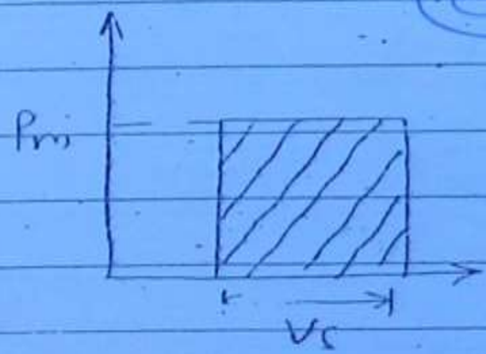
Performance parameters :-

1. Indicated Power (I.P.) :- The power developed inside the cylinder is known as indicated power (I.P.)

(61)



$$W_{net} = \frac{P_m \times V_s}{Cycle}$$

$$I.P = \frac{P_m V_s}{Cycle} \times \frac{N\,cycle}{60\,sec}$$

* $$I.P = \frac{P_m \times A L N}{60}$$ (For two stroke engine)

For four stroke engine

* $$I.P. = \frac{P_m L A N}{2 \times 60}$$

If there are K no. of cylinders then

$$I.P. = \frac{P_m L A N K}{2 \times 60}$$ (for 4-stroke)

$$I.P. = \frac{P_m L A N K}{60}$$ (for 2-stroke)

2. Brake Power (B.P.):- It is the power available at output shaft.

(62)

$$\text{Brake power} = \frac{T \times 2\pi N}{60}$$

T = Brake Torque

3. Frictional Power (F.P.):- The difference between I.P. & B.P. is known as frictional power.

4. Mechanical efficiency (η_m):-

$$\eta_m = \frac{BP}{IP} = \frac{\eta_{bth}}{\eta_{ith}}$$

5. Indicated Thermal efficiency (η_{ith}):-

$$\eta_{ith} = \frac{IP}{m_f \times C.V.}$$

m_f = mass of fuel
CV = Calorific value.

6 Brake Thermal efficiency (η_{bth}):-

$$\therefore \eta_{bth.} = \frac{BP}{m_f \times CV}$$

(63)

7. Indicated specific fuel consumption (ISFC):-

It is the amount of fuel consume to develope I.P.

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

m_f = mass of fuel consume in Kg/hr. and IP is in KW

Note:- Generally specific fuel consumption in $\frac{Kg}{KW-hr}$.

* $$\eta_{th.} = \frac{ip}{m_f\, CV} = \frac{KW}{\frac{Kg}{sec} \times \frac{KJ}{Kg}} = \frac{KW}{KW}$$

Breeke specific fuel consumption (BSFC):- It is the fuel consume to develope brake power

$$BSFC = \frac{m_f}{BP} \quad \frac{Kg}{KW-hr}$$

$$\eta_{m} = \frac{BP}{IP} = \frac{\frac{mf}{BSFC}}{\frac{mf}{ISFC}} = \frac{ISFC}{BSFC}$$

(69)

Combustion in C.I. Engines

(or) Compression ignition engines

(or) Diesel engines

Stages of combustion in C.I Engines:-

1. Delay periode
   a. Physical delay
   b. chemical delay

2. Uncontrolled combustion

3. Controlled combustion

4. After burning

Physical Delay:-

The time between beggining of injection and attenment of chemical reaction condition is known as physical delay. During this periode fuel is atomised (or) vapourised and mixed with air.

(65)

Chemical delay:-

Reaction starts slowly an ignition takes place. Ignition delay in S.I. engine is equivalent to chemical delay for C.I. engines.

As soon as the fuel is injected in to the combustion chambe it will vapourised and mixes with air. The time spend in this process is known as physical delay. The i'me Free flame reactions start and after some time fuel burns automatically. And the time consume in this is known as Chemical delay.

During total delay periode more fuel droplets comes out from the injector and group of droplets burn together. This produces uncontrolled combustion known as Detonation. At the beggining of combustion.

After some periode of time the temp. of combustion chamber is so high then as soon as the fuel droplets enter in the combustion chamb it burns instantaneously and this is called as controlled combustion.

since diesel is less volatile there are some pockets of air/fuel mixture which will burn during expansion known as After burning.

(66)

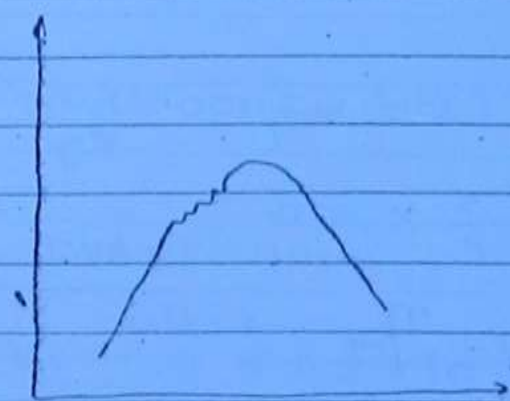
Note:- ① The parameters which controll detonation in S.I. engines increase detonation in C.I. engines and hence a good S.I. engine fuel is a bad C.I. engine fuel.

② If petrol is used in C.I. engines uncontrolled combustion or detonation occurs because the self ignition temp. of petrol is very high then diesel. so that the delay periode will be more resulting in civier knocking and due to this they can be mechanical failure of engine parts.

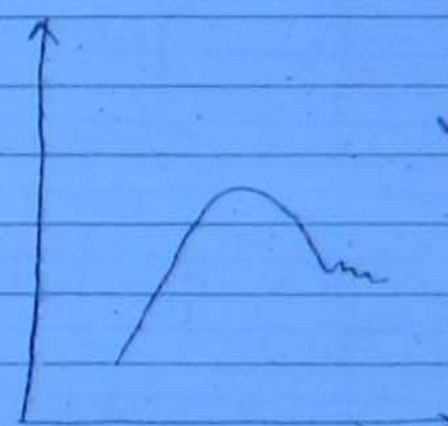
③ If diesel is used in S.I. engines and as diesel is less volatile black fumes comes out from the engine and thereby large no. of carbon atoms deposite at the spark plug And hence the spark plug will be blocked.

Factors controlling detonation

Factors	S.I.	C.I.
S.I.T	high	low
Delay period	high	low
CR	Low	high
Inlet Temp.	Low	high
Inlet pressure	Low	high
Combustion wall temp.	Low	high



C.I. Engines



S.I. Engines

G796

Prob (1) A 4-Cylinder, four stroke S.I. engine has a Comp. ratio 8 and bore of 100 mm with a stroke = bore the volumetric eff^n. of each cylinder is 75% the engine operates at a speed of 4800 rpm with an Air/Fuel ratio of 15. The C.V. of fuel is 42000 KJ/kg

Density of air is 1.12 Kg/m3 and mep in the cylinder is 10 bar and mechanical effn. is 80%. Determine

i. Indicated Thermal effn. &

ii. Brake power.

(68)

Soln:—

$K = 4$ four stroke engine

$r = 8$

$D = L = 100\,mm$

$\eta_{vol} = 0.75$ $N = 4800\,rpm$

$A/F = 15$ $CV = 42000\ \frac{KJ}{Kg}$

$\rho_a = 1.12\ Kg/m^3$ $mep = 10\ bar$

$\eta_m = 0.80$

$$I.P. = \frac{P_m L A N K}{60 \times 2}$$

$$= \frac{(10 \times 100) \times (0.1)\ \pi (0.1)^2 \times 4800 \times 4}{4 \times 60 \times 2}$$

$$= 125.66\ KW$$

$$\eta_m = \frac{B.P}{I.P.}$$

$$B.P = \eta_m \times I.P.$$

$$= 0.8 \times 125.66$$

$$= 100.528\ KW$$

$$\eta_{vol.} = \frac{\text{Act. volume of air taken/cycle}}{\text{Swept volume}}$$

(69)

4800 rpm = 2400 Cycles/min.

(As it is a four stroke engine each cycle is completed in 2 revoluti

$$\eta_{vol.} = \frac{V_a/\text{cycle}}{V_s}$$

$$V_a/\text{cycle} = \eta_{vol.} \times V_s$$

$$= 0.75 \times \frac{\pi}{4}(0.1)^2(0.1) \quad m^3/\text{cycle}$$

$$V_a = 5.89 \times 10^{-4} \quad m^3/\text{cycle}$$

$$V_a = 5.89 \times 10^{-4} \frac{m^3}{\text{cycle}} \times \frac{2400 \text{ cycle}}{60 \text{ sec.}}$$

$$V_a = 0.02356 \frac{m^3}{\text{sec.}}$$

As there are 4-cylinders to

Total volume taken $= 4 \times 0.02356$

$$= 0.09424 \frac{m^3}{\text{sec.}}$$

$$\rho_a = \frac{m_a}{V_a}$$

$$m_a = \rho_a \times V_a$$

$$= 1.12 \frac{kg}{m^3} \times 0.09424 \frac{m^3}{sec}$$

$$= 0.1055 \frac{kg}{sec.}$$

$$\frac{m_a}{m_f} = 15$$

$$m_f = \frac{m_a}{15} = \frac{0.1055}{15}$$

$$m_f = 7.036 \times 10^{-3} \frac{kg}{sec.}$$

$$\eta_{ith} = \frac{IP}{m_f \times C.V.}$$

$$= \frac{125.66 \; kW}{7.036 \times 10^{-3} \frac{kg}{sec.} \times 42 \times 10^3 \frac{kJ}{kg}}$$

$$= 0.425$$

$$\eta_{ith} = 42.5 \%$$

IES ***

(9) The chemical formula of Fuel is C_2H_6O. Calculate stoichiometric Air/Fuel ratio and % Composition of products of composition per kg alcohal.

Soln:-

C_2H_6O (7)

$12 \times 2 \longrightarrow C = 24$

$1 \times 6 \longrightarrow H = 6$

$16 \longrightarrow O = 16$

$= 46$

$\% C = \frac{24}{46} = 0.52$

$\% H_2 = \frac{6}{46} = 0.13$

$\% O_2 = \frac{16}{46} = 0.35$

$$\left(\frac{A}{F}\right) = \left[\frac{8}{3}C + 8H_2 + S - O_2\right] \times \frac{100}{23}$$

$$\left(\frac{A}{F}\right)_{St.} = \left[\frac{8}{3} \times (0.52) + 8(0.13) + 0 - (0.35)\right] \times \frac{100}{23}$$

$$\left(\frac{A}{F}\right)_{St.} = 9.03$$

For 1 kg of fuel burns, 9.03 kg air required.

$C_2H_6O + Air \longrightarrow$ Products + heat

$C_2H_6O + O_2 + N_2 \longrightarrow CO_2 + H_2O + N_2$

$C + O_2 \longrightarrow CO_2$
$12 + 2(16) \longrightarrow 44$

(72)

12 kg C produces 44 kg of CO_2
1 kg C —— ?

1 kg C produces $= \frac{44}{12} = \frac{11}{3}$ kg of CO_2

0.52 kg C produces $= \frac{11}{3} \times 0.52$

$= 1.906$ kg of CO_2

$H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$

$2 + 16 \longrightarrow 18$

2 kg H_2 produces 18 kg of H_2O vapour

1 kg H_2 ,, 9 kg of H_2O vapour

0.13 kg H_2 ,, 9×0.13
$= 1.17$ kg of H_2O vapour

$\underbrace{O_2 + N_2}_{\text{Air}} \longrightarrow 9.06$

100 kg air 77 kg N_2

9.06 Kg air —— $\frac{77 \times 9.06}{100}$

(73) = 6.97 Kg of N_2

CO_2	1.906	$\frac{1.906}{10.05} \times 100$	= 18.96 %
H_2O	1.17	$\frac{1.17}{10.05} \times 100$	= 11.64 %
N_2	6.97	$\frac{6.97}{10.05} \times 100$	= 69.35 %
	10.05		

B) 4 | 2

4-5 g p. [illegible] | 2-5 [illegible]

[illegible] | [illegible]

TM rotation [illegible] | [illegible]

↓

heavy [illegible] | ↓

Power for same [illegible] Stroke | More [illegible]

Low rate of wear [illegible] [illegible] lubricant | [illegible] more lubr parts

Vaulting ↓ light [illegible] | [illegible]

η_{vol} more | η_{vol} less

η_{th} ↑ | η_{th} ↓

Brake Heat [illegible]