Palestine Technical University- Kadoorie (PTUK)

Mechanical Engineering Department

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12210592: Internal Combustion Engine 1

Student Name _____

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Homework # _____

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Date of Submission _____

Exercise 1. An internal combustion engine has the following specifications:

1. Cylinder Bore: 80 mm $D = 8\ cm$
2. Stroke: 90 mm $L = 9\ cm$
3. Piston Clearance: 2 mm $c = 0.2\ cm$
4. Compression Ratio: 10:1 $r = 10$

Given these specifications, answer the following questions:

1. **Calculate the Piston Area**
2. **Determine the Swept Volume**
3. **Find the Clearance Volume**
4. **Calculate the Cylinder Volume**

1- Piston area $(A) = \frac{\pi}{4} D^2 = \frac{\pi}{4} (8)^2 = 50.27\ cm^2$

2- Swept Volume $(V_s) = A \times L = 50.27 \times 9$

$V_s = 452.4\ cm^3$

3- Compression ratio $(r) = 1 + \frac{V_s}{V_c}$

$\Rightarrow V_c = \frac{V_s}{r-1} = \frac{452.4}{10-1} = 50.27\ cm^3$

4- Cylinder volume $(V_t) = V_s + V_c$

$= 452.4 + 50.27 = 502.67\ cm^3$

ans.

Exercise 2. Consider a high-performance engine with the following specifications:

1. Engine Displacement: 4.5 L
2. Number of Cylinders: 8
3. Engine Speed: 4000 RPM
4. Brake Power: 250 kW
5. Fuel Consumption Rate: 25 kg/h
6. Air-Fuel Ratio: 12.5:1
7. Overall thermal efficiency: 35%
8. Volumetric Efficiency: 85%

Given these parameters, answer the following questions:

1. **Calculate the Brake Mean Effective Pressure**
2. **Determine the Engine Torque**
3. **Calculate the Thermal Power**
4. **Compute the Brake Specific Fuel Consumption**
5. **Find the Specific Output**
6. **Calculate actual volume of air drawn inside the engine cylinders**

ans.

1- $BP = BMEP \times A \times L \times N \times n$

$AL = V = 4.5\,L = 4.5 * 10^{-3}\,m^3$ / $BP = 250 \times 10^3\,W$

$N = \frac{4000}{(2)(60)} = 33.3\ rps$ / $n = 8$

$250 \times 10^3 = BMEP \times 4.5 \times 10^{-3} \times 33.3 \times 8$

$BMEP = 208333.3\ Pa = 208\ KPa$

2- $BP = 2\pi N T n$

$T = \frac{250 \times 10^3}{2\pi\ (33.3)} = 1193.7\ N.m$

3- $\eta_{th} = \frac{BP}{TP} \Rightarrow TP = \frac{BP}{\eta_{th}} = \frac{250 \times 10^3}{0.35}$

$TP = 714.29 \times 10^3\ W$

4- $BSFC = \frac{m_f}{BP} = \frac{25 \times 1000}{(3600)(250)} = 0.028\ g/J$

5- Speeific output $= \frac{BP}{V_S} = \frac{250 \times 10^3}{4.5 \times 10^{-3}} = 55.6 \times 10^6\ \frac{W}{m^3}$

6- $\eta_v = \frac{\text{Actual Volume}}{V_S} \times 100\%$

$85\% = \frac{\text{Actual Volume}}{4.5 \times 10^{-3}} \times 100\% \Rightarrow$ Actual Volume $= 8.825 \times 10^{-3}\,m^3$

$= 3.825\,L$

Exercise 3. Consider an internal combustion engine using methane (CH_4) as fuel. The engine operates with the following parameters:

1. Calorific Value 50000 kj/kg
2. Engine Displacement: 3.2 L
3. Number of Cylinders: 6
4. Engine Speed: 3000 RPM
5. Brake Power (BP): 100 kW
6. Actual Air-Fuel Ratio (AF ratio): $14.7:1$
7. Overall thermal efficiency: 40%

Given these parameters, answer the following questions:

1. **Write and Balance the Combustion Reaction for Methane**
2. **Calculate the Stoichiometric Air-Fuel Ratio**
3. **Determine whether it is Fuel-rich, Fuel-lean**
4. **Calculate the Actual Fuel Consumption Rate**
5. **Determine the Actual Air Intake Volume**
6. **Compute the Actual Brake Specific Fuel Consumption**

ans.

1- $CH_4 + 2(O_2 + 3.76\ N_2) \rightarrow CO_2 + 2\ H_2O + 7.52\ N_2$

2-

mass of fuel = $1 \times 12 + 4 \times 1 = 16$

mass of air = $2 \times 32 + 7.52 \times 28 = 274.56$

$$(A/F)_s = \frac{274.56}{16} = 17.16$$

3- $$\phi = \frac{(A/F)_s}{(A/F)_a} = \frac{17.16}{14.7} = 1.167 > 1$$

Fuel rich

4- $$\eta_{th} = \frac{BP}{FC \times CV} \times 100\%$$

$$40\% = \frac{100}{FC \times 50000} \times 100\%$$

$$FC = 5 \times 10^{-3}\ kg/sec = 5\ g/sec$$

5- $(A/F)_a = \frac{\text{mass of air}}{\text{mass of fuel}} = 14.7$

mass of air $= 14.7 \times 5$

$= 73.5$ g/sec

$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{73.5 \times 10^{-3}}{1.293}$

$= 0.057$ m^3/sec

6- $BSFC = \frac{mf}{BP} = \frac{0.005}{100 \times 10^3} = 5 \times 10^{-8}$ kg/J

$= 5 \times 10^{-3}$ g/J