Agricultural and Biosystems Engineering, Iowa State University Fall 2007

**Homework 2**

Question 1: For the following engines:

| | | |
|---|---|---|
| 2 cylinder, 4-cycle; | 2 cylinder 2-cycle; | 3 cylinder, 4-cycle; |
| 4 cylinder, 4-cycle; | 6 cylinder, 4-cycle; | 8 cylinder 4-cycle; |

(a). Determine the average firing interval.
(b). Identify those engines with an uneven power strokes.
(c). Identify those engine with power strokes that overlap. Assuming engines of equal power were available for each of the engine types determine the order of relative size of flywheel required for each engine. (i.e. From largest flywheel to smallest flywheel).
(d). For a 5cylinder, 4 cycle engine, determine the crank angle degrees when intake and exhaust valves would open and close for any 3 of the five cylinders. Assume that a crank angle of 0 degrees corresponds with the piston 1 at TDC at the beginning of the intake stroke. Assume that intake valve opens $15^o$ before TDC and closes $45^o$ after BDC; and that exhaust valve closes $15^o$ after TDC and opens $45^o$ before BDC. The firing order of the engine is 1,5,2,4,3

Question 2:
(a). Is the minor diameter (Measured parallel to the piston pin) and the major diameter (measured perpendicular to the piston pin) of a piston the same when the piston is cold? If not, explain the reasons for this difference.
(b) If the exhaust valve clearance is too small, would this cause the valve to prematurely fail? If this is the case, give two different reasons this could cause valve failure.
(c). After an engine is dismantled the following observations were made on only one of the four engine cylinders (other 3 appeared to have no damage). (1). The front top and back bottom edges of the piston were badly worn in a plane parallel to the crankshaft. Give potential causes for this uneven wear and explain how the wear occurred.

Question 3: The stoichiometric A/F ratio for gasoline engines is 15.05 for complete combustion, producing carbon dioxide and water.
(a). If the A/F ratio was decreased to 12.04, would the air/fuel mixture be considered a rich or a lean mixture, and would complete combustion occur.
(b). Name two additional combustion products that may be produced under these conditions.
(c). Determine the mass of all combustion products at the A/F ratio of 12.04, for gasoline ($C_8H_{18}$)
(c). An engine is tested with the following A/F ratios, (10, 15, 20, 25, 50, and 75). It was found that the engine would run satisfactorily at A/F ratios above 25. Is this a SI engine or diesel engine? Explain your answer.
(d). When would you use a high cetane fuel in a gasoline engine? Explain your answer.

Question 3b: Blended fuels are sometimes used in engines. Different ethanol blends can can be used for automobiles. Given the following information:

| | Chemical Formula | Density | Heating Value |
|---|---|---|---|
| Ethanol | $C_2H_5OH$ | 0.780 kg/L | 21 000 kJ/L |
| Gasoline (Octane) | $C_8H_{18}$ | 0.740 kg/L | 35 000 kJ/L |

Note: For every mole of an oxygen molecule in air, there are 3.76 moles of nitrogen molecules.
a). For a 15% Ethanol Blend (by vol) Determine the composite fuel molecule $C_{xc}H_{yc}0_{zc}$ which can be used to represent blended fuel.
b). Show the balanced Stoichiometric combustion equation for the composite molecule.
c). Calculate the Stoichiometric air to fuel ratio for the fuel blend.

Question 4: The point's T10 , T20 , and T90 refer, respectively to the temperatures on the fuel distillation curve at which 10, 50 and 90 % of the fuel has been distilled.
(a). Why is it important that the T10 temperature is not too high? What would the effect of increasing the T10 temperature be on starting an engine in cold weather?

(b). Engines' warm time up depends on the T50 temperature of the fuel. For gasoline would the T50 temperature be increased or decreased during winter. Explain your reasoning.

(c). A fuel is found to cause dilution of the crankcase oil. Which of the three distillation temperature points are associated with this phenomenon How does the fuel enter the crankcase?

(d). Gasoline volatility is adjusted by petroleum refiners to suit the season. Give one reason why the volatility of gasoline is increased in winter, and a second reason why the volatility is lower in summer.

Question 5: The ignition delay of a fuel after the self-ignition temperature is reached, has important effects on the speed of the flame front, rate of combustion and rate of pressure rise in the engine cylinder.

(a). Why would you tend to use a fuel with a relatively long ignition delay in a spark ignition engine?

(b). What would be the effect of using fuel with a long ignition delay in a diesel engine?

Question 6: The timing of start and end of injection for an in-line injector pump and a rotary distributing type pump are very different

(a). For an in-line injection pump, does the start of injection change with the mass of fuel per injection? Explain your answer

(b). For an in-line injection pump, explain the effect of increasing the injection volume on the start and end of injection.

(c). For a rotary injection pump, Does the timing of the end of injection change as fuel delivery increases? Explain your answer

(d). For a rotary injection pump, explain why the start of injection for a rotary pump changes in proportion to the volume of fuel per injection

Question 7 The dwell angle is important in a spark ignition engine

(a). Define the dwell angle.

(b). What is the effect of decreasing the dwell angle on the spark voltage?

(c). Explain the effect of points gap on dwell angle.

(d). Does engine speed affect the dwell angle? What effect does engine speed have on dwell time and how does this affect spark voltage.

Question 9: You are fitting an turbocharger to a 7.2 litre engine. You wish to develop 250 Hp at 2100 rpm and run at an A/F ratio of 30:1. The brake specific fuel consumption is .027 kg/kW hour.

(a). Find the required fuel consumption

(b). Find the required air consumption

(c). Find the required volumetric efficiency

(d). Determine the Pressure Ratio required if the turbocharger compressor has an efficiency of 0.70.