Design of IC Engine Components - Piston

Functions of Piston

- Transmits force inside the gas cylinder to the crank shaft
- Compresses gas during compression stroke
- Seals the inside portion of the cylinder from the crankcase by means of piston rings
- Takes side thrust resulting from obliquity of connecting rod
- Dissipates large amount of heat from combustion chamber to the cylinder walls

Requirements of Piston Material

- Weight should be as low as possible
- No warping at elevated temperatures
- Low coefficient of thermal expansion
- Thermal conductivity should be high
- Should have good wearing properties
- Should have good resistance to corrosion
- Should have low coefficient of friction for minimum power loss

Common Piston Materials

a. Aluminium

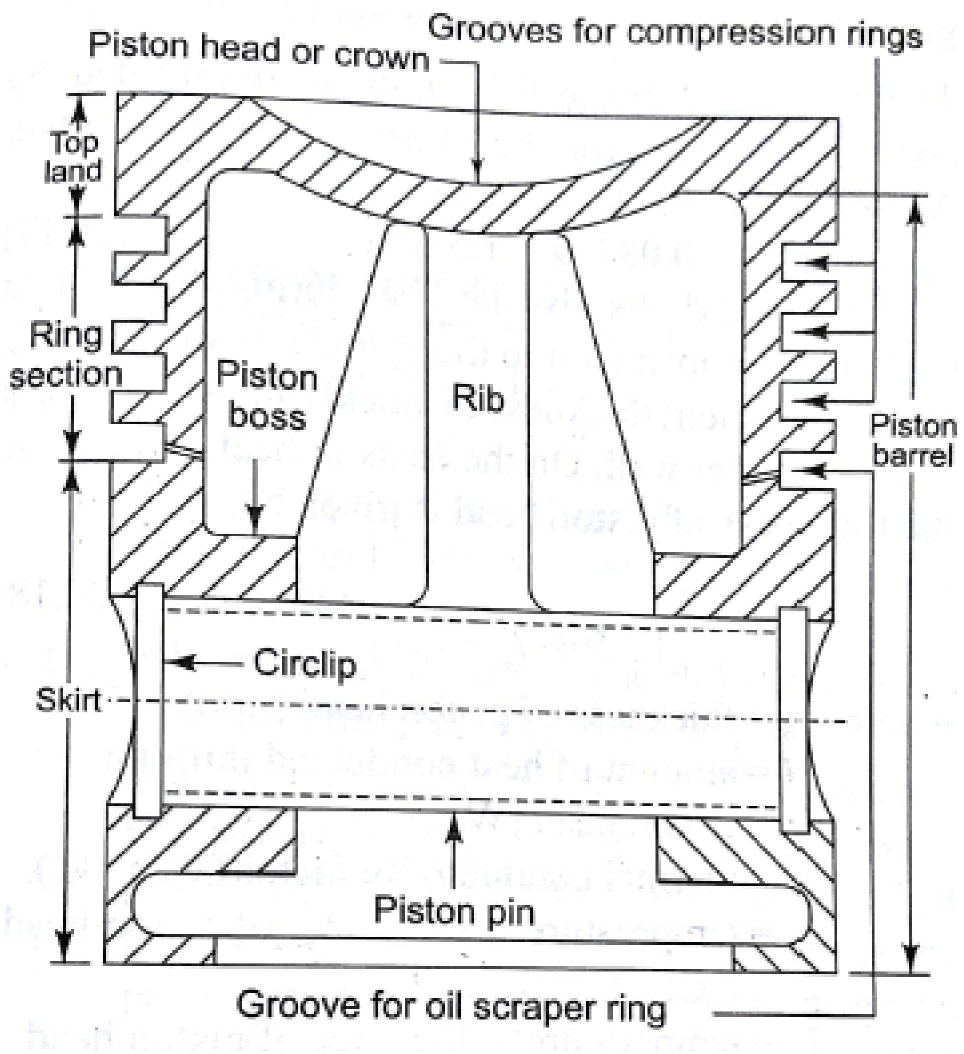
- thermal conductivity thrice as that of cast iron
- density one third that of cast iron (reduced weight)

b. Cast Iron

- higher strength as compared to Aluminium
- relatively more wear strength (than Aluminium)
- approx. half coefficient of thermal expansion

Piston

Piston



Piston head or crown
Grooves for compression rings
Top land
Ring section
Piston boss
Rib
Piston barrel
Circlip
Skirt
Piston pin
Groove for oil scraper ring

Design of Piston

Involves assessment of following dimensions:

- Thickness of piston head (t_h)
- Thickness of Rib (t_r)
- Radial thickness of piston rings (a_1)
- Axial thickness of piston rings (h_1)
- Width of top land
- Thickness of piston barrel at the top end (t_3)
- Thickness of piston barrel at open end (t_4)
- Length of piston skirt
- Total length of piston

Thickness of Piston head

- Strength consideration

$$t_h = D\sqrt{\frac{3\, p_{max}}{16\, \sigma_b}}$$

D = cylinder bore (mm)

p_{max} = maximum gas pressure (4 to 5 MPa)

σ_b = permissible bending stress (35 to 40 MPa for C.I. and 50 to 90 MPa for Al)

Thickness of Piston head

- Heat Dissipation consideration

$$t_h = \left[\frac{H}{12.56\,k\,(T_c - T_e)} \right] \times 10^3$$

H = amount of heat conducted through piston head (W)

k = thermal conductivity factor (46.6 W/m°C for C.I. and 175 W/m°C for Al)

T_c = Temperature at the centre of Piston head

T_e = Temperature at the edge of piston head

$T_c - T_e$ = 220°C for C.I. and 75°C for Al

Thickness of Piston head

- Heat Dissipation consideration

$$H = [\,C \times HCV \times m \times B.P.\,] \times 10^3$$

C = ratio of heat absorbed by piston to total heat developed by cylinder (5%)

HCV = higher calorific value (44000 kJ/kg for diesel and 47000 kJ/kg for Petrol)

m = average fuel consumption (0.24 to 0.3 kg/kW/hr)

B.P. = Brake power

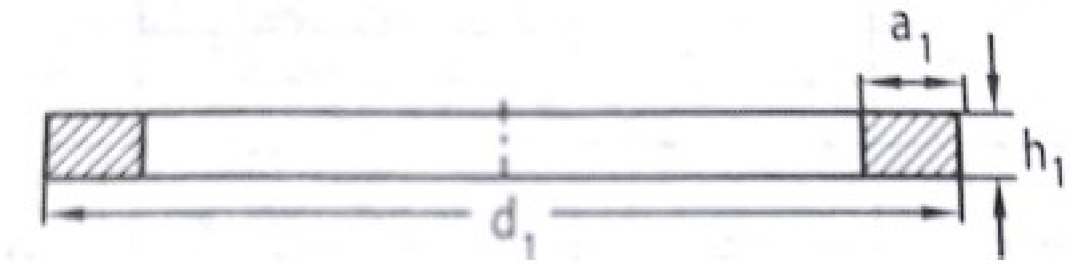
$$B.P. = \frac{p_{mb}\ L\ A\ n}{60} \quad (\text{in kW})$$

Design of Piston

- Thickness of rib $= 1/3$ to $1/2$ (thickness of piston head)

- Radial thickness of piston rings

$$a_1 = d_1 \sqrt{\frac{3\,p_w}{\sigma_t}}$$



d_1 = diameter of cylinder bore (mm)

p_w = allowable pressure (0.025 to 0.042 MPa)

σ_t = permissible tensile stress (85 to 110 MPa)

- Axial width of piston ring $h_1 = 0.7$ to $1.0\ a_1$

Design of Piston (contd.)

- Width of top land = 1.0 to 1.2 t_h
- Width of ring groove = 0.75 to 1.0 h_1
- Thickness of piston barrel at the top end $t_3 = 0.03\ d + a_1 + 4.9$
- Thickness of piston barrel at open end t_4 = 0.25 to 0.35 t_3
- Length of piston skirt 0.65 to 0.8 D
- Total length of piston 1.0 to 1.5 D