Varmafræði – Skiladæmi 7 Andri [illegible]

Q2*

a)

①–②
$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \frac{P_2}{\frac{P_1}{T_1}} = \frac{T_1 P_2}{P_1} = \frac{302,5\ K \cdot 671\ kPa}{119\ kPa}$$

$$= 1705,7\ K$$

svo

$$Q_{1-2} = c_v (T_2 - T_1) = 0,718 \frac{kJ}{kgK} \cdot (1705,7\ K - 302,5\ K)$$

$$= 1007,5 \frac{kJ}{kg}$$

②–③
$$P_2 V_2 = P_3 V_3 \Rightarrow P_3 = \frac{P_2 V_2}{V_3} = \frac{P_2 \cancel{V_2}}{4 \cancel{V_2}} = \frac{671\ kPa}{4} = 167,75\ kPa$$

svo

$$W_{2-3} = R T_2 \cdot \ln\left(\frac{4\cancel{V_2}}{\cancel{V_2}}\right) = 0,287 \frac{kJ}{kgK} \cdot 1705,7\ K \cdot \ln(4)$$

$$= 678,64 \frac{kJ}{kg} = Q_{2-3}$$

③–①
$$W_{1-3} = R(T_1 - T_3) = 0,287 \frac{kJ}{kgK} \cdot (302,5\ K - 1705,7\ K)$$

$$= -402,7 \frac{kJ}{kg}$$

svo

$$\text{Back work ratio} = \frac{W_{1-3}}{W_{2-3}} = \frac{402,7 \frac{kJ}{kg}}{678,64 \frac{kJ}{kg}} = 0,59$$

b)

$$\eta_{th} = \frac{W_{net}}{Q_{in}} = \frac{W_{2-3} - W_{3-1}}{Q_{1-2} + Q_{2-3}} = \frac{(678,64 - 402,7) \frac{kJ}{kg}}{(1007,5 + 678,64) \frac{kJ}{kg}}$$

$$= 0,164$$

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Q4* $r = 7,54$, $P_1 = 94,1$ kPa, $T_1 = 35,7°C = 308,7$ K

First we find T_2: $T_1 V_1^{k-1} = T_2 V_2^{k-1}$

$$\Rightarrow T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{k-1} = T_1 (r)^{k-1}$$

$$= 692,6 \text{ K}$$

Thermal efficiency is: $\eta_{th} = 1 - \frac{T_1}{T_2} = 1 - \frac{308,7 \text{ K}}{692,6 \text{ K}} = 0,554$

Heat added: $Q_{in} = \frac{W_{net,in}}{\eta_{th}} = \frac{120 \text{ kW}}{0,554} = 216,5 \text{ kW}$

Q9*

a) Since we have $W_{net} = W_{turb} - W_{comp}$

and multi-stage expansion with reheating: $W_{turb} \uparrow$

multi-stage compression with reheating: $W_{comp} \downarrow$

we know that W_{net} will increase

b) We have $r = \frac{W_{comp}}{W_{turb}}$ and using the same logic as in a)

we know that r will decrease

c) Intercooling will decrease T_{avg} of the heat added and reheating will increase the T_{avg} that heat is rejected at. Thus thermal efficiency will decrease

d) Like above, reheating will make T_{avg} for the heat rejected higher, and thus heat rejection increases

Q5*

$r_c = 11,8$, $r_0 = 2,3$, $P_1 = 87,4$ kPa , $T_1 = 26,5°C = 299,5$ K

a)

①-②
$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1} \Rightarrow T_2 = T_1 \cdot r_c^{k-1} = 299,5\ K \cdot 11,8^{1,4-1}$$
$$= 803,8\ K$$

②-③
$$\frac{T_3}{T_2} = \frac{V_3}{V_2} \Rightarrow T_3 = T_2 \cdot r_0 = 803,8\ K \cdot 2,3 = 1848,8\ K$$

b)
$$\eta_{diesel} = 1 - \frac{1}{k \cdot r_c^{k-1}} \cdot \left(\frac{r_0^{k}-1}{r_0 - 1}\right)$$
$$= 1 - \frac{1}{1,4 \cdot 11,8^{0,4}} \cdot \left(\frac{2,3^{1,4}-1}{2,3-1}\right) = 0,548$$

c)
$$P_m = \frac{P_1\, r_c^{k}\left(k \cdot (r_0 - 1) - r_c^{1-k} \cdot (r_0^{k} - 1)\right)}{(k-1)(r_c - 1)}$$

$= 638,55$ kPa

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