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CALCULATION FOR IC ENGINE :-

1. Calculation for volume :

a) 2-STROKE ENGINE :

- One cycle — One Rotation
- One cycle = One suction process
= vol^{m} of air taken in Vs

∴ For N Rotation = vol^{m} of air taken $\boxed{V_s \times N}$ *

b) 4-STROKE ENGINE :-

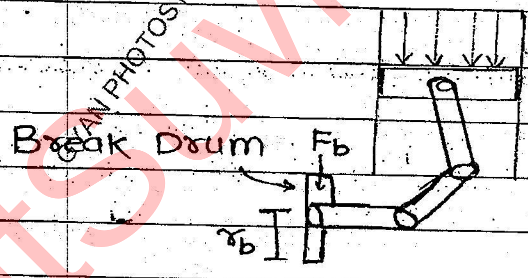
→ One cycle = 2 Rotation

One suction = Vol^{m} of air taken in $\boxed{V_s}$

∴ Avg. Vol^{m} For one Rotation = $\boxed{V_s/2}$

For N Rotation, vol^{m} of air = $\boxed{\frac{V_s}{2} \times N}$ **

2. Mechanical efficiency :-



→ For input to piston p & v of the gases change, This input to the piston is Found from P-V diagram. PV-dig. is also known as the 'indicator dig.' Hence input to the piston is called the 'indicated WD' (IWD)

- The work output of a piston is a energy available at the shaft of the engine which is found by a break mechanism. (Dynamometer). Thus the work output of the piston is called Break WD. (BWD)

↳ The Ratio of (BWD) to (IWD) is known as the mechanical eff of the engine & is given by.

$$\boxed{\eta_{bm} = \frac{BWD}{IWD}} \quad \text{— [a]}$$

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$\Rightarrow \eta_{bm} = \frac{BWD}{IWD} = \frac{bmep \times V_s}{imep \times V_s}$

$\Rightarrow \boxed{\eta_{bm} = \frac{bmep}{imep}}$ —— (b)

3. POWER :

↳ Rate of Doing work.

power : $P = \frac{WD}{time}$

$\Rightarrow \boxed{P = \frac{WD}{Sec}}$ $\left(watt = \frac{Joule}{sec} \right)$

4. Calculation For Break power :–

Let the speed of the engine is N RPm

$B.P = \frac{B.WD}{Sec} \Big| \frac{B.Force \times Displacement}{sec}$

$\Rightarrow \boxed{B.P = F_b * 2\pi r_b * \frac{N}{60}}$ ***

5. HEAT ADDED & CALORIFIC VALUE :–

– Calorific value = HA | Kg of Fuel.

∴ $\boxed{\text{Heat added per sec} = \text{Calorific value} \times \frac{m}{sec}}$

$\boxed{\frac{HA}{Sec} = \frac{HA}{Kg\ of\ Fuel} \times \frac{mass}{sec}}$ **

Vol^{m} of Fuel per sec = $\frac{V_{Fuel}}{cycle} \times \frac{\text{No. of cycle}}{sec}$

$$\boxed{\eta_{BT} = \frac{BWD}{HA}} \quad \& \quad \boxed{\eta_{IT} = \frac{IWD}{HA}}$$

7. Specific Fuel Consumption (SFC)

$$\boxed{SFC = \frac{m_f/hour}{power(kW)}}$$

and Break SFC = $\frac{m_f/hour}{B.power(kW)}$

and Indicated SFC = $\frac{m_f/hour}{I.power(kW)}$

8. Specific gravity OR Relative Density :-

$$Sp.\ gravity = \frac{\rho}{\rho_{water}} \quad \text{and } \rho_{water} = 1\ gm/cm^3 = 1000\ kg/m^3$$

$$\Rightarrow \boxed{\rho = Sp.\ gravity \times 1000}$$

9. Average piston speed :-

$$= \cancel{2LA}\ \boxed{2LN}$$

Ques:- Ch-4 → Q-5 : (Indicated power = input)

$\eta_m = 0.8$, B. power = 60

I.P = ? F.P

$\eta_m = \frac{B.P}{IP} \Rightarrow I.P = 60/.8 = 75$

∴ FP =

** Input = Ind. power
Output = Break power

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Q: 9) 2 cyl. 4 stroke — to proceed the ques by taking only one cyl.

B. power = 15 kW,
i.e 7.5 kW per cylinder.

N = 2400 rpm

Bsfc = .268 kg/kW hr , ρ = .85×1000 = 850

$\frac{Vol}{cycle} = ?$

→ $\frac{Vol}{sec} = \frac{Vol}{cycle} \times \frac{N}{2\times60}$

Now bsfc = $\frac{m_f/hour}{B.power(kW)}$

$= \frac{m_f/hour}{7.5}$

⇒ m_f/hour = .268×7.5 = 2.01 kg/hour.

m_f/sec = 5.58×10^{-4} kg/sec

∴ vol/sec = $\frac{m}{\rho}$ = $\frac{5.58\times10^{-4}}{850}$ = 6.568×10^{-7}

Now $\frac{vol}{sec} = \frac{vol}{cycle} \times \frac{N}{2\times60}$

⇒ $\frac{6.568\times2\times60\times10^{-7}}{2400} = \frac{vol}{cycle}$.

$= 0.033\times10^{-6}$ m3 (b)

Ques:- 14) $\dot{m}_f$ = 10 gm/sec, B.P = 160 kW,
→ m_f = 10×3600×10^{-3} kg/hr = 36 kg/hr

η_m = .75 , ind sfc = ?

Now $\eta_m = \frac{B.P}{IP}$ ⇒ $IP = \frac{160}{.75}$ = 213.33 kW

Now ind sfc = $\frac{m_f/hour}{i.power(kW)}$

= .1687 kg/kWh.

Ques:- 15) $\frac{m_F}{m_a} = 0.05$, $\eta_v = .9$, imep = 6 bar

HA/kg of fuel = 45000 kJ/kg. $\rho_a = 1$ kg/m3

$\eta_{IT} = ?$

Soln :- $\eta_{IT} = \frac{WD}{HA}$

and HA =

IWD = imep x Vs

∵ IWD = imep x V

$m_a = \frac{m_f}{0.05} = \frac{1}{0.05} = 20$ kg/kg fuel

$\rho_a = \frac{m_a}{V_a} \Rightarrow V_a = \frac{20}{1} = 20$ m³/kg fuel

kg fuel. $\eta_v = \frac{V_a}{V_s} \Rightarrow V_s = \frac{V_a}{.9}$

$= (6\times10^5) \times \frac{20}{.9}$

$= 133.33 \times 10^5$ watt

∴ $\eta_{IT} = \frac{IWD}{HA} = \frac{133.33\times10^5}{45000\times1000} = 0.296$

29.6 %

Ques:- (T1)

area of P-v dig provide IWD

∴ IWD = 23.625 x 105 x Vc joule

Now imep x Vs = IWD

⇒ imep x Vs = 23.625 x 105 x Vc

⇒ imep x $\frac{V_s}{V_c}$ = 23.625 x 105 x Vc

⇒ imep x 4.5 $\cancel{V_c}$ = 23.625 x 105 x $\cancel{V_c}$

⇒ imep = 5.25 bar

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

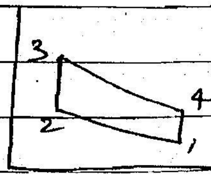
$5.5 = \frac{V_s + V_c}{V_c}$

⇒ Vs = 4.5Vc

(T3) r = 10, $T_1 = 300$, $P_1 = 100$ KPa,

HA = 700 kJ/kg, ~~R~~ = .287, HA = 1500 kJ/kg

mep = ?



$r = \frac{V_c + V_s}{V_c} = \frac{V_2 + V_1}{V_2} = V_1 = 9V_2$

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For 1kg of air

$PV = mRT$

$\Rightarrow V_1 = \frac{m_1 R T_1}{P_1} = 0.861\ m^3$

$\Rightarrow V_c = \frac{V_s}{9} \rightarrow$ from eq (1)

$\cancel{V_c = 0.0957\ m^3}$

$V_s + V_c = V_1$

$\Rightarrow V_s + \frac{V_s}{9} = .861 \Rightarrow V_s = 0.775 m^3$

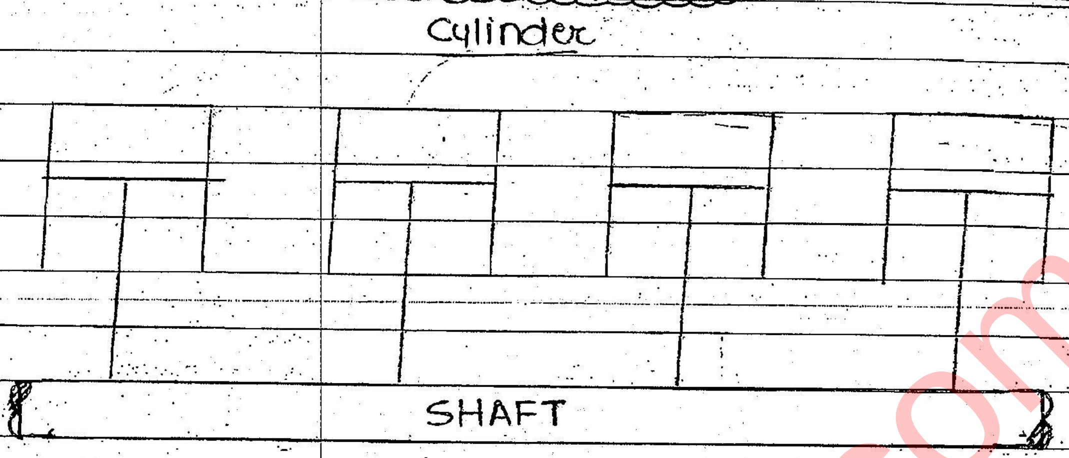
Now: $WD = HA - HR$

$\Rightarrow P_m \times V_s = 800 \times 1000$

or $P_m \times .77 = \frac{800 \times 1000}{.77} = 10.3$ bar

TESTING OF I.C ENGINES

(Molsey Key tests):-



→ All cylinder is connected with one shaft.

→ from this test we find "ind. power". Friction power is find by "motoring test"

↳ let us consider a 4-cylinder Engine.

and let: ind. power = I

B. power = B

F. power = F

To begin the molsey test, the engine is tested with all the cylinder is working (By a break mechanism) Thus the break power is obtain.

↳ we have four eqn

$$4I = 4B + 4F \quad — (1)$$

Later the engine is tested by cutting of one cylinder at a time (For the Diesel engine the Fuel suppy is cut & the spark plug is short-circurred in the case of Petrol engine). 4- different reading is obtain for 3 working sylinder. If this Readings are $3B_1$, $3B_2$, $3B_3$, $3B_4$, we then have.

$$\boxed{3B = \frac{3B_1 + 3B_2 + 3B_3 + 3B_4}{4}}$$

↳ We have 3 working cylinders.

$$3I = 3B + 4F \quad \text{—(2)}$$

Now eq(i) − eq(2)

$$\boxed{I = (4B - 3B)}$$

∴ Indicated power of the engine

$$\boxed{I = 4(4B - 3B)}$$

∴ mechanical eff :—

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

The following point are to be noted

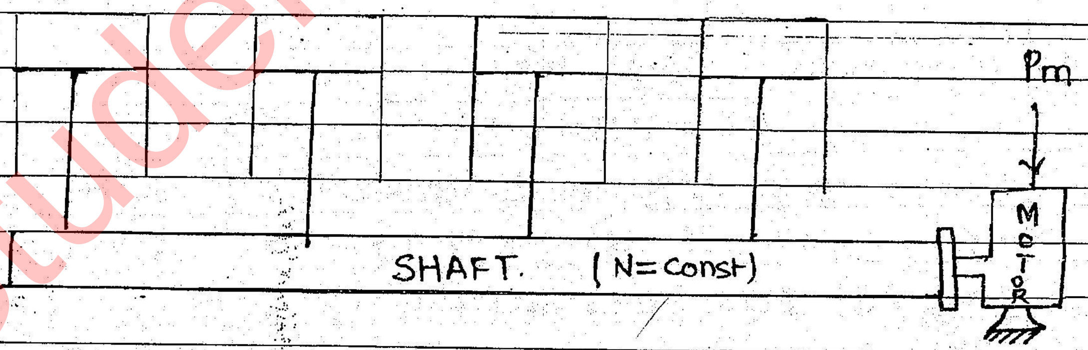
1. No any algebra used Here

i.e $4B \neq 4B \neq 4 \times B$

$\therefore 4B - 3B \neq B$

$(4B - 3B) \neq (3B - 2B)$

MOTORING TEST :—



↳ motoring test is used for finding the frictional power of engine.

↳ The following point are to be noted

1. The speed of the engine during Morse test must be Recorder

AF	idling	Cruising	High-power
	0–15	15–30	>60

2) The engine must be put-off befor starting the motoring test.

3) After attaching the motor to the engine shaft, the speed of the motor must be kept same as that of engine during mosley test. Then the power input to the motor is equal to friction power of motor.

4) If the mech. eff. of motor is given then

$$\boxed{\text{Frictional power} = \text{power of motor} \times \eta_m}$$

η_m → eff. of motor

SUPER CHARGER :–

→ increase mass flow Rate in the cyl. & so that mech. eff. increases (if 35% then more than 50%.)

↳ It is a compressor (Reciprocating) ✗
Rotating compressor used ✓

↳ Two type. a) Engine is used to Rotate compr.
b) Exhaust gas is used to Rotate turbine & then shaft of turbine is connect to compr. shaft & drive it and so called Turbocharger

↳ in Aeroplane about 2 Time A.F mixture Required
if motor : 16–1 then aeroplane : 8–1 (because air is less above the earth)

→ After using supercharge SFC decreases

$$\downarrow SFC = \frac{m_f}{\text{power}\uparrow}$$

→ more power produce so $\eta_m \uparrow$

→ Scavenging is better after using supercharger

→ Some Disadv

→ Force ↑ so piston, bearing etc damage

→ at time of compression, supercharger also sent some air to pres. more increase so Leakage occure & knocking also happenes

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– knocking in Petrol engine is more so when we introduce supercharger the press increase more & knocking increases.

Super charger :

↳ Super charger is a Rotary compressor.

↳ A super charger is used as more mass of air ~~is~~ can be circulated to the engine

↳ The air after Compresson in supercharger will have a press which is 1.5 times to 2 time the suction press.

↳ There are two types of supercharger. In one super charger, it is driven by the engine shaft. In another supercharger, the exhaust gas enters in a turbine & the turbine drives the supercharger. such a Supercharger is known as turbocharger.

↳ The following are the adv. of a Supercharged engine over a normal engine.

1. Higher work & power output, due to which thermal eff. of a Supercharged engine is much high.

II) At high altitude (flight of aircraft) there is a saving of fuel consumption due to supercharging.

iii) The S.F.C is less in a supercharged engine

4. The volm eff of a supercharged engine is higher

5) Energy in the exhaust gas is utilised to Run the turbocharger.

6. Scavenging is much better in a supercharged engine.

Disadvantages of supercharger:-

i) Higher thermal stress in the different moving part in the engine, Resulting more friction loss and frequent ~~leak~~ Replacement of parts including the bearing of the shaft, becomes neccesary.

ii) The leakage of air past the piston, is more during the compression stroke of a s.ced engine.
→ supercharged

3. After supercharging, the temp of the charge is higher, this increases knocking in petrol engine

4) To Reduce knocking, an engine cooler is used b/w the supercharger & engine cylinder of a petrol engine. This increases the overall size of the engine

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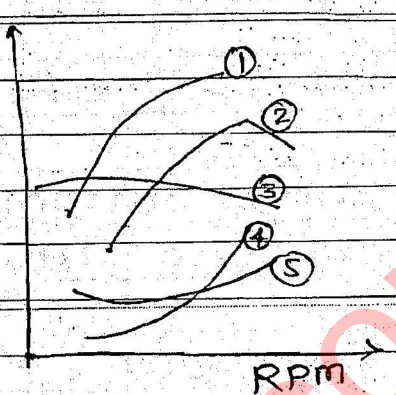
ch-4

Q:1 → $IP = \frac{IWD}{sec} = \frac{imep \times V_s}{sec}$

$= \frac{imep \times V_s}{cycle} \times \frac{N}{2}$



→ $\eta_{vol} = \frac{V_a/sec}{V_s/sec}$

$= \frac{V_a/sec}{\frac{V_s}{cycle} \times \frac{N}{2}}$

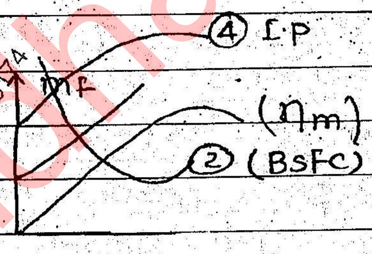
BP = I.P − FP

sp. fuel consumption:

Ques:2 $m_f \propto B.P$

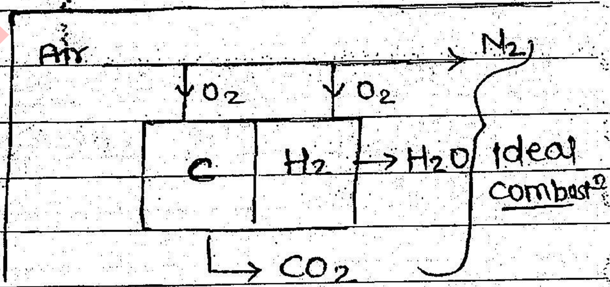
$m_f = b * BP$

and $\boxed{m_f = a + b * BP}$



— $\eta_m = \frac{B.P}{I.P}$

— $BsFc = \frac{m_f}{B.P}$



8) $4B = 3037$

$3B = \frac{3B_1 + 3B_2 + 3B_3 + 3B_4}{4}$

$= \frac{2102 + 2102 + 2100 + 2098}{4} = 2100.5$ kW

now $4I = \overset{3037}{4B} + 4F$ —(1)

and $3I = 2100.5 + 4F$ —(2)

$I = 936.5$

$IP = 4 \times I = 4 \times 936.5 =$

$\eta_m = \frac{B.P}{I.P} = .8107$

C - 85%
H - 15%

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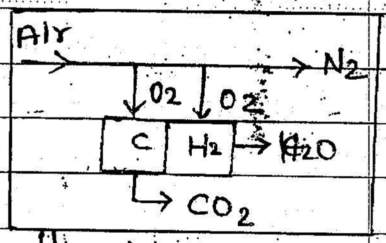
→ In Diesel engine is all parameter is High but $SFC = \frac{2}{3}(SFC)_{petrol}$

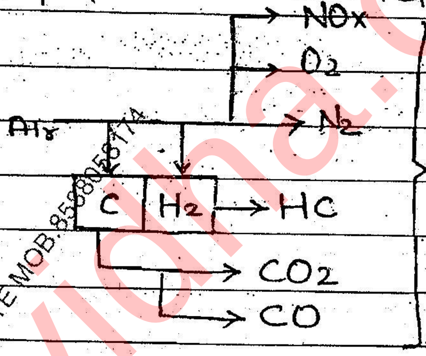
✳ COMBUSTION IN SI ENGINE :- *****

1. Stoichiometric Air Fuel Ratio :-

↳ when the combustion of Fuel take place in such a manner that there is no Fuel Remaining in any form nor is any free oxygen left after comb.



↳ ideal comb.
i.e complete comb. of Fuel.



actual comb.
(i.e some Fuel Remain unburnt)

then the comb. is known as ideal & perfect comb.

The AFR is in such a comb. is known as Stoichiometric AFR

↳ The Stoichiometric AFR by mass b/w 13.4 to 15 & 9 to 9.6 by vol^m.

– Calorific value of Hydrogen is more than carbon
→ O_2 is First taken by Hydron & then carbon.