(10 Marks)

Question One: Chose the most correct answer(s).

Choke is used in the carburetor to :
- Increase amount of air to engine.
- Achieve good combustion.
- Reduce amount of air to engine.
- Reduce engine pollution.
- None of the above.

To prevent blockage of the nozzle by dust particles, the gasoline is filtered by installing a .... at the inlet to the float chamber.
- choke
- fuel strainer
- nozzle
- none of the mentioned

In carburetors, the top of the fuel jet with reference to the level in the float chamber is kept at
- same level
- slightly higher level
- slightly lower level
- may be anywhere

.... Describes how easily the CI engine fuel ignites under cylinder conditions :
- Viscosity
- Injection Quality.
- Cetane Number.
- Ignition quality.
- None of the above.

If a simple carburetor is used at altitudes below those at which it was calibrated, the mixture it supplies becomes :
- Rich.
- Stoichiometric.
- Lean.
- Chemically correct.
- None of the above.

Consider the following statements regarding knock rating of SI engine fuels:
1. Iso-octane is assigned a rating of zero octane number
2. Normal heptane is assigned a rating of hundred octane number
3. Iso-octane is assigned a rating of hundred octane number
4. Normal heptane is assigned a rating of zero octane number

Which of the above statements are correct? 1 and 2 / 2 and 3 / 3 and 4 / 4 and 1

Consider the following statements:
1. *In a carburettor the throttle valve is used to control the fuel supply.*
2. *The fuel level in the float chambers is to be about 4 to 5 mm below the orifice level of main jet.*
3. *An idle jet provides extra fuel during sudden acceleration.*
4. *A choke valve restricts the air supply to make the gas richer with fuel.*

Which of the statements given above are correct? 2 and 4 / 1 and 3 / 1, 2 and 3 / 2, 3 and 4

The two reference fuels used for cetane rating are :
- **cetane and iso-octane**
- cetane and tetraethyl lead
- cetane and n-heptane
- **cetane and α -methyl naphthalene**
- None of the above

Alcohols are unsuitable as diesel engine fuels because
- **The cetane number of alcohol** fuels is very low which prevents their ignition by compression
- **The cetane number of alcohol** fuels is very high which prevents their ignition by compression
- **The cetane number of alcohol** fuels is very low which prevents their ignition by compression
- **None of the above**

In a petrol engine car, which one of the following performance characteristics is affected by the front-end volatility of the gasoline used?
- **Hot starting and vapour lock**
- Engine warm-up and spark plug fouling
- **Spark plug fouling and hot starting**
- Vapour lock, engine warm-up and spark plug fouling

Q3) Answer the following questions

3.1) Butane is burned with air in the engine with equivalence ratio 0.85. Assuming complete combustion.
Write the stoichiometric and actual chemical reaction equations
Calculate the air-fuel ratio
Calculate the excess air
For propane find the AKI, FS

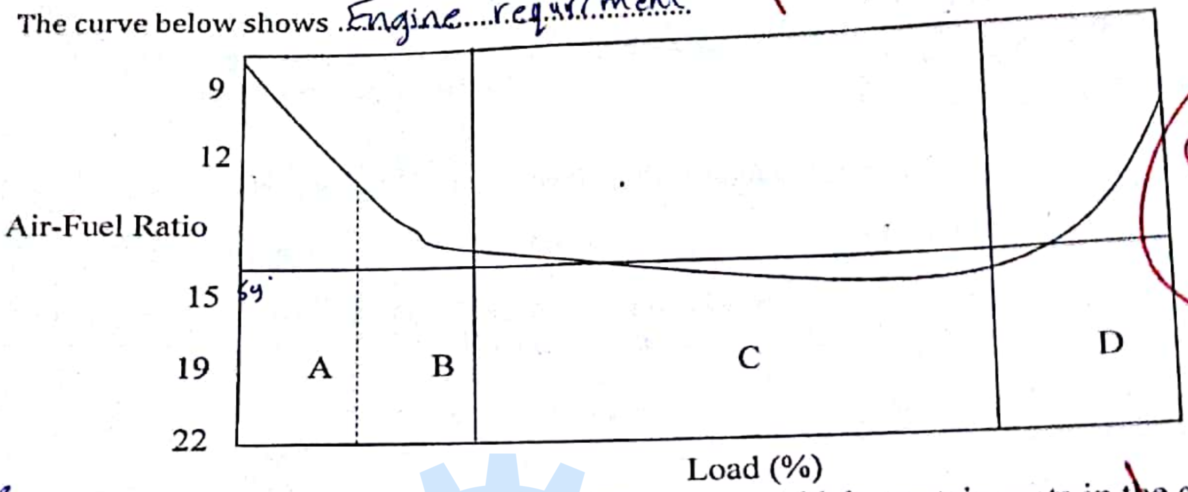
3.2) A single cylinder Diesel engine running at 1500 RPM used to drive generator. The engine has compression ratio 16, Average piton speed (Up) 8.5 m/s. The inlet conditions at the start of compression are 50 C and 120 kPa. It is desired that the combustion should start 15 degrees bTDC using fuel with cetane number 45. When should the fuel injection starts and how much is the ignition delay in milliseconds. Take the activation energy for this fuel as

3.3) The following data relate to an Air-Fuel Otto cycle
Compression ratio = 9; Calorific value of fuel = 42 MJ/kg; Air-Fuel ratio = 13.5:1; The pressure and temperature at the start of compression stroke are 55 C and 100 kPa respectively; the polytropic index for compression is 1.30.
Calculate the maximum cylinder temperature and pressure for the following two cases:
Take $Cv = 0.71 + 20\times10^{-5}\, T\, dT$
Compare your results with constant specific heat $Cv = 0.718$ kJ/kg-K
State FOUR main assumptions when dealing with Fuel Air Cycle.

3.4) A single cylinder, 4-stroke, petrol engine uses is fitted with carburetor which actually supplies 5 kg/hr of fuel with density 800 kg/m^3. The engine's air fuel ratio used is 13.5:1. The jet diameter is 1.1mm and is 5mm below the fuel level when the engine is idling. The discharge coefficient for air throat is 0.85 and that for fuel jet is 0.66. The ambient conditions are 101.325 kPa and 21 °C. Answer the following:
State the main function of a carburetor? How is it different from mixer?
Calculate the throat diameter.
Pressure drop at the throat.
How much, in your opinion, is the minimum velocity needed to just lift the fuel to the jet tip.

Question TWO: Answer the following. **(5 Marks)**

The curve below shows .Engine requrment......



Each one of the above areas (A, B, C and D) are dealt with by certain parts in the carburetor. State them:

A) Choke [Closed] B)

C) throat an Jet D) throat and Jet

❖ List 2 factors affecting the carburetor operation.

① ~~atmosphric~~ ambient conditions (T in, P in altitude ...) (H)

② minfold bends

❖ *List 2 factors affecting the volumetric efficiency (state how).* how

① high Speed of engine (the valve not open enough to inside air

② ampmt condions (Pa)

❖ State what happens if the exhaust valve is opened too early. Give short answer.

~~blow down~~ we lose some of pressure that ~~matter~~ mean on piston ...
work and power

UNIVERSITY OF JORDAN

FACULTY OF ENGINEERING & TECHNOLOGY
MECHANICAL ENGINEERING DEPARTMENT

Winter 2013/2014 | **Internal Combustion** | **Second Exam**

The Olefins is another name for:
- (a) Alkanes
- (b) Alkenes
- (c) Acetylenes
- (d) Paraffins

12

Dienes are mainly characterised with the existence of:
- (a) One double bond
- (b) One triple bond
- (c) Two double bonds
- (d) Two triple bonds

The stoichiometric AFR for Benzene is:
- (a) 13.27
- (b) 10.48
- (c) 15.21
- (d) 26.55

Front-end volatility:
- (a) Can cause poor cold starting characteristics
- (b) Can cause vapour lock problems
- (c) Can Increase the volumetric efficiency
- (d) None of the above

One of the following statements is true:
- (a) Knocking is independent of the compression ratio
- (b) Knocking can be reduced by increasing the flame speed
- (c) Knocking becomes more frequent at lower temperatures
- (d) The main problem with knocking is the noise associated with it

If iso-octane is burned with an equivalence ratio of 0.92 then one of the following gases should not (theoretically) appear in the exhaust:
- (a) CO
- (b) O_2
- (c) CO_2
- (d) N_2

The cetane index of a diesel fuel is:
- (a) Measured experimentally
- (b) Increased with increasing the percentage of aromatic compounds
- (c) A measure of its ignition delay
- (d) Typically around 90

C_5H_8

TEL is a fuel additive that is classified as:
- (a) Octane improver
- (b) Cetane improver
- (c) Flow improver
- (d) Anti-corrosion agent

HC emissions from I.C. engines:
- (a) Reach a maximum near stoichiometry
- (b) Reach a minimum near stoichiometry
- (c) Increase with rich mixtures
- (d) Increase with slightly lean mixtures

NO_x emissions from I.C. engines:
- (a) Increase with increasing A/F ratio
- (b) Increase with decreasing A/F ratio
- (c) Increase with increasing flame temperature
- (d) Increase with decreasing flame temperature

The main problem associated with CO_2 emissions is:
- (a) Toxicity
- (b) Asthma
- (c) Acid rain
- (d) Global warming

Exhaust gas recirculation is an effective way to reduce:
- (a) CO emissions
- (b) HC emissions
- (c) NO_x emissions
- (d) Particulate emissions

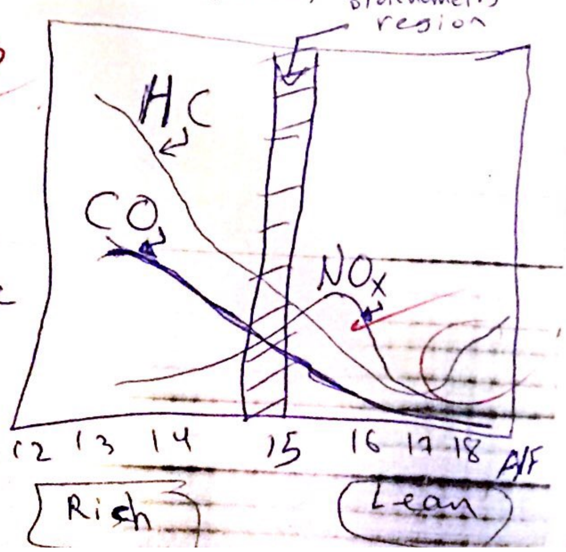
Explain why conventional 3-way catalytic converters are not effective in reducing the NOx emissions from diesel engines. (1 mark)

As reducing NO_x emissions needs ~~lean~~ rich environment while the diesel engines ~~are~~ operate at ~~rich~~ one, Lean.

Explain with the aid of a graph how CO, HC and NOx emissions are affected by the A/F ratio. (3 marks)

HC & CO have a higher emissions in the rich regions However, highly increasing the AF ratio for HC, in the lean mixture can also increasing the emission of HC.

NO_x has a higher emission value at Lean region.



An engine is running on α-Methylnaphthalene ($C_{10}H_7CH_3$) with 20% excess air.

- Determine the A/F ratio at this condition. (4 marks)

$$C_{10}H_7CH_3 + 1.2\,X\,O_2 + (1.2)(3.76)X\,N_2 \longrightarrow$$

$$y\,CO_2 + z\,H_2O + M\,N_2 + 0.2\,O_2$$

C:- $10+1 = y = 11$

H:- $10 = 2z \rightarrow z = 5$

$M = 1.2 * 3.76 * X$

O: $1.2\,X * 2 = 2y + z + 0.2*2$

1.5

$X = 11.4$

$M = 51.51$

13.5

$$C_{10}H_7CH_3 + 1.2\,(11.4)\,O_2 + (1.2)(11.4)(3.76)\,N_2 \longrightarrow$$

$$11\,CO_2 + 5\,H_2O + (1.2)(3.76)(11.4)\,N_2 + 0.2*2.70 / 2\ 2$$

$$(A/F)_{Min} = \frac{m_a}{m_f} = \frac{1.2 * 11.4 \times 4.76 \times 29}{1 \times (10 \times 12 + 7 + 12 + 3)} = 13.3$$

omar sami khader

رقمه الجامعي 0130466	اسم الطالب
الكليـــة	المستـوى
المــادة	القســم
	التاريــخ

العلامــات

(Q 3.4)

(3) Pressure drop at the throat = Δp

$= 3.1044 \text{ kpa}$

(4) $\Delta p = \rho_f g z_f = 800 * 9.81 * 5 \times 10^{-3}$

$= 39.24 \text{ pa}$

U_a theoritical $= \sqrt{\frac{2}{1.2}[39.24]}$

$= 8.08703 \text{ m/s}$

Actual velocity of Air $= 6.874 \text{ m/s}$

Question One: Chose the most correct answer(s). (10 Marks)

الاجابة كلها

8

✓ Choke is used in the carburetor to :

Increase amount of air to engine.

Reduce amount of air to engine.

None of the above.

Achieve good combustion.

Reduce engine pollution.

✓ To prevent blockage of the nozzle by dust particles, the gasoline is filtered by installing a .... at the inlet to the float chamber.

choke

fuel strainer

nozzle

none of the mentioned

✓ In carburetors, the top of the fuel jet with reference to the level in the float chamber is kept at

same level

slightly higher level

slightly lower level

may be anywhere

✓ .... Describes how easily the CI engine fuel ignites under cylinder conditions :

Viscosity

Injection Quality.

Cetane Number.

Ignition quality.

None of the above.

✓ If a simple carburetor is used at altitudes below those at which it was calibrated, the mixture it supplies becomes :

Rich.

Stoichiometric.

Lean.

Chemically correct.

None of the above.

✓ Consider the following statements regarding knock rating of SI engine fuels:

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Which of the above statements are correct? 1 and 2 2 and 3 3 and 4 4 and 1

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✓ The two reference fuels used for cetane rating are :

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cetane and tetraethyl lead

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cetane and α -methyl naphthalene.

None of the above

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The cetane number of alcohol fuels is very low which prevents their ignition by compression

The cetane number of alcohol fuels is very high which prevents their ignition by compression

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Hot starting and vapour lock

Engine warm-up and spark plug fouling

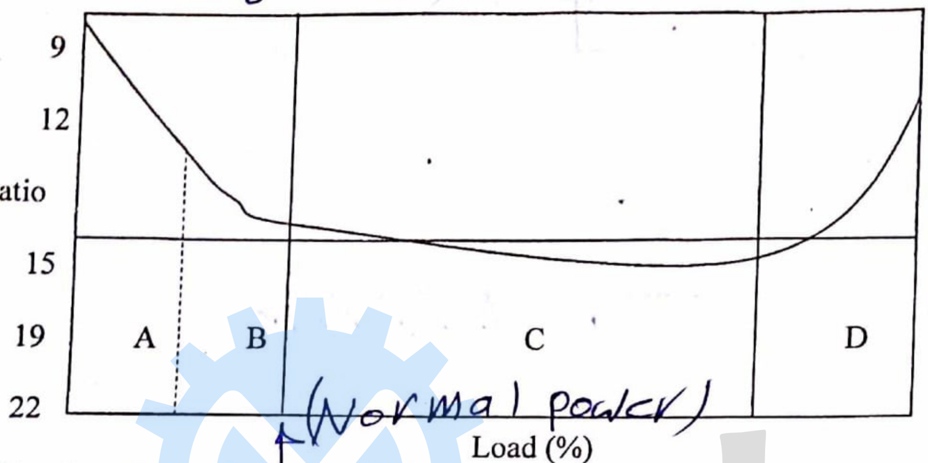
Spark plug fouling and hot starting

Vapour lock, engine warm-up and spark plug fouling

Question TWO: Answer the following. **(5 Marks)**

The curve below shows engine operation at transient and steady state operation

3¼



Each one of the above areas (A, B, C and D) are dealt with by certain parts in the carburetor. State them:

A) car starting B) Fresh charge Dillution from O2

C) fuel economy D) Fullutility of air (Maximum power)

❖ List 2 factors affecting the carburetor operation.

① Type of fuel

② ampient conditions like Temprature and pressure

❖ List 2 factors affecting the volumetric efficiency (state how).

① Temprature of inlet Air

② speed of ~~[illegible]~~ air and speed of engine

❖ State what happens if the exhaust valve is opened too early. Give short answer.

expansion pressure decreases so much

so expansion work decrease

Exhaust blowdown

Q3) Answer the following questions :

3.1) ~~Butane~~ Methane is burned with air in the engine with equivalence ratio 0.85. Assuming complete combustion.

Write the stoichiometric and actual chemical reaction equations.

Calculate the air-fuel ratio

Calculate the excess air

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State the main function of a carburetor? How is it different from mixer?

Calculate the throat diameter.

Pressure drop at the throat.

How much, in your opinion, is the minimum velocity needed to just lift the fuel to the jet tip.

Q3)

Q3.1) methane CH_4

~~Butane ⇒ C4H10~~

(stychometric reaction)

$CH_4 + a_{th}(O_2 + 3.76N_2) \rightarrow A x CO_2 + A y H_2O + 3.76 a_{th} N_2$

$x = 1$

$y = 4 \quad a_{th} = A(x + \frac{y}{4})$

$z = 0 \quad = A(1+1) = 2$

$A = 1$

(4)

* stychometric equation:

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

(actual Reaction equation)

$CH_4 + 2.353(O_2 + 3.76N_2) \rightarrow CO_2 + 2H_2O + 8.847N_2 + 0.353O_2$

① (A/F) ratio $= \left(\frac{Air}{Fuel}\right)$ ratio

$= \frac{2.353(32 + 3.76(28))}{12+4} = 20.1874$

② excess air $= \left(\frac{1}{0.85} - 1\right) \times 100\% = 17.647\%$

③ For propane ⇒ MoN = 97

RoN = 112

AKI $= \frac{RoN + MoN}{2} = 104.5$ Fuel sensitivity $= FS = 15$

AKI: Anti knock Index

-2-

Q 3.2) N = 1500 Rpm nc = 1

CR = 16 up = 8.5 m/s

T1 = 50 c° + 273 = 323 K

P1 = 120 Kpa

θ = 15 BTDC k = 1.4

CN = 45

~~EA = 618840 / (CN + 25) = 618840 / (45 + 25) = 8840.57143~~

~~ID = (0.36 + 0.22 up) {EA [1 / (8.314 × 323 × 16 ...~~

$$EA = \frac{618840}{45+25} = 8840.57143$$

(Ignition delay) ID = 3.1705°

fuel injection start = 15 + 3.1705 = 18.1705 BTDC

$$ID = \frac{3.1705}{6 * rpm} = 3.523 \times 10^{-4} \text{ seconds}$$

= 0.3523 millisecond

Q3.3) $CR = 9$ $Q_{CV} = 42 MJ/kg$
$A/F = 13.5:1$ $T_1 = 55°C$
$P = 100 kPa$ $+273 = 328 K$
$n = 1.3$

5 1/2

① $\frac{42000}{13.5+1} = \int_{T_2}^{T_3} (0.71 + 20\times10^{-5} T) dT$

$T_2 = T_1 CR^{n-1} = 328 (9)^{0.3} = 634.084 K$
$P_2 = P_1 CR^{n} = 1739.9 kPa$

$2896.552 = \int_{634.084}^{T_3} 0.71 + 20\times10^{-5} T dT$

$2896.552 = 0.71 (T_3 - 634.084) + 10\times10^{-5} (T_3^2 - 634.084^2)$

$3386.96 = 0.71 T_3 + 10^{-4} T_3^2$

Peak Temprature $T_3 = 3267.044814 K$

peak pressure $= P_3 = P_2 \frac{T_3}{T_2} = 8964.65 kPa$

② Second case if $C_V = 0.718 \frac{kJ}{kg.K}$

$2896.552 = \int_{643.084}^{T_3} 0.718 dT$

$2896.552 = 0.718 (T_3 - 643.084)$

peak Temprature

$T_3 = 4677.28\ K$ ~~(peak~~

$P_3 = 12834.25809\ Kpa$

peak pressure

for constant specific heat peak Temprature and pressure are higher than variable specific heat

③ ① friction Less ② adiapatic
③ Instantinious Mixing and compusition
④ No change in chemical of fuel

2

Q3.4) $n_c = 1$ $n_r = 2$ $\dot{m}_{f\,actual} = \frac{5\ kg}{hr}$

$\rho_f = 800\ \frac{kg}{m^3}$ $= 1.389 \times 10^{-3}\ \frac{kg}{s}$

4

$A/F = 13.5:1$ $d_j = 1.1\ mm$

$z_f = 5 \times 10^{-3}\ m$ $C_a = 0.85$

$C_f = 0.66$ $P_{amb} = 101.325\ kpa$

$T_1 = 21 + 273 = 294\ K$

① (A) Atomaization and evaporates of fuel
(b) mixing air with fuel at definite properties

2

The diffrence between carburator and mixer that carburator is for Liquid fuel but mixer for gaseous fuel.

② $\rho a = \frac{P}{RT} = \frac{101.325}{(0.287)(294)} = 1.2\ kg/m^3$

$\dot{m}a\ actual = 67.5 \frac{kg}{hr} = 0.01875 \frac{kg}{s}$

$\dot{m}a\ actual = cda\ A_{throat}$

$\dot{m}f\ actual = cdf * \frac{\pi}{4}(1.1\times10^{-3})^2 * u f_{theoritical} * 800$

$1.389\times10^{-3} = 0.66\times\frac{\pi}{4}(1.1\times10^{-3})^2 * u f_{theoritical} * 800$

$u f_{theoritical} = 2.77\ m/s$

$2.77 = \sqrt{\frac{2}{800}\left[\Delta p - 800*9.81*5\times10^{-3}\right]}$

$\Delta p = 3.1044\ kpa$

$U a_{theoritical} = \sqrt{\frac{2}{1.2}(3.1044\times10^3)}$

$= 71.9305\ m/s$

$\dot{m}a\ actual = cda\ A_{throat}\ U a_{theoritical} * \rho a$

$A_{throat} = 2.56\times10^{-4}$

throat diameter $= D_{th} = 18.04\ mm$

الدكتور فقط 2

هذا السؤال مدته 30 دقيقة ويجب أن يجاب عليه أولا

Question One: Concept Questions. (5 Marks)

The time needed by the End-mixture to reach its Self Ignition Temperature :
(a) Delay Period. (b) Ignition Lag. (c) Ignition Quality. (d) Ignition Time.

Antioxidant are added to Gasoline to :
(a) Prevent deposit formation. (b) Make valve operation easy.
(c) Change chemical properties of fuel deposits. (d) Prevent rust and oxidation.

To help in cold starting in Spark Ignition Engines, fuel volatility must be :
(a) High. (b) Low. (c) Moderate. (d) Eliminated.

The Choke system of the carburetor controls the fuel feed for .... operation
(a) Idling (b) Full throttle (c) Cold Starting (d) Low speed

As the temperature of the fresh air increases, the knocking possibility in SI engine ...increase........ and that for CI engine ....decrease.....................

The knocking tendency in petrol engines for specified conditions of fuel rating, compression ratio, speed ... etc, may increase by having .... cylinder diameter
(a) Smaller (b) Bigger (c) Medium (d) Oversquare

An SI engine fuel will produce less knock if it has
(a) Higher self-ignition temperature (b) Lower self-ignition temperature
(c) Higher activation Energy (d) Lower activation energy

Ignition quality of diesel fuel oil is expressed by an value given by
(a) ON (b) FS (c) AKI (d) CN

Maximum dissociation is for .... A/F ratio
(a) Lean (b) Rich (c) Stoichiometric (d) No effect

Time loss factor in Actual Cycle is due to
(a) Friction (b) Valve timing (c) Gas exchange (d) Combustion

---

Give the function of the following additives for fuel : (2 Marks)
Dye : to give colour to fuels, so it can be known by colours.
Antirust : to decrease and eleminate rust and dust on fuel.
Lead : octan No: boosting → increases octan Number value
Metal Deactivators : prevent chemical reactions of fuel with engine contents.

State Two problems with carburetor. (1 Mark)
1- Carburator icing.
2- the Area of air nozzle is decreased by fuel feed ~~access~~ accssesories.

State Two advantages and Two disadvantages of gaseous fuel. (2 Marks)

Advantages :

1- readily mix with air (Mixing time is low).

2- they burn clean and lean

Disadvantages :

1- not easy to store.

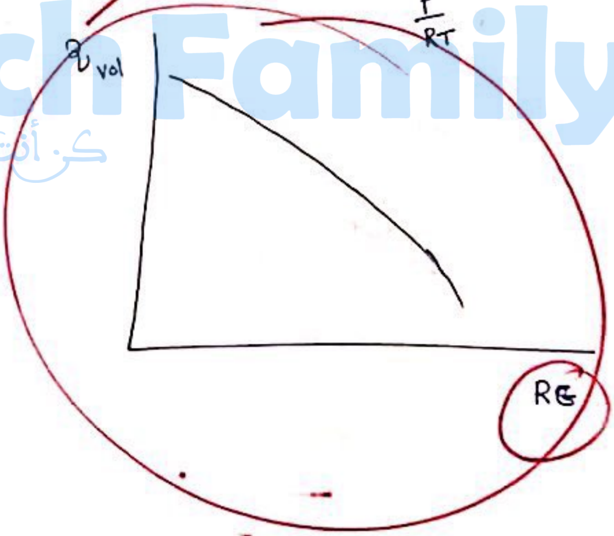
2- not easy to handle.

Discuss the effect of Residual Gas on the volumetric efficiency of IC Engines. (5 Marks)
Your answer should include using proper equations and graphs between residual gas and volumetric efficiency.

→ the Residual gases tend to expand and occupy a space in the cylinder which decreases the volume avalible for the Fresh charge. Also Residual gases increases the temprature of the fresh charge which ~~decrease~~ decrease it's density causing less ~~more~~ ~~lass~~ air mass entering the cylinder for the same volume, but still decreasing the volumetric efficiency.

$$\eta_{vol} = \frac{m_{act}}{\rho_a V_s n_c \frac{N}{60} \frac{1}{n_r}}$$

→ as seen in the equation $\eta_{vol} \downarrow$ as $\rho \uparrow$, $\rho = \frac{P}{RT}$



Question TWO: This question consists of THREE parts : **(15 Marks)**

Notes:

- ✓ **Undefined answers are not accepted.**
- ✓ **Answers should follow this pattern (Voltage (V) = I * R) then apply values and find answer, else, the answer WILL NOT BE ACCEPTED.**

لن يقبل أي جواب بدون وحدة أو غير معرف أو غير معروف طريقة حسابه.

☺ يجب كتابة المعادلة ثم التعويض بها ثم ايجاد الجواب.

يجب تعريف الطرف الأيسر من المعادلة المراد استخدامها لحساب القيمة المطلوبة.

Part (A) : Fuel and combustion

(5 Marks)

A mixture of 85% Iso-Octane and 15% Ethanol by volume are used as fuel for SI engine with equivalence ratio $\phi = 1$.

(Take molecular weight for C = 12 kg/kmol, H = 1 kg/kmol, N = 14 kg/kmol, O = 16 kg/kmol)

Write the stoichiometric combustion equation and find the stoichiometric A/F ratio.

Find the ON, AKI and FS for this fuel blend.

****

A CI engine with a 3.2-inch bore and 3.9-inch stroke operates at 1850 RPM. In each cycle, fuel injection starts at 16°bTDC and lasts for 0.0019 second. Combustion starts at 8° bTDC. Due to the higher temperature, the ignition delay of any fuel injected after combustion starts is reduced by a factor of two from the original ID.

Calculate: (3 Marks)

(a) ID of first fuel injected. [sec]

(b) ID of first fuel injected in degrees of engine rotation [deg].

(c) Crank angle position when combustion starts on last fuel droplets injected.

Hint : 1 inch = 2.54 cm.

Part (B) : Fuel-Air Cycle

(3 Marks)

The compression ratio of an engine working on an Otto cycle is 9 and the air/fuel ratio is 15 : 1, the pressure and temperature at the beginning of a compression stroke being 1 bar and 60°C respectively. The calorific value of the fuel is 44,000 kJ/kg.

Determine the maximum temperature and pressure in the cylinder, if the index of compression is 1.32 and the specific heat at constant volume of the products of combustion is given by $C_v = (0.678 + 0.000137T)$ kJ/(kg K), where T is the temperature in kelvin. Compare this value with that of constant specific heat $C_v = 0.717$ kJ/(kg K).

Part (C) : Fuel Supply System Design

(4 Marks)

An engine having a single jet carburetor consumes 6.0 kg/h of fuel. The density of fuel is 750 kg/m^3. The fuel is at 5 mm height below the throat. Ambient conditions are 1.013 bar and 20°C. The jet diameter is 1.5 mm and its discharge coefficient is 0.65. The discharge coefficient of air is 0.80. The air/fuel ratio is 15.3:1. Neglect the compressibility of air. Determine

a) The critical air velocity for this carburetor
b) The pressure depression at the throat in mm of H_2O
c) The effective throat diameter.
d) The air/Fuel ratio supplied by this carburetor.

المستوى ________ الكلية ________

القسم ________ المادة ________

التاريخ ________

العلامات

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PART A :-

$$(0.85\ C_8H_{18} + 0.15\ C_2H_5OH) + a_{th}(O_2 + 3.76\ N_2) \rightarrow x_1 CO_2 + x_2 H_2O + 3.76\, a_{th}\, N_2$$

$$a_{th} = \left((0.85 \times 8 + 0.15 \times 2) + \left(\frac{0.85 \times 18 + 0.15 \times 6}{2} \right) - \left(\frac{0.15 \times 1}{2} \right) \right)$$

$a_{th} = 15.125$. $x_1 = 0.85 \times 8 + 0.15 \times 2 = 7.1$

$x_2 = 8.1$

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→ Stoichiometric Combustion eqn:-

$$(0.85\ C_8H_{18} + 0.15\ C_2H_5OH) + 15.125(O_2 + 3.76\ N_2) \rightarrow 7.1 CO_2 + 8.1 H_2O + 56.87\ N_2$$

$$\text{Stich. Air-Fuel Ratio} = \frac{\Sigma N_a M_{air}}{\Sigma N_a M_{Fuel}} = \frac{15.125(32 + 3.76(28))}{0.85 \times 114 + 0.15 \times 46}$$

$$\text{Stichiometric A/F Ratio} = (A/F)_s = 20.003$$

	y_i	N_i	M_i	m_i	m_{Fi} (mass fraction)
C_8H_{18}	0.85	0.85	114	96.9	0.933
C_2H_5OH	0.15	0.15	46	6.9	0.06647
				$\Sigma m_i = 103.8$	

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$$\text{Research Octan Number (RON)} = \sum_{i=1}^{n} \%\ \text{of}\ A_i \times ON_i = 0.933 \times (100) + 0.06647(107)$$

$$RON = 100.412$$

$$\text{Moderate octan Number (MON)} = 0.933 \times 100 + 0.6647(89)$$

$$MON = 99.215$$

Part A Completed.

Anti-Knock Index $= \left(\frac{MON + RON}{2} \right) = \left(\frac{99.215 + 100.412}{2} \right)$

Anti-Knock Index. $=$ AKI $= 99.8135$

Fuel sensetivity $= RON - MON$

Fuel sensetivity $= FS = 100.412 - 99.215 = 1.197$

→ question 2 (part A).

$D = 3.2$ inch $\quad N = 1850$ RPM

$S = 3.9$ inch

$\theta_{inj} = 16$ bTDC , $time_{inj} = 0.0019$ s

$\theta_{combus} = 8°$ bTDC

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Ignition Delay of First Fuel. $= ID = \theta_{inj} - \theta_{combustion}$

$= 16° - 8° = 8°$

~~Ig:~~ Ignition Delay of First Fuel in sec $(I_{ID}) = \frac{\theta°}{6N} = \frac{8°}{6(1850)} = 7.207 \times 10^{-4}$ s

~~Crack~~ crank angle rotated during injection ~~at last droplet out~~ $=$ time in second $\times 6 \times N$

$= 0.0019 \times 6 \times 1850$

$= 21.09°$

crank position at last drop combustion = Injection position + ~~Ignition delay~~

thus → crank position at last drop Combustion $= 5.09° + \frac{8°}{2} = 9.09°$ aTDC

Part (B) :-

CR = 9

A/F = 15

P_1 = 1 bar $T_1 = 60°C = 333 K$

Q_{cv} = 44,000 KJ/Kg.

mass flow rate of air — mass flow rate of fuel

let: $\dot{m}_a = 1 \rightarrow \dot{m}_{fuel} = \frac{1}{15} \rightarrow \dot{m}_{mix} = \dot{m}_a + \dot{m}_f = \frac{16}{15}$.

input heat $= Q_{in} = \int_{T_2}^{T_3} C_v \, dT$ → Temperature at end of Compression = $T_2 = T_1 CR^{n-1}$

$T_2 = 333 \times (9)^{1.32-1}$

$= 672.669$ K.

$= Q_{cv} * \dot{m}_f = \dot{m}_{mix} \int_{T_2}^{T_3} C_v \, dT$

pressure at the end of compression $= P_1 CR^{n}$

$= 44,000 \times \frac{1}{15} = \frac{16}{15} \int_{672.669}^{T_3} (0.678 + 0.00013T) dT$

$P_2 = 100 \times 9^{1.32}$

$= 1818.026$ Kpa

$2750 = (0.678 T_3 + \frac{0.00013 T_3^2}{2}) - (0.678 T_2 + \frac{0.00013 T_2^2}{2})$

$2750 = (0.678 T_3 + \frac{0.00013 T_3^2}{2}) - 485.48$

$3235.48 = 0.678 T_3 + \frac{0.00013 T_3^2}{2}$

(Maximum Temp.) Temperature after Combustion $= T_3 = 3358.26$ K.

(Maximum pressure) Pressure after Combustion $= P_3 = P_2 \times \frac{T_3}{T_2} = 9076.38$ Kpa.

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If $C_v = 0.717$.

$Q_{cv} * \dot{m}_f = \dot{m}_{mix} \int_{T_2}^{T_3} C_v \, dT$

$44,000 \times \frac{1}{15} = \frac{16}{15} \int_{672.669}^{T_3} 0.717 \, dT$

$2750 = 0.717 (T_3) - 0.717 (672.669)$

$3232.3 = T_3 (0.717)$

Maximum Temp. $= T_3 = 4508.094$ K

Maximum pressure $= P_3 = P_2 \frac{T_3}{T_2} = 1818.026 \times \frac{4508}{672.669} = 12184.250$ Kpa.

∴ T and pressure are larger at constant Specific Heat.

PART (C):

$\dot{m}_f = 6\ Kg/h = \frac{6}{3600} = 1.6667 \times 10^{-3}\ Kg/s$

$\rho_f = 750\ Kg/m^3$. $Z_f = 5\ mm$.

$d_j = 1.5\ mm$. $C_{da} = 0.8$ $T_1 = 20^\circ C = 293\ K$

$C_{df} = 0.65$ $P_1 = 101.3\ Kpa$

air density $= \rho_{a_1} = \frac{101.3}{293 \times 0.287}$

$\rho_{a_1} = 1.204\ Kg/m^3$.

a) - $A/F = 15.3$

critical air velocity $= U_{critical} = \sqrt{\frac{2}{\rho_a}(\rho_f g Z_f)}$

$= \sqrt{\frac{2}{1.204} \times (750 \times 9.81 \times 0.005)}$

critical velocity of Air $(U_{a_{crit}}) = 7.8172\ m/s$.

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b) - $\dot{m}_f = C_{df} * A_{jet} * \sqrt{2\rho_f(\Delta p - \rho_f g Z_f)}$

$1.667 \times 10^{-3} = 0.65 \times \frac{\pi}{4}(1.5 \times 10^{-3})^2 \times \sqrt{2(750)(\Delta p - 750 \times 0.005 \times 9.81)}$

$1451.27 = \sqrt{2 \times 750 \times (\Delta p - 36.7875)}$

$1404.123 = \Delta p - 36.7875$

Pressure drop in throat $= P_1 - P_2 = \Delta p = 1440.91\ Pa = 0.014409\ bar$.

mm H_2O

c) -

mass flow rate of air $= \dot{m}_a = \dot{m}_f * (\frac{A}{F}) = 0.0255051\ Kg/s$

$\dot{m}_a = C_{da} * \frac{\pi}{4} D_{th}^2 \times \sqrt{2\rho_a(\Delta p)}$

$0.0255051 = 0.8 \times \frac{\pi}{4} \times D_{th}^2 \times \sqrt{2 \times 1.204 \times 1440.91}$

$D_{th}^2 = 6.8912 \times 10^{-4}$

throat diameter $= D_{th} = 0.0262\ m = 26.25\ mm$.

d) - Air Fuel Ratio $= 15.3$ at ambient conditions, it may change if P or T is changed.