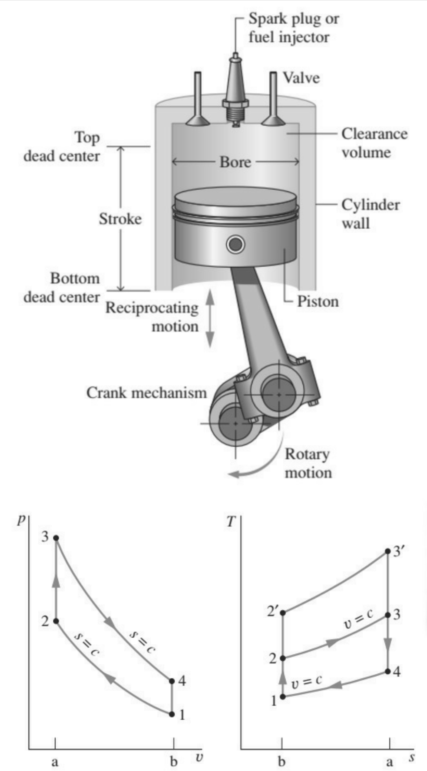
Thermodynamics final Cheat Sheet

by Bama via cheatography.com/66428/cs/16580/

Air Standard Otto Cycle

Process 1–2: An isentropic compression of the air as the piston moves from bottom dead center to top dead center.
Process 2–3: A constant-volume heat transfer to the air from an external source while the piston is at top dead center. This process is intended to represent the ignition of the fuel–air mixture and the subsequent rapid burning.
Process 3–4: An isentropic expansion (power stroke).
Process 4–1: Completes the cycle by a constant-volume process in which heat is rejected from the air while the piston is at bottom dead center.

Air Standard Otto Cycle Diagram and Schematic



$$\eta = \frac{(u_3 - u_2) - (u_4 - u_1)}{u_3 - u_2} = 1 - \frac{u_4 - u_1}{u_3 - u_2}$$

$$\eta = 1 - \frac{1}{r^{k-1}} \quad \text{(cold air-standard basis)}$$

Second Law

Second Law of Thermodynamics

$$\oint \left(\frac{\delta Q}{T} \right)_b = -\sigma_{cycle}$$

$$\frac{dS}{dt} = \frac{\dot{Q}}{T} + \sum \dot{m}_i s_i - \sum \dot{m}_e s_e + \dot{\sigma}$$

$$S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T} \right)_b + \sigma$$

Efficiencies

Power = 1 - Q_C / Q_H	Turbine = W_{ACTUAL} / W_{IDEAL}
Refrigeration = Q_C / Q_H - Q_C	Comp or Pump = W_{IDEAL} / W_{ACTUAL}
Heat = Q_H / Q_H - Q_C	Regenerator = Q_{ACTUAL} / Q_{IDEAL}

Ideal Gases

pv = RT	pV = mRT	C_P = C_V + R	Polytropic Process:
k = C_P / C_V	P_R = P / P_C	T_R = T / T_C	pv^n = constant

Exact Analysis of Isentropic Process for Ideal Air

P_{R2} / P_{r1} = P1 / P2	V_{R2} / V_{R1} = $V2$ / $V1$	Pressure ratio = P2/ P1

Exact Analysis of Entropy Change in Ideal Gasses

Exact Analysis of Entropy change for Ideal Gas (Air)

$$\Delta s = \int_{T_1}^{T_2} \frac{c_p}{T} dT - R \ln(p_2/p_1) = s_2^0 - s_1^0 - R\ln(p_2/p_1) = \int_{T_1}^{T_2} \frac{c_v}{T} dT + R\ln(v_2/v_1)$$

$$\Delta h = \int_{T_1}^{T_2} C_p \, dT$$

Cheatography

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Air Standard Diesel Cycle

The air-standard Diesel cycle is an ideal cycle that assumes heat addition occurs during a constant-pressure process that starts with the piston at top dead center. The cycle consists of four internally reversible processes in series.

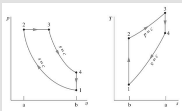
Process 1-2 is the same as in the Otto cycle: an isentropic compression. Heat is not transferred to the working fluid at constant volume as in the Otto cycle, however. **In the Diesel cycle, heat is transferred to the working fluid at constant pressure**.

Process 2–3 also makes up the first part of the power stroke.

Process 3-4 is an isentropic expansion and is the remainder of the power stroke.

Process 4-1 As in the Otto cycle, the cycle is completed by a constant-volume process in which heat is rejected from the air while the piston is at bottom dead center. This process replaces the exhaust and intake processes of the actual engine.

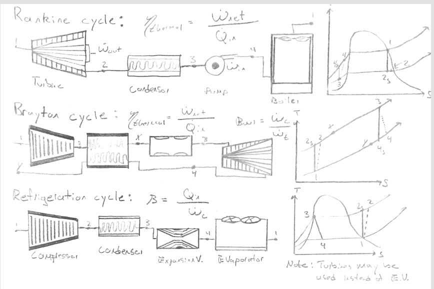
Air Standard Diesel Cycle Diagram and Schematic



$$\eta = 1 - \frac{1}{r^{k-1}}\left[\frac{r_c^k - 1}{k(r_c - 1)}\right] \quad \text{(cold air-standard basis)}$$

$$\eta = \frac{W_{cycle}/m}{Q_{23}/m} = 1 - \frac{Q_{41}/m}{Q_{23}/m} = 1 - \frac{u_4 - u_1}{h_3 - h_2}$$

Cycles



Work

Flow Relationships

$\dot{m} = \frac{AV}{v}$; $\dot{V} = AVelocity$ $\quad \dot{V} = \dot{m} \cdot v$

Boundary Work

$W = \int_1^2 pdV$, $\quad W = p(V_2 - V_1)$ (Constant Pressure)

$W = \frac{p_2V_2 - p_1V_1}{1-n}$ (Polytropic Process) $= pV \ln\frac{V_2}{V_1}$ (Polytropic Process, n=1)

Flow Work $\quad$ Adiabatic power:

$w = -\int_1^2 vdp$ $\quad \dot{W} = \dot{m} v \int dP$

Miscellaneous

Tds = du + pdv	Tds = du + vdp
x = M_{vapor} / M_{total}	S = S_f + (x)S_{fg} = S_f(1 -x) + S_g
Expansion valve: Δh = 0	Condensor: Q_{out}
Evaporator: Q_{in}	First law: E_{in} - E_{out} = ΔE_{system}
h = u +pv	W = VI (electrical)

Specific Heat

Isentropic Relationships for gasses with constant specific heat

$p_2/p_1 = (v_1/v_2)^k$; $\quad T_2/T_1 = (p_2/p_1)^{(k-1)/k} = (v_1/v_2)^{k-1}$

Solid / Liquid Relationships

$\Delta u = \Delta h = c\Delta T$, $\quad \Delta s = c\ln\left(\frac{T_2}{T_1}\right)$ $\quad \Delta U = c_v\Delta T \quad \Delta h = c_p\Delta T$

$\Delta s = c_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} = c_p\ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1}$

Heat Transfer Relationships

- Conduction, $\dot{Q}_x = -\kappa A\frac{dT}{dx}$
- Convection $\dot{Q}_c = hA[T_b - T_f]$
- Radiation σ=5.67×10^{-8} Wm^2·K^4 $\quad \dot{Q}_e = \varepsilon\sigma A[T_b^4 - T_s^4]$