1) a) Explain the following:

1) Morse test: This test is only applicable to multi-cylinder engine. The engine is run at required speed and the torque is measured. One cylinder is cut out by shorting the plug if an S.I engine is under test. The speed decreases because of the loss of power with one cylinder cut out, but speed is restored by reducing the load. The torque is measured again when the speed has reached its original value. If the values of IP of the cylinder are denoted by IP_1, IP_2, IP_3 & IP_4 And friction power in each cylinder is denoted by (FP_1, FP_2, FP_3 & FP_4). The value of BP at the test speed with all cylinders firing is given by:

$$BP = (IP_1 - FP_1) + (IP_2 - FP_2) + (IP_3 - FP_3) + (IP_4 - FP_4) \quad \text{—①}$$

If no. 1 cylinder is cut out then the contribution of IP_1 is lost. And if the losses due to that cylinder remains the same as when it is firing. Then the BP_1 obtained at the same speed by putting $IP_1 = 0$ in eqn ①

$$BP_1 = (0 - FP_1) + (IP_2 - FP_2) + (IP_3 - FP_3) + (IP_4 - FP_4) \quad \text{—②}$$

subtracting ② from ① we get

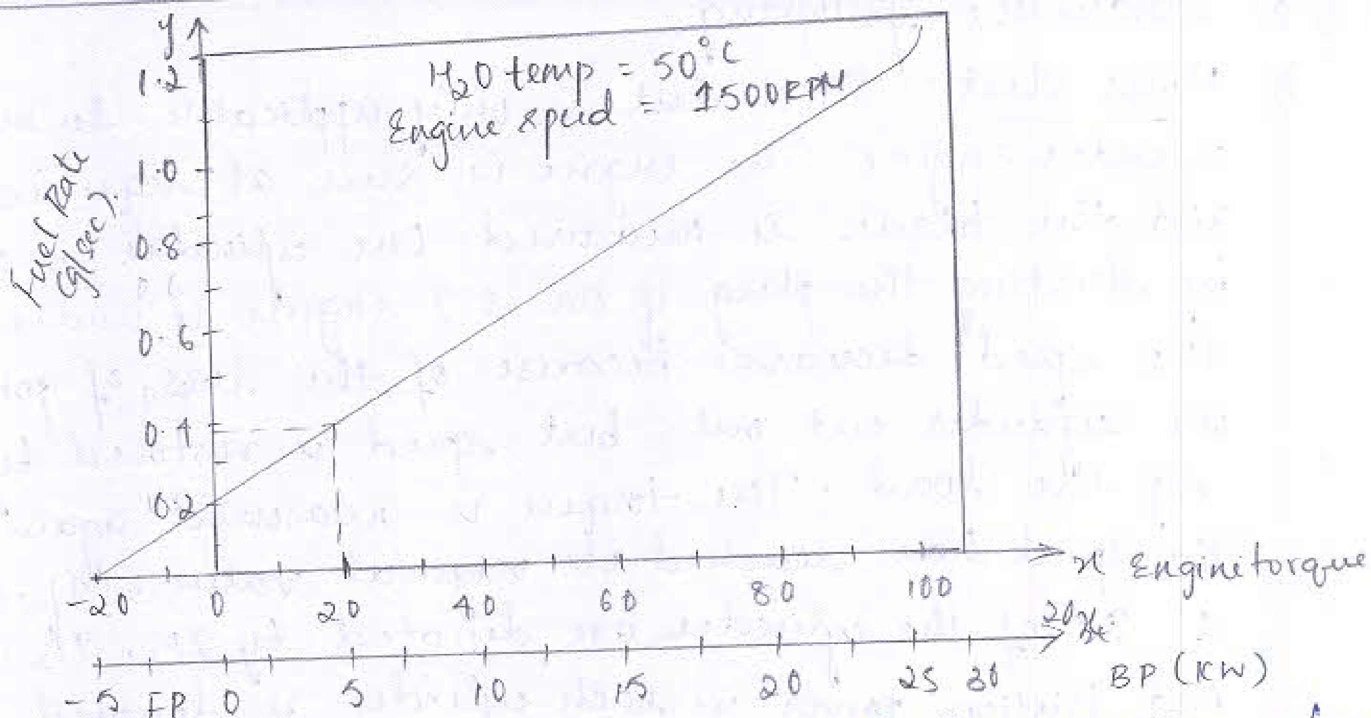
$$BP - BP_1 = IP_1$$

Similarly: $IP_2 = BP - BP_2$, $IP_3 = BP - BP_3$, $IP_4 = BP - BP_4$.

For 'n' no. of cylinder $(FP)_n = (IP)_n - (BP)_n$.

2) Willian's line method: This method is also known as Fuel rate extra-polation

The graph connecting fuel consumption (y-axis) and BP (x-axis) at const speed. Is drawn and



extraplotted on the negative axis of the B.P. The intersect of the negative axis is taken as the friction power of the engine at that speed. The williams line method is shown in the above figure. In the above fig the fuel consumption & brake power is linear. Further when the engine does not develop any power (BP = 0). It consumes a certain amount of fuel. The energy would have been spent to overcome the friction. Hence the extraplotted -'ve intersect of the x-axis will be the work representation, the combined losses due to mechanical friction, pump work, head loss through / due to cooling water & heat lost by exhaust gases & as whole it is termed as the frictional loss of the engine. It should be noted that the measured frictional power by this method will hold good only for a particular speed & is applicable to CI engine.

3) Heat balance sheet:

The performance of the engine is generally given by heat balance sheet. To draw the heat balance sheet for IC engine

1) Engine should run at constant load & speed.
2) The quantity of fuel used in a given time and its C.V noted.
3) The inlet & outlet temps of cooling water are recorded.
4) Mass of exhaust gas at its initial & final temps are recorded from the engine.
5) After calculating IP, BP the heat in diff items is found as follows:

① Total heat supplied by fuel: for petrol & oil engines

heat supplied = $m_f \times C.V$.

For gas engines, $H.S = V_g \times C.V_g$

$\left\{ H.S = m_f \times C.V = \frac{kg}{min} \times \frac{KJ}{kg} = \frac{KJ}{min} \right\}$

② Heat equivalent to IP.

$H.E \Rightarrow IP = IP \times 60$

$BP = BP \times 60$.

$FP = FP \times 60$.

③ Heat carried away by cooling $= M_w C_{pw} (T_f - T_i)$

$M_w \rightarrow$ mass of cooling water used per min.

$\Delta T \rightarrow$ rise in temp.

$C_{pw} \rightarrow$ specific heat of water $= 4.187$ KJ/kg·K

④ Heat taken away by exhaust gas = $M_g C_{pg} (T_f - T_i)$

⑤ Unaccount heat loss = Heat supplied − Heat equivalent to IP/BP/FP − Heat carried away by cooling water − Heat taken away by exhaust gas.

1c. List the automotive pollutants & their effects on environment.

Ans: 1) Unburned hydrocarbons: These are the direct result of incomplete combustion. Hydrocarbons react in the pr of nitrogen oxides & sunlight to form ground level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs & aggregates respiratory problems. It is the most wide spread & interactable urban air pollution problem.

2) Oxides of sulphur: Many fuels used in CI engines contain small amounts of sulphur. When exhausted in the form of SO_2, SO_3 they contribute to the acid rain problems of the world, SO_x acidifies surface water, reducing biodiversity and killing fish. Damages forests through direct impact on leaves & needles, and by soil acidification & depletion of soil nutrients.

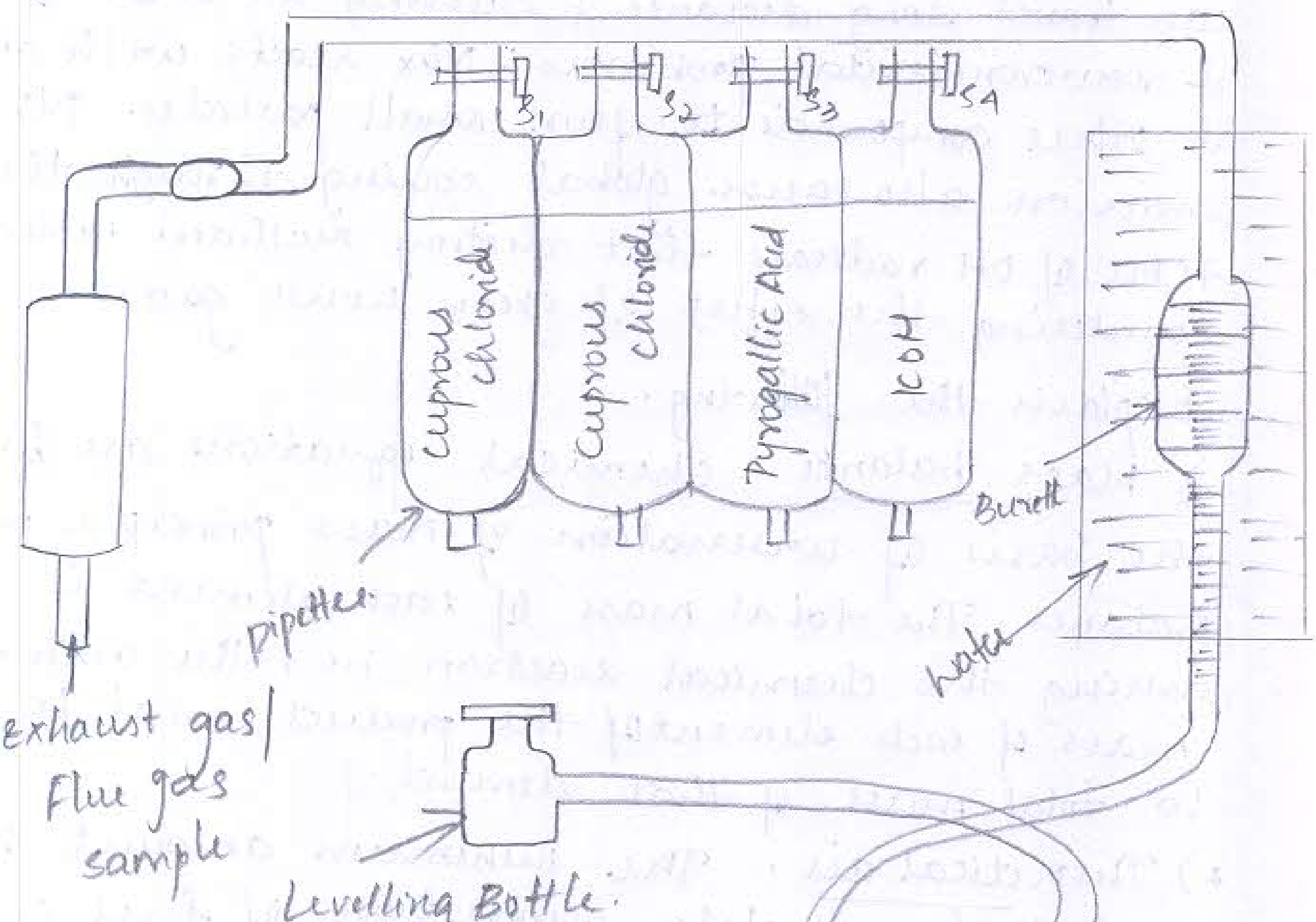
3) Particulates: The exhaust of CI engines contain solid carbon soot particles that are generated in the fuel rich zones with in the cylinder during combustion. Particulate matter can travel long distance & has great health impact on human health, such as asthama, chronic, branchitis & difficult painful breathing.

4) Soot & smoke: Smoke is the visible product of combustion which is due to poor combustion. It originates in a localized volume of rich-fuel-air mixture

5) Calorific value: It is defined as the energy liberated by the complete combustion of unit mass (or) volume of a fuel.

3)c With neat sketch explain analysis of flue gases using Orsat apparatus.

Ans:



Working: 100 cm^3 of exhaust gas is drawn into the bottle by lowering the levelling bottle. The stop cock S_4 is then opened & the whole flue gas is forced to pipette 1. The gas remain in this pipette for sometime & most of the CO_2 is absorbed by KOH present in the pipette. The levelling bottle is then lowered to allow the chemical to come to its original level. The volume of gas thus absorbed is read on the

Any volume in which fuel is burned at relative fuel-air ratio greater than 1.5 in diesel engines produces soot. If this soot once formed finds sufficient oxygen, it will burn completely. soot causes haze & acidification of lakes & rivers.

(5) Oxides of Nitrogen: NOx causes ozone & smog which can travel long distance & causing all kinds of health & environmental problems. NOx reacts with ammonia & other compounds to form small particles. NOx emissions also cause global cooling through the formation of OH radicals that destroy methane molecules, countering the effect of green house gases.

3b. Explain the following:

1) Mass balance: Chemical equations are balanced 4 the basis of conservation of Mass principle or Mass Balance. The total mass of each element is conserved during the chemical reaction i.e, the amount of mass of each element of the product must be equal to total mass of that element.

2) Theoretical air: The minimum amount of air needed for complete combustion of fuel is called Theoretical air fuel ratio.

3) combustion efficiency: Any chemical reaction during which the fuel is oxidised & large quantity of energy is released called combustion efficiency. It is the ratio of heat released to calorific value.

4) Adiabatic flame temperature: The maximum temp obtained by the products in the absence of any work interaction & changes in kinetic or potential energy is called adiabatic flame temp.

scale of measuring bottle. The flue gas is then forced through the pipette 1 for a number of times to ensure that the whole of the CO_2 is absorbed. Further the remaining flue gas is then forced to the pipette 2 which contains pyrogallic acid to absorb whole O_2, the reading on the measuring burette will be the sum of volume of CO_2 & O_2. The oxygen content can the be found out by subtraction. Finally gas is forced through the pipette 3 and 4 containing cuprous chloride which absorbs CO completely. The amount of N_2 in the sample can be determined by subtracting from total vol of gas of the sum of CO_2, CO & O_2 contents.

Orsat apparatus gives an analysis of dry products of combustion. The vol readings are taken at a constant temp & pr and the partial pressure of vapour is constant. This means that the sum of partial pressures of remaining constituents is const. The vapour then occupies the same proportion of total volume at each measurement. Hence the vapour does not affect the result of analysis.

2) b. $$I.P = \frac{n P_{im} L A N \times K \times 100}{60} = \frac{1 \times 8 \times 0.28 \times \pi/4 \times (0.2)^2 \times 350 \times 1 \times 100}{60}$$

$$= 15.39 \text{ KW}$$

$$B.P = \frac{2\pi N T}{60} = \frac{2\pi N (W-S)(D+d)}{60 \times 1000 \times 2}$$

$$= \frac{2\pi (350)(670)(1)}{60 \times 1000 \times 2} = 12.278 \text{ KW}$$

1) Heat supplied = $m_f \times C.V$

$= 1.6 \times 44000$

$= 70400$ KJ/min.

$= \frac{1.6 \times 44000}{20} = 3300$ KJ/min

2) $H.C.C\ H_2O = M_W C_{pw} \Delta T$

$= 160 \times 4.187 \times (52-30)$

$= 14738.24$ KJ/20 min.

$= 736.912$ KJ/min

3) Heat equivalent to I.P = $I.P \times 60 = 15.39 \times 60$

$= 923.4$ KJ/min.

$I.P \times 60 \times 20 = 18468$ KJ/20 min

4) $M_c = M_a + M_f$

$m_f = 1.6$, Air : fuel = 16 : 1

$\frac{m_a}{m_f} = \frac{16}{1} \Rightarrow M_a = 16 m_f$

$M_c = m_a + m_f = 16 m_f + m_f = 17 m_f = 17(1.6)$

$= 27.2$ kg/20 min

Mass of steam, $m_s = m_f \times 1.35 = 1.6 \times 1.35$

$= 2.16$ kg/20 min

Mass of dry exhaust gas = $M_c - M_s$

$= 27.2 - 2.16 = 25.04$ KJ/min

$= 12.52$ KJ/min

Heat carried away by dry gas = $m_{dg} \times C_{pg} (300-25)$

$= 27.2 \times 1 \times (275) = 7480$ KJ/20 min.

$= 2.16 \times 1 \times 275 = 594$ KJ/min

Heat carried away by steam = mass of steam &

$= (h_f + h_{fg}) + C_p (T_{sup} - T_{sat})$

$= 7480 \times (191.8 + 2392.9) + 2.16 (300 - 99.63)$

$= 193.33$ KJ/min $= 3866.6$ KJ/20 min

Unaccountat heat loss

$= 70400 - 14738 - 18468 - 2.16 - 25.04 - 7480$
$- 3866.6$

$= 25820.2$ KJ/20 min

$= 1291.01$ KJ/min

2) a. $\eta = ?$, unaccount Losses = ?

$\eta_{mech} = \frac{B.P}{I.P} = 130.82\%$

$I.P = \frac{n P_m L A N K \times 100}{60}$

$= \frac{(1)(~~0.85~~\ 6.9)(1.5) \frac{\pi}{4} (0.3)^2 (1/2)(12624) \times 100}{60}$

$=$ ~~2426.043~~ ~~1177.119 kW~~ 2308.92 KW

$B.P = \frac{2\pi N T}{60} = \frac{2\pi N (W-S)(D+d)}{60 \times 1000 \times 2}$

$= \frac{2\pi \times 12624 \times 1500 \times 1.78}{60 \times 1000 \times 2} = 1764.89$ kW

3)a. $P = 52\ kW$, $N = 2000\ rpm$, $B.P, T_1 = 177$, $B.P_2 = 170$, $B.P_3 = 168$, $BP_4 = 174$. $BSFC = 0.25\ kg/kW.h$
$CV = 42500\ kJ/kg$.

$$P = \frac{2\pi NT}{60,000}$$

$$\frac{52 \times 60000}{2\pi \times 2000} = T$$

$$T = 248.28$$

$$BP_1 = \frac{2\pi NT_1}{60000} = \frac{2\pi \times 2000 \times 177}{60000} = 37.07\ kW$$

$$BP_2 = \frac{2\pi NT_2}{60000} = \frac{2\pi \times 2000 \times 170}{60000} = 35.60\ kW$$

$$BP_3 = \frac{2\pi NT_3}{60000} = \frac{2\pi \times 2000 \times 168}{60000} = 35.18\ kW$$

$$BP_4 = \frac{2\pi NT_4}{60000} = \frac{2\pi \times 2000 \times 174}{60000} = 36.44\ kW$$

$$BP = \frac{2\pi NT}{60000} = 52\ kW.$$

$$IP_1 = BP - BP_1 = 52 - 37.07 = 14.93\ kW$$

$$IP_2 = BP - BP_2 = 52 - 35.60 = 16.4\ kW$$

$$IP_3 = BP - BP_3 = 52 - 35.18 = 16.82\ kW$$

$$IP_4 = BP - BP_4 = 52 - 36.44 = 15.56\ kW$$

$$IP = 63.71\ kW$$

$$\eta_{mech} = \frac{BP}{IP} = \underline{\underline{81\%}}$$

$$BSFC = \frac{m_f}{B \cdot P}$$

$$m_f = BSFC \times B \cdot P$$

$$= \frac{0.25}{60 \times 60} \times 52$$

$$= \underline{\underline{0.0036}}\ kg/sec$$

$$\eta_{Bth} = \frac{B \cdot P}{m_f \times C \cdot V} \times 100$$

$$= \frac{52}{0.0036 \times 42500} \times 100 = \underline{\underline{33.98\%}}$$

1) b.

$$I \cdot P = \frac{NPLANK \times 100}{60}$$

$$= \frac{(1)(864) \times (0.45)(\pi/4 \times 0.27^2) \times \frac{1}{2} \times 100 \times 9850}{60}$$

$$= \underline{\underline{587.31}}\ kW.$$

$$BP = \frac{2\pi NT}{60} = \frac{2\pi \times (W-S) \times (D+d)}{60 \times 1000 \times 2}$$

$$= \frac{2\pi \times (903) \times 1.62}{60 \times 1000 \times 2} = 76.5\ kW$$