CLASS TEST

S.No.:01SK_ABCDEFG_12112024

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IC ENGINE

MECHANICAL ENGINEERING

Date of Test : 12/11/2024

ANSWER KEY

1.	(d)	7.	(c)	13.	(c)	19.	(a)	25.	(c)
2.	(d)	8.	(b)	14.	(d)	20.	(c)	26.	(b)
3.	(a)	9.	(d)	15.	(c)	21.	(c)	27.	(b)
4.	(b)	10.	(c)	16.	(a)	22.	(a)	28.	(d)
5.	(a)	11.	(b)	17.	(a)	23.	(c)	29.	(d)
6.	(b)	12.	(b)	18.	(d)	24.	(a)	30.	(c)

DETAILED EXPLANATIONS

1. (d)

$$\text{Brake power} = bmep \times \frac{LAN}{60}$$

Given: $N = 2000$ rpm

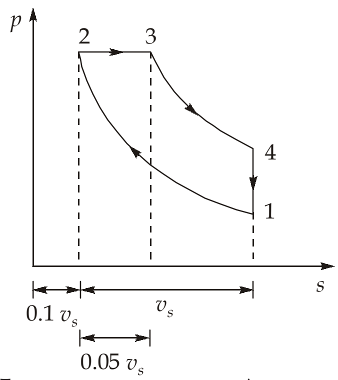
$D = 10$ cm, $L = 20$ cm

$\Rightarrow$ Brake power $= 35$ kW, $bmep = ?$

$$\Rightarrow \quad 35 \times 10^3 = bmep \times \frac{\frac{\pi}{4} \times D^2 \times L \times 2000}{60}$$

$$\Rightarrow \quad bmep = 6.684 \text{ bar}$$

2. (d)



r = compression ratio

$$= \frac{v_1}{v_2} = \frac{v_2 + v_s}{v_2}$$

$$r = 1 + \frac{v_s}{v_2} = 1 + \frac{v_s}{0.1 v_s}$$

$$\Rightarrow \quad r = 1 + 10 = 11$$

$$\Rightarrow \quad \frac{v_3}{v_2} = \text{cut-off ratio} = \frac{0.1 v_s + 0.05 v_s}{0.1 v_s} = \frac{0.15}{0.1} = 1.5$$ Answer

3. (a)

(1) As we know that, $\eta_m = \dfrac{B.P.}{I.P.}$

If, B.P. $= 0$

$\Rightarrow$ $\eta_m = 0$

(2) As we know that, with increase in B.P. η_m increases but max. value of η_m cannot go beyond 100%. So after a particular value with increase in B.P. η_m remains almost constant.

4. (b)

Let, Subscript 'f' $\rightarrow$ for full load

Subscript 'h' $\rightarrow$ for half load

$$(\eta_m)_f = \frac{(bp)_f}{(bp)_f + fp} = 0.9 \Rightarrow fp = \frac{(bp)_f}{0.9} - (bp)_f$$

$$fp = 3.33 \text{ kW}$$

$$\Rightarrow \quad (\eta_m) \text{ at half load} = \frac{(bp)_h}{(bp)_h + fp} = \frac{15}{15 + 3.33} = 81.8\%$$

5. **(a)**

For a two stroke engine

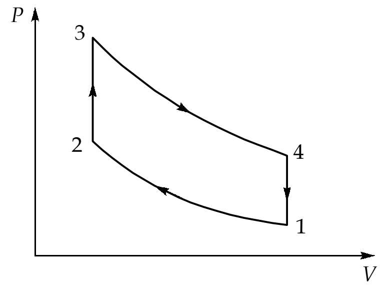
$$\text{I.P.} = \frac{P_i LAN}{60} = \frac{3.0\times100\times0.29\times\frac{\pi}{4}(0.21)^2\times360\times1}{60}$$

$$\text{I.P.} = 18.08 \text{ kW}$$

$$bp = \frac{2\pi NT}{60} = \frac{2\pi\times360}{60}\times(680\times(0.5+0.03))\times10^{-3} = 13.586 \text{ kW}$$

$$\eta_m = \frac{BP}{IP} = 0.7514 = 75.14\%$$

6. **(b)**



$$T_3 = 2800 \text{ K}$$

$$T_2 = 800 \text{ K}$$

$$W_{\text{net}} = 800 \text{ kJ/kg}$$

$$Q_{\text{supplied}} = c_v(T_3 - T_2) = 0.718(2800 - 800) = 1436 \text{ kJ/kg}$$

$$\eta_{\text{Otto}} = \frac{W_{\text{net}}}{Q_{\text{supplied}}} = \frac{800}{1436} = 0.557 = 55.7\%$$

7. **(c)**

- Piston rings are sacrificing component they are made brittle so that no plastic deformation take place and blow by loss can be eliminated,Hence they are made of grey cast iron.
- Connecting rod is under Fatigue loading condition. Hence, they are made of Drop forges steel to reduce internal defects.
- Spark plug should ideally be made of Platinum due to zero coefficient of thermal expansion but due to cost constraint, it is made of Ni-alloys.

9. **(d)**

$$\text{Initial efficiency, } \eta_i = 1-\frac{1}{(r)^{\gamma-1}} = 1-\frac{1}{(10)^{0.4}} = 0.60189$$

$$\eta_i = 60.19\%$$

When γ decreases by 1.5%, value of new γ is:

$$\gamma_n = 1.4\times\frac{(100-1.5)}{100} = 1.37\%$$

New efficiency is

$$\eta_f = 1-\frac{1}{(r)^{\gamma_n-1}} = 1-\frac{1}{(10)^{0.379}} = 0.5822$$

$$\eta_f = 58.22\%$$

So, change in efficiency is $= \dfrac{58.22 - 60.19}{60.19} = -0.0327 = -3.27\%$

Efficiency decreases by 3.27%.

10. **(c)**

$$r = 87.5 \text{ mm} = 87.5 \times 10^{-3} \text{ m}$$
$$N = 1800 \text{ rpm}$$

Mean piston speed, $\bar{v}_p = 2\text{Ln} = 4r\text{n}$

$$= 4 \times 82.5 \times 10^{-3} \times \frac{180}{60} = 10.5 \text{ m/s}$$

11. **(b)**

$$\eta_{\text{diesel}} = 1 - \frac{1}{\gamma r^{\gamma-1}}\left[\frac{r_c^{\gamma} - 1}{r_c - 1}\right]$$

$$= 1 - \frac{1}{1.4 \times 16^{1.4-1}}\left[\frac{1.1^{1.4} - 1}{1.1 - 1}\right] = 0.6636$$

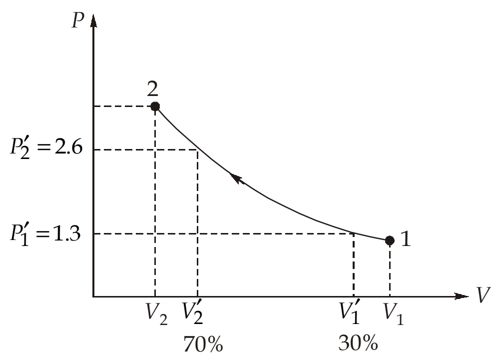
$$\eta_{\text{diesel}} = \eta_{\text{Otto}}$$

$\Rightarrow$ $$0.6636 = 1 - \frac{1}{(r)^{\gamma-1}}$$

$\Rightarrow$ $$0.6636 = 1 - \frac{1}{(r)^{1.66-1}}$$ [γ = 1.66 for helium]

$$2.973 = (r)^{1.66 - 1}$$
$$ln(2.973) = 0.66 \; ln(r)$$
$$r = 5.21$$

12. **(b)**



$$V_1' = V_2 + 0.7(V_1 - V_2)$$

$$= V_2\left[1 + 0.7\left(\frac{V_1}{V_2} - 1\right)\right]$$

$$V_1' = V_2\,[1 + 0.7(r - 1)] = V_2\,(0.7r + 0.3)$$

$$V_2' = V_2\,[1 + 0.3(r - 1)] = V_2\,(0.3r + 0.7)$$

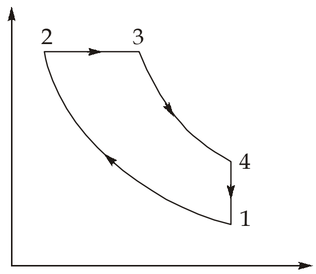
$$\frac{V_1'}{V_2'} = \left(\frac{P_2'}{P_1'}\right)^{1/r} = \left(\frac{2.6}{1.3}\right)^{1/1.4} = 1.6406$$

$$\frac{0.7r + 0.3}{0.3r + 0.7} = 1.6406$$

$$\Rightarrow \quad r = 4.08$$

$$\eta_{\text{air-std}} = 1 - \frac{1}{(r)^{r-1}} = 1 - \frac{1}{(4.08)^{0.4}} = 43.01\%$$

13. (c)



$$T_3 = 1500\,\text{K},\ T_1 = 300\ \text{K},\ r = 17,\ Q_{2-3} = ?$$

$$\frac{T_2}{T_1} = r^{\gamma - 1} = 17^{0.4}$$

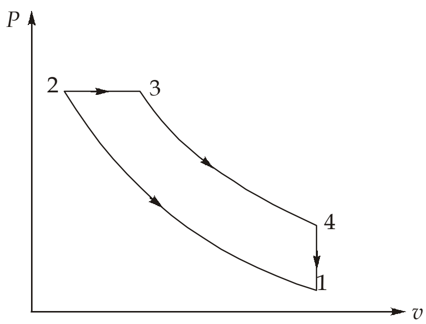
$$\Rightarrow \quad T_2 = 931.75\,\text{K}$$

$$Q_{2-3} = \int_{T_2}^{T_3} c_p\, dT = \int_{931.75}^{1500} \left(0.7 + 20 \times 10^{-5} T\right) dT$$

$$\Rightarrow \quad Q_{2-3} = \left(0.7T + \frac{20 \times 10^{-5} T^2}{2}\right)_{931.75}^{1500} = 535.96\ \text{kJ} \simeq 536\ \text{kJ}$$

14. (d)

Given: $r = 14$, $R = 287$ J/kgK, $c_p = 1005$ J/kgK, $\gamma = 1.4$



$$T_1 = 27°\text{C} = 300\ \text{K}$$

$$P_1 = 1 \text{ bar}$$
$$Q = c_p (T_3 - T_2)$$
$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (r)^{\gamma-1} = (14)^{1.4-1} = 2.8737$$
$$T_2 = 300 \times 2.8737 = 862.11 \text{ K}$$
$$\frac{T_3}{T_2} = \frac{v_3}{v_2} = 2$$
$$T_3 = 2T_2 = 1724.22 \text{ K}$$
$$Q = c_p (T_3 - T_2) = 1.005 \times (1724.22 - 862.11)$$
$$= 866.4 \text{ kJ/kg}$$

15. (c)

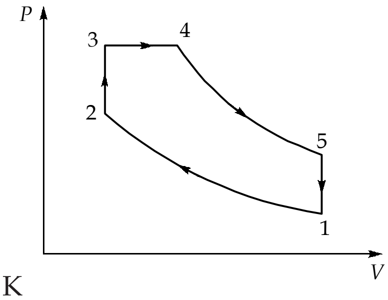
$$\eta_{diesel} = 1 - \frac{1}{\gamma (r)^{\gamma-1}}\left(\frac{r_c^{\gamma} - 1}{r_c - 1}\right)$$
$$\eta_{diesel} = f(\gamma, r, r_c)$$

now $\gamma_{air} = \gamma_{H_2} = \gamma_{cl_2} = 1.4$

and r_c and r for all cycles are same.

$\therefore$ $\eta_{air} = \eta_{cl2} = \eta_{H2}$

17. (a)



$$T_1 = 300 \text{ K}$$
$$P_1 = 1 \text{ bar}$$
$$HA = 1600 \text{ kJ/kg}$$
$$r = 15$$
$$(HA)_p = (HA)_v = 800 \text{ kJ/kg}$$
$$T_2 = T_1 . r^{\gamma-1} = 300 \times 15^{0.4} = 886.25 \text{ K}$$
$$P_2 = P_1 . r^{\gamma} = 1 \times 15^{1.4} = 44.31 \text{ bar}$$
$$(HA)_v = 800 = c_v (T_3 - T_2)$$
$$T_3 = \frac{800}{0.718} + T_2 = 2000.456 \text{ K}$$
$$(HA)_p = 800 = c_p (T_4 - T_3)$$
$$T_4 = \frac{800}{1.005} + 2000.456 = 2796.47 \text{ K}$$
$$P_3 = P_2 \cdot \frac{T_3}{T_2} = 44.31 \times \frac{2000.456}{886.25} = 100.017 \text{ bar}$$
$$P_4 = P_3 = 100.017 \text{ bar} \simeq 100 \text{ bar}$$

18. (d)

for dual cycle

$$\frac{Q_{Rej}}{Q_s} = \frac{5}{12}$$

$$\therefore \qquad \eta_{dual} = 1 - \frac{Q_R}{Q_s} = 1 - \frac{5}{12} = \frac{7}{12} = 0.5833$$

$$\eta_{otto} = 1 - \frac{1}{(n)^{\gamma-1}} \qquad [\gamma = 1.4 \text{ for air}]$$

$$\Rightarrow \qquad \eta_{otto} = \eta_{dual}$$

$$\Rightarrow \qquad = 1 - \frac{1}{(n)^{0.4}} = 0.5833$$

$$\frac{5}{12} = \frac{1}{(n)^{0.4}}$$

$$(n)^{0.4} = 2.4$$

$$0.4 \log n = \log 2.4$$

$$n = 8.92$$

19. (a)

$$Q_{supplied} = \dot{m}_{fuel} \times C.V. \text{ of fuel}$$

$$= 0.063 \times 10^{-3} \times 43756 = 2.7566 \text{ kJ}$$

$$\eta_{thermal} = \frac{W_{net}}{Q_{supplied}} = \frac{0.97}{2.7566} = 0.3518$$

$$\Rightarrow \qquad \eta_{thermal} = 1 - \frac{1}{(n)^{\gamma-1}}$$

$$0.3518 = 1 - \frac{1}{(n)^{0.4}}$$

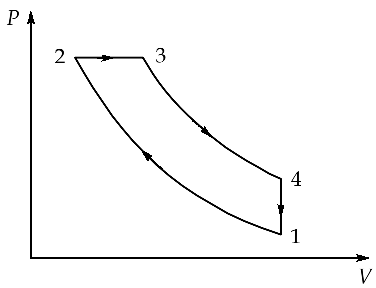
$$0.648 = \frac{1}{(n)^{0.4}}$$

$$1.5429 = (n)^{0.4}$$

$$\Rightarrow \qquad n = 2.9569$$

$\therefore$ Closest answer can be '*a*' i.e. $n = 3$.

20. (c)



$$r = 17$$

$$\rho = 2.6$$

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

$$= 1 - \frac{1}{(17)^{0.4}}\left[\frac{(2.6)^{1.4} - 1}{1.4(2.6 - 1)}\right]$$

$$= 0.596$$

$$\because \quad \eta = \frac{W_{net}}{Q_{supp}} = 0.596$$

$$\text{Work done} = 0.596 \times Q_{supp}$$

$$= 0.596 \times 1438.3 = 857.2 \text{ kJ/kg}$$

$$\because \quad v_1 = \frac{RT}{P_1} = \frac{0.287 \times (15 + 273)}{100} = 0.8265 \text{ m}^3\text{/kg}$$

$$v_2 = \frac{v_1}{r} = \frac{0.8265}{17} = 0.04862 \text{ m}^3\text{/kg}$$

$$\because \quad \text{Work done} = P_{mep}(v_1 - v_2)$$

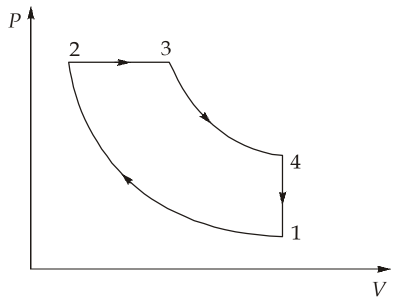
$$P_{mep} = \frac{W_{net}}{v_1 - v_2} = \frac{857.2}{(0.8265 - 0.04862)} = 1101.37 \text{ kPa}$$

$$= 1.1 \text{ MPa}$$

21. (c)

- Volumetric efficiency of two-stroke engine is low due to lesser time for mixture intake.
- Two-stroke engine does not contain valves,it contain ports.
- Due to one power stroke in one revolution,lubrication requirement is high which leads to higher rate of wear and tear in two-stroke engines.

22. (a)



$$\frac{V_3}{V_2} = r_c = 2$$

$$V_3 = V_2 + 0.05 \times V_S$$

$$(V_3 - V_2) = 0.05 \times (V_1 - V_2)$$

$$\left(\frac{V_3}{V_2} - 1\right) = 0.05\left(\frac{V_1}{V_2} - 1\right)$$

$$(2 - 1) = (0.05)(r - 1) \qquad \left(\text{where r is compression ratio} = \frac{V_1}{V_2}\right)$$

$$r = 21$$

We know that,

$$\eta = 1-\frac{1}{(r)^{\gamma-1}}\frac{\left(r_c^{\gamma}-1\right)}{\gamma\left(r_c-1\right)}$$

$$= 1-\frac{1}{(21)^{1.4-1}}\frac{\left(2^{1.4}-1\right)}{1.4(2-1)} = 0.6536 = 65.36\%$$

23. (c)

$$\eta_{mech} = 0.8,\ N = 1800 \text{ rpm},\ D = 1 \text{ m},\ W = 20 \text{ kN}$$

$$S = 13 \text{ kN}$$

$$BP = \pi D n (W\text{-}S)$$

$$= \pi\times 1\times\frac{1800}{60}(20-13)$$

$$= \frac{22}{7}\times 30\times 7 = 660 \text{ kW}$$

$$IP = \frac{BP}{\eta_{mech}} = \frac{660}{0.8} = 825 \text{ kW}$$

24. (a)

Advancing of spark decreases the knocking tendency in both SI and CI engines.

25. (c)

For maximum work,

$$T_2 = \sqrt{T_1T_3}$$

$$\eta_{otto} = 1-\frac{T_1}{T_2} = 1-\frac{T_1}{\sqrt{T_1T_3}} = 1-\sqrt{\frac{T_1}{T_3}}$$

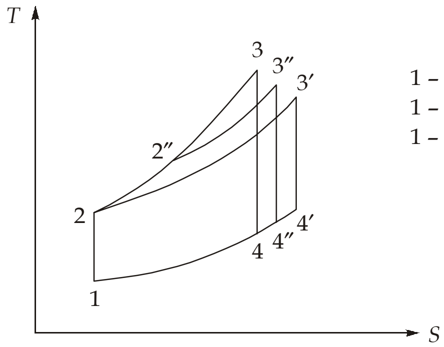
$$= 1-\sqrt{\frac{300}{1200}} = 1-\frac{1}{2} = 50\%$$

26. (b)

By using EGR to decrease NO_x , there is increase in HC emissions and decrease in thermal efficiency of the engine.

27. (b)

In otto, diesel and dual cycle with same compression ratio and heat input.



Conclusion: For same compression ratio and same heat input.

- Minimum heat is rejected in the otto cycle and maximum heat is rejected in the diesel cycle.
- Otto cycle has the largest work area and highest efficiency.
- $\eta_{otto} > \eta_{dual} > \eta_{diesel}$.

28. (d)

- Injection increases volumetric efficiency and hence increases power and torque.
- Injection gives better distribution of mixture to each cylinder and hence lower specific fuel consumption.
- Cost of injection system is high and life is less.

30. (c)

The stages of combustion in CI engine are :

1. Ignition delay period
2. Period of rapid combustion
3. Period of controlled combustion
4. Period of after burning

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