Cycle efficiency,

$$\eta = \frac{(h_1 - h_2) + (h_3 - h_4)}{(h_1 - h_5) + (h_3 - h_2)}$$

$$= \frac{(3605.7 - 331.6) + (3664.5 - 2297.55)}{(3605.7 - 191.8) + (3664.5 - 331.6)} \times 100$$

$$\eta = 0.4403 = \mathbf{44.03\ \%}$$ **Ans.**

1.37. TWO MARK QUESTIONS AND ANSWERS

1. ***List down the sources of useful energy.***

   (i) Fossil fuels such as coal, petroleum products and natural gases which produces thermal, mechanical and electrical energy

   (ii) Chemical energy from reactions among mineral sources

   (iii) Nuclear energy from nuclear reactions of the nuclear fuels available on the earth

   (iv) The sun which produces solar energy in the form of mechanical or electrical energy

   (v) Geothermal energy from cooling, chemical reactions and radioactive decay in the earth.

2. ***What are the conventional energy sources?***

   (a) Fossil fuel energy

   (b) Hydraulic energy

   (c) Nuclear energy.

3. ***Mention the various non-conventional energy resources.***

   (a) Solar energy

   (b) Wind energy

   (c) Tidal energy

   (d) Wave energy

   (e) Geothermal energy

   (f) Biomass energy.

4. *List out the factors with which the unit size of the power plant is being decided.*

[Anna Univ. (Mech.) Nov'08]

(i) Required amount of power.

(ii) Cost.

(iii) Availability of resources.

(iv) Technological aspects.

5. *What are the different sources of energy available for power generation?*

[Anna Univ. (Mech.) May'14]

1. Steam
2. Gas or air
3. Diesel and petrol
4. Nuclear
5. Renewable energy sources such as solar, wind, geothermal, tidal, wave, MHD etc.

6. *Why thermal plants are not suitable for supplying fluctuating loads?*

[Anna Univ. (EEE) May'12]

Thermal plants are not suitable for supplying fluctuating loads because any change in load demand requires the corresponding change in the output energy. In thermal plants, the input energy is produced by burning the coal. So, there is always a large time lapse between change in energy output and input which is not desirable. Therefore, such power stations are used only as base load stations and it supplies the constant power.

7. *List out the four important circuits of steam power plant.*

[Anna Univ. (Mech.) Dec'14 & (EEE) Dec'13]

1. Coal and ash circuit
2. Air and flue gas circuit
3. Water and steam circuit
4. Cooling water circuit.

8. *State the characteristics of steam power plant.*

(i) It produces high efficiency.

(ii) It reduces water requirement.

(iii) It is highly reliable and available.

9. *What are the advantages of steam power plants?*

(i) The power production does not depend on the nature mercy.

(ii) Initial investment is low.

(iii) The power plant can be located near load center. So, the transmission cost and losses are considerably reduced.

(iv) The time requirement for construction and commissioning of thermal power plant require less period of time.

10. *Mention the limitations of steam power plants.*

(i) As compared with hydro-electric power plant, life and efficiency are less.

(ii) Transportation of fuel is a major problem in this type of power plant.

(iii) Power generation cost is considerably high when compared to hydro-electric plant.

(iv) Air pollution is a major problem inviting additional investment.

(v) It cannot be used as a peak load plant.

(vi) The coal (fuel) needed may be exhausted by gradual use.

11. *What is saturation temperature and saturation pressure?* ***[Anna Univ. Nov'07]***

At a given pressure, the temperature at which a liquid boils is called *saturation temperature*. At the given temperature, the pressure at which the liquid boils is called *saturation pressure*. It is also called as *vapour pressure*.

12. *Define latent heat of evaporization.*

The amount of heat added during heating of water from boiling point to dry saturated state is called as *latent heat of vaporization* or *enthalpy of vaporization* or *latent heat of steam*.

13. *What is meant by superheated steam? and indicate its use.*

If the dry steam is further heated, then the process is called *superheating* and the steam is known as *superheated steam*.

Uses:

1. Superheated steam has more heat energy and more work can be obtained using it.

2. Thermal efficiency increases as the temperature of superheated steam is high.
3. Heat losses are due to condensation of steam and cylinder wall friction.

14. Define: sensible heat of water.

The amount of heat required to raise the temperature of unit mass of water from 0°C to the saturation temperature under a constant pressure. It is denoted by h_f.

15. Define the term "Super heat enthalpy".

The heat supplied to the dry steam at saturation temperature to convert it into superheated steam at the temperature T_{sup} is called *superheat heat enthalpy.*

16. What are wet and dry steams?

The steam which is partially evaporated and having water particles in suspension is called *wet steam.* The steam which is completely in evaporated state without any water particles is called *dry steam.*

17. Define dryness fraction of steam ***[Anna Univ. Apr'01&Apr'97]***

Or

What is quality of steam? ***[Anna Univ. Apr'05]***

It is defined as the ratio of the mass of the total steam actually present to the mass of the total mixture steam.

$$\text{Dryness fraction} = \frac{\text{Mass of dry steam}}{\text{Mass of total mixture}}$$

18. What are steam power plant cycles?

(1) Simple Rankine cycle
(2) Reheat Rankine cycle
(3) Regenerative Rankine cycle
(4) Reheat-regenerative Rankine cycle
(5) Binary vapour cycle, and
(6) Superimposed or topping cycle.

19. List down the components in Rankine cycle.

(i) Boiler
(ii) Turbine

(iii) Condenser and

(iv) Pump.

20. *Comment on the thermal efficiency of a steam power plant.*

[Anna Univ. (EEE) Dec'12]

Thermal efficiency is a dimensionless performance which is a measure of a device using thermal energy such as internal combustion engine, steam turbine or steam engine, boiler and furnace or refrigerator.

21. *Define the overall efficiency of a steam power plant.* ***[Anna Univ. (EEE) Dec'10]***

Overall efficiency is defined as the combined efficiency of boiler, steam turbine, condenser and pump.

$$\eta_{Overall} = \eta_{Boiler} \times \eta_{Steam\ turbine} \times \eta_{Condenser} \times \eta_{Pump}$$

22. *Define air standard cycle efficiency.* ***[Anna Univ. (Mech.) Dec'13]***

It is the ratio of work done during the process to the heat supplied.

$$\text{Air Standard Efficiency } \eta = \frac{\text{Workdone}}{\text{Heatsupplied}} = \frac{W}{Q_S}$$

where Work done = Heat supplied – Heat rejected

$$W = Q_S - Q_R$$

23. *Define SSC, SSF and WR.*

(i) Specific Steam Consumption (SSC):

It is defined as the mass flow of steam required to develop 1 unit of power output.

$$SSC = \frac{3600}{W} \text{ in } kg/kWh$$

where W be the network output

$W = (h_1 - h_2) - W_p$ ---- for cycle with pump work

$W = h_1 - h_2$ ---- without pump work.

(ii) Specific steam flow rate (SSF):

It is defined as the steam flow in *kg* required to develop 1 unit of power output.

$$SSF = \frac{3600}{W} \quad \text{in } kg/kWh$$

(iii) Work ratio:

It is defined as the ratio of network to the gross work.

$$\text{Work ratio} = \frac{\text{Net work}}{\text{Gross Work}} = \frac{W_T - W_P}{W_T}$$

24. *What are the operating conditions for improving the cycle efficiency in Rankine cycle?*

(1) Increasing the average temperature at which the heat is supplied.

(2) Decreasing or reducing the temperature at which the heat is rejected.

25. *Give some advantages of regenerative cycle over Rankine cycle.*

(1) The thermal stresses set up in the boiler are minimized.

(2) The thermal efficiency is improved because the average temperature of heat addition is increased.

26. *Explain reheat cycle.*

In reheat cycle, the steam is extracted from a suitable point in the turbine and it is reheated with the help of flue gases in the boiler.

27. *What are the advantages of reheat cycle?*

1) The reheating reduces from 4 to 5% fuel consumption.

2) The reheat cycle reduces the steam flow of 15% to 20% with corresponding reduction in boiler, turbine and feed heating equipment capacity.

28. *What are the methods of reheating?*

1. Flue gas reheating
2. Live steam reheating
3. Combined flue gas and live steam reheating.

29. *What is regenerative cycle?*

The feed water is heated with the help of steam in a reversible manner. Steam temperature and water temperature are same at any section. Such type of heating is known as *regenerative cycle.*

30. *Where is reheat-regenerative cycle used?*

In the actual thermal power plant with high steam pressure (above $90 kg/cm^2$), the reheat regenerative cycle is used to increase the overall efficiency of the cycle.

31. State how the steam boilers are classified. ***[Anna Univ. (Mech.) Dec'14]***

Steam boilers are classified on the basis of boiler pressure, fuel, boiler material, boiler tube type, circulation, method of combustion, type of support, furnace construction, furnace position, use, erection, mobility, ASME code and heat source.

32. Define boiler mountings and accessories. ***[Anna Univ. (EEE) May'11]***

The devices which are used for functioning with the safe operation of a boiler are called *boiler mountings*. The devices which are used to increase the efficiency of the boiler are called *boiler accessories*.

33. Why are superheaters used in steam power plants? ***[Anna Univ. (EEE) Dec'12]***

The steam produced in the boiler is in the state of saturated condition. The moisture in the steam will affect turbine blades and cause corrosion. To avoid it, the superheater is used. It is used to increase the temperature of steam and improve the efficiency.

34. What is the necessity of feed pump in thermal power plant?

[Anna Univ. (EEE) Dec'11]

Feed pump is a pump which is used to deliver the feed water to the boiler. The quantity of water supplied should be at least equal to the amount of evaporation which is supplied to the engine.

35. Mention the two types of feed water heaters in a steam power plant.

[Anna Univ. (EEE) Dec'10]

(i) Open feed water heater

(ii) Closed feed water heater.

36. What is the function of deaerator in a thermal power plant?

[Anna Univ. (EEE) May'12]

A dearearator is a device widely used for the removal of air and other dissolved gases from the feed.

37. Write the use of water level indicator in boiler. ***[Anna Univ. (EEE) Dec'13]***

The water level indicator constantly determines the level of water in the boiler shell.

38. What are the accessories used in a boiler? ***[Anna Univ. (Mech.) May'13]***

(1) Feed water pump

(2) Injector

(3) Pressure reducing valve

(4) Economiser

(5) Air pre heater

(6) Superheater

(7) Steam drier or separator

(8) Steam trap.

39. List out the major advantages of high pressure boilers in modern thermal power plants. ***[Anna Univ. (Mech.) Dec'12 & Dec'13]***

(i) The tendency of scale formation is eliminated due to high velocity of water through tubes.

(ii) Light weight tubes with better heating surface arrangement can be used. The space required is less. The cost of foundation and the time of erection are minimised due to less weight of tubes used.

(iii) Due to use of forced circulation, there is more freedom in the arrangement of surface, tubes and boiler components.

(iv) All parts are uniformly heated. So, the danger of overheating is reduced and the thermal stress problem is simplified.

(v) The difference in expansion is reduced due to uniform temperature and circulation. There is a greater flexibility in components arrangement.

(vi) Efficiency of power plant is increased up to 40 to 45%.

40. Distinguish between fouling and slagging. ***[Anna Univ. (Mech.) May'09]***

Slagging is the formation of molten or partially fused deposits on furnace walls or convection surfaces exposed to radiant heat.

Fouling is defined as the formation of deposit on convection heat surfaces such as superheater and reheaters.

41. Define super critical boilers. ***[Anna Univ. (Mech.) Nov'07]***

Boilers only with economizer and superheater are called *super critical boilers.*

42. What is super-critical boiler? *[Anna Univ. (EEE) June'13 & Dec'15]*

If boilers incorporate only economizer and superheater, they are called *supercritical boilers*. The super critical boilers are above $300MW$ capacity units available.

Ex: Velox boiler and Loeffler boiler.

43. What is meant by fluidized bed combustion?

The mixing of gas particles in equilibrium condition during combustion is called *fluidized bed combustion.*

44. Draw a neat sketch of basic principle of FBC. *[Anna Univ. (Mech) Apr'05]*

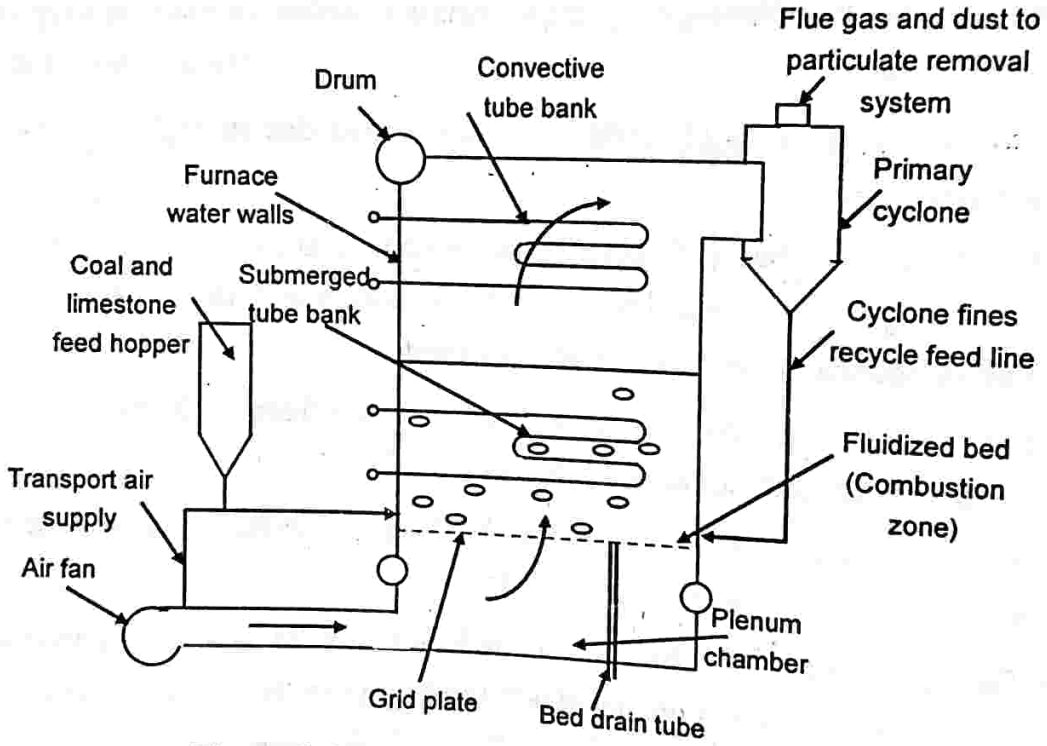

Figure 1.121 Schematic of bubbling fluidized bed boiler

45. What is the use of fluidized bed boiler?

It is used to produce steam from fossil and waste fuels.

46. What are types of fluidized bed boilers? *[Anna Univ. (Mech.) Dec'13]*

1. Bubbling fluidized bed boilers (BFB)
2. Circulating fluidized bed boilers (CFB).

47. What is a steam turbine?

Steam turbine is a device which is used to convert the kinetic energy of steam into mechanical energy.

48. *State the use of large size and small size turbines.*

In large sizes, it is used for driving electric generators. In small sizes, it is used to drive pumps, fans, compressors etc.

49. *Classify steam turbines.*

Steam turbines are classified as follows.

1. On the basis of method of steam expansion
   - (a) Impulse turbine
   - (b) Reaction turbine
   - (c) Combination of impulse and reaction turbine.
2. On the basis of number of stages
   - (a) Single stage turbine
   - (b) Multi-stage turbine.
3. On the basis of steam flow directions
   - (a) Axial turbine
   - (b) Radial turbine
   - (c) Tangential turbine
   - (d) Mixed flow turbine.
4. On the basis of pressure of steam
   - (a) High pressure turbine
   - (b) Low pressure turbine
   - (c) Medium pressure turbine.

50. *How does impulse work?*

The high velocity jet of steam which is obtained from the nozzle impinges on blades fixed on a rotor (disc). The blades change the direction of steam flow without changing its pressure. It causes the change in momentum and the force developed due to this drives the turbine rotor.

51. *What are the principles of impulse and reaction turbines?*

[Anna Univ. (Mech) Dec'11]

In impulse turbines, the high velocity jet of steam which is obtained from the nozzle impinges on blades fixed on a rotor. The blades change the direction of the

steam flow without changing its pressure. It causes the change in momentum and the force developed drives the turbine rotor.

In reaction turbines, there is no sudden pressure drop. There is a gradual pressure drop and it continuously takes place over fixed and moving blades. A number of wheels are fixed to the rotating shaft. Fixed guide ways are provided between pair of rotating wheels.

52. *State the function of fixed blades.*

The function of fixed blades is to guide the steam as well as to allow it to expand to a larger velocity.

53. *State the function of moving blades.*

1. It converts the kinetic energy of the steam into useful mechanical energy.
2. The steam expands while flowing over moving blades. Therefore, it gives a reaction to moving blades. So, the turbine is called *Reaction turbine.*
3. The velocity of the steam decreases as the kinetic energy of the steam absorbed.

54. *What is the fundamental difference between the operation of impulse and reaction steam turbines?* ***[Anna Univ.(Mech.)Nov'03, Apr'04, Dec'10 & May'11]***

S. No.	*Impulse turbine*	*Reaction turbine*
1.	It consists of nozzles and moving blades.	It consists of fixed blades and moving blades.
2.	Pressure drop occurs only in nozzles but not in moving blades.	Pressure drop occurs in fixed as well as moving blades.
3.	Steam strikes the blade with kinetic energy.	Steam passes over the moving blades with pressure and kinetic energy.
4.	It has constant blade channel area.	It has varying blade channel area.
5.	Due to more pressure drop per blade, the number of stages required is less.	The number of stages required is more due to more pressure drop.
6.	Power developed is less.	Power developed is considerably high.
7.	It occupies less space for the same	It occupies more space for the same

	power output.	power.
8.	Velocity of turbine is more.	Velocity of turbine is less.
9.	Efficiency is low.	Efficiency is high.
10.	Blade manufacturing is not difficult and thus, it is not costly.	Blade manufacturing process is difficult.

55. What is meant by compounding of steam turbines? ***[Anna Univ. Nov'10]***

Compounding is a method of absorbing the jet velocity in stages when the steam flows over moving blades.

56. Explain the need of compounding in steam turbines.

[Anna Univ.(Mech) Apr'03 & Apr'08]

or

Explain the purpose of compounding in steam turbines.

[Anna Univ. (Mech)Nov'04]

In the simple impulse turbine, the expansion of steam from the boiler pressure to condenser pressure takes place in a single stage turbine. The velocity of steam at the exit of turbine is very high. So, there is a considerable loss of kinetic energy (i.e. about 10 to 12%). Also, the speed of the rotor is very high (i.e. up to 30000*rpm*). There are several methods of reducing this speed to a lower value. *Compounding* is a method of absorbing the jet velocity in stages when the steam flows over moving blades.

57. What are the different methods of compounding?

1. Velocity compounding
2. Pressure compounding
3. Pressure-velocity compounding.

58. How are fixed blades and moving blades arranged in velocity compounding?

A number of moving blades are arranged in the form of rings of fixed blades keyed in a series on a common shaft.

59. A velocity compounded turbine is known as _____.

Curtis turbine.

60. *State any two advantages and disadvantages of velocity compounded turbines.*

Advantages:

1. Its initial cost is less because of few numbers of stages.
2. Less space is required.

Disadvantages:

1. Frictional losses are high due to high initial velocity. Therefore, the efficiency is low.
2. The ratio of blade velocity to steam velocity is not optimum for all wheels. It also reduces the efficiency.

61. *What is pressure compounding?*

If the pressure is reduced in each stage of nozzle rings, it is called *pressure compounding*.

62. *Rateau turbine is an example of* _____.

A pressure - compounded turbine.

63. *How is pressure-velocity compounding done?*

This method is a combination of pressure and velocity compounding. The total pressure drop is carried out in two stages and the velocity obtained in each stage is also compounded.

64. *A pressure–velocity compounding is also known as* _____.

Curtis and Moore turbine.

65. *What is meant by the term governing in turbines?*

The method of maintaining the speed of the turbine is constant irrespective of variation in load in the turbine known as *governing of turbines*.

66. *What is the function of governors in steam turbine?* ***[Anna Univ.(Mech.) Dec'08]***

The governors regulate the supply of steam to the turbine to maintain constant speed of the turbine as far as possible under varying load conditions.

67. *What are the different methods of governing steam turbines?*

[Anna Univ. (Mech.) Nov'04 & May'13]

1. Throttle governing
2. Nozzle control governing

3. By-pass governing
4. Combination of throttle and nozzle governing or throttle and by-pass governing.

68. *How is throttle governing done?*

Steam pressure at inlet to a steam turbine is reduced by a throttling process to maintain the constant speed of the turbine at part load.

69. *Where is nozzle control governing used?*

Nozzle control governing is used in large power steam turbines to which very high pressure steam is supplied.

70. *Where by-pass governing is more suitable?*

By-pass governing is more suitable for reaction turbines and a single by-pass valve.

71. *State the advantages of steam turbines.*

(i) It requires less space.
(ii) The absence of various links such as piston, piston rod, cross head etc. makes the mechanism simple.
(iii) It is quiet and smooth in operation.
(iv) Its over-load capacity is large.
(v) It can be designed for much greater capacities as compared to steam engine.
(vi) The internal lubrication is not required in steam turbines. So, it reduces the cost of lubrication.
(vii) In the steam turbine, the steam consumption does not increase with increase in year of service.

72. *What is the purpose of condenser?* ***[Anna Univ. (EEE) Dec'10]***

The main purpose of a steam condenser in turbine is to maintain a low back pressure on the exhaust side of the steam turbine.

73. *Explain any two types of surface condensers.* ***[Anna Univ. (Mech.) May'14]***

(i) Down flow type
(ii) Central flow condenser
(iii) Evaporation condenser.

74. Why does the cooling water flow inside the tubes and steam condense outside the tubes of the condenser? *[Anna Univ. (Mech.) Nov'08]*

The exhaust steam condensate is free from impurities because ordinary water is used to reduce the temperature of steam condensate coming from steam turbines.

75. What are the requirements of a modern condenser? *[Anna Univ. (Mech.) Nov'07]*

(i) The steam should be evenly distributed over the whole cooling surface of the condenser with minimum pressure loss.

(ii) The deposition of dirt on the outer surface of tubes should be prevented. It is achieved by passing the cooling water through tubes and allowing the steam to flow over tubes.

(iii) There should be no under cooling of condensate.

(iv) There should be no air-leakage into the condenser because it destroys the vacuum in the condenser. So, it reduces the work obtained per *kg* of steam. If there is leakage of air into the condenser, an air extraction pump should be used to remove air as rapidly as possible.

76. What is a pulveriser and why it is used?

[Anna Univ. (Mech.) May'14 & (EEE) Dec'10 & Dec'15]

A pulverizer or grinder is a mechanical device for grinding many different types of materials. Pulverizer mill is used to pulverize the coal for combustion in the steam-generating furnaces of fossil fuel power plants.

77. What are the advantages of burning coal in pulverized form?

[Anna Univ. (Mech.) Dec'07, Dec'12, Dec'13 & (EEE) Dec'11]

1) Coal is pulverized to increase its surface exposure and complete combustion.
2) High combustion temperature can be obtained.
3) By pass flow can be obtained to reduce the waste heat.
4) Clean combustible gases can be produced.
5) Combustion rate is increased.
6) Thermal-efficiency is increased.
7) Fuel feed rate is increased.
8) It has more heating surface area.

9) It requires less percentage of excess air.

10) Low grade fuel can also be used.

11) It is free from clinker troubles.

12) High temperature can be produced.

13) Preheated air is used to improve the pulverisation process.

14) No cooling equipment is required.

78. State the disadvantages of pulverized coal firing. ***[Anna Univ. (Mech.) Apr'08]***

(i) The capital cost of the pulverized coal firing system is high due to the requirement of many additional auxiliary equipment.

(ii) There is a need to use special and costly ash handling equipment such as electrostatic precipitator to control fly ash.

(iii) The flame temperature is too high. So, it needs water cooled walls for the safety of the furnace.

(iv) The possibility of the explosion is more as coal burn.

(v) The storage of powdered coal needs the special attention and high protection from fire hazards.

79. What is ESP? State its use. ***[Anna Univ. (Mech.) Dec'14]***

An electrostatic precipitator (ESP) is a filtration device which is used to remove fine particles such as dust and smoke from a flowing gas using the force of an induced electrostatic charge minimally impeding the flow of gases through the unit.

80. State the characteristic of good ash handling plant. ***[Anna Univ. (Mech.) May'11]***

(i) It should have large capacity to handle clinkers, boiler refuse, soot and dust.

(ii) It should be in such a way to handle hot and wet ash.

(iii) Both capital cost and running cost should be minimum.

81. Mention the uses of fly ash. ***[Anna Univ. (Mech.) May'11]***

Fly ash is mainly used to make use of this solid waste to save our environment. In addition to them, they are used in the following areas.

a) Concrete production

b) Embankments and other structural fills

c) Grout and flowable fill production

d) Waste stabilization and solidification

e) Cement clinkers production

f) Mine reclamation

g) Stabilization of soft soils

h) Road sub-base construction

i) Mineral filler in asphaltic concrete.

82. *Mention the various modern ash handling systems.* ***[Anna Univ. (EEE) May'10]***

(i) Gravitational separator

(ii) Cyclone separator

(iii) Packed type scrubber

(iv) Spray type wet collector

(v) Electrostatic precipitator (ESP).

83. *What is stoker? Classify it.* ***[Anna Univ. (Mech.) May'11]***

Stoker is a feeding device which feeds solid fuels into the furnace in medium and large size power plants.

Types:

(i) Overfeed stoker, and

(ii) Underfeed stoker.

84. *What are the principles of stokers?* ***[Anna Univ. (Mech.) Dec'12]***

The primary air enters the grate from the bottom. The air passing through the grate is heated by absorbing the heat from the ash and grates itself. So, the grate is cooled. Then the air is passed through a layer of incandescent coke and the oxygen in the air is reacted with coke to form CO_2. The rate of carbon oxidation depends on the rate of air supply. The water vapour present in the air also reacts with coke to form CO, CO_2 and H_2. The gases leaving the fuel bed contain the N_2, CO_2, CO, H_2 and H_2O. Then additional air is supplied to burn combustible gases. The burnt gases entering the boiler contain N_2, CO_2, O_2 and H_2O and some CO if the fuel burning is not completed.

85. *What do you understand by the term boiler draught?* ***[Anna Univ. (Mech.) May'13]***

Draught is defined as the movement of air through full bed which produces a flow of hot gases through the boiler and the chimney requires a pressure difference

between gas pressure and atmospheric pressure. This difference in pressure required to maintain the constant flow of air and discharge the gases known as *draught*.

86. *What are the various methods of obtaining draught control?*

[Anna Univ. (Mech.) May'11]

1. Forced draught unit operation
2. Induced draught unit operation
3. Multiple cell draught unit operation.

87. *List the advantages of balanced draft system.*

[Anna Univ. (Mech.) May'09 & May'11]

A power plant can be operated with a furnace pressure slightly below atmospheric to prevent flue gas leakage to the surroundings. The system allows using both induced and forced draft systems in order to combine the advantages of both.

88. *What are the factors affecting cooling of water in cooling tower?*

[Anna Univ. (EEE) May'10]

(i) The exposing time

(ii) Amount of water surface exposed

(iii) Relative humidity of air

(iv) Velocity of air

(v) Accessibility of air to various parts of cooling tower.

89. *What is superposed or topping cycle?*

Increasing the capacity of power plant by purchasing additional equipment or by superposing a high pressure non condensing steam plant on the existing plant is known as *topping cycle.*

1.38. SOLVED QUESTIONS

1. Draw a general layout of thermal power plant and explain the working of different circuits.

[*Anna Univ. (Mech.) Apr'05, May'11, May'13 & (EEE) May'10, Dec'10, Dec'11, Dec'12 & Dec'15*]

Refer chapter **1.2** in page **1.4**.

$$T_5 = \frac{T_4}{\left(\frac{5.91}{1.01}\right)^{\frac{\gamma-1}{\gamma}}} = \frac{973}{(5.85)^{\frac{1.4-1}{1.4}}} = 587.39K$$

The actual temperature at the end of expansion,

$$\eta_T = \frac{T_4 - T_5'}{T_4 - T_5} = \frac{973 - T_3'}{973 - 587.39} = 0.85$$

$$\therefore \quad T_5' = 645.23\ K$$

Effectiveness of regenerator,

$$\in = \frac{T_3 - T_2'}{T_5' - T_2'} = \frac{T_3 - 528.66}{645.23 - 528.66} = 0.75$$

$$\therefore T_3 = 616.09K$$

Heat supplied,

$$Q_S = m \times C_p (T_4 - T_3) = 1 \times 1.005 \times (973 - 616.09) = 358.69 kJ/kg$$

Network done,

$$W = W_T - W_C$$
$$= C_p (T_4 - T_5') - C_p (T_2' - T_1)$$
$$= 1.005 \times [(973 - 645.23) - (528.66 - 288)] = 87.55\ kJ/kg$$

Efficiency, $\eta = \frac{W}{Q_S} = \frac{87.55}{358.69} = 0.2441 = \mathbf{24.41\%}$ **Ans.**

2.18. TWO MARK QUESTIONS AND ANSWERS

1. ***What is a thermodynamic cycle?*** ***[Anna Univ. Oct' 97]***

Thermodynamic cycle is defined as the series of processes performed on the system so that the system attains its original state.

2. ***Why is Carnot cycle not used in real applications?*** ***[Anna Univ. Dec'10]***

(i) In a Carnot cycle, all four processes are reversible but there is no process reversible in actual practice.

(ii) There are two processes to be carried out during compression and expansion. During isothermal process, the piston moves very slowly and the piston moves as fast

as possible during adiabatic process. This speed variation during the same stroke of the piston is not possible.

(iii) It is not possible to avoid friction between moving parts completely.

3. ***A Carnot cycle works between the temperatures 300 K and 700 K. Find the maximum work possible per kg of air.*** ***[Anna Univ. Nov'07]***

Given data:

$T_H = 700\ K$

$T_L = 300\ K$

☺ ***Solution:***

Maximum possible efficiency of Carnot cycle

$$\eta_{max} = \frac{T_H - T_L}{T_H} = \frac{700-300}{700} = 0.571 = 57.1\ \%$$

Also $\eta_{max} = \frac{W_1}{Q_S}$

Maximum possible work of Carnot cycle

$$W_{max} = Q_S \times \eta_{max} = 1 \times 0.571 = \mathbf{0.571\ kJ\ Ans.}$$

[∵ Assume that 1 *kJ* of heat is supplied]

4. ***What is an air-standard cycle? Why such cycles are conceived?***

[Anna Univ. Oct' 96, Oct' 97, Nov'10, May'11, Dec'12 & May'14]

Cycle is defined as the series of operations or processes performed on a system so that the system attains its original state. The thermodynamic cycles which use air as the working fluid is known as *air standard cycles*.

Air standard cycles are conceived to simplify the analysis of IC engines.

5. ***Name the various "gas power cycles".***

1. Carnot cycle
2. Otto cycle
3. Diesel cycle
4. Brayton cycle
5. Duel combustion cycle
6. Atkinson cycle.

6. *What are the assumptions made for air standard cycle analysis?*

[Anna Univ. Nov'02, May'03, Apr'05, June'09, May'11 & May'13]

1. The working medium is a perfect gas throughout i.e., It follows the law $pV = mRT$
2. The working medium does not undergo any chemical change throughout the cycle.
3. The compression and expansion processes are reversible adiabatic i.e., There are no loss or gain of entropy.
4. Kinetic and potential energies of the working fluid are neglected.
5. The operation of the engine is frictionless.
6. Heat is supplied and rejected in a reversible manner.

7. *Mention the various processes of Otto cycle.*

1. Isentropic compression
2. Constant volume heat supplied
3. Isentropic expansion, and
4. Constant volume heat rejection.

8. *Mention the four thermodynamic processes involved in Diesel Cycle.*

[Anna Univ. Apr'08]

(i) One reversible adiabatic compression,

(ii) One constant pressure processes,

(iii) One reversible adiabatic expansion, and

(iv) One constant volume.

9. *Mention the various processes of dual cycle.*

[Anna Univ. Apr'96]

1. Isentropic compression
2. Constant volume heat addition
3. Constant pressure heat addition
4. Isentropic expansion, and
5. Constant volume heat rejection.

10. Sketch Otto cycle on p-V diagram and name all processes. ***[Anna Univ. Apr'04]***

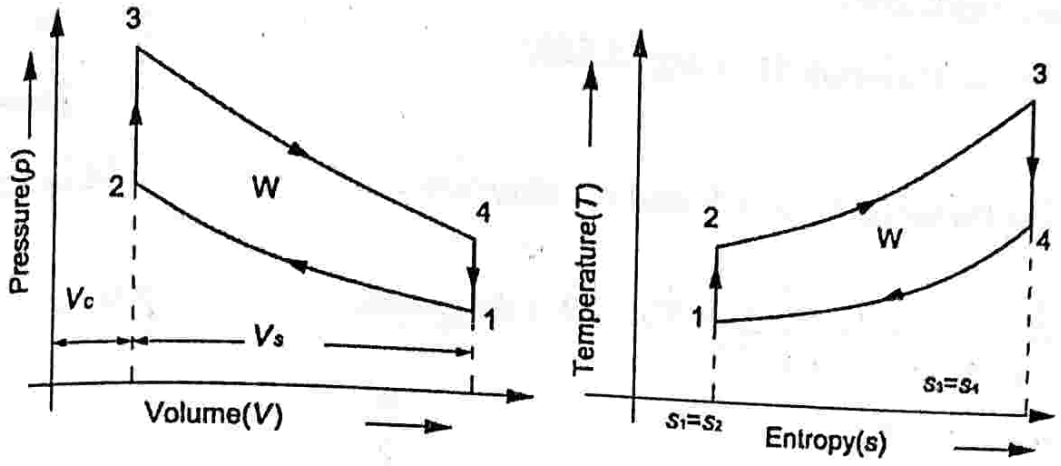

Figure 2.77 Otto cycle

1-2 ⇨ Isentropic compression

2-3 ⇨ Constant volume heat addition

3-4 ⇨ Isentropic expansion

4-1 ⇨ Constant volume heat rejection.

11. In an engine working on an ideal Otto cycle, the temperatures at the beginning at the end of compression are 27° C and 327° C respectively. Find the compression ratio and air standard efficiency of the engine. ***[Anna Univ. Dec'11]***

Given data:

$T_1 = 27° C = 27+273 = 300\ K$

$T_3 = 327° C = 327+273 = 600\ K$

Solution:

$$\frac{V_1}{V_2} = \left(\frac{T_2}{T_1}\right)^{\frac{1}{\gamma-1}}$$

$$\frac{V_1}{V_2} = \left(\frac{600}{300}\right)^{\frac{1}{1.4-1}} = 5.67$$

Air standard efficiency,

$$\eta = 1 - \frac{1}{(r)^{\gamma-1}} = 1 - \frac{1}{(5.67)^{1.4-1}} = 50\%$$

Ans.

12. *In an Otto cycle, the pressure ratio during compression is 11. Calculate the air standard efficiency.* *[Anna Univ. June'09]*

Similar to **Question 11** in page **2.159.**

[Ans:- 49.597%]

13. *Plot the Diesel cycle on p-V and T-s diagrams.* *[Anna Univ. Oct'01]*

or

Sketch the Diesel cycle on p-V and T-s diagrams. *[Anna Univ. Nov'04]*

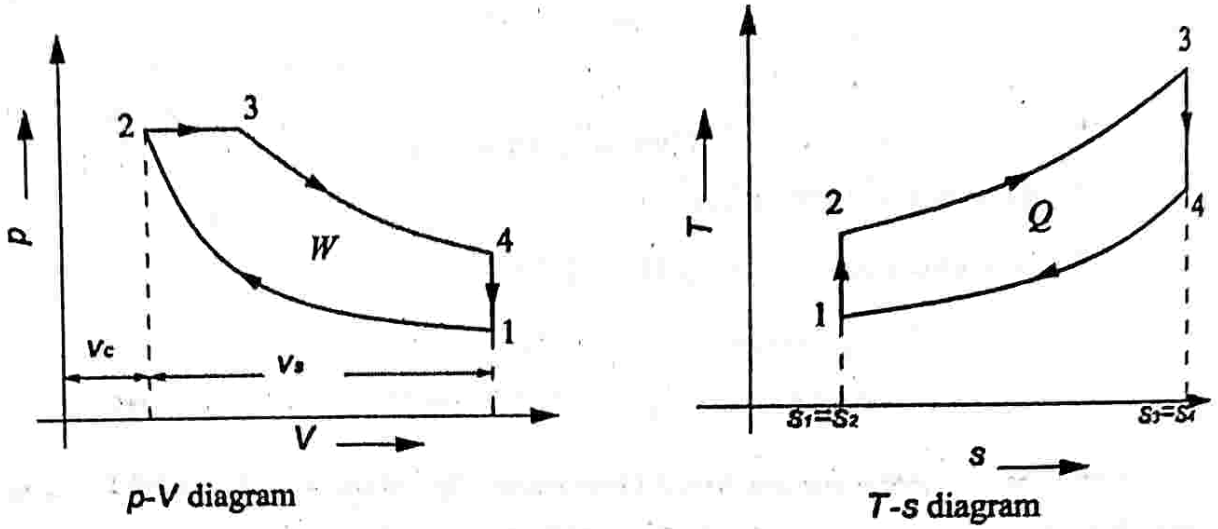

Figure 2.78 Diesel cycle

14. *Define air standard efficiency of Diesel cycle.* *[Anna Univ. Dec'08]*

Air standard efficiency is defined as the ratio of work done by the cycle to the heat supplied to the cycle.

15. *Sketch the dual cycle on p-V and T-s coordinates and name the various processes.*

[Anna Univ. Apr'03, Dec'10 & May'15]

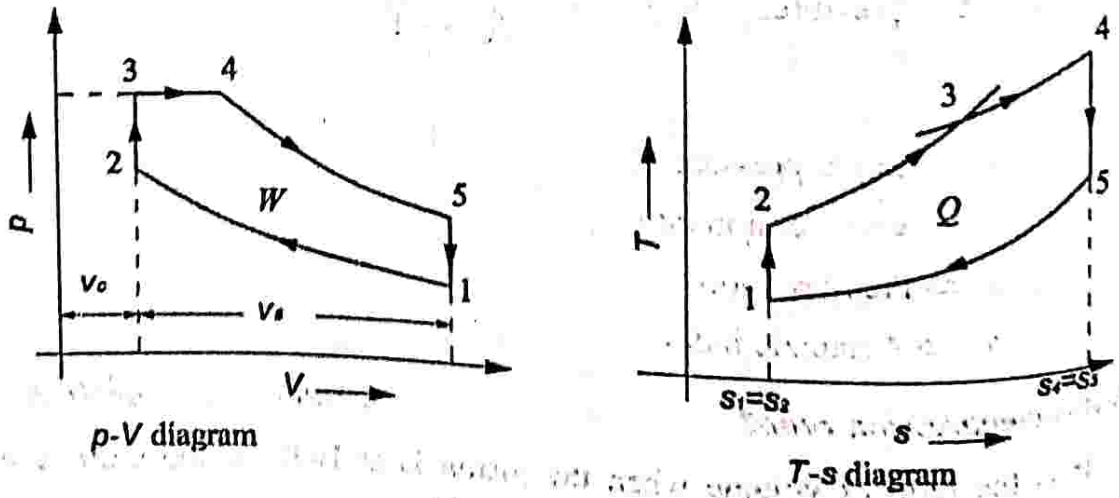

Figure 2.79 Dual cycle

1-2 ⇨ Isentropic compression

2-3 ⇨ Constant volume heat addition

3-4 ⇨ Constant pressure heat addition

4-5 ⇨ Isentropic expansion

5-1 ⇨ Constant volume heat rejection.

16. ***Define mean effective pressure. What is its importance in reciprocating engines?*** ***[Anna Univ. Apr' 95, Apr' 96, Apr'05, Nov'07, Dec'08, Nov'10, May'11, May'12 & Dec'13]***

Mean effective pressure is defined as the constant pressure acting on the piston during the working stroke. It is also defined as the ratio of work done to the stroke volume or piston displacement volume.

Mean effective pressure,

$$p_m = \frac{\text{Indicated power}}{\text{No. of working stroke} \times \text{Stroke volume per second}}$$

The mean effective pressure indirectly refers the capacity of engine. It is useful to compare engines at different displacements and design calculations. It is a measure of performance of the engine.

MEP is the quantity related to the operation of an IC engine and it is a valuable measure of an engine's capacity to do work which is independent of engine displacement.

17. ***Write an expression for mean effective pressure for an Otto cycle in terms of compression ratio and other parameters.*** ***[Anna Univ. Apr' 99]***

Mean effective pressure, $p_m = p_1 r\left(\frac{k-1}{\gamma-1}\right)\left(\frac{r^{\gamma-1}-1}{r-1}\right)$

where

p_1 ⇒ Initial pressure

r ⇒ compression ratio

k ⇒ Pressure ratio

γ ⇒ Adiabatic index.

18. ***What is compression ratio?*** ***[Anna Univ. Nov'10 & May'14]***

It is the ratio of volume when the piston is at BDC to the volume when the piston is at TDC.

Compression ratio, $r = \frac{V_1}{V_2} = \frac{V_1}{V_c} = \frac{V_s + V_c}{V_c}$

19. *How does the change in compression ratio affect air standard efficiency of an ideal Otto cycle?* ***[Anna Univ. Apr'08]***

The efficiency of Otto cycle *increases with increase in compression ratio and vice versa.*

20. *Define cut-off ratio.* ***[Anna Univ. May'14]***

Cut off ratio is defined as the ratio of volume after heat addition to the volume before heat addition.

21. *Define expansion ratio.*

Expansion ratio is the ratio of volume after expansion to the volume before expansion.

22. *Which cycle is more efficient with respect to the same compression ratio?*

[Anna Univ. Oct' 95]

For the same compression ratio, Otto cycle is more efficient than Diesel cycle.

23. *Sketch Otto and Diesel cycle for the same compression ratio and heat input and compare the efficiency.* ***[Anna Univ. Apr'03, May'11, May'12 & Dec'13]***

In *T-s* diagram of Figure 2.80, the cycle 1-2-3-4-1 represents Otto cycle and the cycle 1-2-3'-4'-1 represents Diesel cycle. The area under *T-s* diagram for Otto cycle is higher than Diesel cycle. So, the efficiency of Otto cycle will be higher than Diesel cycle.

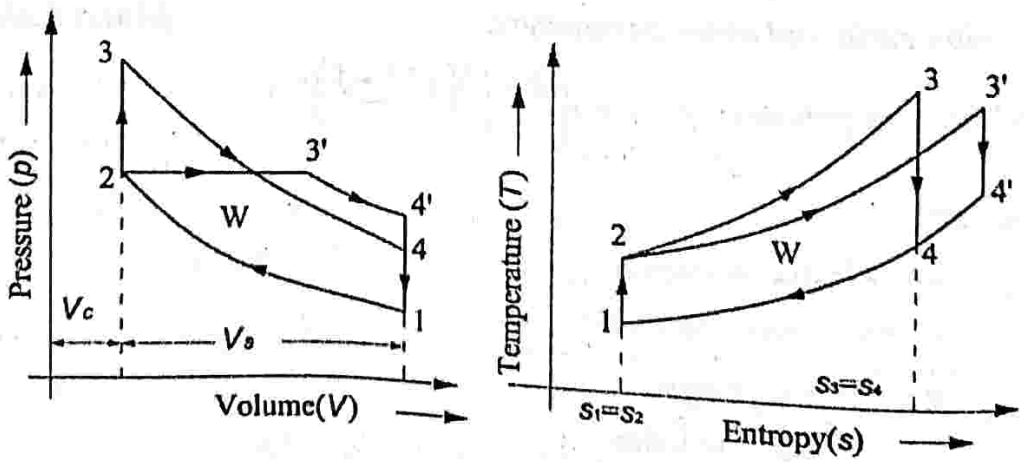

Figure 2.80

$\eta_{otto} > \eta_{Diesel}$

24. ***For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, Diesel and dual cycle.*** ***[Anna Univ. Apr'98 &Oct' 98]***

$\eta_{otto} > \eta_{Dual} > \eta_{Diesel}$

25. ***Represent the Otto, Diesel and dual cycle on p-V coordinates for the same compression ratio and same heat input.*** ***[Anna Univ. Apr' 97]***

1-2-3-4-1 ⇨ Otto cycle

1-2-2'-3'-4'-1 ⇨ Dual cycle

1-2-3"-4"-1 ⇨ Diesel cycle.

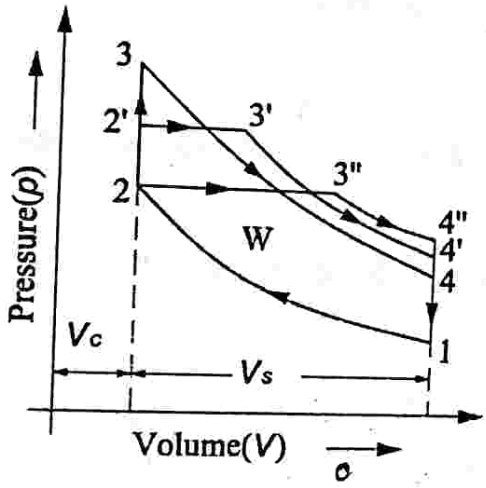

Figure 2.81

26. ***What is the range of compression ratio for Otto and Diesel cycles?***

For Otto cycle 6 to 8 and for Diesel cycle 12 to 16.

27. ***Name the factors that affect air standard efficiency of Diesel cycle.***

[Anna Univ. Apr' 97]

Compression ratio and cut-off ratio.

28. ***What is the effect of cut-off ratio on the efficiency of Diesel cycle when the compression ratio is kept constant?*** ***[Anna Univ. Apr'03]***

When the cut-off ratio of Diesel cycle increases, the efficiency of cycle is decreased when the compression ratio is kept constant and vice versa.

29. ***Write down the expression for mean effective pressure for Diesel cycle and dual cycle in terms of r, p and k.***

For Diesel cycle, $p_m = \dfrac{p_1 r^{\gamma}\left[\gamma(\rho-1) - r^{1-\gamma}\left(\rho^{\gamma}-1\right)\right]}{(\gamma-1)(r-1)}$

For Dual cycle, $p_m = \dfrac{p_1 r^\gamma \left[k\gamma(\rho-1) + (k-1) - r^{1-\gamma}\left(k\rho^\gamma - 1\right)\right]}{(\gamma-1)(r-1)}$

30. The efficiency of the Diesel cycle approaches Otto cycle efficiency when the cut off ratio is ————————

Reduced to zero.

31. In Otto cycle, the compression ratio is ———————— to expansion ratio.

Equal

32. In Diesel cycle, the compression ratio is ———————— than expansion ratio.

Greater

33. Write the expression for efficiency of the Diesel cycle in terms of compression ratio and cut-off ratio.

Air standard efficiency of Diesel cycle,

$$\eta_{Diesel} = 1 - \frac{1}{\gamma(r)^{\gamma-1}}\left(\frac{\rho^\gamma - 1}{\rho - 1}\right)$$

where $\rho \Rightarrow$ Cut-off ratio

$r \Rightarrow$ compression ratio.

34. Write any four major differences between Otto and Diesel cycles.

[Anna Univ. (EEE) Dec'15]

S. No.	*Otto cycle*	*Diesel cycle*
1.	Otto cycle consists of two isentropic ad two constant volume processes.	It consists of two isentropic, one constant volume and one constant pressure process.
2.	Heat addition takes place at constant volume.	Heat addition takes place at constant pressure.
3.	Compression ratio is equal to expansion ratio.	Compression ratio is greater than expansion ratio.
4.	Efficiency is more than Diesel cycle for the same compression ratio and heat input.	Efficiency is less.

35. *Define the terms actual thermal efficiency and relative efficiency.*

[Anna Univ. Dec'12]

Actual efficiency is defined as the ratio of work output by the cycle to the heat input to the cycle.

Relative efficiency is defined as the ratio between actual efficiency and air standard efficiency.

$$\eta_{relative} = \frac{\eta_{actual}}{\eta_{air\ standard}}$$

36. *Draw p-V and T-s diagrams of Brayton cycle.*

[Anna Univ. Apr'05]

or

Sketch the limited pressure cycle on p-V and T-s diagrams and name various processes.

[Anna Univ. Oct'02]

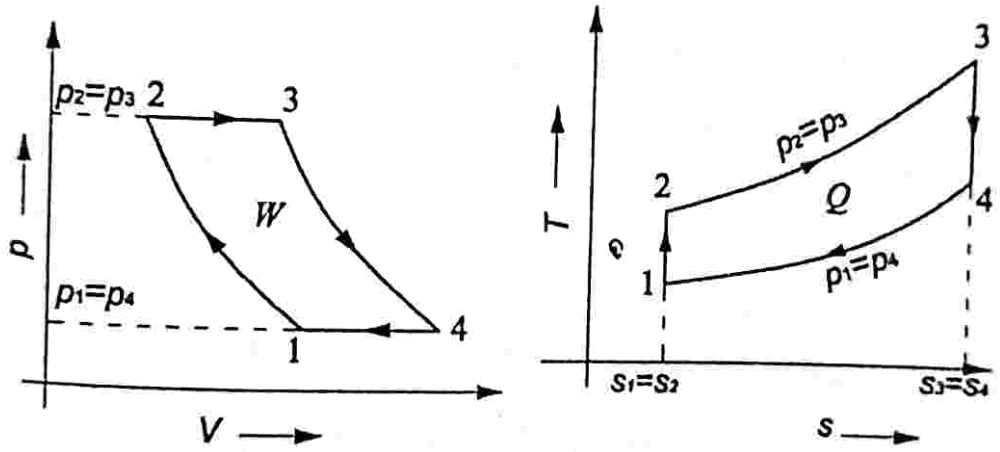

Figure 2.82

37. *List down the various processes of the Brayton cycle.* *[Anna Univ. Oct' 1996]*

1. Isentropic compression
2. Constant pressure heat supplied
3. Isentropic expansion, and
4. Constant pressure heat rejection.

38. *What is meant by Atkinson cycle?* *[Anna Univ. (Mech.) May'11]*

The cycle with two adiabatic processes for both compression and expansion, one constant volume process for heat addition and one constant pressure process for heat rejection is called *Atkinson cycle*.

39. *Mention a few characteristics of Diesel power plant.* ***[Anna Univ. (Mech.) Dec'12]***

(i) Diesel power plants are mainly used where high-torque is required.

(ii) Fuel and fluid characteristics mean that Diesel power plant could be operated with variety of different fuels depending on configuration.

(iii) Hybrid possibilities are to combine with other power producing devices.

40. *Under what circumstance will you recommend Diesel power plants?*

[Anna Univ. (Mech.) Dec'14]

Diesel power plants are mainly recommended where the fuel prices or reliability of supply favour oil over coal where the water supply is limited and relatively small loads.

41. *What are the components present in the Diesel electric power plants?*

[Anna Univ. (Mech.) Apr'08]

(i) Engine

(ii) Air intake system

(iii) Engine starting system

(iv) Fuel system

(v) Exhaust system

(vi) Cooling system

(vii) Lubricating system.

42. *What are the applications of Diesel power plant?*

1. Peak load plant
2. Mobile plants
3. Stand by units
4. Emergency plant
5. Starting station
6. Nursery station.

43. *Name the various types of Diesel engine used for Diesel power plant.*

[Anna Univ. (Mech.) May'13]

(1) Small size diesel engine

(2) Medium size diesel engine

(3) Large size diesel engine.

44. What are the different types of engines used in power generation? State their application domain. ***[Anna Univ. (Mech.) May'11]***

1. Diesel engines
2. Dual engines

45. How is solid injection system classified? ***[Anna Univ. (EEE) June'13]***

1. Individual pump and nozzle system
2. Unit injector system
3. Common rail system
4. Distributor system.

46. What are the methods of cooling in a Diesel engine power plant?

1. Thermo-system cooling
2. Forced or pump cooling
3. Pressurised cooling
4. Evaporative cooling
5. Cooling with thermostatic regulator.

47. What are the methods of starting systems in large and medium size engines?

1. Starting by an auxiliary engine.
2. Use of electric motors or self-starters.
3. Compressed air system.

48. What are the functions of lubrication system? ***[Anna Univ. (EEE) Dec'11]***

- Supplying clean lubricating oil with certain viscidity to friction parts by keeping the liquid friction between two parts moving face to face to avoid dry friction and reduce abrasion. So, it abases the power consumed by friction.
- Taking away the heat and metal scraps bring by friction.

49. What are the different types of lubrication system in a diesel power plant. ***[Anna Univ. (Mech.) May'14]***

1. Wet sump lubrication

2. Dry sump lubrication
3. Mist lubrication system

50. What are the methods of cooling the engine?

1. Air cooling
2. Water cooling.

51. What are equipment of a diesel engine power plant? [Anna Univ. (Mech.) Nov'07]

1. Pneumatic starter
2. Air compressor
3. Air-conditioning, and
4. Coolant circulation pump.

52. What are the methods used for starting a diesel engine?

[Anna Univ. (Mech.) Nov'07]

(i) Starting by an auxiliary engine

(ii) Use of electric motors or self-starters

(iii) Compressed air system.

53. Mention the advantages of diesel engine power plant. [Anna Univ. (EEE) Dec'10]

1. Diesel power plants are cheaper.
2. Plant layout is simple.
3. Location of the plant is near the load center.
4. It provides quick starting and easy pick-up of loads.
5. Skilled manpower is not required.
6. Time schedule for manufacturing are short.
7. Diesel plants operate at high overall efficiency than steam plants.
8. Fuel handling is easier and no problem of ash disposed.
9. Efficiency does not fall so much as that of a steam plant during parts loads.
10. It has no stand by losses.

54. What are the applications of diesel engine power plants?

[Anna Univ. (Mech.) Nov'07& May'11, & (EEE) May'10]

(i) It is quite suitable for mobile power generation.

(ii) It is used as peak load plants in combined with thermal or hydro plants.

(iii) It is used as stand by plants for emergency service.

55. ***What is the basic difference between a diesel engine and a steam turbine?***

[Anna Univ. (EEE) Dec'12]

The basic difference is that Diesel engine is internal combustion (IC) engine whereas the steam turbine is external combustion engine.

56. ***Why is the maximum cycle temperature of gas turbine plant much lower than that of diesel power plant?***

[Anna Univ. (Mech.) May'09]

Air alone is combusted in gas turbine plant instead of air-Diesel combustion in the Diesel power plant.

57. ***How gas turbine power plants are classified?***

[Anna Univ. (Mech.) Nov'07, (EEE) Dec'10 & Dec'13]

1. According to the cycle of operation
   a. Open cycle gas turbine
   b. Closed cycle gas turbine and
   c. Semi closed cycle gas turbine.
2. According to the process
   a. Constant pressure gas turbine and
   b. Constant volume gas turbine.
3. According to the use
   a. Industrial gas turbine and
   b. Air craft gas turbine.
4. According to the type of load
   a. Peak load
   b. Stand by
   c. Base load.
5. According to the application
   a. Aircraft
   b. Marine

c. Locomotive

d. Transport.

6. According to the type of fuel

a. Liquid

b. Gas

c. Solid.

7. According to the number of shafts

a. Single shaft

b. Multi-shaft.

58. State the fuels used in the gas turbine power plants. ***[Anna Univ. (EEE) May'11]***

Residual liquid fuels, the residue left after the profitable light fractions have been extracted from the crude have been used in gas turbines to some extent.

59. What do you understand by a closed cycle gas turbine power plant?

[Anna Univ. (Mech.) May'11]

In a closed cycle gas turbine, the air is isentropically compressed in air compressor to a required pressure and then it is passed through a combustion chamber where the fuel injects to the air and ignited. The high temperature air from combustion chamber expands through a gas turbine where the heat energy is converted into mechanical energy. Then, the exhaust gas from the gas turbine is passed through a pre-cooler where it is cooled at constant pressure with the help of circulating water to its original pressure. Then, the same air is passed through the compressor again and again.

60. What are the main units in a gas turbine power plant?

[Anna Univ. (Mech.) Dec'13 & (EEE) Dec'10]

1. Compressor
2. Combustion chamber
3. Turbine.

61. What is the difference between open cycle and closed cycle gas turbine plant?

[Anna Univ. (Mech.) Apr'08 & (EEE) Dec'11]

S. No.	Open cycle gas turbine	Closed cycle gas turbine
1.	No pre-cooler is required because of burnt gas from gas turbine exhausted to atmosphere.	A separate pre-cooler arrangement is necessary.
2.	For the same power developed, the size and weight of the open cycle gas turbine unit are less.	The size and weight are more.
3.	Initial cost and maintenance cost of the plant are less.	Initial cost and maintenance cost are more.
4.	Combustion efficiency is more.	Combustion efficiency is less.
5.	Coolant is not required, therefore, it is used for moving vehicle such as air craft, jet propulsion etc.	Coolant is required for pre cooler, therefore, it is used for stationary applications such as power generation etc.
6.	The response to load variation is greater than a closed cycle gas turbine.	The response to load variation is less.

62. ***Is it always useful to have a regenerator in a gas turbine power cycle? Why?***

It is not always useful to have a regenerator in a gas turbine cycle. The regenerator causes the pressure drop of 0.035*bar* to 0.2 *bar* in compressed air and about 0.035*bar* in exhaust gases. These pressure drops affect to contain extend the gain in efficiency due to regeneration.

63. ***Why power generation by gas turbines in attractive these days?***

[Anna Univ. (Mech.) May'11 & (EEE) Dec'15]

Gas turbines are attractive because of their ability to quickly ramp up power production.

64. ***List the various factors which influence the performance of gas turbine.***

[Anna Univ. (EEE) Dec'10]

1) Air temperature and site elevation
2) Humidity

4) Fuels
5) Fuel heating
6) Diluent injection
7) Air extraction.

65. *What are all modifications are carried out in Brayton cycle? Why?*

In Brayton cycles, the following devices can be incorporated to increase its thermal efficiency such as (i) regenerator, (ii) reheater and (iii) intercooler.

66. *Sketch the schematic arrangement of open cycle gas turbine plant and name the components.* ***[Anna Univ. Apr'04]***

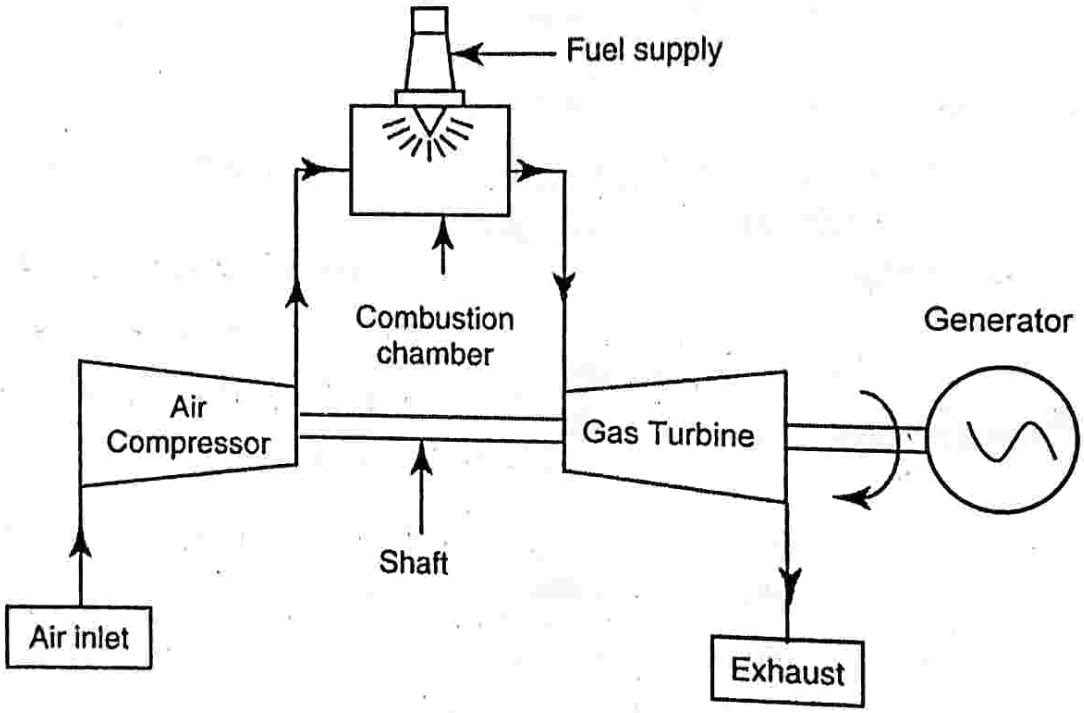

Figure 2.83

67. *What is the expression for optimum pressure ratio for the maximum specific work output in Brayton cycle?*

Optimum pressure ratio $R_p = \left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}$

68. *Why the gas turbine plants are generally designed for optimum pressure ratio for maximum specific work output?*

It results the small plant and the efficiency curve is nearly flat in this region.

69. When will be the gas turbine cycle efficiency reaches maximum?

When pressure ratio, $R_p = 1$ and is equal to $\left(\frac{T_3 - T_1}{T_3}\right)$

70. In case of regenerative cycle, what are the factors affecting thermal efficiency of the cycle?

Maximum cycle temperature and pressure ratio.

71. What are the methods by which thermal efficiency of a gas turbine power plant be improved? *[Anna Univ. (EEE) May'12 & Dec'12]*

1. Intercooling
2. Reheating
3. Regenerator
4. Combination of intercooling, reheating and regenerator.

72. What is intercooling and why it is done? *[Anna Univ. (Mech.) May'14]*

The process of reducing the temperature of the compress gas which reduces its volume is known as *intercooling*. It is done to reduce the work done by the compressor with less volume which will reduce the input power.

73. What are the effects of introducing regeneration in the basic gas turbine cycle?

(i) The fuel economy is improved. The quantity of fuel required per unit mass of air is less.

(ii) The work output from turbine increases when the work required to the compressor will not change.

(iii) The pressure drop will occur during regeneration.

(iv) It increases the thermal efficiency when the low pressure ratio reduces.

74. When will the intercooler be provided between two compressors?

When the pressure ratio is very high, then the intercooler is provided between compressors.

75. What are the effects of providing the intercooler in the gas turbine cycle?

(i) Heat supply is increased.

(ii) It decreases the thermal efficiency.

(iii) Work ratio will be increased.

(iv) Specific volume of air is reduced.

76. When is the reheater employed in the gas turbine cycle?

When the air-fuel ratio is high, the combustion products after expansion in the high-pressure turbine contain more oxygen. It is done by introducing a reheater. So, the exhaust pressure can be sent and again expanded in the low-pressure turbine.

77. What is the condition for maximum work in the case of reheater employed in the gas turbine cycle?

For optimum work, the pressure ratio is equal for all stages.

i.e. $R_{P_1} = R_{P_2} = \ldots\ldots\ldots = (R_P)^{\frac{1}{n}}$

where R_P = pressure ratio

n = number of stages.

78. What are the effects of reheat cycle?

(i) Thermal efficiency is less since the heat supplied is more.

(ii) Turbine output is increased for the same expansion ratio.

79. What is reheating and regeneration of gas turbine? [Anna Univ. (Mech.) Dec'12]

The process of heating the expanded air coming out of the first turbine which will be supplied to the second turbine for further expansion is called *reheating*.

The fraction of steam bled for process operations in the power plant cycle is called *regeneration*.

80. What is meant by regeneration? [Anna Univ. (EEE) May'12]

The temperature of the exhaust gases of the turbine is higher than the temperature of the air after compression. If the heat energy is used to heat the air after compression in the heat exchanger called "*regeneration*". It will reduce the energy requirement from the fuel thereby increasing the efficiency of the cycle.

81. What do you mean by regeneration in gas turbine power plant? [Anna Univ. (EEE) June'13]

The partial bleeding of steam from the turbine to preheat the air to reduce the fuel consumption and increase the efficiency is called *regeneration*.

82. *How does regeneration improve the thermal efficiency of gas turbine cycle?*
[Anna Univ. (Mech.) Dec'14]

Regeneration reduces the energy requirement from the fuel thereby increasing the efficiency of the cycle.

83. *State the merits and demerits of closed cycle gas turbine over open cycle gas turbine power plant.*
[Anna Univ. (EEE) May'10]

Merits:

(i) Efficiency is same throughout the cycle.

(ii) The turbine blades do not wear away since the combustion is external.

(iii) Starting of the plant is easy.

(iv) Low quality fuels can be used since the combustion is external.

(v) Thermal stresses are low.

(vi) There is no need for internal cleaning.

Demerits:

(i) A separate pre-cooler arrangement is necessary.

(ii) The size and weight are more.

(iii) Initial cost and maintenance cost are more.

(iv) Combustion efficiency is less.

(v) Coolant is required for pre-cooler. Therefore, it is used for stationary applications such as power generation etc.

(vi) The response to load variation is less.

84. *How the gas turbine blades are cooled?* ***[Anna Univ. (Mech.) Nov'08 & May'11]***

Film cooling of turbine blades in gas turbines is done by the principle of

(i) drawing cooling air from compressor

(ii) injecting of coolant onto blade surface

(iii) creating of an insulating sub layer

(iv) lowering the effective gas temperature in the boundary layer.

85. *What are the applications of gas turbine plant?*

[Anna Univ. (Mech.) Dec'12 & May'13]

(1) Gas turbine power plants are mainly used as peak load power plants, emergency stand-by unit or hydro-station stand-by unit and base load plant under specific conditions.

(2) It has relatively low installation cost per *kW* installed capacity recommended source of peaking or emergency power.

(3) The quick starting and good response characteristics of the gas turbine plant make the gas turbine as desirable peak load and essential stand-by plant.

(4) The gas turbine can be used as base load plant where the gas turbine fuel is relatively cheap.

86. *What is the principle of operation of simple jet propulsion system?*

[Anna Univ. Nov'03]

When the works output of the gas turbine plant is used to produce high velocity jet of hot gases, this jet is used to propel the vehicles in which the systems are mounted. Such systems are kept as jet propulsion systems.

87. *Mention any two drawbacks of a stationary gas turbine power plant for generation of electricity.*

[Anna Univ. (Mech.) Apr'08]

(i) The part load efficiency is poor.

(ii) The unit is operated at high temperature and pressure, so special metals are required to maintain the unit.

(iii) Major part of the work (about 66%) developed in the turbine is used to drive the compressor.

(iv) The devices that are operated at high temperature are complicated.

88. *What are the pollutants present in the gas turbine exhaust?*

[Anna Univ. (Mech.) May'11]

a) C_xH_y (or H_x or HC) = Hydrocarbons

b) CO = Carbon Monoxide

c) NO_x = Nitrogen oxides

d) SO_2 = Sulphur dioxide

e) PM = Particulate matter

89. What is meant by combined cycle power plant? *[Anna Univ. (EEE) May'11]*

The maximum steam temperature in a power cycle exceeds 600°C but the pulverized coal furnace temperature is about 1300° C. So, there is a lot of energy wasted in the power plant. To increase the efficiency and reduce the fuel, the combined power cycles are introduced by superposing a high temperature power plant as a topping unit to a low temperature power plant as a bottoming unit.

90. List out the inherent advantages of the combined power cycle.
[Anna Univ. (Mech.) Nov'08& Dec'13]

1. It produces low environmental effect.
2. It needs less amount of water.
3. Investment cost is low.
4. The efficiency of combined cycle plant is more than the open cycle power plant.
5. When compared with ordinary steam plants, these plants produce less smoke.
6. It is simple in operation.
7. It gives high ratio of power output to fuel.

91. What is meant by IGCC?

Gasification of coal is the cleanest way of utilization of coal while combined cycle power generation gives the highest efficiency. Integration of these two technologies is known as *IGCC*.

IGCC is a combined cycle process fuelled by coal which is gasified by heating it in a gasifier in the presence of steam and oxygen. The resulting fuel gas is made up mainly of hydrogen and carbon monoxide and when it is cleaned of impurities and burnt in a gas turbine to produce electricity, carbon dioxide and water vapour.

92. What are the advantages of IGCC?

(i) It produces higher efficiencies and lower emissions.

(ii) Improvements in efficiency dramatically reduce the emissions from coal combustion.

(iii) Product flexibility is ensured.

independent and diverse shutdown systems to achieve reactor shutdown with very high reliability. The first shutdown system is gravity driven solid rods, whereas the second one passively injects liquid poison in reactor core.

In addition to normal cooling circuits for power evacuation, an emergency core cooling system is provided for effective removal of heat from the reactor core under accident conditions. In this design, the steam generators are located at higher elevation than core. This ensures removal of heat by thermo-siphon in the event of total loss of AC power to the plant. The concrete vault housing the reactor vessel is filled with water. This provides a large heat sink against progression of any core damage accident. Availability of large volume of low pressure moderator in the reactor vessel is also an inherent advantage for core cooling in case of an accident.

All the standardized PHWR based nuclear power plants are provided with double containment with inner primary containment of pre-stressed concrete acting as a primary barrier against release of any radioactivity to the atmosphere in the event of an accident. The primary containment is designed conservatively for a pressure much higher than that estimated to occur during the postulated design basis accident. Thus it can prevent releases even in case of certain level of beyond design basis accidents.

For the plants constructed before NAPS (viz. TAPS-1&2, MAPS-1&2, RAPS-1&2), significant safety improvements have been carried out through backfits and safety upgrades based on periodic and specific safety reviews. Major among them relate to improvements in seismic safety, emergency core cooling and ageing management.

India has also witnessed a few significant events at its nuclear power plants, namely a large fire at NAPS in 1993, flooding at KAPS-1&2 in 1994, and tsunami at MAPS-1&2 in 2004. Lessons learnt from these events, as also from relevant events at nuclear power plants abroad, have been incorporated by appropriate improvements in design and operating procedures.

The two LWR units at Kudankulam and the FBR at Kalpakkam are of advanced designs. Besides having all the regular design safety features, they incorporate passive air cooled systems for removal of core heat during emergency conditions.

3.25. TWO MARKS QUESTIONS AND ANSWERS

1. ***What are the advantages of nuclear power plant?***

   - There is no atmospheric pollution by combustion products

- Space requirement is less as compared to other conventional power plants of equal size
- Environmental pollution is less when compared to fossil fuel power plants
- It is well suited to meet large power demands. They give better performance at high load factors (80 to 90%)
- It provides the increased reliability of operation
- Fuel transportation cost is less and large storage facilities are not needed since the nuclear fuel has very high energy density
- Nuclear power plants are not affected by adverse weather conditions
- The expenditure on metal structure, piping, storage mechanisms is much lower for nuclear power plants than coal burning power plants
- Water requirement is very less.

2. *What is atom?*

The smallest particle of an element which takes a part in chemical reaction is known as '*atom*'.

3. *State the Daltons atomic theory.*

1. All atoms of one element are precisely alike and they have the same mass but they differ from atoms of other elements.
2. The chemical combination consists of the union of small fixed number of atoms of one element with a small fixed number of other elements.

4. *What is atomic number and mass number?*

The number of protons in the nucleus is called *atomic number*. It is denoted by '*Z*'. The total number of nucleons in the nucleus is called *mass number*. It is denoted by the letter '*A*'.

5. *What are isotopes?*

[Anna Univ. (EEE) Dec'13]

Some elements exist in different forms. Mass number of these forms is different but the atomic number is the same. They are known as *isotopes* of the element.

6. *Name primary and secondary nuclear fuels used in nuclear power generation.*

(i) U^{235} is primary fuel.

(ii) U^{233} and PU^{239} are secondary fuels.

7. ***What are called fissile isotopes?***

These fuels undergo fission process. When the unstable heavy nuclear is bombarded with neutrons, it splits into two fragments of approximately equal mass. A large amount of heat is released during the fission process.

8. ***How can we define fertile fuels?***

U^{233} is produced by nuclear reaction of thorium element. PU^{239} is produced by neutron irradiation of U^{238}. These PU^{239} and U^{233} can be fissioned by neutrons. U^{238} and Th^{232} are known as *fertile fuels*.

9. ***How is nuclear energy calculated?***

Nuclear energy is measured by *Albert Einstein* formula,

$$E = m c^2$$

where E = Energy

m = Mass

c = Velocity or the speed of light.

10. ***Name the different types of fuels used in nuclear reactors.***

[Anna Univ. (EEE) Dec'12]

Uranium, Plutonium and Thorium.

11. ***What is known as binding energy?*** ***[Anna Univ. (EEE) Dec'11]***

The energy released at the moment of combination of two nucleons to form nucleus of an atom is called "*binding energy*".

12. ***What is "half-life" of nuclear fuels?*** ***[Anna Univ. (Mech.) Nov'08]***

The radioactive half-life for a given radioisotope is a measure of the tendency of nucleus to "decay" or "disintegrate" and it is based purely on probability.

13. ***What do you mean by mass defect?*** ***[Anna Univ. (EEE) June'13]***

During the interaction two or more particles to combine together, the total mass of the system will decrease and it will be less than the sum of the masses of the individual particles. The stronger the interaction becomes and more the mass will decrease. It decreases the mass of the system called *mass defect*.

14. ***Explain the radioactivity principles.***

During the emission process, high velocity particles are emitted. These emissions include alpha particles, beta particles or gamma particles. After many

stages of disintegration, atomic specie with a stable nucleus is formed. The emission of radioactive waves (alpha, beta and gamma rays) by an unstable element is called *radioactivity* of the element or simply *radiation*.

15. What is nuclear fission? [Anna Univ. (Mech.) May'11, (EEE) May'11 & May'12]

or

How can nuclear fission be caused? ***[Anna Univ. (EEE) Dec'10]***

Nuclear fission is the process of splitting the nucleus into two almost equal fragments accompanied by the release of heat. In other words, it is the process of splitting the unstable heavy nucleus into two fragments of approximately equal mass when bombarded with neutrons.

16. What are the conditions to be satisfied to sustain nuclear fission process?

Or

Give the requirements of chain reaction.

[Anna Univ. (Mech.) May'09, Dec'13 & (EEE) May'10]

(i) The chain reaction will become self-sustaining or self-propagating only.

(ii) At least one fission neutron becomes available for causing the fission of another nucleus.

(iii) The neutrons emitted in fission must have adequate energy to cause fission of other nuclei.

(iv) The number of neutrons produced must be able not only to sustain the fission process but also to increase the rate of fission.

(v) The fission process must liberate the energy.

(vi) It must be possible to control the rate of energy liberation.

17. What do you understand by moderation? ***[Anna Univ. Dec'04]***

The process of slowing down the speed of neutrons from high velocity without capturing them is known as *moderation*.

18. What is known as moderating ratio? ***[Anna Univ. (EEE) Dec'10]***

Multiplication ratio or *reproduction factor* of the system is defined as the number of neutron in any particular generation in total number of neutrons in the preceding generation.

$$K = \frac{\text{Number of neutrons in any particular generation}}{\text{Number of neutrons in the preceding generation}}$$

19. *What is four factor formula?*

[Anna Univ. (EEE) Dec'10]

The four-factor formula is also known as *Fermi's four factor formula* used in nuclear engineering to determine the multiplication of a nuclear chain reaction in an infinite medium.

20. *What is nuclear fusion?*

Nuclear fusion is the process of combining two lighter nuclei into stable and heavier nuclide. In this process, a large amount of energy is released because mass of the product nucleus is less when compared to mass of the two nuclei which are fussed.

21. *What is the difference between fission and fusion?* *[Anna Univ. (Mech.) Dec'12]*

S. No	*Nuclear fission*	*Nuclear fusion*
1.	It is the process of splitting a heavy nucleus with some projectiles into two or more light fragments by liberation of large amount of energy.	It is a process of fusing two light nuclei into single nucleus with the liberation of large amount of heat.
2.	This process results the emission of radioactive rays.	This process does not emit any kind of radioactive rays.
3.	This process takes place spontaneously at ordinary temperature.	This process takes place at very high temperature (nearly at about $>10^5 K$).
4.	The mass number and atomic number of the daughter elements (new elements) are less than the parent nucleus.	The mass number and atomic number of the product is higher than starting elements.
5.	This process gives a rise to chain reaction.	This process does not give a rise to chain reaction.

6.	During nuclear fission, neutrons are emitted.	During nuclear fusion, protons are emitted.
7.	Nuclear fission can be performed under controlled conditions.	Nuclear fusion cannot be performed under controlled conditions.

22. Explain the function of nuclear reactor. ***[Anna Univ. (Mech.) Apr'08 & May'11]***

A nuclear reactor is similar to the furnace of a steam power plant or combustion chamber of a gas turbine plant. In the nuclear reactor, heat is produced due to nuclear fission chain reaction.

23. What are the essential components of a nuclear reactor?

[Anna Univ. (EEE) May'10]

(i) Reactor core
(ii) Moderator
(iii) Control rods
(iv) Reflector
(v) Cooling system
(vi) Reactor vessel
(vii) Biological shielding.

24. Explain the function of the moderator.

[Anna Univ. (Mech.) May'07& May'11& (EEE) Dec'12]

Moderator is a material which is used to slow down the neutrons from high velocities without capturing them. The fast moving neutrons are far less effective in causing the fission and escape from the reactor.

25. Name the three moderators commonly used in nuclear power reactor.

[Anna Univ. (EEE) May'12]

Heavy water (D_2O), Water (H_2O), Beryllium (Be), Graphite (C) and Helium (He) gas are commonly used moderators.

26. What are the desired properties required for good moderator?

- High thermal conductivity
- High slowing down power

- Low parasite captures
- Lighter
- High resistance to corrosion
- Stability under heat and radiation
- Abundance in pure form
- High meeting point for solids and low melting point for liquids.

27. *What are the functions of control rods?* ***[Anna Univ. (EEE) Dec'15]***

- To control the rate of fission
- To start the nuclear chain reaction when the reactor is started from cold
- To shut down the reactor under emergency condition
- To maintain the chain reaction at a steady state
- To prevent the melting of fuel rods.

28. *Why is shielding of a nuclear reactor necessary?* ***[Anna Univ. (Mech.) May'13]***

Shielding is necessary to protect walls of the reactor vessel from radiation damage and it also protects the operating personnel from exposure to radiation. Thick layers of lead concrete or steel are provided all around the reactor. These layers absorb the gamma rays, neutrons etc.

29. *How are the nuclear reactors classified?* ***[Anna Univ. (Mech.) May'11]***

(i) According to the neutrons energy.

a. Fast reactors in which fast fission is caused by high-energy neutrons.
b. Intermediate or epithermal.
c. Low energy or Thermal reactors in which fission is due to slow moving neutrons

(ii) According to the fuel used

a. Natural fuel reactor in which natural Uranium is used as fuel.
b. Enriched Uranium reactor in which Uranium used in this reactor contains 5 to 10% of U^{235}.

(iii) According to the type of coolant used

a. Water cooled reactors in which ordinary of heavy water is used as coolants.
b. Gas cooled reactors in which CO_2, He, N_2, air etc. are used as coolants.

c. Liquid metal cooled reactors in which liquid metals such as sodium, bismuth and lead are used as *coolants*.

(iv) According to the type of moderators used

a. Graphite moderator reactor

b. Beryllium moderator reactor

c. Water moderator reactor.

(v) According to the construction of core

a. Cubical core reactor

b. Cylindrical core reactor

c. Spherical core reactor

d. Annulus core reactor

e. Slab core reactor.

30. *Define the term "Breeding".* ***[Anna Univ. Apr'05]***

In a fast breeder reactor, the process of producing energy to self-sustain the nuclear fission chain reaction without using moderator is known as *breeding*. Enriched Uranium (U^{235}) or Plutonium is used as fuels which are surrounded by a thick blanket of fertile Uranium (U^{238}).

31. *What factors control the selection of a particular type of a reactor?*

[Anna Univ. Dec'04]

1. Neutrons energy
2. Type of fuel
3. Type of coolant
4. Type of moderators
5. Construction of core.

32. *List down the basic factors those are to be considered for the design of a nuclear power reactor.* ***[Anna Univ. (Mech.) Nov'07]***

(i) Proximity to load center

(ii) Population distribution

(iii) Land use

(iv) Meteorology

(v) Geology

(vi) Hydrology

(vii) Seismology.

33. *What is the function of pressurizer in pressurized water reactor?*

[Anna Univ. (EEE) Dec'11]

The pressure in the primary circuit should be high for boiling of water at high pressure. It enables the water to carry more heat from the reactor. The pressurising tank keeps the water at about 14 MN/m^2 so that it will not boil. An electric heating coil in the pressuriser boils the water to form the steam which is collected in the dome. More steam is forced into the dome by boiling and its pressure rises. Then, it pressurises the entire circuit.

34. *What are the components of pressurized water reactor nuclear power plant?*

[Anna Univ. Dec'05]

1. Reactor
2. Pressuriser
3. Heat exchanger
4. Coolant pump

35. *Mention the various types of fast breeders.*

(i) GFR : Gas Cooled Fast Reactor system cooled with helium

(ii) LFR: Lead Fast Reactor cooled with lead or lead-bismuth eutectic

(iii) MSR: Molten Salt Reactor fuelled with molten salts

(iv) SFR: Sodium Fast Reactor

(v) SCWR: Super-Critical Water-cooled Reactor

(vi) VHTR: Very High Temperature Reactor cooled with helium at $1000°C$ at the core outlet for efficient production of hydrogen.

36. *What are the advantages and disadvantages of breeder reactor?*

[Anna Univ. (Mech.) May'11]

Advantages:

(i) No moderator is required.

(ii) High breeding is possible.

(iii) It gives high power density than other reactors.

(iv) High efficiency in the order of 40% can be obtained.

(v) It has better fuel utilization.

(vi) Absorption of neutrons is low.

Disadvantages:

(i) It has to be cooled with liquid sodium

(ii) It is even more complicated and expensive than a normal reactor

(iii) It has potential for misuse of plutonium by terrorists.

37. *What is a gas cooled nuclear reactor?* ***[Anna Univ. (Mech.) Dec'14]***

A gas such as carbon dioxide is used to carry away the heat produced due to nuclear fission in the reactor. For example, the gas cooled reactor is with CO_2 gas as coolant and graphite as moderator.

38. *Point out any four disadvantages of gas cooled reactors.*

(i) Fuel loading is more elaborated and costly.

(ii) The cost of heavy water (D_2O) is high (Rs. 500 per *kg*).

(iii) Power density is very low (*9.7kW/litre*) and hence, a large size of vessel is required.

(iv) Large amount of fuel loading is initially required since the critical mass is high.

39. *What is LMFBR? Why is a liquid metal the preferred coolant in a fast breeder reactor?*

[Anna Univ. (EEE) June'13]

LMFBR stands for liquid metal fast breeder reactor. The liquid metal is always preferred as the coolant since it is an excellent heat transfer material. Ex: sodium and potassium.

40. *State the advantages of sodium fast reactor.*

1. No moderator is required.
2. Full advantage is taken of excellent heat removal characteristics of sodium.
3. Sodium doesn't react with Uranium and thorium.
4. Fuel can be bonded to container with liquid metal.
5. Electromagnetic pumps can be used with fair efficiency.

41. *What are the components of pressurized water reactor nuclear power plant?* *[Anna Univ. Dec'05]*

(i) Reactor
(ii) Pressuriser
(iii) Heat exchanger
(iv) Coolant pump.

42. *Distinguish between PHWR and LMFBR.* *[Anna Univ. (EEE) May'11]*

S.No.	PHWR	LMFBR
1.	A nuclear power reactor commonly uses unenriched natural uranium as its fuel which uses heavy water (deuterium oxide D_2O) as its coolant and moderator.	A nuclear reactor is capable of generating more fissile material than it consumes
2.	Pressurized heavy water reactors (PHWR) running on natural uranium have a conversion ratio of 0.8.	The conversion ratio is higher than 1.
3.	It is costly.	Its cost is comparatively less.

43. *List some of the disadvantages of nuclear power plant. [Anna Univ. (EEE) Dec'10]*

(i) Similar to fossil fuels, nuclear fuels are non-renewable energy resources.
(ii) If the accident occurs, large amounts of radioactive material could be released into the environment.
(iii) Nuclear waste also remains radioactive and it is hazardous to health for thousands of years.

44. *How do you cater for safety of nuclear power plant?* *[Anna Univ. (Mech.) May'14 & (EEE) Dec'15]*

Nuclear safety and security cover the actions taken to prevent nuclear and radiation accidents or to limit their consequences. The main safety concern is the emission of uncontrolled radiation into the environment which could cause harm to human both at the reactor site and off-site. The nuclear power industry has improved

the safety and performance of reactors and it has proposed new and safer reactor designs.

45. State the engineered nuclear plant safety measures adopted.

(i) Emergency cooling system is to supply the water to reactor core in the event of a loss of coolant accident.

(ii) The containment vessel is to provide a barrier to escape radioactivity to the environment.

(iii) A clean up system is for removing part of the radioactivity and heat which may be present in the contamination atmosphere.

(iv) Hydrogen control is to prevent the formation of explosive hydrogen-oxygen mixture in the containment.

46. What are the criteria used for evaluation of nuclear plant safety?

[Anna Univ. Nov'07]

(i) There is no unreasonable risk.

(ii) It has adequate protection of public health and safety.

(iii) Risk is reasonably low.

(iv) Safety is as high as reasonably achievable.

(v) It limits the risk by use of best technologies at acceptable economic costs.

3.26. SOLVED QUESTIONS

1. Write short notes on need of nuclear energy.

   Refer chapter **3.1** in page **3.1**.

2. Explain the nuclear life cycle.

   [Anna Univ. (EEE) Dec'10]

   Refer page **3.6**.

3. Explain the following term "Fission of nuclear fuel".

   [Anna Univ. (EEE) Apr'05 & May'10]

   Refer chapter **3.3** in page **3.13**.

4. What is meant by Uranium enrichment? Describe some methods of Uranium enrichment.

   [Anna Univ. (EEE) Dec'13]

   Refer chapter **3.2** in page **3.8**.

5. Many portable devices can be powered by fuel cells such as laptop computers, mobile phones and other low power applications.
6. To meet the demand of isolated sites such as construction sites, military camps and small village community or hamlet, fuel cells are more suitable than diesel generator.
7. For remote and inaccessible locations fuel cells can be used unattended for a long period.
8. Emergency / auxiliary supply to critical loads such as hospitals, laboratory etc. can be better met using fuel cells as compared to diesel generator.

4.9.14. Problems With Fuel Cells

Although the potential benefits of fuel cells are significant, many challenges and technical challenges must be overcome before fuel cells will be successful and competitive alternate device for consumers. They include cost, durability, fuel storage and delivery issues and public acceptance. Still, scientists and industry are working hard to overcome these challenges and bring hydrogen and fuel cells to the marketplace.

Fuel cell uses oxygen and hydrogen to produce electricity. The oxygen required for a fuel cell comes from air. In PEM fuel cell, ordinary air is pumped into cathode. The hydrogen is not so readily available. Hydrogen has some limitations which make it impractical for the use in most applications.

Hydrogen is difficult to store and distribute. So, it will be much more convenient if fuel cells can use fuels which are more readily available. This problem is addressed by a device called a *reformer*.

4.10. TWO MARK QUESTIONS AND ANSWERS

1. ***Define the term "Hydrology".*** *[Anna Univ. (EEE) Dec'10]*

   Hydrology is the study of science concentrating the properties of the earth's water and the movement of earth with respect to land.

2. ***What is hydrograph?*** *[Anna Univ. (Mech.) May'13]*

   A hydrograph is a graph plotted for the rate of flow versus time past a specific point in a river or other channel or conduit carrying flow.

3. ***For which purposes hydro projects are developed?*** *[Anna Univ. (EEE) Dec'13]*

   (i) To meet the power needs during peak and off peak requirements.

(ii) To run of the river.

(iii) To obtain a clean process of power generation.

(iv) To avoid suffering from the limitation of inflation on account of fuel consumption in the long run.

4. ***What is the purpose of using dams?*** ***[Anna Univ. (EEE) Dec'12]***

The dam is used in hydro power plants to increase the height of water level thereby increasing the capacity of reservoir. The dam also helps to increase the working head of the power plant.

5. ***Define Run-off.*** ***[Anna Univ. (EEE) Dec'13]***

Runoff is defined as the movement of land water to the oceans mainly in the form of rivers, lakes and streams.

6. ***Classify power plants on the basis of traditional use. [Anna Univ. (Mech.) May'11]***

(i) Concrete gravity dam type hydroelectric power plant.

(ii) Embankment dam type hydroelectric power plant.

7. ***List out the important parameters of a turbine.*** ***[Anna Univ. (Mech.) Nov'07]***

(i) Power output of the turbine.

(ii) Friction losses based on isentropic efficiency.

(iii) Maximum temperature which can be taken by the turbine.

(iv) Temperature at the exhaust of the turbine.

8. ***What is hydraulic turbine?***

Hydraulic turbines are the machines which convert the energy of flowing water into mechanical energy.

9. ***What is hydroelectric power?***

The turbine converts the hydraulic energy into mechanical energy. Again, this mechanical energy is converted into electrical energy. So, the conversion of energy from hydraulic form to electric form is called *hydroelectric power*.

10. ***List any four advantages of hydro power.*** ***[Anna Univ. (EEE) Dec'10]***

(i) The electricity can be produced at constant rate from hydro power.

(ii) If the electricity does not require, the sluice gates can be shut and stopped electricity generation.

(iii) Dams are designed to last many decades and they can contribute to the generation of electricity for many years.

(iv) The lake forms behind the dam using water sports and leisure/pleasure activities.

(v) The lake's water can be used for irrigation purposes.

(vi) The energy from stored water in the lake can be stored and it can be released to produce electricity.

(vii) Electricity produced by dam systems does not produce greenhouse gases. They do not pollute the atmosphere.

11. What is the basis of classification of turbines?

a. According to the action of the water flowing.

b. According to the main direction of flow of water.

c. According to head and quantity of water required.

d. According to the specific speed.

12. What are the types of water turbines? ***[Anna Univ. (EEE) Dec'12]***

Action of the water flowing:

a. Impulse turbine

b. Reaction turbine.

Main direction of water flow:

i) Tangential flow turbine

ii) Radial flow turbine

iii) Axial flow turbine

iv) Mixed flow turbine.

Head and quantity basis:

i) High head turbine

ii) Medium head turbine

iii) Low head turbine.

Specific speed basis:

i) Low Specific speed

ii) Medium Specific speed

iii) High Specific speed.

13. *Classify the hydroelectric turbines with respect to high medium and low head.* ***[Anna Univ. (EEE) May'11]***

1. Low head power plant:

If a power plant has the operating head of water less than 10 *m*, it is known as *low head power plant*. Kaplan turbine is used as a prime mover in this type of power plant.

2. Medium head power plant:

The operating head of water ranges from 10 *m* to 50 *m*, then the power plant is known as *medium head power plant*. Francis turbine is used as a prime mover in this type of power plant.

3. High head power plant:

If the operating head of water exceeds 50 *m*, the plant is known as "*high head power plant*". Pelton turbine is used as a prime mover in this type of power plant.

14. *Give an example for a low head turbine, a medium head turbine and a high head turbine.* ***[Anna Univ. (Mech.) Nov'02]***

a. High head turbine (above 250 *m*). e.g. Pelton wheel.

b. Medium head turbine (60 *m* to 250 *m*). e.g. Modern Francis turbine.

c. Low head turbine (less than 60 *m*). e.g. Kaplan turbine.

15. *What is impulse turbine? Give an example.*

In the impulse turbine, the whole energy is converted into kinetic energy. Turbines will develop high kinetic energy power. This turbine is called *impulse turbine*.

Example: Pelton turbine.

16. *What are reaction turbines? Give examples.* ***[Anna Univ. (Mech.) Apr'03]***

In a reaction turbine, the runner utilizes both potential and kinetic energies. Here, a portion of potential energy is converted into kinetic energy before entering the turbine.

Example: Francis and Kaplan turbine.

17. *Differentiate the impulse and reaction turbine.* *(Anna Univ. (Mech.) Nov'04)*

S.No.	*Impulse turbine*	*Reaction turbine*
1.	The whole potential energy is converted into kinetic energy by a nozzle before entering the turbine runner.	Only a portion of the fluid energy is transferred into kinetic energy before the fluid enters the turbine.
2.	Blades are only in action when they are in front of nozzle.	Blades are in action at all times.
3.	Water may be allowed to enter a part or whole of the wheel circumference.	Water is admitted over the circumference of the wheel.
4.	Wheel does not run full and air has free access to buckets.	Water completely fills the vane passages throughout the operation of the turbine.
5.	Unit is installed above the tailrace.	Unit is entirely kept submerged in water below the tailrace.
6.	Flow regulation is possible without loss.	Flow regulation is possible with loss.
7.	Flow is regulated by means of a needle valve fitted into the nozzle.	Flow is regulated by means of a guide-vane assembly.

18. *What is tangential flow turbine?*

The water flows along the tangent to the path of rotation of the runner.

Example: Pelton wheel.

19. *What is radial flow turbine?*

In the turbine, water flows along the radial direction and mainly in the plane normal to the axis of the rotation as it passes through the runner. It may be either inward radial flow type or outward radial flow type.

20. *What is axial flow turbine? Give an example.*

In the axial flow turbine, water flows parallel to the axis of the turbine shaft.

Example: Kaplan turbine and propeller turbine.

21. *What is mixed flow turbine?*

In the mixed flow turbine, water enters the blades radially and comes out axially which is parallel to the turbine shaft.

Example: Modern Francis turbine.

22. *Differentiate between the inward flow reaction turbine and outward flow reaction turbine.*

S. No.	*Inward flow reaction turbine*	*Outward flow reaction turbine*
1.	Water enters the outer periphery and it flows inward and towards the centre of the turbine and also it discharges at the outer periphery.	Water enters the outer periphery and it flows outward and then it discharges at the outer periphery.
2.	The discharge does not increase.	The discharge increases.
3.	Easy and effective speed control can be obtained.	It is very difficult to achieve the desired speed control.
4.	It is good for medium and high heads and best suitable for large output and units.	It is good for medium or low heads.
5.	It is commonly used for power projects.	It is practically obsolete.

23. *Differentiate the Francis and Kaplan turbines.*

S. No.	*Francis turbine*	*Kaplan turbine*
1.	Correct disposition of the guide and moving vanes is obtained at full load only.	Correct disposition of the guide and moving blades is obtained at any load.
2.	System may have one or two servomotors depending on the size of the unit.	Two servomotors respective of the size of the unit always do governing.
3.	Since the guide vanes are only controlled and high efficiency is	Both guide and runner vanes are controlled and high efficiency is

	obtained.	obtained even at partial loads.
4.	Servomotors are kept outside the turbine shaft.	Both servomotors are kept inside the hollow shaft of the turbine runner.

24. *What are the main parts of Pelton wheel?*

Pelton wheel consists of the following main parts

i. Penstock
ii. Spear and nozzle
iii. Runner with buckets
iv. Break nozzle
v. Outer casing
vi. Governing mechanism.

25. *What is penstock in Pelton wheel? Explain.*

Penstock is a large sized pipe which conveys water from high level reservoir to the turbine. Depending on low head or high head installations, a penstock is made of wood, concrete or steel. In order to control the water flow, the penstock has different control valves at different sections.

26. *What is the function of spear and nozzle?*

The nozzle is used to convert the whole hydraulic energy into kinetic energy. Thus, the nozzle delivers the high-speed jet. To regulate the water flow through nozzle and to obtain a good jet of water, a spear or nozzle is arranged.

27. *What is the function of outer casing?*

A casing is made of cast iron or fabricated steel plate. It is used to prevent the splacing of water and discharging water to tailstock. It is also act as a safeguard against accidents.

28. *What is break nozzle and mention its function?*

If the spear nozzle set closes, the runner will revolve for long time due to inertia. To stop the runner in a short time, a small nozzle is provided which directs a jet of water on the backside of buckets.

29. *What is the function of governing mechanism in Pelton wheel?*

Governing mechanism is used to regulate the water flow to the turbine at constant level so that the speed of the turbine is kept constant. It automatically regulates the quantity of water flowing through the runner in accordance with any variation in load.

30. *What is scroll or spiral casing?*

The water from the penstock enters the scroll casing which completely surrounds by the runner. The cross sectional area of the scroll casing decreases along the flow direction, area is maximum at inlet and nearly zero at exit.

31. *What is speed rings or stay ring?*

The speed rings consist of an upper and lower ring held together by series of fixed vanes called *stay vanes*. The number of stay vanes is usually taken as half of the direct water from scroll casing to guide vanes and it also resists the load imposed upon it.

32. *What is the function of guide vanes or wicket gates in Francis turbine?*

The guide vanes direct the water onto the runner at appropriate angles as per the design. It is also used to regulate the quantity of water supplied to the runner. The guide vanes are airfoil shaped and they may be made of cast steel, stainless steel or plate steel.

33. *What is a draft tube?* ***[Anna Univ. (EEE) Dec'10]***

After passing through the runner, the water is discharged to the tailrace through a gradually expanding tube called *draft tube*.

The pressure at the exit of the runner of a reaction turbine is generally less than atmospheric pressure. By passing through reduced size draft tube, the outer velocity of water is reduced and gain in useful pressure head is achieved to increase the output of turbine.

34. *What is the function of draft tube?* ***[Anna Univ. (EEE) Dec'11 & June'13]***

1. It allows the turbine to be set above tail. Water level is without loss of head for doing inspection and maintenance.
2. It regains the major portion of the kinetic energy delivered from the runner by the diffuse action.

35. *What are the different types of spill ways?* *[Anna Univ. (EEE) Dec'11]*

(i) Chute spillway

(ii) Stepped spillway

(iii) Bell-mouth spillway.

36. *What are the main components in Kaplan turbine?*

Kaplan turbine consists of the following main components.

i) Scroll casing

ii) Stay ring

iii) Guide vanes

iv) Draft tube

v) Runner.

37. *Define unit speed of turbine.* *[Anna Univ. Nov'03]*

Unit speed is defined as the speed of turbine when working under a unit head.

$$\text{Unit speed, } N_u = N/\sqrt{H}$$

38. *What do you understand by the term specific speed of a water turbine?*

[Anna Univ. (Mech.) Dec'14]

Specific speed is the speed of a geometrically similar turbine, (i.e., a turbine identical in shape, dimensions, blade angles and gate openings etc.) which will develop unit power when working under a unit head.

$$\therefore \text{Specific speed, } N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$$

where

N = Speed of the turbine in rpm

P = Power developed by the turbine

H = Head of the turbine.

39. *What is the significance of specific speed of hydraulic turbines?*

[Anna Univ. (Mech.) May'09 & May'11]

1. To predict the behaviour of a turbine working under different conditions.

2. To make the comparison between the performance of turbine of same types with different sizes.
3. To compare the performance.

40. Define unit discharge.

It is the theoretical discharge of a turbine when working under unit head.

$$\text{Unit discharge, } Q_u = Q/\sqrt{H}.$$

41. Define unit power.

It is the theoretical power of a turbine when working under unit head.

$$\text{Unit power } P_u = P/H^{3/2}$$

42. Give the range of specific speed values for Kaplan turbine and Pelton wheel.

1. Range of specific speed for Kaplan turbine = 257 to 858
2. Range of specific speed for Pelton wheel = 10 to 30-single jet
   = 17 to 50-two jets
   = 24 to 70-with four jets.

43. What is a surge tank? ***[Anna Univ. (EEE) May'10]***

A surge tank is a small reservoir or tank in which the water level rises or falls to reduce.

44. What is the purpose of surge tank in a hydroelectric power plant?

[Anna Univ. (Mech.) Dec'13]

a. When the valve closes suddenly, the sudden reduction of rate of flow in the penstock will occur. To avoid this reduction of rate of flow, surge tanks are provided in the upstream of the pipeline.

b. To reduce the rapid velocity fluctuation in pipeline during the start and shut down of a turbine.

45. What for surge tank is provided in the hydel plant? ***[Anna Univ. (EEE) May'12]***

The surge tank is introduced between dam and turbine to keep in reducing the sudden rise in pressure in the penstock. When the water flows into the turbine reduced suddenly due to decreased load demand, water rises in the surge tank. It

reduces the velocity of water in the penstock and thus, it avoids the water hammer in the penstock. When water flows into the turbine, it is increased suddenly due to increased load demand and additional water is supplied by the surge tank. It increases the velocity in the penstock and it avoids vacuum created. Therefore, the surge tank helps in stabilizing the velocity and pressure in penstock and it reduces water hammer effect.

46. *What are the functions of a surge tank and forebay?*

[Anna Univ. (Mech.) Nov'08 & May'11]

Surge tank is used to reduce the sudden rise of water in the penstock, stabilize the velocity and pressure in penstock and reduce water hammer effect.

Forebay serves as a temporary regulating reservoir which is used to store water when the load on the plant is reduced and it provides water for the initial increment of an increasing load while the water in the canal is being accelerated.

47. *What are the different types of surge tanks?*

i) Simple surge tank

ii) Inclined surge tank

iii) Differential surge tank.

48. *A turbine develops 5MW under a head of 20m at 125rpm. What is the specific speed?*

Given data:

$P = 5\ MW = 5000\ kW$

$H = 20\ m$

$N = 125\ rpm$

Solution:

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{125\sqrt{5000}}{(20)^{5/4}} = 208.98$$ Ans.

49. *What is a draft tube? In which type of turbine it is mostly used?*

[Anna Univ. (Mech.) Nov'03& Nov'04]

The tube which increases the outlet velocity of turbines is known as *draft tube*. So, the head is saved by fitting a draft tube.

50. What is necessity of draft tubes? List the types.

[Anna Univ. (Mech.) May'09 & May'11]

1. To decrease the pressure at the runner exit less than the atmospheric pressure in order to increase the working head.
2. To recover some of kinetic energy going to tail race as waste.

Types of draft tube:

(i) Straight conical or concentric tube
(ii) Elbow type
(iii) Moody spreading type.

51. Write the function of draft tube in turbine outlet. ***[Anna Univ. (Mech.) Apr'05]***

1. It allows the turbine to be set above tail-water level without loss of head for doing the inspection and maintenance.
2. It regains the major portion of the kinetic energy delivered from the runner by the diffuse action.

52. What are the factors to be considered in selecting turbines?

[Anna Univ. (Mech.) May'14 & (EEE) May'12]

1. Rotational speed of the turbine
2. Specific speed
3. Maximum efficiency
4. Part load efficiency
5. Head
6. Type of water
7. Runaway speed
8. Cavitation
9. Number of turbine units
10. Overall cost.

53. On what basis hydraulic turbines are selected? ***[Anna Univ. (Mech.) Dec'12]***

1. Water availability
2. Water storage
3. Water head
4. Various geological investigations

5. Environmental aspects
6. Consideration of water pollution effects.

54. List any four advantages of hydro-electric power plant.
[Anna Univ. (Mech.) Nov'08, May'11, (EEE) May'10, May'11 & June'13]

1. Water is the cheapest source of energy. The fuels needed for the thermal, diesel and nuclear plants are exhaustive and expansive.
2. Water is the renewable source of energy. It is neither consumed nor converted into something else.
3. The fuel cost is totally absent.
4. There is no air pollution.
5. There is no problem of handling the fuel and ash. No nuisance of smoker exhaust gases and soot's and no health hazards due to air pollution.
6. The running cost of hydropower installation is very low when compared to thermal or nuclear power stations.
7. The hydraulic power plant is relatively simple in concept and self-contained in operation.
8. Variable load does not affect the efficiency in the case of a hydro-plant.
9. Modern hydropower equipment has greater life expectancy and it can easily last 50 years or more.
10. Hydro-plants provide auxiliary benefits such as irrigation and flood control.
11. The efficiency does not change with age.
12. Maintenance cost is low.
13. It requires less supervising staff for the operation of the plant.

55. Enumerate the disadvantages of hydropower plants.
[Anna Univ. (Mech.) Nov'08, May'11 & (EEE) May'10]

1. Hydropower projects are capital-intensive with a low rate of return.
2. Power generation is dependent on the quantity of water available which may vary season-to-season and year-to-year.
3. Initial cost of the plant is high.

4. The hydel power plants are often far away from the load center and they require long transmission lines to deliver power.
5. Large hydro-plants disturb the ecology of the area by way of deforestation, destroying vegetarian and uprooting people.
6. It takes considerably long time for its installation as compared with thermal power plants.

56. *What do you understand by zero energy houses?* ***[Anna Univ. (EEE) June'13]***

A zero-energy building is also known as a *zero net energy (ZNE) building or net-zero energy building (NZEB)*. It refers a building with zero net energy consumption and zero carbon emissions annually.

57. *What is wind energy?*

Wind energy is an indirect form of solar energy.

58. *Write down the applications of wind power.*

1. Wind turbines are used to generate electricity.
2. Windmills are used for producing mechanical power.
3. Wind pumps are used for water pumping or drainage, and
4. Wind power is used in sails to propel ships.

59. *Mention characteristics of wind energy.*

(i) Wind-power systems do not pollute the atmosphere.

(ii) Fuel provision and transport are not required in wind-power systems.

(iii) Wind energy is a renewable source of energy.

(iv) Wind energy when produced on small scale is cheaper but competitive with conventional power generating system when produced on a large scale.

60. *What is meant by wind turbine?*

A *wind turbine* is a rotating machine which converts the kinetic energy of wind into mechanical energy.

61. *Mention the various advantages of wind power.* ***[Anna Univ. (EEE) Dec'15]***

1. Clean:

Aside from the manufacturing process, wind power emits absolutely no greenhouse gases.

2. Free:

There are no fuel concerns as long as the wind blows, electricity will be generated. There are no worries about sourcing the fuel from elsewhere to make it work.

3. Place-ability:

Due to their nature, wind turbines can be placed in a variety of locations rather inhospitable locations.

4. Decentralised:

One wind power plant cannot generate huge amount of electricity.

5. Domestic:

Wind power lends itself well to domestic applications as wind turbines can be virtually any size.

62. *Obtain the distribution profile of wind speed.*

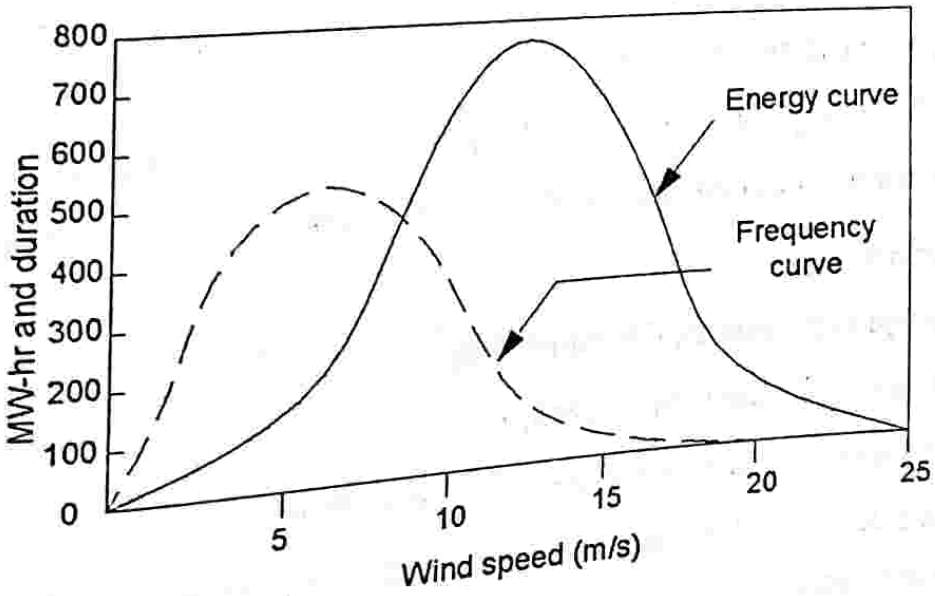

Figure 4.78 Distribution of wind power

63. *What are the disadvantages of wind power?*

1. Reliability:

Wind power needs wind. It is not always wind available. The turbines need minimum wind speed to get them spinning and it can only operate up to a maximum wind speed after which they have to be locked.

2. Expense:

Wind turbines are quite expensive especially to match the output of a regular power station.

3. National security:

There was a recent discovery that wind power can even affect the national security.

4. Wildlife:

They have been long arguments. Wind turbines affect migratory birds but more recently. They can make bats lungs explode.

5. Aesthetics:

It one really is down to personal taste but it should be included because farms have often been banned for exactly this reason.

64. Define Betz limit of a wind turbine.

Betz limit is the theoretical limit assigned to efficiency of a wind turbine.

65. What is meant by stalling?

If the air pressure increases on the low pressure side, enormous turbulence is produced which reduces the lift force and it leads to increase the drag significantly called *stalling*.

66. State the characteristics of lift and drag.

a. Drag is in the direction of airflow.

b. Lift is perpendicular to the direction of airflow.

c. Generation of lift always causes a certain amount of drag to be developed with a good aerofoil.

d. The lift produced can be thirty times greater than drag.

e. Lift devices are generally more efficient than drag devices.

67. What are the components of wind energy system?

- Wind turbine
  - Nacelle
  - Rotor i.e. the assembly of blades
  - Hub and shaft.

- Transmission system
- Electric generator
- Yaw control system
- Storage
- Energy converters
- Tower to support the rotor system.

68. *State the types of wind turbines.*

1) Lift type wind turbine
2) Drag type wind turbine.

69. *Classify wind turbines based on the rotation of rotor.*

1. Horizontal-axis wind machines
2. Vertical-axis wind machines.

70. *List any four advantages of wind turbine.* ***[Anna Univ. Dec'10]***

(i) Wind industry developers and manufacturers make lot of money by investing them due to government subsidies and cash incentives.

(ii) They make the environmentalists happy may be because man is finally punished against the earth.

71. *Mention any four advantages of HAWT.*

(i) Variable blade pitch gives the turbine blades the optimum angle of attack.

(ii) The tall tower base allows the access to stronger wind in sites with wind shear.

(iii) It produces high efficiency since the blades always move perpendicularly to the wind which receives power through the whole rotation.

(iv) The face of a horizontal axis blade is struck by the wind at a consistent angle regardless of the position in its rotation.

72. *State any four disadvantages of HAWT.*

(i) Massive tower construction is required to support heavy blades, gearbox and generator.

(ii) Reflections from tall HAWTs may affect side lobes of radar installations creating signal clutter although filtering can suppress it.

(iii) Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes, creating local opposition.

(iv) Downwind variants suffer from fatigue and structural failure caused by turbulence when a blade passes through tower's wind shadow.

73. *Classify vertical axis wind turbine based on blade profile.*

(i) Multiple blade type

(ii) Savonius type

(iii) Darrieus type.

74. *Write down any two advantages and disadvantages of VAWT.*

Advantages:

(i) VAWTs may be built at locations where taller structures are prohibited.

(ii) VAWTs situated close to the ground can take the advantage of locations where mesas, hilltops, ridgelines and it passes funnel the wind. It increases wind velocity.

Disadvantages:

(i) The stress in each blade due to wind loading changes sign twice during each revolution as the apparent wind direction moves through 360°.

(ii) While VAWTs' parts are located on the ground, they are also located under the weight of the structure above it which can make changing out parts nearly impossible without dismantling the structure if not designed properly.

75. Mention the sites selected to install wind mills.

(i) Plane sites

(ii) Hill top sites

(iii) Sea-shore sites

(iv) Off-shore shallow water sites.

76. Name factors to be considered for installing wind mills.

1. Wind farms are located away from main cities due to the resistance to the air movement created by buildings.
2. Wind power is based on the wind velocity. So, the flat area is advisable to locate the wind mill.

3. The site provides the average of wind velocity throughout the year for continuous generation of energy.
4. The proposed site should be checked for higher altitude for the reason of strong winds which will increase the electric power output of wind energy conversion system.

77. State the various applications of wind energy.

(i) Wind energy is used in water pumping.
(ii) Systems for community centers, schools and health clinics.
(iii) Wind energy used in heating and cooling processes.
(iv) Wind energy used in electricity generation.

78. List down the main industrial applications wind energy.

(i) Telecommunications
(ii) Radar
(iii) Pipeline control
(iv) Navigational aids such as ship with sails
(v) Cathodic protection
(vi) Weather stations/seismic monitoring
(vii) Air-traffic control.

79. What are the advantages of pumped storage plant? *[Anna Univ. Dec'10]*

a) It is free from effects of environment pollution.
b) Such plants are readily adoptable to automation as well as remote control.

80. What are the different operating cycles of pumped storage plants?

a) Daily peak load operation
b) Week-end storage or weekly operation
c) Storing during rainy season or yearly operation.

81. List down the components of combined pumped storage wind and steam power plant.

(i) Upper basin
(ii) Pressure conduit
(iii) Base load steam plant

(iv) Turbine

(v) Motor or generator

(vi) Pump.

82. What are the components of tidal power plants?[Anna Univ. (Mech.) May'09]

1. The dam or dyke
2. Sluice ways
3. The power house.

83. What is the basic principle of tidal power?

Tides are produced mainly by the gravitational attraction of the moon and sun on the water of solid earth and oceans. About 70% of the tide producing force is due to the moon and remaining 30% is produced due to the sun.

84. What are the different methods of producing electricity with tides?

[Anna Univ. (Mech.) May'11]

1. Single basin arrangement
   a) Single ebb-cycle system
   b) Single tide-cycle system
   c) Double cycle system
2. Double basin arrangement.

85. List out the advantages of tidal power plants over hydel power plants.

[Anna Univ. (Mech.) Nov'07 & May'11, (EEE) May'10 & Dec'10]

(i) It is free from pollution as it does not use any fuel.

(ii) Large area of valuable land is not required.

(iii) It does not produce any unhealthy waste such as gases and ash.

(iv) It has unique capacity to meet the peak power demand effectively when it works with the combination of thermal or hydroelectric system.

(v) It is much superior to hydropower plants as it is totally independent of rain which always fluctuates year to year.

(vi) Tidal power is in exhaustible.

(vii) It is free from pollution.

(viii) These power plants do not demand for large area of valuable land.

86. *What are the limitations of tidal power plant?*

[Anna Univ. (Mech.) May'11, (EEE) May'10, Dec'10 & Dec'15]

a) The tidal ranges are highly variable and therefore, turbines have to work on a wide range of head variation.

b) Construction in sea is found difficult.

c) Cost is not favourable when compared to other sources of energy.

d) The output is not uniform.

e) More corrosion will occur due to corrosive sea water.

f) Massive construction leads to more consumption to start the plant.

g) The tidal power plant is costly.

h) The power transmission cost is high because the tidal power plants are located away from load centers.

87. *What are the factors to be considered for suitable site selection of tidal power plant?* ***[Anna Univ. (EEE) Dec'11]***

- The location of the plant must be near the ocean
- Site selection for the plant should be in such a way that the tidal range of ocean is large (generally greater than 7 *m*).
- The geographic features of the plant must be enclosed with large area with short dams i.e. a narrow entrance to the inlet and plenty of water moving through it at each tide
- The sluice gates of dam should allow water to or from basins
- There should also be a nearby demand for electricity, otherwise, the energy which is produced has to be stored in some way or transported to where it is needed which increases the cost
- Environmental impacts need to be assessed.

88. *Mention the applications of solar energy.*

1. Passive heating applications.
2. Solar thermal energy applications of medium temperature and high temperature.
3. Solar to electrical energy direct conversion by photo-voltaic cells (PV-cells or solar cells) for low and medium power ratings.
4. Large solar central receiver thermal power plants in *MW* range.

89. State the various characteristic features of a solar collector system.

1. Type of solar collector: Whether Focusing or non-focusing.
2. The temperature of working fluid such as low temperature, medium temperature and high temperature.
3. Whether tracking system is used or not. If used, what type of tracking system used i.e. Tracking type or non-tracking type, and tracking in one plane or two planes.
4. Cost of the solar collector system such as low cost or high cost.
5. Design of the solar collector system such as complex or simple design.
6. Layout and configuration of collectors in the solar field.

90. What is shadow factor?

$$\text{Shadow factor} = \frac{\text{Surface of the collector receiving light}}{\text{Total surface of the collector}}$$

91. What is cosine loss factor?

For maximum power collection, the surface of collector should perpendicularly receive the sun rays. If the angle between collector surface in the perpendicular direction and direction of sun ray θ. The area of solar beam intercepted by the collector surface is proportional to cos θ. Here the term cos θ is the *cosine loss factor*.

92. Define reflective loss factor.

The collector glass surface and the reflector surface collect dust, dirt and moisture. The reflector surface gets rusted, deformed and losses the shine. Therefore, the efficiency of the collector is significantly reduced with the passage of time. This effect is called *reflective loss factor*.

93. What are the two types of flat plate type solar collector?

1. Non-concentrating or flat plate type solar collector.
2. Concentrating (focusing) type solar collector.

94. Name the various types of air heaters operated by solar principles.

1. Solar air heater with non-porous absorber.
2. Solar air heater with porous absorber.

95. State any two advantages and disadvantages of solar air heaters.

Advantages:

1. It is compact, simple in construction and requires little maintenance.
2. The need to transfer thermal energy from the working fluid to another fluid is eliminated as air is used directly as the working fluid.

Disadvantages:

1. A large amount of fluid is to be handled due to low density. As a result, the electrical power required to blow the air through the system can be significant if the pressure drop is not kept within prescribed limits.
2. Heat transfer between the absorber plate and air is poor.

96. Write down the applications of solar air heaters.

1. Heating greenhouse buildings
2. Drying agricultural products
3. Heat source for a heat engine
4. Air-conditioning buildings.

97. What are the factors affecting performance of flat plate collectors?

1. Incident solar radiation falling on the solar collector.
2. Number of cover plates.
3. Slope of the flat plate collector which is tilted at an angle of latitude of the location.
5. Spacing between absorber plate and cover plate. Internal heat loss can be prevented by providing more space.
6. Inlet temperature of the working fluid.
7. Dust deposited on the cover which should be minimised for obtaining higher efficiency.

98. Write down the advantages of flat-plate collectors.

1. It has the advantages of using both beam and diffuse solar radiations.
2. It does not require orientation towards the sun.
3. It requires a little maintenance.
4. These collectors are simpler than concentrating reflectors.

99. *Mention the disadvantages of flat-plate collectors.*

1. The temperature attained by the working fluid is low.
2. The construction is heavy in weight.
3. Conduction heat loss is more as the area is large.
4. Initial installation cost of the collector is more.

100. *What are the different applications of flat-plate collectors?*

1. It is used in solar water heating systems.
2. It is used in solar space heating and cooling systems.
3. It is used in low temperature power generation.
4. It is used in solar heating dryers.

101. *What is heliostat?*

'Heliostat' is a large and flat reflecting mirror with a provision to track the sun in two planes. The solar rays are reflected by each individual heliostat on to the central receiver mounted on a tall tower. A central receiver is mounted on a tall tower.

102. *What are the different types of concentrating collectors?*

1. Line focusing, and
2. Point focusing type.

103. *What are the main types of concentrating collectors?*

1. Parabolic through collector
2. Mirror strip reflector
3. Fresnel lens collector
4. Flat plate collector with adjustable mirrors.

104. *State the advantages of concentrating collectors over flat-plate type collectors.*

1. The reflecting surface of the concentrating collector requires less material and structurally simpler than flat-plate collectors.
2. The absorber area of a concentrator system is smaller than a flat-plate system.
3. The area from which the heat is lost to surroundings is less than flat-plate collectors.
4. It can be used for electric power generation.

105. *What are the disadvantages of concentrating collectors over flat-plate type collectors?*

1. In concentrating collectors, only the beam component is collected because the diffuse component cannot reflect.
2. Costly orienting systems must be used to track the sun.
3. Additional maintenance is required to retain the quality of reflecting surface against dirt, weather and oxidation.
4. It is non-uniform flux on the absorber whereas the flux in flat-plate collectors is uniform.
5. Optical losses and interrupt loss are in energy balance.

106. *Name the components of a solar water heater.*

(a) A flat plate collector to absorb solar radiation and convert it into thermal energy.

(b) Storage tank to hold water for use and cold water feeding the flat plate collector.

(c) Connecting pipes inlet and outlet for feeding cold water from the storage tank and taking hot water to the storage tank or point of use.

107. *What do you mean by solar direct thermal applications?*

Direct thermal applications involve the direct use of heat, resulting from the absorption of solar radiation for space heating and cooling of residences and other buildings, to provide hot-water for such buildings, and to provide heat for agricultural, industrial and other processes that require only moderate temperatures.

108. *What is passive solar heating?*

Passive solar energy technologies absorb solar energy, store and distribute it in a natural manner without using mechanical elements and also use natural ventilation.

109. *What is the power cycles employed in solar thermal power generation?*

(1) Low temperature cycle

(2) Medium temperature cycle

(3) High temperature cycle.

110. State the advantages of vapour absorption solar cooling system.

(1) It is compact and less bulky. Hence, less space is required for installation.

(2) It has no moving part except the motor driven pump and hence, it produces less wear.

(3) It is quiet in operation and it has less moving parts.

(4) Less maintenance is required.

111. What is a solar cell? ***[Anna Univ. (EEE) May'12 & Dec'12]***

A solar cell is a device which directly converts the energy of light into electrical energy through the process of photovoltaic effect.

112. What is the efficiency of a solar cell?

$$\text{Efficiency of a solar cell} = \frac{\text{Electrical power output}}{\text{Power intercepted}}$$

113. What are the components of photo-voltaic system?

1. Solar cell array
2. Load leveler
3. Storage system
4. Tracking system.

114. What are the applications of solar photovoltaic system?

1. Water pumping sets for micro irrigation and drinking water supply.
2. Weather monitoring.
3. Railway signaling equipment.

115. State the advantages of photovoltaic solar energy conversion.

1. It does not need moving parts.
2. It is highly reliable.
3. It is a long effective life.
4. It does not create pollution.

116. What are the disadvantages of solar energy conversion?

1. It is costly.
2. It requires energy storage.
3. It needs no insolation at night.

117. What are the three different types of 'Homojunction' PV cells?

1. Amorphous silicon
2. Poly crystalline silicon
3. Single crystal silicon.

118. Mention the problems in solar thermal central receiver systems.

[Anna Univ. (Mech.) May'09]

(i) A heliostat reflector assembly for a solar central receiver system is one of the most pressing problems.

(ii) Orientation of receiver according to the energy density of sunrays will be difficult.

119. What is geothermal energy?

Geothermal energy is the heat from high pressure steam coming from within the earth. It is a renewable source of energy derived from the rain water in the earth heated to over 180°*C* by subterranean hot rocks.

120. What are the applications of geothermal energy?

a. Generation of electric power

b. Space heating for buildings

c. Industrial process heat.

121. List some geothermal fluids.

a) Hot water

b) Hot brine

c) Wet stream

122. What are the forms of geothermal energy stored deeply inside the earth?

a) Hot water springs

b) Fumaroles

c) Volcanic eruptions.

123. What are the important criteria while selecting the geothermal energy?

a) Temperature of geothermal fluid, °*C*.

b) Discharge rate, m^3/day

c) Useful life of production well, years

d) Mineral contents $gram/m^3$.

124. What are the classifications of geothermal energy?

[Anna Univ. (EEE) Dec'11, Dec'12& June'13]

1. Hydrothermal convective systems
2. Geopressured resources
3. Petro-thermal or hot dry rocks
4. Magma resources
5. Volcanoes.

125. What are the applications of geothermal energy?

d. Generation of electric power

e. Space heating for buildings

f. Industrial process heat.

126. Give some geothermal energy sources in India.

i. Puga Valley of the Ladakh region in Jammu and Kashmir.

ii. Cambay region of Gujarat and Maharastra.

iii. Tattapani-Hydro-Geothermal field, Madhya Pradesh.

127. What are the different geothermal fluids?

d) Hot water

e) Hot brine

f) Wet stream

g) Combination all of above.

128. What are the forms of geothermal energy stored deeply inside the earth?

d) Hot water spring

e) Fumarole

f) Volcanic eruption.

129. What are the important criteria while selecting the geothermal energy?

e) Temperature of geothermal fluid, °C.

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g) Useful life of production well, *years*

h) Mineral contents $gram/m^3$

130. What are the different types of geothermal fluid and give its temperature range. *[Anna Univ. (EEE) May'11]*

a) Dry steam – Steam-turbine cycle

b) Hot water, temperature > $180°C$ – Steam-Turbine cycle

c) Hot water, temperature <$150°C$ – Binary-cycle

d) Hot brine (pressurized) – Binary-cycle

e) Hot brine (flashed) – Special turbines

- Impact turbine
- Screw expander
- Bladless turbine

131. What are the types of geothermal power plants? *[Anna Univ. (Mech.) Dec'13]*

1. According to geothermal energy resource

a) Geothermal steam

b) Geothermal brine

c) Geothermal hot water

d) Hot rock.

2. According to thermodynamic cycle

a) Steam Turbine cycle

b) Binary cycle

c) Total flow concept.

132. What are the different types of turbines for driving generator rotor in geothermal power plants?

a) Steam turbines

b) Gas turbine

c) Impact turbine driven by brine

d) Helical screw expander

e) Bladeless turbine.

133. What are the different working fluids in binary cycle geothermal power plants?

1. Isobutane (C_4H_{10})
2. Ammonia
3. Propane
4. Freon-12.

134. What are the classifications of geothermal fields?

1. Non thermal areas –Temperature gradient 10 – 40°*C/km* depth.
2. Semi-thermal areas –Temperature gradient – 70°*C/km* depth.
3. Hyper-thermal areas – Temperature gradients are many times greater than in normal areas.

135. What are Geo pressured resources?

Drilling for oil and gas has revealed the existence of reservoirs containing salt water at moderately high temperature and very high pressure in a belt some 1200 *km* in length.

136. What is magma resources?

In some cases, especially in the vicinity of relatively recent volcanic activity molten or practically molten rock occurs at moderate depth. The very high temperature above 650°*C* and the large volume make magma a substantial geothermal resource.

137. What are the arrangements for hybrid plants?

1. Geothermal preheat
2. Fossil superheat.

138. What are the different types of prime-movers for geothermal energy conversion?

1. Impulse/Reaction Machines:

(*a*) Axial flow – Curtis, Rateau steam turbine.

(*b*) Radial inflow – Francis turbine, multiple disc drag turbine.

(*c*) Radial outflow– Rotating nozzle.

(*d*) Multiple disc turbine – Bladeless impulse or reaction drag turbine.

2. Positive displacement machines:

(*a*) Helical and screw expander.

(*b*) Rotating and oscillating vane machine.

3. Impulse machines:

(*a*) Tangential flow – peloton wheel, re-entry type turbine.

(*b*) Axial flow, De-laval turbine, Curtis turbine.

139. What are the applications of geothermal energy?

1. Generation of electric power.
2. Industrial process heat, and
3. Space heating for various kinds of buildings.

140. What is biomass and biomass energy?

Biomass is organic matter produced by plants or by both terrestrial (those grown on land) and aquatic (those grown in water).

E.g., Wood and Agriculture residue.

The energy obtained from biomass is called *biomass energy*.

141. What are the two major classifications of biomass resources?

1. Biomass from cultivated fields, crops, forests and harvested periodically.
2. Biomass derived from waste e.g., municipal waste, animal dung, forest waste, agricultural waste and bioprocess waste.

142. What is the scope of biomass energy?

1. Rural application of biomass energy.
2. Urban and industrial applications of biomass energy.
3. Biomass as a primary source for large scale electrical power generation.

143. What are the different types of biomass waste?

(i) Urban waste

(ii) Process waste

(iii) Agricultural waste

(iv) Forest waste

(v) Fishery and poultry.

(vi) Animal and human excreta.

144. What are the major categories of biomass conversion process?

1. Direct combustion (Incineration)
2. Thermo chemical conversion
3. Biochemical conversion.

145. What is fermentation?

It is the breakdown of complex molecules in organic compound under the influence of ferment such as yeast, bacteria, enzymes *etc.*

146. What are the factors affecting biodigestion or generation of gas?

1. pH or the hydrogen-ion concentration
2. Temperature
3. Total solid content
4. Loading rate
5. Seeding
6. Diameter to depth ratio
7. Nutrients
8. Type of feed stocks
9. Pressure
10. Uniform feeding.

147. Define pyrolysis.

Biomass can be converted into gases, liquids and solids through pyrolysis at temperature of 500-900°*C* by heating in a closed vessel in the absence of oxygen.

148. What are two biochemical conversions?

1. Anaerobic digestion.
2. Fermentation.

149. Define anaerobic digestion.

It is a type of biochemical conversion involving the microbial digestion of biomass. It generates methane and CO_2 gas.

150. Define photosynthesis.

(i) Photosynthesis means the synthesis process with light.

(ii) Photosynthesis converts solar energy into biomass energy.

(iii) It consists in building up of simple carbohydrates such as sugar in the green leaf in the presence of sunlight.

151. What are the necessary conditions for photo-synthesis process?

1. Light:

It is one of the important inputs for biomass production.

2. CO_2 concentration:

It is the primary raw material for photo synthesis.

3. Temperature:

Photosynthesis is restricted to the temperature range 0°C to 60°C.

152. What is the classification of biogas plants?

1. Continuous and batch type
2. Dome and drum type
3. Different variations in the drum type.

153. What is Gobar gas?

Biogas produced from cow dung in a plant is called *biogas*. It is used in cooking, lighting, running diesel engines and fuel for furnaces.

154. What is anaerobic digestion?

It is the process of making complete digestion of a biomass. It is applicable to wet organic matters. The process involves microbial digestion of biomass. An anaerobe is a microorganism which lives and grows on biomass at low temperature (<65°C).

155. What is the average composition of biogas?

Methane (CH_4) – 55 to 60%

Carbon dioxide (CO_2) – 35 to 40%

Hydrogen (H_2) – 5%

H_2S and O_2 – Traces.

156. What are the main features of continuous type gas plant?

1. It will produce gas continuously.

2. It requires small digestion chamber.
3. It needs less period for digestion.

157. *What are the main features of the batch type gas plant?*

1. The gas production is intermittent.
2. It needs several digesters.
3. Batch type plants are good for long fibrous materials.

158. *What are the materials used for bio-gas generation?*

1. Animal waste
2. Human waste
3. Agricultural waste
4. Waste of aquatic origin.

159. *What is pyrolysis?*

It is an irreversible chemical change caused by the action of heat in the absence of oxygen. This process may yield solid, liquid or gaseous fuels.

160. *What is hydrolysis?*

Hydrolysis is the technology which converts the cellulose into alcohols through fermentation.

161. *What is fuel cell?* ***[Anna Univ. (EEE) May'10 & Dec'10]***

A fuel cell is a device which uses hydrogen (or a hydrogen-rich fuel) and oxygen to create an electric current.

In other words, it can be defined as an electrochemical device in which the chemical energy of a conventional fuel is converted directly and efficiently into low voltage direct-current electrical energy.

162. *List down the possible reaction involved in fuel cells.*

Hydrogen/oxygen 1.23 *V* $2H_2 + O_2 \Rightarrow 2H_2O$

Hydrazine 1.56 *V* $N_2H_4 + O \Rightarrow 2H_2O + N_2$

Carbon (Coal) 1.02 *V* $C + O_2 \Rightarrow CO_2$

Methane 1.05 *V* $CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O$

163. Draw a schematic of a fuel cell.

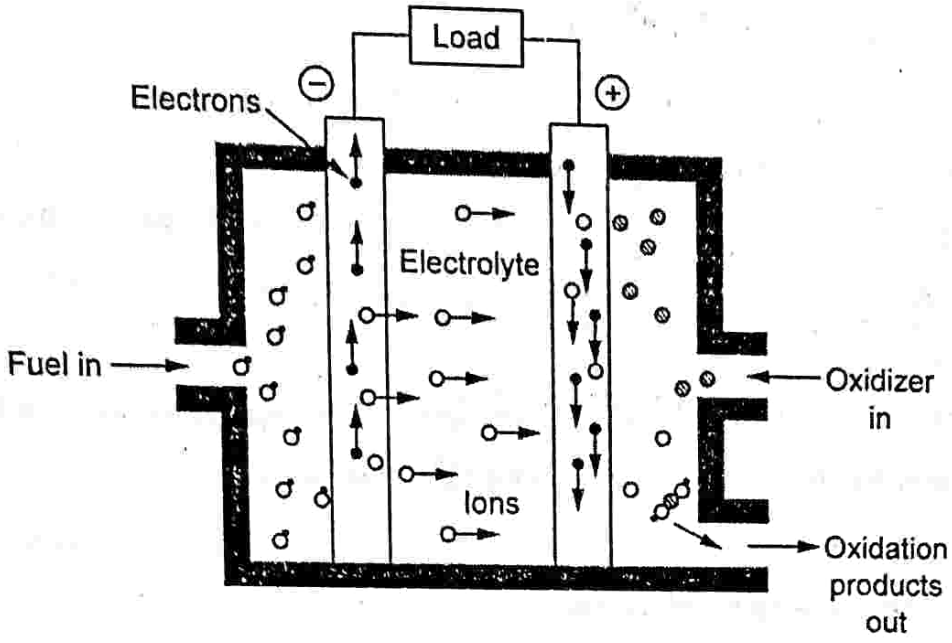

Figure 4.80 Schematic of a fuel cell

164. Mention the various parts of fuel cell.

1. Membrane electrode assembly
2. Catalyst
3. Chemistry of a Fuel Cell
4. Hardware

165. List down the major sections of a fuel cell.

(i) Fuel processing section
(ii) Fuel cell power pack
(iii) Power conditioning section
(iv) Switchgear and supply section
(v) Control subsystem section
(vi) Heating section.

166. Classify fuel cells.

1) Hydrogen-oxygen fuel cell
2) Polymer electrolyte membrane (PEM) fuel cell
3) Direct methanol fuel cell
4) Alkaline fuel cell
5) Phosphoric acid fuel cell

6) Molten carbonate fuel cell

7) Solid oxide fuel cell

8) Regenerative fuel cell.

167. What are the advantages of fuel cells?

1) Fuel cells have the potential to replace the internal combustion engine in vehicles and they provide power for stationary and portable power applications.

2) They can be used in transportation applications such as powering automobiles, buses, cycles and other vehicles.

3) Many portable devices can be powered by fuel cells such as laptop computers and cell phones.

4) They can also be used for stationary applications such as providing electricity to power homes and businesses.

168. What are the disadvantages of fuel cells?

1. Initial cost is high.
2. It requires less service life.

169. List the various applications of fuel cells.

1. Domestic use
2. Automotive vehicles
3. Central power stations
4. Special applications.

170. Differentiate between renewable and non-renewable sources of energy.

[Anna Univ. (Mech.) May'13]

The difference between renewable energy and nonrenewable energy is in which non-renewable energy can be used up. Ex. Fossil fuels but renewable energy sources are unlimited and cannot be used up. Ex. Solar, wind, tidal and wave energies.

(b) Capacity factor = 1

(c) Maximum demand = 40000 kW]

AU Problem 11

Determine the generating cost per unit of 80MW power station with the following data:

Capital Cost = Rs 160×10^7

Annual Cost of fuel = Rs 32×10^6

Annual wages and taxes = 10% of Capital cost

Annual load factor= 45%. *[(Mech.) Apr'08]*

Similar to **Problem 15** in page **5.47.**

[**Ans:-** Generating cost = Rs. 0.723 = *72.3Paise*]

5.19. TWO MARK QUESTIONS AND ANSWERS

1. ***What are the various operating costs of coal fired steam power plant?***

[Anna Univ. Apr'05]

(a) Cost of fuel

(b) Lubricating oil, grease and water cost

(c) Cost of maintenance and repairs

(d) Cost of operating labour

(e) Cost of supervision

(f) Taxes

(g) External cost

(h) Internal cost.

2. ***Define the term connected load.***

It is the combined continuous rating of all receiving apparatus on consumer's premises.

3. ***Distinguish between peak load and connected load.***

Peak load is the highest load which occurs on the power plant operation throughout the cycle.

Connected load is the combined continuous rating of all receiving apparatus on consumer's premises.

4. *What is demand?*

It is the load which is drawn from the source of supply at the receiving terminals averaged over a suitable and specified interval of time.

5. *Define demand for electricity.* *[Anna Univ. (EEE) Dec'13]*

It is defined as the electricity requirement during the period of time of high price or more stress.

6. *What is meant by maximum effective load?*

It is the maximum load which is used by a consumer at any time. It is determined by measurement according to specifications over a prescribed interval of time.

7. *Define demand factor and load factor.* *[Anna Univ. (Mech.) May'13]*

Demand factor is the ratio of actual maximum demand of the system to the total connected demand of the system.

$$\text{Demand factor} = \frac{\text{Actual maximum demand}}{\text{Total connected demand}}$$

Load factor is the ratio of the average load over a given time interval to the peak load during the same time interval.

$$\text{Load factor} = \frac{\text{Average load over a given time interval}}{\text{Peak load during the same time interval}}$$

8. *Define the following terms plant use factor, reserve factor, diversity factor and capacity factor.*

Plant use factor is the ratio of energy produced in a given time to the maximum possible energy that could have been produced during the actual number of hours the plant was in operation.

$$\text{Plant use factor} = \frac{\text{Actual energy produced in given time period}}{\text{Maximum possible energy produced during same period of operation}}$$

$$= \frac{E}{C \times t_1}$$

where t_1 ⇒ Actual number of hours when the plant has been in operation.

Reserve factor is the ratio of load factor to the capacity factor.

$$\text{Reserve factor} = \frac{\text{Load factor}}{\text{Capacity factor}}$$

Capacity factor is the ratio of actual energy produced in *kilowatt hours* (*kWh*) to the maximum possible energy which could have been produced during the same period.

$$\text{Capacity factor} = \frac{\text{Actual energy produced in } kWh}{\text{Rated capacity of the plant}} = \frac{E}{C \times t}$$

$$\text{Capacity factor} = \frac{\text{Average load}}{\text{Rated capacity of the plant}}$$

where E ⇒ Energy produced in kWh

C ⇒ Capacity of the plant in kW

t ⇒ Total number of hours in given period.

9. *Define "Diversity factor".* ***[Anna Univ. (Mech.) Dec'05 & Dec'14]***

Diversity factor is defined as the ratio of sum of individual maximum demand to the actual peak load of the system.

$$\text{Diversity factor} = \frac{\text{Sum of individual maximum demand}}{\text{Actual peak load of the system}}$$

10. *What are the major factors that decide the economics of power plants?*

[Anna Univ. (Mech.) Apr'08]

(i) Connected load

(ii) Demand

(iii) Maximum demand

(iv) Demand factor

(v) Load factor

(vi) Capacity factor or plant capacity factor

(vii) Utilisation factor

(viii) Reserve factor

(ix) Diversity factor

(x) Plant use factor.

11. *State the general value of load factors of domestic load.*

The value of load factor for domestic load is 10-15%.

12. *Define load curve.*

It is a graphical representation which shows power demands for every instant during a certain time period.

13. *What do you understand by load duration curves?* ***[Anna Univ. (Mech.) May'14]***

Re-arrangement of all load elements of load curve is in descending order of magnitude. This curve is derived from the load curve.

14. *State the importance of load curves.* ***[Anna Univ. (Mech.) May'11]***

1. To obtain the average load on the power station and the maximum demand of the power station.
2. To know the incoming load thereby helping to decide the installed capacity of the power station.
3. To decide the economical sizes of various generating units.

15. *What is the significance of load curve?*

[Anna Univ. (Mech.) May'13 & (EEE) Dec'15]

The load curve gives full information about the incoming load and it helps to decide the installed capacity of the power station. It is also useful to decide the economical sizes of various generating units.

16. *What is the use of load curves in power plant?* ***[Anna Univ. (Mech.) Apr'08]***

Load curve is a graphical representation which shows the power demands for every instant during certain time period. By drawing these load curves, the peak load can be identified. Therefore, the capacity of power plant can be judged.

These curves give full information about the incoming load and they help to decide the installed capacity of the power station. It is also useful to decide the economical sizes of various generating units.

17. What is the specific indication of load factor values?

Load factor is always less than unity. It plays an important part on the cost of power generation per unit. Higher is the load factor, lesser will be the cost of power generation per unit for the same maximum demand.

18. What is the information provided by the yearly load curve? Or state the uses of load curve.

This curve gives full information about the incoming load and it helps to decide the installed capacity of the power station. It is also useful to decide the economical size of various generating units.

19. What are the various types of load?

(i) Residential load

(ii) Commercial load

(iii) Industrial load

(iv) Municipal load

(v) Irrigation load

(vi) Traction load.

20. What is meant by dump factor?

This term is used in hydroelectric power plants. It shows the power in excess of load requirements.

21. What is meant by base load power stations? Give examples.

The base load is the load below which the demand never falls and it is supplied at 100% of the same time. The power plants used to supply base loads are called *base load power plants*.

22. What do you mean by variable load on the power plant design?

Load varies in the power plants for every instant during certain time period. The variable load operation problem affects the power plant design and operation as well as the cost of generation. The necessity of supplying a variable load influences the characteristics and the method of using the power plant equipment. The generation of power must be regulated according to the demand. For that purpose, governing is necessary to achieve it. The response is quick to varying load.

23. How does the fuel cost related to the load and the cost of power generation? *[Anna Univ. (Mech.) Nov'08 & Apr'11]*

The cost of power generation is directly proportional to the fuel cost because the operating cost is directly linked with the fuel cost.

24. What are fixed and operating costs? *[Anna Univ. (Mech.) Dec'12 & May'14]*

Fixed costs are the cost required for the installation of complete power plant. This cost includes the cost of land, buildings, equipment, transmission and distribution lines, cost of planning and designing the plant and many others. It also consists of interest, taxes, depreciation, insurance etc.

Operating cost includes the cost of fuel, cost of lubricating oil, greases, cooling water, cost of maintenance and repairs, operating labour cost, supervision cost and taxes.

25. What are the elements of fixed and operating costs?

The elements of fixed costs are given below.

(a) Land, building and equipment cost

(b) Interest

(c) Depreciation cost.

The elements of operating costs are given below.

(a) Cost of fuel

(b) Lubricating oil, grease and water cost

(c) Cost of maintenance and repairs

(d) Cost of operating labour

(e) Cost of supervision, and

(f) Taxes.

26. Define flat rate tariff. *[Anna Univ. (Mech.) May'11 & Dec'13]*

The charging of amount depending only on the connected load and fixed number of hours of use per month or year is called *flat rate tariff.*

27. List the types of tariffs to calculate energy rate. *[Anna Univ. (Mech.) Dec'12]*

1. Flat demand rate
2. Straight line meter rate

3. Block-meter rate
4. Hopkinson demand rate of two-par tariff
5. Doherty rate or tree part tariff.

28. *How the tariff for electrical energy is arrived?* ***[Anna Univ. (Mech.) May'11]***

Tariff is calculated by the following equation.

$$E = Ax + By + C$$

where

E = Total amount of bill for the period considered

A = Rate per kW of maximum demand

x = Maximum demand in *kW*

B = Energy rate per *kWh*

y = energy consumed in *kWh* during the period considered

C = Constant amount charged to the consumer during each bill period. This charge is independent of demand or total energy.

29. *What is the significance of two part tariff and three part tariff?*

[Anna Univ. (Mech.) Nov'07]

Two-part tariff:

This method of charging depends on the maximum demand and energy consumption.

Three part tariff:

This method is proposed by Henry L, Doherty. In this method of charging, the consumer has to pay some fixed amount in addition to charges for maximum demand and energy consumed. The fixed amount to be charged depends on the occasional increase in price and wage charge of workers etc.

30. *Define depreciation.*

It is the amount to be set aside per year from income to meet the depreciation caused by the age of service, wear and tear of machinery.

31. *Mention any four methods for calculating depreciation.*

1. Straight line method

2. Sinking fund method
3. Diminishing value method
4. Net percent value method
5. Double sinking fund method.

32. What is the reason for the operating cost of hydel power plant being high?

No fuel cost is required for running the power plant.

33. How can be the cost of power generation reduced?

1. Periodic maintenance.
2. Installing waste heat recovery system.
3. Using energy efficient devices such as insulated compressors and insulated turbines.
4. Using higher grade fuels.

34. What are the factors that contribute for energy cost?

1. Cost of fuel.
2. Cost of operating labour.
3. Cost of maintenance labour and materials.
4. Cost of supplies.

35. List out four important factors to be considered for the selection of site for power plants.

1. Cost of land as well as taxes on land.
2. It should be near load centers.
3. It should be accessible by road, rail etc.,
4. Sufficient quantity of cooling water should be available.
5. The selected site should be away from the populated area.
6. Enough space should be available for future expansion of plants.
7. The selected site should satisfy geological factors.

36. What are the different pollutions in the flue gas?

(1) Oxides of nitrogen

(2) Oxides of sulphur

(3) Carbon monoxide

(4) Particulates.

37. What are the methods used for reduction of SO_2 pollutant?

(1) Adding lime stone ($CaCO_3$) to the coal

(2) Using wet scrubbers

(3) Using electro static precipitator.

38. What are the methods used for controlling the NOx?

(1) Reduction of temperature in combustion zone.

(2) Reduction of residence time in combustion zone.

(3) Increase in equivalence ratio in the combustion zone.

39. What is Acid rain?

CO_2, SO_2 and NO_x contact the water during rainy season. So, H_2SO_4 and HNO_3 acids are formed and mixed with water during rainfall.

40. What are the equipment used to control the particulates?

[Anna Univ. (EEE) May'09]

(1) Scrubbers

(2) Cyclone separator

(3) Fabric filters

(4) Electro static precipitators.

41. List down the nuclear waste disposal methods. *[Anna Univ. (Mech.) May'09]*

(i) Disposal in sea

(ii) Disposal in land

(iii) Disposal by reduction process through chemical reaction

(iv) Disposal by solidification process.

42. What are the various methods followed to transport solid waste?

(i) *Wet slurry method:* This method uses water slurry to transport the material to the disposal area.

(ii) *Pneumatic method:* This method uses the air to transport solid wastes to the disposal area.

(iii) Trucking.

(iv) Rail transport,

(v) Conveyor usually fixed or movable belt conveyor systems is used, and

(vi) Barge uses waterways to transport waste materials.

SOLVED QUESTIONS

1. Write an explanatory note on the economics of power generation.

[*Anna Univ. (Mech.) Nov'07 & Dec'14*]

Refer chapter **5.1** in page **5.1.**

2. Define the following terms:

(a) Maximum demand

Refer page **5.2.**

(b) Plant use factor

Refer page **5.3.**

(c) Plant utilization factor, and

Refer page **5.3.**

3. What is meant by load factor and diversity factor? [*Anna Univ. (Mech.) Apr'05*]

Refer page **5.2** for load factor and page **5.3** for diversity factor.

4. Elucidate the objectives and requirements to tariff and general form of tariff.

[*Anna Univ. (Mech.) May'13 & (EEE) Dec'15*]

Refer chapter **5.2.2** in pages **5.5.**

5. What are the significance of two part tariff and three part tariff?

[*Anna Univ. (Mech.) May'11*]

Refer page **5.8.**

6. What are the various types of loads?

Refer page **5.10.**

7. Write short notes on load duration curve.

Refer chapter **5.7** in page **5.19.**

8. Describe actual load curves.

Refer chapter **5.6** in page **5.18.**