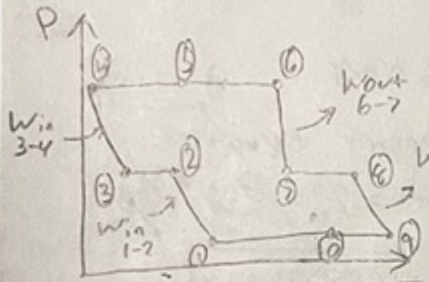
Colby Watts
MET 350 Test 1
Professor Ayala
2/18/24

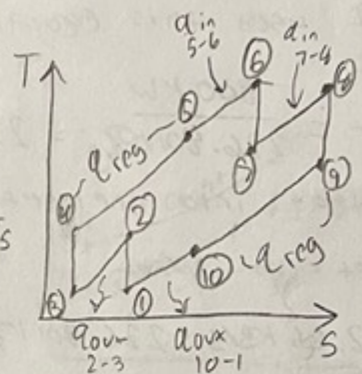
Colby Watts
Thermal Applications test 1

Purpose Part 1 $\boxed{A}$ & $\boxed{B}$

Calculate the effectiveness of the regeneration heat exchanger from problem 9-133. Also, at full load engine produces 800KW of power. What is the produced power if the reheater is off. Explain if thermal efficiency changes.

Drawings & Diagrams





There is no regeneration so it is only

Sources

Thermodynamics "an engineering approach" book
Slides & notes from class
Dr. Ayala problem solutions

Design considerations

If the effectiveness is very low that means the design is horrible. This design is not safe.

Data & variables

$$\varepsilon = \frac{T_5 - T_4}{T_9 - T_4}$$

$T_5 = 451.06K$
$T_9 = 540.51K$
$T_4 = 431.08K$

$W = 800 KW$ $\quad W_{net} = 226.801 \, KJ/kg$

Procedure & Calculations

To find effectiveness of regeneration you use this equation from the book

A $$\varepsilon = \frac{T_5 - T_4}{T_9 - T_4} = \frac{451.08K - 431.08K}{540.51K - 431.08K} = 0.182 = \boxed{18\%}$$

So, since the effectiveness was very low that means this was designed horribly.

Then to calculate for the power produced if the reheater is turned off I used this equation to calculate for mass flow rate.

B $$\dot{m} = \frac{\dot{P}}{W} = \frac{800\ KW}{226.801\ KJ/kg} = 2.66\ Kg/s$$

Then plug that into the net power equation.

$$\dot{W}_{net} = \dot{m} \cdot W_{net} \qquad W_{net} = 226.801\ KJ/kg$$

$$\dot{W}_{net} = 2.66\ Kg/s \cdot 226.801\ KJ/kg = \boxed{603.11\ KW}$$

Thermal efficiency would change due to a lower power output. Since there is no reheater thermal efficiency decreases because it is no longer being heated back up.

Materials

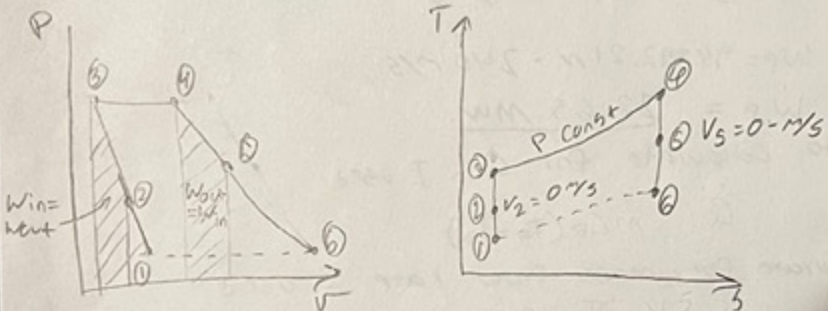
ideal gas is Air

Part 2 $\boxed{A}$ & $\boxed{B}$

Purpose

Calculate the propulsive efficiency of the Jet propulsion cycle solved in class 9-142. Then repeat the problem using a compressor efficiency of 80% and a turbine efficiency of 85%. Calculate the propulsive efficiency of the Jet propulsion cycle and compare to the previous one. Does the efficiency change?

Drawings & Diagrams



Sources

Thermodynamics "an engineering approach" book
Slides & notes provided in class
Dr. Ayala Solved Problems

Design Considerations

- I am assuming constant C_P, C_V at room temperature
- Ideal operation of all components

Data & Variables

$\eta_P = \frac{\dot{W}_P}{\dot{Q}_{in}}$ $F = 94392.21\ N$ $D = 1.6$ $V_1 = 240\ m/s$ $T_4 = 830.15\ K$

$V_{aircraft} = 240\ m/s$ $v_1 = 1.659\ m^3/kg$ $T_3 = 600.99\ K$

$C_P = 1.004\ kJ/kg \cdot K$

$\dot{m} = \frac{V_1}{v_1}\frac{\pi}{4}D^2$ $\dot{Q}_{in} = \dot{m}C_P(T_4 - T_3)$ $\dot{W}_P = F \cdot V_{aircraft}$

Procedure & Calculations $\boxed{A}$

To calculate for propulsive efficiency, I used the propulsive efficiency equation.

$$\eta_p = \frac{\text{Propulsive Power}}{\text{Energy input rate}} = \frac{\dot{W}_P}{\dot{Q}_{in}}$$

Now, to solve for $\dot{W}_P$, I used this equation from the book

$$\dot{W}_P = F \cdot V_{aircraft}$$

Plug in F and V

$$\dot{W}_P = 94392.21\,N \cdot 240\,m/s$$

$$\dot{W}_P = \underline{22.65\ MW}$$

Then to calculate for $\dot{Q}_{in}$ I used

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

To calculate for mass flow rate I used

$$\dot{m} = \frac{V_1}{v_1}\frac{\pi}{4}D^2$$

To solve for this plug in values

$$\dot{m} = \frac{240\,m/s}{1.659\,m^3/kg} \cdot \frac{\pi}{4} \cdot (1.6^2)\,m$$

$$\dot{m} = 290\ kg/s$$

Then I solved for $\dot{Q}_{in}$ pluggin $\dot{m}$ into the equation

$$\dot{Q}_{in} = (290\,kg/s)(1.004\,kJ/kg \cdot K)(830.15K - 600.99K)$$

$$\dot{Q}_{in} = \underline{66.293\ MW}$$

Then plug the values for $\dot{Q}_{in}$ and $\dot{W}_P$ back into the propulsive efficiency equation.

$$\eta_P = \frac{22.65\ MW}{66.293\ MW} = 0.3403$$

$$\boxed{\eta_P = 34.03\ \%}$$

$\boxed{B}$

$$① \xrightarrow{\text{Isent}} ② \xrightarrow{\text{Isent}} ③ \xrightarrow{\text{P const}} ④ \xrightarrow{\text{Isent}} ⑤ \xrightarrow{\text{Isent}} ⑥$$

①	②	③	④	⑤	⑥
$P_1 = 45\,kPa$	$V_2 = 0\,m/s$	$T_3 = 600.99\,K$	$P_4 = 8433\,kPa$	$P_5 = 161.715$	$T_6 = 359.41\,K$
$T_1 = 260.15\,K$	$T_2 = 288.81\,K$	$v_3 = 0.205\,m^3/kg$	$T_4 = 830.15\,K$	$T_5 = 517.77\,K$	$v_6 = 2.29\,m^3/kg$
$v_1 = 1.659\,m^3/kg$	$P_2 = 64.87\,kPa$		$v_4 = 0.283\,m^3/kg$	$v_5 = 0.919$	$V_6 = 564.52\,m/s$
	$v_2 = 1.278\,m^3/kg$		$h_4 = 855.20$		

All h values tabulated from tables and from the given temperatures

positive

$$0.80 = \frac{h_{3s} - h_2}{h_{3a} - h_2}$$

$$0.80 = \frac{607 - 288.97}{h_{3a} - 288.97}$$

$$h_{3a} = 686.51$$

$$0.85 = \frac{h_4 - h_{5a}}{h_4 - h_{5s}}$$

$$h_{5a} = \frac{855.20 - h_{5a}}{855.20 - 521.54}$$

$$h_{5a} = 571.59\,kJ/kg$$

$$q_{in\,3\text{-}4} = h_4 - h_{3a}$$

$$q_{in\,3\text{-}4} = 168.69\,kJ$$

$$\dot{Q}_{in} = \dot{m}c_p(h_4 - h_{3a}) = \left(290\,\tfrac{kg}{s}\right)\left(1.004\,\tfrac{kJ}{kg\cdot K}\right)(855.20 - 686.51)\,K$$

$$\dot{Q}_{in} = 49.14\,MW$$

From previous problem $\dot{W}_P = 22.65\,MW$

$$\eta_P = \frac{\dot{W}_P}{\dot{Q}_{in}} = \frac{22.65\,MW}{49.14\,MW} = .4612$$

$$\eta_P = \boxed{46.12\,\%}$$

Propulsion efficiency is higher due to the compressor and turbine being 80% and 85%.