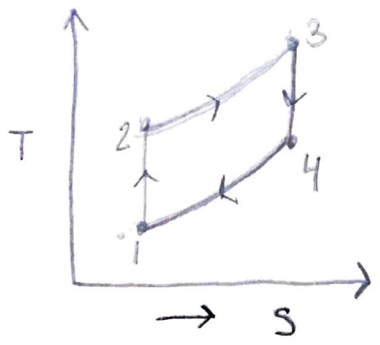
88.



$r_p = 10$

$P_1 = 70\ kPa$

$T_1 = 0°C = 273K$

$\dot{Q}_{in} = 500\ kW$

$\dot{m} = 1\ kg/s$

Gas constant

$R = 0.287\ kJ/kg \cdot K$

$C_p = 1.005\ kJ/kg \cdot K$

$C_v = 0.718\ kJ/kg \cdot K$

$K = 1.4$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{r_p}$$

$$\frac{T_2}{273} = (10)^{\frac{1.4-1}{1.4}}; \quad T_2 = (10)^{\frac{1.4-1}{1.4}} \cdot 273$$

$T_2 = 527.1\ K$

$$Q_{in} = \dot{m}\, c_p\, (T_3 - T_2)$$

$$500 = (1)(1.005)(T_3 - 527);$$

$T_3 = 1024.5\ K$

$$\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{K-1}{K}}$$

$$\frac{T_4}{1024.5} = \left(\frac{1}{10}\right)^{\frac{1.4-1}{1.4}}; \quad T_4 = \left(\frac{1}{10}\right)^{\frac{1.4-1}{1.4}} \cdot 1024.5\ K$$

$$W_{net} = m\{C_{pr}(T_3 - T_4) - C_p(T_2 - T_1)\}$$

$$= (1)(1.005)\{(1024.5 - 530.637) - (527.08 - 273)\}$$

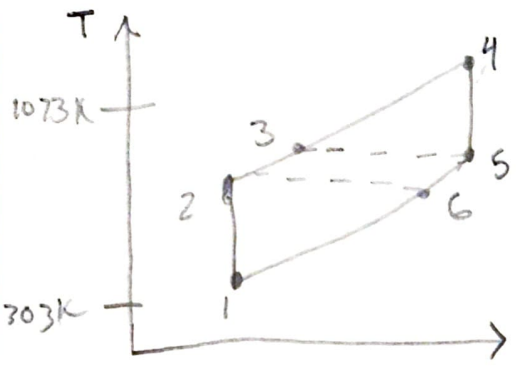
$$= 1.005\{493.863 - 254.08\}$$

$$W_{net} = 240.98 \text{ KW}$$

$$\eta_{th} = \frac{\dot{W}_{net}}{Q_{in}} = \frac{240.98}{500} = 0.48196$$

$$\boxed{\eta_{th} = 48.2\%}$$

99.



$$T_2 = 303(10)^{1.41-.4/1.4}$$

$$T_2 = 585 \text{ K}$$

$$T_5 = T_4 (1/r_p)^{(k-1)/k}$$

$$T_5 = (1{,}073 \text{ K})(1/10)^{0.4/1.4}$$

$$T_5 = 555.8 \text{ K}$$

$$T_3 = T_5 - 10$$

$$= 555.8 - 10$$

$$T_3 = 545.8 \text{ K}$$

$$Q_{out} = (0.4864)(1.005)(595 - 303)$$

$$\boxed{Q_{out} = 143 \text{ KW}}$$

$$T_6 = T_5 - (T_3 - T_2)$$

$$= 555.8 - (545.8 - 585)$$

$$T_6 = 595 \text{ K}$$

$$W_{net} = C_p(T_4 - T_5) - C_p(T_2 - T_1)$$

$$= [(1.005)(1{,}073 - 555.8)] - [(1.005)(585 - 303)]$$

$$\boxed{W_{net} = 236.4 \text{ KJ/Kg}}$$

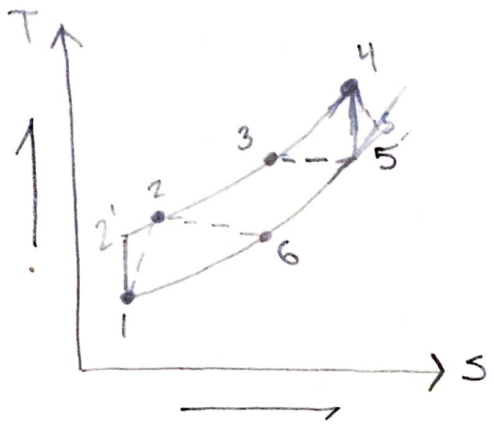
$$\dot{m} = \frac{\dot{W}_{net}}{W_{net}} = \frac{115 \text{ KW}}{236.4}$$

$$\dot{m} = 0.4864 \text{ Kg/s}$$

$$Q_{in} = (0.4864)(1.005)(1073 - 545.8)$$

$$\boxed{Q_{in} = 258 \text{ KW}}$$

19.



$r_p = 7$ $\quad \eta_t = 82\%$

$T_1 = 310K$ $\quad \eta_c = 75\%$

$T_4 = 1150K$ $\quad \varepsilon = 65\%$

* from 1 – 2'

at T_1

$h_1 = 310.24$ KJ/Kg

$P_{r_1} = 1.5546$

$$P_{r_{2'}} = P_{r_1}\left(\frac{P_2}{P_1}\right) = (1.5546)(7)$$

$$P_{r_{2'}} = 10.88$$

at $P_{r_{2'}}$

$$h_{2'} = 533.98 + (544.35 + 533.98)\left(\frac{10.8822 - 10.37}{11.10 - 10.37}\right)$$

$$h_{2'} = 541.25 \text{ KJ/Kg}$$

$$h_2 = \frac{h_{2'} - h_1}{\eta_c} = \frac{541.25}{.75}$$

$$h_2 = 618.26 \text{ KJ/Kg}$$

at $T_4 = 1150$

$$h_4 = 1207.57 + (1230.92 - 1207.57)\left(\frac{1150 - 1140}{1160 - 1140}\right)$$

$$h_4 = 1219.25 \text{ KJ/Kg}$$

$$P_{r_4} = 193.1 + (207.2 - 193.1)\left(\frac{1150 - 1140}{1160 - 1140}\right)$$

$$P_{r_4} = 200.15$$

From 4-5'

$$\frac{P_{r4}}{P_{r5'}} = \frac{P_4}{P_5} = \frac{P_2}{P_1}$$

$$\frac{200.15}{P_{r5'}} = 7$$

$$P_{r5'} = 28.59$$

at $P_{r5'}$

$$h_{5'} = 702.52 + (713.27 - 702.52)\left(\frac{28.59 - 27.29}{28.8 - 27.29}\right)$$

$$h_{5'} = 711.79 \text{ KJ/kg}$$

$$\eta_t = \frac{h_4 - h_5}{h_4 - h_{5'}}$$

$$0.82 = \frac{1219.25 - h_5}{1219.25 - 711.79}$$

$$h_5 = 803.13 \text{ KJ/kg}$$

a) at h_5

$$T_5 = 780 + (800 - 780)\left(\frac{803.13 - 800.03}{821.95 - 800.03}\right)$$

$$\boxed{T_5 = 782.82 \text{K}}$$

b) $$\varepsilon = \frac{q_{reg}}{q_{reg,max}} = \frac{h_3 - h_2}{h_5 - h_2}; \quad h_3 = (0.65)(803.13 - 618.26) + 618.26$$

$$= 738.43 \text{ KJ/Kg}$$

$$W_{net} = W_t - W_c$$

$$W_{net} = (h_4 - h_5) - (h_2 - h_1)$$

$$= \{(1219.24 - 803.13) - (618.26 - 310.24)\}$$

$$\boxed{W_{net} = 108.094 \text{ KJ/Kg}}$$

c)

$$q_{in} = (h_4 - h_3)$$

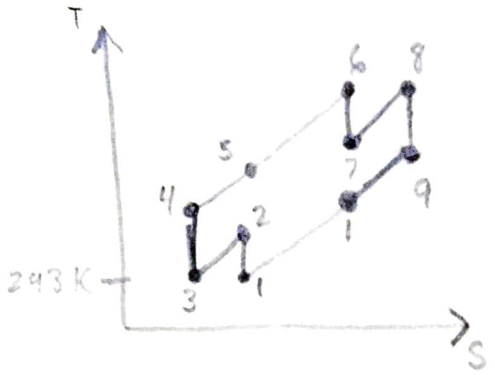
$$= 1219.25 - 738.43$$

$$q_{in} = 480.82 \text{ KJ/Kg}$$

$$\eta_{th} = w_{net} / q_{in} = \frac{108.09}{480.82}$$

$$\boxed{\eta_{th} = 22.48\%}$$

123.



$P_1 = 100$ Kpa

$T_1 = 17^\circ C = 290$ K

$r_p = 4$

$q_{in} = 300$ KJ/Kg

$T_2 = 20^\circ C = 293$K

$T_2 = T_{41} = T_1 r_p^{(k-1)/k} = (290)(4)^{1.4-1/1.4} = 430.9$K

$T_5 = T_{41} + 20 = 430.9 + 20 = 450.9$k

$q_{in} = c_p(T_6 - T_5)$

$T_6 = T_5 + \frac{q_{in}}{c_p} = 450.9 + \frac{300}{1.005} = 749.4$ K

$T_7 = T_6\left(\frac{1}{r_p}\right)^{(k-1)/k} = (749.4)(1/4)^{1.4-1/1.4} = 504.3$K

$T_8 = T_7 + \frac{q_{in}}{c_p} = 504.3 + \frac{300}{1.005} = 802.8$ K

$T_9 = T_8\left(\frac{1}{r_p}\right)^{(k-1)/k} = (802.8)(1/4)^{(1.4-1)/1.4} = 540.2$K

$T_{10} = T_9 - 20 = 540.2 - 20 = 520.2$K

$q_{in} = 300 + 300 = 600$ KJ/Kg

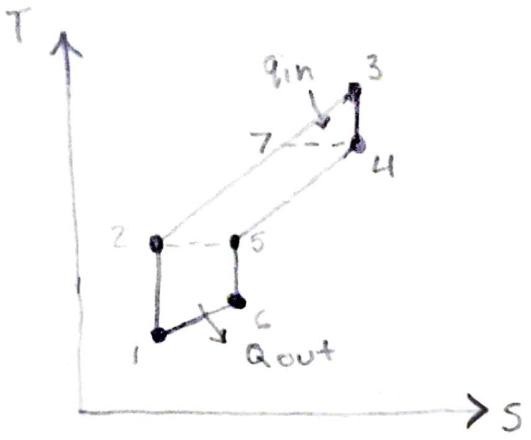
$q_{out} = c_p(T_{10} - T_1) + c_p(T_7 - T_3)$

$= (1.005)(520.2 - 290 + 430.9 - 290)$R

$= 373.0$ KJ/Kg

$\eta_{th} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{373.0}{600} = 0.378$

167.



$$T_5 = T_2 = T_1\left(\frac{P_2}{P_1}\right)^{(K-1)/K}$$

$$T_7 = T_4 = T_3\left(\frac{1}{\sqrt{r_p}}\right)^{(K-1)/K} = T_3 r_p^{(K-1)/2K}$$

$$T_6 = T_5\left(\frac{P_6}{P_5}\right)^{(K-1)/K} = T_5\left(\frac{1}{\sqrt{r_p}}\right)^{(K-1)/K} = T_1 r_p^{(K-1)/2K}$$

$$q_{in} = h_3 - h_7 = c_p(T_3 - T_7)$$

$$q_{in} = c_p\left(T_3 - T_3 r_p^{(1-K)/2K}\right) = c_p T_3\left(1 - r_p^{(1-K)/2K}\right)$$

$$q_{out} = h_6 - h_1 = c_p(T_6 - T_1) = c_p\left(T_1 r_p^{(K-1)/2K} - T_1\right)$$

$$q_{out} = c_p T_1\left(r_p^{(K-1)/2K} - 1\right)$$

$$\eta_{th} = 1 - \frac{c_p T_1\left(r_p^{(K-1)/2K} - 1\right)}{c_p T_3\left(1 - r_p^{(1-K)/2K}\right)}$$

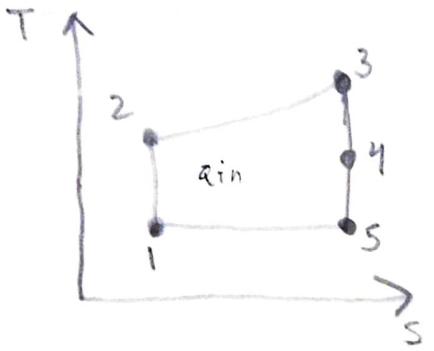
$$= 1 - \frac{T_1\left(r_p^{(K-1)/2K} - 1\right)}{T_3\left(1 - 1/r_p^{(K-1)/2K}\right)}$$

$$= 1 - \frac{T_1\left(r_p^{(K-1)/2K} - 1\right)}{T_3\left(\frac{r_p^{(K-1)/2K} - 1}{r_p^{(K-1)/2K}}\right)}$$

$$= 1 - \frac{T_1\left(r_p^{(K-1)/2K} - 1\right)\left(r_p^{(K-1)/2K}\right)}{T_3\left(r_p^{(K-1)/2K} - 1\right)}$$

$$\boxed{\eta_{th} = 1 - \frac{T_1}{T_3} r_p^{(K-1)/2K}}$$

135



$r_p = 9$

$T_1 = 7°C = 280\,K$

$P_1 = 95\ kPa$ at 20 kg/s

A-17

$h_1 = 280.13\ kJ/kg$

$P_{r_1} = 1.0889$

$$\left.\begin{aligned} \frac{P_2}{P_1} &= \frac{P_{r_2}}{P_{r_1}} \\ P_{r_2} &= P_{r_1}\left(\frac{P_2}{P_1}\right) \end{aligned}\right\} 1\text{-}2$$

$P_{r_2} = (1.0889)(9) = 9.8001$

$$h_2 = \frac{(9.8001 - 9.684)(533.98 - 523.63)}{(10.37 - 9.684)} + 523.63$$

$$h_2 = 525.38\ kJ/kg$$

$Q_{in} = \dot{m}_{fuel} \cdot H.V$

$= 0.5(42700)$

$= 21350\ KW$

$$q_{in} = \frac{Q_{in}}{\dot{m}_a} = \frac{21350}{20}$$

$q_{in} = 1067.5\ kJ/kg$

$q_{in} = h_3 - h_2;\ h_3 = q_{in} + h_2$

$h_3 = 1067.5 + 525.38$

$= 1592.88\ kJ/kg$

$$T_3 = \frac{(1592.88 - 1587.63)(1480 - 1460)}{(1611.79 - 1587.63)} + 1460$$

$= 1464.35\ K$

$$Pr_3 = \frac{(1592.88 - 1587.63)(568 - 537.1)}{(1611.79 - 1587.63)} + 537.1$$

$$= 543.99$$

$$h_3 - h_4 = h_2 - h_1 ; \quad h_4 = h_3 - h_2 + h_1$$

$$h_4 = 1592.88 - 525.38 + 280.13$$

$$h_4 = 1347.63 \text{ kJ/kg}$$

$$\frac{543.99}{Pr_5} = 9$$

$$Pr_5 = 60.44$$

$$h_5 = \frac{(60.44 - 57.60)(888.27 - 866.08)}{(63.09 - 57.60)} + 866.08$$

$$= 877.57 \text{ kJ/kg}$$

$$V_{exit}^2 = 2(h_4 - h_5)$$

$$V_{exit} = \left[\sqrt{2(1347.63 - 877.57}\right] \times \frac{1000 \text{ m}^2/\text{s}^2}{1 \text{ kJ/kg}}$$

$$= 969.59 \text{ m/s}$$

$$F = 20(969.59 - 0)$$

$$= \boxed{19391.95 \text{ N}}$$