e. None supply from below

9. The difference between recuperative air pre-heater and regenerative air pre-heater is:
   a. The shell and tube form of the regenerative air-preheater.
   b. The recuperative air pre-heater is known as Ljungstrom pre-heater.
   c. The heat is transfer from hot gas to the air directly in the regenerative air-preheater
   d. All
   e. None gas flow inside tube

10. The dispersion is one of the stack function where it: hot gases firstly
   a. Define the wind direction
   b. Produce the concentration profile
   c. Control the dilution rate of the hot gases with the ambient air.
   d. All
   e. None

Q2: The diameter of a wheel of a single- stage impulse turbine is 1060 mm and the shaft speed is 3000 rpm. If the nozzle inlet angle is 72°. The ratio between the blade speed (U) to the steam inlet velocity (V) is 0.42. The ratio of the relative velocity that leaves the blade to that inter the blade is 0.84. The outlet flow angle of the relative velocity (β) is 3° more than the inlet flow angle. The mass flow rate is 7.23 kg/s. a) draw the velocity diagram for the blades. b) find the rotor efficiency. c) find the power developed by the rotor blade. **10 points**

Q3: A 32 m high down comer-riser system operates at 800 bar. If the exit quality of the steam is what will be the driving pressure. Assume S to be 1.4. **5 points**

X = 0.5

Q4: find the driving pressure for a stack that has a height of 18 m and carry a hot gas mixture with an average density of 1.2 k/m3. If you know that the total heat rejection by the stack is 1450 KJ and the c_p of the hot gas is 1.8 KJ/Kg.K while the hot gas inlet and outlet temperature are 650 K and 500 K respectively. Assume the hot gas pressure as 2.3 bar while the ambient pressure is 1 bar. **5 points**

Q2: Diameter = 1060 mm, V_2 = 3000 rpm, $\alpha_2 = 72$, $\frac{U}{V} = 0.42$, $\frac{W_3}{W_2} = 0.84$

β ... 3, m = 7.23 kg/s

$C_N = 0.42$ $C_R = 0.84$

$\frac{2W}{2W + V_3^2 + \lambda_R W_3^2} = \frac{2*3792.29*10^3}{2*3792.29*10^3 + 1078.4^2 + 0.417*1429.17^2}$

$= 0.79 = 79\%$

$U(W_{u2} - W_{u3}) = U(1 + C_R C) W_2 \sin\beta_2$

... = 1.03

$\to U = \frac{1}{2} * V_2 \sin\alpha_2 = \frac{1}{2} * 3000 * \sin 72$

$= 1426.5$ m/s

$\to V_{x2} = V_2 \cos\alpha_2$, $V_{u2} = V_2 \sin\alpha_2$

$= 927.05$ m/s, $= 2853.16$

$* W_{x2} = V_{x2} = 927.05$, $W_{u2} = V_{u2} - V = 1426.66$

$* W_2 = \sqrt{W_{x2}^2 + W_{u2}^2} = 1701.4$

$* \beta_2 = \tan^{-1}\left(\frac{W_{u2}}{W_{x2}}\right) = 56.9°$

$* \beta_3 = -56.9 - 3 = -59.98°$

$* W_3 = C_R * W_2 = 1429.17$

$* V_{x3} = W_3 * \cos\beta_3 = 715$, $V_{u3} = 807.3$

$* V_3 = 1078.4$

$W = 1426.5(1 + 0.84 * 1.03) 1701.4 * \sin 56.9$

$= 3792.292$ KJ/Kg

$\lambda_R = \frac{1}{0.84^2} - 1 = 0.417$

Subject Date No.

3) The rate of heat transfer per unit projected area

$$\frac{Q}{A} = \frac{\dot{m}_g h_{fg}}{D_o H}$$

$\dot{m}_{tot} = \dot{m}_{Downcomer} = \rho_f * A_i * \bar{V}_f$

$= 7.22.543 * \frac{\pi}{4}((76.2-2*6.1)\times 10^{-3})^2 * 1.5$

$= 3.4866$ kg/s

$x_{top} = \frac{\dot{m}_g}{\dot{m}_{tot}} \Rightarrow \dot{m}_g = 0.08 * 3.4866 = 0.2789$ kg/s

$\therefore Q = \frac{\dot{m}_g h_{fg}}{D_o H} = \frac{0.2789 * 1441.3}{76.2\times 10^{-3} * 18} = 293.1$ KW/m2

A 15m high downcomer-riser circuit operates at 16 MPa. The riser receives uniform heat flux and saturated water. The exit quality is 50%. Calculate the pressure head developed due to natural circulation. Take slip factor as 1.2.

- H = 15m
- P = 16 MPa
- The riser recieves uniform flux and Sat. water
- $x_{top} = 0.5$, $S = 1.2$, Find ΔP

N O T E B O O K

Review Questions on Steam Generators

A furnace wall riser, 18m long, 76.2mm outer diameter, and 6.1mm thickness. It receives saturated water at 8 MPa and 1.5 m/s velocity. Assuming a circulation ratio of 12.5 and slip ratio of 1.2, calculate :

1) The pressure head developed
2) The void fraction at riser exit
3) The heat transferred to the riser per unit area.

$H = 18\,m$, $OD = 76.2\,mm$, $t = 6.1\,mm$

@Riser inlet : Saturated water @ 8 MPa $\overline{V_f} = 1.5\ m/s$

$CR = 12.5$, $S = 1.2$

1) $\Delta P = gH(\rho_D - \rho_m)$

@ 8 MPa, $v_f = 0.001384\ \frac{m^3}{kg} \Rightarrow \rho_f = \rho_D = \frac{1}{v_f} = 722.543\ kg/m^3$

$v_g = 0.023525\ \frac{m^3}{kg}$

$v_{fg} = 0.022141\ m^3/kg$

Method I for calculating ρ_m

$\rho_m = \frac{\rho_{top} + \rho_{bottom}}{2}$, $\rho_{bottom} = \rho_f = 722.543\ kg/m^3$

$\rho_{top} = \frac{1}{v_{top}} \Rightarrow v_{top} = v_f + x_{top} v_{fg} = 0.001384 + 0.08 * 0.022141$
$= 0.031552\ m^3/kg$

$x_{top} = \frac{1}{CR} = \frac{1}{12.5} = 0.08$

N O T E B O O K

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$\therefore \rho\ \ \ \ 1\ \ \ \ 31.927\ kg/m^3$

Subject Date No.

$$\therefore \rho_{top} = \frac{1}{v_{top}} = 316.937\ kg/m^3$$

$$\therefore \rho_m = \frac{\rho_{top} + \rho_{bottom}}{2} = \frac{316.937 + 722.543}{2}$$

$$= 519.74\ kg/m^3$$

$$\therefore \Delta P = 9.81 * 18 * [722.543 - 519.74] = 35.8\ KPa$$

Method II:

$$\psi = \frac{v_f}{v_g} * S = \frac{0.001384}{0.023525} * 1.2 = 0.706$$

α_e = void fraction at riser exit $= \dfrac{1}{1 + \dfrac{1 - x_{top}}{x_{top}} \psi}$

S

2 ضعف

$$= \frac{1}{1 + \frac{1 - 0.08}{0.08} * 0.706} = 0.552$$

$$\rho_m = \rho_f - \left(\frac{\rho_f - \rho_g}{1 - \psi}\right) * \left[1 - \left[\frac{1}{\alpha_e(1-\psi)} - 1\right] * \ln\left[\frac{1}{1 - \alpha_e(1-\psi)}\right]\right]$$

$$= 523.786\ kg/m^3$$

$$\therefore \Delta P = 9.81 * 18 * [722.543 - 523.786] = 35.096\ KPa$$

NOTEBOOK

The University of Jordan
Department of Mechanical Engineering
School of Engineering, fall 2017-2018

Power plants-Course # ME0904361 — **Midterm Examination**

Fall 2019/2020

Instructor: Dr. Mohammad Alrbai. — **Date: Nov 13, 2019**

Time allowed: 75 min

Student Name	[redacted]	
	Total Grade out of 40	

4

Q1: Answer the following with a specific and short answer (**10.5 Points**)

1. Boiling water reactors is much better than gas cooled reactor since the first Cooling ______.
2. Pressurized Water Reactors are used when Coal boiler ______.
3. On comparison to utility steam generators, Industrial steam generators can operate with Low Temp ______.
4. The function of the feedwater system in the natural circulation water tube boiler is density difference will make the circulation rapidly
5. The DNP problem is common in pipes that contains 2 phase ______.
6. To avoid DNP problem, the tubes of the boiler should have internal twisters & springs Internaly grooved, corrugated, Ribbed.
7. When gravity separation is considered in the steam drum, the position of the down comer and the riser with respect to the steam outlet can limit the separation process as Position down corner & Riser Nozzle with Respect of Nozzle outlet Steam velocity

Q2: A 32 m high down comer-riser system operates at 400 bar. If the exit quality of the steam is 0.6 what will be the driving pressure. Assume S to be 1.4. vf= 0.00204 m3/kg & vg=0.0059 m3/kg. **5 points**

Q3: find the driving pressure for a stack that has a height of 18 m and carry a hot gas mixture with an average density of 1.2 k/m3. If you know that the total heat rejection by the stack is 1450 KJ and the c_p of the hot gas is 1.8 KJ/Kg.K while the hot gas inlet and outlet temperature are 650 K and 500 K respectively. Assume the hot gas pressure as 2.3 bar while the ambient pressure is 1 bar. **5 points**

Q4: The shaft of small impulse turbine turns at 20000 rpm, and the blade speed is U = 250 m/s. The axial velocity leaving the stator is Vx2 = 175 m/s. The angle at which the absolute velocity leaves the stator blades is 67°, the flow angle of the relative velocity leaving the rotor is -60°, and the absolute velocity leaves the rotor at the angle is 20°. Find (a) the mean radius of the blades, (b) the angle of the relative velocity entering the rotor, (c) the magnitude of the axial velocity leaving the stator, and (d) velocity leaving the rotor and the magnitude of the absolute velocity leaving the rotor and the specific work (e) Draw the velocity diagram at the stator and rotor (**10 Points**)

pressurized water reactors are used when formation of low-pressure
steam is required // strong pressure vassel is required.
Non-Electric solar power system is basically used for heating and lighting
power towers are used to produce steam for solar powerplants by

using molten salt heat transfer // concentrating heat // steam generators
in parabolic trough system, the system is generated in solar field piping network
// using reflections panels // inside the absorber tube
Among the following has high heat loss from the heat exchanger boiling water reactor plants.
Wind energy has many advantages like Supply the Power to Remote Areas
// Handle variable wind speed // Low energy density by friction
Bert conveyor and Vee bucket elevators are used for Load and loading
coat in steam power plants // Carrying the resulted ash of the cumber
// Preparation of the coal roar combustions
Mechanical stokers are used in steam power plant for Attain uniform operation
//Use solid coal//large boilers using
In pulverized coal system hot air is employed mainly for Helps in drying the coal powder
//remove undesirable matters from the coal powder.
Belt conveyor and Vee bucket elevators are used for load and loading coal in steam
// Carrying the resulted ash of the chamber.
Horizontal Axl Wind Turbine is Axis of rotation is parallel //More output energy //
Always face the win//More stress on base of the blades // Selection of site is easy //
Overall efficiency is more.
Vertical Axis Wind Turbine is the axis of rotation is perpendicular //
Less output energy//Always against the wind//More stress is a center of the blades
//Overall efficiency is less
The difference between recuperative air pre-heater and generative air pre heater
Gas flow inside tube.
The dispersion is one of the stock functions where it controls the dilution rate
Of the hot gases with ambient air.

Close

$W_{pump,1}=$

At $h_1=h_p=251.42$

$V_1=V_f=0.001017$

$W_{pump,1}=$

$H_2=h_1+W_{pump,1}$

$H_2=251.42+14.43=265.55$

$W_{pump,2}=$

$H_3=h_f=762.51$, $V_3=V_f=0.001127$

$W_{pump,2}=$

$H_{11}=h_{10}=h_4$

$H_5=3476.5$, $P_5=12.5Mpa$, $P_6=5Mpa$

$H_6=3476.5-0.88(3476.5-3185.6)=3220.5$

$H_7=3434.7+(3666.9-3434.7)\times$

$S_8=S_7=7.1238$, $P_8=1Mpa$

$H_8=3550.9-0.88(3550.9-3051.1)=3111.1$

$T_8=300+(350-300)\times$

$(1-y)(777.25-265.85)=y(3111.1-762.51)$

$y=0.1788$

$Q_{in}=3029.7$

$Q_{out}=1840.1$

$W_{net}=$

$W_{net}=24(3029.7-1840.1)=28550.4$

12:37 4G

cdn.fbsbx.com Done

State 1: $h_1 = h_f$ @ 45 C

$h_1 = 188$ kj/kg

State 2: $h_2 = W_p + h_1$

$h_2 = 0.9042 + 188 = 188.9042$

State 3: $h_3 = h_g$ @ 180 C

$h_3 = 2778$

$S_3 = S_g$ @180 C

$S_3 = 6.59$

State 4: $h_4 = h_{f1} + Xh_{fg1}$ @ T=45 C

$h_4 = 188 + 0.7920(2394) = 2084.1$

Isentropic Compression

$W_p = V_f(P_2 - P_1)$

Wp=0.0010(1000-95.8) =0.9042

$S_3 = S_4$

6.59=0.638+X (7.515)

X=0.7920

$Q_m = h_3 - h_2 = 2589.1$

$W_p = h_2 - h_1 = 0.9042$

$W_T = h_3 - h_4 = 693.91$

$W_{net} = W_T - W_p = 693.0096$

OPEN

At 450 C and 6Mpa

H_1=3302.76

Specific entropy = 6.721

H_b=h_L=604.723, H_g=2738.056

S_l=1.776, S_g=6.895

S_1=S_a=S_L+ (S_g-$S_{L)}$

X=0.966

H_a=h_L+X(h_g-h_L)

604.723+0.966(2738.05-604.723)

H_a=266.54, H_L=251.39, H_g=2608.94

S_1=S_2=at 80 C

S_L=0.8319, S_g=7.907

S_1=0.831+X (7.907-0.8319)

X=0.892

H_2=2213.801

S_4=0.8319, T_4=61.38 C, H_4=257.24

%m=0.144

S_b=S_5=1.776

T_5=151.40 C, H_5=641.72, H_5=641.72

W_T=1023.91, W_p=42.01

W_{net}=W_T-W_P=981.89

...t system
...system
...above.

... flame in the combustion chamber of SI ...
...mber geometry
...el-air turbulence
...gnition time
...f the above
...e.

...n system varies the spark timing based on the engine:
...oad
...peed
Air fuel ratio
All of the above
None.

...g a Morse test on a 4 cylinder engine, the following measurements of b... ...aken ...constant speed.

All cylinders firing	3037 kW
Number 1 cylinder not firing	2102 kW
Number 2 cylinder not firing	2102 kW
Number 3 cylinder not firing	2100 kW
Number 4 cylinder not firing	2098 kW

The mechanical efficiency of the engine is

a) 96.53% b) 81.07% c) 84.07% d) 68.22% e) None

Q2: A pickup truck has a five-litre, V6, SI engine operating at 2400 rpm. The engine has a compression ratio of 10.2:1 and its volumetric efficiency is 0.91. The bore and the stroke are as L=0.92B. Calculate

1. Stroke length (1 mark)
2. Piston bore (1 mark)
3. Average piston speed (1 mark)
4. Clearance volume of one cylinder (1 mark)

...N of fu...

...etical = $\sqrt{\frac{...}{\rho_f}...}$

= $\sqrt{\frac{2}{\rho_a}(P_1 - P_2)}$, ...

Instructor: Dr. Mohammad Alrbai. Fall Semester 2017/2018

Time allowed: 60 min Date: OCT 22, 2018

Q1: Choose the most correct answer for the following. If your answer is none, write the correct answer.

1. Diesel power plants are used:
   a. For Mobile power generation
   b. When the power load is in the peak state.
   c. As stand by for hydro-electric systems
   d. All
   e. None
2. The function of the oil coolant in the diesel power plants is:
   a. Reduce the friction force over the piston.
   b. Enhance the heat losses in the engine.
   c. Cooling the intake air of the system.
   d. All
   e. None
3. The location of the silencers in the diesel power plants are within
   a. The starting system
   b. The injection system
   c. The exhaust system
   d. The cooling system
   e. None
4. When diesel power plant is compared with steam power plant of the same size then:
   a. The diesel plant is more efficient
   b. The diesel plant is less efficient
   c. The diesel plant is cheaper
   d. The diesel plant has more emissions
   e. None.
5. ... power plant cite needs to be selected, many factors should be considered like:
   ... center
   ... extension
   ... ture of the cite
   ... all
   e. None
6. Among the advantages of coal mechanical handling is :
   a. low transport requirements
   b. Capital cost is less
   c. Low power consumption
   d. All

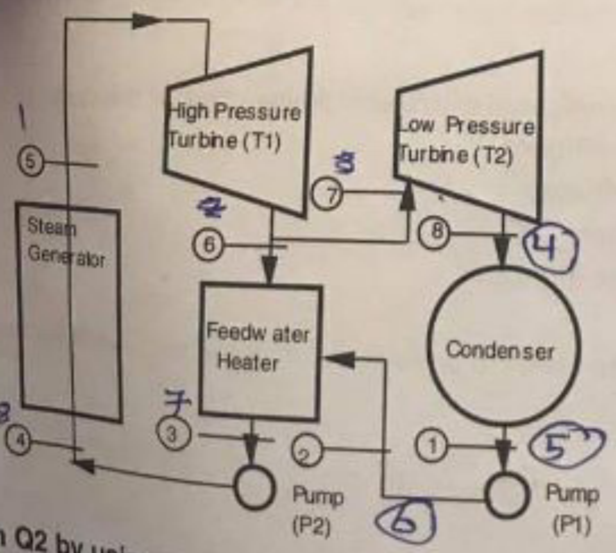
e. None

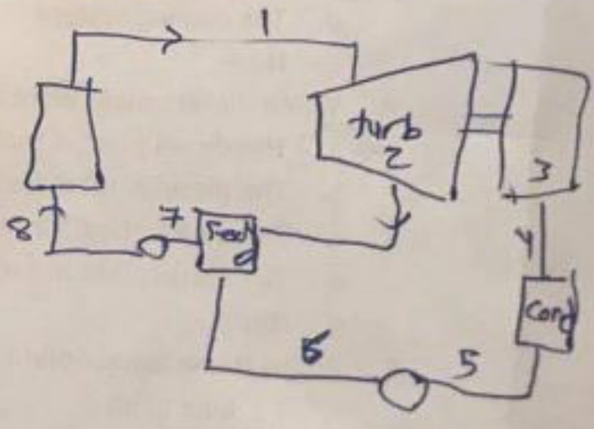
7. Belt conveyor and Vee bucket elevators are used for:
   a. Load and loading coal in steam power plants
   b. Carrying the resulted ash of the chamber
   c. Preparation of the coal for combustions
   d. All
   e. None

8. Mechanical stokers are used in steam power plant for:
   a. Attaining uniform operation
   b. Obtain higher burning rates
   c. Large boilers using
   d. All
   e. None

9. In pulverized coal system, hot air is employed mainly for:
   a. Cary coal powder inside the combustion chamber
   b. Helps in drying the coal powder
   c. Remove undesirable matters from the coal powder
   d. All
   e. None

Q2: A ste... nt operates on an ideal regenerative Rankine cycle. Steam enters the tur... nd 450°C and is condensed in the condenser at 20 kPa. Steam is extr... rbine at 0.4 MPa to heat the feedwater in an open feedwater heater. ... edwater heater as a saturated liquid. Show the cycle on a T-s diagram ...) the net work per kilogram of steam flowing through the boiler and (b) ... iciency of the cycle (c) work ratio (d) TTD value





Q3:Design Q2 by using a closed feedwater heater with drain backward. Assume that the feedwater leaves the heater at the condensation temperature of the extracted steam and that the TTD value is 7 °C. Find (a) the network per kilogram of steam flowing through the boiler and (b) the thermal efficiency of the cycle (c) work ratio (d) the maximum efficiency with respect to the open feed water plant.

« powerplants »

* Belt Conveyor and Vee bucket elevators are used for : ① Load and Loading Coal is steam power plants
② Carrying the resulted ash of the Chamber.
③ Prepartion of the Coal for Combustions.

Mechanical stokers are used in steam power plant for :
to feed solid fuel like Coal, Coke into funance of a steam boiler.

In pulverized Coal System, hot air is employed mainly for : Hot air is pased coal in the factor to dry the coal in pulverized Coal system.

---

* The dimpersion is one of the black function where it

جواب : Control the dilution rate of the hot games with the ambiert air.

The difference between recupertaive air pre heater and regenarative air pre heater is :

recupertaive → gas flow inside tube

regenarative → hot gases firstly

Q2
السؤال الثاني

5L, 6 cylinder, $N = 2400\ rpm$, $CR = 10.2$, $\eta_v = 0.91$

$L = 0.92\,B$

1) $V_{s1} = \dfrac{5 \times 10^{-3}}{6} = \dfrac{\pi}{4} D^2 \times 0.92 \times D$

$D = B = 0.104869\ m$

$Stroke = 0.92 \times 0.104869 = 0.09648\ m$

2) $B = D = 0.104869\ m$

3) $\overline{U_p} = \dfrac{2 \times 0.09648 \times 2400}{60} = 7.7184\ m/s$

In the mechanical separation of the steam, the secondary stage is responsible about :

Removing the mist and Solid from the steam

The function of the feedwater system in the natural Circulation water tube boiler is :

When saturated water at the bottom of the steam drum returns to the lower drum via large bore called down Comer tubes where it preheats the feed water

Feed water is supplied to the steamdrum and the downcomers supply the water to the bottom.

Convection Super heaters are used at :

when the temperature difference between the saturated and superheated steam is not more than 50 degree. and is located in the convective zone

---

The inverted type mechanical Support that is used in Super heater :

Needs slow restart to purge water

The dispersion is one of the stack function where it : wind direction

---

One Comparison to utility steam generators, Industrial steam generators Can Operate with:

Natural gas, stoker Coal, Pulverized Coal

1. **In 4-stroke CI engine the intercooler is recommended since it:**
   a) Increases the ignition delay significantly.
   b) Decrease the ignition delay significantly.
   c) Increase the mean adiabatic flame temperature.
   d) Decreases the mean adiabatic flame temperature.
   e) None.

2. **The function of automobile catalytic converter is to control emissions of:**
   a) Carbon dioxide and hydrocarbon
   b) Carbon monoxide and hydrocarbon
   c) Carbon monoxide and carbon dioxide
   d) Carbon monoxide and nitrogen dioxide
   e) None

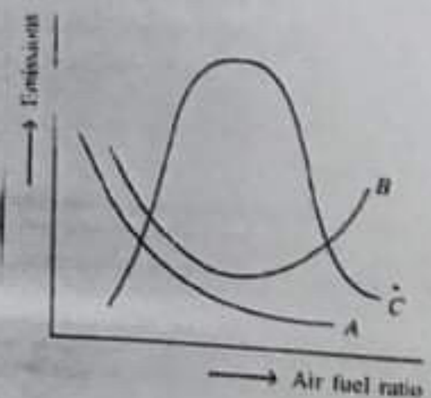
3. **Global warming is caused by .... emissions.**
   a) Ozone
   b) carbon dioxide
   c) Nitrogen
   d) carbon monoxide
   e) None

Consider the following emissions of an IC engine:
1. CO_2 2. HC 3. NO_x 4. Particulates

4. **Which of these emissions cause photochemical smog**
   a) 1 and 4
   b) 1 and 2
   c) 2 and 3
   d) 3 and 4
   e) None

5. **The presence of nitrogen in the products of combustion ensures that:**
   a) Complete combustion of fuel takes place
   b) Incomplete combustion of fuel occurs
   c) Dry products of combustion are analyzed
   d) Air is used for the combustion
   e) None

6. **In the figure supplied, curve "C" represents .... emissions.**
   a) CO_2
   b) NO_x
   c) HC
   d) All
   e) None



7. **Knocking tendency in an S.I. engine reduces with increasing**
   a) Compression ratio
   b) wall temperature
   c) supercharging
   d) engine speed
   e) None

8. **During the flame propagation in SI engines, the produced work from combustion will be:**
   a) The minimum.
   b) The maximum.
   c) Has no relation to the flame propagation.

Q3) السؤال الثالث

$n_c = 4$, $D = 57\,mm$, $S = 90\,mm$, $N = 2800\,rpm$

Radius = 0.356 m → load = 155 N   Fuel = 6.74 L/hr

$Q_{cv} = 44200$ S.G = 0.735

1. $\tau_B = F\,d = 155 \times 0.356 = 55.18\ N\cdot m$

2. $W_B = \frac{2\pi \times 2800}{60} \times 55.18 = 16.17\ kW$

3. $P_{m,\bar{B}} = \Rightarrow$

$16.17 = P_{m,\bar{B}} \times 4 \times \frac{\pi}{4} \times (0.057)^2 \times (0.09) \times \frac{2800}{60 \times n_r}$

3) $\overline{Up} = \frac{2 \times 0.09648 \times 2400}{60} = 7.7184 \ m/s$

4) $V_{c_1} \rightarrow \quad CR = \frac{V_{s_1} + V_{c_1}}{V_{c_1}}$

$$10.2 = \frac{(5/6) \times 10^{-3} + V_{c_1}}{V_{c_1}}$$

$$9.2 \ V_{c_1} = \frac{5}{6} \times 10^{-3} \rightarrow \boxed{V_{c_1} = 9.058 \times 10^{-5} \ m^3}$$

5) $\eta_v = \frac{\dot{m}_a}{\rho_a \times 5 \times 10^{-3} \times \frac{2400}{60 \times 2}} \rightarrow \dot{m}_a = \frac{0.91 \times 5 \times 10^{-3} \times 2400}{60 \times 2} \times \rho_a$

ρ_a → 1.2 اعتبرها

[illegible]

$$\boxed{\dot{m}_a = 0.1092 \ kg/hr}$$

6) [illegible]

$$\frac{\pi}{4} (0.104869)^2 \times 6 = \boxed{0.05182 \ m^2}$$

(10 Points):

1. Valves overlap is introduced in the actual engine cycles, this overlap:
   a) Is done by delaying the opening of the intake valves until all of the EGR gases escaped.
   b) Has some advantages to the overall performance although; it can reduce the system efficiency.
   c) Control the combustion process by affecting the air fuel content within the combustion chamber.
   d) All of the above.
   e) None. Answer____________.
2. Using the LHV of the fuel indicates that the H2O form in the combustion products is:
   a) In the vapor form.
   b) In the liquid form.
   c) H2O is not related to the HHV since the process is affected by the temperature.
   d) H2O in the actual cycle will react with other compounds like NO, so no pure H2O is found.
   e) None. Answer____________.
3. Front end volatility is required for the fuel:
   a) To ensure good cold staring and acceleration characteristics.
   b) Decrease the self-ignition temperature of the fuel.
   c) Maximize the volumetric efficiency.
   d) All of the above.
   e) None. Answer____________.
4. Engines with variable intake valve timing affected mostly by:
   a) The engine size.
   b) The engine speed.
   c) The engine load.
   d) All of the above.
   e) None. Answer____________.
5. Self-ignition temperature for any fuel can be defined as:
   a) The temperature at which the fuel-air mixture will have the knocking phenomenon.
   b) The temperature at which the fuel-air mixture will ignite without any external cause.
   c) The temperature at which fuel-air mixture will reach at the end of the ignition delay time.
   d) All of the above.
   e) None. Answer____________.
6. Increasing the octane number can affect the combustion process by:
   a) Increasing the combustion peak temperature.
   b) Decreasing the combustion peak temperature.
   c) Increasing the ignition delay time.
   d) Decreasing the ignition delay.
   e) None. Answer____________.
7. Knocking can be avoided for Gasoline fueled engines by:
   a) Limiting the compression ratio.
   b) Fuel property control.
   c) Increasing the flame speed within the combustion chamber.
   d) All of the above.

② B mep
③ η_{th}

Sol:

Brake torque $(\tau_B) = 622 \times 0.461 = 286.742$ N.m

① $\dot{W}_B$ (Brake Power) $= \tau_B \omega = 286.742 \times \frac{2\pi \times 5000}{60} = 150.137$ kW

$$B_{mep} = \frac{\tau_B}{\frac{V_d\, n_c}{2\pi n_r}} = \frac{286.742}{2.495 \times 10^{-3}} \times 2\pi \times 2 = 1444.21 \text{ kPa}$$

$$\eta_{th,B} = \frac{\dot{W}_B}{Q_{in}} = \frac{150.137}{\dot{m}_f \times 44200 \times 1} = \frac{150.137}{0.012642 \times 44200 \times 1} = 0.2691 = 26.91\%$$

$\dot{m}_f = 17.2$ ml/s $= 17.2 \times 10^{-3}$ L/s $= 17.2 \times 10^{-6}$ m³/s

$$\dot{m}_f = 17.2 \times 10^{-6} \frac{m^3}{s} \times 735 \frac{kg}{m^3} = 0.012642 \text{ kg/s}$$

Q2: A petrol engine of compression ratio 6 uses a fuel of calorific value 44000 kJ/kg. The fuel air ratio is 1:15 15:1. The temperature and pressure of the charge at the end of the suction stroke are 333 K and 1 bar respectively. Estimate the maximum pressure in the cylinder if the index of compression is 1.32 and the specific heat at constant volume is expressed by the relation (c_v = 0.71 + 20 x 10-5 T) kJ/kg K, where T is the temperature in K. Compare this value with that of constant specific heat c_v=0.71 kJ/kg K. (10 Points)

CR = 6
Qv = 44000
(A/F) = 15:1
T_1 = 333 K
P_1 = 1 bar
n = 1.32
C_v = 0.71 + 20 × 10^{-5} T

$Q_{cv} = \dot{m}_{fuel} = \dot{m}_{mix} \int_{T_2}^{T_3} 0.71 + 20\times10^{-5} T\, dT$

$\frac{T_2}{T_1} = CR^{n-1}$

T_2 = 590.81 K

$\frac{44000}{16}$ = 0.71 × 333 + $\frac{10^{-5}}{2}$ 333^2 ...

T_3 = 4089.25 K

$\frac{P_2}{P_1} = 6^{1.32}$

P_2 = 10.675 bar

$\frac{P_2}{T_2} = \frac{P_3}{T_3}$ ⇒ P_3 = 73.786 bar

at constant Cv

$Q_{cv} = \dot{m}_{fuel}$ = 16 × 0.71 × ($T_3 - T_2$)

T_3 = 4464.049 K

$\frac{P_2}{T_2} = \frac{P_3}{T_3}$

P_3 = 80.434 bar

Q3: Octane (C8H18) is burned with dry air. The volumetric analysis of the products on a dry basis is, N2: 83.48%, CO_2: 10.02%, O_2: 5.62 % and CO: 0.88 %. Determine the air-fuel ratio and the percentage of theoretical air used in the process. (10 Points)

A C_8H_{18} + B(O_2 + 3.76 N_2) → x CO_2 + y H_2O + z N_2

A = 1, B = 12.5, x = 8, y = 9, z = 47

$(A/F)_{theo} = \frac{\dot{m}_{air}}{\dot{m}_{fuel}} = \frac{12.5(16\times2 + 3.76\times14\times2)}{8\times12 + 18\times1} = \frac{1716}{114}$ = 15.0526

A C_8H_{18} + B(O_2 + 3.76 N_2) → 0.8348 N_2 + 0.1002 CO_2 + 0.0088 CO + 0.562 H_2O

$(A/F)_{actual}$ = 11.77

$\phi = \frac{15.526}{11.77}$ = 1.278

mass of Air ??

Examination

C - 12
H - 1

Q5: A four-stroke SI engine delivers a brake power of 442 kW with a mechanical efficiency of 85 %. The measured fuel consumption is 160 kg of fuel in one hour and air consumption is 410 kg during one sixth of an hour. The heating value of the fuel is 42000 kJ/kg. Calculate (i) indicated power, (iii) air-fuel ratio, (iv) indicated thermal efficiency and (v) brake thermal efficiency. (8 Marks)

V TDC = k

$r_c = (V_c + V_d)/V_c$ $\quad V_{BDC} = V_c + V_d$

$W_{net} = W_{gross} + W_{pump}$

$\eta_{mech} = W_b/W_i * 100\ \%$

$V_d = N\ S\ \pi\ B^2/4$ $\quad mep = W / V_d$

$U = 2 * S * N$

$P = (bmep * U * A_p) / 2\ n$

$P = (\ bmep * V_d * N\ ) / n$

$\phi = (A/F)_{ideal} / (A/F)_{actual}$

$\eta_c = Q / \dot{m}_f\ (C.V.)$

$\eta_v = \dot{m}_a / \rho\ V_d$

$A/F = m_a / m_f$

$P = 2\ \pi\ T * N$

$\frac{S}{...} \quad \pi \quad ... \left[1 ... \frac{\cos\theta}{...^{1/2}} \right]$

e) None. Answer___________.

8. For a 2-stroke diesel engine, an increasing in the flash point of the fuel will:
   a) Enhance the engine efficiency and performance.
   b) Increase the combustion peak temperature.
   c) Reduce the combustion peak temperature.
   d) Increase the combustion peak temperature.
   e) None. Answer___________.
9. The function of the primary venturi in the carburetor system is:
   a) To enhance the volumetric efficiency.
   b) To enhance the fuel control.
   c) To limit the AF ratio.
   d) All of the above.
   e) None. Answer___________.
10. The idle valve used at the end of the carburetor venturi is used:
   a) Increasing the fuel content.
   b) Decreasing the fuel content.
   c) Control the air flow rate.
   d) Control the engine performance at high load.
   e) None. Answer___________.

Q2: **(a) It`s known that the combustion products are removed from the combustion chamber in every engine cycle. Explain how? (5 Marks)**

(b) Define the knocking and the pre-ignition and misfire phenomena in IC engines. (5 Marks)

Q3: Butane (C4H10) is burned with 150% excess air. Determine the air-fuel ratio and the equivalence ratio. (4 marks)

Q4: A four cylinder, four-stroke engine of a capacity 2.495 liters has a bore of 94 mm and a compression ratio of 12:1. When tested against a dynamometer with a torque arm of 0.461 m, a load of 622 N was obtained at 5000 rpm. The fuel consumption was 17.2 ml/s. If you know that the specific gravity of the fuel is 0.735 and that its calorific value is 44200 kJ/kg, calculate the power, bmep, bsfc and the thermal efficiency of the engine at this condition (8 Marks).

d) constant
e) None.

9. Magnetic pick up coil and hall effect device are used in ignition systems in order to:

a) Amplify the output voltage of the 12V battery.
b) Increase the spark intensity to ensure the ignition.
c) Control the ignition time.
d) All of the above.
e) None.

10. compressive heating occurs within the combustion process in SI engines due to:

a) Increasing the compression ratio
b) Increasing fuel-air mixture temperature
c) Increasing the ignition delay
d) All of the above.
e) None.

11. Among ignition system types:

a) Distributorless system
b) Contact point system
c) Electronic system
d) All of the above.
e) None.

12. The speed of the flame in the combustion chamber of SI engine depends on:

a) The chamber geometry
b) The fuel-air turbulence
c) The ignition time
d) All of the above
e) None.

13. The ignition system varies the spark timing based on the engine:

a) Load
b) Speed
c) Air fuel ratio
d) All of the above
e) None.

14. During a Morse test on a 4 cylinder engine, the following measurements of brake power were taken at a constant speed.

All cylinders firing	3037 kW
Number 1 cylinder not firing	2102 kW
Number 2 cylinder not firing	2102 kW
Number 3 cylinder not firing	2100 kW
Number 4 cylinder not firing	2098 kW

The mechanical efficiency of the engine is

a) 96.53% b) 81.07% c) 84.07% d) 68.22% e) None

Q2: A pickup truck has a five-litre, V6, SI engine operating at 2400 rpm. The engine has a compression ratio of 10.2:1 and its volumetric efficiency is 0.91. The bore and the stroke are related as L=0.92B. Calculate

1. Stroke length **(1 mark)**
2. Piston bore **(1 mark)**
3. Average piston speed **(1 mark)**
4. Clearance volume of one cylinder **(1 mark)**

5. Airflow rate into the engine **(1 mark)**
6. Heat transfer area **(1 mark)**

Q3: A four-cylinder petrol engine has a bore of 57 mm and a stroke of 90 mm. Its rated speed is 2800 rev/min and it is tested at this speed against a brake which has a torque arm of 0.356 m. The net brake load is 155 N and fuel consumption is 6.74 l/h. The specific gravity of the petrol used is 0.735 and it has a lower calorific value, Q net, v, of 44 200 kJ/kg. A Morse test is carried out and the cylinders are cut out in the order 1.2.3.4. with corresponding brake loads of 111, 106.5, 104.2, and 111 N, respectively. Calculate for the speed of the following;

1. engine torque, T **(2 marks)**
2. brake power, bp **(2 marks)**
3. brake min effective pressure, b.m.e.p **(2 marks)**
4. brake thermal efficiency, **(2 marks)**
5. specific fuel consumption, s.f.c **(2 marks)**
6. mechanical efficiency **(4 marks)**

engine cycle. Explain how?
(3 Points)

Enter your answer

15

A two cylinder, four-stroke gasoline engine has
240 rpm, the torque developed was 11.86 kN.m.
speed, the brake mean effective pressure, the br
efficiency
(9 Points)

b.power=298. p.a.speed=4.68 ,mep=11.23

16

A four cylinder, four-stroke engine of a capacity 2.4
compression ratio of 12:1. When tested against a dy
a load of 622 N was obtained at 5000 rpm. The fuel

4.) $\eta_{th,B} = \frac{\dot{W}_B}{\dot{m}_f \cdot Q_{cv} \cdot \eta_c} = \frac{16.17}{0.001376 \cdot 44200 \cdot 1} = 0.26587$

$= 26.587\,\%$

$\dot{m}_f = \frac{6.74 \cdot 10^{-3}\ m^3}{hr} \cdot 735\ \frac{kg}{m^3} = 4.9539\ kg/hr$

$= 0.001376\ kg/sec$

5.) $BSFC = \frac{\dot{m}_f}{\dot{W}_B} = \frac{4.9539\ (kg/hr)}{16.17\ (kW)} = 0.3064\ kg/kW \cdot hr$

6.) $\eta_m = \frac{\dot{W}_B}{\dot{W}_I} = \frac{16.17}{19.54133} = 0.827477 = 82.7477\,\%$

لإيجاد $\dot{W}_I$

$111 \cdot 0.356 = 39.516\ N.m \rightarrow 55.18 - 39.516 = 15.664$

$106.5 \cdot 0.356 = 37.914\ N.m \rightarrow 55.18 - 37.914 = 17.266$

$104.2 \cdot 0.356 = 37.0952\ N.m \rightarrow 55.18 - 37.0952 = 18.0848$

$111 \cdot 0.356 = 39.516\ N.m \rightarrow 55.18 - 39.516 = 15.664$

متوسطهم ⟹ $T_i = 66.6788\ N.m$

$\dot{W}_I = \frac{2\pi \cdot 2800 \cdot 66.6788}{60} = 19.54133\ kW$

(1.) $\tau_B = F\,d = 155 \times 0.356 = 55.18\ N.m$

(2.) $\dot{W}_B = \frac{2\pi \times 2800}{60} \times 55.18 = 16.17\ KW$

(3.) $P_{m,\bar{B}} = \Rightarrow$ [illegible]

$16.17 = (P_{m,\bar{B}}) \times 4 \times \frac{\pi}{4} \times (0.057)^2 \times (0.09) \times \frac{2800}{60 \times 2}$

(4.) $\eta_{th,B} = \frac{\dot{W}_B}{\dot{m}_f \times Q_{cv} \times \eta_c} = \frac{16.17}{0.001376 \times 44200 \times 1} = 0.26587$

$= 26.587\ \%$

$\dot{m}_f = \frac{6.74 \times 10^{-3}\ m^3}{hr} \times 735\ \frac{kg}{m^3} = 4.9539\ Kg/hr$

$= 0.001376\ kg/sec$

Q2) Q3) Q4) Q5) Q6)

Q7) 39

Q8) 1

Q9) 5/8

Q10)

15.664

n 4-stroke CI engine the intercooler is recommended for ?

The idle valve used at the end of the carburetor venturi is used to ?

The function of automobile catalytic converter is to control emissions of

Carbon monoxide level is maximum at which conditions

Which emissions cause photochemical smog ?

The presence of nitrogen in the products of combustion ensures what ?

During the flame propagation in SI engines, the produced work from

(a) The air-fuel ratio is determined by taking the ratio of the mass of the air to the mass of the fuel (Eq. 15-3),

$$\mathrm{AF} = \frac{m_{\text{air}}}{m_{\text{fuel}}} = \frac{(16.32 \times 4.76 \text{ kmol})(29 \text{ kg/kmol})}{(8 \text{ kmol})(12 \text{ kg/kmol}) + (9 \text{ kmol})(2 \text{ kg/kmol})}$$

$$= \mathbf{19.76 \text{ kg air/kg fuel}}$$

(b) To find the percentage of theoretical air used, we need to know the theoretical amount of air, which is determined from the theoretical combustion equation of the fuel,

$$C_8H_{18} + a_{th}(O_2 + 3.76N_2) \rightarrow 8CO_2 + 9H_2O + 3.76a_{th}N_2$$

O_2: $a_{th} = 8 + 4.5 \rightarrow a_{th} = 12.5$

Then,

$$\text{Percentage of theoretical air} = \frac{m_{\text{air,act}}}{m_{\text{air,th}}} = \frac{N_{\text{air,act}}}{N_{\text{air,th}}}$$

$$= \frac{(16.32)(4.76) \text{ kmol}}{(12.50)(4.76) \text{ kmol}}$$

$$= \mathbf{131\%}$$

That is, 31 percent excess air was used during this combustion process. Notice that some carbon formed carbon monoxide even though there was ... than needed for complete combustion.

e) None. Answer___________.

8. For a 2-stroke diesel engine, an increasing in the flash point of the fuel will:
   a) Enhance the engine efficiency and performance.
   b) Increase the combustion peak temperature.
   c) Reduce the combustion peak temperature.
   d) Increase the combustion peak temperature.
   e) None. Answer___________.
9. The function of the primary venturi in the carburetor system is:
   a) To enhance the volumetric efficiency.
   b) To enhance the fuel control.
   c) To limit the AF ratio.
   d) All of the above.
   e) None. Answer___________.
10. The idle valve used at the end of the carburetor venturi is used:
    a) Increasing the fuel content.
    b) Decreasing the fuel content.
    c) Control the air flow rate.
    d) Control the engine performance at high load.
    e) None. Answer___________.

Q2: (a) It`s known that the combustion products are removed from the combustion chamber in every engine cycle. Explain how? (5 Marks)

(b) Define the knocking and the pre-ignition and misfire phenomena in IC engines. (5 Marks)

Q3: Butane (C_4H_{10}) is burned with 150% excess air. Determine the air–fuel ratio and the equivalence ratio. (4 marks)

Q4: A four cylinder, four-stroke engine of a capacity 2.495 liters has a bore of 94 mm and a compression ratio of 12:1. When tested against a dynamometer with a torque arm of 0.461 m, a load of 622 N was obtained at 5000 rpm. The fuel consumption was 17.2 ml/s. If you know that the specific gravity of the fuel is 0.735 and that its calorific value is 44200 kJ/kg, calculate the power, bmep, bsfc and the thermal efficiency of the engine at this condition (8 Marks).

1.- c
2.- a
3.- d
4.- B
5.- B
6.- a
7.- C
8.- a
9.- D
10.- c

19. A four-stroke SI engine delivers a brake power of 884 kW with a mechanical efficiency of 85 %. The measured fuel consumption is 320 kg of fuel in one hour and air consumption is 820 kg during one sixth of an hour. The heating value of the fuel is 42000 kJ/kg. Calculate (i) indicated power, (iii) air-fuel ratio, (iv) indicated thermal efficiency and (v) brake thermal efficiency.
(5 Points)

Powerind. = 1040 kw , A/f = 15.37 , thermal ind.eff. = 27.67% , break thermal eff. = 23.68%

Submit

⇒ **Specific compression work.**

$$= \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \quad 1000 \times$$

$$= \frac{100 \times 5.598 \times 10^{-4} - 22.79 \times 100 \times 60 \times 10^{-6}}{1.4 - 1}$$

$(W_c = -0.2019)_{1\ \text{cylinder}}$ (negative (−) means given to system)

$(W_c)_{4cy.} = -0.2019 \times 4 = -0.8076$ KJ/kg.

⇒ **Specific expansion work)**

$$W_{expansion} = 4\left(\frac{P_3 V_3 - P_4 V_4}{\gamma - 1}\right)$$

$$\frac{P_3}{P_4} = \left(\frac{V_4}{V_3}\right)^{\gamma} = \left(\frac{V_1}{V_2}\right)^{\gamma} = (9.33)^{1.4}$$

$P_4 = 2.305$ bar.

$$(W_e)_{total} = 4\left(\frac{\overset{(bar)}{52.545} \times 60 \times 10^{-6} - \overset{(bar)}{2.305} \times 5.598 \times 10^{-4}}{1.4 - 1}\right) \times 100$$

$= 1.8622$ KJ/kg.

⇒ **mass of air charge.** $(V_s)_{total} = 2 \times 10^{-3}\ m^3$

$V_{1\,total} = 4(V_1)_1$

$(V_1)_{total} = 4 \times 5.598 \times 10^{-4} = 2.24 \times 10^{-3}\ m^3$

$P_1 \times V_1 = (m_a)_{total} \times R \times 297$

$$(m_{ac})_{total} = \frac{2.24\times10^{-3}\times0.287\times297}{100\,kPa}$$

$$(m_{ac})_{total} = 1.909\times10^{-3}$$

4 stroke = 2 cyle.

$$(m_{ac})_{total} = \frac{1.909\times10^{-3}}{2} = 9.55\times10^{-4}\ kg/cycle.$$

for 1 cylinder percycle

$$m_{ac}/cylinder/cycle = \frac{(m_{ac})_{total}/cycle}{4} = 2.3067\times10^{-4}\ kg/cyl.$$

$$\left[P_{mep} = \frac{1}{V_s}(\text{Net work output under cycle})\right]$$

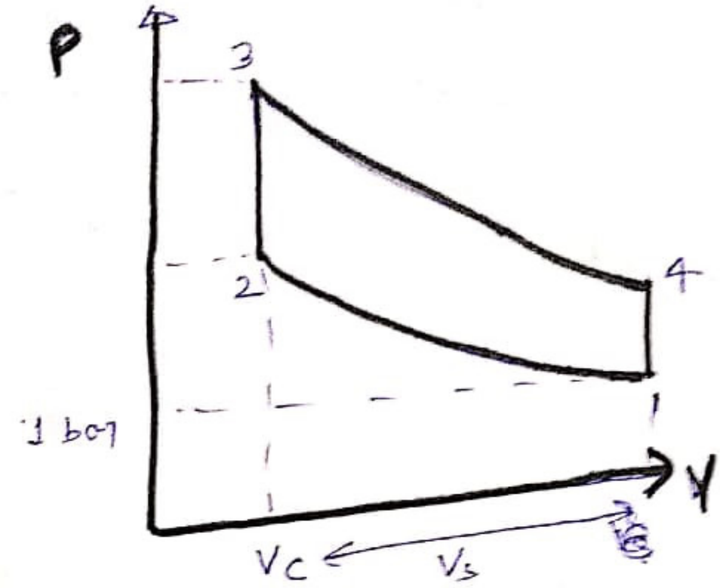
$$= \frac{1}{V_s}(1.8622 - 0.0076)$$

$$= \frac{1}{2\times10^{-3}}(1.0622 - 0.00762)$$

$$P_{mep} = 527.3\ kPa = 5.27\ bar$$

what ?

During the flame propagation in SI engines, the produced work from combustion will be ?



$(V_s)_{total} = 2 \times 10^{-3}\ m^3$

$(V_s)_1 = \frac{(V_s)_{total}}{4}$

$(V_s)_1 = \frac{2 \times 10^{-3}}{4}$

$(V_c)_1 = 60 \times 10^{-6}\ m^3$

$r = 1 + c$

$= 1 + \frac{(V_s)_1}{V_c}$

$= 1 + \frac{2 \times 10^{-3}}{4 \times 60 \times 10^{-6}}$

$= 1 + 8.33$

$\boxed{r = 9.33}$

$(V_1 = V_c + (V_s))_1 = 5.598 \times 10^{-4}\ m^3$

from process 1-2 →

$\left(\frac{V_1}{V_2}\right)^{\gamma - 1} = \frac{T_2}{T_1}$

$T_2 = T_1 (r)^{\gamma - 1}$

$[T_2 = 725.62\ K]$ taking $(\gamma = 1.4)$

$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = (9.33)^{1.4} \Rightarrow$

$P_2 = 100\ kPa \times 9.33^{1.4} = 2279.47$

$= 22.79$ bar.

$P_2 = 22.79$ bar

from 2-3 process →

$\frac{T_3}{T_2} = \frac{P_3}{P_2} \Rightarrow P_3 = \frac{P_2 \times (1400 + 273)}{725.62}$

$P_3 = 52.545$ bar.

Engine Cycles

Note: For problems 1-3, assume at all conditions that:

- $c_p = 1.000$ kJ/kg.K
- $c_v = 0.714$ kJ/kg.K

1- A 2.0 litre, 4-cylinder, gasoline engine has a clearance volume (per cylinder) of 60 cm^3. If the induction conditions are 1 bar and 24°C, and the peak temperature in the cylinder is 1400°C, calculate the following on the basis of the air standard Otto cycle:

- Indicated thermal efficiency
- Peak pressure in the cylinder
- Specific compression and expansion work
- Mass of the air charge/cycle
- Indicated mep.

2- An engine is assumed to be operating on the air standard Diesel cycle with an A/F ratio equal to 22. If it has a compression ratio of 15:1 and the intake conditions are 1.05 bar and 35°C, calculate the cut-off ratio and the thermal efficiency of the engine. (Assume that the calorific value of the fuel is equal to 42000 kJ/kg)

3- A gas engine with a compression ratio of 18:1 takes in air at 1.01 bar and 20°C. Knowing that the maximum pressure in the engine is 69 bar, and assuming that the engine operates on a dual cycle, calculate the thermal efficiency of the engine. Assume that heat added at constant volume is equal to heat added at constant pressure.

A four-stroke SI engine delivers a brake power of 442 kW with a mechanical efficiency of 85 %. The measured fuel consumption is 160 kg of fuel in one hour and air consumption is 410 kg during one sixth of an hour. The heating value of the fuel is 42000 kJ/kg. Calculate (i) indicated power, (ii) frictional power, (iii) air-fuel ratio, (iv) indicated thermal efficiency and (v) brake thermal efficiency.

Answer:

* A four - stroke 85 engine delivers a brake power with a mechanical efficiency.

$B.P = 442\ KW$

$\eta_{mech} = 0.85$

$\dot{m} = 160\ Kg/h$

$= \frac{160}{3600 sec}$

$= 0.0444\ Kg/sec$

Air consumption $= \frac{410\ kg}{\frac{1}{6}\ hr}$

$= \frac{6 \times 410}{3600} \frac{kg}{sec}$

$= \frac{2460}{3600}$

$= 0.6833\ Kg/sec$

$CV = 42000\ KJ/Kg$

(Q3) Butane (C_4H_{10}), 150% excess air — (A/F, ϕ)

(Sol:)

$$\% \text{ excess air} = \left(\frac{1}{\phi} - 1\right) \times 100\%$$

$$150\% = \left(\frac{1}{\phi} - 1\right) \times 100\%$$

$$1.5 = \frac{1}{\phi} - 1 \rightarrow \frac{1}{\phi} = 2.5 \rightarrow \phi = \frac{1}{2.5}$$

$$\phi \left(\begin{matrix}\text{Equivalence} \\ \text{ratio}\end{matrix}\right) = \frac{1}{2.5} = 0.4$$

$$C_4H_{10} + a_{th}(O_2 + 3.76N_2) \rightarrow A\,CO_2 + B\,H_2O + 3.76\,a_{th}\,N_2$$

$A \rightarrow 4$

$B \rightarrow 5$

a_{th}: $2a_{th} = 2 \times 4 + 5 \rightarrow a_{th} = 6.5$

→ Stoichemtric

$$C_4H_{10} + 6.5(O_2 + 3.76N_2) \rightarrow 4CO_2 + 5H_2O + 24.44\,N_2$$

$$(A/F)_s = \frac{6.5(32 + 3.76 \times 28)}{4 \times 12 + 10} = 15.385$$

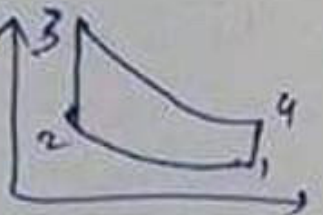
$$\phi = \frac{(A/F)_s}{(A/F)_a} \rightarrow (A/F)_a = \frac{15.385}{0.4} = 38.4625$$

d) Increase the pressure drop for the incoming air.
e) None. Answer______________.

18. The function of the secondary venturi in the carburetor system is:
a) To enhance the volumetric efficiency.
b) To enhance the fuel control.
c) To limit the AF ratio.
d) All of the above.
e) None. Answer______________.

19. At idle conditions the flow rate through the carburetor venturi is:
a) Increasing.
b) Decreasing.
c) Depending on the fuel flow rate.
d) Depending of the engine speed.
e) None. Answer______________.

20. In 4-stroke SI engine the intercooler is not recommended since it:
a) Increases the ignition delay significantly.
b) Decrease the ignition delay significantly.
c) Increase the mean adiabatic flame temperature.
d) Decreases the mean adiabatic flame temperature.
e) None. Answer______________.



Q2: A petrol engine of compression ratio 6 uses a fuel of calorific value 44000 kJ/kg. The fuel air ratio is 1:15 15:1. The temperature and pressure of the charge at the end of the suction stroke are 333 K and 1 bar respectively. Estimate the maximum pressure in the cylinder if the index of compression is 1.32 and the specific heat at constant volume is expressed by the relation (c_v = 0.71 + 20 x 10-5 T) kJ/kg K, where T is the temperature in K. Compare this value with that of constant specific heat c_v=0.71 kJ/kg K. (10 Points)

CR = 6
Q_v = 44000
(A/F) = 15:1
T_1 = 333 K
P_1 = 1 bar
n = 1.32
C_v = 0.71 + 20 × 10^{-5} T

$Q_{cv} = \dot m Q_{cal} = \dot m_{mix} \int_{T_2}^{T_3} 0.71 + 20\times10^{-5}T\,dT$

$\frac{T_2}{T_1} = CR^{n-1}$

T_2 = 590.81 K

$\frac{44000}{16} = 0.71 \times 333 + \frac{10^{-5}}{2} 333^2$ ... $0.71x + \frac{10^{-5}}{2}x^2$

T_3 = 4087.25 K

$\frac{P_2}{P_1} = 6^{1.32}$

P_2 = 10.645 bar

$\frac{P_2}{T_2} = \frac{P_3}{T_3}$

P_3 = 73.6786 bar

at constant Cv:

$\dot Q = \dot m Q_{cal} = 16 \times 0.71 \times (T_3 - T_2)$

T_3 = 4464.049 K

$\frac{P_2}{T_2} = \frac{P_3}{T_3}$

P_3 = 80.474 bar

Q3: Octane (C8H18) is burned with dry air. The volumetric analysis of the products on a dry basis is, N2: 83.48%, CO_2: 10.02%, O_2: 5.62 % and CO: 0.88 %. Determine the air-fuel ratio and the percentage of theoretical air used in the process. (10 Points)

$A\, C_8H_{18} + B(O_2 + 3.76N_2) \rightarrow x\,CO_2 + y\,H_2O + z\,N_2$

A = 1, B = 12.5, x = 8, y = 9, z = 47

$(A/F)_{theo} = \frac{\dot m_{air}}{\dot m_{fuel}} = \frac{12.5(16\times2 + 3.76\times14\times2)}{8\times12 + 18\times1} = \frac{1716}{114} = 15.0526$

actual: $A\,C_8H_{18} + B(O_2 + 3.76N_2) \rightarrow 0.8348\,N_2 + 0.1002\,CO_2 + 0.0088\,CO + 0.562\,O_2$

2.481, 0.208, 0.031, 0.312

$(A/F)_{actual}$ = 11.77

$\phi = \frac{15.0526}{11.77} = 1.278$

mass of Air ??

16

A four cylinder, four-stroke engine of a capacity 2.495 liters has a bore of 94 mm and a compression ratio of 12:1. When tested against a dynamometer with a torque arm of 0.461 m, a load of 622 N was obtained at 5000 rpm. The fuel consumption was 17.2 ml/s. If you know that the specific gravity of the fuel is 0.735 and that its calorific value is 44200 kJ/kg, calculate the power, bmep, bsfc and the thermal efficiency of the engine at this condition.

(8 Points)

Pb = 150.137 KW , BMEP = 361.05 Kpa , BSFC = 0.303 KJ/ KWH , Eff = 26.86%

Submit

$$= \frac{0.6833}{0.0444}$$

$$= 15.3896$$

Air-fuel ratio = 15.3896

(iv) Calculate the indicated thermal efficiency:

$$\eta_{I.T} = \frac{I.P}{m_f \times CV}$$

$$= \frac{520}{(0.0444 \times 42000)}$$

$$= \frac{520}{1864.8}$$

$$= 0.2788$$

$$\eta_{I.T} = 27.89\ \%$$

Thermal efficiency ($\eta_{I.T}$) = 27.89 %

(v) Brake thermal efficiency:

$$\frac{BP}{m_f \times CV} = \frac{442}{(0.0444)(42000)}$$

$$= \frac{442}{1864.8}$$

$$= 0.2370$$

Brake thermal efficiency($\eta_{B.T}$) = 23.7 %

Q1: **Choose the correct answer from the following (30 Points):**

1. In comparison to the ideal cycle, the actual cycle of 2-stroke SI engine has:
   a) A delay in closing the intake valves in order to increase the thermal efficiency.
   b) A constant heat addition since the cycle is similar to Otto cycle.
   c) Lodger power stroke in order to get more energy.
   d) All of the above.
   e) None. Answer__________.
2. The actual compression stroke in 4-stroke gasoline engine starts:
   a) Immediately after the fuel and air get mixed in the combustion chamber.
   b) Near the BDC while the exhaust vale is open to ensure that EGR gases are getting out.
   c) Typically, the compression stroke in gasoline engines starts after the BDC where all valves should b closed.
   d) In the case of the SI engines, the compression stroke is variable since the spark will control the combustion process.
   e) None. Answer__________.
3. In the actual 2-Stroke SI engine, the combustion is initiated before the TDC in order to:
   a) Increase the engine thermal efficiency.
   b) Reduce the unburnt fuel content.
   c) Ensure the optimum power stroke.
   d) All of the above.
   e) None. Answer__________.
4. Valves overlap is introduced in the actual engine cycles, this overlap:
   a) Is done by delaying the opening of the intake valves until all of the EGR gases escaped.
   b) Has some advantages to the overall performance although; it can reduce the system efficiency.
   c) Control the combustion process by affecting the air fuel content within the combustion chamber.
   d) All of the above.
   e) None. Answer__________.
5. Methane, Ethane and propane are examples of:
   a) Alkenes
   b) Dienes
   c) Cyclo-Alkanes
   d) Aromatic compounds
   e) None. Answer__________.
6. Using the HHV of the fuel indicates that the H2O form in the combustion products is:
   a) In the vapor form.
   b) In the liquid form.
   c) H2O is not related to the HHV since the process is affected by the temperature.
   d) H2O in the actual cycle will react with other compounds like NO, so no pure H2O is found.
   e) None. Answer__________.
7. The adiabatic flame temperature for any fuel-air mixture is:
   a) The temperature at which the fuel-air mixture will ignite.
   b) The temperature at which the fuel-air mixture is mixed.
   c) The temperature at which the fuel-air mixture will have at the end of the compression stroke.
   d) This temperature is just calculated for engines that have an adiabatic process.
   e) None. Answer__________.
8. Gasoline is usually compared to Iso-Octane since:
   a) Both fuels are considered as hydrocarbon fuels.
   b) Iso-Octane is originally a Gasoline with high ON.
   c) Gasoline could contain Iso-Octane with high percentages.
   d) All of the above.
   e) None. Answer__________.

9. The volatility of any fuel depends basically on:
a) The MW of the fuel.
b) The temperature of the fuel.
c) The nature of the compounds in the fuel.
d) All of the above.
e) None. Answer________.

10. High end volatility is required for the fuel:
a) To ensure good cold staring and acceleration characteristics.
b) Decrease the self-ignition temperature of the fuel.
c) Maximize the volumetric efficiency.
d) All of the above.
e) None. Answer________.

11. Self-ignition temperature for any fuel can be defined as:
a) The temperature at which the fuel-air mixture will ignite without any external cause.
b) The temperature at which fuel-air mixture will reach at the end of the ignition delay time.
c) The temperature at which the fuel-air mixture will have the knocking phenomenon.
d) All of the above.
e) None. Answer________.

12. Knocking can be avoided for Gasoline fueled engines by:
a) Limiting the compression ratio.
b) Increasing the flame speed within the combustion chamber.
c) Fuel property control.
d) All of the above.
e) None. Answer________.

13. Increasing the Cetane number can affect the combustion process by:
a) Increasing the combustion peak temperature.
b) Decreasing the combustion peak temperature.
c) Increasing the ignition delay time.
d) Decreasing the ignition delay.
e) None. Answer________.

14. For a 2-stroke diesel engine, an increasing in the flash point of the fuel will:
a) Enhance the engine efficiency and performance.
b) Reduce the combustion peak temperature.
c) Increase the combustion peak temperature.
d) Increase the combustion peak temperature.
e) None. Answer________.

15. Engines with constant intake valve timing affected mostly by:
a) The engine speed.
b) The engine load.
c) The engine size.
d) All of the above.
e) None. Answer________.

16. The main difference between the internal and the external multi-point injection systems is:
a) That internal injection systems have more injectors above the cylinder.
b) That internal injection systems mix the fuel and air in longer time.
c) That internal injection systems works with lower injection pressures.
d) All of the above.
e) None. Answer________.

17. The venturi tube in the carburetor system is important since it:
a) Decrease the flow rate of the intake air through the throttle.
b) Decrease the pressure differential so less losses are accounted.
c) Decrease the air velocity and hence the air density.

d

d) Increase the pressure drop for the incoming air.

e) None. Answer___________.

18. The function of the secondary venturi in the carburetor system is:

a) To enhance the volumetric efficiency.

b) To enhance the fuel control.

c) To limit the AF ratio.

d) All of the above.

e) None. Answer___________.

19. At idle conditions the flow rate through the carburetor venturi is:

a) Increasing.

b) Decreasing.

c) Depending on the fuel flow rate.

d) Depending of the engine speed.

e) None. Answer___________.

20. In 4-stroke SI engine the intercooler is not recommended since it:

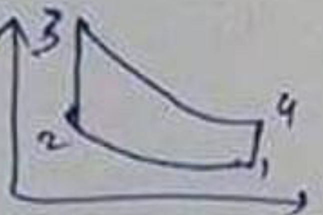
a) Increases the ignition delay significantly.

b) Decrease the ignition delay significantly.

c) Increase the mean adiabatic flame temperature.

d) Decreases the mean adiabatic flame temperature.

e) None. Answer___________.



Q2: A petrol engine of compression ratio 6 uses a fuel of calorific value 44000 kJ/kg. The fuel air ratio is 1:15 15:1. The temperature and pressure of the charge at the end of the suction stroke are 333 K and 1 bar respectively. Estimate the maximum pressure in the cylinder if the index of compression is 1.32 and the specific heat at constant volume is expressed by the relation (c_v = 0.71 + 20 x 10-5 T) kJ/kg K, where T is the temperature in K. Compare this value with that of constant specific heat c_v=0.71 kJ/kg K. (10 Points)

CR = 6
Qv = 44000
(A/F) = 15:1
T1 = 333 K
P1 = 1 bar
n = 1.32
Cv = 0.71 + 20 × 10^-5 T

$T_2/T_1 = CR^{n-1}$
T2 = 590.81 K
T3 = 4087.25 K
P2/P1 = 6^1.32
P2 = 10.645 bar
P3 = 73.6786 bar

At constant Cv: Qv · m_fuel = 16 × 0.71 × (T3 − T2)
T3 = 4464.049 K
P2/T2 = P3/T3
P3 = 80.434 bar

Q3: Octane (C8H18) is burned with dry air. The volumetric analysis of the products on a dry basis is, N2: 83.48%, CO_2: 10.02%, O_2: 5.62 % and CO: 0.88 %. Determine the air-fuel ratio and the percentage of theoretical air used in the process. (10 Points)

A C8H18 + B(O2 + 3.76 N2) → x CO2 + y H2O + z N2
A = 1, B = 12.5

(A/F)theo = m_air / m_fuel = 12.5(16×2 + 3.76×14×2) / (8×12 + 18×1) = 1716 / 114 = 15.0526

Actual: A C8H18 + B(O2 + 3.76 N2) → 0.8348 N2 + 0.1002 CO2 + 0.0088 CO + 0.562 H2O ...

(A/F)actual = 11.77

Φ = 15.0526 / 11.77 = 1.278

mass of Air = ?

(i) Indicated power:

$$\eta_{mech} = \frac{B.P}{I.P.}$$

$$0.85 = \frac{442}{IP}$$

$$I_P = \frac{442}{0.85}$$

$$I_P = 520 \text{ KW}$$

Indicated power (I_P) = 520 KW

(ii) frictional power calculation:

frictional power = IP − B.P

= 520 − 442

= 78 KW

The frictional power = 78 KW

(iii) Air-fuel ratio calculation:

$$\text{Air-fuel ratio} = \frac{\dot{m}_{air}}{\dot{m}_{fuel}}$$

UNIVERSITY of JORDAN
FACULTY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING
Internal Combustion Engines (0954585)
First Semester Mid-Term Exam (2009/2010)

Date: Wednesday 9th December, 2009
Dr. Jehad A. A. Yamin **Time:** 90 minutes.

ANSWER ALL QUESTIONS (Q1 & Q2 = 30 minutes, Q3 = 60 minutes)

Q1: Chose the most correct answer(s). **(6 Marks)**

1. As the cut-off ratio of diesel engine increases, its thermal efficiency :
(a) Increases. (b) Decreases.
(c) Increases then decreases. (d) Does not change.
(e) Non of the above.

2. Pumping work is that produced :
(a) By the engine. (b) During the expansion stroke.
(c) During the exhaust stroke. (d) On the piston.
(e) Non of the above.

3. In 4-stroke engines, the engine completes one cycle in ……. Rotations of the crank shaft :
(a) Three. (b) Four. (c) Two. (d) One. (e) Non of the above.

4. In 4-stroke CI engine, during the suction stroke :
(a) Air and Fuel is admitted. (b) Only fuel is admitted.
(c) Only Air is admitted. (d) Air, Fuel and oil is admitted.
(e) Non of the above.

5. The volumetric efficiency of 2-Stroke engines are ………… That of 4-Stroke engines:
(a) Greater than. (b) Lesser than.
(c) Same as. (d) Double.
(e) Non of the above.

6. Replacing lean mixture with stoichiometric one, the spark timing has to be :
(a) Advanced. (b) Retarded.
(c) Unchanged. (d) Decreased by 10 Degrees.
(e) Non of the above.

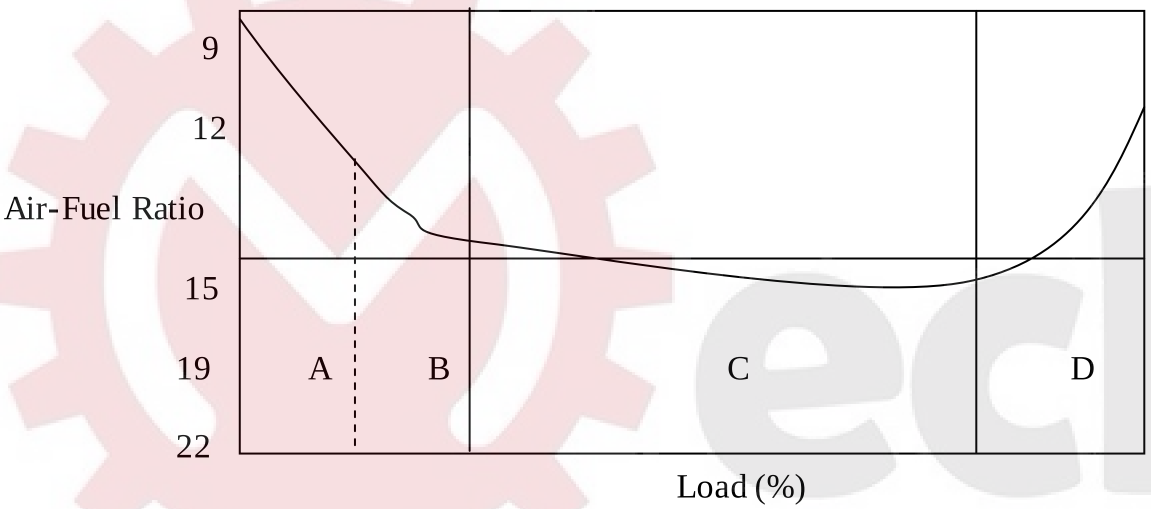
7. Two stroke engines :
(a) Produce double the power of 4-Stroke. (b) Have stroke length lesser than 4-Stroke.
(c) Widely used as the consume lesser fuel. (d) Burns the fuel better than 4-Stroke.
(e) Non of the above.

8. In the starting of an SI engine, ………. Mixture is used :
(a) Rich . (b) Lean . (c) Stoichiometric. (d) 10% rich.
(e) Non of the above.

9. The device used to enrich the fuel in the carburettor when starting at cold weather is called :
(a) Carburetor.
(b) Emulsion tube.
(c) Throttle valve.
(d) Enrichment pump.
(e) Non of the above.

10. ………….... is the parameter that indicates how effectively the engine is converting the converting the chemical energy of the fuel into useful work :
(a) Volumetric Efficiency.
(b) Relative Efficiency.
(c) Mechanical Efficiency.
(d) Thermal Efficiency.
(e) Non of the above.

11. The curve below shows ………………………………………



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

12. The stoichiometric Air-Fuel Ratio for gasoline (C8H18) is about :
(a) 5. (b) 10. (c) 12. (d) 15. (e) Non of the above.

Q2: State whether true or false and correct the false statement. **(4 Marks)**

1. Ram effect is the effect of fresh charge as well as the exhaust gas momentum.
2. Pumping losses are those losses occurred during the discharge of exhaust gases.
3. Two stroke engines actually develop 30% more power than four strokes.
4. The thermal efficiency of Diesel cycle increases with increasing the cut-off ratio.
5. Cut-off ratio is the ratio between volumes, which tells how much fuel is added.
6. Equivalence Ratio is the ratio of stoichiometric fuel-air ratio to the actual fuel-air ratio.
7. Volumetric efficiency is a measure of the performance of exhaust system.
8. If the air quantity supplied to the engine is higher than the Stoichiometric one, then the mixture is called lean one.

Q3: A 4-Stroke 4-Cylinder S.I. engine develops 50 kW at 2000 rpm with CR = 9 at sea level where it was calibrated. A Morse test was carried out on the engine and the following data was collected: brake torque with each cylinder cut-off is $\tau_1 = 164$, $\tau_2 = 162$, $\tau_3 = 160$ and $\tau_4 = 163$ N-m, A/F ratio = 13.5:1, brake thermal efficiency = 25%, stroke-to-bore ratio = 0.85, volumetric efficiency = 80% and fuel calorific value = 43000 kJ/Kg, atmospheric conditions are 101.325 kPa and 25 ^oC.

List FOUR main factors that affects the operation of a carburettor then calculate:

(20 Marks)

1. Mass flow rate of air and fuel.
2. Power (Indicated and Friction).
3. Mean Effective Pressure (Brake and Indicated)
4. Specific Fuel Consumption (Indicated and Brake).
5. Specific Air Consumption (Brake and Indicated).
6. Indicated Thermal Efficiency, Mechanical Efficiency & Relative Efficiency,
7. Output per Displacement and Specific power (kW/m^2).
8. Carburetor throat and jet diameters for Cda =0.75, Cdf = 0.575, fuel specific gravity = 0.745 and pressure depression at the throat = 140 mm of water and that at jet tip = 80% of that at the throat.
9. If this carburetor is used at an altitude of 5000m above calibrated conditions given in the question above. How much will be the change in the A/F ratio delivered by the engine and its enrichment percentage.
10. Make an energy balance for this engine if during this test the following temperatures were recorded : jacket water temperature rise 26 ^oC, jacket water flow rate = 65 kg/min. The exhaust was fitted with air-type heat exchanger and gave the follwing data : air outlet temperature 55 ^oC, air inlet temperature = 25 ^oC, cooling air flow rate = 15 kg/min.

~~~~~~

WISH YOU THE BEST
~~~~~~

→ from exhustgasses so the density will decrease and volumatric efficiency will be reduced.

8

Q1: Give short answers to the following. **(10 Marks)**

- State TWO factors affecting the volumetric efficiency and state how.

Factor (1) : The density of the fresh charge based on the tempretur.

Effect : If the tempretur of the fresh charge increased by the heat transfer into it

Factor (2) : The resdual exhust gasses on the clearance volume

Effect : The exhaust gases will reduce the availble space for the fresh charge so the flow of air will be reduced so the volumatric efficincy will reduce

- State TWO factors affecting the operation of Carburettors and state how.

Factor (1) : The atmosphric conditions (one of the biggest limitations of carborator)

Effect : affect the density of the air and affect the need of Heater.

Factor (2) : The speed of the engine

Effect : affect the speed of the air

- State TWO problems that caused carburetors to be eliminated :

1. The huge effect of the atmospheric conditions
2. The problem of freezing ~~and~~ Icing

- Give TWO disadvantages of using Hydrogen as fuel for SI engines

1. The problem of storage
2. The problem of handling

- Give TWO additives to gasoline and their effect.

Additive (1) : Antioxidants

Effect : The antioxidants are chemicals added to gasoline to prevent form a gum content.

Additive (2) : lubricants

Effect : The lubricants added for the lubrication of injector

- Crankcase dilution occurs if the SI fuel is ...low........... volatile while vapor lock is caused by fuel that has .high....... volatility.

- Dissociation has the greatest effect during Combustion....... process.

- For the case of easiness in cold starting, the volatility temperature should be ....High....

- To avoid the vapor lock in Spark Ignition engines, fuel volatility must be ......low.....

- If the carburetor is used at altitudes HIGHER than that at which it was calibrated, it will give ..rich.. mixture.

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h > hmc

Patm < Pay

Zatm < Zc

Q2 (ABET Question): Answer the following. **(20 Marks)**

2-1) A flexible-fuel four-cylinder SI engine running on a mixture of methanol and gasoline at an equivalence ratio of 0.90. The mixture consists of 10% methanol and 90% gasoline by mass. (10 Marks)

A) Write the stoichiometric equation for this mixture. Find it's A/F ratio.
B) Write the actual equation and find its actual A/F ratio.
C) The ON of this mixture.
D) The AKI and FS. Comment on FS value what it means.
E) What happens to part (C) if we add 0.4ml of lead to the mixture.
F) What are the advantages of adding methanol to Gasoline? State two

10

$n = \frac{m}{M}$, $y = \frac{n}{n_{mix}}$

	mf_i	M	m (kg)	n	y_i
gasoline (C_8H_{15})	0.9	111	9	0.081081	0.7218
methanol (CH_3OH)	0.1	32	1	0.03125	0.278196
Σ	1		10 kg (assumed)	0.112331	1

A) stoichimetric equation:

$0.7218\ C_8H_{15} + 0.278196\ CH_3OH + B_{th}(O_2 + 3.76 N_2) \rightarrow x_1 CO_2 + x_2 H_2O + x_3 N_2$

C: $0.7218(8)(12) + 0.278196(1)(12) = x_1(1)(12) \rightarrow x_1 = 6.0526$

H: $(0.7218)(15)(1) + 0.278196(4)(1) = x_2(2)(1) \rightarrow x_2 = 5.969842$

O: $(0.278196)(1)(16) + B_{th}(32) = x_1(32) + x_2(16) \rightarrow B_{th} = 8.8985$

N_2: $x_3 = 33.4582$

stoichimetric equation:

$0.7218\ C_8H_{15} + 0.278196\ CH_3OH + 8.8985(O_2 + 3.76 N_2) \rightarrow 6.0526\ CO_2 + 5.969842\ H_2O + 33.4582\ N_2$

$(A/F)_s$ (Air-fuel ratio stio): $\frac{8.8985(32 + 3.76 \times 28)}{0.7218(111) + 0.278196(32)} = 13.7272$

B) Actual equation: lean mix $\phi = 0.9$

$0.7218\ C_8H_{15} + 0.278196\ CH_3OH + \frac{8.8985}{0.9}(O_2 + 3.76 N_2) \rightarrow x_1 CO_2 + x_2 H_2O + x_3 N_2 + x_4 O_2$

$\frac{8.8985}{0.9} = 9.88723$

$x_1 = 6.0526$
$x_2 = 5.969842$
$x_3 =$
$x_4 = 0.989182$
$x_3 = 37.170$

Actual equation:

$0.7218\ C_8H_{15} + 0.278196\ CH_3OH + 9.88723(O_2 + 3.76 N_2) \rightarrow 6.0526\ CO_2 + 5.96982\ H_2O + 37.176\ N_2 + 0.989182\ O_2$

Actual Air-fuel ratio $(A/F)_a = \frac{9.88723(32 + 3.76(28))}{0.7218(111) + 0.278196(32)}$

$(A/F)_a = 15.247$

تكملة الحل →

Q-2) A 4-stroke gasoline engine has engine displacement of 1600 c.c. The volumetric efficiency is 75% and the air/fuel ratio is 13:1 at 3500 RPM. At this speed the theoretical air speed at throat is 100 m/s. The coefficient of discharge for the throat is 0.85 and that of the main petrol is 0.65. An allowance should be made for the emulsion tube, the diameter of which can be taken as (1/3) of the throat diameter. The petrol surface is 6mm below the throat at this engine condition. Take the specific gravity of fuel as 0.75. The atmospheric conditions as 1.013 bar and 20 °C, R_{air} = 0.287 kJ/kg-K. Take compressibility effect into calculations. (10 Marks)

Calculate:

1) The pressure drop at the throat.
2) The fuel velocity and air velocities.
3) Design suitable throat, fuel jet and emulsion tube dimensions.
4) The A/F ratio supplied by this carburetor ate 5000m above sea level. Take calibrated A/F = 13.
5) The amount of fuel enrichment/enleanment at this height. Comment on your results.

6 + 4/22

$n_r = 2$, $V = 1600\ cm^3$, $\eta_{vol} = 0.75$, $\frac{A}{F} = 13$, $N = 3500$ RPM, U_{th2} (a) = 100 m/s

$C_D = 0.85$, $C_f = 0.65$, $D_e = \frac{1}{3} D_{th}$, $Z_f = 6$ mm, $\rho_f = 750$ kg/m³

Exact analysis

$\eta_{vol} = \dfrac{\dot m_{act}}{\rho_{air} (V_s\, n_c) \left(\frac{N}{60}\right)\frac{1}{n_r}}$ ⇒ $\dot m_{act}$ (air) = 0.0404 kg/s

$\rho_{a1} = \dfrac{101.3}{0.287(293)}$, $\rho_{a(1)} = 1.20465$ kg/m³

$\dfrac{\dot m_a}{\dot m_f} = 13$ → $\dot m_f$ (act) = 3.1072×10^{-3} kg/s

$U_{a\,th(th)} = \sqrt{2 C_{pa} T_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right]}$ (100; 1005; 293; 1.013) ⇒ $P_2 = 0.954$ bar

$P_2 = 95406.456$ Pa

1) pressure drop at the throat (ΔP_{1-2}) = 5893.543 Pa

2) fuel velocity theoritical ($U_{f(th)}$) = $\sqrt{\frac{2}{\rho_f}[P_1 - P_2 - Z_f g \rho_f]}$

$\rho_{(a)2} = \rho_{a(1)} \left(\frac{0.954}{1.013}\right)^{1/k}$

$\rho_{(a)2} = 1.1541$ kg/m³

$U_{f(th)2} = 3.95$ m/s

$U_{f(actual)2} = 2.567$ m/s — Actual velocity of fuel

$U_1 \cong 0$ for fuel

velocity of Air (theritical) $U_{th\,air_2} = 100$ m/s

actual velocity of Air $(U_{act})_2 = 85$ m/s

$U_1 \cong 0$ for Air

3) $\dot m_{a(act)} = C_D \frac{\pi}{4}\left(D_{th}^2 - \frac{D_{th}^2}{9}\right) \rho_{a2} \left(\frac{P_2}{P_1}\right)^{1/k} U_{th}$ (0.0404; 0.85; 1.1541; 100)

→ Throat diameter (D_{th}) = 0.024864 m

Area of throat = 4.2986×10^{-4} m²

→ emulsion tube diameter (D_e) = 8.27136×10^{-3} m

خلف الصفحة →