MEGR3210 Equation Sheet J. Hill 2013

$\overline{U}_p$ = 2sN = mean piston speed   s = stroke, N = revolutions/time

$w_{i,g}$ = gross indicated work per cycle = indicated work considering only compression and expansion

$w_{i,n}$ = indicated net work per cycle

$P_{i,g}$ = gross indicated power, P_f = power to overcome friction + pumping losses, P_b = net power at the crank

$P_b = P_{i,g} - P_f = \tau\omega = 2\pi N \tau$ τ = torque, ω = rotational speed in rad/time

mep = w_{net}/V_d w_{net} = net work per cycle, V_d = displacement volume

imep = (indicated net work)/V_d

bmep = $P_b/(V_d N/n)$ n = number of crank revolutions per cycle τ = bmep $V_d/(2\pi n)$ so max τ at max bmep

fmep = friction mean effective pressure = imep - bmep

$\eta_m = P_b/P_{i,g}$ = mechanical efficiency (Caution: Some books use $P_{i,net}$)

η_c = combustion efficiency = (amount of fuel burned)/(amount of fuel delivered)

bsfc = brake specific fuel consumption = $\dot{m}_f/P_b$

η_{fc} = fuel conversion efficiency = $P_b/(\dot{m}_f Q_{LHV})$ Q_{LHV} = Lower heating value of fuel used as approximation

η_v = volumetric efficiency = $\dot{m}_a/(\rho_a V_d N/n)$ ρ_a can be atmospheric or intake air density, must be specified

A/F = $\dot{m}_a/\dot{m}_f = 1/(F/A)$ $\phi = (F/A)_{actual}/(F/A)_{stoic}$ = equivalence ratio = $1/\lambda$

$P_b = \eta_{fc}\dot{m}_f Q_{LHV} = \dot{m}_a (F/A) \eta_{fc} Q_{LHV} = \eta_v \eta_{fc} \rho_a V_d (F/A) Q_{LHV} N/n$ (F/A) optimized for particular operating point.

$\tau = \eta_v \eta_{fc} \rho_a V_d (F/A) Q_{LHV}/(2\pi n)$ No explicit dependence on engine speed! τ tracks η_v.

$\frac{T_0}{T} = 1 + \frac{k-1}{2} M^2$ $\frac{P_0}{P} = [1 + \frac{k-1}{2} M^2]^{\frac{k}{(k-1)}}$ Ram air: $\frac{P_{b2}}{P_{b1}} = [1 + \frac{k-1}{2} M^2]^{\frac{k+1}{2(k-1)}}$ where P_b = power

$\dot{m} = \rho \vec{V} A = \frac{P_0}{\sqrt{T_0}} AM\sqrt{\frac{k}{R}}[1 + \frac{k-1}{2}M^2]^{-[\frac{k+1}{2(k-1)}]} = \rho_0 c_0 A\sqrt{\frac{2}{k-1}[\left(\frac{P}{P_0}\right)^{\frac{2}{k}} - \left(\frac{P}{P_0}\right)^{\frac{k+1}{k}}]}$ Zero subscripts indicate stagnation cond.

for choked flow $\dot{m} = \rho_0 c_0 A[\frac{k+1}{2}]^{-[\frac{k+1}{2(k-1)}]}$

$\frac{P_{b2}}{P_{b1}} = \frac{P_2 - P_{v2}}{P_1 - P_{v1}}\sqrt{\frac{T_1}{T_2}}$ Power correction for pressure, temperature and humidity.