POSTAL Book Package 2023

Mechanical Engineering

Objective Practice Sets

Power Plant Engineering

Contents

MADE EASY Publications

5 CHAPTER

Steam Cycle Analysis

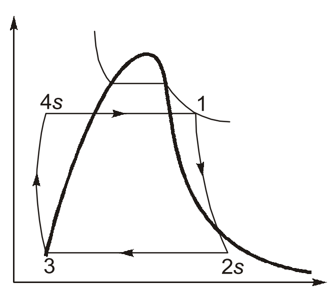
MCQ and NAT Questions

Q.1 Which of the following is often one of the parameter to express the capacity of a steam plant?
(a) Heat Rate (b) Net output power
(c) Steam Rate (d) Efficiency

Q.2 In a plant working on a vapour power cycle, the heat added in the boiler to form steam is 3600 kW and the heat rejected from the condenser 1200 kW. The heat rate is:
(a) 3 (b) 0.5
(c) 1.2 (d) 1.5

Q.3 The steam rate for the above cycle, given the mass flow rate of fluid is 20 kg/s is:
(a) 20 kg/kWhr (b) 30 kg/kWhr
(c) 40 kg/kWhr (d) 50 kg/kWhr

Q.4 The graph shows Rankine cycle on which coordinates?



(a) h-s (b) p-v
(c) p–T (d) T-v

Q.5 In a simple Rankine cycle, steam enters the condenser as saturated vapour and leaves as saturated liquid. The condenser and the boiler pressures are maintained at p_1 and p_2, respectively. If v_f and v_g are the specific volumes of saturated liquid and saturated vapour at condenser pressure, then pump work can be approximated as
(a) $v_g(p_2 - p_1)$ (b) $v_f(p_2 - p_1)$
(c) $p_1(v_g - v_f)$ (d) $p_2(v_g - v_f)$

Q.6 Critical temperature and pressure for steam is
(a) 313°C and 225 bar (b) 375°C and 225 bar
(c) 375°C and 252 bar (d) 313°C and 252 bar

Q.7 Rankine cycle efficiency of a good steam power plant is in the range of
(a) 20 to 25%
(b) 35 to 45%
(c) 10 to 20%
(d) > 50%

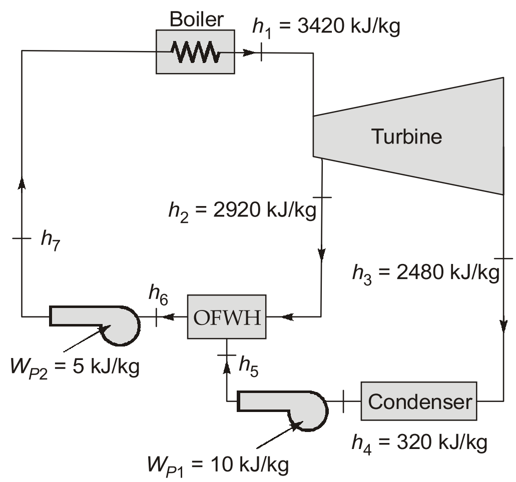
Q.8 Thermal efficiency of steam power plant is maximum at boiler pressure of
(a) 120 bar (b) 146 bar
(c) 166 bar (d) 156 bar

Q.9 Employing superheated steam in turbine leads to
(a) increase in erosion of blading
(b) decrease in erosion of blading
(c) no erosion of blading
(d) no effect on blading

Q.10 The enthalpy of steam entering a turbine in a Rankine cycle is 3200 kJ/kg. The enthalpy after isentropic expansion is 2400 kJ/kg and the enthalpy at the end of actual expansion is 2560 kJ/kg. What is the turbine efficiency ?
(a) 75% (b) 80%
(c) 85% (d) 90%

Q.11 Why is the thermal efficiency of superheat (modified) Rankine cycle higher than that of simple Rankine cycle?
(a) Enthalpy of steam is higher for superheat cycle
(b) Mean temperature of heat addition is higher
(c) Temperature of condenser is high
(d) Quality of steam in condenser is low

Q.12 From the consideration of erosion of blades in later stages of a turbine, the moisture content at turbine exhaust is not allowed to exceed:
(a) 88% (b) 90%
(c) 12% (d) 10%



(a) Net work output in regeneration cycle is 815 kJ/kg.
(b) Efficiency of regeneration cycle is 33.54%.
(c) Net work output in the cycle without regeneration is 925 kJ/kg.
(d) Efficiency of the cycle without regeneration is 29.98%.

Q.61 An ideal reheat Rankine Cycle operates between the pressure limits of 10 kPa and 8 MPa, with reheat being done at 4 MPa. The temperature of steam at the inlets of both turbine is 500°C and the enthalpy of steam is 3185 kJ/kg at the exit of the high pressure turbine and 2247 kJ/kg at the exit of low pressure turbine. The enthalpy of water at the exit from the pump is 191 kJ/kg. Use the following table for relevant data:

Superheated steam temp (°C)	Pressure (MPa)	Specific enthalpy (kJ/kg)	Specific entropy (kJ/kg-K)
500	4	3446	7.0922
500	8	3400	6.7266

Which of the following is/are correct neglect the pump work?
(a) Net work output in the cycle is 1414 kJ/kg.
(b) Heat supplied in the cycle is 3209 kJ/kg.
(c) Heat rejected in the cycle is 1795 kJ/kg.
(d) Efficiency of the cycle is 40.75%.

Q.62 In the Rankine cycle for a steam power plant the turbine entry and exit enthalpies are 2940 kJ/kg and 1921 kJ/kg, respectively. The enthalpies of water at pump entry and exit are 128 kJ/kg and 134 kJ/kg respectively. Which of the following options is/are correct?
(a) Net work output in the cycle is 1013 kJ/kg.
(b) Heat rate in the cycle is 2.34.
(c) Specific steam consumption of the cycle is 3.554 kg/kWh.
(d) Heat supplied in the cycle is 2806 kJ/kg.

■■■■

Answers Steam Cycle Analysis

1. (c)	2. (d)	3. (b)	4. (b)	5. (b)	6. (b)	7. (b)
8. (c)	9. (b)	10. (b)	11. (b)	12. (c)	13. (a)	14. (c)
15. (d)	16. (c)	17. (b)	18. (d)	19. (b)	20. (a)	21. (c)
22. (b)	23. (b)	24. (c)	25. (c)	26. (c)	27. (b)	28. (c)
29. (c)	30. (a)	31. (c)	32. (d)	33. (d)	34. (b)	35. (d)
36. (b)	37. (b)	38. (d)	39. (a)	40. (c)	41. (d)	42. (a)
43. (d)	44. (b)	45. (c)	46. (c)	47. (a)	48. (a)	49. (c)
50. (c)	51. (a)	52. (b)	53. (5.26)	54. (33.33)	55. (870)	56. (0.347)
57. (57.33)	58. (a, b, c, d)	59. (a, b, c)	60. (b, c, d)	61. (a, d)	62.. (a, c, d)	

Explanations Steam Cycle Analysis

1. (c)

The capacity of a steam plant is often expressed in terms of steam rate or specific steam consumption. It is defined as the rate of steam flow (kg/s) required to produce unit shaft output (1 kW)

$$\text{Steam rate} = \frac{1}{W_{net}} \text{kg/kW-s} = \frac{3600}{W_{net}} \text{kg/kWh}$$

2. (d)

$$\text{Heat Rate} = \frac{Q_1}{W_T - W_P} = \frac{Q_1}{Q_1 - Q_2}$$

$$= 1.5$$

3. (b)

$$\text{Steam rate} = \frac{\dot{m}_s}{P} = \frac{\dot{m}_s}{\dot{m}_s \times W_{net}}$$

$$= \frac{3600}{W_{net}} \text{kg/kWhr}$$

$$W_{net} = (Q_1 - Q_2)/\dot{m} = 120 \text{ kJ/kg}$$

$\Rightarrow$ Steam rate = 30 kg/kWhr

4. (b)

- 4s – 1 $\rightarrow$ Constant pressure heat addition in boiler.
- 2s – 3 $\rightarrow$ Constant pressure heat rejection in condenser

These two processes represents that Rankine cycle is drawn on P-V coordinates.

5. (b)

Pump work, $W_P = v_f(p_2 - p_1)$

6. (b)

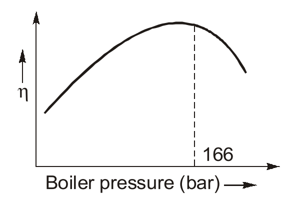
The critical temperature of steam is defined as the temperature above which it is impossible to liquefy the steam by pressure alone.

$$T_{critical} = 374.15°C$$
$$P_{critical} = 225.65 \text{ bar}$$

7. (b)

Efficiency of a good steam power plant lies in the range of 35 - 45%.

8. (c)



It has been observed that by increasing the boiler pressure (other factors remaining same) the cycle tends to rise and reaches a maximum value at a boiler pressure of about 166 bar.

9. (b)

Superheating of steam leads to decrease in erosion of turbine blades and increase in the life of turbine blades.

10. (b)

$$\eta_{turbine} = \frac{3200 - 2560}{3200 - 2400} = \frac{640}{800}$$

$$= 0.8 \text{ or } 80\%$$

11. (b)

Since the mean temperature of heat addition increases in superheat cycle, hence, the efficiency increases.

12. (c)

The value of dryness fraction allowed is 88%. Maximum allowable water content in the steam at exit of turbine is 12%, otherwise more blade erosion takes place causing more frequent blade replacement/maintenance.

13. (a)

Second law efficiency,

$$\eta_{II} = \frac{\text{minimum exergy intake to perform the given task}}{\text{actual exergy intake to perform the same task}}$$

$$\eta_{II} = \frac{A_{min}}{A}$$

But for rankine cycle,

$$A = Q_I\left(1 - \frac{T_L}{T_H}\right)$$

$$A_{min} = W_0$$