PROJECT No. (1)

⌘ Objectives

1. To have an idea about the basics of engine simulation.
2. To study the effect of various engine design conditions on its ideal performance.

⌘ Model Input data required

3. Engine design parameters: D, S, CRL, CR, RPM
4. Fuel and air data : CV, A/F, Cv, Cp, Ma
5. Inlet conditions : P1 and T1.

⌘ Main Program

1. <u>Compression Stroke (1-2), (0 ≥ θ ≥180)</u>

- Start with calculation of V(θ) using equation No.(4) see next page.
- Then calculate $P(\theta+1) = P_\theta * \left[\frac{V_\theta}{V(\theta+1)}\right]^k$
- Then finally calculate $T(\theta+1) = T\theta * \left[\frac{V_\theta}{V(\theta+1)}\right]^{K-1}$

2. <u>Combustion Stroke (2-3), (θ =180)</u>

In order to calculate for this process, one must calculate the amount of heat added first.
- $Q_{add} = M_f$ * Calorific Value = (Calorific Value / (A/F)) kJ/Kg of air.

Now the total mass of the charge per 1 Kg of air (M_t) = 1 + F/A
[In case we are simulating for air standard cycle M_t = Ma]
- Then; $Q_{add} = M_t * Cv * (T_3 - T_2)$ From which we can find

$T_3 = T(\theta = 180) = (Q_{add} / M_t * Cv) + T_2$
[In case we are simulating for air standard cycle $T_3 = T(\theta = 180) = (Q_{add} / Ma * C_V) + T_2$]
- Then calculate $P_3 = P(\theta = 180) = P_2 * (T_3 / T_2)$

3. <u>Expansion Stroke (3-4), (180 ≥ θ ≥360)</u>

- Start with calculation of V(θ) using equation No.(4).
  - Then calculate $P(\theta+1) = P_\theta * \left[\frac{V_\theta}{V(\theta+1)}\right]^k$
  - Then finally calculate $T(\theta+1) = T\theta * \left[\frac{V_\theta}{V(\theta+1)}\right]^{K-1}$

4. <u>Exhaust Stroke (4-1), (θ = 360)</u>

Since this is a simplified model and for the sake of this project only, restore the final values to the initial values.

Main equations used

- $Vs = 0.25 * PI * D^2 * S$ (1)
- $V_{TDC} = V_2 = V(\theta = 0) = Vs * (1 / (CR-1))$ (2)
- $V_{BDC} = V_1 = V(\theta = 180) = Vs * (CR / (CR-1))$ (3)
- $V(\theta) = Vs * \left[\left(\frac{CR}{CR-1}\right) - \left(\frac{1-\cos(\theta)}{2}\right) + \left(\frac{R}{S}\right) - \frac{1}{2} * \sqrt{\left(\frac{2*R}{S}\right)^2 - \sin^2(\theta)}\right]$ (4)
- $IMEP = WD / Vs$ (5)
- $IP = (IMEP * A * S * (N/n_r))$
- $IT = IP/2*PI*N$ (6)
- $WD = M_t * Cv * [(T_3 - T_2) - (T_4 - T_1)]$ (7)
- $\eta_{ith} = WD/Q_{add} = IP/(M_f * Q_{CV})$ (8)
- $ISFC = M_f / IP$

Where;

Vs = Stroke volume (m)	D = Cylinder diameter (m)	S = Stroke length (m)
CR = Compression Ratio	R = Connecting Rod Length (m)	θ = Crank Angle (rad)
WD = Net Work Done (kJ)	IP = Indicated Power (kW)	A = Cylinder Area (m^2)
IT = Ind Torque (N-m)	N = Engine Revolutions (RPS)	n_r = 2 for 4-strokes
IMEP = Ind Mean Effective Pressure (bar)		η_{ith} = Ind Thermal Eff.
ISFC = Ind Specific Fuel Consumption (Kg/kW-hr)		

Plots required

- Pressure and temperature variations with crank angle.
- Pressure and temperature variations with cylinder volume.
- Effect of CR on engine performance parameters like (IMEP, ISFC, IP, WD & IT) taking 4 different values for CR (6,7,8 & 9).
- Effect of specific heat ratio (γ) on P-V and T-V diagrams.

This program can be done using any of the programming languages (C, FORTRAN, PASCAL, BASIC ...etc) or worksheets (EXCELL ....etc).

Last date of submission of this project is Thursday 15 May 2014.

To test the output of your program, use the following data :

D = 7.94 cm, S = 11.12 cm, CRL = 23.34 cm, N = 4000 rpm, CR = 6
Q_{CV} = 42000 kJ/Kg, A/F = 14.6, Cv = 0.718 kJ/Kg-K, P_1 = 1.0135 bar, T_1 = 300 K

You should be able to get the following output :
P2 = 12.452 bar, T2 = 614.302 K, P3 = 88.468 bar, T3 = 4364.035 K, P4 = 7.2 bar & T4 = 2132.65K, IMEP = 24.98 (bar), WD = 1376.465 (kJ/Kg), IP = 45.88 (kW), ISFC = 0.164 (kg/kW-h), ηith =0.5215

Once your model is verified, you can go for the engine performance study.