ENGINE Heat Transfer

IMPORTANCE OF Heat Transfer :-

The peak burned gas temperature in the cylinder of an internal combustion engine is of order 2500K.

In region of high heat flux, thermal stress must be kept below levels ~~than~~ that would cause fatigue cracking (so temperatures must be less than about 400°C for cast iron and 300°C for aluminium alloys)

The gas-side surface of the cylinder wall must be kept below about 180°C to prevent deterioration of the lubricating oil film. Spark plug and valves must be kept cool to avoid knock and preignition problems which result from overheated spark plug electrodes or exhaust valves

P.T.O

MODES OF HEAT TRANSFER

CONDUCTION:

Heat is transferred by conduction through the cylinder head, cylinder walls, and piston; through the piston rings to the cylinder wall; through the engine block and manifolds

CONVECTION:-

Heat is transferred by forced convection between the in-cylinder gases and the cylinder head, valves, cylinder walls and piston during induction, compression, expansion and exhaust processes. Heat is transferred by forced convection from the cylinder walls and head to the coolant. and from the piston to the lubricant. Heat Transfer by convection in the inlet system is used to raise the temperature of the incoming charge. Heat is also transferred from the engine to the environment by convection

(P.T.O)

Radiation

Heat exchange by radiation occurs through the emission and absorption of electromagnetic waves. The wavelengths at which energy is ~~transferred~~ transformed into thermal energy are the visible range (0.4 to 0.7 μm) and the infrared (0.7 to 40 μm).

Heat transfer by radiation occurs from the high-temperature combustion gases and the flame region to the combustion chamber walls.

Heat transfer by radiation to the environment occurs from all the hot external surfaces of the engine.

Overall Heat Transfer process

$\bar{T}_g, \bar{T}_c$ mean gas & coolant temp.

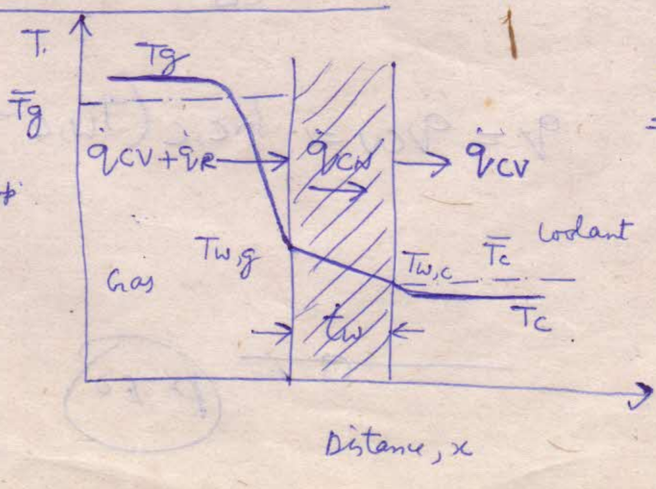


fig 1 - Schematic of temperature distribution and heat flow across the combustion chamber wall.

For steady one-dimensional heat flow through a wall as indicated in fig(1)., the following equations relate the heat flux $\dot{q} = \dot{Q}/A$ and the temperatures indicated:

Gas side:

$$\dot{q} = \dot{q}_{cv} + \dot{q}_{R} = h_{c,g}\left(\bar{T}_g - T_{w,g}\right) + \sigma\varepsilon\left(\bar{T}_g^4 - T_{w,g}^4\right) \quad \text{—(1)}$$

ε = emissivity

The radiation term is generally negligible for S.I engine

Wall:

$$\dot{q} = \dot{q}_{cw} = \frac{k\left(T_{w,g} - T_{w,c}\right)}{t_w} \quad \text{—(2)}$$

Coolant side

$$\dot{q} = \dot{q}_{cv} = h_{c,c}\left(T_{w,c} - \bar{T}_c\right) \quad \text{—(3)}$$

P.T.O

Woschni's relation for convective heat transfer coefficient

$$h_c\,(W/m^2\cdot K) = 3.26\, B(m)^{-0.2}\, P(kPa)^{0.8}\, T(K)^{-0.55}\, w(m/sec)^{0.8}$$

P = instantaneous cylinder pressure.

T = cylinder gas temp

$= \frac{P}{\rho R}$

$P = \rho R T$ ✓

B = bore

$$W = \left[C_1 \bar{S}_p + C_2 \frac{V_d T_r}{P_r V_r} (P - P_m) \right]$$

For gas exchange period $C_1 = 6.18$, $C_2 = 0$

For compression period $C_1 = 2.28$ $C_2 = 0$

For the combustion & expansion period

$C_1 = 2.28$ $C_2 = 3.24 \times 10^{-3}$

V_d = displaced volume

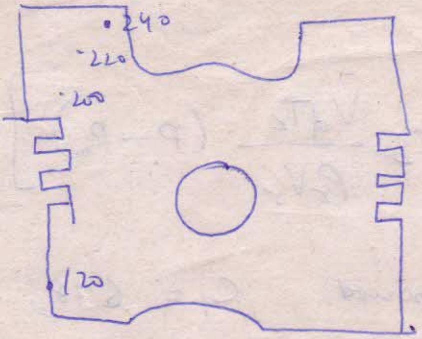
P_r, T_r, V_r are the working fluid pressure, ~~volume~~ temp and volume at some reference state (say IVC).

P_m = motored cylinder pressure.

$\bar{S}_p$ = mean piston speed.

Component temp distribution

Piston



Liner

Cylinder head temp

220°C – 100°C