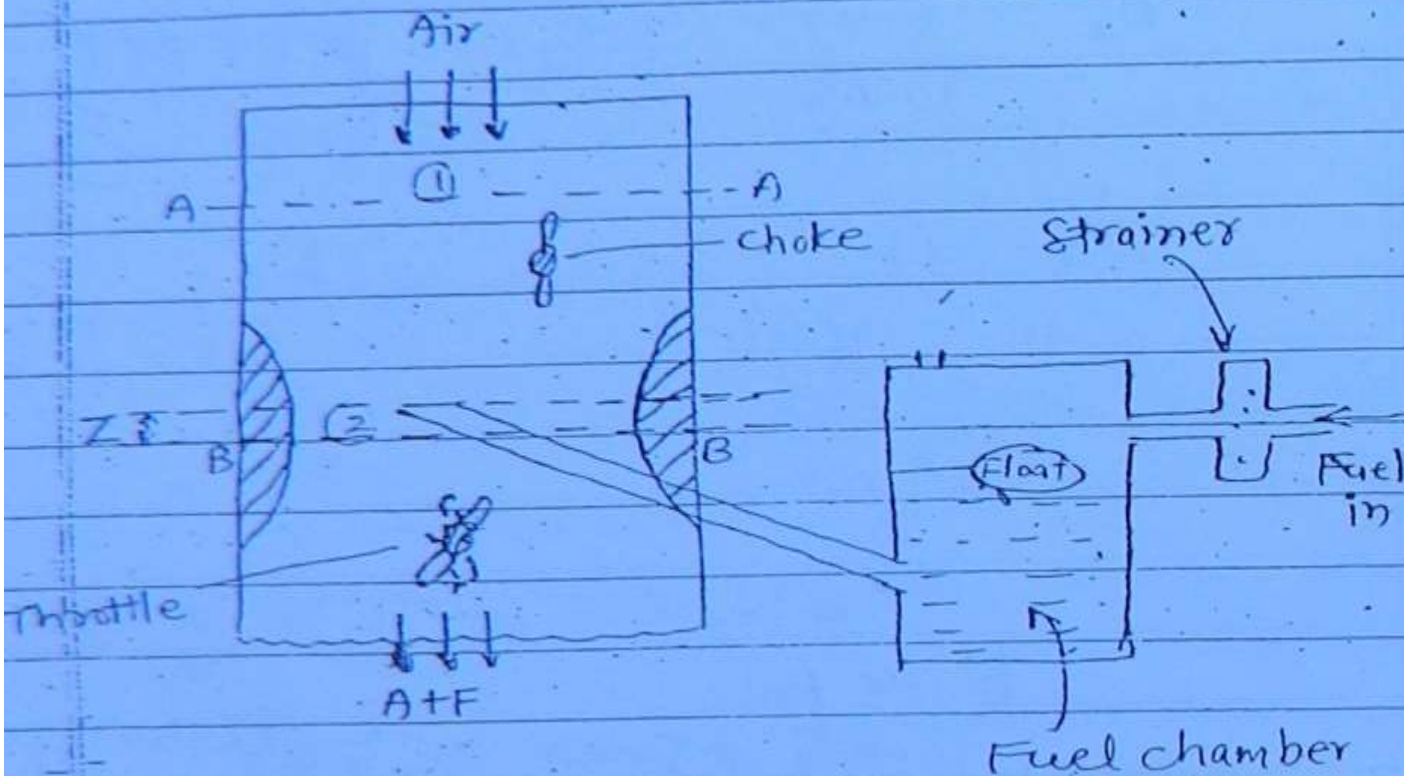
Carburetion & Fuel Injection

Simple Carburetor :-

74



Carburetor is a device which supplies combustible mixture to the cylinder

Exact analysis to find Air/Fuel ratio:-

$$h_1 + \frac{c_1^2}{2} = h_2 + \frac{c_2^2}{2}$$

$$c_1 <<< c_2$$

$$h_1 = h_2 + \frac{c_2^2}{2}$$

$$C_2 = \sqrt{2(h_1 - h_2)}$$

C_2 = velocity of air at throat

$$C_2 = \sqrt{2(C_pT_1 - C_pT_2)} \quad 75$$

$$C_2 = \sqrt{2C_pT_1\left(1 - \frac{T_2}{T_1}\right)}$$

Note:- Assuming isentropic flow

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

P_2 = Throat pressure
P_1 = Atm. pressure

$$\boxed{C_2 = \sqrt{2C_pT_1\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]}}$$

$$m_a = \rho_2 A_2 C_2 \qquad [\because m = \rho AC]$$

$$m_a = \rho_2 Q$$

m_a = Theoritical mass $= \rho_2 A_2 C_2$

Actual mass

$$\dot{m}_a = C_d \cdot \rho_2 A_2 C_2$$

Theoritical mass flow rate ⇒

$$m_a = \rho_2 A_2 C_2$$

where A_2 = Area of venturi at the float

ρ_2 = density of air at float

76

Actual mass flow rate of Air

$$m_a = C_d \, \rho_2 A_2 C_2$$

C_d = Coefficient of discharge for venturi

$$pV = mRT$$

$$p = \left(\frac{m}{V}\right) RT \qquad \rho = \frac{p}{RT}$$

$$p = \rho RT \qquad \therefore \rho_1 = \frac{p_1}{RT_1}$$

P_1, T_1 — atm. pressure & Temp.

Isentropic

$$pV^{\gamma} = \text{const.}$$

$$\frac{p_1}{\rho_1^{\gamma}} = \frac{p_2}{\rho_2^{\gamma}}$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{p_2}{p_1}\right)^{1/\gamma}$$

$$\rho_2 = \rho_1 \left(\frac{p_2}{p_1} \right)^{1/\gamma}$$

$\therefore$ 77

$$m_a = C_d \rho_2 A_2 C_2$$

$$m_a = C_{da} \cdot \rho_1 \left(\frac{p_2}{p_1} \right)^{1/\gamma} \cdot A_2 C_2$$

$$\boxed{m_a = C_{da} \cdot \rho_1 \left(\frac{p_2}{p_1} \right)^{1/\gamma} A_2 \cdot \sqrt{2 C_p T_1 \left[1 - \left(\frac{p_2}{p_1} \right)^{\frac{\gamma-1}{\gamma}} \right]}}$$

Mass of Fuel :-

Assuming fuel to be incompressible (ρ_f = const.)

* The nozzle tip is kept at a height with respect to fuel surface to avoid spilling of fuel.

$$\frac{p_1}{\rho_f g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho_f g} + \frac{v_2^2}{2g} + z_2$$

$$\frac{p_1}{\rho_f g} + \frac{0^2}{2g} + 0 = \frac{p_2}{\rho_f g} + \frac{C_f^2}{2g} + z$$

$$\frac{p_1}{\rho_f g} - \frac{p_2}{\rho_f g} - z = \frac{C_f^2}{2g}$$

$$\frac{P_1 - P_2 - \rho_f g z}{\rho_f g} = \frac{C_f^2}{2g}$$

78

$$\boxed{C_f = \sqrt{\frac{2\left[(P_1 - P_2) - \rho_f g z\right]}{\rho_f}}}$$

Theoritical

$$m_f = \rho_f A_f C_f$$

Actual mass flow rate of fuel

$$m_f = C_{df} \rho_f A_f C_f$$

$$m_f = C_{df} \rho_f A_f \sqrt{\frac{2\left[(P_1 - P_2) - \rho_f g z\right]}{\rho_f}}$$

$$\boxed{m_f = C_{df} \cdot A_f \sqrt{2 \rho_f \left[(P_1 - P_2) - \rho_f g z\right]}}$$

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Approximate analysis to find A/F ratio :-

Air is asumed to be incompressible.

$$m_a = \rho A C$$

79

$$m_a = C_{da} \rho_a A_2 C_2$$

$$\frac{P_1}{\rho g} + \frac{C_1^2}{2g} = \frac{P_2}{\rho g} + \frac{C_2^2}{2g}$$

$$C_1 <<< C_2$$

$$C_2 = \sqrt{\frac{2(P_1 - P_2)}{\rho_a}}$$

$$m_a = C_{da} \rho_a A_2 \sqrt{\frac{2(P_1 - P_2)}{\rho_a}}$$

$$\boxed{m_a = C_{da} A_2 \sqrt{2 \rho_a (P_1 - P_2)}}$$

**

$$\boxed{\frac{A}{F} = \frac{m_a}{m_f} = \frac{C_{da} A_2 \sqrt{2 \rho_a (P_1 - P_2)}}{C_{df} A_f \sqrt{2 \rho_f \{(P_1 - P_2) - \rho_f g z\}}}}$$

Note:- If nozzle tip height z is neglected

$$\frac{A}{F} = \frac{C_{da} A_2 \sqrt{\rho_a}}{C_{df} A_f \sqrt{\rho_f}}$$ 8(a)

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$$\boxed{\frac{A}{F} = \frac{C_{da} A_2}{C_{df} A_f} \sqrt{\frac{\rho_a}{\rho_f}}}$$

At higher altitudes the density of air decreases and hence from the above equation A/F will be less that is the mixture becomes rich and hence the drawback of simple Carburetor is it supplies rich mixture at higher altitudes.

INS 9

(1) A simple carburetor has to supply 5 kg of air/min. the atm. air is at a pressure of 1.013 bar and at the temp. of 27°C. Calculate throat diamet of venturi if the air flow velocity at the ~~float~~ (throat) is 90 m/sec & velocity coefficient is 0.8. Assume isentropic flow and treat air as compressible flow.

(81)

Soln:-

$m_a = 5$ kg/min

$P_1 = 1.013$ bar $\qquad T_1 = 27 + 273$

or $P_1 = 101.3$ KPa $\qquad = 300$K

$C_2 = V_2 = 90$ m/sec

$C_v = 0.8$

$$\rho_2 = \rho_1 \left[\frac{P_2}{P_1}\right]^{1/\gamma} \qquad \rho_1 = \frac{P_1}{RT_1}$$

$$= \frac{1.013 \times 10^2}{0.287 \times 300}$$

$$\rho_2 = 0.01176 \left[\frac{P_2}{P_1}\right]^{1/\gamma}$$

$$= 0.01176$$

$$\rho_1 = 1.176 \text{ KPa}$$

$$C_2 = C_v \times \sqrt{2 C_P T_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma - 1}{\gamma}}\right]}$$

$C_P = 1.005 \frac{kJ}{kg\text{-}K}$

$C_P = 1005$ J/kg-K

$$90 = 0.8 \times \sqrt{2 \times 1005 \times 300 \left[1 - \left(\frac{P_2}{1.013}\right)^{\frac{1.4-1}{1.4}}\right]}$$

$P_2 = 0.941$ bar

$$\rho_2 = \rho_1 \left[\frac{P_2}{P_1}\right]^{1/\gamma}$$

$$= 1.176 \left[\frac{0.941}{1.013}\right]^{1/1.4}$$

$$\rho_2 = 1.1054 \quad kg/m^3$$

assume $C_d = 1$ (82)

$$m_a = \rho_2 A_2 C_2$$

$$\frac{5}{60} = 1.1054 \times A_2 \times 90$$

$$A_2 = 8.37 \times 10^{-4} \quad m^2$$

$$A_2 = \frac{\pi}{4} d_2^2$$

$$d_2 = \sqrt{\frac{4A}{\pi}}$$

$$= \sqrt{\frac{4 \times 8.37 \times 10^{-4}}{\pi}}$$

$$d_2 = 0.0325 \, m.$$

$$d_2 = 3.25 \, cm.$$

or

$$d_2 = 32.5 \, mm.$$

IES-JA

(2) Determine Air/Fuel ratio at 6000 m altitude in a carburetor adjusted to give an air/fuel ratio of 15 at sea level where air temp is 27°C and pressure is 1.013 bar.

The temp of air decreases with altitude and is given by

$$t = t_s - 0.0065h$$

where h = height in meter

and t_s = sea level temp in °C

The air pressure decreases with altitude as per the relation

$$h = 19220 \log_e \left(\frac{1.013}{P}\right)$$

where P is in bar.

Sol^n:-

$$\frac{\text{air}}{\text{fuel}} = 15 \qquad m_a = 15$$

$$P_1 = 1.013 \text{ bar} = 101.3 \text{ kPa}$$

$$T_1 = t_1 = 27 + 273 = 300 \text{ K}$$

$$\rho_a = \frac{P_1}{RT_1} = \frac{101.3}{0.287 \times 300}$$

$$(\rho_a)_{SL} = 1.176$$

$$\frac{A}{F} = \frac{m_a}{m_f} = \frac{C_{da} A_2}{C_{df} A_f} \sqrt{\frac{\rho_a}{\rho_f}}$$

$$\left(\frac{A}{F}\right) \propto \sqrt{\rho_a}$$

SL – Sea level

$$\frac{\left(\frac{A}{F}\right)_{SL}}{\left(\frac{A}{F}\right)_{h}} = \sqrt{\frac{(\rho_a)_{SL}}{(\rho_a)_{h}}}$$

84

$$\left(\frac{A}{F}\right)_{h} = \left(\frac{A}{F}\right)_{SL} \sqrt{\frac{(\rho_a)_{h}}{(\rho_a)_{SL}}}$$

$t = t_s - 0.0065\,h$

at $h = 6000$

$t = 27 - 0.0065\,(6000)$

$t = -12^{\circ}\,C$

$T = 273 - 12 = 261\,K$

$$h = 19220 \log_e\left(\frac{1.013}{p}\right)$$

$$6000 = 19220 \log_e\left(\frac{1.013}{p}\right)$$

$p = 0.742$ bar

(or)

$p = 74.2$ KPa

$$\left(\frac{A}{F}\right)_{h} = 15\sqrt{\frac{0.991}{1.176}} = 13.75$$

Requirements of A/F ratio under various requirements :-

There are two types of operations

(1) Steady State operation (85)

a. Idling

b. Cruising

c. Maximum power

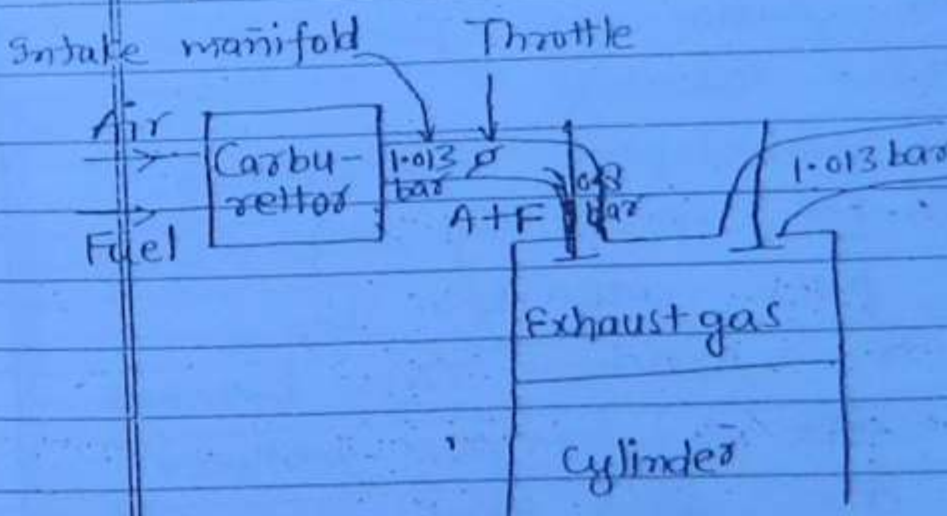
(2) Transient operation

a. Starting

b. Acceleration

Idling :-

Idling is no load low speed operation.



Under idling the engine operates at no load and with nearly closed throttle under idling case engine requires rich mixture. The amount

brought in during idling is much less then during full throttle 96 operation due to very small opening of throttle. This results in much larger proportion of exhaust gas being mixed with fresh charge.
Under idling conditions the pressure in the intake manifold is less then or below atm. pressure due to restriction of air flow.
when the intake valve opens the pressure differential b/w combustion chamber & intake manifold results in initial backward flow of exhaust gases as a result the mixture of Fuel/Air ratio in combustion chamber is diluted.
This results in poor combustion.
It is therefor necessary to provide more flow fuel particles by richening the mixture. This increases the probability of contact between fuel and Air and hence improves combustion.

The general air/Fuel ratio under idling conditions are
$12 - 12.5$ $(\phi > 1)$

Cruising :- (or) (Normal Range)

(37) The exhaust gas dilution problem is insignificant in cruising and the primary aim is better fuel ecconomy.

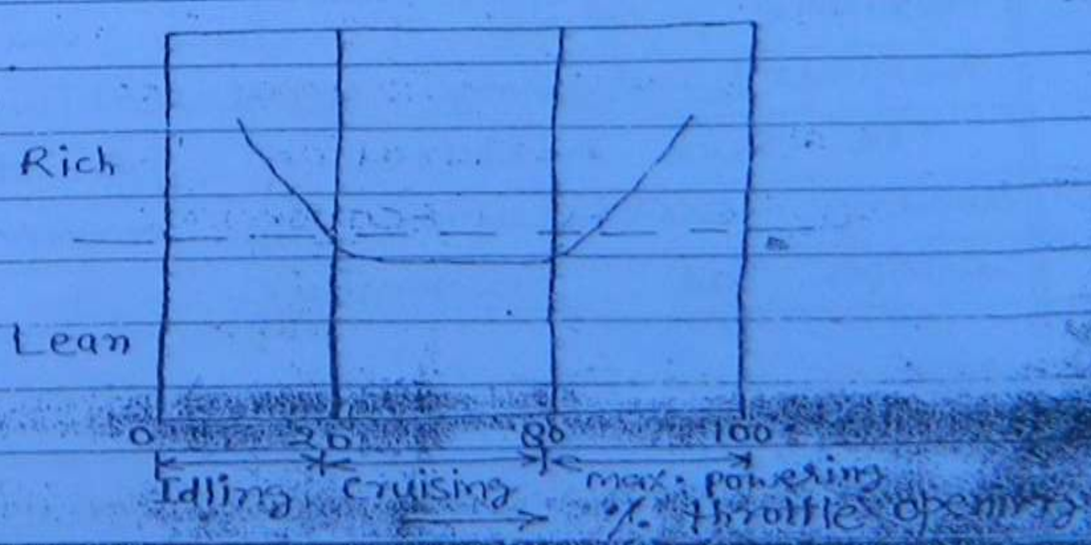
20 - 80 % of throttle opening operation is known as cruising.

For better fuel economy slightly lean mixture is supply because more oxygen would result in complete combustion of fuel and hence the general

* Air/Fuel ratios are 16 — 16.5 . ($\phi < 1$)

Maximum power range :

Engine requires during - peake power operation Richer mixture. To provide better power and to prevent overheating of exhaust valve. The general A/F ratios are around 13. ($\phi > 1$).



(2) Transient Operation (98)

Starting :- During starting the temp. are low and the fuel remains in liquid form also fuel may condance on coming in contact with cold cylinder walls eventhough air/fuel ratio is within normal combustion range the ratio of evapored fuel to air is less and hence during staring very rich mixture must be supplied. (A/F of 3—5).

Acceleration:- The purpose of opening throttle is to provide an increase in torque. when throttle is suddenly open during acceleration the liquid fuels lags behind. And thus cylinder recieves lean mixture. while the rich mixture is required during acceleration. The rich mixture is provided during acceleration by means of a device as Economiser.

IASO

(1) A venturi of a simple carburettor has a throat dia. of 20 mm (D_2) and fuel orifice dia. of 1.12 mm The level of petrol surface in the float chamber is

(2) 6 mm below the throat. The coefficient of discharge of (C_{da}) for venturi, and coeff. of fuel orifice are 0.85 & 0.78 resp. specific gravity of petrol is 0.75.

(99)

Calculate

i. A/F ratio for a pressure drop of 0.08 bar

ii. Petrol consumption in kg/hr.

** iii. Critical air velocity

The intake conditions are

$P_1 = 1$ bar & $T_1 = 290$ K

For air -- $C_p = 1.005$ kJ/kg-K

$C_v = 0.718$ kJ/kg-K

neglect compressibility of air

Soln:-

$D_2 = 20$ mm , $D_f = 1.12$ mm

$z = 6$ mm , $C_{da} = 0.85$, $C_{df} = 0.78$

$S = 0.75$ $\Delta P = 0.08$

$P_1 = 1$ bar $= 100$ kPa

$T_1 = 290$ K

$$\rho_a = \frac{P_1}{RT_1}$$

$$= \frac{100}{0.287 \times 290} = 1.201 \text{ kg/m}^3$$

$$P_1 - P_2 = 0.08 \text{ bar}$$
$$100 - P_2 = 8 \text{ KPa}$$

100

$$P_2 = 92 \text{ KPa}$$

$$\frac{A}{F} = \frac{C_{da} A_2 \sqrt{2 \rho_a (P_1 - P_2)}}{C_{df} A_f \sqrt{2 \rho_f [(P_1 - P_2) - \rho_f g z]}}$$

$$= \frac{0.85 \times (20)^2 \sqrt{1.2 (0.08 \times 10^5)}}{0.78 \times (1.12)^2 \sqrt{750 [0.08 \times 10^5 - 750 \times 9.81 (6 \times 10^{-3})]}}$$

$$\frac{A}{F} = 13.94$$

$$m_f = C_{df} A_f \sqrt{2 \rho_f [(P_1 - P_2) - \rho_f g z]}$$

$$m_f = 0.78 \times \frac{\pi}{4} (1.12 \times 10^{-3})^2 \times \sqrt{2 \times 750 [(0.08 \times 10^5) - 750 \times 9.81 \times 6 \times 10^{-3}]}$$

$$m_f = 2.65 \times 10^{-3} \text{ Kg/sec.}$$

$m_f =$ 2.5 %/...

$$C_{air} = \sqrt{\frac{2(P_1 - P_2)}{\rho_a}}$$

101

$$(P_1 - P_2) > \rho_f g z$$

$$P_1 - P_2 = \rho_f g z$$

$$C = \sqrt{\frac{2 \rho_f g z}{\rho_a}}$$

$$C = \sqrt{\frac{2 \times 750 \times 9.81 \times 6 \times 10^{-3}}{1.2}}$$

$$C_{air} = 8.5 \text{ m/s.}$$

(2) The following observations has been made from the test of a 4-Cylinder two stroke petrol engine.

Diameter	10 cm.
Stroke	15 cm.
Speed	1600 rpm.
Area of positive loop of indicator diagram	5.75 cm^2
Area of negative loop of indicator diagram	0.25 cm^2

Length of the diagram (l_d) 5.5 Cm

spring constant (k_s) 3.5 bar/cm

102

Find

Indicated power in KW.

Mean effective pressure

$$P_m = \frac{k_s\, a_d}{l_d}$$

where

k_s = spring constant

a_d = area of indicator diagram

l_d = length of the diagram

$$P_m = 3.5\ \frac{\text{bar}}{\text{cm}} \times \frac{(5.75 - 0.25)\ \text{cm}^2}{5.5\ \text{cm}}$$

$$P_m = 3.5\ \text{bar}$$

OR

$$P_m = 350\ \text{KPa}$$

$$IP = \frac{P_m\, L\, A\, N . K}{60}$$

$$= \frac{350 \times 0.15 \times \frac{\pi}{4} (0.1)^2 \times 1600 \times 4}{60}$$

~~IP = 5.14.8~~

$$P = 43.98\ \text{KW}$$

3) A single cylinder engine running at 1800 rpm. develops a Torque of 8 N-m. The indicated power of the engine is 1.8 kW. Find friction power.

Sol^n:

$N = 1800$ rpm

$IP = 1.8$ kW

(103)

Frictional Power = I.P. − B.P

$$B.P. = \frac{2\pi NT}{60}$$

$$= \frac{2\pi \times 1800 \times 8}{60} \quad \frac{Nm}{sec}$$

$BP = 1508$ W

(or)

$BP = 1.508$ kW

$FP = 1.8 - 1.508$

$FP = 0.292$ kW

(4) Find brake specific fuel consumption in Kg/kWh of a diesel engine whose fuel consumption is 5 gm/sec and power output (BP) is 80 kW. If the mechanical eff^n. is 75%. Calculate indicated specific fuel consumption in Kg/kW-h.

Sol^n:-

$$BP = 80 \text{ kW}$$

$$\eta_m = 0.75 \qquad 104$$

$$\eta_m = \frac{BP}{I.P.} \qquad \eta_m$$

$$I.P. = \frac{B.P.}{\eta_m} = \frac{80}{0.75} = 106.6 \text{ kW}$$

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

$$m_f = \frac{5 \text{ gm}}{\text{sec}} = \frac{5 \times 10^{-3} \text{ kg}}{\frac{1}{3600} \text{ hr}}$$

$$m_f = 18 \text{ kg/hr}$$

$$BSFC = \frac{18 \text{ kg/hr}}{80 \text{ kW}}$$

$$BSFC = 0.225 \frac{\text{kg}}{\text{kW-hr}}$$

$$ISFC = \frac{m_f}{IP}$$

$$IP = \frac{m_f}{ISFC}$$

$$\eta_m = \frac{BP}{IP} = \frac{m_f / BSFC}{m_f / ISFC} = \frac{ISFC}{BSFC}$$

$$\eta_m = 0.75 = \frac{ISFC}{0.225} \quad (105)$$

$$ISFC = 0.1687 \ \text{Kg/Kw-hr.}$$

Prob. (5) A 6-cylinder petrol engine operates on 4-stroke cycle. The bore of each cylinder is 80 mm and stroke is 100 mm the clearance volume per cylinder is 70 CC. At a speed of 4000 rpm the fuel consumption is 20 Kg/hr and Torque developed is 150 N-m. Find

i. Brake power

ii. Brake thermal eff^n. (CV = 43000 KJ/kg)

iii. Relative eff^n. based on brake power bases

Assume the cycle to be working on otto cycle. and $\gamma = 1.4$

Sol^n:-

$$D = 80 \text{ mm} \quad , \quad L = 100 \text{mm}$$

$$= 0.8 \text{m} \qquad L = 1 \text{m}$$

$$V_c = 70 \text{ CC}$$

$$N = 4000 \text{ rpm}$$

$T = 150$ N-m , $CV = 43000$ KJ/Kg

Fuel 1

166

$$BP = \frac{2\pi N T}{60}$$

$$= \frac{2\pi \times 4000 \times 150 \text{ N-m}}{60 \text{ sec.}}$$

$$BP = 62.83 \times 10^3 \text{ W}$$

or

$$BP = 62.83 \text{ KW}$$

$$\eta_{bth} = \frac{BP}{m_f \times C.V.}$$

$$= \frac{62.83}{\frac{20}{3600} \frac{\text{Kg}}{\text{sec.}} \times 43000 \frac{\text{KJ}}{\text{Kg}}}$$

$$\eta_{bth} = 0.2628$$

or

$$\eta_{bth} = 26.28\ \%$$

$$\eta_{rel.} = \frac{\eta_{bth.}}{\eta_{air\ std.}}$$

$$\eta_{air\ std.} = 1 - \frac{1}{(r)^{\gamma-1}}$$

$$r = 1 + \frac{V_s}{V_c}$$

$$r = 1 + \frac{\frac{\pi}{4} D^2 L}{V_c}$$ 107

$$r = 1 + \frac{\frac{\pi}{4} (8)^2 \times 10}{70}$$

$$r = 8.18$$

$$\eta_{air\,sd.} = 1 - \frac{1}{(8.18)^{1.4-1}}$$

$$\eta_{air\,sd.} = 0.5685$$

$$\eta_{rel.} = \frac{0.2628}{0.5685}$$

$$\eta_{rel.} = 0.4622$$

(or)

$$\eta_{rel.} = 46.22\ \%$$

Fuel Injection Equations

108

Volume of fuel injection/cycle $= C_d \times$ Area of orifice $\times$ velocity of injection $\times$ time of injection

Velocity of injection

$$V_f = \sqrt{\frac{2(P_{inj.} - P_{cyl.})}{\rho_f}}$$

$P_{inj.}$ — injection pressure
$P_{cyl.}$ — cylinder pressure

Time of injection

rad/sec, rad.

$$\omega = \frac{\phi}{t}$$

$$180° — \pi$$
$$\theta° —$$
$$\frac{\pi\theta}{180} \text{ rad.}$$

$$t = \frac{\phi}{\omega}$$

$$t = \frac{\pi\theta}{180} \times \frac{1}{\frac{2\pi N}{60}}$$

$$t = \frac{\pi \theta \times 60}{180 \times 2\pi N}$$

$$\boxed{t = \frac{\theta \times 60}{360 \times N}}$$

here N in ~~rad~~ rpm

No: (1) A single cylinder 4-stroke diesel engine running at 1500 rpm uses 2.5 kg of fuel per hr. The specific gravity of fuel is 0.88. The injection periode is 25° crank angle, if the injection pressure is 150 bar and cylinder pressure is 30 bar. Find the diameter of fuel orifice. Take Cd for fuel orifice 0.88.

Soln:- 4-stroke

$N = 1500$ rpm

$m_f = 2.5$ kg/hr.

$\rho_f = 880$ kg/m^3

$\theta = 25^\circ$

$P_{inj} = 150$ bar

$P_{cyl} = 30$ bar

$C_d = 0.88$

Vol. of fuel injection/cycle $= C_d \times A \times V \times t$

(110)

$$\rho_f = \frac{m_f}{V_f}$$

$$V_f = \frac{m_f}{\rho_f} = \frac{2.5\ kg}{3600\ sec} \times \frac{1}{880\ \frac{kg}{m^3}}$$

$$V_f = 7.89 \times 10^{-3}\ \frac{m^3}{sec}$$

for 4-stroke engine

$$\frac{1500}{2} = 750 \text{ cycle/min.}$$

$$\frac{V_f}{cycle} = \frac{7.89 \times 10^{-3}\ m^3/sec}{\frac{750}{60}\ \frac{cycles}{sec}}$$

Volume of fuel injection/cycle $= 6.313 \times 10^{-8}\ m^3/cycle$

$$\text{Velocity} = \sqrt{\frac{2(P_{inj} - P_{cyl.})}{\rho_f}}$$

$$V = \sqrt{\frac{2(150-30)\times 10^5}{880}}$$

114

$$V = 165.14 \ m/sec.$$

Time of injection

$$t = \frac{\theta \times 60}{360 \times N}$$

$$t = \frac{25 \times 60}{360 \times 1500}$$

$$t = 2.77 \times 10^{-3} \ sec.$$

$$\therefore \quad 6.313 \times 10^{-8} = 0.88 \times A \times 165.14 \times 2.77 \times 10^{-3}$$

$$A = 1.5688 \times 10^{-7} \ m^2$$

$$A = \frac{\pi}{4} d^2 = 1.5688 \times 10^{-7}$$

$$d = 4.4 \times 10^{-4} \ m.$$

(or)

$$d = 0.44 \ mm$$

(2) The specific fuel consumption of 4-stroke diesel engine producing 25 kW while running at 3000 rpm is 0.3 kg/kW-hr. If the injection pressure is 160 bar and pressure in the cylinder is 30 bar. Coefficient of velocity is 0.88 and coefficient of discharge is 0.65. Jet dia is 0.8 mm find crank angle travelled during injection periode. and take density of fuel as 875 kg/m³. (112)

Solⁿ:-

$BP = 25 kW$

$N = 3000 rpm$

$BSFC = 0.3 \ kg/kW\text{-}hr$

$P_{inj.} = 160 \ bar$

$P_{cyl.} = 30 \ bar$

$C_v = 0.88$

$C_d = 0.65$

Jet dia $= 0.8 mm$

$\rho_f = 875 \ kg/m^3$

$$V_f = \frac{m_f}{\rho_f}$$

$$= \frac{0.3 \ kg/kW\text{-}hr}{875 \ kg/m^3}$$

$$V_f = 9.52 \times 10^{-8}\ m^3/sec.$$

(113)

$$V = C_v \sqrt{\frac{2(P_{inj} - P_{cyl.})}{\rho_f}}$$

$$= 0.88 \sqrt{\frac{2(160 - 30) \times 10^5}{875}}$$

$$V = 151.69\ m/sec.$$

$$BSFC = \frac{m_f}{BP}$$

$$m_f = BSFC \times BP$$

$$m_f = \underset{(BP)}{25\ KW} \times \underset{(BSFC)}{0.3\ \frac{Kg}{Kwhr}}$$

$$m_f = 7.5\ Kg/hr.$$

(or)

$$m_f = \frac{7.5\ Kg}{3600\ sec.} = 2.08 \times 10^{-3}\ \frac{Kg}{sec.}$$

$$\rho_f = \frac{m_f}{Vol.f}$$

$$Vol.f = \frac{m_f}{\rho_f} = \frac{2.08 \times 10^{-3}\ Kg/sec.}{875\ Kg/m^3}$$

rpm = 3000

$\Rightarrow$ 1500 cycles/min = $\frac{1500}{60}$ $\frac{\text{cycle}}{\text{sec}}$

$$Vol._f = \frac{2.38 \times 10^{-6} \ m^3/sec}{\frac{1500}{60} \ cycles/sec}$$

$$Vol._f = 9.52 \times 10^{-8} \ \frac{m^3}{cycle}$$

$$Area = \frac{\pi}{4} d^2$$

$$= \frac{\pi}{4} (0.8 \times 10^{-3})^2$$

$$A = 0.502 \times 10^{-6} \ m^2$$

Volume of fuel injected/cycle $= C_d \times A \times Vel. \times t$

$$9.52 \times 10^{-8} = 0.65 \times 0.502 \times 10^{-6} \times 151.69 \times t$$

$$t = 0.00192 \ sec$$

$$t = \frac{\theta \times 60}{360 \times N}$$

$$0.00192 = \frac{\theta \times 60}{360 \times 3000} \Rightarrow \theta = 34.57^{\circ}$$

***

(3) When the pressure inside the Combustion chamber is 30 bar and injection pressure is 160 bar. The fuel penetrates distance of 24 cm. in 20 milli sec. Estimate the time taken by the fuel to penetrate the same distance when the injection pressure is changed to 250 bar. other variables remaining same.

Soln.:-

$$P_{inj} = 160 \text{ bar}$$

115

$$P_{cyl.} = 30 \text{ bar}$$

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

$$V = \frac{D}{t}$$

$$D = Vt \qquad \because V = \sqrt{\frac{2(\Delta P)}{\rho_f}}$$

$$D \propto (\sqrt{\Delta P})t \qquad V \propto \sqrt{\Delta P}$$

$$D = K\sqrt{\Delta P}\, t$$

$$(\sqrt{\Delta P}\, t)_1 = (\sqrt{\Delta P}\, t)_2$$

$$\Delta P_1 = P_{inj} - P_{cyl.} = 160 - 30$$

$$\Delta P_1 = 130 \text{ bar}$$

$\Delta P_2 = 250 - 30 = 220$ bar

$$\frac{t_2}{t_1} = \frac{\sqrt{\Delta P_1}}{\sqrt{\Delta P_2}}$$ (116)

$$t_2 = t_1 \sqrt{\frac{\Delta P_1}{\Delta P_2}}$$

$$t_2 = 20 \sqrt{\frac{130}{220}}$$

$t_2 = 15.37$ milli sec.

A 6- cylinder, 4-stroke diesel engine develops 100KW at 3000 rpm when Brake thermal effn. 25%. Calculate quantity of fuel injected per cylinder per cycle.

Also calculate the fuel orifice dia. if the injection pressure is 160 bar, pressure inside the combustion chamber is 50 bar and crank travell during injection periode is 25°.

Take C_d for fuel orifice 0.65

$d_f = ...$

$V_f = 7.47 \times 10^{-8}\ m^3/cycle$

4 - stroke diesel engine

$K = 6$

$BP = 100\ kW$

$N = 3000\ rpm$

$\eta_{bth} = 25\%$

117

$P_{inj} = 160\ bar$

$P_{cyl} = 50\ bar$

$\theta = 25$

$CV = 42000\ kJ/kg$

$\rho_f = 850\ kg/m^3$

$$\eta_{bth} = \frac{B.P}{m_f \times C.V}$$

$$m_f = \frac{B.P}{\eta_{bth} \times C.V}$$

$$m_f = \frac{100\ kW}{0.25 \times 42000\ kJ/kg}$$

$$m_f = 9.523 \times 10^{-3}\ kg/sec$$

$$\therefore\ V_f = \frac{m_f}{\rho_f}$$

$$= \frac{9.523 \times 10^{-3}\ kg/sec}{850\ kg/m^3}$$

$$V_f = 1.12 \times 10^{-5}\ m^3/sec$$

and

$$V = \sqrt{\frac{2\,(P_{inj} - P_{cyl.})}{\rho_f}}$$

$$= \sqrt{\frac{2\,(160-50)\times 10^5}{850}} \quad 118$$

$$V = 160.87 \quad m/s.$$

rpm = 3000 rpm

$$\therefore \frac{3000}{60\times 2} = \frac{1500}{60} \frac{cycle}{sec.}$$

$$\frac{V_f}{cycle} = \frac{1.12\times 10^{-5}}{\frac{1500}{60}} \frac{m^3}{sec.}$$

$$= 4.48\times 10^{-7} \quad m^3/sec.$$

$$4.48\times 10^{-7} = C_d \times A \times Vel. \times t$$

$$t = \frac{\theta\times 60}{360\times N} = \frac{25\times 60}{360\times 3000}$$

$$= 1.38\times 10^{-3} \quad sec.$$

$$4.48\times 10^{-7} = 0.65 \times A \times 160.87 \times 1.38\times 10^{-3}$$

$$\frac{\pi}{4} D^2 = \frac{4.48\times 10^{-7}}{0.65\times 160.87\times 1.38\times 10^{-3}}$$

D = [illegible]