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DEPARTMENT OF AGRICULTURAL ENGINEERING

COURSE CODE & NAME: 19AGT301 & HEAT POWER ENGINEERING

III YEAR / V SEMESTER

UNIT : IV IC ENGINE PERFORMANCE AND AIR COMPRESSORS

TOPIC 2 :Problems on IC Engine Performance Parameters

Content

- Performance Parameters of IC Engine
- Solved Examples

Example 1 A four-cylinder, two-stroke cycle petrol engine develops 40 kW at 1500 rpm. The mean effective pressure in each cylinder is 7.5 bar. The mechanical efficiency is 85 %. Determine the cylinder bore and piston stroke, if stroke to bore ratio is 1.5. Also determine the fuel consumption if brake thermal efficiency is 30 %. Take calorific value of petrol as 44 MJ/kg.

Solution.

Given : $i = 4$, $n = 1$, $BP = 40$ kw, $N = 1500$ rpm, $p_{mi} = 7.5$ bar,

$\eta_{mech} = 0.85$, $L/D = 1.5$, $CV = 44$ MJ/kg, $(\eta_{th})_b = 0.3$

$$IP = \frac{BP}{\eta_{meoh}} = \frac{40}{0.85} = 47.06 \text{ kN}$$

$$IP = \frac{P_{mi} ALNi}{60 \times 10^3 \times \eta}$$

$$47.06 = \frac{7.5 \times 10^5 \times \frac{\pi}{4} d^2 \times 1.5d \times 1500 \times 4}{60 \times 10^3 \times 1}$$

$$d^3 = 5.3261 \times 10^{-4}$$

$$d = 0.081 \text{ m or } 81 \text{ mm}$$

$$L = 1.5d$$

$$= 1.5 \times 81$$

$$= 121.5 \text{ mm}$$

Brake thermal efficiency,

$$(\eta_{th})_b = \frac{BP \times 60}{\dot{m}_f \times CV}$$

$$\dot{m}_f = \frac{40 \times 60}{0.3 \times 44 \times 10^3} = 0.1818 \text{ kg/min}$$

Example 2 A six-cylinder petrol engine operates on the four-stroke cycle. The bore of each cylinder is 70 mm and stroke 100 mm. The clearance volume per cylinder is 67 cm^2. At a speed of 3960 rpm the fuel consumption is 19.5 kg/h and the torque developed is 140 N.m. Calculate (*a*) *BP*, (*b*) *BMEP*, (*c*) brake thermal efficiency, if LCV of fuel is 44 MJ/kg, and (*d*) relative efficiency on brake power basis. The engine works on the constant volume cycle basis. Assume $\gamma = 1.4$ for air.

Solution.

Given : $i = 6$, $n = 2$, $d = 0.07$m, $L = 0.1$ m, $V_C = 67 \times 10^{-6}$ m^3, $N = 3960$ rpm,

$$LCV = 44 \text{ MJ/kg}, \ \gamma = 1.4, \ \dot{m}_f = 19.5 \ kg/h, \ T = 140 \text{ N.m.}$$

$$(a) \quad BP = \frac{2\pi NT}{60 \times 10^3} = \frac{2\pi \times 3960 \times 140}{60 \times 10^3} = 58 \text{ kW}$$

$$(b) \quad BP = \frac{p_{mb} ALNi}{60 \times 10^3 \times n}$$

$$p_{mb} = \frac{58 \times 60 \times 10^3 \times 2}{\frac{\pi}{4}(0.07)^2 \times 0.1 \times 3960 \times 6} = 7.61 \text{ bar}$$

(c) $(\eta_{th})_b = \dfrac{BP \times 3600}{\dot{m}_f \times LCV} = \dfrac{58 \times 3600}{19.5 \times 44 \times 10^3} = 0.244$ or 24.4 %

(d) Swept volume per cylinder, $V_s = \dfrac{\pi}{4} d^2 \times L = \dfrac{\pi}{4}(0.07)^2 \times 0.1 = 3.848 \times 10^{-4}$ m^3

Compression ratio, $r = \dfrac{V_s + V_c}{V_c} = \dfrac{384.8 + 67}{67} = 6.743$

Air standard efficiency, $\eta_a = 1 - \dfrac{1}{r^{\gamma - 1}} = 1 - \dfrac{1}{(6.743)^{0.4}} = 0.534$

Relative efficiency, $\eta_r = \dfrac{(\eta_{th})_b}{\eta_a} = \dfrac{0.244}{0.534} = 0.457$ or 45.7 %

Example 3 A single-cylinder, four-stroke cycle oil engine is fitted with a rope brake. The diameter of the brake wheel is 600 mm and rope diameter is 26 mm. The dead load on the brake is 200 N and the spring balance reads 30 N. If the engine runs at 450 rpm, what will be the brake power of the engine?

Solution.

Given: $n = 2$, $D_b = 600$ mm, $d_r = 26$ mm, $W = 200$ N, $S = 30$ N, $N = 450$ rpm

$$BP = \frac{(W - S)\,\pi(D_b + d_r)N}{60 \times 10^3}$$

$$= \frac{(200 - 30) \times \pi(0.6 + 0.026) \times 450}{60 \times 10^3}$$

$$= 2.507 \text{ kW}$$

Example 4 A six cylinder, four-stroke, spark ignition engine of bore 10 cm and stroke 12 cm with a compression ratio of 6 is tested at 4800 rpm on a dynamometer of arm 55 cm. During a 10 minute test, the dynamometer reads 450 N and the engine consumes 5 kg of petrol of calorific value 45 MJ/kg. The carburettor receives the air at the rate of 10 kg/min. Calculate :

(*a*) Brake power, (*b*) *BSFC*, (*c*) *BMEP*, (*d*) *BSAC*, (*c*) brake thermal efficiency, and (*f*) air-fuel ration.

Solution. Given : $d = 10$ cm, $L = 12$ cm, $r = 6$, $N = 4800$ rpm, $i = 6$, $n = 2$,

$$l = 55 \text{ cm}, t = 10 \text{ min}, W = 450 \text{ N}, m_f = 5 \text{ kg}, CV = 45 \text{ MJ/kg}, \dot{m}_s = 10 \text{ kg/min}$$

(*a*) Torque, $$T = Wl = 450 \times 0.55 = 247.5 \text{ N.m}$$

Brake power, $$BP = \frac{2\pi NT}{60 \times 10^3} = \frac{2\pi \times 4800 \times 247.5}{60 \times 10^3} = 124.41 \text{ kW}$$

$$BP = \frac{p_{mb} ALNi}{60 \times 10^3 \times n}$$

$$124.41 = p_{mb} \times \frac{\pi}{4}(0.1)^2 \times 0.12 \times \frac{4800 \times 6}{60 \times 10^3 \times 2}$$

(b) $\dot{m}_f = \frac{m_f}{t} = \frac{5 \times 60}{10} = 30$ kg/h

$$BSFC = \frac{\dot{m}_f}{BP} = \frac{30}{124.41} = 0.241 \text{ kg/kWh}$$

(c) $p_{mb} = 5.5$ bar

(d) $\dot{m}_a = 10 \times 60 = 600$ kg/kwh

$$BSAC = \frac{600}{124.41} = 4.823 \text{ kg/kWh}$$

(e) $\eta_{bt} = \frac{BP}{\dot{m}_f \times CV} = \frac{124.41 \times 3600 \times 10^3}{30 \times 45 \times 10^6} = 0.3317$ or 33.17 %

(f) $\frac{A}{F} = \frac{\dot{m}_a}{\dot{m}_f} = \frac{600}{30} = 20:1$

Example 5 A six-cylinder, 4-stroke SI engine delivers 400 kW at 2200 rpm. Determine the bore and stroke from the following data :

Compression ratio = 7.6; stroke to bore ratio = 1.25, i.m.c.p. = 100 N/cm^2, mechanical efficiency = 0.75, calorific value of fuel = 105000 k cal/kg.

What is the brake specific fuel consumption ?

Solution.

Given : $i = 6$, $n = 2$, $BP = 400$ kW, $N = 2200$ rpm, $r = 7.6$, $L/d = 1.25$,

$imep = 100$ N/cm^2 or 10 Pa, $\eta_{mech} = 0.75$, $CV = 105000 \times 4.184 = 439320$ kJ/kg,

$$IP = \frac{BP}{\eta_{mech}} = \frac{400}{0.75} = 533.33 \text{ kW}$$

$$IP = \frac{p_{mi} \times ALNi}{60 \times 10^3 \times n}$$

$$533.33 = \frac{10 \times 10^5 \times \frac{\pi}{4} d^2 \times 1.25d \times 2200 \times 6}{60 \times 10^3 \times 2}$$

$$d^3 = 4.9386 \times 10^{-3}$$

$$d = 0.1703 \text{ m or } 170.3 \text{ mm}$$

$$L = 1.25\ d = 1.25 \times 170.3 = 212.8 \text{ mm}$$

Indicated thermal efficiency,

$$(\eta_{th})_i = 1 - \frac{1}{r^{\gamma-1}}$$

$$= 1 - \frac{1}{(7.6)^{0.4}} = 0.5557$$

$$(\eta_{th})_i = \frac{IP}{\dot{m}_f \times CV}$$

$$\dot{m}_f = \frac{533.33}{0.5557 \times 439320} = 0.00218\ kg/s$$

$$BSFC = \frac{\dot{m}_f \times 3600}{BP} = \frac{0.00218 \times 3600}{400} = 0.0197\ kg/kWh$$

Thank You