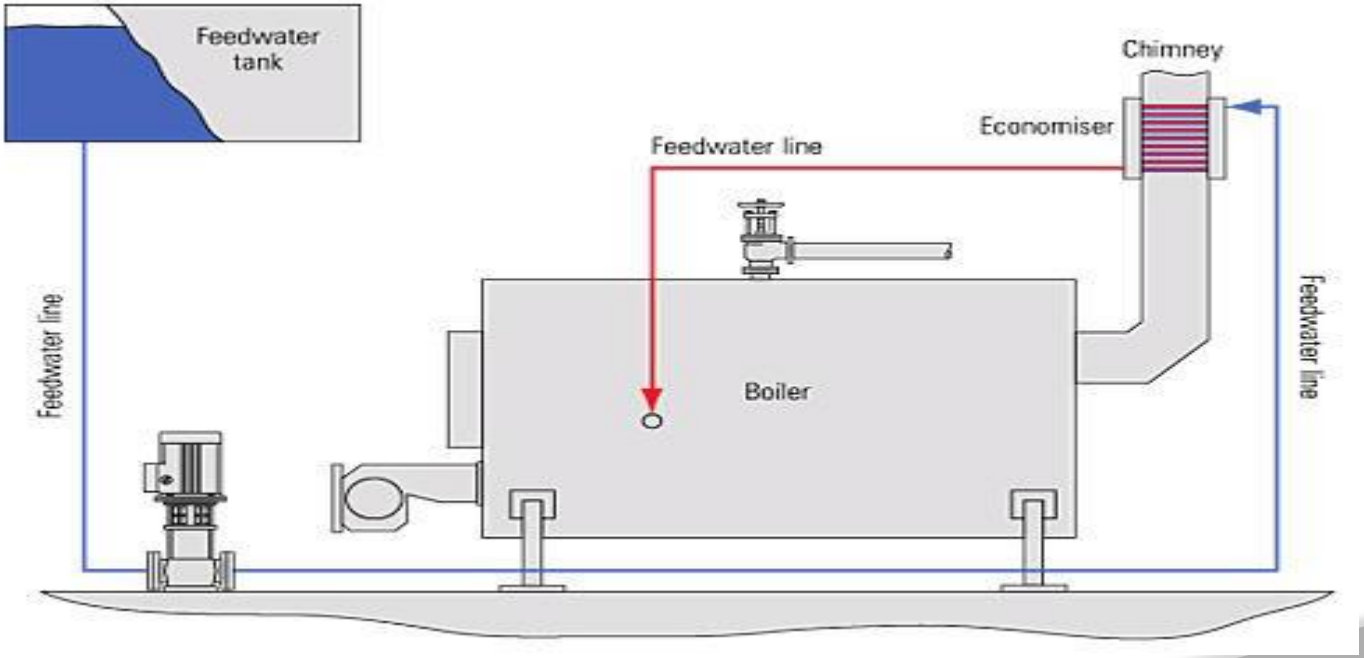
FEED WATER HEATER

Advantages of heating water before feeding back to the boiler:-

- Feed water heating improves overall plant efficiency.
- The dissolved oxygen and carbon dioxide which would otherwise cause boiler corrosion are removed in feed water heater
- Thermal stresses due to cold water entering the boiler drum are avoided.
- Quantity of steam produced by the boiler is increased.
- Some other impurities carried by the steam and condensate, due to corrosion of boiler and condenser are precipitated outside the boiler.

ECONOMISER

Flue gases coming out of the boiler carry lot of heat. An economiser extracts a part of this heat from flue gases and uses it for heating feed water. This use of economiser results in saving coal consumption and higher boiler efficiency.



MAIN AND AUXILIARY EQUIPMENTS

AIR PREHEATER

After flue gases leave economiser, some further heat can be extracted from them and used to heat incoming heat. Cooling of flue gases by 20 degree centigrade increases the plant efficiency by 1%.

Air preheaters may be of three types

- Plate type
- Tubular type
- Regenerative type

UNIT II
MEASUREMENTS IN POWER PLANTS

IMPORTANCE OF MEASUREMENTS IN POWER PLANTS

- Efficient Operation of the plant.
- Economic Operation of the plant.
- Safe operation of the plant.
- Pollution control

MEASUREMENT QUANTITIES

For a Plant Measurement system needs to be:

- Very accurate
- Reliable
- Delays should be as small as possible
- Should be switched on manually when a overall control system fails.

Quantities to be measured:

- Pressure
- Temperature
- Flow
- Level
- Expansion/ Contraction
- Analysis of (1) Water (2) Steam (3) Flue Gases And Others

MEASUREMENT OF PRESSURE

Pressure measuring devices are divided into two groups:

- Liquid Columns
- Expansion Elements

Liquid columns:.

- Low range pressure measurement
- May be of U-Tube type or well-Type.

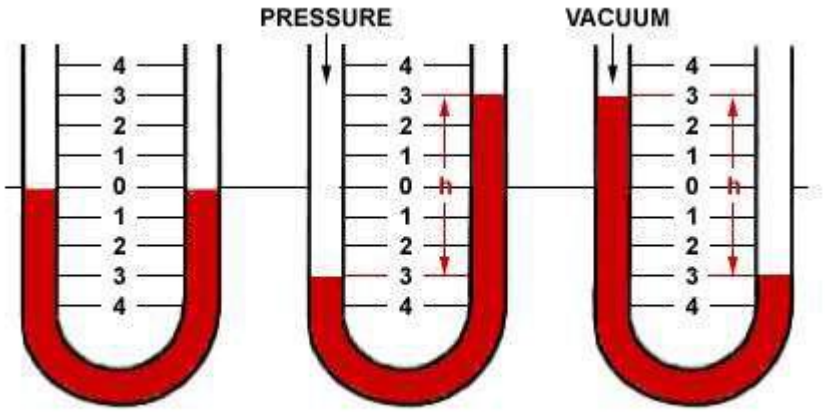
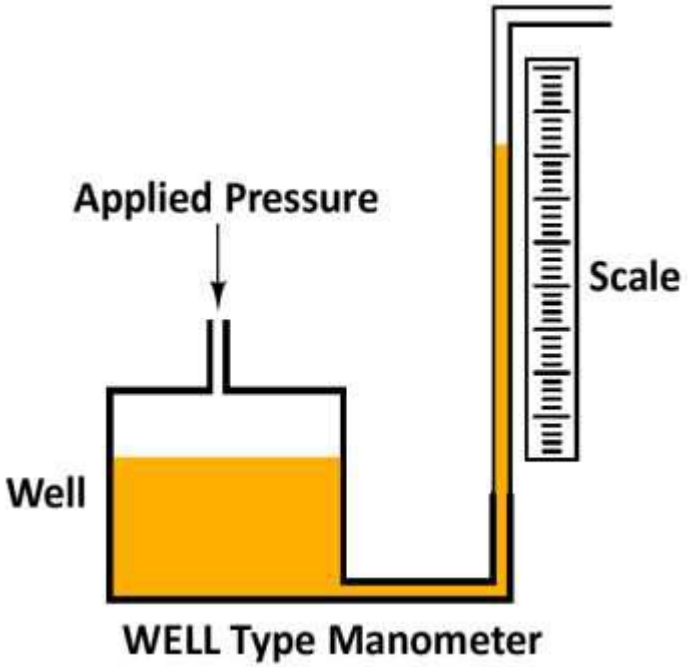


Fig. 2-1 Fig. 2-2 Fig. 2-3



MEASUREMENT OF PRESSURE

- These are not favoured in modern power plant but are still used in older power plants.

Expansion Elements:

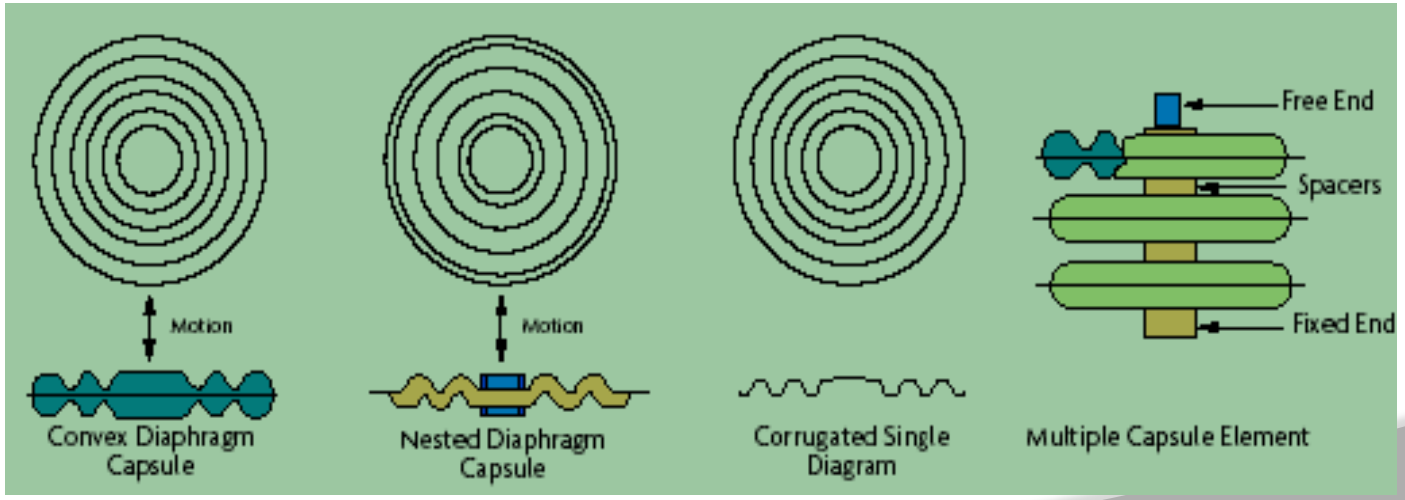
- Used in modern power plants.
- Usually metallic & its movement indicates the pressure.
- Either directly coupled with mechanical linkages or indirectly by an electrical transducer connected to a read out device .

Main Expansion Elements are:

- Diaphragms.
- Bellows
- Bourden tube

Diaphragms

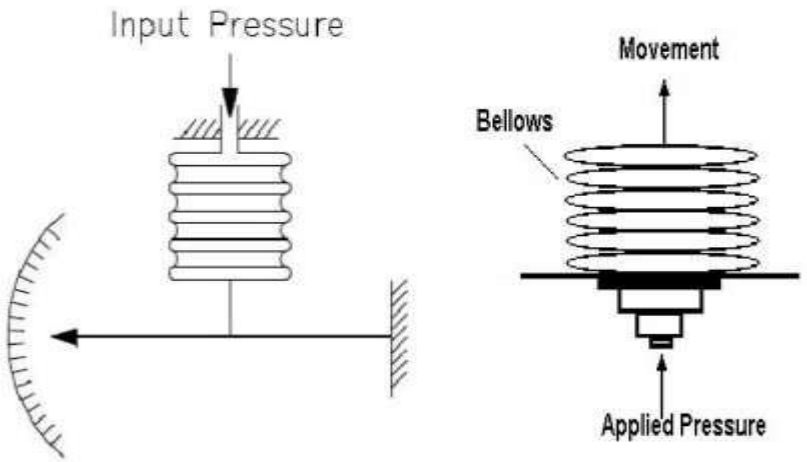
- Commonly corrugated diaphragms are used because large deflection can be produced without nonlinearity compared with flat type.
- In order to increase the deflection capabilities two or more corrugated diaphragms are welded at the circumferences---Capsule element.



MEASUREMENT OF PRESSURE

Bellows:

- Manufactured from Brass, Brass alloys, Stainless steel.
- Used for low pressure measurement.
- For high pressure measurement bellows are connected with spring.



MEASUREMENT OF PRESSURE

Bourden Tube

- C shaped and made into an arc of about 270 degree.

- Material from which it made depends upon the pressure range of the device.
- Bourdon tubes are also used in forms other than C type:-
- **Spiral element:** large movement than C tube.
- **Helical element:** produce more or less circular movement which is useful for driving a recorder pen directly.

MEASUREMENT OF TEMPERATURE

The most important parameter in thermal power plant is temperature and its measurement plays a vital role in safe operation of the plant.

Rise of temperature in a substance is due to the resultant increase in molecular activity of the substance on application of heat; which increases the internal energy of the material .

The efficiency of generation also depend on the temperature measurement

$$\eta = 1 - \frac{T2}{T1}$$

T2 = Temperature inside the condenser.

T1= Superheater temperature.

MEASUREMENT OF TEMPERATURE

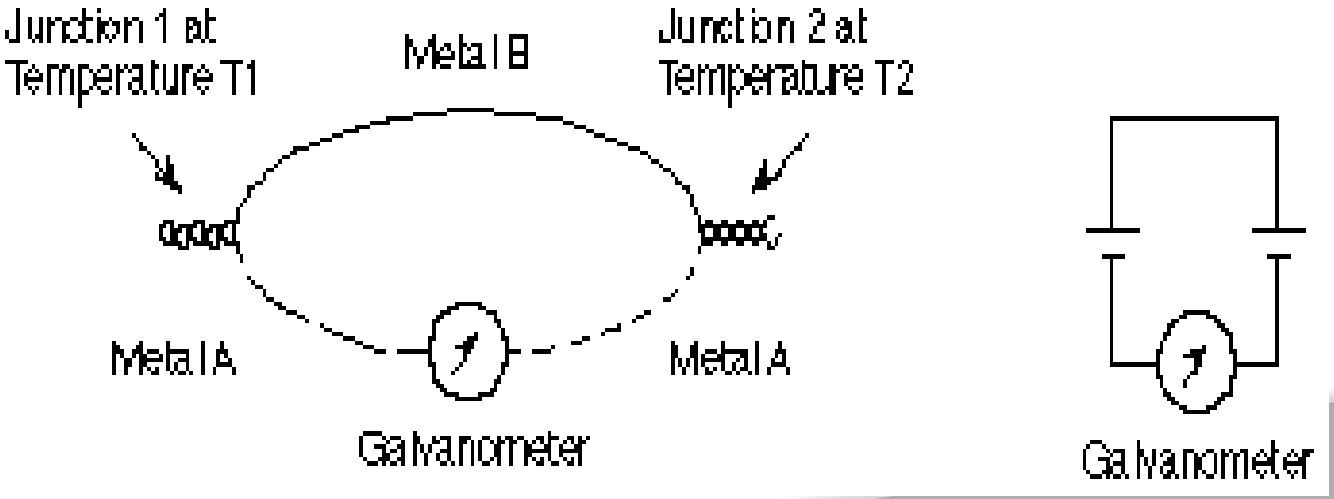
Expansion Thermometer

- In this type of measurement two dissimilar metal tube having different expansion coefficient are attached end to end.
- For same temperature change difference in the lengths are compared and calibrated for unknown temperature measurement.
- Variation in length is slight and has to be magnified for detection.

MEASUREMENT OF TEMPERATURE

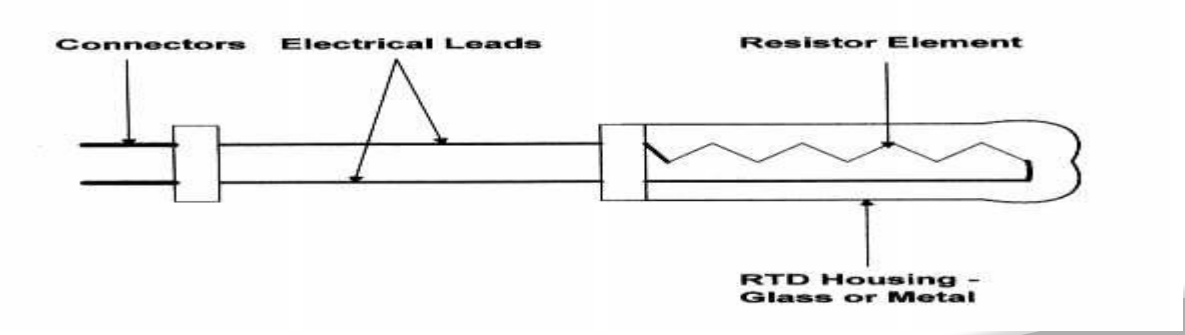
THERMOELECTRIC THERMOMETRY

- This device is based on SEEBACK and PELTIER effect. It comprises of two junctions at different temperature. Then the emf is induced in the circuit due to the flow of electrons. This is an important part in the plant.
- The actual value depend upon the material used and on temperature difference between the junctions.



RESISTANCE THERMOMETRY

- Suggested by Siemens in 1871- but not satisfactory used for high temperature .
- Today RTD is given by H.L.Calender in 1891
- PROPERTY-The resistance of the conductor changes when its temperature is changed.
- Copper is occasionally used.
- Platinum, nickel or nickel alloys are commonly used .
- Tungsten is used for high temperature applications



MEASUREMENT OF TEMPERATURE

ULTRA VIOLET SENSOR

- This device is used in furnace and it measures the intensity of ultra violet rays there and according to the wave generated which directly indicates the temperature in the furnace.

MEASUREMENT OF FLOW

- A universal flow meter for all applications in power station is not available.
- Infact there are more ways of measuring flow than measuring pressure & temperature.
- Dual function meters usually measure flow rate with linear output & minimum error.
- Vortex & Ultrasonic meters have become available in recent years (1986) & their full potential is not still fully developed.

MEASUREMENT OF FLOW

- Two principle measurements are made by flow meters viz. quantity of flow and rate of flow.
- 'Quantity of flow' is the quantity of fluid passing a given point in a given time, i.e. gallons or pounds.
- ‘Rate of flow' is the speed of a fluid passing a given point at a given instant and is proportional to quantity passing at a given instant, i.e. gallons per minute or pounds per hour.

UNIT III
ANALYSERS IN POWER PLANTS

IMPORTANCE OF ANALYSERS

- The power plants using steam need some water source. As all of us know, water is no more a free resource. Further, the quality of water available from rivers, dams or underground sources is deteriorating every day.
- If we use such contaminated water for generating steam, it will have an immediate impact on the complete plant and machinery in the power plant, as there will be a lot of erosion and corrosion that will take place.

IMPORTANCE OF ANALYSERS

•In any power plant running on steam, the purity of boiler feed water and steam is absolutely crucial; especially to steam turbine, steam boiler, super heater, condenser and other steam equipment. To prevent damage of steam turbine, steam boiler and other apparatus due to scaling and corrosion, on line steam and water analysis of critical parameters is inevitable. A well-engineered SWAS can measure all these parameters accurately and reliably. As we know, anything that can be measured accurately can be controlled accurately.

IMPORTANCE OF ANALYSERS

Critical parameters

- pH
- CONDUCTIVITY
- HYDRAZINE
- SILICA
- DISSOLVED OXYGEN
- SODIUM

Other parameters:

• Monitoring of other parameters such as alkalinity, hardness, calcium, chloride, phosphate, dissolved ozone is also required, depending on the size of the plant and the quality of water / steam equipment.

CRITICAL PARAMETERS

✓**pH**

In a sol^{n}. pH approximates but is not equal to p[H], the positive logarithm (base10) of the molar concentration of dissolved hydronium ions(H_3O^+); a low pH indicates high concentration of hydronium ions& a high pH indicates low concentration. It is a measure of the acidity or basicity of a solution. The pH scale ranges from 0 to 14.

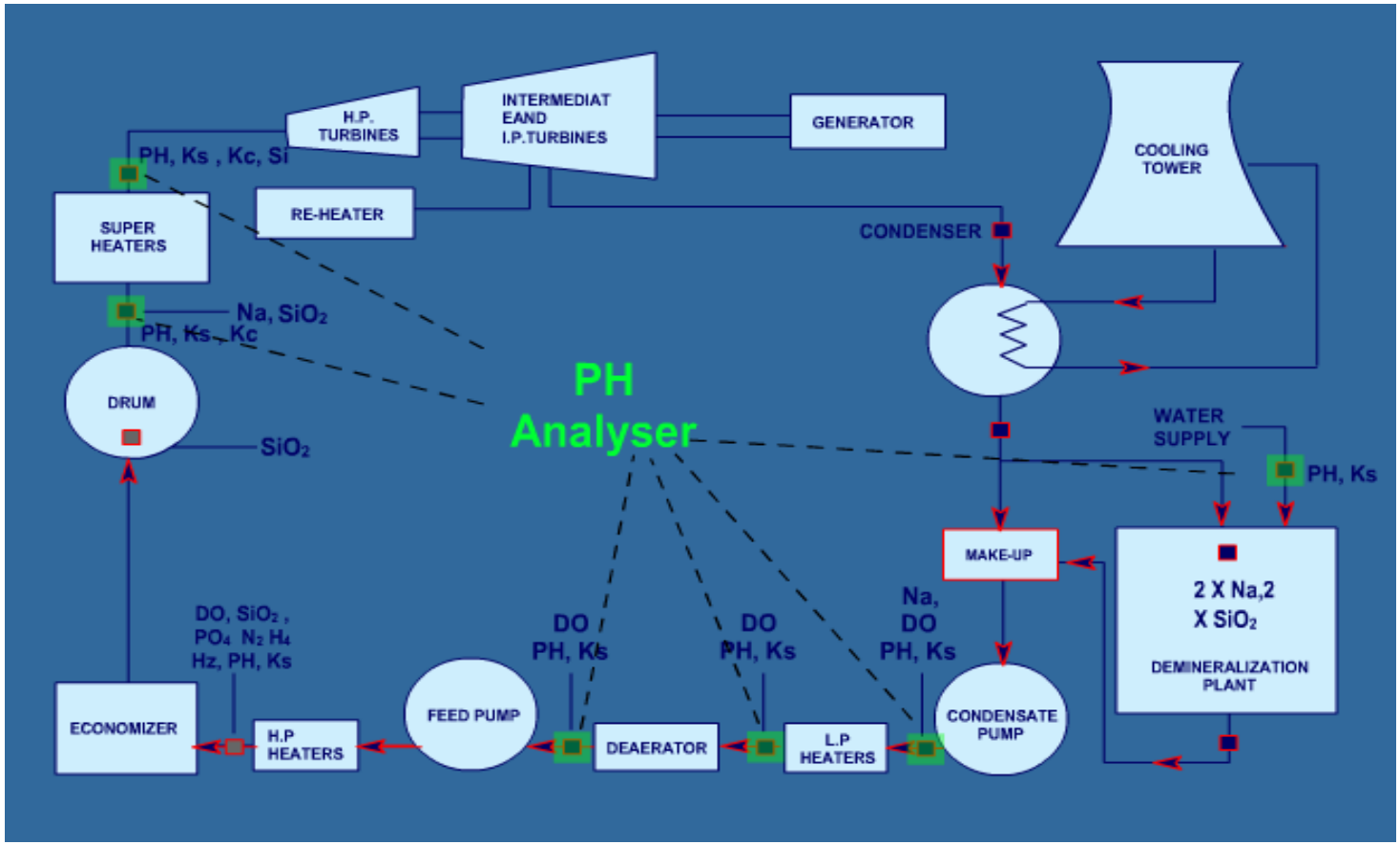
• Ultra pure water has a neutral pH value of 7. A pH less than 7 is acidic and greater than 7 is basic or alkaline. In the steam circuit the normal practice is to keep the pH value of feed water at slightly alkaline levels. Accurate pH analysis can therefore help in preventing the corrosion of pipe work and other equipment.

CRITICAL PARAMETERS

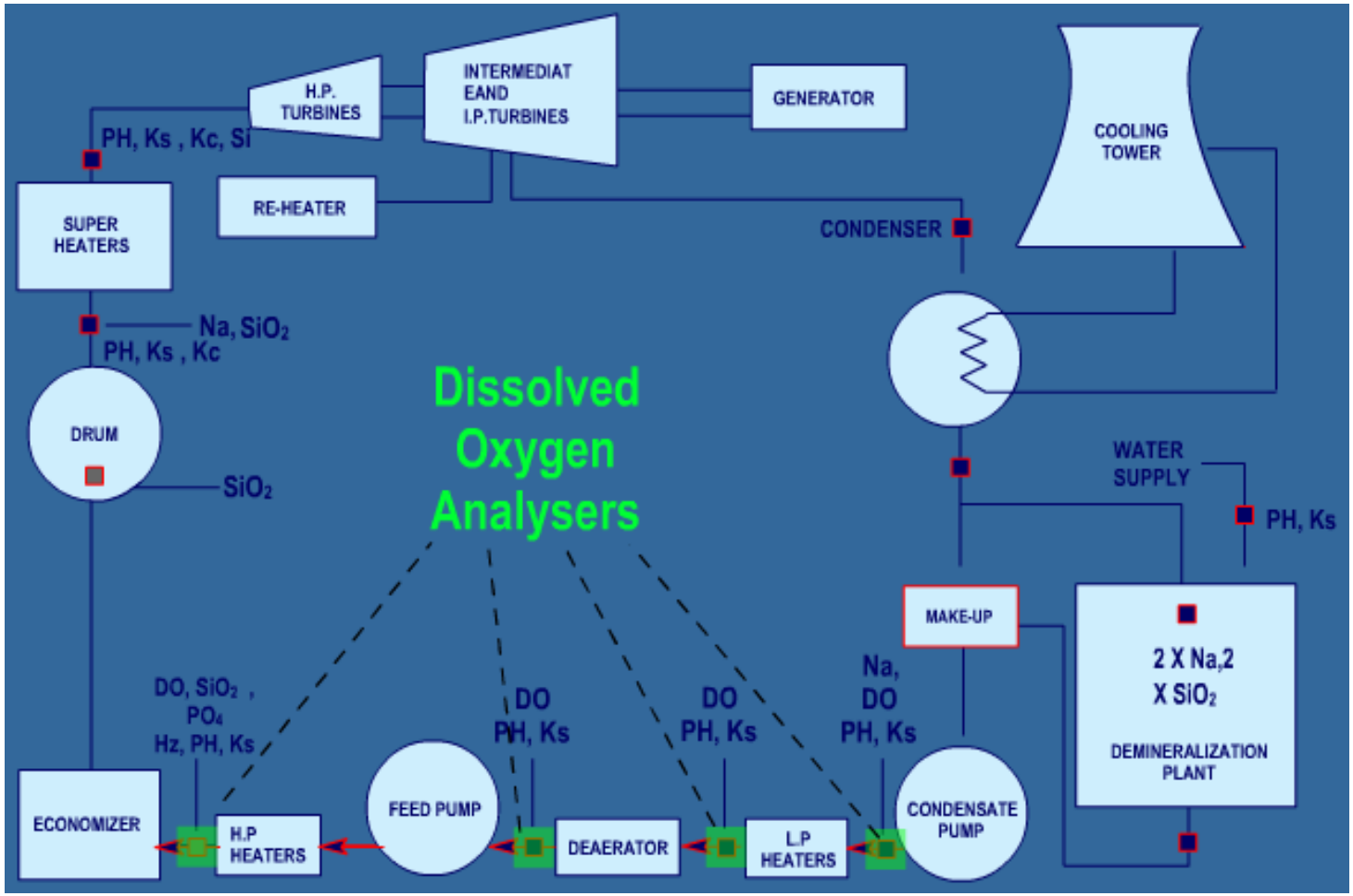
✓**DISSOLVED OXYGEN (DO_2)**

- At high temperatures dissolved oxygen attacks and causes corrosion of components and piping. The result is pitting, which may eventually causes puncturing and failures.
- Dissolved oxygen is also responsible for leakage at joints and gaskets.
- Hence it is essential to measure and control it precisely.
- 10 ppb of DO_2 in a boiler of 450TPH creates 90 Kg of rust per year !

pH MEASUREMENT



DISSOLVED OXYGEN ANALYSER



POLLUTANTS FROM THERMAL POWER PLANT

- The pollutants from thermal power plant includes unwanted gas, ash, dust, heat and contaminated waste waters. The gases coming from thermal power plants through stack causes air pollution in large measure.
- This is due to combustion of conventional hot condenser water and water discharged into the rivers carrying the ash of the plant.

POLLUTANTS FROM THERMAL POWER PLANT

- The pollutants or emission from thermal power plants can be classified as follows:
- Gaseous emission: SO2, Nox, CO2, CO, H2S, and many other.
- Particulate emission: smoke, dust, fumes, fly-ash, cinders
- Solid waste emission: ash
- Thermal pollution: waste heat.

- During stack emission, SO2 and Nox are realeased which subsequently get oxidised to sulphate(S04) and nitrate(NO3). In the presence of water vapours in the atmosphere these are changed to sulphuric acid and nitric acid.

POLLUTANTS FROM THERMAL POWER PLANT

Control of sulphur oxide
Control of nitrogen oxide
Control of particulates.

Control of SO2:Methods used to control SO2 is either by removing or reducing the sulphur content from fossil fuel or to remove SO2 from flues gases.
Desulphurisation of fuels: desulphurisation of oil can be done by chemical process using hydrogen gas. In this treatment hydrogen gas combines with sulpher of fuel to form hydrogen sulphide (H2S) which is then isolated by absorption in suitable chemicals.

CONTROL OF POLLUTANTS

- Froth floatation process is used to reduce sulphur in coal. In this process coal is suspended in water through which air is bubbled. These air bubbles tend to attack coal particles and other mineral waste including sulphur falls at the bottom and discharged.
- In other method, crushed coal is passed through a
- magnetic field which removes pyrite (FeS2) from coal.
- This method of sulphur removal is called magnetic
- separation.

CONTROL OF POLLUTANTS

Removal of SO2 from flue gases:

- The SO2 from flue gases can be removed by using wet scrubbers and electrostatic precipitators. Another method used for removal of SO2 is by catalystic oxidation. It is used to produce H2SO4 from dilute SO2 in flue gases. Sulphuric acid is seperated from flue gas before discharged through the chimney.

UNIT IV
CONTROL LOOPS IN BOILER

BOILER CONTROLS & INSTRUMENTATION

- The various goals of boiler control includes:

  1. To minimize excess air
  2. To minimize blow down
  3. To minimize steam pressure
  4. To measure efficiency

- The major loops in boiler control are
  1) Combustion control
  2) Feed water control

COMBUSTION CONTROL

A combustion control system is broken down into

(a) fuel control and

(b) combustion air control subsystems.

- The interrelationship between these two subsystems necessitate the use of fuel air ration controls.
- The primary boiler fuels are coal, oil and gas. The control of gas and oil fuels requires simplest controls- i.e a control valve in the fuel line.

- The steam drum pressure is an indication of balance between the inflow and outflow of heat. Therefore by controlling the steam supply one can establish balance between the demand for steam (process load) and supply of water.

HARDWARE USED IN BOILER CONTROL

- ON/OFF controls:

Are still used in many industries but are generally used in small water tube boilers. When the pressure drops to a present value, fuel & air are automatically fed into the boiler at predetermined rate until pressure has risen to its upper limit.

- Positioning systems:

Respond to changes in header pressure by simultaneously positioning the forced draft damper and fuel valve to a predetermined alignment. This is not used in liquid , gaseous fuel – fired boilers.

HARDWARE USED IN BOILER CONTROL

Metering control system:

- In this system control is regulated in accordance with the measured fuel and air flows. This maintains combustion efficiency over a wide load ranges & over long period of time.

- Both metering & positioning control systems use steam header pressure as their primary measured variable & as a basis for firing rate demand. A master pressure controller responds to changes on header pressure & positions the dampers to control air flow and fuel valve to regulate fuel supply.

FEEDWATER CONTROL

- Feedwater control is the regulation of water to the boiler drum. It provide a mass accounting system for steam leading and feedwater entering the boiler.
- Proper boiler operation requires that the level of water in the steam drum should be maintained within certain band.
- A decrease in this level may uncover boiler tubes, allowing them to become overheated.
- An increase in the level of water may interfere with the internal operation of internal devices in the boiler drum.
- It is important to made that the water level in the boiler drum must be above 50% all the time.

FEEDWATER CONTROL

- As system for feedwater control must be designed to maintain the mass balance over expected boiler load changes so that the level in the steam drum remains within the required limits for safe and efficient operation.

- Control system complexity is based on number of measured variables used to initiate control action and include single element ,two element,3 – element and advanced control schemes to improve accuracy of final control action.

SINGLE ELEMENT CONTROL SYSTEMS

- For small boilers having relatively high storage volumes and slow changing loads ,single element control system is used.
- It controls feed water flow based on drum level.
- Response is very slow because a change in feedwater flow takes a long time to show up the level change.
- As a result the steam drum causes water to increase and decrease in volume, resulting in false measurements.

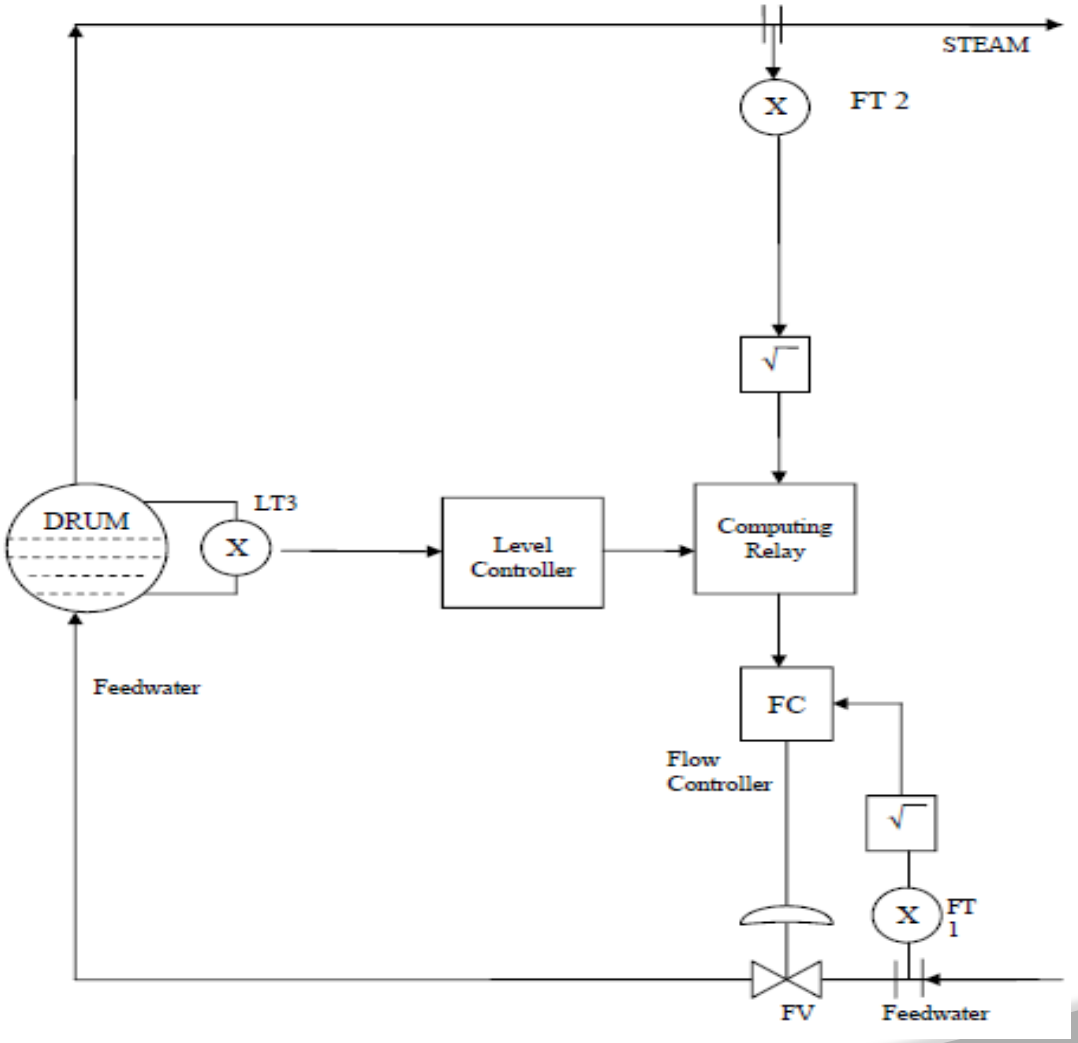
TWO ELEMENT CONTROL SYSTEMS

- The two element system overcome these inadequacies by using steam flow changes as a feed forward signal.
- This control is used in intermediate boilers as well as large boilers.
- Here the flow and level transmitters are summed by a computing relay and will be the set point for feedwater.
- Here the response is faster.

THREE ELEMENT CONTROL

- Boilers that experiences wide and rapid load changes require three element control.
- Three element control is similar to two element system except that the water flow loop is closed rather than open.
- The level and steam flow signals are summed and used as an index or set point to the feedwater flow. The feedwater flow measurement provides corrective action for variation in feedwater pressure.

THREE ELEMENT CONTROL



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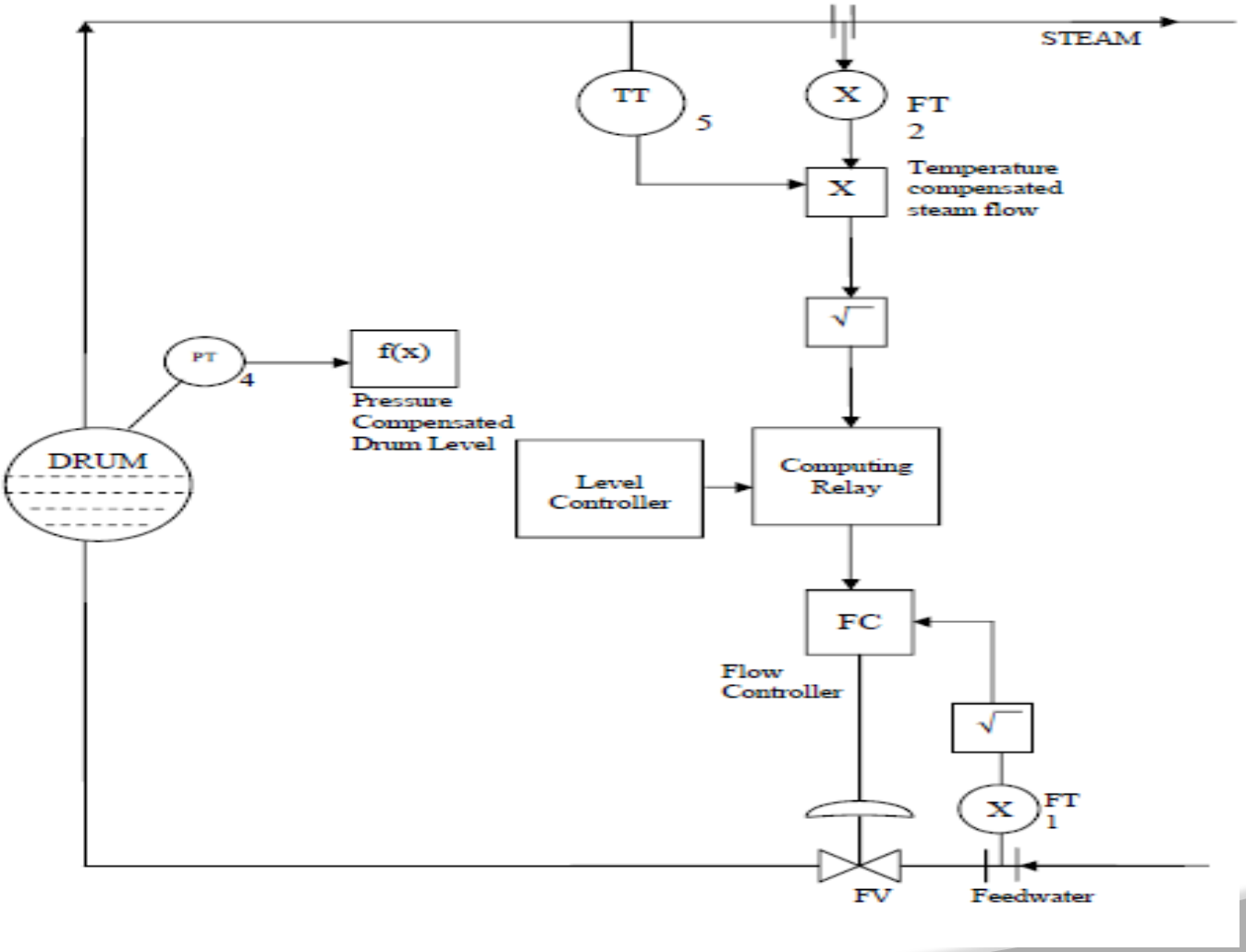
FIVE ELEMENT CONTROL

- Additional elements can be added to a feedwater control system to improve response accuracy.

- A five element feedwater control system is essentially a three element configuration in which the steam flow measurement is temperature compensated and drum level measurement is pressure compensated.

FIVE ELEMENT CONTROL



MULTIPLE ELEMENT CONTROL

❖ **Advantages:** Multiple element feedwater control can help:

i. Faster response of systems.

ii. More accurate control.

iii. Maximum system stability.

❖ Metering control system maintains combustion efficiency over wide load changes and over long period of time.

❖ **Disadvantages:**

i. Boilers require quick responding controls.

ii. Level of the water in the boiler must be kept above 50% of height.

FLOWMETER

- The flow meter is designed to measure flow rate of a fluid.
- Measurement is based on Faraday's law of induction, according to which a voltage is induced in an electrically conductive body which passes through a magnetic field.
- The following expression is applicable to the voltage.

$$U = K * B * V * D$$

Where:

U = induced voltage
K = an instrument constant
B = magnetic field strength
V = mean velocity
D = pipe diameter

RELATION BETWEEN FEEDWATER FLOW AND STEAM FLOW

- In feedwater control the flow rate of feedwater is proportional to the change in displacement of the valve stem i.e.
- Change in flow rate = k(change in steam displacement)

where k = constant

If Q = flow rate, S = steam displacement, Qmax = maximum flow rate, Smax = maximum stem displacement, then,

$$Q/Q_{max} = S/S_{max}$$

- Percentage change in the flow rate = percentage change in the stem displacement

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UNIT V
TURBINE MONITORING AND CONTROL

TURBINE CONTROL

Need

- The unwanted acceleration of a fixed unit over a fixed boundary is defined as vibration .
- Vibration in turbine is monitored in power plants as

➢ It reduces the efficiency of the turbine and

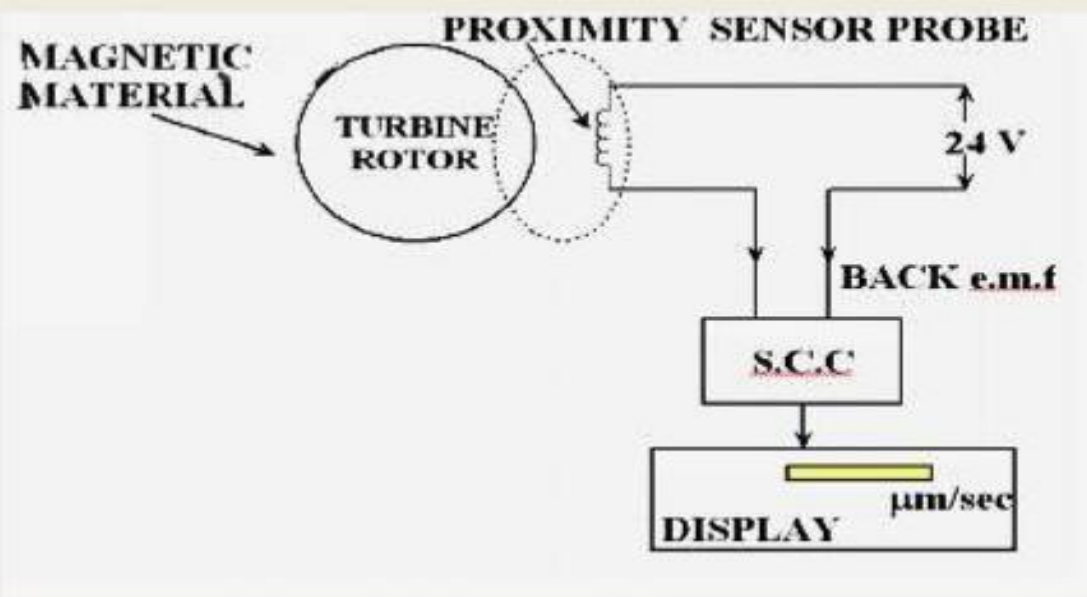
➢ Causes damage to the blades of the turbine.

Monitoring

- The vibration in turbine can be measured by means of two methods.
- Non-contact measurement method
- Direct contact measurement method

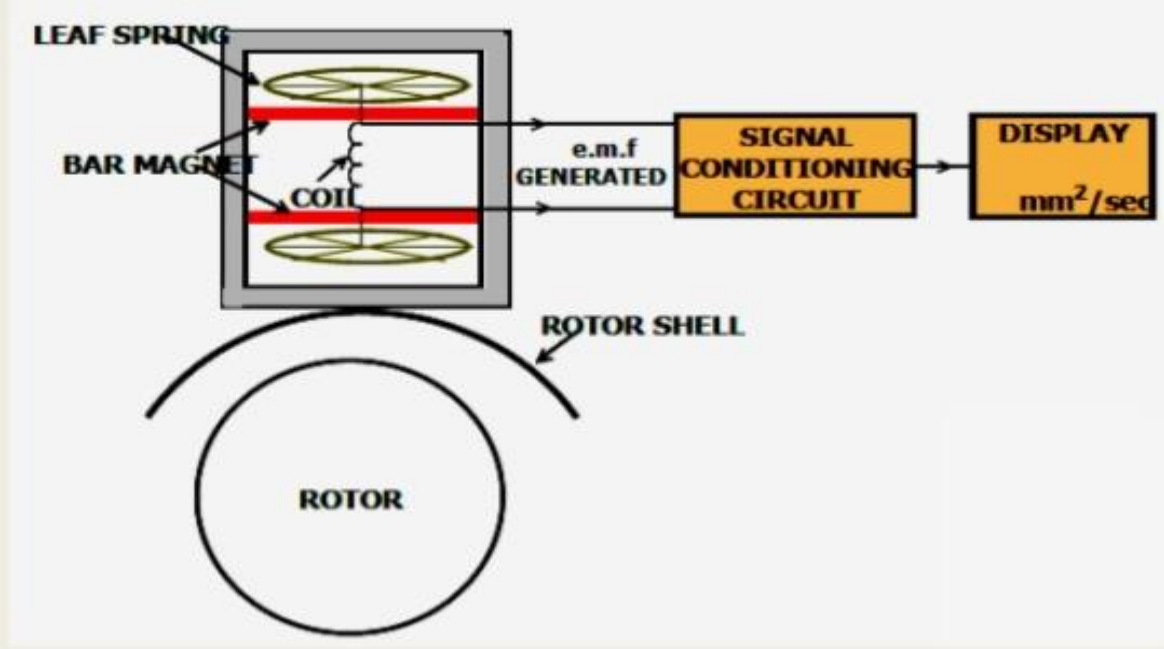
TURBINE CONTROL

- Non-contact measurement method



TURBINE CONTROL

- Direct contact measurement method

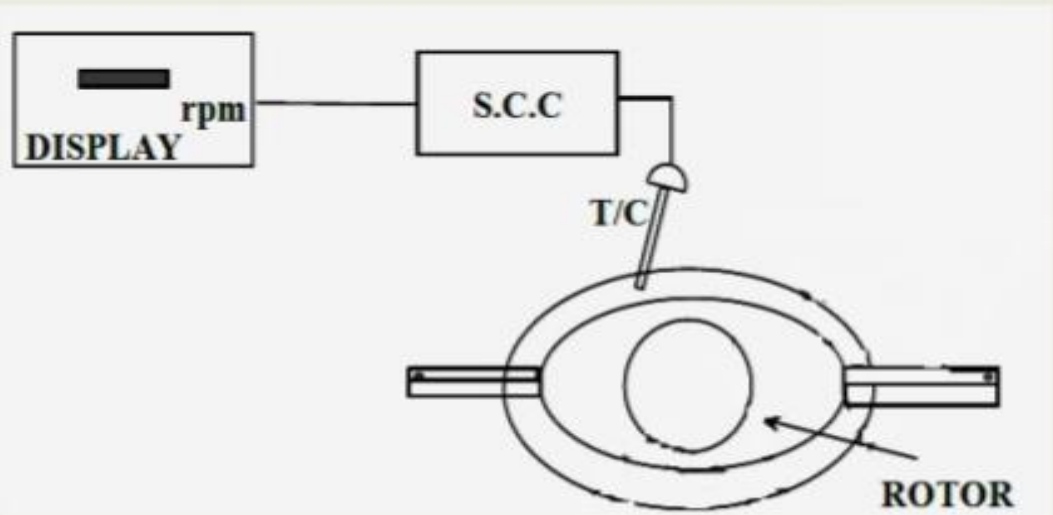


SHELL TEMPERATURE

- Shell is also known as casing. It is the principal stationary element.
- It surround the rotor and holds, internally, any nozzles, blades and diaphragms that may be necessary to control the path and the physical state of the expanding steam.
- The casing is normally thermally insulated from outside to prevent radiation losses. For this purpose, shell/casing temperature is monitored at different locations.

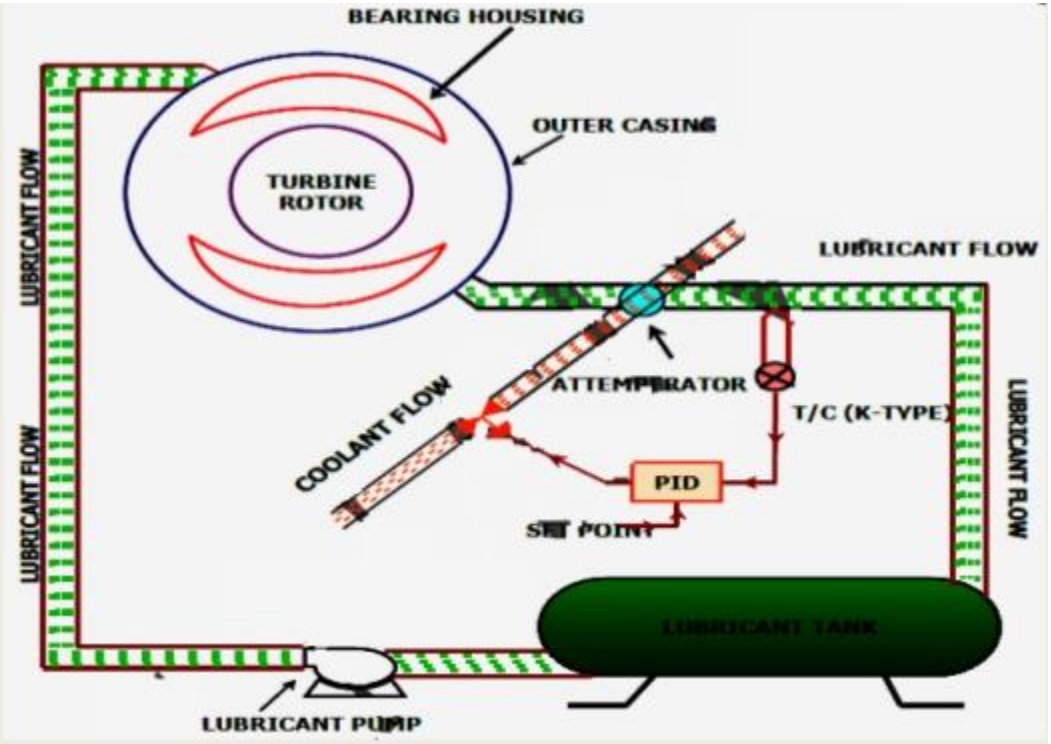
Monitoring

A thermocouple is placed on the outer casing (shell) of the turbine rotor and after proper signal conditioning, the temperature of the shell is monitored.



TURBINE CONTROL

Lubricant oil temperature monitoring



TURBINE CONTROL

The temperature of the lubricant is measured after the lubrication process by means of thermocouple and compared with the set point in the controller, the controller gives command accordingly to control the cooling water sprayed over the lubricant to reduce the lubricant temperature.

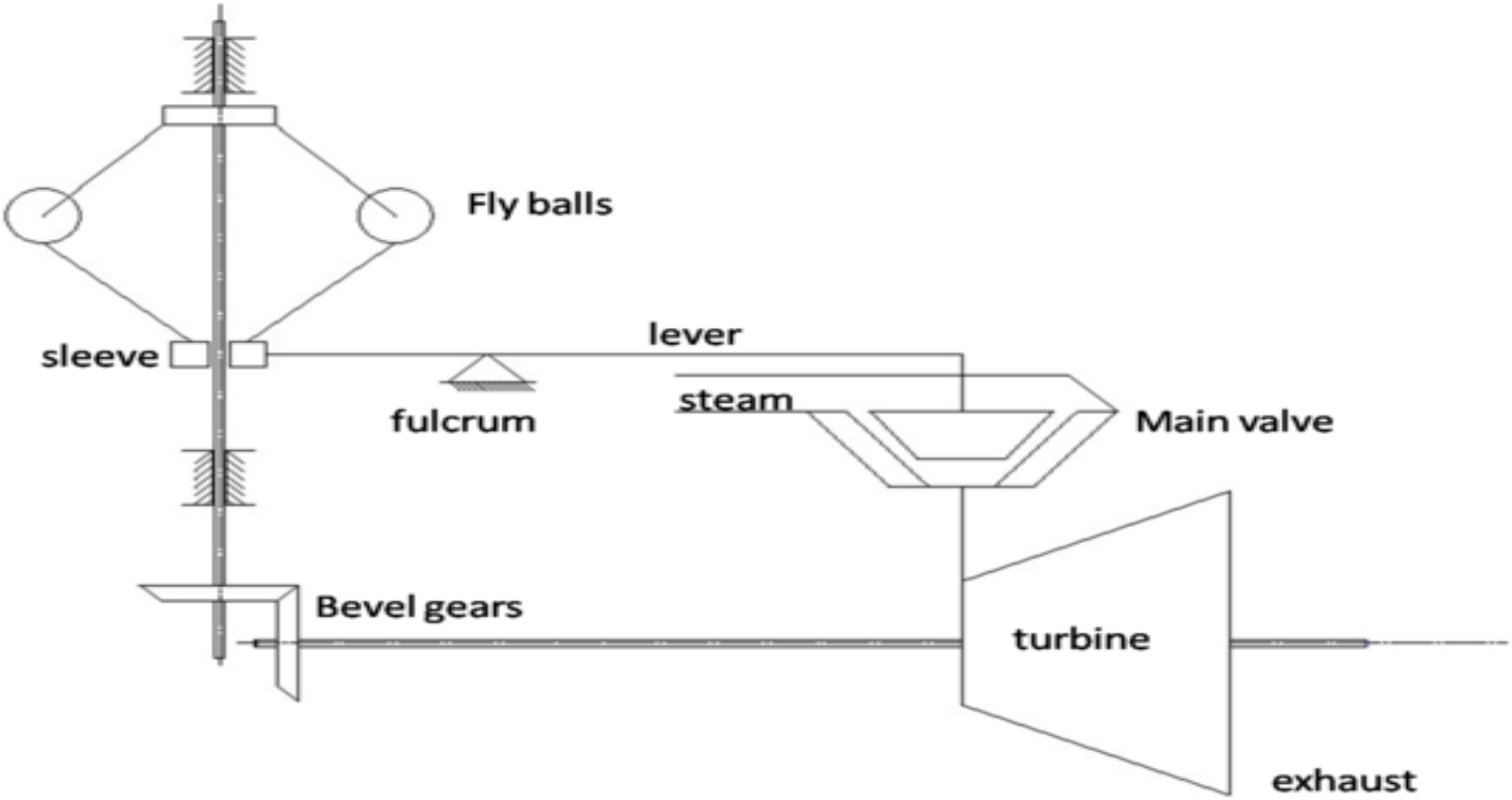
TURBINE GOVERNOR

- **Steam turbine governing** is the procedure of controlling the flow rate of steam into a steam turbine so as to maintain its speed of rotation as constant.
- The variation in load during the operation of a steam turbine can have a significant impact on its performance.
- In a practical situation the load frequently varies from the designed or economic load and thus there always exists a considerable deviation from the desired performance of the turbine.
- The primary objective in the steam turbine operation is to maintain a constant speed of rotation irrespective of the varying load. This can be achieved by means of governing in a steam turbine.

TURBINE GOVERNOR

- In throttle governing the pressure of steam is reduced at the turbine entry thereby decreasing the availability of energy.
- In this method steam is allowed to pass through a restricted passage thereby reducing its pressure across the governing valve.
- The flow rate is controlled using a partially opened steam control valve. The reduction in pressure leads to a throttling process in which the enthalpy of steam remains constant,
- Low initial cost and simple mechanism makes throttle governing the most apt method for small steam turbines. The mechanism is illustrated in the figure.
- The valve is actuated by using a centrifugal governor which consists of flying balls attached to the arm of the sleeve.

TURBINE GOVERNOR



TURBINE GOVERNOR

Throttle governing

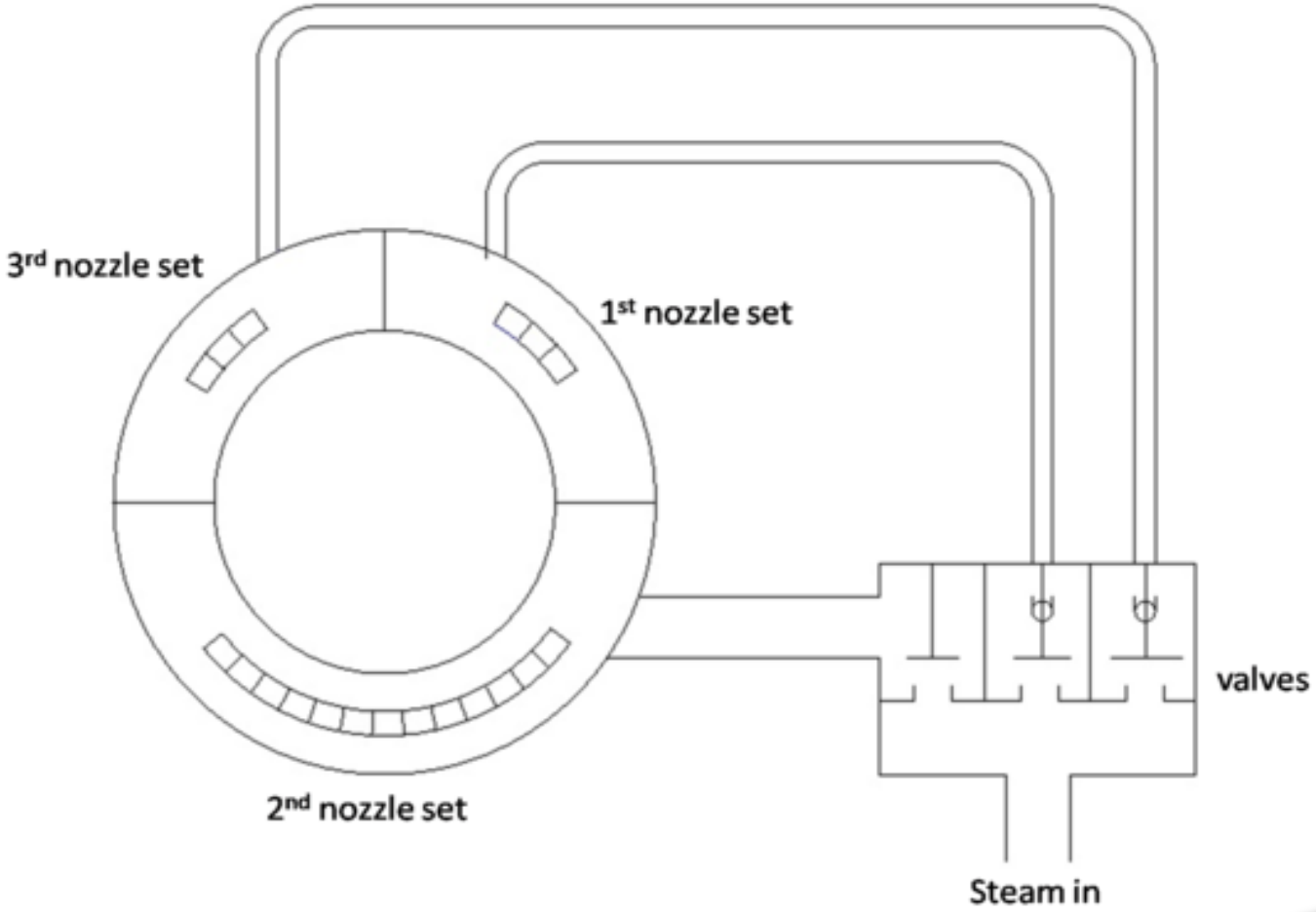
- A geared mechanism connects the turbine shaft to the rotating shaft on which the sleeve reciprocates axially.
- With a reduction in the load the turbine shaft speed increases and brings about the movement of the flying balls away from the sleeve axis.
- This result in an axial movement of the sleeve followed by the activation of a lever, which in turn actuates the main stop valve to a partially opened position to control the flow rate.

TURBINE GOVERNOR

Nozzle governing

- In nozzle governing the flow rate of steam is regulated by opening and shutting of sets of nozzles rather than regulating its pressure.
- In this method groups of two, three or more nozzles form a set and each set is controlled by a separate valve.
- The actuation of individual valve closes the corresponding set of nozzle thereby controlling the flow rate.
- In actual turbine, nozzle governing is applied only to the first stage whereas the subsequent stages remain unaffected. Since no regulation to the pressure is applied.
- Figure shows the mechanism of nozzle governing applied to steam turbines. As shown in the figure the three sets of nozzles are controlled by means of three separate valves.

TURBINE GOVERNOR

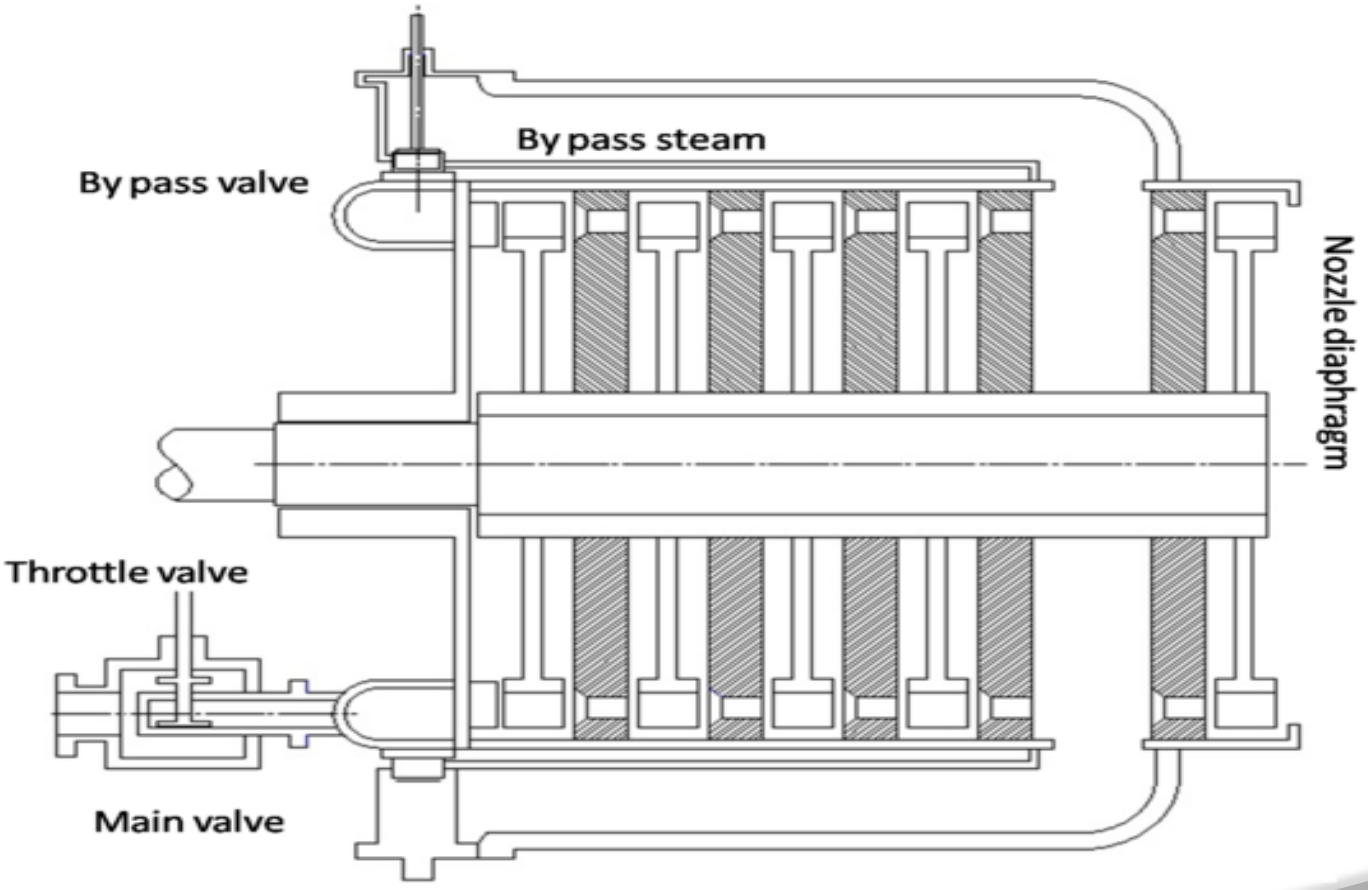


TURBINE GOVERNOR

By pass governing

- Occasionally the turbine is overloaded for short durations.
- During such operation, bypass valves are opened and fresh steam is introduced into the later stages of the turbine.
- This generates more energy to satisfy the increased load.
- The schematic of bypass governing is as shown in figure.

TURBINE GOVERNOR



TURBINE GOVERNOR

- The total amount of steam entering the turbine passes through the valve A which is under the control of speed governor.
- B is a nozzle box or steam chest .
- For all loads greater than the economic load , a by pass valve c is opened, allowing steam to pass from the first stage nozzle box in to the steam belt D and so in to the nozzle of downstream stage.
- The valve c is designed such that it is not opened until the lift of the valve a diminishes.
- The by pass valve c remains under control of a speed governor for all loads within its range.


Thank you