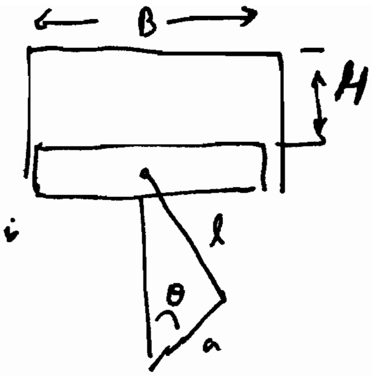
8.8) The engine geometry is:

The exposed area of the cylinder is

$$A = \pi B H + \left(\frac{\pi B^2}{4}\right) \times 2$$

where $H = V / (\pi B^2/4)$



$B = 8.6\,cm$

$a = 8.6/2\,cm$; $L = 2a = 8.6\,cm$

$l/B = 1.58$; $R = \frac{l}{a} = 3.16$

$V_c = 58.77\,cc$

$V_D = \frac{\pi B^2}{4} \cdot L = 499.56\,cc$

$r_c = (V_D + V_c)/V_c = 9.5$

$$\frac{V}{V_c} = 1 + \frac{1}{2}(r_c - 1)\left[R + 1 - \cos\theta - (R^2 - \sin^2\theta)^{1/2}\right]$$

The mean piston speed is

$$\bar{S}_p = 2NL = 2 \times \left(\frac{RPM}{60}\right) \cdot L$$

The average charge density is $\rho = \frac{m}{V}$ where $m = \left(\eta_v V_D \frac{p_i}{RT_i}\right)(1 + F/A)$

The Reynolds no $Re = \rho \bar{S}_p B / \mu$

Then the heat transfer is given by $Nu = 0.35 Re^{0.8} Pr^{0.4}$ and $h = Nu\,k/B$.

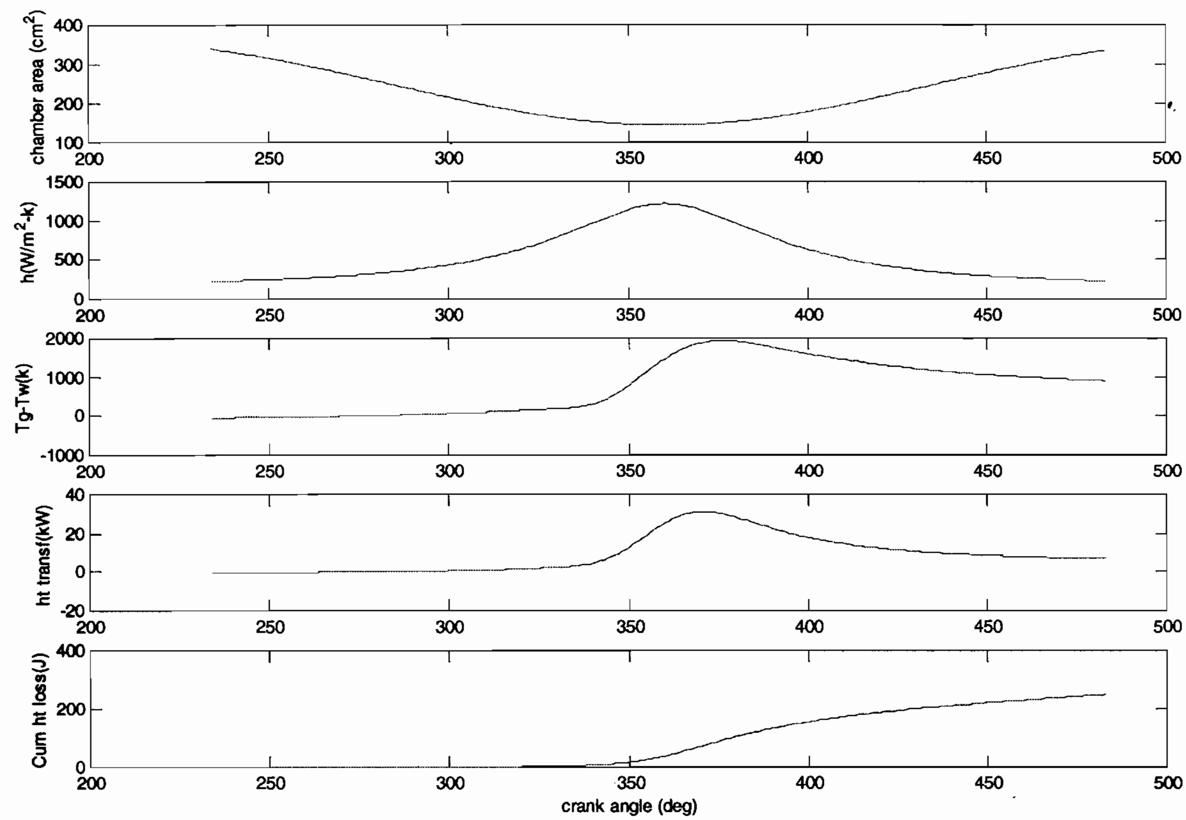
The gas temperature $\bar{T}_g = (x_b c_{p_b} T_b + (1 - x_b) c_{p_u} T_u)/(x_b c_{p_b} + (1 - x_b) c_{p_u})$

(Note that strictly speaking, it should be c_v in the above eq, but $c_p \propto c_v$)

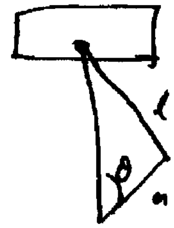
Finally $\dot{Q} = A h \Delta T$ and Q is obtained from $\dot{Q}$ by integration.

$$Q = \int_{IVC} \dot{Q}\, dt = \int_{IVC} \dot{Q}\left(\frac{dt}{d\theta}\right) d\theta \quad \text{where } \frac{dt}{d\theta} = \frac{(60/RPM)}{2\pi} \text{ for } \theta \text{ in radian}$$

Numerical values: – here $\theta = 360$ is TDC compression.



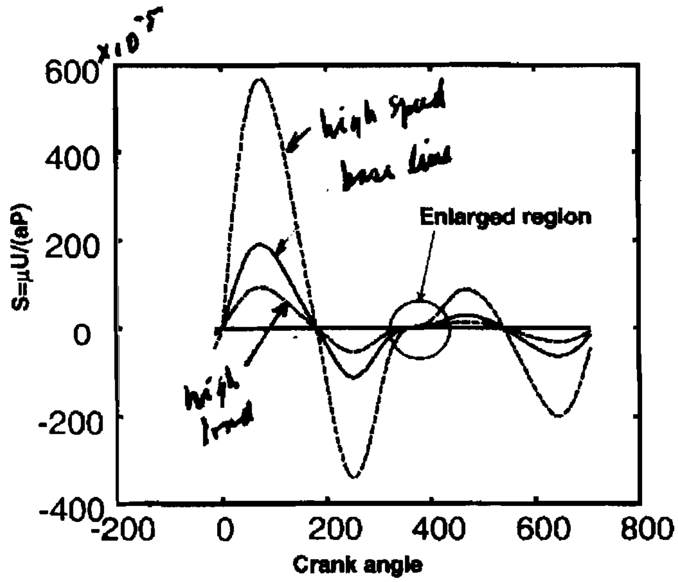
9-2) Instantaneous piston speed



$R = l/a = 3.16$; $L = 2a = 8.6\,cm$

$$\frac{U(\theta)}{2NL} = \frac{\pi}{2}\sin\theta\left[1 + \frac{\cos\theta}{(R^2 - \sin^2\theta)^{1/2}}\right]$$

The corresponding values of $S = [U(\theta)/P(\theta)]\frac{\mu}{a}$ are plotted. Note that $U(\theta) \propto N$, the revolution per second of the engine.



Note: The reason why $S_{critical}$ is such a small value (10^{-5}) is because the real criterion is h/ε where h is the film thickness and ε the surface roughness height.

$$\left(\frac{h}{\varepsilon}\right) = \left(\frac{a}{\varepsilon}\right)\cdot\left(\frac{h}{a}\right)$$

$\left(\frac{h}{a}\right)$ is $\simeq \sqrt{S}$; so

$$\left(\frac{h}{\varepsilon}\right) = \left(\frac{a}{\varepsilon}\right)\sqrt{S}$$

If the critical $\left(\frac{h}{\varepsilon}\right) = 1$, and ε is typically $\sim 3\,\mu m$, then $(a/\varepsilon) \simeq 300$

and $S_{critical} = \left[\left(\frac{h}{\varepsilon}\right)\left(\frac{\varepsilon}{a}\right)\right]^2 = \left(\frac{1}{300}\right)^2 \simeq 10^{-5}$