1/2/19 Testing of I.C engines

- The purpose of testing is to determine the information which cannot be obtained from calculations
- To validate the data assumed at the time of designing
- To satisfy the customer.

Indicated power :- The power developed with in the cylinder is known as 'Indicated power'.

Brake power :- The power available at the engine crank shaft is known as 'Brake power'.

Frictional power :- while transmitting the power from combustion chamber to the crank shaft through the piston and connecting rod. Due to friction, the power available at the crank shaft is less than the power ~~available~~ developed with in the engine. Therefore

~~extra~~ frictional power = Indicated power - brake power.

Indicated Mean effective pressure :- ~~I~~IMEP of an engine is obtained from the indicator diagram drawn with help of engine indicator. Therefore

$$IMEP = \frac{A \times S}{L}$$

where A = Area of indicator diagram

L = length of indicator diagram

S = spring index

→ Indicated power = $\frac{P_m L A n}{60}$ W

n = no. of working stokes/min

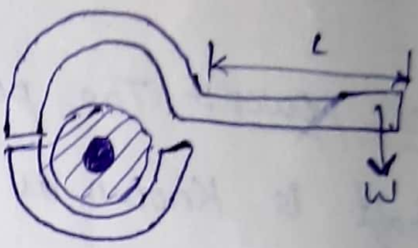
$n = N$ for 2-s

$n = \frac{N}{2}$ for 4-s

→ Brake power = The engine brake power can be calculated by using dynamometer

i) prony brake dynamometer

$$B.P = \frac{2\pi N T}{60} \text{ Watts}$$



$\therefore T = L \times W$

ii) Rope brake dynamometer

$$BP = \frac{\pi D N (W-S)}{60}$$

$$BP = \frac{\pi (D+d) N (W-S)}{60}$$

→ **Morse test:-**

It is used to find Indicated power developed by each cylinder of a multi cylinder engine with out using indicator diagram.

consider a 4 cylinder engine

when 4 cylinders are in working

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

when 1st cylinder is cutt off.

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

when 2nd cylinder is cut off

$$BP_2 = (IP_1 + IP_3 + IP_4) - (FP_1 + FP_2 + FP_3 + FP_4) \quad \text{--- (3)}$$

when 3rd cylinder is cut off

$$BP_3 = (IP_1 + IP_2 + IP_3) - (FP_1 + FP_2 + FP_3 + FP_4) \quad \text{--- (4)}$$

when 4th cylinder is cut-off

$$BP_4 = (IP_1 + IP_2 + IP_3) - (FP_1 + FP_2 + FP_3 + FP_4) \quad \text{--- (5)}$$

$$IP_1 = B.P - BP_1$$

$$IP_2 = BP - BP_2$$

$$IP_3 = BP - BP_3$$

$$IP_4 = BP - BP_4$$

→ **Mechanical efficiency :-**

$$\eta_{mech} = \frac{\text{brake power}}{\text{Indicated power}} \times 100$$

Overall efficiency :- It is defined as the ratio of work obtained at the crank shaft in a given time to the energy supplied by the fuel during the same time.

$$\eta_{overall} = \frac{\text{work obtained}}{\text{energy supplied}} = \frac{B.P}{m_f \times C.V}$$

Indicated thermal efficiency :- It is the ratio of heat equivalent in one KW hour to the heat in the fuel per I.P hour

$$\eta_{i.th} = \frac{I.P \times 3600}{m_f \times CV}$$

Brake thermal efficiency :-
(or)
(overall thermal efficiency)

$$\eta_{B.th} = \frac{B.P \times 3600}{m_f \times C.V}$$

Relative efficiency :- It is defined as the ratio of Indicated thermal efficiency to the air standard efficiency

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

$$\eta_{air(d)} = 1 - \frac{1}{r^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right].$$

→ Heat balance sheet

The complete record of heat supply and heat rejected in a given time (min/hour/sec) by an I.C engine is entered in a tabulated form known as heat balance sheet.

The following values are required to complete the heat balance sheet.

1. heat supplied by the fuel = mass of fuel per min.

2. heat absorbed in producing I.P = $P_M L A n$

P_M = mean effective pressure

3. heat rejected to cooling water = $m_w C_w \times (T_1 - T_2)$

M_w = mass of cooling water supplied in kg/min

C_{pw} = specific heat of water = 4.2×10^{-3} J/kg.K

T_1 = inlet temperature of water in K

T_2 = outlet temperature of water in K.

4. heat carried by exhaust gases = $m_g C_g (\Delta T)$

m_g = mass of exhaust gases produced kg/min

C_g = specific heat of exhaust gases J/kg k

ΔT = temp. rise of exhaust gases.

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5. Unaccounted losses :- These includes loss of heat due to friction, leakage, radiation etc. which cannot be determine experimentally. These losses can be obtained by substracting heat absorbed in producing I.P. C.W, and exhaust gases from total heat supplied.

S.NO	particulars	Heat (J/min)	%
1.	Total heat supplied	$m_f \times C.V$	100%
2.	Heat absorbed in producing I.P	$P_m LAn$	x
3.	heat absorbed by cooling water	$m_w C_w (\Delta T_w)$	y
4.	Heat carried by exhaust gases	$m_g C_g (\Delta T)$	z
5.	unaccounted gases	1 - (2+3+4)	100 - (x+y+z)

$$\frac{\;}{7.75} \times 10 = 64.9\%$$

⑥ A Four cylinder 2-stroke petrol engine develops 23.5×10^3 W brake power at 2500 rpm. The mean effective pressure on each cylinder is 8.5 bar and mechanical efficiency is 85%. calculate the diameter and stroke of each cylinder by assuming stroke length = 1.5 times the diameter

Sol

$B.P = 23.5 \times 10^3$

$N = 2500$ rpm

$P_m = 8.5 \times 10^5 \ N/m^2$

$\eta_{mech} = 0.85$. $L = 1.5d$, $n = N$

$$I.P = K\left(\frac{P_m L A n}{60}\right)$$

$$= \frac{4 \times 8.5 \times 10^5 \times 1.5d \times \pi(d^2) \times 2500}{4 \times 60}$$

$$I.P = 166897109.7\, d^3$$

$$\eta_{mech} = \frac{BP}{IP}$$

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

$$166897109.7\, d^3 = \frac{23.5 \times 10^3}{0.85}$$

$$166897109.7\, d^3 = 27647.05$$

$$\boxed{d = 0.055 \text{ m}}$$

$$\boxed{L = 0.082 \text{ m}}$$

7) During the test on single cylinder oil engine working on 4-stroke cycle fitted with rope brake dynamometer, the following readings are taken

1) effective dia of brake wheel = 630 mm.

2) Dead load on brake = 200 N

3) Spring balance reading = 30 N

4) Area of indicated diagram = 420 mm²

5) speed N = 450 rpm.

6) L = 60 mm

7) diameter of cylinder = 100 mm = 0.1 m

8) spring scale = 1.1 bar/mm

9) stroke length = 150 mm = 0.15 m

10) quantity of oil used m = 0.815 kg/hr

11) Calorific value of oil used C_v = 42000 kJ/kg.

calculate brake power, I.P, η_{mech}, brake thermal efficiency, brake specific fuel consumption.

Sol

$$P_m = \frac{A \times S}{L}$$

$$= \frac{420 \times 1.1}{60} = 7.7 \text{ bar}$$

$$I.P = \frac{P_m L A n}{60} \qquad n = \frac{N}{2}$$

$$= \frac{7.7 \times 10^5 \times 0.15 \times \frac{\pi}{4} \times (0.1)^2 \times \frac{450}{2}}{60}$$

$$\boxed{I.P = 3401.75 \text{ W}}$$

$$B.P = \frac{(W-S)\,\pi\,(D_b + d_r)\,N}{60}$$

$$= \frac{(200-30)\,\pi\,(0.63+0)\,450}{60}$$

$$\boxed{B.P = 2523.48\ W}$$

$$\eta_{mech} = \frac{BP}{IP} \times 100$$

$$= \frac{2523.48}{3401.75} \times 100$$

$$\boxed{\therefore \eta_{mech} = 74.18\,\%}$$

$$\eta_{bth} = \frac{B.P \times 3600}{m_f \times C.V}$$

$$= \frac{2523.48 \times 3600}{0.815 \times 42000 \times 10^3} \times 100$$

$$\boxed{\therefore \eta_{bth} = 26.5\%}$$

$$B.S.F.C = \frac{BP}{m_f} = \frac{2.523\ kW}{0.815}$$

$$= 3.09\ kg.kW/hr$$

(8) A 4 cylinder engine running at 1200 rpm develops 18.6 kW brake power. The average torque when one cylinder was cut out was 105 N-m. Determine indicated thermal efficiency if calorific value of fuel is 42000 KJ/kg and the engine uses 0.34 kg of petrol per brake power hour.

Brake power when 4 cylinders acting = 18.6 KW

For single cylinder = 4.65 KW

for 3 cylinder = 13.95 KW

$$\text{brake power} = \frac{2\pi NT}{60}$$

$$= \frac{2 \times \pi \times 1200 \times 105}{60}$$

$$= 13.19 \text{ KW}$$

$$\text{Frictional power/cyl} = 13.95 - 13.19 = 0.76 \text{ /cyl.}$$

$$\text{For 4-cyl} = 4 \times 0.76 = 3.04 \text{ KW}$$

$$I.P = B.P + F.P$$

$$= 18.6 + 3.04$$

$$\therefore I.P = 21.64 \text{ KW}$$

$$\eta_{ith} = \frac{I.P \times 3600}{m_f \times CV}$$

$$= \frac{21.64 \times 3600}{6.324 \times 42000} \times 100$$

$$\left[\therefore m_f = 0.34 \text{ kg/BP-hr} = 0.34 \times 18.6 = 6.324 \text{ kg/hr} \right]$$

$$\therefore \eta_{ith} = 29.33\%$$

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(9) The diameters and stroke length of single cylinder 2-stroke gas engine working on constant volume cycle are 200mm and 300mm respectively with clearance volume as 2.78 lit. when the engine is running at 135 rpm, the IMEP was 5.2 bar and gas consumption 8.8 m^3/hr. If CV of gas used is 16350 KJ/m^3, Find Air standard efficiency, Indicated

power, and Indicated thermal efficiency.

$$r = \frac{V_c + V_s}{V_c} \Rightarrow \frac{\frac{\pi}{4} d^2 L}{2.78 \times 10^{-3}}$$

$$= \frac{\frac{\pi}{4} \times (0.2)^2 \times (0.3)}{2.78 \times 10^{-3}}$$

~~$\therefore r = 3.427$~~

~~Air standard efficiency $= 1 - \frac{1}{(r)^{\gamma-1}}$~~

~~$= 1 - \frac{1}{(3.427)^{1.4-1}} \times 100$~~

~~$= 0.389 \times 100$~~

~~$= 38.9\%$~~

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

$$= \frac{2.78 \times 10^{-3} + \frac{\pi}{4} \times (0.2)^2 \times 0.3}{2.78 \times 10^{-3}}$$

$$r = 4.39$$

Air standard efficiency $= 1 - \frac{1}{(r)^{\gamma-1}} \times 100$

$$= 1 - \frac{1}{(4.39)^{1.4-1}} \times 100$$

$$= 44.6\%$$

Indicated power $= \frac{P_m L A n}{60} w$

$$= \frac{5.2 \times 10^5 \times 0.3 \times \frac{\pi}{4} \times (0.2)^2 \times 135}{60}$$

$$I.P = 11.02 \text{ KW}$$

$$\eta_{ith} = \frac{I.P \times 3600}{m_f \times CV}$$

$$= \frac{11.02 \times 3600}{8.8 \times 16350}$$

$$= 27.5\%$$

27.5%

$$\eta_{rel} = \frac{\eta_{air}}{\eta_{ith}}$$

$$= \frac{0.446}{0.275}$$

$$= 1.62$$

(11) A 4-stroke petrol engine 80 mm bore and 100mm stroke is tested at full throttle at constant speed. The fuel supply is fixed at 0.068 kg/min and the plugs of 4 cylinders are successively short circuited with out change of speed, brake torque being correspondingly adjusted. The brake power measurements are as follows.

with all cylinders firing 12.5KW with cylinder 1 cut-off

With cylinder 2 cut-off $BP_1 = 9$ kw

3 cut-off $BP_2 = 9.15$ kw

$BP_3 = 9.2$ kw

$BP_4 = 9.1$ kw

CV = 44100 kJ/kg.

determine Indicated power and relative efficiency if Calorific value of fuel is 44100 kJ/kg. and clearance volume of one cylinder is 70×10^3 mm^3

50

$d = 80$ mm, $L = 100$ mm, $m_f = 0.068$ kg/min

C.V = 44100 kJ/kg. $V_c = 70 \times 10^3$ mm^3.

$IP = IP_1 + IP_2 + IP_3 + IP_4$

$= (BP - BP_1) + (BP - BP_2) + (BP - BP_3) + (BP - BP_4)$

$= 3.5 + 3.35 + 3.3 + 3.4$

I.P = 13.55 kW

F.P = IP − BP ⇒ 13.55 − 12.5

F.P = 1.05 kW

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$$\eta_{ith} = \frac{I.P \times 60}{m_f \times C.V}$$

$$= \frac{13.55 \times 60}{0.068 \times 44100} = 27.1\%$$

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

$$r = \frac{V_s + V_c}{V_c} = \frac{\frac{\pi}{4} \times d^2 L + 70 \times 10^3}{70 \times 10^3}$$

$$= \frac{\frac{\pi}{4} \times (80)^2 \times 100 + 70 \times 10^3}{70 \times 10^3}$$

$$\boxed{r = 8.18}$$

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

$$\boxed{\eta_{air} = 56.8\%}$$

$$\eta_{rel} = \frac{\eta_{air}}{\eta_{ith}} = \frac{0.568}{0.271}$$

$$\boxed{\eta_{rel} = 2.1\%}$$

(12) A 4-stroke diesel engine has a cylinder bore 150mm, stroke 250mm. The crank shaft speed is 300 rpm. fuel consumption 1.2 Kg/hr, calorific value = 39900 KJ/kg, P_{Mean} = 5.5 bar compression ratio = 15, cut-off ratio = 1.8. calculate relative efficiency.

(13) A petrol engine has cylinder of bore 60mm, and stroke 100mm. If mass of charge admitted 0.0002 kg/cycle find the volumetric efficiency of engine. R = 287 J/kg K.

Sol

$d = 60mm, \quad L = 100\ mm$

$m = 0.0002\ kg, \quad R = 287\ J/kg\ K$

$PV_a = mRT$

$$V_a = \frac{mRT}{P} = \frac{0.0002 \times 287 \times 273}{1.013 \times 10^5}$$

$$\therefore V_a = 1.54 \times 10^{-4}\ m^3$$

$$V_s = \frac{\pi}{4} d^2 L \Rightarrow \frac{\pi}{4} \times (0.06)^2 \times 0.1$$

$$\therefore V_s = 2.82 \times 10^{-4}\ m^3$$

$$\eta_{vol} = \frac{V_a}{V_s} \times 100$$

$$= \frac{1.54 \times 10^{-4}}{2.82 \times 10^{-4}} \times 100$$

$$\boxed{\eta_{vol} = 54.6\%}$$

(14) Find the engine dimension of 2-cylinder 2-stroke I.C engine with the following data

engine speed = 4000 rpm

Volumetric efficiency = ~~87~~ %

$\eta_{mech} = 75\%$

fuel consumption = 10 lit/hr

Specific gravity of fuel = 0.73

Air fuel ratio $\frac{M_a}{M_f} = \frac{18}{1}$

(2LN) piston speed = 600 m/min

P_{mean} = 5 bar

Find also brake power take R = 281 J/kg K at S.T.P

Sol.

$$\eta_{vol} = 0.77 = \frac{V_a}{V_s}$$

$$m_f = 10 \, lit/hr = 10 \times 10^{-3} \, m^3/hr \times 730 \, kg/m^3$$

$$= 7.3 \, kg/hr$$

$$S.g_f = 0.73 \Rightarrow \rho_f = 730 \, kg/m^3$$

$$\frac{m_a}{m_f} = \frac{18}{1} \Rightarrow m_a = 18 \, m_f = 18 \times 7.3 = 131.4 \, kg/hr$$

$$2LN = 600 \, m/min$$

$$L = \frac{600}{2N} = \frac{600}{2 \times 4000} = 0.075 m$$

$$P_{mean} = 5 \, bar$$

$$V_a = \frac{m_a R T}{P}$$

$$= \frac{131.4}{3600} \times \frac{281 \times 288}{1.013 \times 10^5}$$

$$\therefore V_a = 0.029 \, m^3/s$$

$$\eta_{vol} = \frac{V_a}{2\left(\frac{\pi}{4} d^2 L \times \frac{N}{60}\right)}$$

$$0.77 = \frac{0.029}{2\left(\frac{\pi}{4} \times d^2 \times 0.075 \times \frac{4000}{60}\right)}$$

$$d = 0.0692 \, m$$

$$d = 69.2 \, mm$$

$$\eta_{mech} = \frac{BP}{IP}$$

$$IP = 2\left(\frac{P_m L A n}{60}\right)$$

$$= 2\left(\frac{5\times10^5 \times 0.075 \times \frac{\pi}{4}\times(0.069)^2 \times 4000}{60}\right)$$

$$\therefore I.P = 18.69\ KW$$

$$0.75 = \frac{BP}{18.69}$$

$$BP = 0.75 \times 18.69$$

$$\therefore BP = 14.01\ KW$$

(15) An I.C engine uses 6 kg of fuel having calorific value 44000 KJ/kg in one hour. The I.P developed is 18 KW. The temperature of 11.5 kg of cooling water was found to rise through 25°C per min. The temperature of 4.2 kg of exhaust gas with specific heat 1 KJ/kg K was found to rise through 220°C. Draw the heat balance sheet for the engine per min basis.

So

$$\text{total heat} = m_f \times CV$$

$$= \frac{6}{60} \times 44000$$

$$= 4400\ KJ/min$$

Heat equivalent to I.P = 18 KJ/sec = 1080 KJ/min ——— 24.5%

Heat carried by cooling water = $M_{cw}\, C_{cw}\, \Delta T_{cw}$

$$= 11.5 \times 4.2 \times 25$$

$$= 1207.5\ KJ/min$$ ——— 27.4%

Heat carried by exhaust gases $= m_{eg} \cdot C_{eg} \, \Delta T_{eg}$

$= 4.2 \times 1 \times 220$

$= 924$ kJ/min ——— 21.0%

un accounted losses = ① − ② + ③ + ④

$= 4400 - 1080 + 1207.5 + 924$

$= 1188.5$ kJ/min ——— 27.1%

3211.5

S.No	particular	Heat in kJ/min	%
①	Total heat	4400	100%
②	Heat equivalent to I.P	1080	24.5%
③	Heat carried by cooling water	1207.5	27.4%
④	Heat carried by exhaust gases	924	21.%
⑤	unaccounted losses	1188.5	27.1%

(16) A gas engine working on 4-stroke constant volume cycle gave falling results when loaded by friction brake during a test of an hour duration.

cylinder diameter = 240 mm

stroke length = 480 mm

Clearance volume = 4450×10^{-6} m^3

effective circumference of brake wheel = 3.86 m.

Net load (W−S) = 1260 N

Speed = 226.7 rpm

average explosions per min = ~~76~~ 77

Mean effective pressure = 7.5 bar

gas used = $13 m^3/hr$

at 15°c, 771 mm of Hg, calorific value 49350 kJ/m^3

at NTP. Mass of cooling water = 660 kg/min

temperature raised = 34.2°c

Heat lost to exhaust gases = 8%

calculate (i) IP (ii) BP (iii) η_{ith} (iv) η_{Bth} (v) η_{mech}

(v) Efficiency ratio and also draw heat balance sheet.

$$I.P = \frac{P_m L A n}{60}$$

$$= \frac{7.5 \times 10^5 \times (0.48) \times \frac{\pi}{4} \times (0.24)^2 \times 77}{60}$$

$\therefore$ I.P = 20.9 KW

$$B.P = \frac{(W-S)\pi(D_b + d_r)N}{60}$$

$\pi D = 3.88$

$$= \frac{1260 \times \pi D \times 226.7}{60}$$

B.P = 18.3 KW

$$\frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1}$$

$$V_0 = \frac{771 \times 13 \times 273}{288 \times 760}$$

$V_0 = 12.5 m^3/hr$

$$\eta_{ith} = \frac{I.P \times 3600}{m_f \times CV}$$

$$= \frac{20.9 \times 3600}{12.5 \times 49350} = 12.19\%$$

$$\eta_{bth} = \frac{BP \times 3600}{V_0 \times C.V} = \frac{18.3 \times 3600}{12.5 \times 49350}$$

$= 10.6\%$

$$\eta_{mech} = \frac{B.P}{I.P} \times 100$$

$$= \frac{10.6}{12.19} \times 100 = 87.6\%$$

$$\eta_{rel} = \frac{\eta_{air}}{\eta_{ith}}$$

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

$$= \frac{4450\times10^{-6} + \frac{\pi}{4}\times(0.24)^2 \times 0.\ldots}{4450\times10^{-6}}$$

$$\boxed{r = 5.87}$$

$$\eta_{air} = 1 - \frac{1}{r^{\gamma-1}}$$

$$= 1 - \frac{1}{(5.87)^{1.4-1}} \times 100$$

$$\boxed{\eta_{air} = 50.7\%}$$

$$\eta_{rel} = \frac{\eta_{air}}{\eta_{ith}} = \frac{0.507}{0.121} = 4.19\%$$

Heat balance sheet.

$$\text{total heat supplied} = W_f \times C.V$$

$$= 12.5 \times 49350$$

$$= 616875 \text{ KJ/hr}$$

$$\text{Heat equivalent to I.P} = 20.9 \times 60 \times 60$$

$$= 75240 \text{ KJ/hr} \text{ — } 12.19\%$$

$$\text{Heat carried by cooling water} = m_{cw}\, C_{cw}\, \Delta T_{cw}$$

$$= 660 \times 4.2 \times 34.2$$

$$= 94802.4 \text{ KJ/min} \text{ — } 15.3\%$$

$$\text{Heat equivalent to exhaust gases} = \frac{8}{100} \times 616875$$

$$= 49350 \text{ KJ/hr.} \text{ — } 8\%$$

particulars	SI engine (petrol)	CI engine (diesel)
compression ratio	8 to 10	15 to 20
Air fuel ratio	8:1 to 10:1 (14.7:1)	15:1 to 18:1 (70:1)
calorific value	45800 KJ/kg	45500 KJ/kg
Flash point	-43°c	>52°c
S. I. T	260°c	210°c
comp. temp	350°c	600°c to 700°c
comp. pr	20 bar	depends on C.R (C.R x 1 bar)
comb. temp	1000°c	2500°c
comb. pr	50 bar	100 bar.

...as to transform the normal battery voltage (6 to 12 volts) to 8000 volts. In addition to this, the ignition system has to provide spark in each cylinder at the appropriate time. Following two ignition systems of petrol engines are important from the subject point of view :

1. Coil ignition system, and 2. Magneto ignition system.

These ignition systems are discussed, in detail, in the following pages :

26.29. Coil Ignition System

It is also known as *battery ignition system*, and has an induction coil, which consists of two coils known as primary and secondary coils wound on a soft iron core, as shown in Fig. 26.17. The primary coil consists of a few hundred turns (about 300 turns) of wire. Over this coil, but insulated from it, are wound several thousand turns (about 20,000 turns) of secondary coil. The one end of the primary coil is connected to a ignition switch, ammeter and battery generally of 6 volts. The other end of the primary coil is connected to a condenser and a contact breaker.

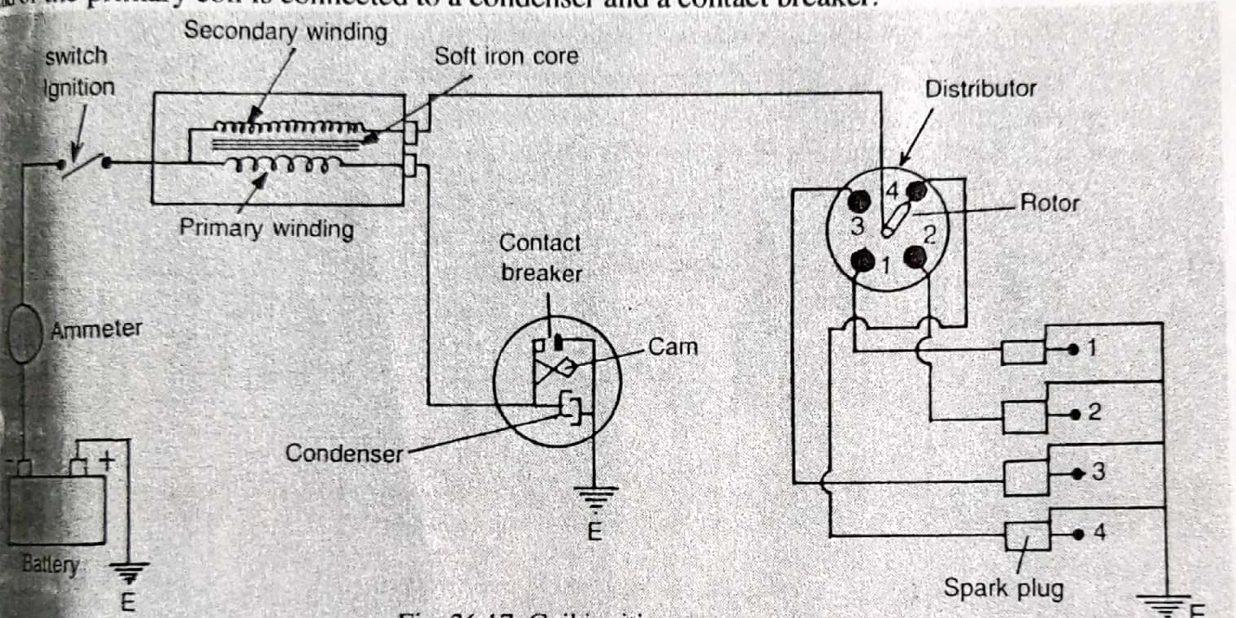


Fig. 26.17. Coil ignition system.

A condenser is connected across the contact-breaker for the following two reasons :

1. It prevents sparking across the gap between the contact breaker points
2. It causes a more rapid break of the primary current, giving a higher voltage in the secondary circuit.

The secondary coil is connected to a distributor (in a multi-cylinder engine) with the central terminal of the sparking plugs. The outer terminals of the sparking plugs are earthed together, and connected to the body of the engine.

When the current flows through the primary coil, it sets up a magnetic field which surrounds both the primary and secondary coils. As the switch is on, the contact-breaker connect the two ends. The magnetic field in coils has tendency to grow from zero to maximum value. Due to this change of the magnetic field, a voltage is generated in both the coils, but opposite to the applied voltage (of battery). Thus the primary coil does not give the final value. The voltage in the secondary coil is, therefore, not sufficient to overcome the resistance of the air gap of the sparking plug, hence no spark occurs.

When the current in the primary coil is switched off by the moving* cam, the magnetic field generated around the coil collapses immediately. The sudden variation of flux, which takes place, gives rise to the voltage generated in each coil. The value of the voltage depends upon the number

* A four lobed cam for four cylinder engine is an essential component of the make and break arrangement. It is rotated at half the engine speed.

of turns in each coil. As a matter of fact, the voltage required to produce a spark across the g between the sparking points, is between 10 000 to 20 000 volts. Since the secondary coil has sev thousand turns, so it develops a sufficient high voltage to overcome the resistance of the gap of sparking plug. This high voltage then passes to a distributor. It connects the sparking plugs in rotat depending upon the firing order of the engine. Hence, the ignition of fuel takes place in all the eng cylinders.

The coil ignition system is employed in medium and heavy spark ignition engines such as cars.

26.30. Magneto Ignition System

The magneto ignition system, as shown in Fig. 26.18, has the same principle of working that of coil ignition system, except that no battery is required, as the magneto acts as its own generato

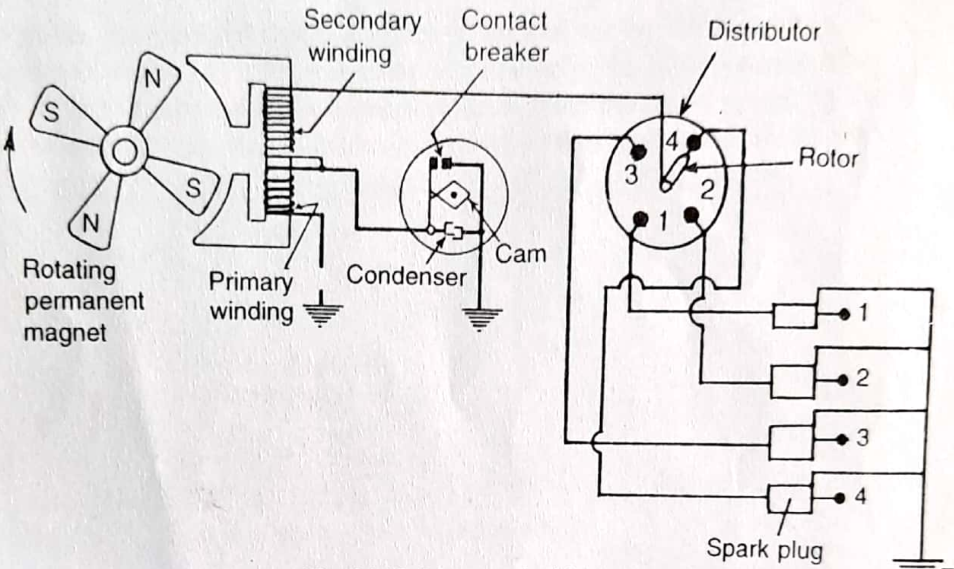


Fig. 26.18. Magneto ignition system.

It consists of either rotating magnets in fixed coils, or rotating coils in fixed magnets. The current produced by the magneto is made to flow to the induction coil which works in the same way as that of coil ignition system. The high voltage current is then made to flow to the distributor, which connects the sparking plugs in rotation depending upon the firing order of the engine.

This type of ignition system is generally employed in small spark ignition engines such as scooters, motor cycles and small motor boat engines.

26.31. Fuel Injection System for Diesel Engines

The following two methods of fuel injection system are generally employed with diesel engines (*i.e.* compression ignition engines) :

1. Air injection method, and 2. Airless or solid injection method.

These methods are discussed, in detail, as follows :

1. *Air injection method.* In this method of fuel injection, a blast of compressed air is used to inject the fuel into the engine cylinder. This method requires the aid of an air compressor which is driven by the engine crankshaft. The air is compressed at a pressure higher than that of engine cylinder at the end of its compression stroke. This method is not used now-a-days because of complicated and expensive system.

2. *Airless or solid injection method.* The most modern compression ignition engines use, now-a-days, the solid injection system. In this method, a separate fuel pump driven by the main crankshaft is used for forcing the fuel. The fuel is compressed in this pump to a pressure higher than that of engine cylinder at the end of compression. This fuel under pressure is directly sprayed into

Function of Lubrication

To reduce friction and wear between the moving parts
To provide sealing action
To cool the surfaces by carrying away the heat generated in engine components
To clean the surfaces by washing away carbon and metal particles caused by wear
Is to provide sufficient quantity of cooled & filtered oil to give +ve and adequate lubrication to all the moving parts

The various lubrication system used for IC engine

Mist Lubrication
Wet sump Lubrication
Dry sump Lubrication

Mist Lubrication System

This system is used where crankcase lubrication is not suitable
In 2-stroke engine as the charge is compressed in the crankcase, it is not possible to have the lubricating oil oil in the sump
In such engines the lubricating oil is mixed with the fuel, the usual ratio being 3% to 6%
The oil and the fuel induced through the carburetor the fuel is vaporized and the oil is in the form of mist goes via the crankcase in to the cylinder
Advantage of this system
simplicity, low cost (does not required oil pump, filter)
Disadvantages
Causes heavy exhaust smoke
Get contaminated with acids and result in the corrosion of bearings surface
Calls for through mixing for effective lubrication (this requires either separate mixing prior to use of some additive to give the oil good mixing characteristics)
The engine will suffer from insufficient lubrication as the supply of fuel is less

Wet Sump lubrication System

The bottom of the crankcase contains an oil pan or sump from which the lubricating oil is pumped to various components by a pump
After lubricating the parts the oil flows back to the sump by gravity
There are 3 varieties in wet sump lubricating system
The splash system
The splash and pressure system
The pressure feed system

Splash System

This type of lubrication system is used in light duty engines.
The lubricating oil charged in to the bottom of the crankcase and maintained at predetermined level.
The oil is drawn by a pump and delivered through a distributing pipe in to the splash troughs
A splasher or dipper is provided under each connecting road cap

Splash & pressure lubrication system

The lubricating oil is supplied under pressure to main and camshaft bearings
The oil is also supplied under pressure to pipes which direct a stream of oil against the dippers on the big end connecting rod bearing cup
The crankpin bearings are lubricated by the splash or spray of oil thrown up by dipper

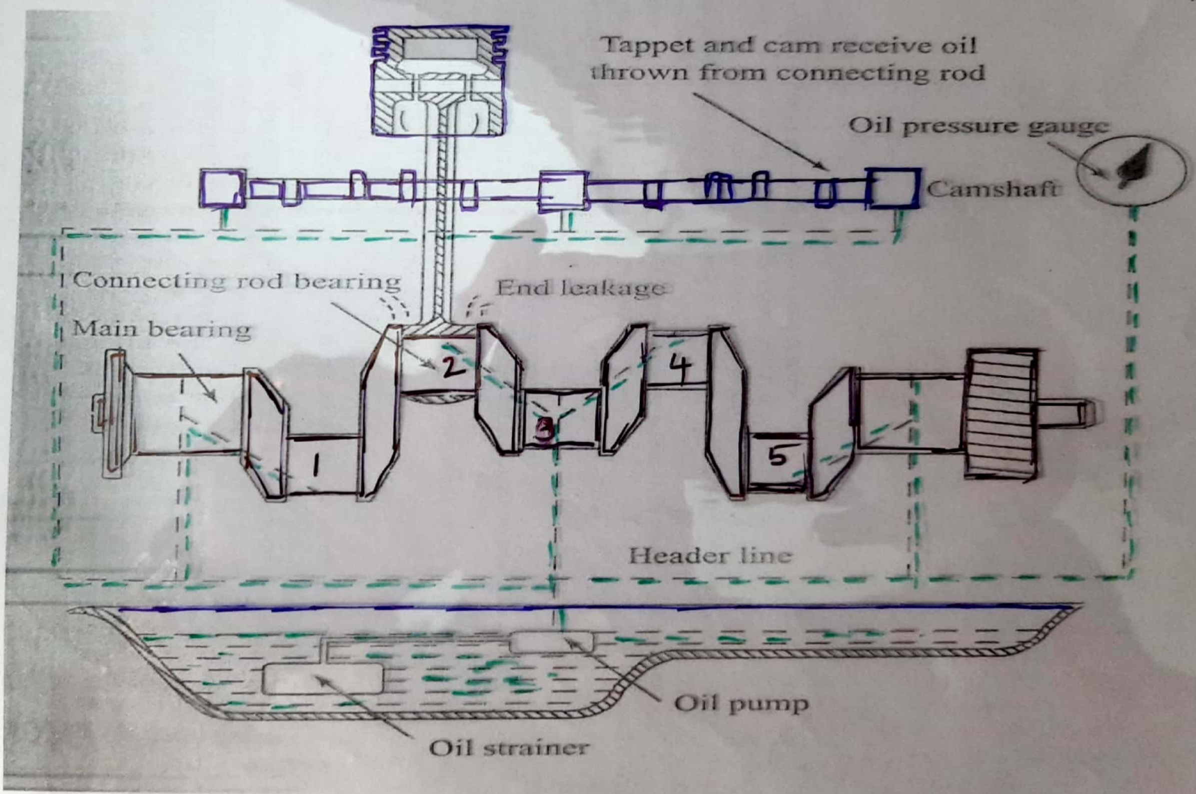
Pressure feed system

The oil is forced to all the main bearings of crankshaft Pressure relief valve is fitted to maintain the predictable pressure values
Oil hole is drilled from the center of each crankpin to the center of an adjacent main journal through which oil can pass from the main bearing to the crankpin

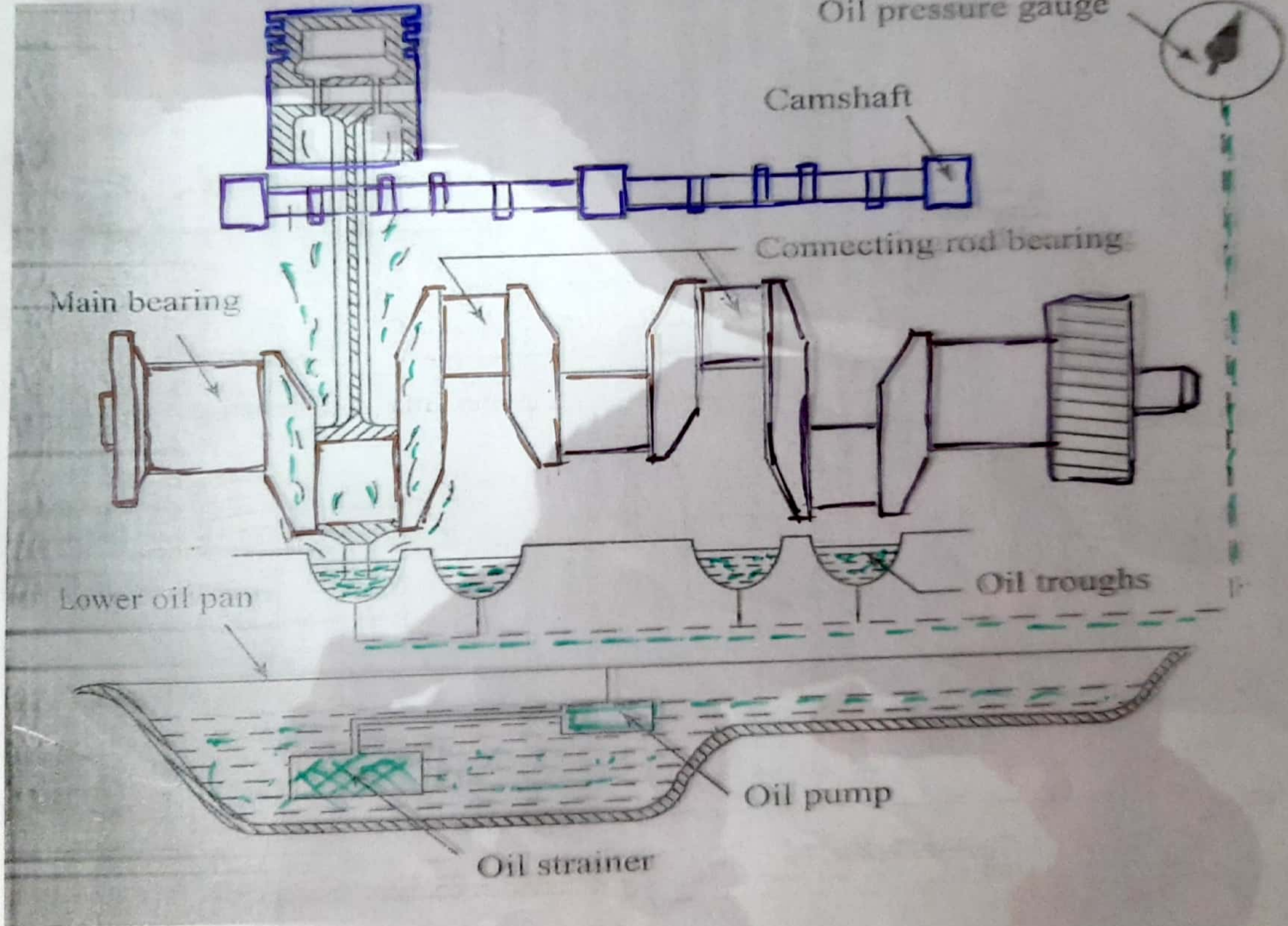
Dry sump lubrication system

In this system the oil is carried in an external tank
An oil pump draws oil from the supply tank and circulates it under pressure to the various bearings of the engine
Oil dripping from the cylinders and bearings in to the sump is removed by a scavenging pump which in turn the oil is passed through a filter and fed back to the supply tank
The capacity of scavenging pump is always greater than the oil pump
A separate oil cooler provided to remove heat from the oil

Pressure feed system



Splash Lubrication System



Splash & pressure lubrication system

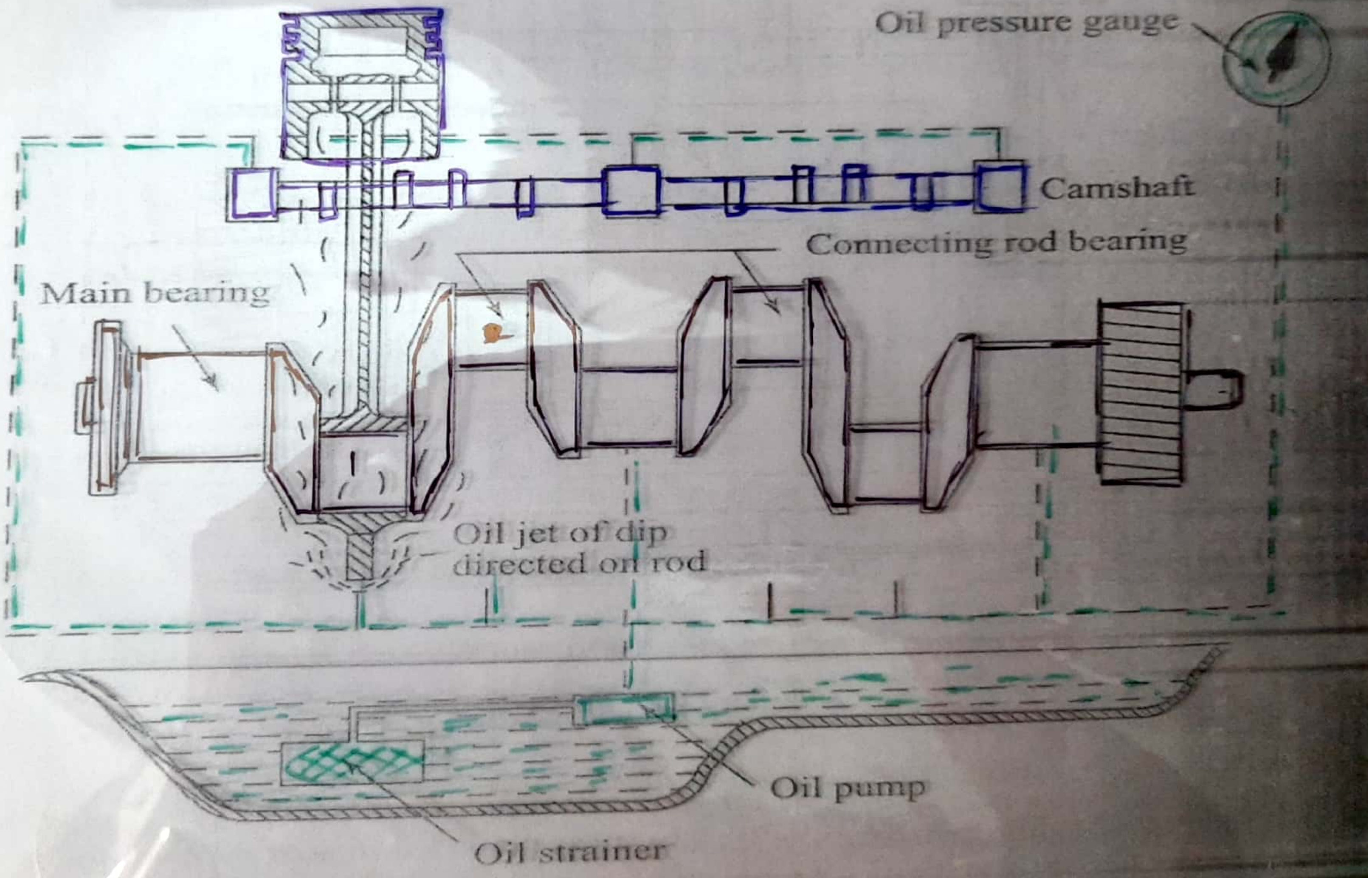


Fig. 13.10 Splash and Pressure Lubrication System

Dry sump lubrication system

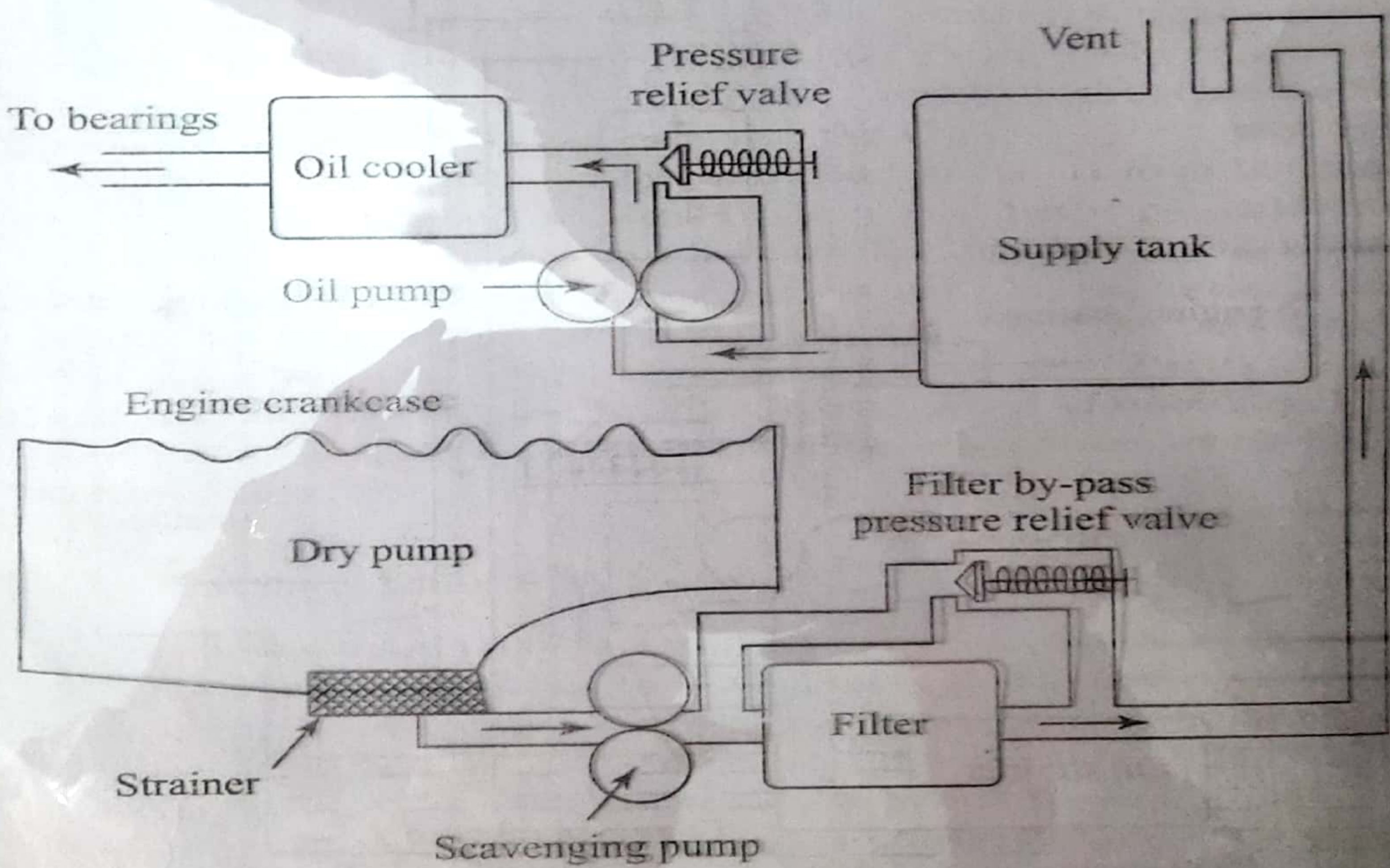


Fig. 13.14 Dry Sump Lubrication System

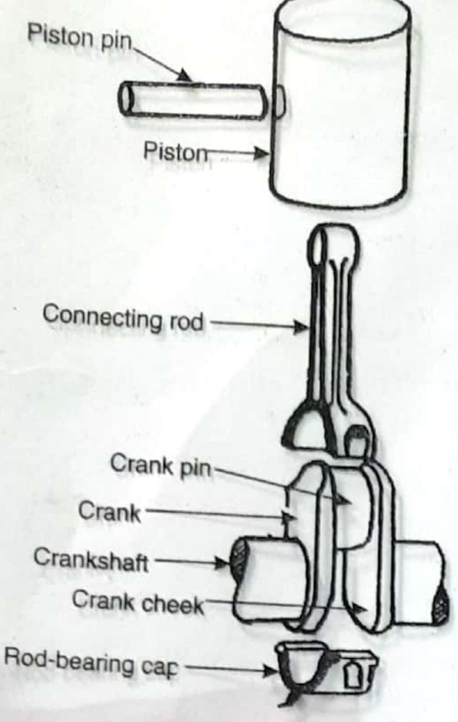


Fig. 23.12

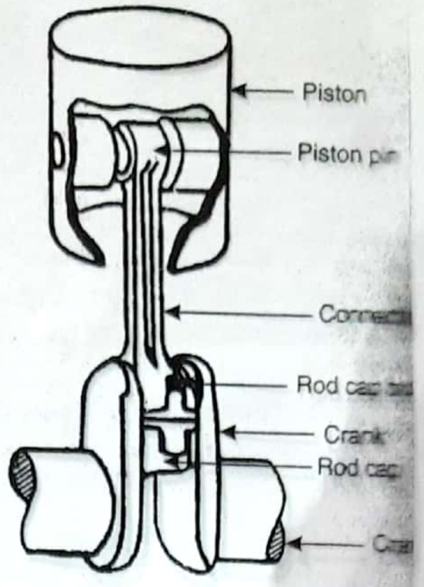


Fig. 23.13

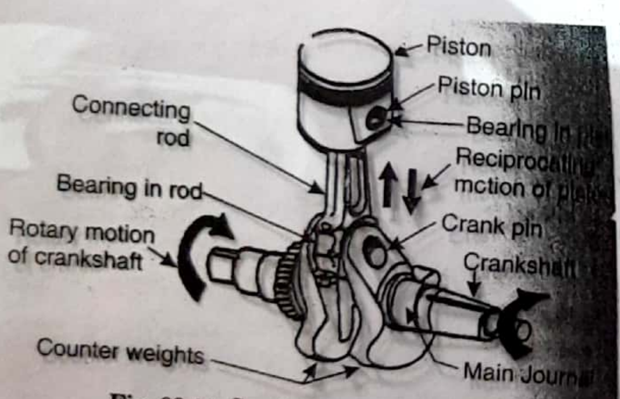


Fig. 23.14. Crankshaft and other parts.

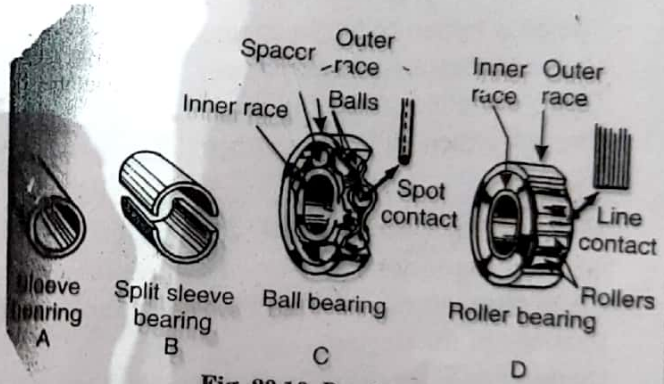


Fig. 23.16. Bearings.

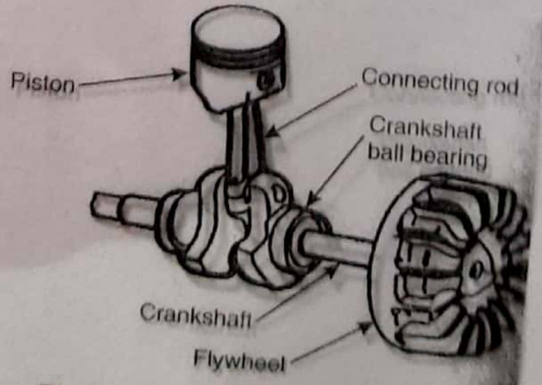


Fig. 23.18. Flywheel secured on crankshaft

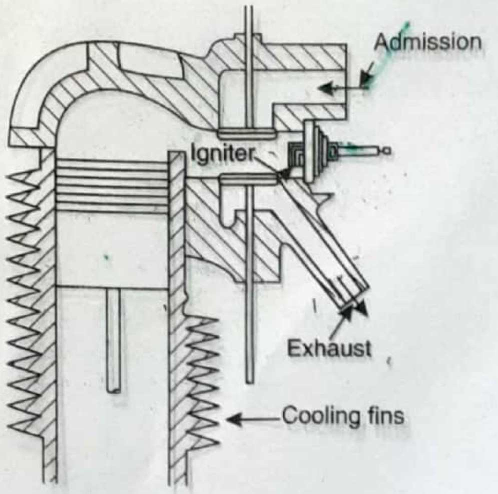


Fig. 23.3. Air-cooled cylinder.

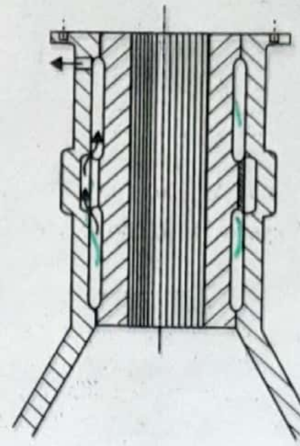
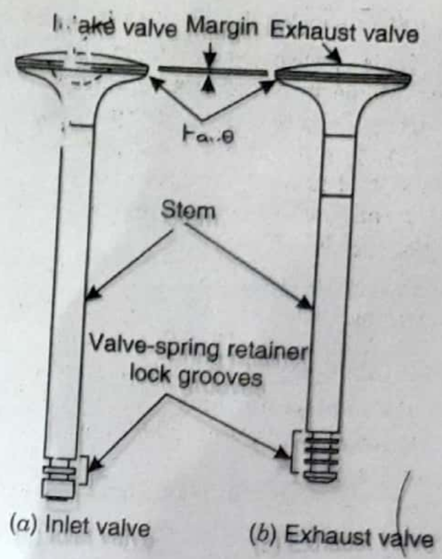


Fig. 23.4. Water-cooled cylinder.



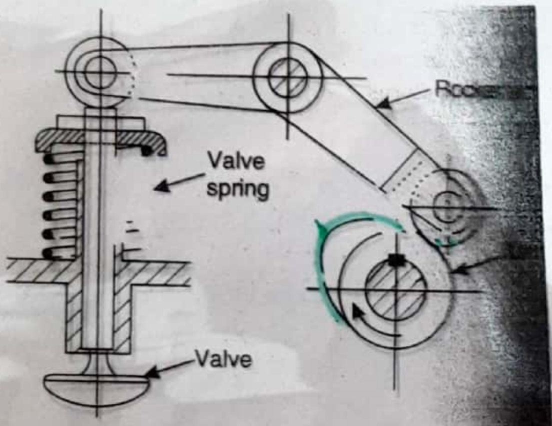


Fig. 23.6. Cam and rocker arm.

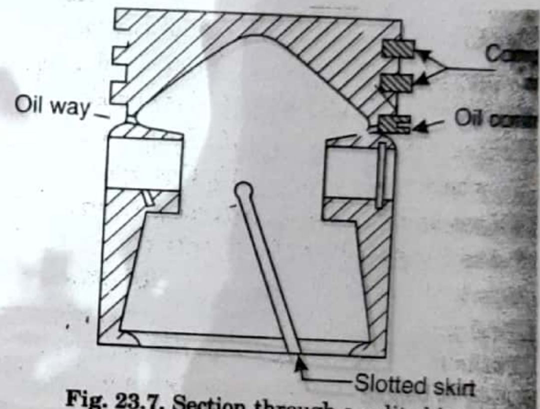


Fig. 23.7. Section through a split skirt piston

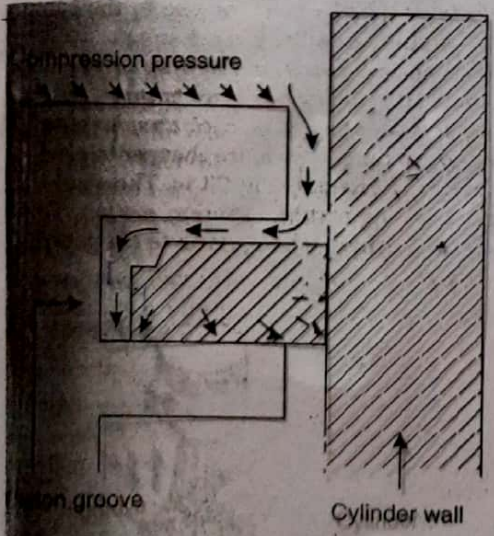


Fig. 23.8. Working of a piston ring.

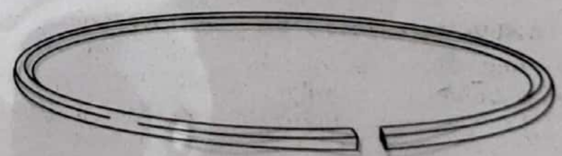


Fig. 23.9. Compression ring.

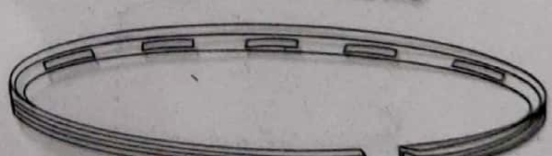


Fig. 23.10. Oil ring.

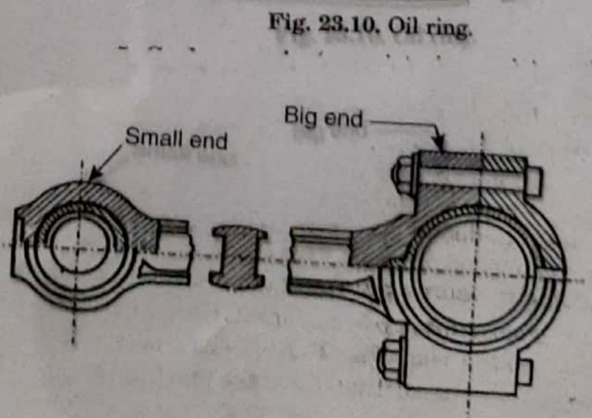


Fig. 23.11. Connecting rod.

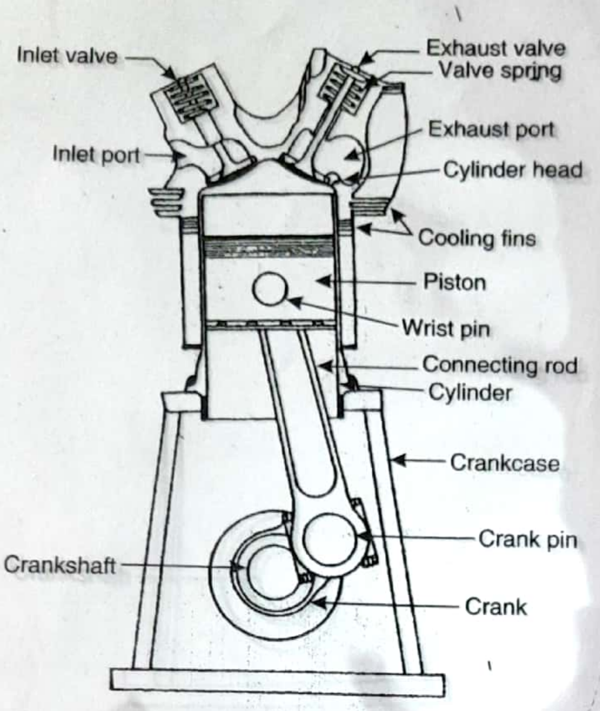


Fig. 23.2. Air-cooled I.C. engine.

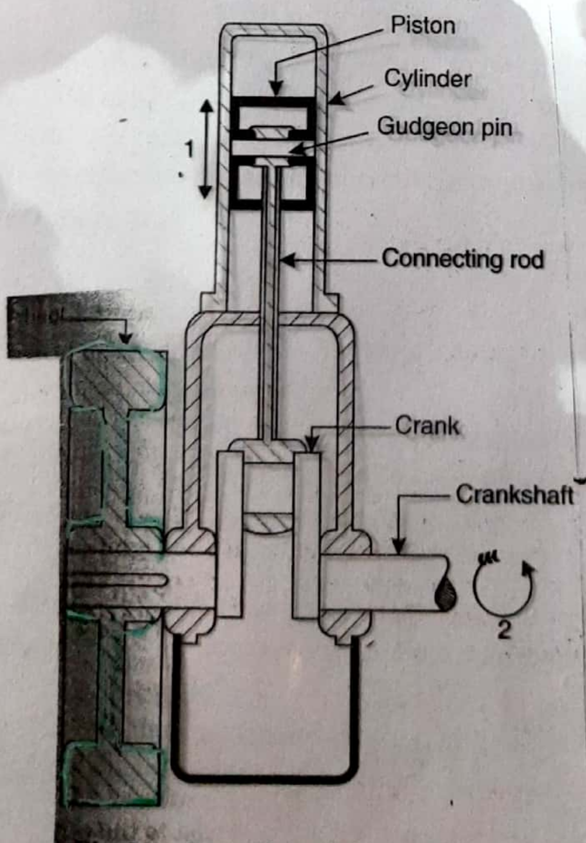


Fig. 23.1. Basic idea of I.C. engine.

26.4 Main Components of I.C. Engines

As a matter of fact, an I.C. engine consists of hundreds of different parts, which are importa for its proper working. The description of all these parts is beyond the scope of this book. Howev the main components, which are important from academic point of view, are shown in Fig. 26.1 a are discussed below :

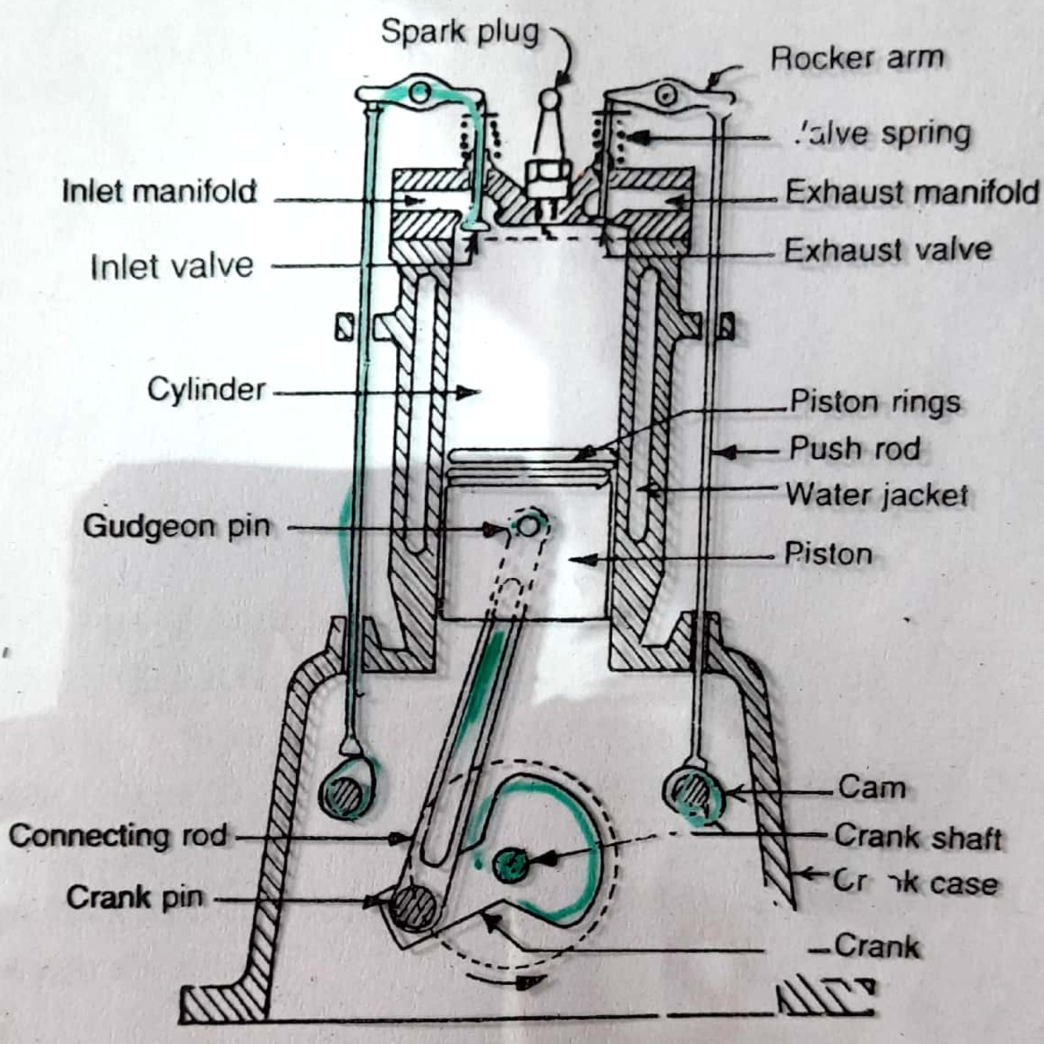


Fig. 26.1. Main components of I.C. engines.