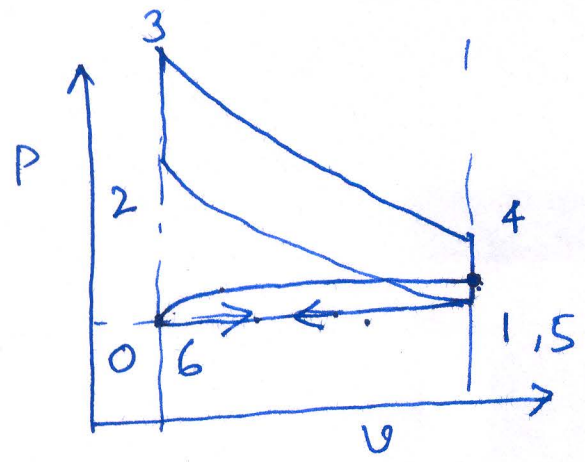
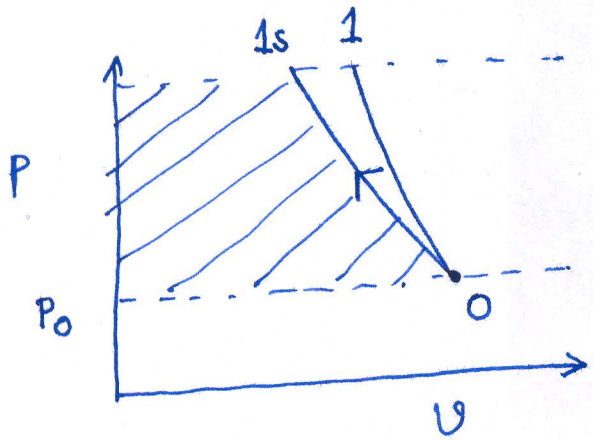
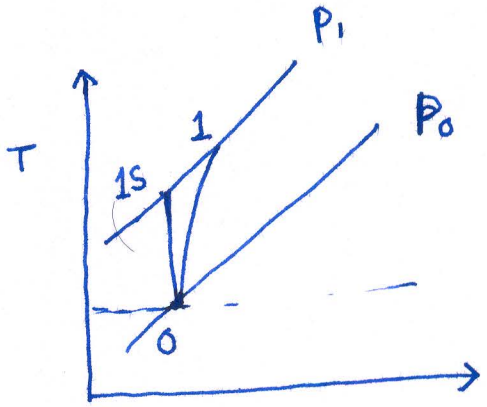
Supercharge or turbocharge



SI

$$_0\omega_1 = -\int_0^1 \upsilon dP$$





$$\omega_c = (h_1 - h_0)$$

$$\omega_{cs} = (h_{1s} - h_0)$$

$$\eta_c = \frac{h_{1s} - h_0}{h_1 - h_0}$$

$$q - \omega = \left(h_2 + \frac{V_2^2}{2} + gz_2\right) - \left(h_1 + \frac{V_1^2}{2} + gz_1\right)$$

$$V_2 \approx V_1$$

$$-\omega = (h_2 - h_1)$$

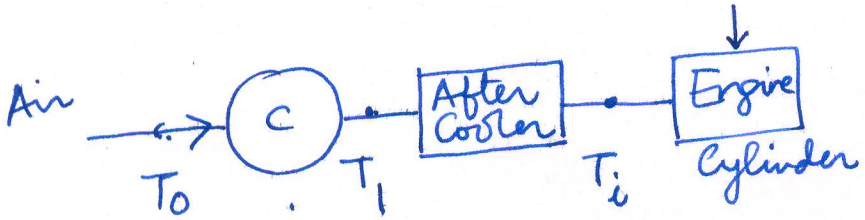
$h = \varphi T$

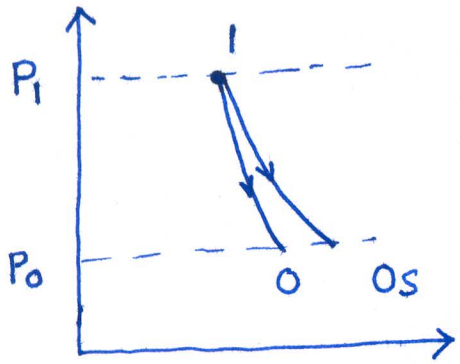
$$\eta_c = \frac{T_{1s} - T_0}{T_1 - T_0}$$

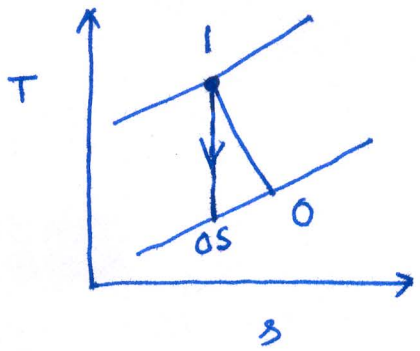
$$\frac{T_{1s}}{T_0} = \left(\frac{P_1}{P_0}\right)^{\frac{\gamma-1}{\gamma}}$$

ϵ = Effectiveness

$$= \frac{T_1 - T_i}{T_1 - T_0}$$







$$\omega_T = (h_1 - h_0)$$

$$\omega_{TS} = (h_1 - h_{0s})$$

$$\eta_T = \frac{\omega_T}{\omega_{TS}} = \frac{h_1 - h_0}{h_1 - h_{0s}} = \frac{T_1 - T_0}{T_1 - T_{0s}}$$

Aftercooler

Brake power = 628 KW

Brake efficiency = 40.4%

Compressor efficiency = 57%

Intercooler effectiveness = 0.78

1. A turbocharged six-cylinder Diesel engine has a swept volume of 39 litres. The inlet manifold conditions are 2.0 bar and 53^0C. The volumetric efficiency of the engine is 95% and it is operating at a load of 16.1 bar bmep, at 1200 RPM with an AF ratio of 21.4. The power delivered to the compressor is 100 kW, with entry conditions of 25^0C and 0.95 bar. The fuel has a calorific value of 42 MJ/kg. (c_p=1.01 kJ/kg-K). Calculate:
   a) The power output of the engine
   b) The brake efficiency of the engine
   c) The compressor isentropic efficiency
   d) The effectiveness of the inter-cooler

(5) Inter-cooler

Brake power, $W_b = p_b V_b (N^*) \frac{N}{2 \times 60}$

$= 16.1 \times 10^5 \times 39 \times 10^{-3} \times \frac{1200}{120}$

$= 628 \text{ kW} \Leftarrow$

To find the brake efficiency

$\eta_v = V_a / (V_s N^*)$ (2) $p = \rho RT$, $\rho = \frac{p}{RT}$

$m_a = \rho V_a = \rho \eta_v V_s N^*$

$= \eta_v V_s N^* \frac{p}{RT}$

$= 0.95 \times 39 \times 10^{-3} \times \frac{1200}{120} \times 2 \times 10^5 / [287 \times (287+53)]$

$= 0.792 \text{ kg/s}$

$m_f = m_a / AFR = 0.037 \text{ kg/s}$

$\eta_b = W_b / (m_f \times CV) = 628 \times 10^3 / (0.037 \times 42 \times 10^6) = 40.4\% \Leftarrow$

Compressor efficiency

$W_C = m_a c_p (T_2 - T_1)$

$T_2 - T_1 = \frac{W_C}{m_a c_p} = \frac{100 \times 10^3}{0.792 \times 1.01 \times 10^3} {}^\circ K = 125 \text{ K}$

$T_{2s} = T_1 (P_2/P_1)^{\frac{\gamma-1}{\gamma}} = (273+25)(2/0.95)^{\frac{1.4-1}{1.4}} = 369 \text{ K}$

$\eta_C = \frac{T_{2s} - T_1}{T_2 - T_1} = \frac{369 - 298}{125} = 0.57 \text{ or } 57\% \Leftarrow$

Intercooler effectiveness is defined as

$\epsilon = \frac{T_2 - T_3}{T_2 - T_1} = \frac{423 - 326}{423 - 298}$

$= 0.78 \Leftarrow$

$T_3 = 273 + 53$

$= 326 \text{ K}$

$T_2 = 273 + 125 + 25$

$= 423 \text{ K}$

$423 - 298$

$= 125$