TEST ID: 408

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Engineering Academy

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ESE- 2019 (Prelims) - Offline Test Series Test – 15

MECHANICAL ENGINEERING

SUBJECT: IC engines, Refrigeration and Air conditioning + Power Plant Engg. + Renewable Sources of Energy — SOLUTIONS

01. Ans: (a)

Sol: The minimum temperature to which water can be cooled in cooling tower is wet bulb temperature.

02. Ans: (b)

Sol: Efficiency of diesel cycle :

$$\eta = 1 - \frac{1}{(r_v)^{\gamma-1}} \times \frac{\rho^{\gamma} - 1}{\gamma(\rho - 1)}$$

as $\rho \uparrow \Rightarrow \eta \downarrow$

where, ρ = cut-off ratio,

r_v = compression ratio,

$$\gamma = \frac{c_p}{c_v}$$

03. Ans: (c)

Sol: Series and parallel combinations of solar cells are called solar photovoltaic modules.

04. Ans: (b)

Sol: In Orsat apparatus, caustic potash solution (KOH) absorbs carbon-dioxide (CO_2), alkaline pyrogalic acid absorbs oxygen (O_2), Cuprous chloride absorbs carbon monoxide (CO).

05. Ans: (c)

Sol:

- If the inlet temperature increases, the temperature at the end of compression also increases. Therefore, the flame speed increases.
- A richer mixture is required during idling. Because of richer mixture, unburnt hydrocarbon will be more.

06. Ans: (b)

07. Ans: (d)

Sol: There are five methods for determining the engine friction. These are

1. From IP and BP measurements.
2. Morse test
3. Willan's line method
4. Motoring method
5. Deceleration method

Rope brake test is used to determine brake power.

08. Ans: (a)

Sol: Maximum power occurs at about 10 % richer mixture of the fuel.

09. Ans: (c)

Sol: Flat plate collectors absorb both direct and diffuse radiation.

10. Ans: (b)

Sol:

- As the cooling water temperature increases, the temperature inside the engine cylinder also increases due to which end charge temperature increases more rapidly. Therefore, knocking tendency increases.
- The SI engine utilises quantity governing.
- The speed and load control of engine is obtained by regulation of throttle valve. The air fuel ratio is nearly constant.

11. Ans: (c)

12. Ans: (b)

Sol: Hot arid zones are preferred for solar power plants.

13. Ans: (a)

Sol: Fluid friction, throttling and mixing are the causes of internal irreversibility of Rankine cycle.

14. Ans: (c)

Sol: An increase in compression ratio reduces the delay period.

15. Ans: (b)

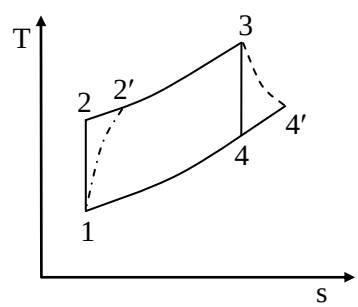
Sol:

- With intercooling and reheating, the compressor work decreases and turbine output increases. Therefore, the work ratio increases.
- The thermal efficiency of gas turbine cycle decreases with intercooling and reheating.

16. Ans: (b)

17. Ans: (c)

Sol:



$W_{net} = W_T - W_c$

$$W_{net} = c_p(T_3 - T_4') - c_p(T_2' - T_1)$$

$$= c_p\left[\eta_T(T_3 - T_4) - \frac{(T_2 - T_1)}{\eta_C}\right]$$

$$W = c_p\left[\eta_T T_3\left(1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}}\right) - \frac{T_1}{\eta_C}\left((r_p)^{\frac{\gamma-1}{\gamma}} - 1\right)\right]$$

For maximum work, $\frac{dW}{dr_p} = 0$

We get, $r_p = \left(\eta_c \times \eta_t \cdot \frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}$

18. Ans: (c)

Sol: Mechanical efficiency, $\eta_m = \frac{B.P}{I.P}$

$$0.75 = \frac{90}{I.P}$$

$$I.P = \frac{90}{0.75} = 90 \times \frac{4}{3} = 120 \text{ kW}$$

Frictional power = 120 – 90 = 30 kW

19. Ans: (a)

Sol: When beam radiations are blocked, shadow of an object is created.

20. Ans: (a)

Sol:

- The air cycle approximation of air standard theory has simplified approximations. Fuel cycle approximation is based on actual properties of cylinder gases.
- With no dissociation maximum temperature is obtained with correct mixture strength. Dissociation reduces the mixture temperature by 300°C.
- Dissociation effects are not as pronounced in CI engine as in the SI engine. It is because hetrogenous mixture and excess air in CI engines, both of which reduce overall temperature.

21. Ans: (b)

Sol: A long ignition delay period increases the knocking tendency in C.I engine.

22. Ans: (c)

Sol: Due to delination angle, the day and night lengths of north and south poles are 6 months.

23. Ans: (b)

Sol: Air standard efficiency,

$$\eta = 1 - \frac{1}{(r)^{\gamma-1}} = 1 - \frac{1}{(9)^{(1.5-1)}}$$

$$= 1 - \frac{1}{(3)} = \frac{2}{3} = 0.67$$

24. Ans: (c)

Sol: The best position of spark plug is nearer to the exhaust valve.

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25. Ans: (d)

Sol: While selecting a material for solar collector, thermo-physical, physical as well as environmental properties are considered.

26. Ans: (d)

Sol: Carbonisation of coal is the process of strongly heating coal for about 48 hours in the absence of air in a closed vessel.

27. Ans: (b)

Sol: Normally, the range of centane number is 45 to 60 in India.

28. Ans: (b)

Sol: Work done, $W = \frac{V_1^2 - V_2^2}{2} = \frac{60^2 - 20^2}{2}$

V_1 = 60 m/s at nozzle exit

V_2 = 20 m/s at blade exit

$W = \frac{3600 - 400}{2}$ = 1600 kJ/kg

29. Ans: (c)

Sol:

- In VC cycle, the condenser pressure should be kept as low as possible.
- Increase in condenser pressure, increases the work of compression.

30. Ans: (b)

Sol: $I_T = I_b r_b + I_d r_d + (I_b + I_d) r_r$

$= 100 \times 1.1 + 50 \times 0.9 + (100 + 50) \times 0.09$

$= 110 + 45 + 13.5$

$I_T = 168.5\ W/m^2$

31. Ans: (b)

Sol: In cold region the condenser temperature and pressure is lower due to lower temperature of cooling water which results in higher specific output and efficiency.

32. Ans: (b)

Sol: $COP = \frac{h_1 - h_4}{h_2 - h_1} = \frac{T_{sat}(s_1 - s_4)}{h_2 - h_1}$

$= \frac{250 \times (6.85 - 6.55)}{190 - 160}$

$= \frac{250 \times 0.3}{30} = \frac{75}{30} = 2.5$

33. Ans: (b)

Sol: h_1 = 3100 kJ/kg,

h_2 = 2100 kJ/kg

$W_T = h_1 - h_2$ = 1000 kJ/kg

$\frac{W_T}{Q_s} = \frac{1000}{1000 + Q_{rej}}$

= 0.4 [Neglecting pump work]

$Q_{rej} = 1500\ kJ/kg$

34. Ans: (a)

Sol: Solar cell is the source of energy for satellites.

35. Ans: (a)

Sol: COP of refrigeration system increases with decrease in condenser temperature.

36. Ans: (c)

37. Ans: (b)

Sol: There are two peaks that occur in a single pool tidal system.

38. Ans: (c)

Sol: In throttling process :

- Enthalpy = constant
- External work transfer = 0
- External heat transfer = 0

39. Ans: (c)

Sol: Feed check valve is a boiler mounting. It allows feed water under pressure to be passed to the boiler, but stops simultaneously any water escaping back.

40. Ans: (c)

Sol: When the sea water moves away from the shore, the tide is called ebb tide.

41. Ans: (b)

Sol: Junker calorimeter is a continuous flow gas calorimeter. It is used to find out the calorific value of gaseous fuel.

42. Ans: (c)

Sol: Cooling and dehumidification process is involved in summer air conditioning.

43. Ans: (c)

Sol: Drag is the resistance experienced by a body when a fluid flows over it.

44. Ans: (a)

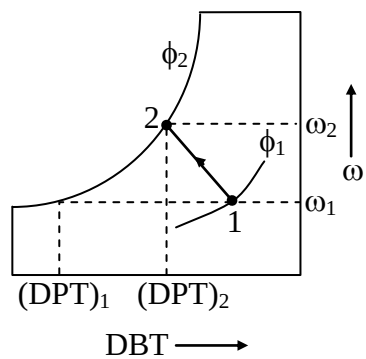
Sol: Jet steam condenser is a direct contact type condenser where steam and cooling water directly mix.

45. Ans: (a)

Sol: The gas turbines are used in air crafts because of its low weight per unit weight.

46. Ans: (a)

Sol:



In adiabatic saturation process 1 – 2 :

- $\omega_2 > \omega_1$
- $\phi_2 > \phi_1$
- Enthalpy remains constant
- $(DPT)_2 > (DPT)_1$

47. Ans: (b)

48. Ans: (a)

Sol: Thermal irreversibility decreases due to decrease in temperature difference between flue gas and steam.

49. Ans: (c)

Sol: In sensible cooling process, dew point temperature remains constant, while others change.

50. Ans: (d)

Sol: The function of compressor is performed by pump, absorber and generator in VARS.

51. Ans: (b)

Sol: Anaerobic decomposition process produces carbon dioxide and methane.

52. Ans: (a)

Sol: COP of Bell Coleman cycle $= \dfrac{1}{\left(r_p\right)^{\frac{\gamma-1}{\gamma}}-1}$

$$= \frac{1}{\frac{T_{exit}}{T_{entry}}-1}$$

$$= \frac{1}{\frac{500}{300}-1}$$

$$= \frac{3}{5-3} = 1.5$$

53. Ans: (b)

Sol: $\eta = 1 - \dfrac{1}{\left(r_p\right)^{\frac{\gamma-1}{\gamma}}} = 0.25$

$$\left(r_p\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{4}{3}\right)$$

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

$$= 300 \times \frac{4}{3} = 400 \text{ K}$$

$W_c = m\, c_p\, (T_2 - T_1)$

$= 2 \times 1(400 - 300)$ kW $= 200$ kW

54. Ans: (c)

Sol: Biogas from an anaerobic digestor is collected is an inverted drum.

55. Ans: (b)

Sol: COP of heat pump $(COP)_{HP} = 3$

$(COP)_{refrigerator} = 3 - 1 = 2$

$$COP = \frac{\text{Desired effect}}{\text{Energy input}}$$

$$2 = \frac{\text{Cooling load}}{4}$$

Cooling load = 8 kW

$$= 8\left(\frac{kJ}{s}\right) \times \frac{60}{60} = 480 \text{ kJ/min}$$

56. Ans: (b)

Sol: The flash point of a liquid fuel is the temperature at which the fuel ignites cleanly with visible flash.

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57. Ans: (c)

Sol: Automatic expansion valve is used to maintain the constant pressure in the evaporator. It is used when load is almost constant.

58. Ans: (c)

Sol: In practice diesel engines are operated at compression ratio appreciably higher than those which can be employed in SI engines. The normal compression ratio of diesel engines range from 15 to 22, where as in SI engines they are from 6 to 10. The actual efficiency is higher than petrol engine.

For Otto cycle, $\eta = 1 - \frac{1}{(r)^{\gamma-1}}$

For diesel cycle, $\eta = 1 - \frac{1}{(r)^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$

The term $\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$ is always greater than unity. Thus for same compression ratio the efficiency of Otto cycle is higher than diesel cycle.

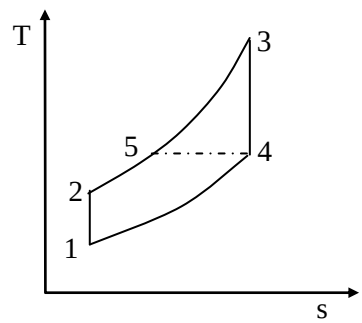
59. Ans: (b)

Sol:

- Supercharging of petrol engine increases pressure and temperature of engine due to which ignition delay is reduced and flame speed is increased. Both these effects result in greater tendency to detonate and pre-ignite. For this reason supercharged petrol engines employ lower compression ratio.
- The use of lower compression ratios and increased heat losses to higher value of specific heats and dissociation losses at higher temperatures result in lower thermal efficiencies for such engines. Thus, supercharged engines have a greater fuel consumption than naturally aspirated engines.

60. Ans: (a)

Sol:



For ideal regenerative heat exchanger,

$T_4 = T_5$

Work ratio $= \frac{W_T - W_C}{W_T}$

$= \frac{c_p(T_3 - T_4) - c_p(T_2 - T_1)}{c_p(T_3 - T_4)}$

$= 1 - \frac{T_2 - T_1}{T_3 - T_4}$

Thermal efficiency

$$= \frac{c_p(T_3 - T_4) - c_p(T_2 - T_1)}{c_p(T_3 - T_5)}$$

$$= 1 - \frac{(T_2 - T_1)}{T_3 - T_4} \qquad (\because T_5 = T_4)$$

Thus, thermal efficiency = Work ratio.

61. Ans: (b)

62. Ans: (c)

Sol:

- Number of chlorine atoms in HCFCs are less as compared to CFCs. Therefore, HCFCs cause less ozone depletion that the CFCs.
- There is no chlorine atom present in HCFCs, therefore it has zero ozone depletion potential.

63. Ans: (a)

Sol: Oil separator is installed between compressor and condenser.

64. Ans: (b)

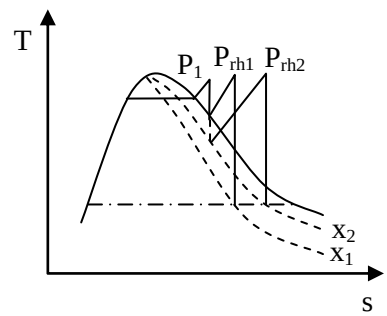
Sol:

- Line 1 $\rightarrow$ Suction line
- Line 2 $\rightarrow$ Discharge line
- Line 3 $\rightarrow$ Liquid line

65. Ans: (b)

66. Ans: (b)

Sol: The efficiency increases as the reheat pressure is lowered and reaches a peak at a pressure ratio $\frac{P_{rh}}{P_1}$ between 0.2 to 0.25 (where, P_{rh} = reheat pressure and P_1 = initial steam pressure of the plant). If the reheat pressure is further decreased, efficiency of the plant decreases.



As reheat pressure is lowered, the quality of steam at turbine exhaust increases.

$$P_{rh1} > P_{rh2}$$

$$x_1 < x_2$$

67. Ans: (b)

68. Ans: (d)

Sol: V-C cycle is an irreversible cycle because throttling process is an irreversible process.

69. Ans: (a)

Sol: If the wetted surface is absorbing latent heat of vapourization from the air, the temperature of air will be lowered.

70. Ans: (b)

71. Ans: (a)

Sol: Both statements are correct and Statement (II) is the right explanation of statement (I).

72. Ans: (a)

Sol: In evaporator or the boiler there is a phase change. As the pressure increases latent heat decreases and so heat absorbed in evaporator decreases.

73. Ans: (d)

74. Ans: (b)

Sol: The efficiency of a gas turbine cycle with heat exchanger is given by

$$\eta = 1 - \frac{T_{min}}{T_{max}}\left(r_p\right)^{\frac{\gamma-1}{\gamma}}$$

Efficiency increases with decrease in pressure ratio (r_p)

Lower pressure ratios and high cycle temperature are favourable for regenerative cycle, since a large heat recovery is then possible.

75. Ans: (c)

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