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2.61 Internal Combustion Engines
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Quiz (1 ½ hour), March 20, 2008

(You may use your text book, your lecture notes, and calculator.)

Problem 1

Spark Ignition engine compression ratio is limited by knocking. A strategy to abate this limitation is to operate the engine in the Miller cycle. In this arrangement, the intake valve is close late in the compression process so that the effective compression ratio is smaller than the geometric one. Thus the compressed temperature is reduced, thereby reducing the knock tendency, while the efficiency, which is mainly governed by the expansion ratio, is not significantly affected.

In the following ideal cycle calculations, assume that the working fluid has specific heat ratio γ of 1.33.

- (a) Carefully sketch the pressure volume diagram for an ideal Constant Volume combustion cycle under Wide-Open-Throttle (WOT) condition; then sketch on the same figure, the Miller cycle with the intake valve closed at 90° crank angle after BDC.
- (b) If the geometric compression ratio is 14 and the inlet temperature is 300° K, what are the corresponding compression temperatures (in the ideal cycle analysis) for the regular cycle and for the Miller cycle in part (a)?
- (c) A draw back for the Miller cycle is that by closing the valve late, less charge is trapped and therefore, there is a corresponding power loss. Name two strategies that would compensate for this power loss.
- (d) For an ideal Constant Volume combustion cycle, what is the fuel conversion efficiency at compression ratio of 14?
- (e) (*Do not do this part if you run out of time.*) For a Miller cycle with effective compression ratio (r) of 7 and expansion ratio (ϵ) of 14, if the intake temperature is 300° K and the temperature rise in the constant volume combustion process is 3000° K, what is the fuel conversion efficiency? Compare this answer with part (d).

Problem 2

In the drag racing business, it is known that substantial power increase may be obtained by injecting nitrous oxide (N_2O) into the intake manifold.

- (i) Explain qualitatively the above power increases.

Use isooctane as fuel, we want to compare the power output of the same engine using a stoichiometric isooctane/ air mixture and a stoichiometric mixture of isooctane and a gas comprising of 70% air and 30% nitrous oxide by volume. You may assume that the pressure and temperature of the charge at the point of Intake-Valve-Close are the same, and that all the isooctane has vaporized; neglect any residual gas fraction.

The heat of formation of N_2O (Δh_f^0) is $+82.5$ KJ/mole; those for other species are listed in Table D2 of text.

- (ii) What is the heating value per unit mass of the stoichiometric iso-octane/ air mixture?
- (iii) What is the heating value per unit mass of the stoichiometric iso-octane/ air/ N_2O mixture?
- (iv) What is the ratio of the power output of this engine operating by using these two different oxidizers?