MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

2.61 INTERNAL COMBUSTION ENGINES

Homework Set #5

Problems:

1) Problem 6.1 of text book. For part (c), think about under the same engine speed and BMEP, why would the inlet manifold pressure and thus the Pumping MEP be different for the two fuels. Hint: the volumetric efficiency is due predominantly to quasi-static effects as depicted in Eq. 6.2, for which the {} term and the intake temperature may be assumed to be the same for the two fuels.

2) This problem is an exercise to get an idea of the flame propagation environment under typical engine condition. In the problem set directory, the simulation results for operating an engine under vehicle cruise condition (see engine specification below) are tabulated in the ascii file si_sim.oum. The columns are explained in the matlab m-file si_sim.m and also documented below. (If you are using matlab, executing the m-file si_sim.m will automatically load the data file into the various variables; if you want to use Excel, you can import the ascii file into a spread sheet.)

Engine specification: 1500 rpm; intake pressure=38 kpa; λ =1; ignition at 30° BTC
                          Bore = 86 mm; stroke = 86 mm; con-rod to bore ratio = 1.58
                          Clearance vol.=58.77 cc.

Plot the following quantities as a function of the mass burned fraction. Use Eq. 9.36 for the laminar flame speed calculation. The residual gas mole fraction is 20%. After the plots (by the computer), take a look at the values to appreciate the magnitude of the various quantities. Note that for stoichiometric gasoline combustion, the burned and unburned gas have approximately the same molecular weights of 29. (Good engineers/scientists should always be familiar with the numbers for the phenomena they are working on.)

(i)   The unburned and burned gas temperatures
(ii)   The pressure
(iii) The laminar flame speed
(iv)   The laminar flame expansion velocity
(v)   The mass fraction burn rate $d(x_b)/d\theta$
(vi)   The volume of burned gas as a fraction of the charge volume
(vii) Assuming that the engine has a flat head and a flat piston, and assuming that the burned gas occupies a cylindrical volume of radius R and a height equals to the combustion chamber height, plot the ratio of 2R/B where B is the bore. (In reality, the 'flame ball' is more likely to be roughly hemispherical at first until it touches the piston; then it will transition into a cylindrical geometry.)

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For Problem 2, the columns of data in the file si_sim are:

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theta=si_sim(:,1);          %crankangle
p    =si_sim(:,2);          %pressure (bar)
tu   =si_sim(:,3);          %unburned gas temp (k)
tb   =si_sim(:,4);          %bunred gas temp (k)
m_int=si_sim(:,5);          %cumulative mass inducted (g)
m_exh=si_sim(:,6);          %cumulative mass exhausted (g)
viv  =si_sim(:,7);          %velocity at intake valve (m/s)
vexh =si_sim(:,8);          %velocity at exhaust valve (m/s)
xb   =si_sim(:,9);          %mass fraction burned
x_net=si_sim(:,10);         %net ht rel / (LHV*fuelmass)
qdot_h=si_sim(:,11);        %heat transfer (J/deg)
w_pist=si_sim(:,12);        %work transfer to piston (KJ)
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