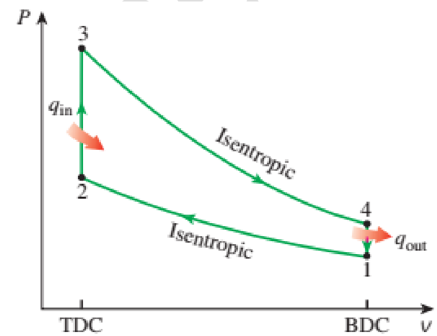
EX1: in an air, standard Otto cycle the maximum and minimum temperature are 1400 ^{0}C and 15 ^{0}C. the heat supplied per Kg of air is 800 KJ. Calculate the compression ratio and the thermal efficiency. Calculate also the ratio of maximum to minimum pressure in the cycle.

Solution

Q=$mC_v\Delta T$ 800=1*0.717 (1673 – T_2) T_2=557.2 K

$\frac{T_2}{T_1} = (r_c)^{\gamma-1}$ $\frac{5572}{288} = (r_c)^{1.4-1}$ $r_c = 5.2$



$$\eta_{th} = 1 - \frac{1}{(r_c)^{\gamma-1}} = 1 - \frac{1}{(5.2)^{1.4-1}} = 0.483$$

$$\frac{T_2}{T_1} = (\frac{P_2}{P_1})^{\frac{\gamma-1}{\gamma}}$$

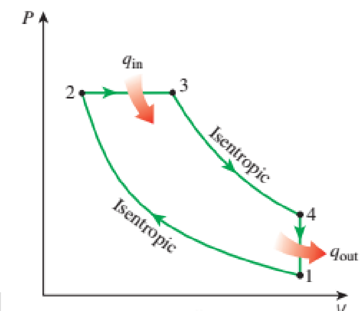
$\frac{P_3V_3}{T_3} = \frac{P_2V_2}{T_2}$ $V_2 = V_3$

$\frac{P_3}{P_2}$

$\frac{P_3}{P_2} = \frac{P_3}{P_1}.\frac{P_1}{P_2}$

EX2: A diesel engine has an inlet temperature and pressure of 15 ^{0}C, and 1 bar respectively. The compression ratio is 12:1 and the maximum cycle temperature is 1100 ^{0}C. Calculate the air standard Thermal efficiency based on the Diesel engine.

Solution



(a) P-v diagram

T_1=15+273 = 298 K

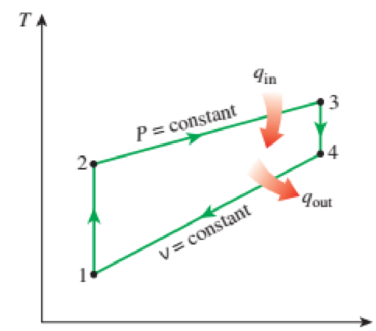
T_3=1100+273 = 1373 K

$\frac{T_2}{T_1} = (r_c)^{\gamma-1}$ **T_2=778 K**

Process 2-3

$\frac{P_3 V_3}{T_3} = \frac{P_2 V_2}{T_2}$ $P_2 = P_3$

$\frac{V_3}{V_2} = \frac{T_3}{T_2} = \frac{1373}{728}$ **=1.767**



(b) T-s diagram

$\frac{V_4}{V_3} = \frac{V_4}{V_2} \cdot \frac{V_2}{V_3} = \frac{V_1}{V_2} \cdot \frac{1}{\frac{V_3}{V_2}} = 12 * \frac{1}{1.765} = 6.8$

$\frac{T_3}{T_4} = (\frac{V_4}{V_3})^{\gamma-1}$ $\frac{1373}{T_4} = (6.8)^{1.4-1}$ $T_4 = 638\ K$

Q_1 $= mC_P(T_3 - T_2) = 1.005\,(1373 - 778) = 598\ KJ/Kg$

Q_2 $= mC_v(T_4 - T_1) = 0.718\,(638 - 288) = 251\ KJ/Kg$

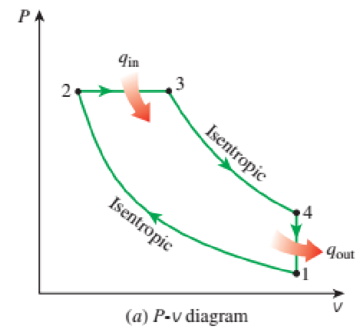
$\eta_{th} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{251}{251} = 0.58$

EX3: An engine uses air a working substance, at the beginning of compression the pressure is 90 Kpa and temperature is 40 ^{0}C. during the adiabatic compression the volume is reduced to one-sixteenth of its volume at the beginning of compression stroke. Heat is then added at constant pressure until the temperature is 1400 ^{0}C.the stroke is completed by adiabatic expansion until the initial volume. Find a: the temperature and pressure all four corner b: thermal efficiency.

Solution

Point 1

P_1=90 Kpa, T_1=313 K



(a) P-v diagram

Point 2 $V_2 = \frac{1}{16}\frac{V_1}{}$ $P_2 = \left(\frac{V_1}{V_2}\right)^{\gamma} . P_1 = 16^{1.4} * 90 = 4365\ Kpa$

$$T_2 = \left(\frac{V_1}{V_2}\right)^{\gamma-1} . T_1 = 16^{0.4} * 313 = 949\ K$$

Point 3

$$P_2 = P_3 = 4365\ KPa$$

T_3=1400+273=1673 K

Point 4

$$\frac{\boldsymbol{T_4}}{\boldsymbol{T_3}} = \left(\frac{\boldsymbol{V_3}}{\boldsymbol{V_4}}\right)^{\boldsymbol{\gamma-1}} = \left(\frac{\boldsymbol{V_3}}{\boldsymbol{V_1}}\right)^{\boldsymbol{\gamma-1}}$$

$$\frac{\boldsymbol{T_4}}{\boldsymbol{T_3}} = \left(\frac{\boldsymbol{V_3}}{\boldsymbol{V_2}} . \frac{\boldsymbol{V_2}}{\boldsymbol{V_1}}\right)^{\boldsymbol{\gamma-1}} = \left(\frac{\boldsymbol{T_3}}{\boldsymbol{T_2}} . \frac{\boldsymbol{V_2}}{\boldsymbol{V_1}}\right)^{\boldsymbol{\gamma-1}}$$

$$T_4 = \left(\frac{\boldsymbol{T_3}}{\boldsymbol{T_2}} . \frac{\boldsymbol{V_2}}{\boldsymbol{V_1}}\right)^{\gamma-1} . T_3 = 1673 . \left(\frac{1673}{949} . \frac{1}{16}\right)^{1.4-1} = 692\ K$$

$$P_4 = \left(\frac{\boldsymbol{T_4}}{\boldsymbol{T_3}}\right)^{\frac{\gamma}{\gamma-1}} . P_3 = 4365\ \left(\frac{\boldsymbol{692}}{\boldsymbol{949}}\right)^{\frac{1.4}{1.4-1}} = 198.6\ Kpa$$

$$\boldsymbol{\eta_{th} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{C_v(T_4 - T_1)}{C_P(T_3 - T_2)} = 1 - \frac{(T_4 - T_1)}{\gamma(T_3 - T_2)} = 1 - \frac{(692 - 313)}{1.4\ (1673 - 949)} = 0.63}$$