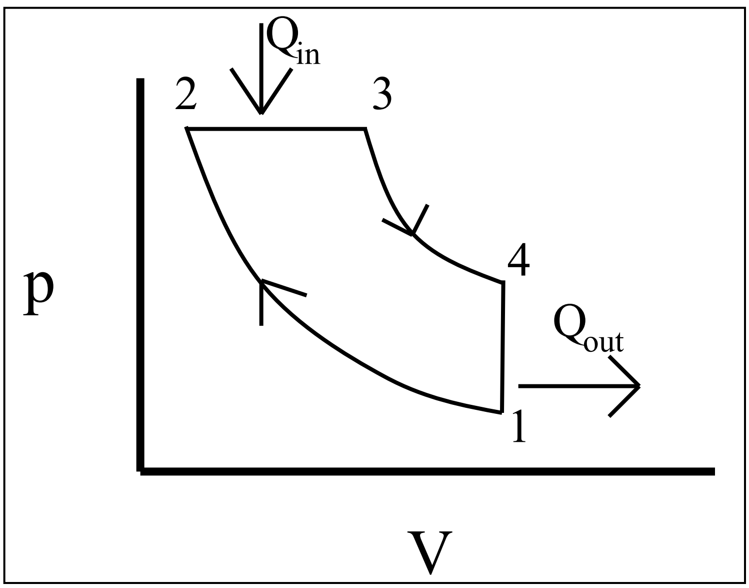
4) The Diesel cycle

- similar to Otto cycle.
- fuel injected into cylinder at TDC,
- takes time
- idealised as constant pressure



Compression ratio

$$r = \frac{V_1}{V_2} \qquad (4)$$

Cut-off ratio

$$r_c = \frac{V_3}{V_2} = \frac{T_3}{T_2} \,(\text{const pres}) \qquad (5)$$

noting V1 = V4

$$\frac{r_c}{r} = \frac{V_3}{V_2}\frac{V_2}{V_1} = \frac{V_3}{V_4} \qquad (6)$$

Const. vol. and const. pressure heat transfer

$$\eta = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{m\,c_v\left(T_4 - T_1\right)}{m\,c_p\left(T_3 - T_2\right)} = 1 - \frac{1\left(T_4 - T_1\right)}{\gamma\left(T_3 - T_2\right)} \qquad (7)$$

Can show,

$$\boxed{\eta = 1 - \frac{1}{\gamma\, r^{\gamma-1}}\left(\frac{r_c^{\gamma} - 1}{r_c - 1}\right)} \qquad (8)$$

Proof (put all temps in terms of T1)

Isentropic (polytropic with n = γ = c_p/c_v = 1.4)

$$T_2 = T_1\, r^{\gamma-1} \qquad (9)$$

TOPIC V - Gas Cycles

Engine Cycles (Lecture 2/4)

Ideal gas

$$T_3 = r_c\, T_2 = r_c\, r^{\gamma-1}\, T_1 \qquad (10)$$

Isentropic

$$T_4 = \left(\frac{V_3}{V_4}\right)^{\gamma-1} \times T_3 = \ldots$$

$$\left(\frac{r_c}{r}\right)^{\gamma-1} \times T_3 = r_c^{\gamma}\, T_1 \qquad (11)$$

Cycle efficiency

$$\eta = 1 - \frac{1}{\gamma}\frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{1}{\gamma}\frac{\left(r_c^{\gamma} - 1\right)T_1}{\left(r_c\ r^{\gamma-1} - r^{\gamma-1}\right)T_1} = \ldots$$

$$1 - \frac{1}{\gamma\, r^{\gamma-1}}\left(\frac{r_c^{\gamma} - 1}{r_c - 1}\right)$$

For same r, η less than Otto Cycle

5) The Stirling cycle (Non exam)

Externally heated/ cooled.

Theoretically – all processes reversible so Carnot cycle efficiency

Regenerator - porous matrix, LHS at TH & RHS at TL

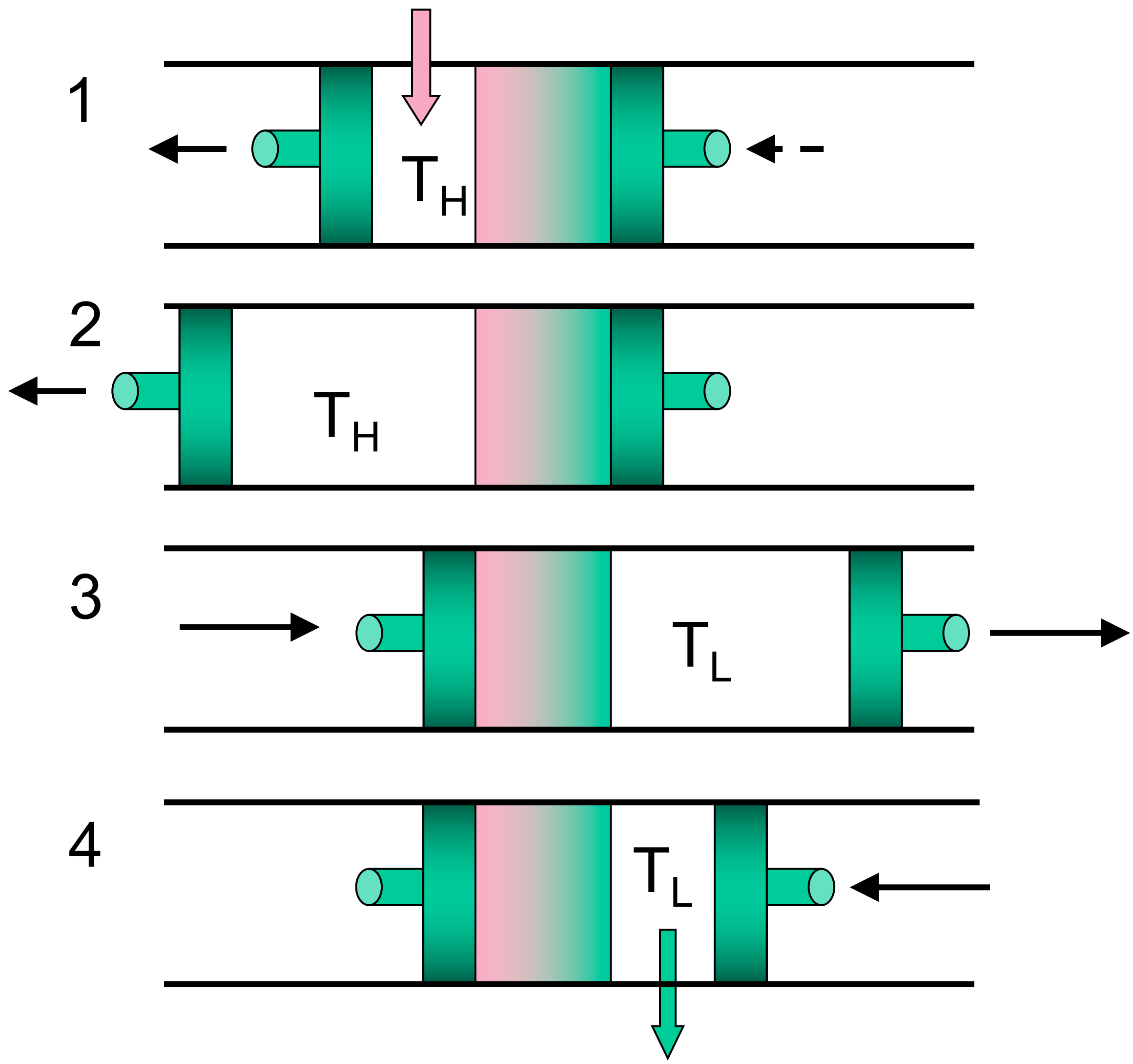
Pistons force gas through regenerator and/ or provide power.

Moving gas to left heats it from TL to TH

Moving gas to right cools it from TH to TL

TOPIC V - Gas Cycles

Engine Cycles (Lecture 2/4)



1-to-2: Isothermal heat addition at TH

2-to-3: Internal cooling at constant volume.

3-to-4: Isothermal heat rejection at TL

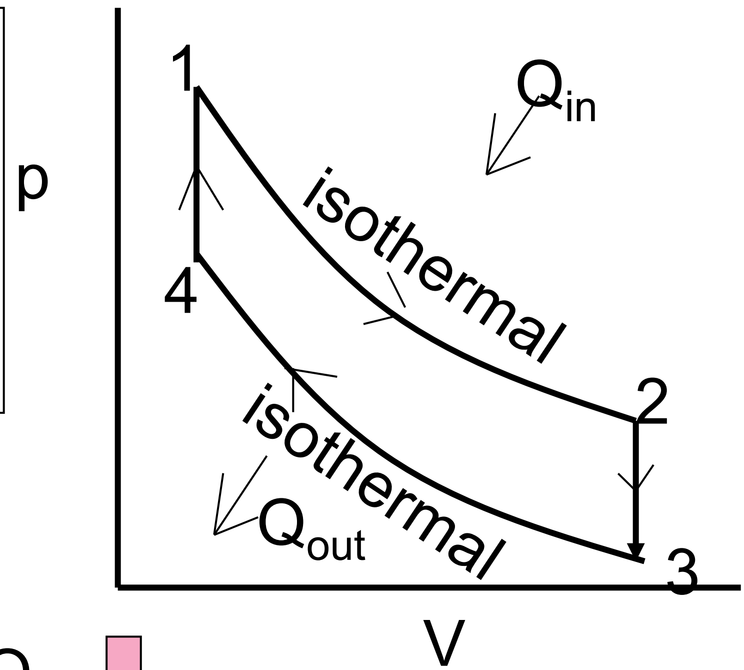
4-to-1: Internal heating at constant volume,

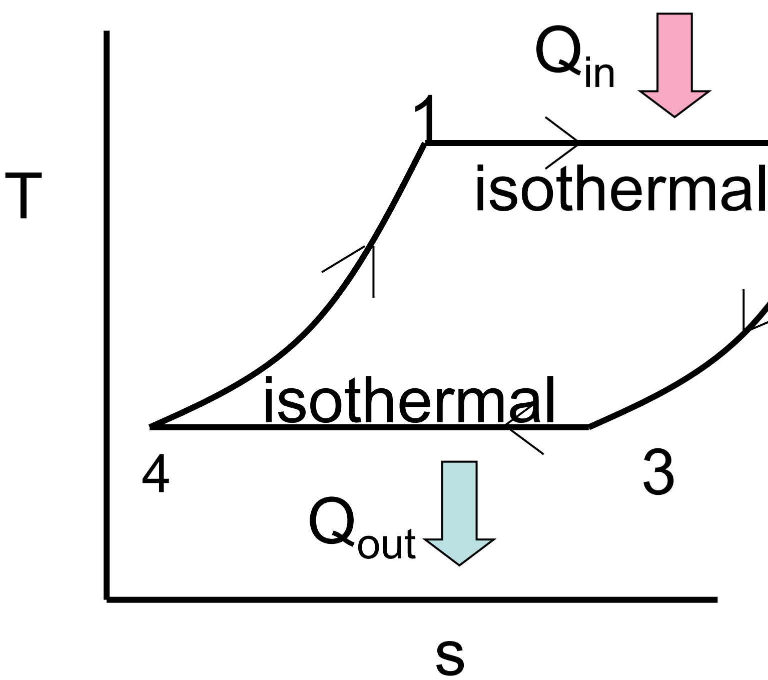
Engine Cycles (Lecture 2/4)

<u>Stirling cycle</u>

Process diagrams

T is an average value





(My proof (in notes): heat transfer processes S2 – S1 = S3 – S4, as in Carnot)

6.) The Ericsson cycle

- Steady flow version of Stirling cycle.
- Regenerator => a heat exchanger.
- 1-to-2 isothermal reversible compression.
- 2-to-3 isobaric heat addition
- 3-to-4 isothermal reversible expansion
- 4-to-1 isobaric heat rejection

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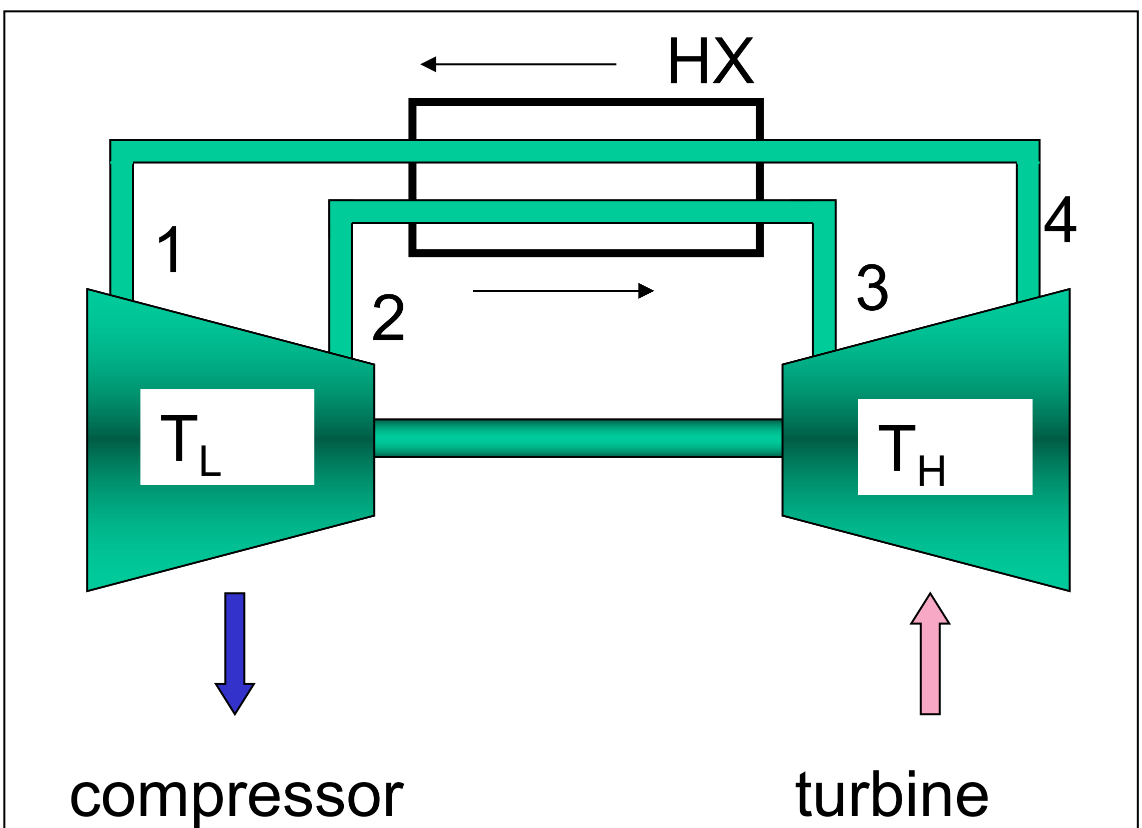

Conclusions

Diesel – additional cut-off ratio models fuel-injection + combustion

Diesel – model each process to get heat flows and efficiency.

Sterling and Ericcson – if reversible, then same efficiency as Carnot. Never done in practice! (Not examinable)