TEST ID: 308

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Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad - 500001.
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ESE- 2020 (Prelims) - Offline Test Series Test - 15

MECHANICAL ENGINEERING

Subject: IC Engines, Refrigeration & Air-conditioning + Power Plant Engg. + Renewable Sources of Energy — SOLUTIONS

01. Ans: (b)

Sol: $(COP) = \dfrac{T_L}{T_H - T_L} = \dfrac{1}{\frac{T_H}{T_L} - 1}$

$(COP) \propto \dfrac{1}{T_H}$

T_H is minimum in winter.

$\therefore$ $(COP)_{\text{Refrigeration Cycle}}$ is more in winter.

02. Ans: (a)

Sol: Extra cost and savings consideration are the factors on which the number of feed water heaters in a regenerative Rankine cycle is determined.

03. Ans: (c)

Sol: Brake specific fuel consumption (bsfc) increases as the load on IC engine is decreased.

04. Ans: (c)

05. Ans: (b)

Sol: P + F = C + 2

1 + F = 2 + 2

F = 3

But, we can locate the state of moist air with the help of any '2' variables (DPT, WBT, RH, humidity ratio) and atmospheric pressure is constant.

$\therefore$ The effective degree of freedom for moist air is 2.

06. Ans: (d)

Sol: The dryness fraction of steam at the outlet of a condenser in Rankine cycle is zero (Condensate leaves the condenser in saturated liquid condition).

07. Ans: (d)

Sol: For experimental determination of motor octane number the spark advance before TDC is 19 - 26°.

08. Ans: (c)

09. Ans: (d)

Sol: To vaporize one kg of water, 7 to 8 kg of mercury must condense. This can be found from the energy balance of the mercury condenser-steam boiler.

10. Ans: (c)

Sol: When 7 cells are connected in series, the voltage across this combination is $7 \times 1.2 = 8.4$ V. Now for such set when connected in parallel, the voltage will be the same.

11. Ans: (d)

Sol: Thermostatic expansion valve maintains a constant degree of super heat in the evaporator coil.

12. Ans: (c)

Sol: The compressor of Carnot vapor cycle handless (liquid + vapour) system due to which it has to be large.

13. Ans: (c)

Sol: Higher proportion of residual gases in the cylinder results in lower volumetric efficiency.

14. Ans: (b)

Sol: Given data,

Room sensible heat (RSH) = 60 kW

Room latent heat (RLH) = 15 kW

Outside air sensible heat (OASH) = 20 kW

Outside air latent heat (OALH) = 25 kW

Bypass factor of coil (BPF) = 0.15

Effective room sensible heat factor

$$(\text{ERSHF}) = \frac{\text{ERSH}}{\text{ERSH} + \text{ERLH}}$$

$\text{ERSH} = \text{RSH} + \text{OASH} \times \text{BPF}$

$= 60 + 0.15 \times 20$

$= 63$ kW

$\text{ERLH} = \text{RLH} + \text{OALH} \times \text{BPF}$

$= 15 + 25 \times 0.15$

$= 18.75$ kW

Effective room sensible heat factor,

$$\text{ERSHF} = \frac{63}{63 + 18.75} = 0.77$$

15. Ans: (d)

Sol: A cooling tower is specified by (a) approach, (b) range and (c) cooling efficiency.

- Warm water from the condenser enters the cooling tower at temperature t_{c1} and is cooled to t_{c2}, higher than the wet bulb temperature t_{wb}. This unattainable temperature difference is the approach which varies from 6 to 8°C.
- The cooling range is defined as the difference in temperatures of the incoming warm water (t_{c1}) and the exiting cooled water (t_{c2}). This range varies from 6 to 10°C.

16. Ans: (a)

17. Ans: (d)

Sol: In Petrol engine fuel injector is not used.

18. Ans: (d)

19. Ans: (a)

Sol: To conserve water, dry cooling is preferred in preference to wet cooling.

20. Ans: (c)

21. Ans: (a)

Sol: Bypass factor decreases with increasing coil length.

22. Ans: (c)

Sol: Labyrinth packing in a steam turbine is between nozzle diaphragm and shaft.

23. Ans: (c)

Sol:

- Reversed Brayton cycle consists of two constant pressure processes and two adiabatic processes.

- Because of lighter weight of the system is used in aircraft refrigeration system.

24. Ans: (d)

25. Ans: (d)

Sol: More cooling water in condenser will be required if air pressure in the condenser increases.

26. Ans: (b)

Sol: COP = 5

$$\text{COP} = \frac{T_2}{T_1 - T_2}$$

$$5 = \frac{1}{\frac{T_1}{T_2} - 1}$$

$$\frac{T_1}{T_2} - 1 = 0.2$$

$$\frac{T_1}{T_2} = 1.2$$

27. Ans: (c)

Sol: Inter-cooling in gas turbine results in increase in net output due to reduction in compressor work but decrease in thermal efficiency.

28. Ans: (b)

Sol: Generator temperature, $T_G = 350$ K

Condenser temperature, $T_C = 300$ K

Evaporator temperature, $T_E = 275$ K

$$(\text{COP})_{\max} = \frac{T_E}{T_C - T_E} \times \frac{T_G - T_C}{T_G}$$

$$= \frac{275}{25} \times \frac{350 - 300}{350} = \frac{275 \times 2}{350}$$

$$= 1.5714$$

29. Ans: (a)

Sol: Methyl alcohol is added as anti-icing agent to gasoline.

30. Ans: (a)

31. Ans: (c)

Sol: When pressure at throat is less than exit pressure, the steam nozzle gets chocked.

32. Ans: (b)

Sol: COP of vapour absorption system is low compared to vapour compression system.

33. Ans: (a)

Sol: Heating of steam at constant temperature is same as heating it at constant pressure.

34. Ans: (b)

35. Ans: (b)

Sol: Pressure cap is used in a radiator of an IC engine.

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36. Ans: (c)

Sol: COP of vortex tube refrigeration system is low.

37. Ans: (c)

Sol: For induced draft, the pressure inside the boiler furnace will be less than atmospheric pressure.

38. Ans: (b)

Sol: $P \propto V^3$

Thus, if $V_2 = 2V_1$,

Then $P_2 = 8P_1$.

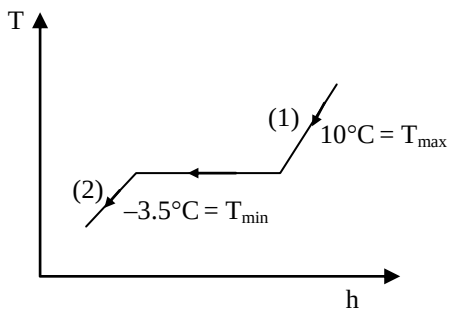
39. Ans: (d)

Sol: For a two stroke engine

- Exhaust and transfer ports open before BDC.
- Exhaust port opening is more than transfer port opening.
- Inlet port opens before TDC and closes after TDC.

40. Ans: (d)

Sol:



Given,

$m_{Ice} = 10$ kg/min,

$T_{water} = 10°C$

$(c_p)_{water} = 4.2$ kJ/kgK

$(c_p)_{ice} = 2$ kJ/kgK

$h_{fg} = 335$ kJ/kgK

$$(COP)_{Carnot} = \frac{T_{min}}{T_{max} - T_{min}}$$

$$\frac{269.5}{283 - 269.5} = \frac{269.5}{13.5} \cong 20$$

Total heat removed from water

$(Q) = m_w (c_p)_w \Delta T + m\, h_{fg} + m_{Ice} (c_p)_{Ice} \Delta T$

$Q = 10 (4.2 \times 10 + 335 + 2 \times 3.5)$

$Q = 3840$ kJ/min

$$(COP)_{Carnot} = \frac{Q}{W_{min}}$$

$$W_{min} = \frac{Q}{(COP)_{Carnot}} = \frac{3840}{20}$$

$W_{min} = 192$ kJ/min

41. Ans: (d)

Sol: In a battery ignition system secondary windings have more turns and higher gauge when compared to primary.

42. Ans: (c)

Sol: Electrolux refrigeration system uses low grade energy (solar heat) to obtain refrigeration effect.

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43. Ans: (c)

44. Ans: (d)

Sol: Black smoke is obtained in CI engine when the air fuel ratio is in the range 10 to 18.

45. Ans: (b)

Sol: Given data,

D = 200 mm , L = 300 mm

N = 300 rpm, $\eta_o = 0.85$, k = 1

$$\eta_v = \frac{m \times v_1}{\frac{\pi}{4} D^2 \times L \times N \times k}$$

where,

m = mass flow rate of refrigerant

v_1 = specific volume of refrigerant at inlet of compressor

$$0.85 = \frac{m \times 0.42}{\frac{\pi}{4} \times (0.2)^2 \times (0.3) \times 300 \times 1}$$

$\Rightarrow$ m = 5.7221 kg/min

46. Ans: (b)

Sol: Mercury has higher boiling point than that of water due to which it is used in the top cycle in a steam power plant.

47. Ans: (d)

48. Ans: (d)

Sol: Piston rings are coated with chromium, cadmium and phosphorous to reduce wear and prevent scuffing.

49. Ans: (d)

50. Ans: (c)

Sol: m_1 = 30 kg/min, h_1 = 15 kJ/kg.da

m_2 = 15 kg/min, h_2 = 30 kJ/kg.da

Energy Balance,

$m_1h_1 + m_2h_2 = (m_1 + m_2)h_3$

where h_3 is the enthalpy of the mixture.

$$h_3 = \frac{m_1h_1 + m_2h_2}{m_1 + m_2} = \frac{30 \times 15 + 15 \times 30}{(30 + 15)}$$

h_3 = 20 kJ/kg.da

51. Ans: (d)

Sol: In diesel engine accumulation of carbon in cylinder increases effective compression ratio.

52. Ans: (b)

Sol:

- Sensible heating/cooling process $\rightarrow$ Horizontal lines
- Humidification/dehumidification process $\rightarrow$ Vertical lines
- Humidify ratio or specific humidity lines $\rightarrow$ Horizontal lines

- Specific volume lines → Inclined straight lines

53. Ans: (d)

Sol: HC emissions decrease and then increase as the fuel mixture in an SI engine is being leaned.

54. Ans: (d)

Sol: There should neither be expansion nor be contraction upon mixing.

- Obeys Dalton's law in vapour phase.
- Obeys Rault's law in liquid phase.

55. Ans: (b)

Sol: Enthalpy of air (h) = $h_a + \omega h_v$

$h_a \rightarrow$ enthalpy of dry air.

$h_v \rightarrow$ enthalpy of water vapour.

$h_v = c_{p_v} t_{dpt} + h_{fg}$

$c_{p_v} = 1.88\,kJ/kg.K$

$h_{fg} = 2500\,kJ/kg$ at 0°C

$h_v = 1.8 \times 22 + 2500 = 2539.6$ kJ/kg

$h = h_a + \omega h_v$

$= c_{p_{air}} \times t_{dpt} + \omega h_v$

$= 1.005 \times 22 + 0.005 \times 2539.6$

h = 34.808 kJ/kg of dry air

56. Ans: (d)

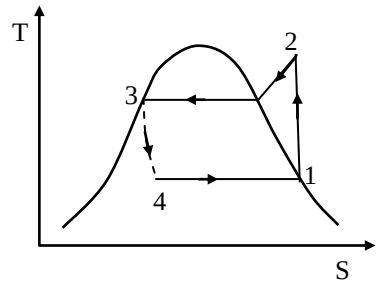
Sol: At high engine speeds the friction in highest.

- during suction and exhaust processes
- near the end of compression
- initial part of expansion

57. Ans: (b)

58. Ans: (b)

Sol:



$h_1 = 200$ kJ/kg, $h_2 = 250$ kJ/kg

$h_3 = h_4 = 50$ kJ/kg

$$COP = \frac{NRE}{W_{input}} = \frac{h_1 - h_4}{h_2 - h_1}$$

$$= \frac{200 - 50}{250 - 200} = \frac{150}{50}$$

COP = 3

59. Ans: (c)

Sol: The losses in descending order in fuel air actual cycle are :

- heat loss to cylinder walls
- burning time loss
- exhaust blow down loss

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60. Ans: (b)

Sol:

- Above figure represents heating and humidification processes used in winter air condition system.
- Content of water vapour increases.

61. Ans: (d)

Sol: In a four stroke SI Engine it is advisable to practically open the valve (exhaust) 40° to 70° before BDC.

62. Ans: (a) **63. Ans: (c)**

64. Ans: (c) **65. Ans: (b)**

66. Ans: (a)

67. Ans: (b)

Sol: Both statements are correct but statement (II) is not the correct explanation of statement (I).

68. Ans: (d)

69. Ans: (b)

Sol: Both statements are correct but statement (II) is not the correct explanation of statement (I).

70. Ans: (a)

71. Ans: (a)

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

72. Ans: (a)

Sol:

- In a pure impulse turbine the axial thrust on the blades is entirely due to the change in momentum of the steam in the axial direction and is usually very small.
- In the reaction turbine, however, there is a pressure drop across the blades of each ring, and so there can be a large force exerted on the blades in the axial direction.

73. Ans: (b)

Sol: Both statements are correct but statement (II) is not the correct explanation of statement (I).

74. Ans: (b)

Sol:

- A shroud is a band placed around the periphery of the blade tips in order to stiffen the blades and prevent spillage of steam over the tips. Shrouding is beneficial in high pressure impulse blade with partial

admission, which are subject to vibration. Thus, statement (I) is correct.

- If shrouding is not provided in long blades, then lacing or lashing wires must be used to keep the blades in alignment and to add stiffness. Thus, statement (II) is also correct but not the correct explanation of statement (I).

75. Ans: (a)

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