Internal Combustion Engine Fundamentals
Hand-In Assignments

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1 First Hand-In

Prerequisite, set the path to CHEPP or install it.

The goal is to become familiar with

- the properties of burned and unburned gases and how they are modeled
- the magnitude of the absolute enthalpy for air and fuel and combustion products
- knowledge about different gas models and how their thermodynamic properties are calculated, as well as experience from working with these fluids.

Assignments

1. CHEPP accounts for molecules in the gas phase only. Therefore only one type of heating value can be determined from the properties that are returned. Which one?
2. Use CHEPP and generate figures similar to those in Chapter 3, e.g. Figure 3.5. Give a rough estimate of what temperature spans are relevant to study.
3. Study the absolute enthalpy, and heating values for dry air, an air/fuel mixture, and burned gases. Look at the cases $\phi = [0.5, 1.0, 1.5]$ and study both Methanol and Isooctane. Perform the study by plotting, comparing and reflecting about the magnitudes and the interconnections between the quantities.
4. Complete exercises 3.5, and 3.6 in Heywood.
5. How big is the difference between q_{LHV_p} and q_{LHV_v} for Methanol (and optionally Isooctane)?
6. Complete 4.3 and 4.4 in Heywood.
7. Use CHEPP to perform exercise 4.15 in Heywood.
8. Assuming that Equations 4.19a-c in Heywood are "correct" according the assumptions from the thermodynamic laws. When are Equations 4.20a-b correct and when are they not?
9. Compare the gas models in Tab 4.2, with respect to how they influence the ideal Otto cycle efficiency for different compression ratios. Compare for example the cycle efficiencies with respect to extreme values in c_v.
10. Select at least one of the following tasks.
    (a) Use CHEPP and make a script that reproduces Figure 5.10.
    (b) Use CHEPP and make a script that reproduces Figure 5.9 and also varies the residual gas fraction.

Second hand-in

1. Study the experimental data from the lab and analyze the influence of load and speed on the volumetric efficiency. It is also interesting to study the influence that the inlet and exhaust valve openings have on the volumetric data. (You do not have to do an in-depth analysis of the data; just see of there are there or aren't any clear trends in the data.)
   Per Öberg has provided data.

2. Create the turbine and compressor map from the data that is measured in a steady state flow bench. That is calculate the corrected flows, corrected speeds, pressure ratios, and efficiencies. Then plot the data in the same way as the turbo charger maps are normally presented.
   Oskar Leufvén has provided measurement data for the map.

Third hand-in

Cylinder pressure data is provided from a naturally aspirated SI engine.

1. Compute mass fraction burned and the net heat release trace for the cylinder pressure data. Perform the calculations using the Rassweiler and Withrows method (described on page 385 in [1]) and the net heat release method (originally developed in [2] and that is described by the two first terms in (9.27) in [1]). Note that the crank angle and pressure offsets have to be determined.

2. How much heat is released according to the net heat release method and where is the mfb-50 positioned? Assuming that $Q_{ch} \propto mfb$, are there any big differences between the traces from the methods.

3. Is there a noticeably higher heat release in the cycle just after a cycle with a skipped firing? Approximately how much higher?

4. Next we will study the cycle to cycle variations in the mass fraction burned traces. Using the standard methods from the basic course in statistics, develop and describe a method for how to determine the number of cycles that are needed if you want to determine average values of the crank angle position for the 50% mass fraction burned to within X degrees. How many cycles does the provided data indicate for X=0.5 degrees.

Fourth Hand In

There is a two-zone model available that simulates pressure and temperatures in the zones. See the instructions below.

1. Calculate the NO_x concentrations at EVO with the aid of the Zeldovich-mechanism and compare them for the following temperature and pressure traces. (Note that the first two items below correspond to Figure 11-7 in Heywood.)

   - A zone that burns early, for example the first element that burns.
   - A zone that burns late.
   - A zone that follows the temperature of the burned zone.
   - A zone that follows the average temperature of the cylinder.

2. Study and comment on how the combustion phasing influences the NO_x generation. Can some conclusions be drawn?

3. (Extra task) The temperature has a strong influence on the NO_x emissions and the temperature distribution in the burned zone is not homogeneous. A common method for achieving a good description of the NO_x generation is to divide the burned zone into several zones. How does the total NO_x at EVO depend on the number of zones that have been selected[1].

PsPack Instructions These are the instructions in for PsPack and they are written for those who are working on the Unix system.

1. psPack i specialutförande ligger på `~oberg/Share/psPack_Heywood.tar.gz`.
2. packa upp med `tar zxfv psPack_Heywood.tar.gz`.
3. Starta matlab och gå till `psPack_Heywood/psExamples`
4. Kör det som finns i `doSim.m`.
5. Använd gärna Matlab 7.2 om det strular med andra versioner.
6. Ha inte Chepp i din sökväg, den version Per använder kan kollidera med Lasses. Jag har varit tvungen att vända på riktningen på en vektor.
7. Man får några få (högst två) varningar från Chepp men de är inget att bry sig om.

References

[1] J.B. Heywood. *Internal Combustion Engine Fundamentals*. McGraw-Hill series in mechanical engineering. McGraw-Hill, 1988.

[2] R.B. Krieger and G.L. Borman. The computation of apparent heat release for internal combustion engines. *ASME*, 1967.

[1] Some researchers claim that 3 zones are sufficient while other claim that 5 are needed.