2.61: Internal Combustion Engine - Engine Laboratory Exercise

OBJECTIVE

The objective of the laboratory is to provide the students with some familiarity to how do a real engine behave, to operate the engine and the exhaust gas emissions measurement system, and to acquire and explain the engine data.

ORGANIZATION

The class will be divided into a Tuesday group and a Thursday group. Each group will work on the engine for one afternoon from 12:30 to 2:30 pm. The data gathering is a team effort, with the raw data to be shared by all members of the group. Each student, however, has to write a lab report individually based on independent analysis of the raw data.

The report title will be **"The Spark timing and λ Dependence of SI Engine Behaviors"**. The data presented in the report should have been reduced to meaningful results. It is important that the results be explained according to your understanding of the physical phenomena involved.

LABORATORY MEASUREMENTS

The engine is a turbocharged in-line 4-cylinder, 4-valve per cylinder production spark ignition engine with direct fuel injection. The engine is the GM LNF engine, which powers the Chevrolet Cobalt and Pontiac Solstice. We will be operating the engine at part load. The specifications are:

Displacement	1998 cc		
Bore	86 mm	IVO	1° ATDC gas exchange
Stroke	86 mm	IVC	51° ABDC compression
Compression Ratio	9.21	EVO	42° BBDC exhaust
Connecting Rod Length	158 mm	EVC	0° ATDC gas exchange

The fuel used is a certification gasoline with RON/MON = 96/88.5 and a H to C ratio of 1.85. The fuel is injected into the cylinder in the intake stroke. In this set of experiments, the fuel amount is fixed (controlled by the fuel pulse width). The nominal NIMEP is 3.5 bar. The equivalence ratio is sensed by the Universal Exhaust Gas Oxygen (UEGO) sensor at the exhaust. The throttle is adjusted to control the air intake to give the desired λ. The engine is running under part load condition so that the intake pressure is sub-atmospheric. The turbocharger is not active under this condition.

In engine tests involving sweeping the value of a parameter, it is important to specify what the fixed parameters are. In all cases, the speed is at 1500 rpm.

a) At λ =1, and fixed fuel amount, do a spark sweep in the range of MBT timing +/- 20°. Note that the NIMEP will change in the sweep.
b) At the fixed fuel amount, do a λ sweep from 0.8 to 1.2. For each λ value, do a quick spark sweep to set the spark at MBT.

Plot the following measurements as a function of the swept parameter:

1. Net Indicated Specific fuel consumption
2. The CA0 (i.e. spark point), CA10, CA50 and CA90 on one graph
3. The NIMEP and COV of the NIMEP
4. Exhaust gas temperature
5. NOx, both as ppm and as specific emission index (i.e., on a per cycle basis, mass of NOx divided by mass of fuel; in unit of gram of NOx per kg of fuel). In reporting the mass of NOx, assume that all the nitrogen oxide species are NO_2 per EPA regulation.
6. HC, as ppmC1 and specific emission index (g of HC per kg of fuel). Use the EPA definition to convert the HC from ppmC1 to HC mass.
7. CO as mole fraction and specific emission index (g of CO per kg of fuel)
8. CO_2 as mole fraction and specific emission index (g of CO2 per kg of fuel)

You are to explain the dependence of the above quantities on λ and on spark timing.

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