MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

2.61 INTERNAL COMBUSTION ENGINES

Homework Set #4

Problems:

1) The fuel injector flow rate (mass per unit time) is constant so that the amount of fuel delivered is controlled by the pulse width. This flow rate is sized by the requirements that at idle, the injector should meter the fuel accurately (thus the lower the flow rate the better, since the corresponding pulse width will be longer and the metering error will be less), and at WOT and max engine speed, there is enough fuel delivered within the time constrain of a cycle.

For a four-cylinder 2L displacement engine, with a max speed of 6500 rpm

(a) Estimate the smallest injector flow rate that will do the job

(b) What is the fuel pulse width at idle? (Idle intake pressure ~0.3 bar.)

2) Consider the discrete form of the x-τ model. At cycle i, the following definitions are used:

f_i mass of fuel injected

M_i puddle mass

k fraction of puddle mass evaporated; can be interpreted as $\Delta t/\tau$ where Δt is the time per cycle

m_i mass of fuel vapor delivered to cylinder

x fraction of injected fuel going into puddle

The fuel puddle dynamics may then be described by the finite difference equations

$$\text{Puddle increment}: M_i - M_{i-1} = xf_i - kM_{i-1}$$
$$\text{Vapor to cylinder}: m_i = (1-x)f_i + kM_{i-1}$$

(a) if the fuel injection amount is a constant equal to f_0, what are the equilibrium values for the puddle mass M_0 and the fuel delivered to the cylinder m_0?

(b) If the fuel injection has a step change from f_0 to f_1, the fuel delivered will not jump to the new equilibrium value instantaneously. Simulate on the computer the time history of m_i and M_i . The numerical values for a typical 2L, 4-cylinder engine are f_0=10 mg, f_1=35 mg, k=.05, x=0.7. (You can also work out the problem analytically. The puddle mass development is a geometric series.)