ME 410 Day 19

Topics

- Calculations with Unburned Mixture
- Calculations with Burned Mixture
- Combustion at Constant Volume

1. Unburned Mixture

Remarks:

- Last time I commented that in making unburned mixture calculations, the residual mass fraction,

$$x_b = \frac{\text{mass of residual}}{\text{mass of charge}}$$

  is set to zero. That was not completely correct. In calculating the temperature and pressure at the end of the process one does find that the burned gas or residual gas has little effect. But, in order to go on to combustion, it is very important to have the correct internal energy and/or enthalpy at the end of the step. To get this x_b is needed.

- We have a problem in modeling using EES which needs to be noted. There is not any isooctane in EES. What EES has is n-octane, a different fuel. (It actually has a negative octane number!) But this is the closest thing to gasoline that we are going to be able to get. Therefore, reproducing the texts results will be somewhat hit or miss -- they are mostly based on isooctane.

Software:

- I will demonstrate an EES file which does Example 4.2 in the text. It is a continuation of the lean mixture file from a previous day. Note how x_b does not effect pressure and temperature at 2, but does effect enthalpy.

2. Burned Mixture

Remarks:

- For the burned mixture, let's use the full chemical equilibrium routine demonstrated earlier.

- If we wished, we could call this program whenever we needed it in an EES routine that was doing engine modeling. But, for now, let's call it from a simple routine, where we can study the internal energy, enthalpy and molecular weight of the burned gas as functions of temperature and pressure.

- For this piece of modeling, there is no need to worry about the fraction x_b, it's all burned now!

- The fuel air equivalence ratio is also important, of course.

- One nice thing is that there is now no need to worry about the distinction between isooctane and n-octane. Since they have the same chemical formula, the combustion products will be the same!

- Because of this, we should be able to reproduce the burned gas charts from the text. These are Figures 4-5 through 4-9.

- Please note that the entropy is not just a function of temperature, it also depends on pressure!

Software:

- An EES file which can be used to reproduce curves from the burned gas charts. Figures 4-5 through 4-9.

Final note:

- At this point, we are ready to do fairly sophisticated models of all of the engine cycles. At this point, we will pause to consider some simpler models first. These are the ones you became familiar with in Thermo II.

Demonstration:

Let's put the burned gas calculation into the unburned mixture file. We will assume adiabatic constant volume combustion. What this gives us is a way of calculating:

- compression stroke, followed by
- combustion process.

We are over halfway through a fuel air cycle!

However, before going on, we need to consider the overall process and do a little bit of reviewing.

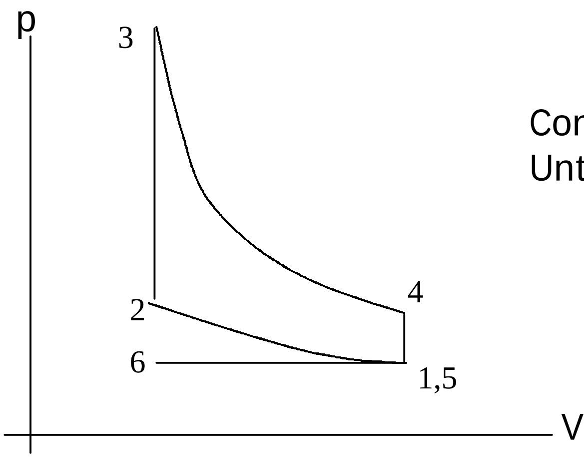
Models of Engine Processes

(See Ch. 5 in Text.)

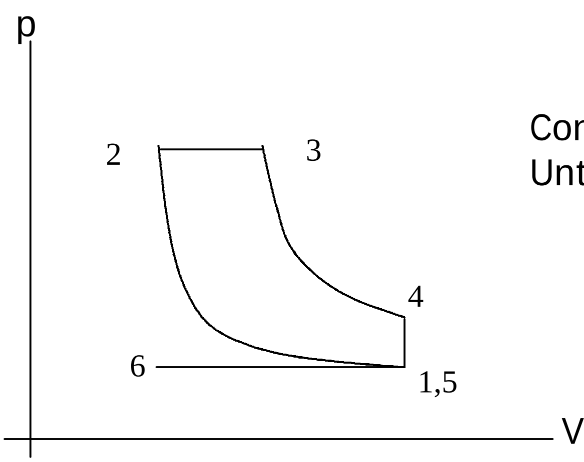
Table 5.1 From Heywood

Process	Assumptions
Compression (1-2)	Adiabatic and Reversible, hence Isentropic
Combustion (2-3)	1. Adiabatic 2. Combustion occurs at a) constant volume b) constant pressure c) Part at constant volume and part at constant pressure
Expansion (3-4)	Adiabatic and Reversible, hence Isentropic
Exhaust (4-5-6) and Intake (6-7-1)	1. Adiabatic 2. Valve events at top center and bottom center 3. No change in cylinder volume as pressure differences across open valves drop to zero 4. Inlet and exhaust pressure constant 5. Velocity Effects negligible

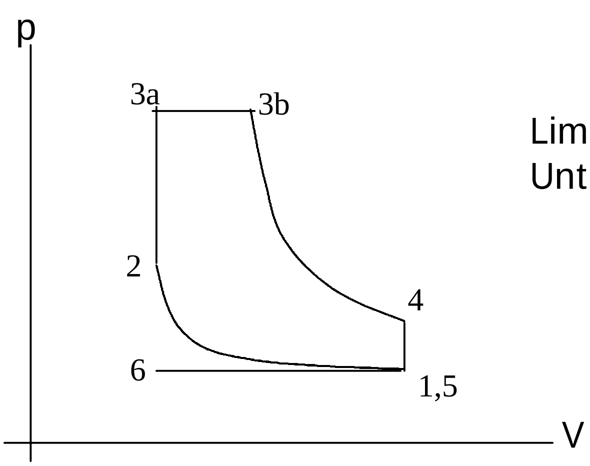
These are idealized. They serve as a starting point for engine models and are not supposed to be in complete agreement with what we know is actually happening.



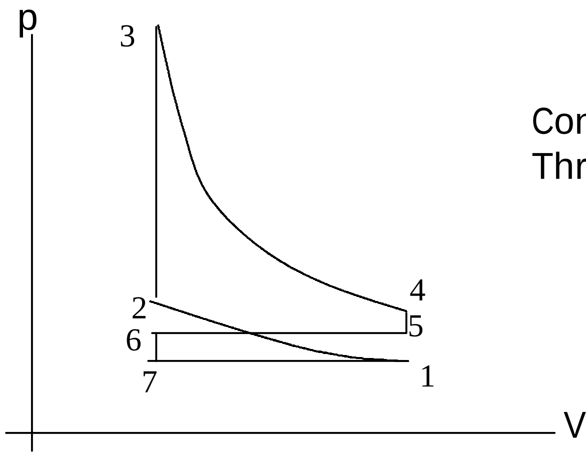
Constant Volume Combustion
Unthrottled operation



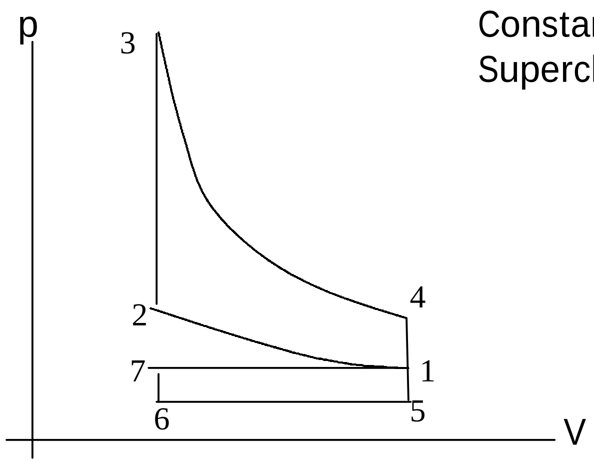
Constant Pressure Combustion
Unthrottled operation



Limited Pressure Combustion
Unthrottled operation



Constant Volume Combustion
Throttled operation



Constant Volume Combustion
Supercharged operation

There are others of course. For example, see if you can sketch a limited pressure supercharged cycle in pV space.