

Q.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  $H = \frac{V}{(\pi B^2/4)}$

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  $m = \left(\pi V \frac{P_c}{RT_c}\right) (1 + F/A)$

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  $h = Nu k / B$ .

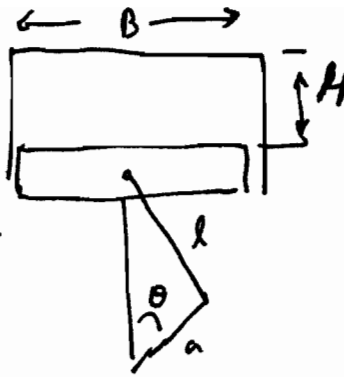
The gas temperature  $T_g = (x_b c_{pb} T_b + (1-x_b) c_{pu} T_u) / (x_b c_{pb} + (1-x_b) c_{pu})$

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

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

$$Q = \int_{T_{2c}}^{T_{1c}} \dot{Q} dt = \int_{T_{2c}}^{T_{1c}} \dot{Q} \left(\frac{dt}{d\theta}\right) d\theta \quad \text{where } \frac{dt}{d\theta} = \frac{(60/RPM)}{2\pi} \text{ for } \theta \text{ in radians}$$

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



$$B = 8.6 \text{ cm}$$

$$A = 8.6/2 \text{ cm}; L = 2A = 8.6 \text{ cm}$$

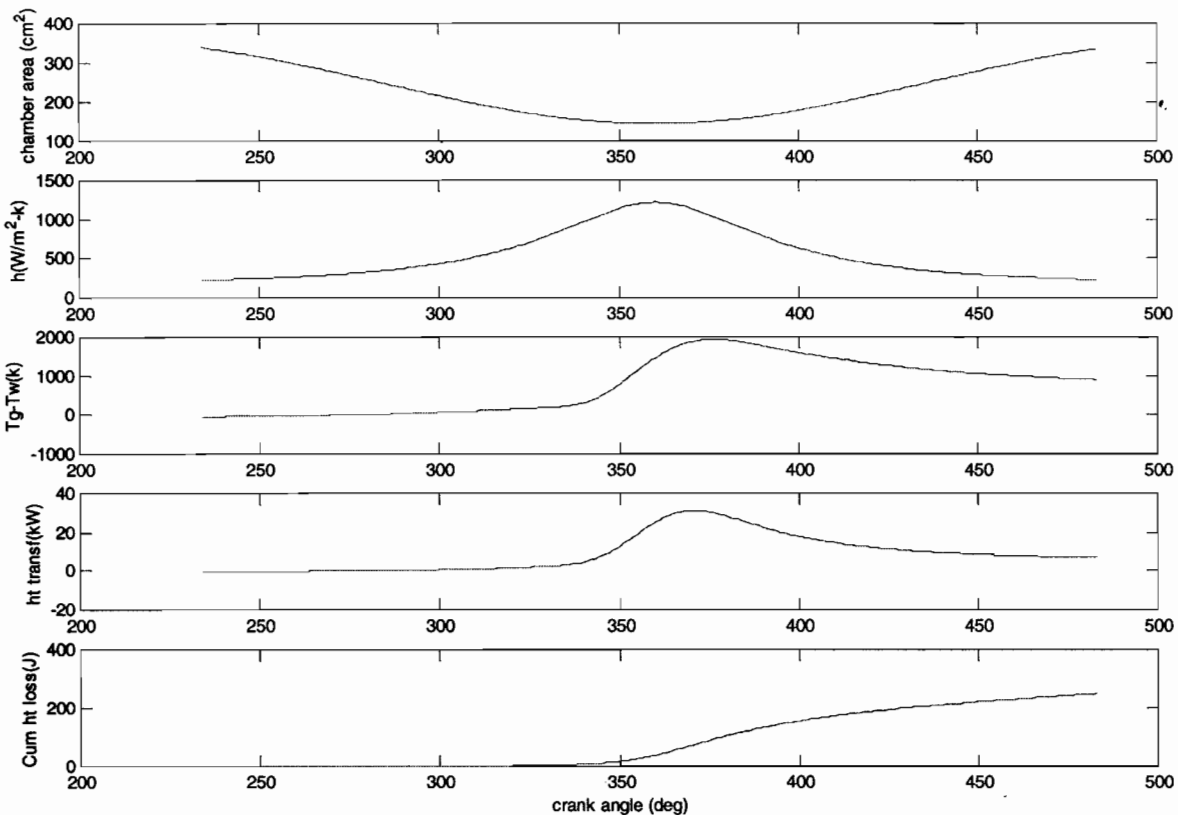
$$L/B = 1.58; R = \frac{L}{A} = 3.16$$

$$V_c = 58.77 \text{ cc}$$

$$V_D = \frac{\pi B^3}{4} \cdot L = 499.56 \text{ cc}$$

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

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



9.2) Instantaneous piston speed

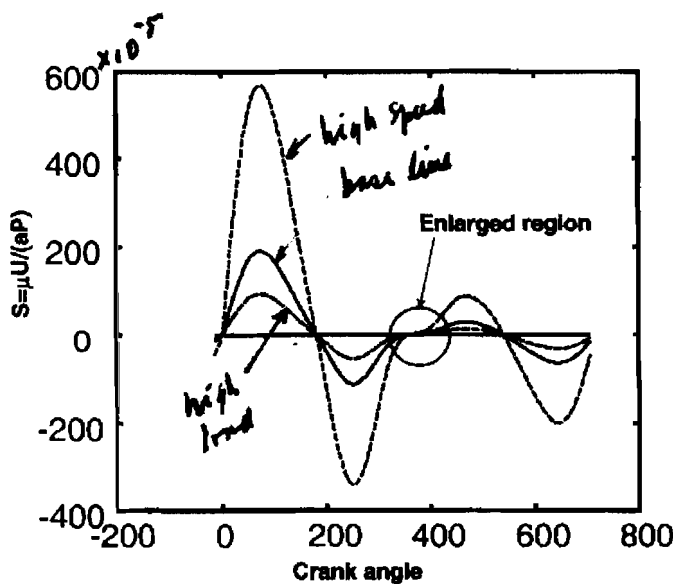
$$\frac{U(\theta)}{2NL} = \frac{\pi}{2} \sin \theta \left[ 1 + \frac{\cos \theta}{(R^2 - \sin^2 \theta)^{1/2}} \right]$$



$$R = \frac{l}{a} = 3.16$$

$$L = 2a = 8.6 \text{ cm}$$

The corresponding values of  $S = [U(\theta)/\pi l_0]_{\text{rms}}$  are plotted. Note that  $U(\theta) \propto \omega$ , 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  $h/e$  where  $h$  is the film thickness and  $e$  the surface roughness height.

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

$$\left(\frac{h}{a}\right) \text{ is } \approx \sqrt{5}; \text{ so}$$

$$\left(\frac{h}{e}\right) = \left(\frac{a}{e}\right) \sqrt{5}$$

If the critical  $\left(\frac{h}{e}\right) = 1$ , and  $e$  is typically  $\approx 3 \mu\text{m}$ , then  $(a/e) \approx 300$

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

