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I.C. Engine

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CLASS TEST 2019-2020

MECHANICAL ENGINEERING

Date of Test : 18/09/2019

ANSWER KEY ➤ I.C. Engine

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

Detailed Explanations

1. (b)

Over square engine has diameter greater than stroke length.

Swept volume $V_S = \frac{\pi}{4} d^2 L$ $\left\{\frac{d}{L} = 1.1 \Rightarrow d = 1.1L\right\}$

$\Rightarrow$ $490 = \frac{\pi}{4} \times (1.1L)^2 L$

$\Rightarrow$ $L = 8.02$ cm

Crank radius $= \frac{8.02}{2} = 4.01$ cm $= 40.1$ mm

4. (c)

$$\text{Indicated power} = \frac{\text{Brake Power}}{\eta_m}$$

$$= \frac{100}{0.8} = 125 \text{ kW}$$

Frictional power = Indicated power – break power

= 125 – 100 = 25 kW

5. (a)

$V_c = V_2 = 30$ cm^3

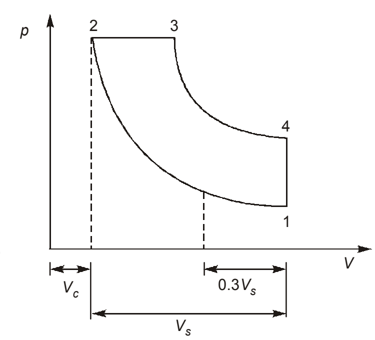
$r = 20 = 1 + \frac{V_s}{V_c}$

$V_s = 570$ cm^3

After 30% of compression stroke

$V_1' = V_c + 0.7\, V_s = 30 + 0.7 \times 570$

$= 429$ cm^3



6. (b)

$$\text{Fuel consumption/hr} = \left(\frac{10 \times 3600}{10^3}\right)$$

$$\text{Indicated specific fuel consumption} = \frac{\text{Mechanical efficiency} \times \text{Fuel consumption/hr}}{\text{Break Power}}$$

$$= \frac{0.85 \times 10 \times 3600}{10^3 \times 180} = 0.17 \text{ kg/kWh}$$

7. (a)

$$\text{Power} = \frac{P_m LAn}{60{,}000} \text{ kW}$$

As four stroke, so $n = \frac{N}{2} = 1000$ rpm

$$P_m = \frac{93 \times 60000}{0.0259 \times 1000}$$

$$= 215444.0154 \text{ N/m}^2 = 2.154 \text{ bar}$$

8. (a)

As the compression ratio increases the pressure also increases and so does the temperature. With increased temperature the auto ignition temperature of the fuel is reached and this causes fuel to ignite and this causes detonation in SI engines.

9. (b)

$$\text{Equivalence ratio} = \phi > 1 \text{ for idling condition}$$

$$\Rightarrow \quad \phi = \frac{\left(\frac{F}{A}\right)_{\text{Actual}}}{\left(\frac{F}{A}\right)_{\text{Stoichiometic}}} = \frac{\left(\frac{A}{F}\right)_{\text{Stoichiometric}}}{\left(\frac{A}{F}\right)_{\text{Actual}}} > 1$$

$$\Rightarrow \quad \left(\frac{A}{F}\right)_{\text{Actual}} < \left(\frac{A}{F}\right)_{\text{Stoichiometric}}$$

10. (d)

An increase in spark advance increases the peak pressure of the cycle and therefore increases pressure and temperature of the last charge. This shortens the delay period and increases tendency to knock.

12. (d)

$$(BP)_{1234} = 2700 \text{ kW}$$

$$(IP)_{1234} = (BP)_{1234} + (FP)_{1234} \quad \ldots(1)$$

Cylinder 1 not firing

$$\Rightarrow \quad (BP)_{234} = 1800 \text{ kW}$$

$$(IP)_{234} = (BP)_{234} + (FP)_{1234}$$

$$(IP)_{234} = (BP)_{234} + (IP)_{1234} - (BP)_{1234}$$

$$\Rightarrow \quad (IP)_{1234} - (IP)_{234} = (BP)_{1234} - (BP)_{234}$$

$$\Rightarrow \quad (IP)_1 = 2700 - 1800 = 900 \text{ kW}$$

$$\text{Similarly } (IP)_2 = 2700 - 1800 = 900 \text{ kW}$$

$$(IP)_3 = 2700 - 1750 = 950 \text{ kW}$$

$$(IP)_4 = 2700 - 1700 = 1000 \text{ kW}$$

$$(IP)_{1234} = 3750 \text{ kW}$$

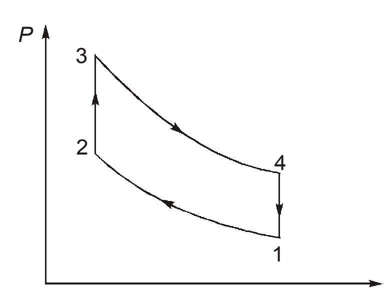
15. (d)

For Otto cycle ($P_{max}/P_{min} = r \times T_{max}/T_{min}$)

$$T_{max} = T_3$$

$$T_{min} = T_1$$

$$\frac{T_{max}}{T_{min}} = \frac{T_3}{T_1} = 6$$



$$r = 5.2$$

$$P_{max} = P_3$$

$$P_{min} = P_1$$

For process 2-3

$$\frac{P_3}{P_2} = \frac{T_3}{T_2}$$

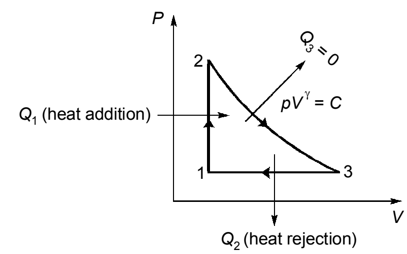
$$\Rightarrow \quad \frac{P_3}{P_1 r^{\gamma}} = \frac{T_3}{T_1 r^{\gamma-1}}$$

$$\Rightarrow \quad \frac{P_3}{P_1} = \frac{T_3 r^{\gamma}}{T_1 r^{\gamma-1}} = \frac{T_3 r}{T_1} = 6 \times 5.2 = 31.2$$

17. (c)

Thermal efficiency,
$$\eta = \frac{Q_1 - Q_2}{Q_1}$$

$$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{c_p(T_3 - T_1)}{c_V(T_2 - T_1)}$$



Using $pV = nRT$ and $\frac{c_p}{c_v} = \gamma$

$$\therefore \quad \eta = 1 - \gamma \frac{(V_3 - V_1)}{(p_2 - p_1)} \frac{p_1}{V_1}$$

18. (b)

$$\text{B.P.} = 40 \text{ kW}$$

$$\eta_{\text{mechanical}} = 0.8 = \frac{BP}{IP}$$

$$0.8 = \frac{40}{IP}$$

$$\Rightarrow \quad IP = 50 \text{ kW}$$

$$\text{Friction power} = IP - BP = 50 - 40 = 10 \text{ kW}$$

At 50 % of the rated load,
$$\text{BP} = 20 \text{ kW}$$

$$IP = BP + FP = 20 + 10 = 30 \text{ kW}$$

$$\eta_{\text{mech}} = \frac{20}{30} \times 100 = 66.67\ \%$$

19. (b)

$$\text{Compression ratio, } r = \frac{V_1}{V_2} = \left(\frac{T_2}{T_1}\right)^{\frac{1}{\gamma-1}} = \left(\frac{646}{323}\right)^{\frac{1}{0.4}} = 5.66$$

$$\eta_{\text{Otto}} = 1 - \frac{1}{r^{\gamma-1}} = 1 - \frac{T_1}{T_2} = 1 - \frac{323}{646} = 0.5 = 50\,\%$$

20. (b)

$$\eta_{\text{th}} = \frac{BP}{m_f \times CV} = \frac{50}{\frac{16 \times 10^{-3} \times 750}{3600} \times 44000} = 34.1\ \%$$

21. (b)

$$\eta_{\text{th}} = \frac{W}{Q_s} = \frac{W}{mc_V \cdot \Delta T}$$

$$\Rightarrow \quad W = \eta_{th} \cdot mc_V \cdot \Delta T = \eta_{th} \cdot m \cdot \Delta T \times \frac{R}{\gamma - 1} = \frac{\eta_{th}}{\gamma - 1} \times mR\Delta T$$

$$\Rightarrow \quad W = \frac{\eta_{th}}{\gamma - 1} \times \Delta P \cdot V_c$$

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

$$\Rightarrow \quad V_s = (r-1)V_c$$

$$P_m = \frac{W}{V_s} = \frac{\frac{\eta_{th}}{\gamma-1}\times \Delta P \cdot V_c}{(r-1)\cdot V_c} = \frac{\eta_{th}\cdot(\Delta P)}{(\gamma-1)\cdot(r-1)}$$

23. (c)

$$\text{Net area of diagram} = 5.75 - 0.25 = 5.5 \text{ cm}^2$$

$$P_{imep} = \frac{\text{Area of diagram}}{\text{Length of diagram}} \times \text{Spring constant} = \frac{A\times k}{L}$$

$$= \frac{5.5}{5.5}\times 3.5 = 3.5 \text{ bar}$$

24. (a)

b.p. when all cylinders are working,

$$(\text{b.p.})_{\text{all cy.}} = \frac{2\pi NT}{60000} = \frac{2\pi\times(3500)\times(300\times 0.35)}{60000} = 38.48 \text{ kW}$$

b.p. of engine (with 5 $\text{cylinders}_{\text{firing}}$) when each cylinder is cut off in turn

$$(\text{b.p.})_{5\text{- cy.}} = \frac{2\pi\times 3500\times 240\times 0.35}{60000} = 30.79 \text{ kW}$$

$$\therefore \quad \text{i.p. of cut off cylinder} = 38.48 - 30.79 = 7.7 \text{ kW}$$

$$\text{Indicated power of engine} = 6\times 7.7 = 46.2 \text{ kW}$$

$$\Rightarrow \quad 46.2\times 10^3 = p_{imep}\times 0.1\times\frac{\pi}{4}\times 0.08^2\times\frac{3500}{2\times 60}\times 6$$

$$\Rightarrow \quad p_{imep} = 5.25\times 10^5 \text{ Pa} = 5.25 \text{ bar}$$

25. (a)

$$\eta_{bth} = \frac{BP}{m_f\times CV}$$

$$\Rightarrow \quad m_f = \frac{50}{0.25\times 4000} = 4.545\times 10^{-3} \text{ kg/sec} = 16.36 \text{ kg/hr}$$

$$= \frac{16.36}{0.74} = 22.1\ l/\text{hr}$$

$$\eta_{ith} = \frac{\eta_{bth}}{\eta_m} \qquad \left\{\eta_m = \frac{b.P.}{i.P.} = \frac{\eta_{bth}}{\eta_{ith}}\right\}$$

$$= \frac{0.25}{0.75} = 33.3\ \%$$

26. (b)

In four stroke cycle there is one effective working stroke in every two revolution of the engine crankshaft i.e. $n = \frac{N}{2}$.

$$\text{Indicated power} = \frac{P_m LAnk}{1000} kW = \frac{4.5\times10^5 \times 0.25 \times \frac{\pi}{4} \times 0.2^2 \times \frac{360}{2\times60} \times 1}{1000}$$

$$= 10.6 \text{ kW}$$

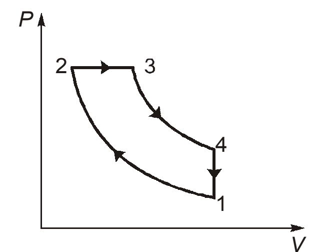
$$\text{Indicated thermal efficiency} = \frac{i.p.}{m_f \times CV} = \frac{10.6}{\frac{5}{3600}\times 44000} = 17.35\%$$

27. ((c)

$$\text{Cut-off ratio; } (r_c)_1 = 4$$

$$(r_c)_2 = 8$$

$$\text{Compression, } r = 12$$



$$\eta_1 = 1 - \frac{1}{r^{\gamma-1}}\left[\frac{r_{c_1}^{\gamma} - 1}{\gamma(r_{c_1} - 1)}\right]$$

$$= 1 - \frac{1}{(12)^{1.4-1}}\left[\frac{4^{1.4} - 1}{1.4(4-1)}\right] = 0.474$$

$$\eta_2 = 1 - \frac{1}{r^{\gamma-1}}\left[\frac{r_{c_2}^{\gamma} - 1}{\gamma(r_{c_2} - 1)}\right] = 1 - \frac{1}{(12)^{0.4}}\left[\frac{8^{1.4} - 1}{1.4(8-1)}\right] = 0.343$$

$$\text{Loss in efficiency} = \frac{\eta_1 - \eta_2}{\eta_1} \times 100 = \frac{0.474 - 0.343}{0.474} \times 100 = 27.62\%$$

28. (a)

$$\text{Mechanical efficiency} = \eta_m = 90\% = 0.9$$

$$\text{Motor efficiency} = \eta_{motor} = 0.75$$

$$\text{Frictional power} = FP = 4 \times 0.75 = 3 \text{ kW}$$

$$\text{Indicated power} = \text{IP, Brake power} = \text{BP}$$

$$\eta_m = \frac{BP}{IP} = \frac{BP}{BP + FP}$$

$$\Rightarrow \quad 0.9 = \frac{BP}{BP + 3}$$

$$\Rightarrow \quad BP \times 0.9 + 0.9 \times 3 = BP$$

$$\Rightarrow \quad BP = 27 \text{ kW}$$

$$BP = T \times \omega$$

$$\Rightarrow \quad 27 = T \times 2\pi \times \frac{1000}{60}$$

$$\Rightarrow \quad T = 0.25783 \text{ kNm} = 257.83 \text{ Nm}$$

$$\text{Mass on dynamometer} = m \text{ kg}$$

$$\text{Drum diameter} = 1 \text{ m}$$

$$\text{Drum radius} = 0.5 \text{ m}$$

$$T = m \times g \times r$$

$$\Rightarrow \quad 257.83 = m \times 9.81 \times 0.5$$

$$\Rightarrow \quad m = 52.56 \text{ kg}$$

29. (b)

$$\text{Volumetric efficiency} = \frac{\text{Actual intake volume}}{\text{Swept volume}}$$

$$\therefore \quad \text{Actual intake volume} = 200 \times 0.85 = 170 \text{ cm}^3$$

30. (b)

Break power: $$bp = \frac{\pi DN(W-S)}{60} \text{ watt}$$

where D = effective break drum diameter

N = rpm

W = dead weight

S = spring balance reading

here, D = 600 + 26 = 626 mm

N = 450 rpm

W = 200 N

S = 30 N

$$\therefore \quad bp = \frac{3.14 \times 0.626 \times 450 \times (200-30)}{60{,}000} = 2.5062 \text{ kW}$$

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