CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	AUTOMOTIVE ENGINE TECHNOLOGY
COURSE CODE	:	BNG 30403
PROGRAMME	:	BNG
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTION ONLY

THIS QUESTIONS PAPER CONSISTS **SIX (6)** PAGES

Q1 (a) Explain the influences of the fuel type in engine design and state **THREE (3)** basic engine designs together with their configuration.

(3 marks)

(b) Define the following matters with the aid of sketch:

(i) Combustion chamber;
(ii) Displacement volume;
(iii) Cubic capacity;
(iv) Clearance volume; and
(v) Compression ratio.

(5 marks)

(c) A four-cylinder, four-stroke, 1.6 L gasoline engine operates on the Otto cycle with a compression ratio of 10. The air is at 100 kPa and 37 °C at the beginning of the compression process, and the maximum pressure in the cycle is 7.5 MPa. The compression and expansion processes may be modeled as polytropic with a polytropic constant of 1.3. Using constant specific heats at 850 K. the air-fuel ratio, defined as the amount of air divided by the amount of fuel intake, is 16. Determine:

(i) The temperature at the end of the expansion processes;
(ii) The net work output and the thermal efficiency;
(iii) The mean effective pressure;
(iv) The engine speed for a net power output of 50 kW; and
(v) The specific fuel consumption (g/kWh).

(17 marks)

Q2 (a) In engines combustion, explain the influence of intake air temperature on engine efficiency.

(3 marks)

(b) Explain the Premixed Charge Compression Ignition (PCCI) combustion as shown in **FIGURE Q2 (b)** (introduced by Toyota) and how it is improving the combustion process in order to reduce the exhaust emissions.

(5 marks)

(c) A **TWO (2)** liter engine of six-cylinder that operates on four stroke cycle at 3800 RPM (revolutions per minute). The compression ratio, r_c is 12, the length of the connecting rods, r is 15.5 cm, and the engine is square ($B = S$), B = bore, S = stroke. At this speed, combustion ends at 20° TDC (Top-Dead-Center). Calculate:

(i) Cylinder bore, B and stroke length, S;
(ii) Average piston speed $\overline{U_p}$;
(iii) Clearance volume of one cylinder V_c;
(iv) Crank offset R;
(v) Piston speed at the end of combustion U_p;
(vi) Distance the piston has traveled from TDC at the end of combustion, x;

(vii) Volume in the combustion chamber at the end of combustion V.

(17 marks)

Q3 (a) Explain the importance of achieving stoichiometric combustion, rich combustion and lean combustion.

(5 marks)

(b) Diesel combustion engines prove more attractive than spark ignition engines with referring to the fuel consumption and thermal efficiency. However, the key element in diesel combustion is the influences fuel-air premixing during the ignition delay on ignition process. Explain and construct the ignition delay period in heat release rate *(dQ/dt)* diagram of diesel engine combustion. Discussion should be focused on the relation between mixture formation and ignition process.

(5 marks)

(c) A 1400 cm^3, four-stroke cycle, four-cylinder compression ignition (C.I) engine, operating at 3500 RPM, produces 55 kW of brake power. The engine volumetric efficiency is 0.93 and with operating air-fuel ratio of 20:1. Calculate:

(i) The required mass air flow rate into the engine (kg/sec);
(ii) Brake specific fuel consumption, bsfc (g/kW.hr);
(iii) The mass flow rate of the exhaust gas (kg/hr); and
(iv) Brake power output per displacement (kW/litre).

(15 marks)

Q4 (a) Explain and compare Spark Ignition and Compression Ignition engines with respect to

(i) Fuel used.
(ii) Ignition process.
(iii) Compression ratio.
(iv) Efficiency.
(v) Weight.

(5 marks)

(b) Explain the reason for the operation of forcing additional pressurized air in the engine cylinder with supercharging equipment

(5 marks)

(c) A 4 cylinder, 2 stroke diesel engine with 11 .5 cm bore and 13.8 cm stroke produces 98 kW of brake power at 2600 rpm. The compression ratio, r_c is 17:1. Calculate:

(i) The engine displacement (cm^3);
(ii) Brake mean effective pressure (kPa);
(iii) Engine torque (Nm); and

(iv) Clearance volume of one cylinder (cm^3).

(15 marks)

Q5 (a) Describe the main exhaust emissions from the following engine types and suggest the suitable after-treatment system for;

(i) Spark-ignition engine; and
(ii) Compression-ignition engine.

(4 marks)

(b) Discuss the advantages and disadvantages of engine performance simulation

(4 marks)

(c) Explain the term of *Dynamometers* and *Test facilities* in observing the internal combustion engine performance.

(4 marks)

(d) Explain the *Zeldovich mechanism* and discuss the relation between temperature and NOx-production in diesel combustion. Describe the Exhaust Gas Recirculation (EGR) system and explain how EGR reduces the NOx (oxides of nitrogen) emissions.

(5 marks)

(e) Explain the differences between superchargers and turbochargers

(4 marks)

(f) Explain the operation of catalytic converters and how are they helpful in reducing HC, Carbon Monoxide (CO) and NOx emissions. Construct the catalytic converters configuration.

(4 marks)

- END OF QUESTIONS –

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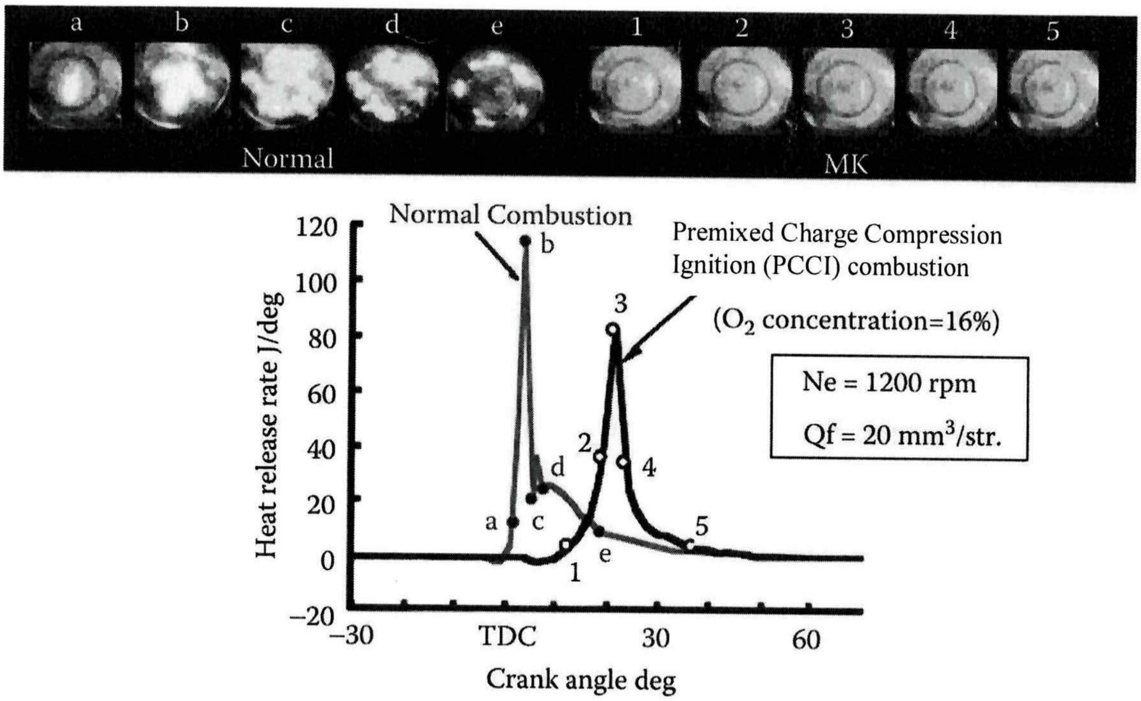

FIGURE Q2 (b)

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Power output motor (watt) = Power output engine (watt) = volts x amps

Piston speed, $\overline{U_P} = 2SN$ ambient density (air), $\rho_a = 1.181 kg/m^3$

Compression ratio, r_c is defined as : $r_c = V_{BDC}/V_{TDC}$, $r_c = (V_d + V_c)/V_c$

Instantaneous piston speed; $U_p/\overline{U_p} = (\pi/2)\sin\theta\left[1+\left(\cos\theta/\sqrt{R^2-\sin^2\theta}\right)\right], R = r/a, a = S/2$

Piston position or the distance between the crank axis and wrist pin axis or piston is given by, s:

$$s = a\cos\theta + \sqrt{r^2 - a^2\sin^2\theta}$$

Where a = crankshaft offset, r = connecting rod length and θ = crank angle, measure from the centerline and it is zero when the piston is at TDC

Distance from TDC , $x = r + a - s$

Instantaneous volume, V at any crank angle, θ : $\frac{V}{V_c} = 1 + \frac{1}{2}(r_c - 1)\left[R + 1 - \cos\theta - \sqrt{R^2 - \sin^2\theta}\right]$

Vc = clearance volume, R = r/a

For an engine with N_c cylinders, displacement volume , N_d :

$V_d = V_{BDC} - V_{TDC}$ $V_d = N_c\left(\frac{\pi}{4}\right)B^2S$ Where B = cylinder bore, S = stroke, S=2a

The cylinder volume at any crank angle is given by: $V = V_c + \left(\frac{\pi B^2}{4}\right)(r + a - s)$, Where V_c = clearance volume

Brake work of one revolution, W_b : $W_b = 2\pi T$; $W_b = \frac{V_d(bmep)}{n}$, Where T = engine torque, bmep = brake mean effective pressure, n = number of revolutions percycle

Mean effective pressure; $mep = \frac{Wn}{V_d N}$

Engine torque, T, for 2-stroke and 4-stroke cycles: $T_{2-stroke} = \frac{V_d(bmep)}{2\pi}$ $T_{4-stroke} = \frac{V_d(bmep)}{4\pi}$

Engine power, $\dot{W} = \frac{WN}{n}$, $\dot{W} = 2\pi NT$, N = engine speed

Specific fuel consumption $sfc = \frac{\dot{m}_f}{\dot{W}}$