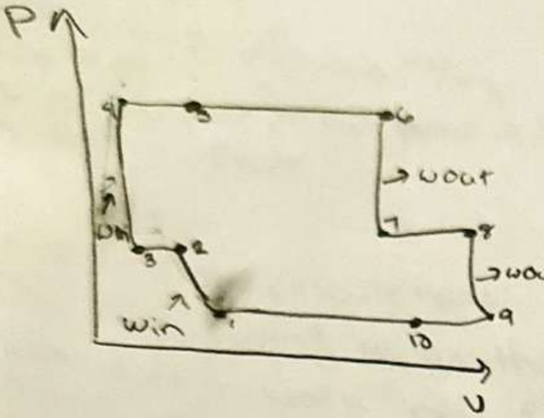
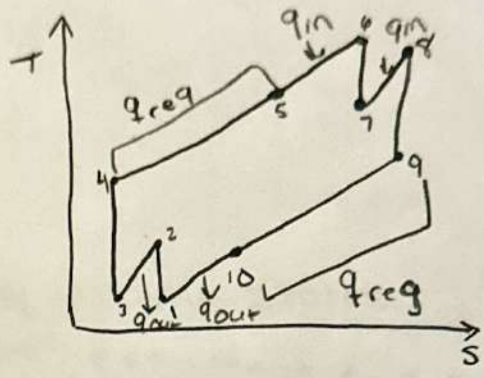
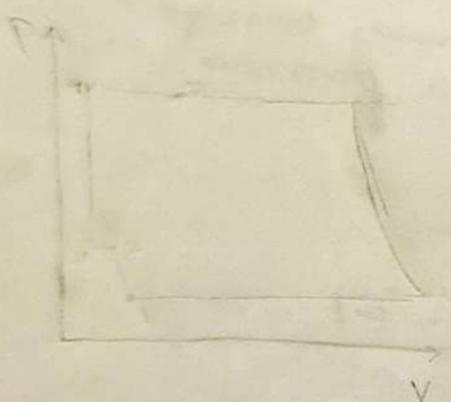
Ashley

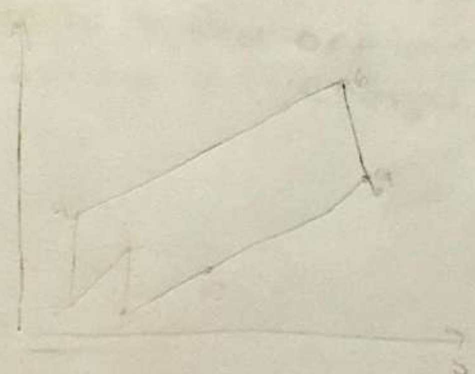
Purpose: Find the effectiveness of the regeneration heat exchanger and determine the produced power if the heater is turned off. Also if the thermal efficiency changed.

Drawings and Diagrams.









Sources: thermodynamics, an engineering Approach, 9th Edition, Yunus Cengel and Micheal Boles, Mcgraw hill

Design and Considersations:

1) Air enters a gas turbine
2) System has regenerator, reheating and intercooling
3) $rp = 4$ at each compression stage
4) Assume isentropic compression and expansion
5) C_P and C_V constant at room temperature

Data and Variables:

$T = 17°C = 290 K$
Heat added at $300 \, kJ/kg$
100 kPa
Power produced at Full Power is 800kPa
materials: Air

Procedure and Calculations:

First I am going to go through the differnt states. Then I will work on find the effiectness for the first part. The last thing I am going to do is find the Power Produced when the heater is turned off and find the thermal efficeincy and see if it changed.

1 —isent→ 2 —Pconst→ 3 —Isent→ 4 —Pconst regenator→ 5 —Pconst q_{in}→ 6 —Isent→ 7 —Pconst q_{in}→ 8 —Isent→ 9 —Pconst regenator→ 10 —Pcost

State 1
$P_1 = 100\,kPa$
$T_1 = 290.15\,K$
$v_1 = \frac{RT_1}{P_1} = 0.833\ m^3/kg$
$Pr_1 = 1.231$
$h_1 = 290.16$

State 2
$P_2 = r_p P_1$
$P_2 = 400\,kPa$
$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$
$T_2 = 431.16\,K$
$v_2 = \frac{RT_2}{P_2} = 0.31\ m^3/kg$
$\frac{P_2}{P_1} = \frac{Pr_2}{Pr_1}$
$Pr_2 = 4.924$
$h_2 = 431.43$

State 3
$P_3 = P_2$
$P_3 = 400\,kPa$
$T_3 = T_1$
$v_3 = \frac{RT_3}{P_3} = 0.21\ m^3/kg$
$Pr_3 = 1.231$
$h_3 = 290.16$

State 4
$P_4 = r_p P_3$
$P_4 = 1600\,kPa$
$\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$
$= 431.08\,K$
$v_4 = \frac{RT_4}{P_4} = 0.071\ m^3/kg$
$\frac{P_4}{P_3} = \frac{Pr_4}{Pr_3}$
$Pr_4 = 4.924$
$h_4 = 431.43$

State 5
$P_5 = P_4$
$P_5 = 1600\,kPa$
$T_5 = T_4 + 20$
$T_5 = 451.081\,K$
$v_5 = 0.081\ m^3/kg$
$Pr_5 = 5.78$
$h_5 = 452.02$

State 6
$P_6 = P_5$
$P_6 = 1600\,kPa$
$q_{in} = C_P(T_6 - T_5)$
$q_{in} = 300\ kJ/kg$
$T_6 = T_5 + \frac{q_{in}}{C_P}$
$T_6 = 749.61\,K$
$v_6 = 0.134\ m^3/kg$

State 7
$P_7 = P_6/r_p$
$P_7 = 400\,kPa$
$\frac{T_7}{T_6} = \left(\frac{P_7}{P_6}\right)^{\frac{k-1}{k}}$
$= 504.35\,K$
$v_7 = 0.362\ m^3/kg$

State 8
$P_8 = P_7$
$P_8 = 400\,kPa$
$T_8 = T_7 + \frac{q_{in}}{C_P}$
$T_8 = 803.05\,K$
$v_8 = 0.576\ m^3/kg$

State 9
$P_9 = P_{10}$
$P_9 = 100\,kPa$
$\frac{T_9}{T_8} = \left(\frac{P_9}{P_8}\right)^{\frac{k-1}{k}}$
$T_9 = 540.51\,K$
$v_9 = 1.551\ m^3/kg$
$Pr_9 = 11.10$
$h_9 = 544.35$

State 10
$P_{10} = P_1$
$P_{10} = 100\,kPa$
$T_{10} = T_9 - \frac{(5-4)}{20}$
$= 520.51\,K$
$v_{10} = 1.464\ m^3/kg$

$$\varepsilon = \frac{h_5 - h_4}{h_9 - h_4} = \frac{452.02 - 431.43}{544.35 - 431.43} = 0.182$$ $\boxed{\varepsilon\ 18.2}$

1 —isent→ 2 —Pconst→ 3 —Isent→ 4 —Pconst regenater→ 5 —Pconst q_{in}→ 6 —Isen→ 7 —Pconst q_{in}→ 8 —Pcos regen→ 9 → 10

State 1
$P_1 = 100\,kPa$
$T_1 = 290.15\,K$
$v = \frac{RT_1}{P_1} = 0.833$
$Pr_1 = 1.231$
$h_1 = 290.16$

State 2
$P_2 = r_p P_1$
$P_2 = 400\,kPa$
$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{k-1}$
$T_2 = 431.16\,K$
$v_2 = \frac{RT_2}{P_2} = 0.31\ m^3/kg$

State 3
$P_3 = P_2$
$P_3 = 400\,kPa$
$T_3 = T_1$
$v_3 = \frac{RT_3}{P_3}$
$= 0.21\ m^3/kg$

State 4
$P_4 = r_p P_3$
$P_4 = 1600$
$\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$
$= 431.08\,K$
$v_4 = \frac{RT_4}{P_4}$

State 5
$P_5 = P_4$
$P_5 = 1600$
$T_5 = T_4 - 20$
$T_5 = 411.08$
$v_5 = 0.074\ m^3/kg$

State 6
$P_6 = P_5$
$P_6 = 1600\,kPa$
$q_{in} = C_P(T_6 - T_5)$
$T_6 = T_5 + \frac{q_{in}}{C_P}$
$T_6 = 709.59$
$v_6 = 0.127\ m^3/kg$

State 7
$P_7 = P_6/r_p$
$P_7 = 400$
$T_7 = 477.51$
$v_7 = 0.34$

State 8
$P_8 = P_7$
$T_8 = T_7$
$v_8 = 0.34$

State 9
$P_9 = 100$
$T_9 = 321.34$

State 10
$P_{10} = P_1$
$T_{10} = 322.34$

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

$w_{net} = w_{out} + w_{out} - w_{in} - w_{in}$
$w_{in,1-2} = C_P(T_2 - T_1) = 141.705\ kJ/kg$
$w_{in,3-4} = C_P(T_4 - T_3) = 141.624\ kJ/kg$
$w_{out,6-7} = C_P(T_6 - T_7) = 233.24$
$w_{out,8-9} = C_P(T_8 - T_9) = 156.95$
$w_{net} = 106.86$

$q_{in} = q_{in,5-6} + q_{in,6-9}$
$q_{in} = 300 + 0$
$q_{in} = 300$

$$\boxed{\eta_{th} = 0.356}$$

$\dot{W}_{net} = \frac{m}{t} = \frac{m}{\left(\frac{2\times 60}{n}\right)}$ $w_{net} = \frac{m}{120} w_{net} n$

$n = \frac{120 \times 400}{0.089 \times 106.86} = 5047.03$

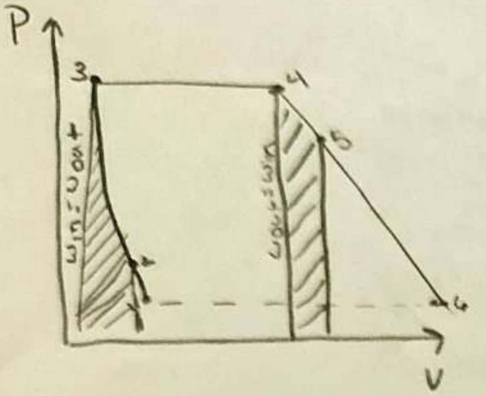
$\dot{W}_{net} = \frac{0.089}{120}(106.86)(5047.03)$
$\boxed{= 399.99\ kW}$

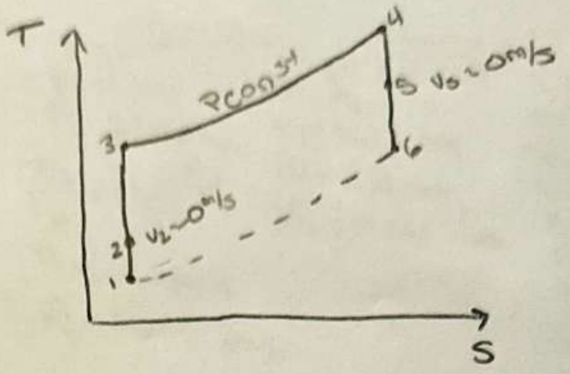
Summary: The effectiveness of regeneration heat exchanger is 0.182. The Power produced when the reheater is turned off is 39999kW and the thermal efficiency 0.356.

Analysis: the thermal efficiency changed because the reheater was turned off which caused the second q_{in} to not eqaul 300 kJ/kg. Also the w_{net} was not the same. The effectiveness compared to the values in the figure is smaller than those in figure but not by much.

Purpose: Find the Propulsive efficiency of the Jet Propulsion cycle. Comparing the two Propulsive efficiencies and See if they changed.

Drawings and Diagrams





Sources: Thermodynamics, an engineering Approach, 9th Edition, Yunus Cengel and Micheal Boles, Mcgraw hill

Design Considerations:

1) A Pure Jet engine
2) $r_p = 13$ (Compressor)
3) C_p, C_v Constant at room temperture ($C_p = 1.005$, $C_v = 0.718$, $k = 1.4$)
4) Ideal operation of all Componants

Data and variables:

$V_{aircraft} = 240$ m/s

$P_1 = 45$ kPa $T_1 = -13°C$

$D_{engine\ inlet} = 1.6$ m

$T_{inlet\ turb} = 557$ C

$\eta_c = 0.80$ $\eta_T = 0.85$

materials:

Jet engine

Procedure and Calculations: I will first find the Propulsive efficiency. Then re solve problem using the efficiency and calculate the new Jet Propulsive efficiency. But I am going to do the different states first.

1 —(Isent, Diffuser)→ 2 —(Isent)→ 3 —(Pconst)→ 4 —(Isent, $W_C = W_T$)→ 5 —(Isent, Nozzle)→ 6

State 1

$P_1 = 45\,kPa$

$T_1 = 260.15\,K$

$v_1 = \frac{RT_1}{P} = 1.659$

$V_1 = 240\,m/s$

State 2

$V_2 = 0\,m/s$

$T_2 = T_1 + \frac{V_1^2}{2c_p}$

$T_2 = 288.81\,K$

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

$P_2 = 64.87\,kPa$

$v_2 = 1.278\,m^3/kg$

State 3

$P_3 = r_p P_2$

$P_3 = 8133\,kPa$

$\frac{T_3}{T_2} = \left(\frac{P_3}{P_2}\right)^{\frac{k-1}{k}}$

$T_3 = 600.99\,K$

$v_3 = 0.205\,m^3/kg$

State 4

$P_4 = P_3$

$P_4 = 848.31\,kPa$

$T_4 = 836.15\,K$

$v_4 = 0.283\,m^3/kg$

State 5

$V_5 = 0\,m/s$

$T_5 = T_4(T_3 - T_2)$

$T_5 = 517.97\,K$

$\frac{P_5}{P_4} = \left(\frac{T_5}{T_4}\right)^{\frac{k}{k-1}}$

$P_5 = 161.715\,kPa$

$v_5 = 0.919\,m^3/kg$

State 6

$P_6 = P_1$

$P_6 = 45\,kPa$

$\frac{T_6}{T_5} = \left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}}$

$T_6 = 358.44\,K$

$v_6 = 2.29\,m^3/kg$

$V_6 = \sqrt{2c_p(T_5 - T_6)}$

$V_6 = 564.52\,m/s$

$$\eta_P = \frac{\dot{W}_P}{\dot{Q}_{in}}$$

$$\dot{W}_P = F V_{aircraft} = \dot{m}(V_{exit} - V_{inlet})V_{aircraft}$$

$$= \frac{240}{1.659}\left(\frac{\pi}{4} \times 1.6^2\right)(564.52 - 240)(240)\left(\frac{1}{1000}\right)$$

$$= 22654.13\,kW$$

$$\dot{Q}_{in} = c_v(T_4 - T_3)$$

$$= 47858.37$$

$$\boxed{\eta_P = 0.473}$$

1 — Isen Diffuser — 2 — Isent η_c — 3 — P const — 4 — Isent $w_c = w_T$ — 5 — Isent Nozzle — 6

$P_1 = 45\ kPa$
$T_1 = 260.15K$
$\nu_1 = 1.659$
$V_1 = 240 m/s$
$P_{r_1} = 0.8405$
$h_1 = 260.09$

$V_2 = 0 m/s$
$T_2 = T_1 + \frac{V_1^2}{2c_p}$
$T_2 = 288.81K$
$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\frac{k}{k-1}}$
$P_2 = 64.87 kPa$
$\nu_2 = 1.278 m^3/kg$
$P_{r_2} = 5.39$
$h_2 = 441.67$
$T_2 = 440.1$

$P_3 = r_p P_2$
$P_3 = 843.8 kPa$
$\frac{T_3}{T_2} = \left(\frac{P_3}{P_2}\right)^{\frac{k-1}{k}}$
$T_3 = 600.99K$
$\nu_3 = 0.205 m^3/kg$
$P_{r_3} = 70.07$
$h_3 = 911.73$
$T_3 = 881.09$

$P_4 = P_3$
$T_4 = 830.15K$
$\nu_4 = 0.283$
$P_{r_4} = 55.093$
$h_4 = 855.03$

$V_5 = 0 m/s$
$T_5 = T_4(T_3 - T_2)$
$T_5 = 517.97$
$P_5 = 161.75$
$\nu_5 = 0.919 m^3/kg$
$P_{r_5} = 10.56$
$h_5 = 534.17$
$T_5 = 530$

$P_6 = P_1$
$T_6 = 389.4$
$\nu_6 = 2.29 m^3/K$

$V_6 \sqrt{2c_p (T_5 - T_6)}$
$V_6 = 560.32 m/s$

$P_{r_6} = 2.93$
$h_6 = 370.63$
$T_6 = 370$
$V_6 \sqrt{2c_p(T_5 - T_6)}$
$V_6 = 564.6 m/s$

$$\eta_c = \frac{h_2 - h_1}{h_{2a} - h_1}$$

$h_{2a} = 592.55$
$T_{2a} = 586.03$

$$\eta_T = \frac{h_5 - h_{6a}}{h_5 - h_6}$$

$h_{6a} = 399.6$
$T_{6a} = 398.62$

$$F = \dot{m}(V_{exit} - V_{inlet}) = \frac{V_1}{\nu_1} \frac{\pi}{4} D^2 (V_6 - V_1)$$

$F = 94415.48N$

$$\eta_p = \frac{W_p}{q_{in}}$$

$W_p = F_{aircraft} = \dot{m}(V_{exit} - V_{inlet}) V_{aircraft}$
$= 22659.71$

$Q_{in} = c_v(T_4 - T_3)$
$= 14816.77$

$$\boxed{\eta_p = 1.52}$$

Summary: Propulsive efficiency is 0.473 and Pro Pulsive efficiency when solving with 80 percent Compressor efficiency and 85 percent turbine efficiency is 1.52.

Analysis: The two Propulsive efficiency are differnt from each other by alot. they changed because the Probelm was Solved differntly than before for each State beccause Compressor effieincy and turbine effiency was used to Solve it.