Soal 5.3

Udara

$C_p = 1.0035$ W/kg . K

$C_v = 0.7165$ W/kg . K

$R = C_p - C_v = 0.287$

$k = \frac{C_p}{C_v} = 1.4$

Dik. Siklus Gabungan

$r_v = 10$

$P_1 = 100$ kPa

$T_1 = 24\ ^oC = 297$ K

$q_{m1} = 1100$ kJ/kg

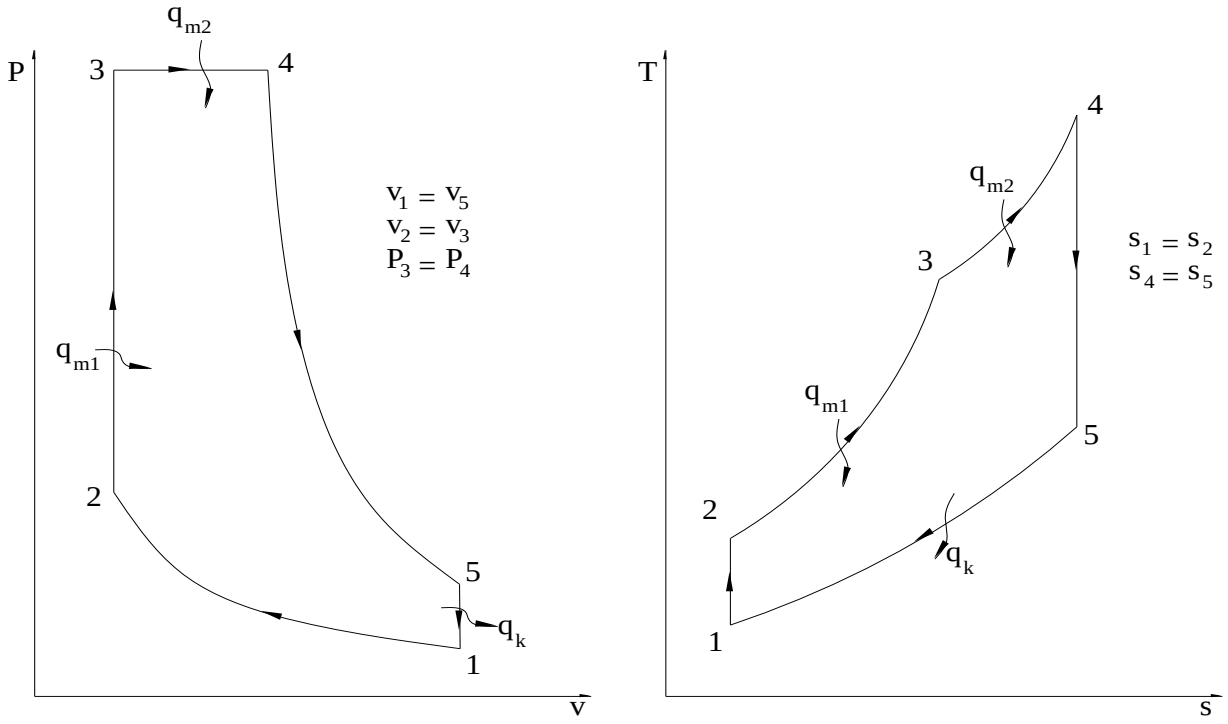
$q_{m2} = 1100$ kJ/kg

Diminta - T, P, v

- η_{th}

Jawab

* Diagram P - v dan T - s



* T, P, v pada setiap titik

Titik 1

$$v_1 = \frac{RT_1}{P_1} = \frac{0.287\ .\ 297}{100} = 0.8524\ \ m^3/kg$$

Titik 2

$$r_v = \frac{v_1}{v_2} \rightarrow v_2 = \frac{v_1}{r_v} = \frac{0.8524}{10} = 0.0852 \ m^3/kg$$

Proses 1 - 2 Isentropik

$$\frac{T_2}{T_1} = r_v^{k-1} \rightarrow T_2 = 297 \ (10)^{0.4} = 746.0 \ K$$

$$\frac{P_2}{P_1} = r_v^{k} \rightarrow P_2 = 100 \ (10)^{1.4} = 2511.9 \ kPa$$

Titik 3

$$v_3 = v_2 = 0.0852 \ m^3/kg$$

$$q_{m1} = C_v \ (T_3 - T_2)$$

$$1100 = 0.7165 \ (T_3 - 746.0)$$

$$T_3 = \frac{1100}{0.7165} + 746.0 = 2281.3 \ K$$

$$P_3 = \frac{RT_3}{v_3} = \frac{0.287 \ . \ 2281.3}{0.0852} = 7681.0 \ kPa$$

Titik 4

$$P_4 = P_3 = 7681.0 \ kPa$$

$$q_{m2} = C_p \ (T_4 - T_3)$$

$$1100 = 1.0035 \ (T_4 - 2281.3)$$

$$T_4 = \frac{1100}{1.0035} + 2281.3 = 3377.4 \ K$$

$$P_4 = \frac{RT_4}{v_4} \rightarrow v_4 = \frac{RT_4}{P_4} = \frac{0.287 \ . \ 3377.4}{7681.0} = 0.1262 \ m^3/kg$$

Titik 5

$$v_5 = v_1 = 0.8524 \ m^3/kg$$

Proses 4 - 5 Isentropik $\rightarrow$ $T \ v^{k-1} = C$

$$T_4 \, v_4^{k-1} = T_5 \, v_5^{k-1} \rightarrow T_5 = T_4 \left(\frac{v_4}{v_5} \right)^{k-1}$$

$$T_5 = 3377.4 \left(\frac{0.1262}{0.8524} \right)^{0.4} = 1573.1 \text{ K}$$

$$P_5 = \frac{RT_5}{v_5} = \frac{0.287 \ . \ 1573.1}{0.8524} = 530 \text{ kPa}$$

$$q_m = q_{m1} + q_{m2}$$

$$q_m = 1100 + 1100 = 2200 \text{ kJ/kg}$$

$$q_k = C_v \ (T_5 - T_1) = 0.7165 \ (\ 1573.1 - 297 \ ) = 914.3 \text{ kJ/kg}$$

$$W_{net} = q_m - q_k = 2200 - 914.3 = 1285.7 \text{ kJ/kg}$$

* Efisiensi termal (η_{th})

$$\eta_{th} = \frac{W_{net}}{q_m} = \frac{1285.7}{2200} = 58.4 \ \%$$

* $$\text{mep} = \frac{W_{net}}{v_1 - v_2} = \frac{1285.7}{0.8524 - 0.0852} = 1675.9 \text{ kPa}$$