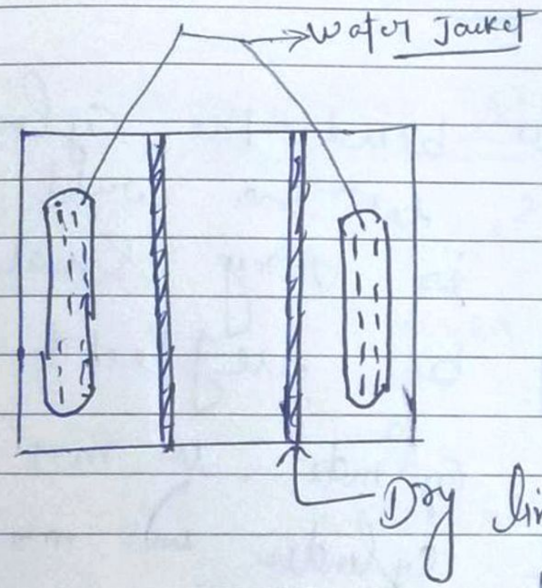
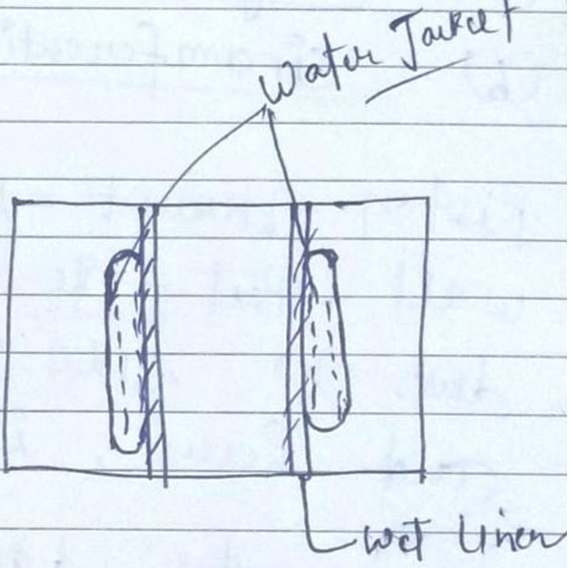
Expt. No. .... **UNIT-2** (Internal Combustion Engine)

Cylinder & Cylinder Liner :→ The funtion of a cylinder is to retain the working fluid and guide the Piston. Since the cylinder has to withstand high temperature due to combustion of fuel, therefore some arrangement must be provided to cool the cylinder.

Single Cylinder - Scooter & Motorcycle

Multi cylinder = Car, Jeep





The cylinder linears are two types -

(1) Dry linear

(2) Wet Linear

Design of a cylinder :→ The

(1) Thickness of cylinder wall :→ The cylinder wall is subjected to gas pressure and the piston side thrust. The gas pressure produces the following two types of stresses

(a) Longitudinal stress
(b) Circumferential stress

Piston thrust tends to bend the cylinder wall. But the stress in the wall due to side thrust is very small and hence it may be neglected.

D_0 = outer diameter of cylinder in mm
D = Inside diameter of cylinder in mm
p = Maximum pressure inside the engine cylinder in N/mm^2
t = Thickness of cylinder wall

$\frac{1}{m}$ = Poisson's ratio. It is usually taken as

0.25

The longitudinal stress is given by

$$\sigma_l = \frac{\text{force}}{\text{Area}} = \frac{\frac{\pi}{4} \times D^2 \times p}{\frac{\pi}{4}[D_o^2 - D^2]} = \frac{D^2 \cdot p}{D_o^2 - D^2}$$

Circumferential stress: →

$$\sigma_c = \frac{\text{force}}{\text{Area}} = \frac{D \times l \times p}{2t \times l} = \frac{D \cdot P}{2t}$$

Net longitudinal stress $= \sigma_l - \frac{\sigma_c}{m}$

Net circumferential stress $= \sigma_c - \frac{\sigma_l}{m}$

Step)

The thickness of cylinder wall (t) is usually obtained by a thin Cylindrical formula

$$t = \frac{p \times D}{2 \sigma_c} + C$$

p = Maximum pressure inside the cylinder in N/mm^2

D = Inside dia of the cylinder

σ_c = permissible circumferential or hoop stress for cylinder material

C = Allowance for reboring

(2) Bore and length of the cylinder :→

The Bore ~~and length~~ (inner diameter) and length of the cylinder may be determined below :

We know the power produced inside the engine cylinder i.e. Indicated Power,

$$I.P. = \frac{P_m \times l \times A \times n}{60} \text{ watts}$$

Where P_m = Indicated ~~Pressure~~ mean effective pressure in N/mm^2

D = cylinder bore in mm

A = cross-sectional Area of cylinder in mm^2

$= \pi/4 \, D^2$

l = length of stroke in meters

N = speed of the engine in r.p.m.

n = No of working strokes per min

$n = N$ for two stroke engine

$n = N/2$ for four stroke engine

The Stroke length is generally taken as 1.25D to 2D

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$d_c = 0.84 \cdot d$

(3) Cylinder flange & stud →

The diameter of the stud or bolt may be obtain by equating gas load due to maximum pressure in the cylinder to the resisting force by all studs or bolts

$$\frac{\pi}{4} D^2 \cdot p = \frac{\pi}{4} (d_c)^2 \cdot \sigma_t \times n_s$$

D = Cylinder Bore in mm

p = Maximum pressure in N/mm^2

n_s = No of studs $0.01D + 4$ to $0.02D + 4$

d_c = core dia of bolt

$19\sqrt{d}$ $28.5\sqrt{d}$ is min & max pitch of stud

4) Cylinder head

$$t_h = D\sqrt{\frac{CP}{\sigma_c}}$$

C = Constant whose value is taken as 0.1

D = Bore dia

P = Maximum inside pressure in cylinder N/mm²

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Problem: A four stroke diesel engine has the following specifications:

B.P. = 5 KW
speed = 1200 r.p.m.
P_m = 0.35 N/mm²
η_m = 80%

Determine: (i) Bore and length of cylinder
(ii) Thickness of cylinder head
(iii) Size of studs for the cylinder head

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

$$0.80 = \frac{5 \times 10^3 \, W}{I.P}$$

$$I.P. = \frac{5 \times 10^3 \, W}{0.80}$$

$$I.P = 6250 \, W$$

$$I.P. = \frac{P_m \times l \times A \times n}{60} \ W$$

$$l = 1.5D \text{ mm}$$

$$l = \frac{1.5D}{1000} \text{ m}$$

$n = N/2 = 600$ for four stroke

$$6250 = \frac{0.35 \times 1.5D \times \pi . D^2 \times 600}{60 \times 1000 \times 4}$$

$$D^3 = \frac{6250}{4.12} \times 10^{-3}$$

$$\boxed{D = 115 \text{ mm}}$$

$$l = 1.5D$$

$$l = 1.5 \times 115$$

$$\boxed{l = 172.5 \text{ mm}}$$

(2) Thickness of the Cylinder head :→

$$t_h = D\sqrt{\frac{CP}{\sigma_c}}$$

$\sigma_c = 42$ MPa Assume

Taking $C = 0.1$

$P = 9\,P_m$

$= 9 \times 0.35$

$= 3.15\ N/mm^2$

$$= 115\sqrt{\frac{0.1 \times 3.15}{42}}$$

$$t_h = 9.96 \cong 10\ mm$$

(3) Size of stud for cylinder head →

$$\frac{\pi}{4} D^2 \times P = \frac{\pi}{4}(d_c)^2 \times \sigma_t \times n_s$$

n_s = no. of stud $= 0.01D + 4$ to $0.02D + 4$

$= 0.01 \times 115 + 4$ to $0.02D + 4$

$= 5.15$ $\quad 0.02 \times 115 + 4$

6.3

$$n_s \cong 6$$

$$\frac{\pi}{4} \times (115)^2 \times 3.15 = \frac{\pi}{4} (d_c)^2 \times 65 \times 6$$

Take $\sigma_t = 65\ N/mm^2$

$d_c = 0.84d$

$$32702\,N = 216\, d^2\, N$$

$$d^2 = \frac{32702}{216}$$

$$d = 12.3 \approx 14\ mm$$

minimum Pitch $19\sqrt{d}$ to $28.5\sqrt{d}$

Design a Cast iron Piston for a single acting four stroke engine for the following data.

Cylinder Bore (D) = 100 mm

Stroke length (L) = 125 mm

Maximum gas pressure (P) = 5 N/mm^2

Indicated mean effective Pressure P_m = 0.75 N/mm^2

Mechanical efficiency η_m = 80% = 0.8

fuel consumption (m) = 0.15 kg/BP/h = 41.7×10^{-6} kg/BP/s

Higher calaric value of fuel (HCV) = 42×10^{3} kJ/kg

speed (N) = 200 r.p.m.

(i) Piston head or crown :→

The thickness of the piston head or crown is determined on the basis of strength as well as on the basis of heat dissipation and the larger of two values is adopted.

We know that the thickness of piston head on the basis of strength.

$$t_H = \sqrt{\frac{3 p D^2}{16 \sigma_t}}$$

$\sigma_t = 38\ N/mm^2$

$$t_H = \sqrt{\frac{3 \times 5 \times (100)^2}{16 \times 38}}$$

$$t_H = 16\ mm$$

Thickness of the piston head on the basis of heat dissipation

$$t_H = \frac{H}{12.56 K (T_C - T_E)}$$

K (thermal conductivity) $= 46.6\ W/m/°C$

$T_C - T_E = 220°C$

$H = C \times HCV \times m \times B.P.$

$\eta_m = \frac{BP}{IP}$

$A = \frac{\pi}{4}(D)^2 = 7855\ mm^2$

$IP = \frac{P_m L A n}{60}$

$= \frac{0.75 \times 125 \times 7855 \times 1000}{60} = 12270\ W$

$\boxed{IP = 12.27\ kW}$

$B.P = \eta_m \times IP$

$\boxed{B.P = 0.8 \times 12.27 = 9.8\ kW}$

$H = 0.5 \times 42 \times 10^3 \times 41.7 \times 10^{-6} \times 9.8$

$H = 0.86\ kW$

$\boxed{H = 860\ W}$

$t_H = \frac{860}{12.56 \times 46.6 \times 220} = 0.0067\ m$

$t_h = 6.7\ mm$

$\boxed{t_h \cong 16\ mm}$

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(2) Radial ribs may be four in number

thickness of radial ribs varies from

$t_H/3$ to $t_H/2$

$16/3$ to $16/2$

5.3 to 8

Let us adopt ≅ 7 mm

Piston rings ; Total four rings

⇒ Three compression rings
⇒ One is an oil ring } (oil control rings)

we know that radial thickness of the piston rings

$$t_1 = D\sqrt{\frac{3P_w}{\sigma_t}} \qquad P_w = 0.035\ N/mm^2$$

$$t_1 = 100\sqrt{\frac{3\times 0.035}{90}}$$

$$= 3.4\ mm$$

Axial thickness

$t_2 = 0.7\, t_1$ to t_1

$t_2 = 0.7 \times 3.4$ to 3.4

$t_2 = 3$ mm

And Now b_1 & b_2

The distance from the top of the piston to the first ring groove:

$b_1 = t_H$ to $1.2\, t_H$

$b_1 = 16$ to 1.2×16

$b_1 = 16$ to $19.2 = 18$ mm

$b_2 =$ width of other ring lands

$b_2 = 0.75 t_2$ to t_2

$= 0.75 \times 3$ to 3

$= 2.25$ to 3

$= 2.5$

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(4) Piston skirt

Maximum side thrust on the Cylinder due to gas Pressure (P) = Maximum side thrust due to bearing Pressure (P_b)

~~$P = P_b$~~ $\quad R_1 = R_2$

$$\mu \times \frac{\pi D^2}{4} \times P = P_b \times D \times l$$

$$\frac{0.1 \times \pi (100)^2}{4} \times 5 = 0.45 \times 100 \times l$$

$$\boxed{l = 90 \text{ mm}}$$

Total Length

= Length of skirt + Length of ring Section + top land

$$= l + (4t_2 + 3b_2) + b_1$$

$$= 90 + (4 \times 3 + 3 \times 3) + 18$$

$$= 129$$ l