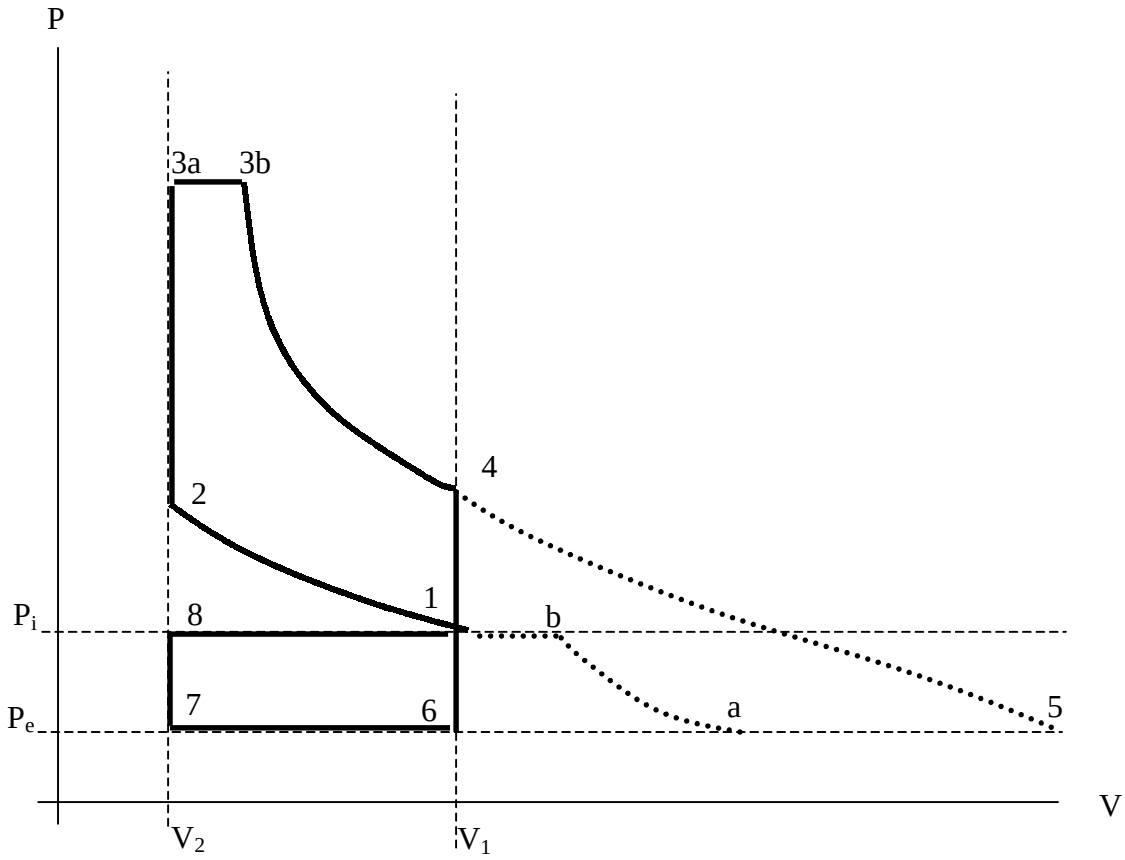
ME 410 Day 25

- Example Problem and Exercise:
  Turbocharged Limited Pressure “Air” Engine

PV Diagram -- Not to Scale



- Solid lines indicate processes in the cylinder
- Dashed lines indicate other processes of interest.

Note how $P_i > P_e$. This is the effect of turbocharging the engine with a compressor which is driven by the hot exhaust gases.

There is an intercooler which removes heat from the air after compression.

Exercise:

Predict the performance of this engine.

- Indicated Fuel Conversion Efficiency (Gross & Net)
- Indicated Power at 4000 rpm (Gross & Net)
- Imep at 4000 rpm (Gross and Net)
- Estimated Brake Power at 4000 rpm. $\eta_m = 0.70$
- Estimated Brake Torque at 4000 rpm

Engine Data

Specification	
Max cylinder volume (liters)	3.687
Min cylinder volume (liters)	0.410
Displacement (liters)	3.277
Compression ratio	9
AF	15
Fuel Heating Value (kJ/kg)	44,300

Cycle / Process Data

Point	Description	Property	Value
a	Air at intake	T (K)	333
		P (kPa)	103.4
		v (m^3/kg)	0.9244
		h (kJ/kg)	333.7
		u (kJ/kg)	238.1
		s (kJ/ kg-K)	5.797
b	After turbocharging	T (K)	361.5
		P (kPa)	137.9
		v (m^3/kg)	0.7524
		h (kJ/kg)	362.3
		u (kJ/kg)	258.6
		s (kJ/ kg-K)	5.797

Point	Description	Property	Value
1	Start of compression	T (K)	333
		P (kPa)	137.9
		v (m^3/kg)	0.6931
		h (kJ/kg)	333.7
		u (kJ/kg)	238.1
		s (kJ/ kg-K)	5.714
2	End of compression	T (K)	772.5
		P (kPa)	2879
		v (m^3/kg)	
		h (kJ/kg)	791.9
		u (kJ/kg)	570.2
		s (kJ/ kg-K)	
3a	End of cv combustion	T (K)	2253
		P (kPa)	
		v (m^3/kg)	
		h (kJ/kg)	2569
		u (kJ/kg)	1923
		s (kJ/ kg-K)	6.676
3b	End of cp combustion	T (K)	3307
		P (kPa)	
		v (m^3/kg)	0.1130
		h (kJ/kg)	3922
		u (kJ/kg)	2972
		s (kJ/ kg-K)	7.168
4	End of expansion	T (K)	1952
		P (kPa)	808.5
		v (m^3/kg)	
		h (kJ/kg)	2192
		u (kJ/kg)	1631
		s (kJ/ kg-K)	

Point	Description	Property	Value
5	Expanded exhaust 7 residue	T (K)	1200
		P (kPa)	103.4
		v (m^3/kg)	3.33
		h (kJ/kg)	1277
		u (kJ/kg)	932.7
		s (kJ/ kg-K)	7.168
6	In cylinder after blowdown	T (K)	
		P (kPa)	
		v (m^3/kg)	
		h (kJ/kg)	
		u (kJ/kg)	
		s (kJ/ kg-K)	

1. Begin by filling in all blanks in this table based on your knowledge of the engine processes.

2. Calculate the masses:
   - mass of charge filling cylinder at 1
   - residual fraction
   - mass of residual in the charge
   - mass of fuel in the charge
   - mass of air in the charge

3. Calculate the total heat in (kJ) added at constant volume. Do the same for the total heat added at constant pressure.

4. Calculate the works:
   - Work done on the gas in compression stroke
   - Work done by the gas during expansion 3a to 3b
   - Work done by the gas during expansion 3b to 4
   - Work done by the gas during intake stroke

- Gross and net work per cycle

5. Calculate the fuel conversion efficiencies:
   - Net based on net work per cycle
   - Gross based on gross work per cycle
   - Which is greatest?

6. Calculate the powers:
   - Net based on net work per cycle
   - Gross based on gross work per cycle
   - Which is greatest?
   - Base the brake power estimate on gross work/cycle

7. Calculate the imeps
   - Net based on net work / cycle
   - Gross based on gross work / cycle

8. Calculate the torque estimate based on brake power.

Complete this as hw by Thursday, October 24.

There are a couple of other interesting things that we will go over together.

- heat removal in intercooler
- energy available to run turbo

There will be a question similar to this one on the next test.