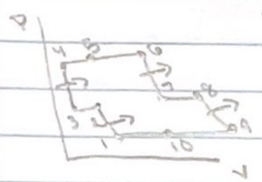
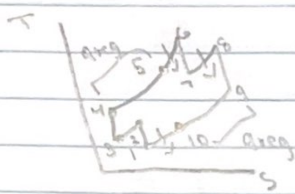
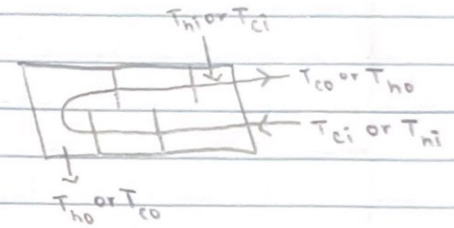
TEST 1 - MET 350 - KAYLA DAVIES

① PURPOSE: CALCULATE THE EFFECTIVENESS OF THE REGEN. HEAT EXCHANGER & COMPARE TO TYPICAL VALUES, FIND THE PRODUCED POWER IF TURNED OFF & DETERMINE WHY THE THERMAL EFFICIENCY DID/DID NOT CHANGE.

DIAGRAMS:







SOURCES:

- CENGEL & BOLES. THERMODYNAMICS - AN ENGINEERING APPROACH. 8TH EDITION MCGRAW HILL. 2015
- CANVAS NOTES/SLIDES

DESIGN CONSIDERATIONS

ASSUME THE FOLLOWING:

1) AIR BEHAVES AS AN IDEAL GAS; R=0.3704
2) REGENERATOR OPERATES PERFECTLY
3) ISENTROPIC COMPRESSION + EXPANSION
4) CONSTANT CP, CV AT ROOM TEMP
   └ C_p=1.004976 C_v=0.717926 k=1.4

DATA & VARIABLES

T=17C° P=100 kPa @ inlet, r_p=4, 300 kJ/kg heat added in each chamber, W_{net}= 226.801 kJ/kg, q_{in}= 600 kJ/kg, η_{TH}= 0.378

MATERIALS

AIR AS AN IDEAL GAS

PROCEDURE:

I obtained all states first, and then calculated the net power produced by the cycle to find the thermal effiency. The effectiveness was then calculated using the states found & compared to the values in fig 11.12. POWER WAS FOUND TO NOT EXIST (ERROR)

CALCULATIONS:

from prob. 9-133 : $\frac{P_2}{P_1} = \frac{P_4}{P_3}$ & $\frac{P_6}{P_7} = \frac{P_8}{P_9}$

① isen ② CP ③ isen ④ CP ⑤ CP ⑥ isen ⑦ CP (heater removed) ⑧ isen ⑨ CP ⑩ CP

①
$P_1 = 100$ kPa
$T_1 = 290$ K

②
$\frac{P_2}{100} = 4$
$P_2 = 400$ kPa
$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{r-1}{r}}$
$T_2 = 290 \times 4^{\frac{0.4}{1.4}}$
$T_2 = 430.9$ K

③
$P_3 = 400$ kPa
$T_3 = 290$ K

④
$\frac{P_4}{400} = 4$
$P_4 = 1600$ kPa
$\frac{T_4}{T_3} = \frac{P_4}{P_3}^{\frac{r-1}{r}}$
$T_4 = 290 \times 4^{\frac{0.4}{1.4}}$
$T_4 = 430.9$ K

⑤
$P_5 = 1600$ kPa
$T_5 = 430.9$ K

⑥
$P_6 = 1600$ kPa
$T_6 = 430.9$

⑦
$\frac{T_6}{T_7} = \frac{1}{3}\frac{P_6}{P_7}^{\frac{r-1}{r}}$
$T_7 = \frac{1}{4}^{\frac{0.4}{1.4}} \times 430.9$
$T_7 = 289.97$

⑧
$P_8 = 400$ kPa
$T_8 = 400^{\frac{-.4}{1.4}}$
$T_8 = 400$ K

⑨
$P_9 = 100$ kPa
$\frac{T_9}{T_4} = \frac{1}{4}^{\frac{-.4}{1.4}}$
$T_9 = 430.9$

⑩
$P_{10} = 100$ kpa
$T_{10} = 100 \times 1^{\frac{1.4-1}{1.4}}$
$T_{10} = 100$ kPa

$w_{net} = w_{out_{6-7}} + w_{out_{8-9}} - w_{in_{1-2}} - w_{in_{3-4}}$

$w_{out_{6-7}} = C_p(T_6 - T_7) = 1.005(430.9 - 289.67) = 141.9$ kJ/kg

$w_{out_{8-9}} = C_p(T_8 - T_9) = 1.005(400 - 430.9) = 31.05$ kJ/kg

$w_{in_{1-2}} = C_p(T_2 - T_1) = 1.005(430.9 - 290) = 141.6$ kJ/kg

$w_{in_{3-4}} = C_p(T_4 - T_3) = 1.005(430.9 - 290) = 141.6$ kJ/kg

$w_{net} = 141.9 + 31.05 - 141.6 - 141.6 = |-103.1| = 103.1$ kJ/kg

$\eta_{TH} = \frac{103.1}{300} = 0.344$

calculating the difference:

$\frac{0.378 - 0.344}{0.378} = 0.089 \rightarrow$ **8.99%**

$\varepsilon_{reg} = \frac{h_{in}}{h_{out}} = \frac{T_5 - T_4}{T_9 - T_4} = \frac{430.9 - 430.9}{430.9 - 430.9}$

$\varepsilon_{reg} = 0$?

$W_{max} = \frac{P}{\varepsilon} = \frac{800}{0} =$ DNE

SUMMARY

comparison table

9-133	TEST 1	
226.801 kJ/kg	103.1 kJ/kg	w_{net}
600 kJ/kg	275.74 kJ/kg	Q_{in}
0.378	0.344	η_{TH}

ANALYSIS

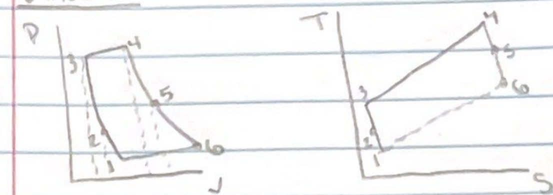
WHEN THE REHEATER WAS TURNED OFF, THE EFFECIENCY CHANGED 8.99%. REHEATING IS USED IN CYCLES TO INCREASE EFFICIENCY DUE TO THE DECRESE OF ENTROPY. THE EFFECTIVENESS WAS CALCULATED TO BE Ø which makes sense DUE TO $C_{min}/C_{max} = 0$. HOWEVER, THAT ALLOWED FOR THE POWER TO NOT EXIST WHICH IS INCORRECT.

TEST 1 - MET 350 - KD

(2)

PURPOSE: CALCULATE THE PROPULSIVE EFFICIENCY OF THE JET PROPULSION CYCLE, THEN REPEAT USING DIFFERENT EFFICIENCIES, VARIABLE CP/CV, & COMPARE TO THE PREVIOUS ONE.

DIAGRAMS:



SOURCES:

CENGEL & BOLES. THERMODYNAMICS - AN ENGINEERING APPROACH. 8TH EDITION. MCGRAW HILL 2015

CANVAS NOTES

DESIGN CONSIDERATIONS:

I ASSUME THE FOLLOWING:

1) A PURE JET ENGINE
2) CP, CV CONSTANT @ ROOM TEMP
   ↳ CP = 1.004926 , CV = 0.717926 k = 1.4
3) IDEAL OPERATION OF ALL COMPONENTS

DATA & VARIABLES

$V_{aircraft}$ = 240 m/s P_1 = 45 kPa T_1 = -13°C = 260 K

$D_{engine, inlet}$ = 1.6 m r_p = 13 (compressor) $T_{inlet\ turb}$ = 557°C - 830 K

$V_{engine\ nozzle\ exit}$ = 564.52 m/s   F = 94392.21 N η_C = 80%. η_T = 85%.

MATERIALS

AIR AS AN IDEAL GAS

PROCEDURE

I STARTED BY FINDING ALL OF THE STATES (P, V, T) AND USED THE $V_{\text{engine nozzle exit}}$ and F to CALCULATE THE PROPULSION EFFICIENCY IN PROB 9-142.

CALCULATIONS

$P_3 = P_4$ / $P_1 = P_6$ $\quad \frac{P_2}{P_1} = 13 = \frac{P_3}{P_2}$

$W_c = W_T$

① —isen→	② —isen→	③ —cp→	④ —isen→	⑤ —isen→	⑥ —cp
$P_1 = 45\ kPa$	$T_2 = 260 + \frac{240^2}{2(0.717)}$	$T_3 = 600.99$	$P_4 = 845\ kPa$	$T_5 = T_4 - T_3 + T_2$	$P_6 = 45\ kPa$
$T_1 = 260\ k$	$T_2 = 288.81\ K$	$P_3 = 13 \times 65$	$T_4 = 830\ k$	$T_5 = 517.81$	$\frac{T_6}{T_5} = \left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}}$
$V_1 = 240\ m/s$	$P_2 = 45 \times \frac{288.81}{260}^{\frac{.4}{1.4}}$	$P_3 = 845\ kPa$	$V = 0.283\ m^3/kg$	$\frac{P_5}{P_4} = \left(\frac{T_5}{T_4}\right)^{k/k-1}$	$T_6 = 517.81\left(\frac{45}{167.1}\right)^{0.4/1.4}$
	$P_2 = 65\ kPa$			$P_5 = 167.1\ kPa$	$T_6 = 359\ K$
	$V_2 = 0\ m/s$				

$P_{ideal} = F \times V_{eng.} = 94392.2 \times 564.52 = 53286284.74\ Nm/s \rightarrow (1\ Nm/s = 1\ W)$

$\eta_p = \frac{F}{P_{ideal}} = \frac{94392.2}{53286284.74} = 0.001$ or $\boxed{0.17\%}$

DIDNT HAVE TIME TO FINISH

SUMMARY

THE EFFICIENCY OF JET CYCLE WAS FOUND TO BE 0.17%.

ANALYSIS

ALTHOUGH I DIDNT FINISH, I CAN PREDICT THAT THE EFFICIENCY WOULD INCREASE DUE TO THE VELOCITY AT THE EXIT OF THE NOZZLE BEING MINIMAL.