MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

2.61 INTERNAL COMBUSTION ENGINES

Homework Set #6

Problems

1) Many inventors claim that they have invented a high energy spark plug which would substantially improve combustion and engine efficiency. Typical commercial spark discharge system puts out ~30 mJ per pulse; because of heat loss to electrodes, only about 10% of this energy gets delivered to the charge. (For a stoichiometric mixture, only ~0.2 mJ is needed for ignition.) For a high energy spark plug (300 mJ per pulse – ten times the energy delivered by the commercial system), say 30 mJ is delivered to the charge. To see whether this has substantial effect on the overall combustion behavior, estimate the size of the flame such that the heat release from the burned gas is equivalent to 30 mJ. (You may assume a spherical flame ball and determine its radius. The mixture is stoichiometric with 20% residual)

2) One strategy to prevent the engine from knocking is to enrich the mixture to a fuel equivalence ratio of Φ =1.2. There are two effects: (a) the lowering of the charge temperature by more fuel being evaporated; (b) the value of γ for the unburned mixture decreases with Φ. Compared to the case of Φ =1, estimate the decrease in compression temperature due to the effects of (a) and (b). You may assume a compression ratio of 9, and γ = 1.33 and 1.30 for Φ = 1 and 1.2, and make other reasonable assumptions.

3) The large local pressure and temperature rises due the very fast compression ignition of the end gas (knocking) could cause severe damage to the combustion chamber. To estimate the magnitude of these quantities, consider the constant volume combustion of a mass element of stoichiometric gasoline mixture with 10% residual gas at TDC of a naturally aspirated SI engine operating at WOT. The effective compression ratio is 9 (the effective compression ratio is due to that IVC is not at BDC). Assume that the density of the trapped charge is 1 kg/m^{3}at IVC, and that the charge may be considered as an ideal gas with γ = 1.33.

   (a) What is the pressure rise due to the constant volume combustion of the mixture?
   (b) If the pressure before knocking is 20 bar, what is the temperature of this burned gas? (The actual temperature is lower because of dissociation.)

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