ME 646 – Internal combustion engine lab
Spring 2017

References: Robert B. Heywood, Internal Combustion Engine Fundamentals, 1988, chapter 2 and 3.

Purpose: The goal of this lab is to analyze a Kohler Model CH20S spark-ignition (SI) engine to determine its performance. The engine is connected to an instrumented brake (i.e., an eddy-current dynamometer) controlled by a Dyn-Loc IV digital dynamometer controller. The output of the dynamometer controller is torque, speed, and power.

Note: For your safety, please stay inside the engine control room while the engine is running. The TA's will perform the necessary tasks near the engine. Ear plugs will be supplied and are recommended.

Data Collection Procedures:

The dynamometer control unit will be used to control engine load (and speed) by varying the <u>dynamometer</u> speed from 1100 RPM to 500 RPM in 100 RPM increments. ***<u>Note that the engine speed is 3.16x the speed of the dynamometer as a result of the transmission between the engine and the load. The torque produced by the engine is 3.16x smaller than the dynamometer reading.</u>***

Record the mass of the fuel tank at the beginning and end of a measured time interval (60 seconds) once the engine stabilizes at a given engine speed. Enter these data in the first two columns of a five column table where the other columns are RPM of the dynamometer, torque, and power.

The TA's will record cylinder pressure vs. time and a pulse at top dead center of the piston stroke for each engine speed. The data will be posted on Canvas.

Deliverables: Your report consists of plots and tables followed by the Matlab code you developed for deliverable 1 and 2 all summarized in single pdf. You may use Excel for deliverable 3 but you must integrate the table into the single pdf. All plots must be properly labelled and have a descriptive figure caption. Remember to use symbols for discretely obtained data unless the data is so densely obtained that the symbols overlap (deliverable 1 should not have symbols, deliverable 4 and 5 should use symbols).

1. Data files of optical sensor output vs. time and cylinder pressure vs. time will be posted for each engine speed. Create plots of:
    a. Optical sensor output voltage vs. time, crank angle (in radians) vs. time, cylinder volume vs. time, and pressure vs. time for five cycles in four stacked plots for a single engine speed.
    b. Pressure vs. cylinder volume for a single, representative cycle at a single engine speed
    c. Pressure vs. cylinder volume for all cycles at a single engine speed.
2. Integrate the PV diagram for ten single cycles to determine the average work per cycle per cylinder and the average power per cycle per cylinder for all engine speeds. Compute the standard deviation of these two quantities. Summarize this information in a table.
3. Create a seven column table that has RPM for column 1, mass of fuel per cylinder per cycle for column 2, mass of air per cycle per cylinder for column 3, horsepower in column 4, engine

torque in column 5, and brake thermal efficiency in column 6, mechanical conversion efficiency in column 7. You need to perform the following tasks to obtain the data for the table.

a. Convert the dynamometer measurements to engine speed and torque produced by the engine. Use the transmission information above to make this conversion. Put the information in the table.
b. Compute the average mass of fuel injected per cycle, per cylinder for each engine speed. Remember that one cycle takes two rotations and the engine has two cylinders. Put the information in the table.
c. Using the results from (3b), compute the average mass of air inducted per cycle per cylinder for each engine speed assuming that the ratio of air to fuel is stoichiometric. Use a mass ratio of 14.7:1. Put the information in the table.
d. Using the results from 3b and 3c, compute the total heat released per cycle for each engine speed assuming complete combustion (the only products are $H_2O(g)$ and $CO_2(g)$) Assume the heat content of the fuel to be 44 MJ/kg.
e. Compute the fuel conversion efficiency as a function of engine speed in RPM. This is brake thermal efficiency. Put the information in the table.
f. Compute the mechanical conversion efficiency by dividing the brake power by the average power per cycle from the integrated PV data from 2. Remember that you only measured PV data for one cylinder so you need to multiply your integrated PV work by two but you must consider the number of cycles per revolution.

4. Create a plot of brake torque vs engine speed and brake power vs. engine speed on the same plot. List the maximum torque and maximum power on the plot. (Based on the data you took in the lab). You must use a yy vs. t plot where the y axes are separate. Carefully indicate which axis each data set refers to.
5. Create a plot of brake thermal efficiency vs. engine speed (from 3.e.)

Engine data

- Max Power @3600 RPM hp (kW): 20 (14.9)
- Two cylinder, four stroke engine.
- Displacement cu in (cc) : 38.1 (624)
- Connecting rod length in. (cm) 4.55 (11.6)
- Bore in (mm) : 3.03 (77)
- Stroke in (mm): 2.64 (67)
- Peak Torque @ Maximum ft-lbf (Nm): 32.7 (44.3)
- Compression Ratio: 8.5:1
- Dry Weight lbs (kg): 90 (41)
- Oil Capacity U.S. quarts (L): 2 (1.9)
- Lubrication Full pressure w/full-flow filter
- Dimensions L x W x H in: 14 x 17.7 x 19.0

Pressure sensor data: 0.0104 V/psi. The sensor output is 1.046 pC/psi. The output of the sensor goes to a charge to voltage converter with a conversion coefficient of 1 mV/pC. The output of the charge to voltage converter goes to a signal conditioner with a gain of 10.