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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	INTERNAL COMBUSTION ENGINE
COURSE CODE	:	BDE 40603
PROGRAMME	:	4 BDD
EXAMINATION DATE	:	JUNE 2016 / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ANY **FIVE (5)** QUESTIONS ONLY

THIS PAPER CONTAINS **EIGHT** (8) PAGES

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Q1 (a) Explain the flash point of fuel oil in internal combustion engines

(3 marks)

(b) Explain the phenomena of knock in Spark Ignition (S.I) engine.

(3 marks)

(c) A four-cylinder, 2.4-liter engine operates on a four-stroke cycle at 3200 RPM. The compression ratio is 9.4:1, the connecting rod length r = 18 cm, and the bore and stroke are related as S = 1.06B. Calculate :

(i) Clearance volume of one cylinder in cm^3 and L ;
(ii) Bore and stroke ; and
(iii) Average piston speed.

(14 marks)

Q2 (a) Explain the ***Zeldovich Mechanism*** and discuss the effects of mixture formation and ignition process that influences the Soot-NOx Trade-off in diesel combustion.

(3 marks)

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

(3 marks)

(c) A 3.1-liter, four-cylinder, two stroke cycle SI engine is mounted on an electrical generator dynamometer. When the engine is running at 1200 RPM, out put from the 220-volt DC generator is 54.2 amps. The generator has an effeicincy of 87%. Calculate:

(i) Power ouput of the engine in kW;
(ii) Engine tourque; and
(iii) Engine bmep.

(14 marks)

Q3 (a) State three basic engine designs and sketch their configuration.

(3 marks)

(b) Define the following matters and sketch their configuration:

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

(5 marks)

(c) A 1500-cm^3, four-stroke cycle, four-cylinder CI engine, operating at 3000 RPM, produces 48 kW of brake power. Volumetric efficiency is 0.92 and air-fuel ratio AF is 21:1. Calculate:

(i) Rate of air flow into engine;
(ii) Brake specific fuel consumption;
(iii) Mass rate of exhaust flow; and
(iv) Brake out per displacement.

(12 marks)

Q4 (a) Explain and compare Spark Ignition (S.I) and Compression Ignition (C.I) engines with respect to

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

(5 marks)

(b) Explain the phenomena of flame propagation during combustion process.

(2 marks)

(c) The volumetric percentages of exhaust gas analysis of gasoline (C_8H_{15}) engine presented in Table 1.

Table 1-Properties of blended gasoline

Exhaust content	Volumetric Percentage (%)
CO_2	11.45
CO	1.40
O_2	2.85

(i) Estimate the nitrogen content of the exhaust gas (%);
(ii) Derive the balanced reaction;
(iii) Calculate the actual air-fuel ratio;
(iv) Determine the stoichiometric air-fuel ratio; and
(v) Calculate the value of equivalence ratio.

(13 marks)

Q5 (a) One way to lower NOx emissions in diesel engines is to add water to the fuel. Since water is not mixable with diesel fuel, it has been emulsified by surfactant. Explain how it works and why this arrangement is more effective than injecting water in the intake manifold.

(3 marks)

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

(3 marks)

(c) In turbocharger diesel combustion, fuel-air premixing during ignition delay period is important process due to the mixture formation is indispensable to improve heat release and exhaust emissions. Explain the relation of fuel-air mixing during early stage of combustion on the flame development and history of heat release *(dQ/dt)* as shown in **Figure Q5 (c).**

(4 marks)

(d) With sketches, describe the Exhaust Gas Recirculation (EGR) system and explain how EGR reduces the NOx (oxides of nitrogen) emissions.

(4 marks)

(e) 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.

(3 marks)

(f) Explain the dynamometers and requirement of test facilities during the internal combustion engine testing.

(3 marks)

Q6 (a) In engines combustion, explain the influence of intake air temperature on engine efficiency.

(2 marks)

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

(i) Ignition process; and
(ii) Heat release.

(3 marks)

(c) A 1300 cm^3, four-stroke cycle, four cylinder compression ignition (C.I) engine, operating at 3000 RPM, produces 50 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)

- END OF QUESTION –

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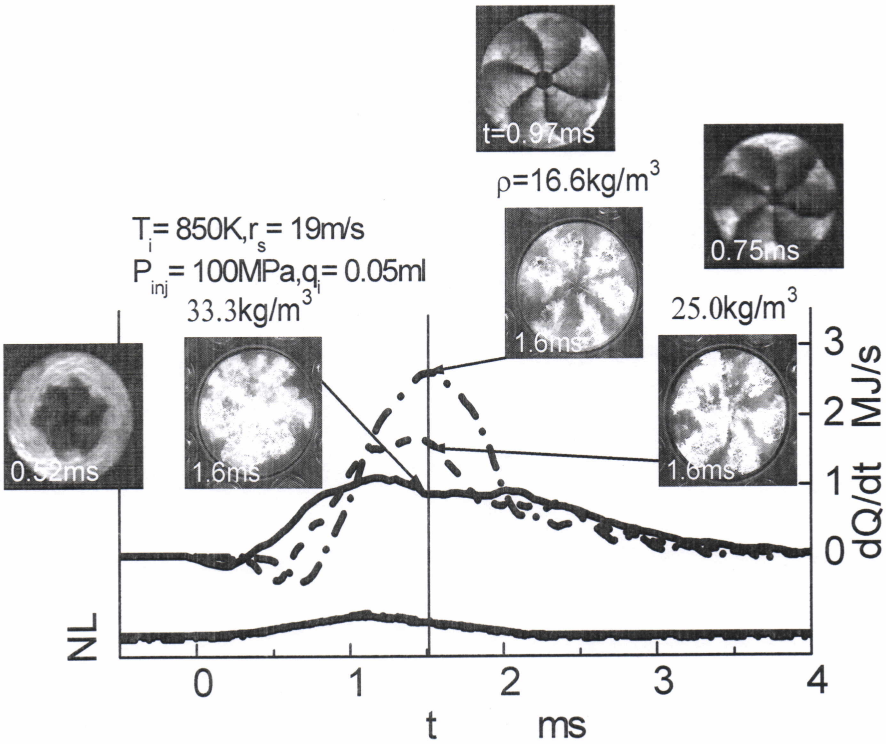

Figure Q5 (c) Effects of ambient density(Turbocharger system) on mixture formation, flame development and heat release in diesel engine combustion

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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 :

$$V_d = V_{BDC} - V_{TDC} \qquad V_d = N_c\left(\frac{\pi}{4}\right)B^2 S$$

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 $sfc = \frac{\dot{m}_f}{\dot{W}}$

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TABLE A-2 PROPERTIES OF FUELS

Fuel		Molecular Weight	Heating Value HHV (kJ/kg)	Heating Value LHV (kJ/kg)	Stoichiometric $(AF)_s$	Stoichiometric $(FA)_s$	Octane Number MON	Octane Number RON	Heat of Vaporization (kJ/kg)	Cetane Number
gasoline	C_8H_{15}	111	47300	43000	14.6	0.068	80–91	92–99	307	
light diesel	$C_{12.3}H_{22.2}$	170	44800	42500	14.5	0.069			270	40–55
heavy diesel	$C_{14.6}H_{24.8}$	200	43800	41400	14.5	0.069			230	35–50
isooctane	C_8H_{18}	114	47810	44300	15.1	0.066	100	100	290	
methanol	CH_3OH	32	22540	20050	6.5	0.155	92	106	1147	
ethanol	C_2H_5OH	46	29710	26950	9.0	0.111	89	107	873	
methane	CH_4	16	55260	49770	17.2	0.058	120	120	509	
propane	C_3H_8	44	50180	46190	15.7	0.064	97	112	426	
nitromethane	CH_3NO_2	61	12000	10920	1.7	0.588			623	
heptane	C_7H_{16}	100	48070	44560	15.2	0.066	0	0	316	
cetane	$C_{16}H_{34}$	226	47280	43980	15.0	0.066			292	100
heptamethylnonane	$C_{12}H_{34}$	178			15.9	0.063				15
α-methylnaphthalene	$C_{11}H_{10}$	142			13.1	0.076				0
carbon monoxide	CO	28	10100	10100	2.5	0.405				
coal (carbon)	C	12	33800	33800	11.5	0.087				
butene-1	C_4H_8	56	48210	45040	14.8	0.068	80	99	390	
triptane	C_7H_{16}	100	47950	44440	15.2	0.066	101	112	288	
isodecane	$C_{10}H_{22}$	142	47590	44220	15.1	0.066	92	113		
toluene	C_7H_8	92	42500	40600	13.5	0.074	109	120	412	
hydrogen	H_2	2	141800	120000	34.5	0.029		90		

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